ELECTRIFICATION OF TRANSPORT IN CANADA,

THE TIME IS NOW

Report from Electric Mobility Canada

December 2021

Electric Mobility Canada /Mobilité électrique Canada – www.emc-mec.ca – info@emc-mec.ca
38 place du Commerce, 11-530 Ile des Sœurs, QC H3E 1T8

Authors

Daniel Breton

President and CEO of Electric Mobility Canada, author on multiple books on electric mobility, former Environment Minister of Québec, he has a degree in sustainable carbon management.

Pierre Langlois, Ph.D.

Physicist, consultant in electric mobility, author of the book “Rouler sans pétrole” in 2008 and of more than 200 articles on electric mobility in blogs and newsletters (www.planglois.com).

Jean-Marc Pelletier, M.Sc.A., P. Eng.

Engineer & consultant, he devoted his entire career in the field of energy within Hydro-Québec's Research Center (IREQ).

Geneviève Dufour, Ph.D.

Professor for the Faculty of Law at University of Sherbrooke, where she heads the Master of International Law and Applied International Policy

David Pavot, Ph.D.

Assistant Professor of International Law at the School of Management of the University of Sherbrooke

ELECTRIC MOBILITY CANADA
ACCELERATING ELECTRIC TRANSPORTATION

MOBILITÉ ÉLECTRIQUE CANADA
ACCÉLÉRER L'ÉLECTRIFICATION DES TRANSPORTS

TABLE OF CONTENTS

Electric Mobility Canada /Mobilité électrique Canada – www.emc-mec.ca – info@emc-mec.ca
38 place du Commerce, 11-530 Ile des Sœurs, QC H3E 1T8

Summary

1. Introduction

Since 2008, Canada has missed some important opportunities to help develop a thriving electric mobility industry. There are lessons to be learned from that last major crisis in the way we will collectively want to emerge from the present crisis. Not only are we presently dealing with a historic public health and economic crisis, but Canada, and the world, also have to deal with the climate crisis.

If we want an economic recovery that will not only create jobs in the short term, but also help the environment, there are some key sectors that can be supported by all the major stakeholders, from governments to the private sector, from institutions to consumers and from BC to the Maritimes and to the North. And electric and smart transportation is certainly one of them but we must learn from past mistakes.

In 2008, "The Electric Vehicle Technology Roadmap for Canada" was published by a group of different stakeholders, including Electric Mobility Canada, CAW/TCA, OEMs such as Ford and GM, utilities and other groups specialized on the topic in order to propose a vision of what could be done to reach the target of 500 000 Zero Emission Vehicles by 2018. 13 years later, many of the proposals still haven't been implemented.

In 2009, when GM and Chrysler were in trouble, the US government helped them in exchange for research & development on EVs. No such obligation was asked by the Canadian government in return for their financial support. We then lost an important opportunity. Although the Canadian government created the Automotive Innovation Fund that same year, it was not adapted for SMEs in the electric mobility sector.

2. Canada and the World

The purpose of this chapter is to establish where we are in 2021 with respect to the electrification of transportation on a global scale, in order to better position Canada in relation to other countries. The analysis is based primarily on electric vehicle (EV) sales statistics and their evolution, as well as on incentive policies and their correlation with observed EV sales market shares. Globally, the market share of EVs has increased from 2.5% in 2019 to 4.2% in 2020.

China increased its EV market share to 6.3% in 2020, but this was not enough to maintain the EV market dominance it had until 2019 in terms of numbers sold. It was Europe that took the lead in 2020, with Norway, Sweden, Germany, the UK and France in particular outperforming as shown below.

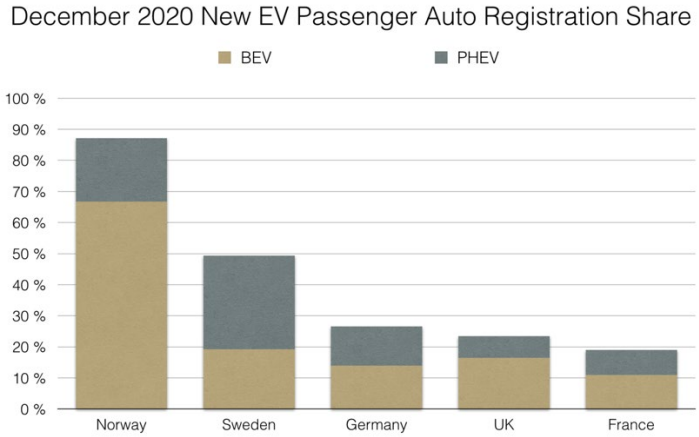


Figure S.1: Market shares of electric vehicle sales in different European countries for the month of December 2020, including Plug-in Hybrid Electric Vehicles (PHEVs) and Battery Electric Vehicles (BEVs). Source: Clean Technica.

In the US, there is a split between California and the rest of the country. Indeed, the market share of EVs was 7.8% in 2020 in California compared to 1.5% for the rest of the country. California's zero-emission standard is likely to have played an important role in this.

Canada's official statistics for the third quarter of 2020 show an EV market share of 3.7% for Canada as a whole, higher than the US. British Columbia and Quebec, which are the only provinces to have implemented a zero-emission vehicle (ZEV) standard and have more EV purchase subsidies than other provinces, show similar results to California, with a market share of 8.4% for British Columbia and 6.7% for Quebec in Q3 2020.

3. New Raw Materials for EVs: the Mining Sector and Electromobility

This chapter first describes the changes in raw materials required for electric vehicles compared to traditional thermal vehicles. Copper requirements will almost quadruple by 2030. Li-ion batteries require nickel, cobalt, lithium and graphite and electric motor magnets contain neodymium and other rare earths.

Geopolitical considerations follow and it is noted that China controls the majority of the resources. This fact, combined with cheaper labour, makes it very difficult to compete with this industrial giant.

However, more and more electric vehicle manufacturers are demanding responsibly extracted raw materials from their suppliers, which has been reported is not necessarily the case in China at present.

There is therefore an opportunity for Canada, which has most of the mining resources required for EVs on its territory, in addition to abundant renewable electricity. Already, some Canadian mining projects are aiming to significantly reduce their emissions by electrifying mining vehicles and tools. It would also be in Canada's interest to transform its raw materials into more sophisticated ones, and even better to manufacture cells and batteries on its territory.

4. The Value Chain of Batteries

The battery value chain starts in the mines, continues in the cathode and anode materials factories, and ends in the cell factories, which are then assembled into battery packs for installation in EVs. While reviewing this chain, the Canadian companies that are involved are mentioned.

After observing China's control over raw materials in Chapter 3, it should come as no surprise that China also controls battery production. In fact, more than 90% of battery factories are owned by Asian companies (China, Japan and South Korea).

Canada must act quickly if it wants to attract the big players here and establish partnerships to set up one or more battery gigafactories on its territory. Canada has a number of strengths in this regard. Canada has a well-established research base in the field of batteries. Several Canadian players are featured in this chapter, including Jeff Dawn's lab at Dalhousie University in Nova Scotia (working with Tesla, among others), Hydro-Québec's Centre of Excellence for Transportation Electrification and Energy Storage, and several National Research Council groups. Several universities are also involved. So Canada has a skilled workforce. And, let us repeat, the country has an abundance of clean, renewable electricity.

Finally, we should mention the recycling of Li-ion batteries, which is well underway in Canada, thanks to three companies (Lithion in Quebec, Li-Cycle in Ontario and Retriev Technologies in British Columbia), two of which (Li-Cycle and Lithion) are in the start-up phase, with a new hydrometallurgy technology offering a recovery rate of around 95%.

5. A Larger Perspective on the EV Ecosystem

The electric vehicle ecosystem has evolved rapidly from 2011 to 2021. The range of EVs has increased from 130 km to 400 km or even 500 km, and the power of chargers has increased from 6 kW to 150 kW, 250 kW and even up to 450 kW in some places. In addition, electrification now extends to a whole range of vehicles: bicycles, scooters, motorbikes, 3-wheeled microcars, cars and SUVs, small and large trucks and buses, recreational vehicles (snowmobiles, personal watercraft, boats for water sports or pleasure) and even large ferries. While describing this ecosystem in this chapter, Canadian companies related to it are mentioned, giving an overview of what is being done in transport electrification in Canada.

In addition, a questionnaire was sent to various important Canadian players in transport electrification: manufacturers of light and heavy duty EVs, the Unifor union, a public transit manager and three non-governmental organizations. The questions focused on their vision for the electrification of transport until 2030, their concerns, and how the Government of Canada could help them accelerate EV penetration. A summary of the answers is presented in this chapter and the full answers in Appendix 2.

The main points raised in the various answers are :

- the need to maintain or implement purchase rebates appropriate to the price of EVs,
- the need to have enough EVs available at dealerships,
- the need for governments to invest in charging infrastructure ,
- the need to educate the public and train technical staff.

6. Electrical Infrastructures – A New Paradigm

With a number of vehicles estimated at ≈ 35 million vehicles in 2050 in Canada, the electrification of vehicles will prove to be a major challenge for the provision of electricity in Canada and will induce strong growth in electricity generation and transmission infrastructure.

This increase must be aligned with two layers overlapping each other, i.e. electric topology (generating stations -> transmission network -> distribution network -> end user) and market structure (generation - wholesale - distribution - client) which varies from one province and territory to the other, some being deregulated ("free market") and other fully integrated.

Also, special attention should be paid to sparsely populated territories covering large areas which present particular challenges in the electrification of vehicles in these territories.

Thus, this in-depth overhaul in the electricity supply must take into account the fact that the energy sector is of provincial or territorial jurisdiction. Therefore, the measures put forward by the federal government should not interfere with local jurisdictions but rather offer "incentives" to support the choices of each jurisdiction, while presenting "varied options" to set up a "level playing field" taking into account the particularities of the provinces and territories.

7. Role of Governments, Utilities and Private Companies in the Transition to Electric Vehicles

The transition in land transport to electric vehicles will require close coordination between end users of electric vehicles ("the Prime Movers") and the governments who will have to promote this transition through an appropriate legislative framework and fiscal incentives. Also, companies have an important role as actors in the transition to electric transportation and more specifically medium and large size companies who have the financial means to carry on this transition.

As far as electricity companies are concerned, they will play a key role in the transition to the massive use of electric vehicles. This challenge will be mainly at the level of electricity generation but will involve the reinforcement of the transmission networks as well as an upgrade of the low voltage distribution networks.

Also, to the extent that the supply of electricity in the provinces and territories falls under the jurisdiction of these governments, they will have to support the transition through financial incentives for the purchase of electric vehicles and for the setting up of charging stations. And, with regard to electricity generation and managers of electricity transmission and distribution networks, to adopt appropriate fiscal measures in order to support the investments they will have to make in the event that these services fall under private companies operating on "free markets" conditions.

Lastly, the federal government, without interfering in a field of provincial or territorial jurisdictions, can nevertheless support these governments by proposing financial incentives which would make it possible to "level" the conditions of access to the electrification of transport, regardless of the type of territory to be served and the specific conditions in each of these.

Electric Mobility Canada /Mobilité électrique Canada – www.emc-mec.ca – info@emc-mec.ca
38 place du Commerce, 11-530 Ile des Sœurs, QC H3E 1T8

8. Public Procurement of EVs, Charging Infrastructures and Relates Products/Services in Canada

In chapter 8, we look at the impact of international free trade agreements on EV related companies that build vehicles, infrastructure and other products and the positive effect that "greener procurements" could have on Canadian jobs in this sector. It is a trend that has been seen elsewhere in the world and that could inspire Canadian governments.

Traditionally, government procurement has been governed by the rule of the lowest bidder. If buyers were allowed to impose certain technical requirements, these had to adhere to the strict specifications of the product. However, since the end of the 2000s, certain considerations not necessarily linked to the intrinsic characteristics of products are becoming commonplace. This is the case for the criteria and requirements related to environmental protection which contribute to the phenomenon of 'greenifying' public procurement.

The Canadian industry on the electrification of transportation could certainly benefit from this 'greening' of public market. Canadian production in the field may offer comparative advantages that could allow the industry to position itself advantageously in the context of calls for tenders and to become even more competitive in international markets, which could lead to an increase in Canadian purchases.

9. The Role of Government Incentives in Canadian EV Industry Strategy

During the 2010s, statistics show us that there is a strong trend among consumers to move away from small cars to larger, more fuel-efficient SUVs. And, given the 12-14 year lifespan of vehicles, we can expect that the electrification of transport will not be completed before 2045 - 2050. These facts argue for government action to accelerate the penetration of EVs and reduce greenhouse gas (GHG) emissions from gasoline and diesel vehicles if we are to meet our GHG emission reduction targets.

Chapter 9 focuses on four main government actions: the continuation of the zero-emission vehicle (ZEV) rebate, which includes EVs and fuel cell-hydrogen vehicles (FCHVs); the implementation of a ZEV standard to increase the availability of ZEVs; the upgrade to a more stringent fuel economy standard for conventional vehicles; and the implementation of a cleaner fuel standard. Several details, statistics and arguments are presented to support each of these actions.

10. Conclusion: The Time Is Now

There are many important health and economic reasons for Canada to support electric mobility.

Here are 3 of them:

559,400 clean jobs by 2030: Almost 50% in clean transport.

According to *The Fast Lane, tracking the energy revolution 2019* from Clean Energy Canada, demand for clean energy and clean transportation jobs will keep growing at a very fast rate. "That's jobs like

Electric Mobility Canada /Mobilité électrique Canada – www.emc-mec.ca – info@emc-mec.ca
38 place du Commerce, 11-530 Ile des Sœurs, QC H3E 1T8

manufacturing electric cars, buses, and trucks that are forecast to hit our roads in record numbers. In fact, several transit authorities have committed to buying only electric buses over the next decade"

Economic impact of air pollution in Canada: $120 billion a year

According to a 2021 report published by Health Canada titled *Health Impacts of Air Pollution in Canada: Estimates of morbidity and premature mortality outcomes,* the "total annual economic value of health outcomes associated with air pollution is approximately **$120 billion.** This amount primarily reflects premature mortalities valued at $108 billion. Health Canada estimates the number of annual mortalities in Canada that can be attributed to air pollution from human sources in North America to be **15,300 deaths** per year based on 2016 population counts."It represents **8 times** the death toll of motor vehicle accidents. Considering the fact that Transportation is a major source of air pollution in Canada, accounting for 31% of black carbon emissions, 33% of carbon monoxide emissions and 41% of nitrogen oxide emissions[1], accelerating the transition to zero emission vehicles will therefore end up saving thousands of lives and billions of dollars for Canadians every year.

Over $190 billions in potential sales revenue

According to a 2020 analysis from Electric Mobility Canada titled *The case for a Canadian EV industry & a ZEV standard,* if Canada decides to implement regulatory policies inspired by jurisdictions like BC, Québec or California, Canada could see EV related sales revenue of more than $190 Billions between 2021 and 2030[2], from electric LDVs to HDVs, from utilities growing revenue to charger sales and installation revenue.

[1] https://www.canada.ca/content/dam/eccc/documents/pdf/cesindicators/air-pollutant-emissions/2020/air-pollutant-emissions-en.pdf

[2] https://emc-mec.ca/wp-content/uploads/EMC-The-case-for-the-EV-industry-and-a-ZEV-standard-DEC-6-2020.pdf

Electric Mobility Canada /Mobilité électrique Canada – www.emc-mec.ca – info@emc-mec.ca
38 place du Commerce, 11-530 Ile des Sœurs, QC H3E 1T8

1. Introduction

As the world transition towards a greener more sustainable future, a lot of focus is now being put on electric mobility. From cars to trucks, from buses to boats, it seems that the future is electric. But what are the environmental, infrastructure, policy or even geopolitical implications of this transition?

As we will see more and more electric vehicles on the roads in Canada and everywhere in the world to help the fight against climate change and air pollution, there is one more very important question that Canadians need to ask themselves:

Will Canada take advantage of the fight against climate change and air pollution to create jobs in an innovative hightech sector such as the electrification of transport or will Canadians end up just importing electric vehicles, batteries and technologies developed elsewhere and miss the boat of high quality high paying longterm jobs?

This is a key question. And Canadians don't have a lot of time to think about this. Right now, there are countries and regions in the world who are resolutely engaged in building an EV industry. From China to Korea to Europe, countries are imposing more stringent regulations while helping the industry make the transition towards light and Heavy-Duty electric vehicles. Canada is now positioning itself to be a leader in electric mobility with:

- The Ford and GM announcements to build electric vehicles in Ontario last fall,
- The $1,5 Billion loan from the Canada Infrastructure Bank in 2020,
- The $2.7 Billion electric bus and school bus financial support announcement in February 2021
- The Lion Electric battery plant announcement in March 2021,
- The federal EV rebates
- The infrastructure deployment program

But there still is more work to be done to be able to catch up with the world leaders, and we must learn from the past Canadian lessons in transport electrification (see Appendix 1).

The newly announced Roadmap for a Renewed U.S.-Canada Partnership commits to "building back better" including low-carbon transportation, and efforts to achieve a zero-emission vehicle future. Canada *can and must* capitalize on its advantages to be a global leader in electrified transportation powered by renewable electricity. It will require a strategy focused on implementation, investment and regulation. If Canada doesn't seize the day, investment and talent will go elsewhere, to those jurisdictions that provide the greatest opportunities… and market certainty. With all the Canadian talent and natural resources at hand, electric mobility is indeed a historic Canadian opportunity.

So we can either see the shift towards electric mobility as a difficult challenge...or a great opportunity.

The time for us to decide is now.

Please note that in this report electric vehicles (EVs) include both battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs).

Electric Mobility Canada /Mobilité électrique Canada – www.emc-mec.ca – info@emc-mec.ca
38 place du Commerce, 11-530 Ile des Sœurs, QC H3E 1T8

2. Canada and the World

This chapter takes stock of the state of electric vehicles around the world in order to better position Canada in the face of this disruptive technology for the automotive industry, an important economic sector in the Canadian economy.

2.1. An Overview of the Global Situation

The EVvolumes.com website, which is a global database on electric vehicles, presented an article on its home page on 20 January 2021 summarizing the results for sales in 2020. From the compilations in this article, several revealing graphs can be presented. Figure 2.1 shows a snapshot of light-duty electric vehicle sales by country. The acronyms BEV and PHEV stand for Battery Electric Vehicle and Plug-in Hybrid Electric Vehicle respectively.

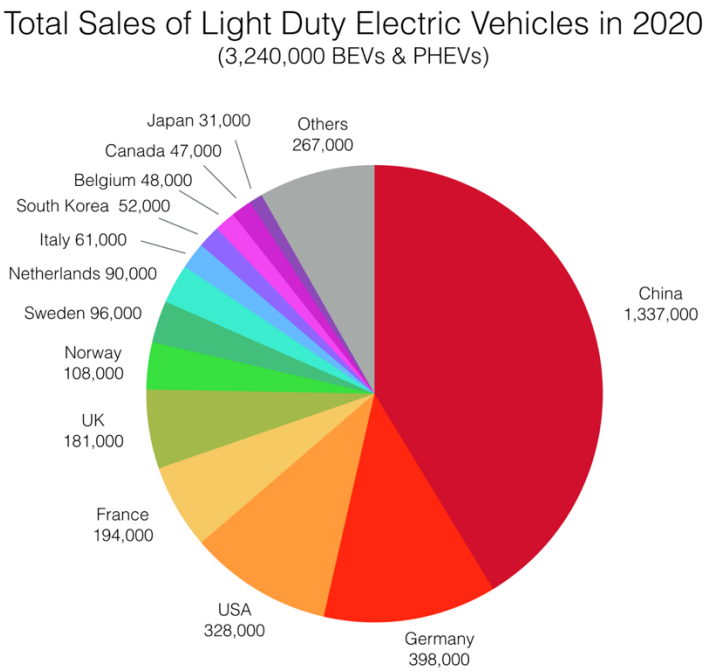


Figure 2.1: Total sales of light electric vehicles (EVs) worldwide in 2020, by country, including plug-in hybrid electric vehicles (PHEVs) and battery electric vehicles (BEVs). Source: EVvolumes.com.

Figure 2.2 groups the countries of Europe in a single block and compares the sales of 2020 with those of 2019.

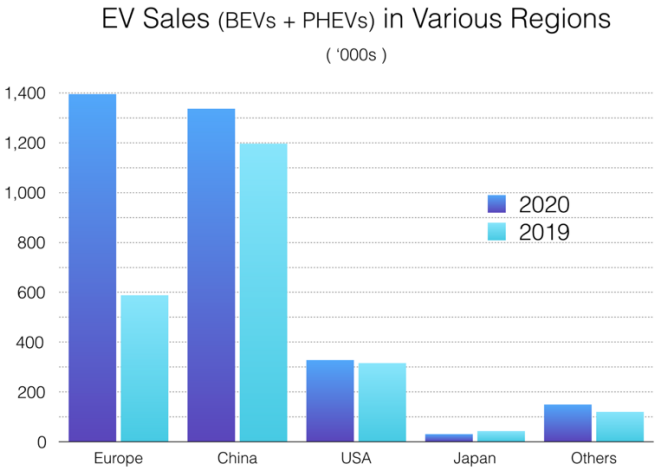


Figure 2.2: Total sales of light electric vehicles (EVs) worldwide in 2019 and 2020, with European countries grouped together, including plug-in hybrid electric vehicles (PHEVs) and battery electric vehicles (BEVs). Source: EVvolumes.com.

When countries are assessed individually, China is the largest market for electric vehicles. But when the European countries are grouped together, it is clear that Europe has dethroned China in 2020. Moreover, while sales of electric vehicles are exploding in Europe, they are stagnating in the United States. The next sections will highlight certain circumstances that shed light on this situation.

But, before looking in more detail at the different regions of the world, two other graphs are important for understanding the electrification of transport from other angles. Figure 2.3, again taken from EVvolumes.com data, shows the evolution of sales from 2011 to 2020 for different regions.

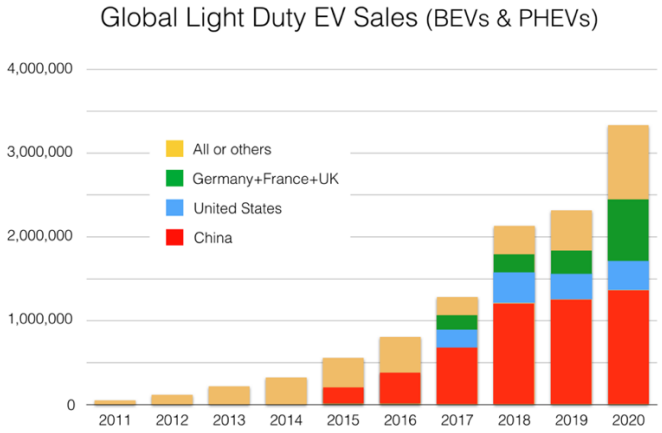


Figure 2.3: Global annual sales of light electric vehicles (EVs) from 2011 to 2020, by country or group of countries, including plug-in hybrid electric vehicles (PHEVs) and battery electric vehicles (BEVs). Source: EVvolumes.com.

This last graph clearly shows that sales growth is exponential and non-linear. It also reveals that something happened in 2019 to slow the evolution of sales in China while the reverse occurred in the three largest European countries in 2020.

Finally, to make a fair comparison of the efforts of the different countries to increase their electric vehicle fleets, it is important to take into account the population of these countries. The next graph uses EVvolumes.com sales figures divided by the respective populations of the different countries, which is shown in Figure 2.4.

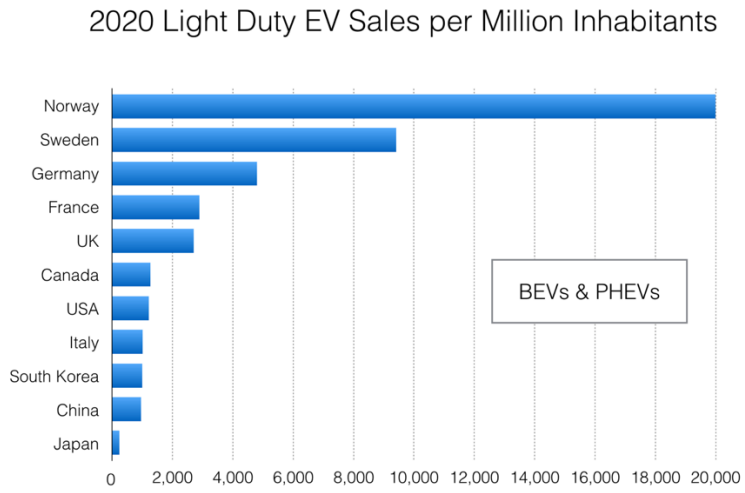


Figure 2.4: Sales of light electric vehicles (EVs) per million inhabitants for different countries in 2020, including plug-in hybrid electric vehicles (PHEVs) and battery electric vehicles (BEVs). Source: sales : EVvolumes.co; populations: Wikipedia.

Figure 2.4 shows that Norway, with only 5.4 million inhabitants, has the highest penetration rate of electric vehicles, while China, who has seen some of the highest EV sales globally remains far behind. This is why it is often said that Norway is the leader in the electrification of transport.

To be even more concrete with regard to the penetration rate of electric vehicles, we can establish the share of a country's electric vehicle sales in relation to total vehicle sales in that country, which is called the market share. Figure 2.5 shows these market shares for five European countries. The data in this chart has been obtained by compiling the information contained in 5 different articles[3] for the month of December 2020.

[3] a) M. Holland, *Norway Hits Record 87% Plug-in EV Share $ 66% Pure Electric in December*, Clean Technica, January 6th, 2021 (https://cleantechnica.com/2021/01/06/norway-hits-record-87-plug-in-ev-share-66-pure-electrics-in-december/) b) M. Holland, *Sweden Hits Record 50% Electric Vehicle Share in December!*, Clesn Technica, January 5th, 2021(https://cleantechnica.com/2021/01/05/sweden-hits-record-50-electric-vehicle-share-in-december/) c) M. Holland, *German EV Market Reaches Escape Velocity – Record 27% Share in December*, Clean Technica, January 8th, 2021 (https://cleantechnica.com/2021/01/08/german-ev-market-reaches-escape-velocity-record-27-share-in-december/) d) M. Holland, *New UK EV Record – Almost Quarter of Auto Sales Now Plug-ins!*, Clean Technica, January 5th, 2021 (https://cleantechnica.com/2021/01/06/new-uk-ev-record-almost-quarter-of-uk-auto-sales-now-plugins/) e) Jose Pontes, *19% Plugin Vehicle Market Share in France in December*, Clean Technica, January 17th, 2021 (https://cleantechnica.com/2021/01/17/19-plugin-vehicle-market-share-in-france-in-december-2020/).

Electric Mobility Canada /Mobilité électrique Canada – www.emc-mec.ca – info@emc-mec.ca
38 place du Commerce, 11-530 Ile des Sœurs, QC H3E 1T8

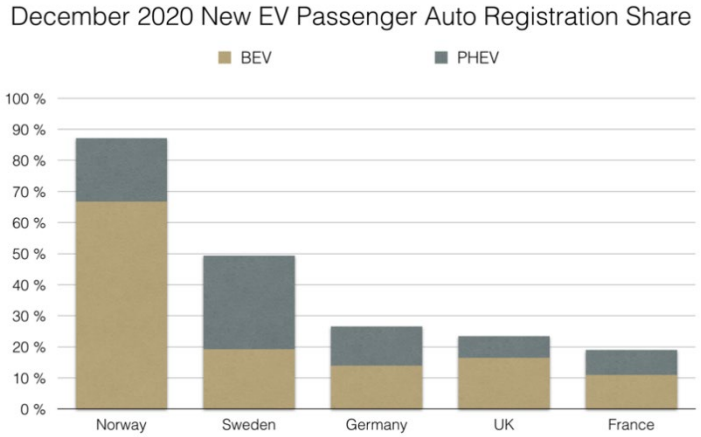


Figure 2.5: Market shares of electric vehicle sales in different European countries for the month of December 2020, including Plug-in Hybrid Electric Vehicles (PHEVs) and Battery Electric Vehicles (BEVs). Source: Clean Technica.

It is amazing to realize that by December 2020 electric vehicle sales in Norway where 87% of light-duty passenger vehicle sales, and Germany, with its 83 million inhabitants, is approaching 30% market share for light electric passenger vehicle sales! **Worldwide, the market share of light-duty electric vehicles has risen from 2.5% in 2019 to 4.2% in 2020**, according to the EVvolumes.com article mentioned at the beginning of this chapter.

All these results are all the more impressive given that in 2020 the COVID-19 pandemic has negatively affected the global economy, reducing total vehicle sales by 20% in Europe, 15% in the United States and 4% in China, according to the references we have given so far.

2.2. China, the Former Leader slows Down

If sales of electric vehicles in China are so impressive it is of course because the country has a very large population. But the Chinese government has also put in place aggressive incentive policies to get there. An article by Jack Perkowski in Forbes[4] magazine sums them up very well.

Since 2009, the Chinese government has introduced subsidies for both automobile manufacturers and consumers for the purchase of an electric vehicle. The subsidy level provided is determined by vehicle performance criteria, such as the electric range of the vehicle, the energy density of the batteries and the efficiency of the vehicle. The idea is to promote both market penetration and technology improvement. Initially, the central government gave consumers the equivalent of US $3,000 to US $6,600 when they purchased their vehicle, while most local governments could add 15% to 50% to this basic amount. This meant that total purchase subsidies could reach around US $10,000. In 2015, the government announced that the subsidies would gradually decrease and be abolished in 2020. But

[4] Jack Perkowski, *What China's Shifting Subsidies Could Mean for its Electric Vehicle Industry*, Forbes, July 13th, 2018 (https://www.forbes.com/sites/jackperkowski/2018/07/13/china-shifts-subsidies-for-electric-vehicles/?sh=260f04665703).

due to the economic difficulties caused by the pandemic in 2020, China has postponed the end of subsidies to 2022.

2.2.1. **A Slowdown**

Nevertheless, in 2019 the initial subsidies from the central government were cut by half on average[5] and those from manufacturers were also cut back following a scandal of abuse and misappropriation of subsidies[6]. These reduced subsidies for both consumers and manufacturers are very likely to be a major reason for the stagnation of sales in China in 2019, as can be seen in figure 2.3.

2.2.2. **A Relaunch**

China is counting on three main areas of intervention. The first is the introduction of a **zero-emission vehicle standard**[7], starting in 2018, which forces car manufacturers to sell an ever-increasing percentage of new energy vehicles (NEVs: all-electric, plug-in hybrid or fuel cell/hydrogen), or face heavy fines. The target for 2020 was to reach 12% credits, forcing a manufacturer to sell 4% to 5% of NEVs.

The second axis is that of the **fuel consumption standards for gasoline-powered vehicles**, which are becoming increasingly strict, and which are another way of imposing the introduction of more electric vehicles to reduce the average fuel consumption of manufacturers' fleets. The target set by the regulations[8] for 2025 is an average consumption of 4 L/100 km for passenger cars, under the New European Driving Cycle (NEDC).

Finally, the third line of intervention consists in **not restricting the right to buy a NEV**, unlike internal combustion vehicles where there are quotas on the number of vehicles that can be sold each year due to the critical level of urban pollution in China. Registration rights for traditional

---

[5] Bloomberg News, *China Considers Cutting Electric-Car Subsidies again*, The Detroit News, November 10th, 2019 (https://www.detroitnews.com/story/business/autos/2019/11/11/china-considers-cutting-electric-car-subsidies/40574333/).

[6] Jon Lesage, *China Faces Another EV Subsidy Scandal*, OilPrice.com, September 9th, 2019 (https://oilprice.com/Energy/Energy-General/China-Faces-Another-EV-Subsidy-Scandal.html).

[7] Report of The International Council on Clean Transportation, *China's New Energy Vehicle Mandate Policy (Final Rule)*, ICCT, January 2018 (https://theicct.org/sites/default/files/publications/China-NEV-mandate_ICCT-policy-update_20032018_vF-updated.pdf).

[8] Report of The International Council on Clean Transportation, *Comments on China's Proposed 2021-2025 Fuel Consumption Limits, Evaluation Methods, and Targets for Passenger Cars*, ICCT, March 11th, 2019 (https://theicct.org/news/comments-chinas-proposed-2021-2025-fuel-consumption-limits-evaluation-methods-and-targets).

vehicles are drawn by lottery, and there are often more people who want to buy a vehicle than can get one. So this is a major incentive for electric vehicles. This type of incentive has been used in some Chinese cities in the past, but in 2019 the Chinese central government has expressed its intention to adopt this policy[9] to stimulate sales of electric vehicles.

Apart from government incentives, the fact remains that when the purchase price of electric vehicles is low, people will buy them in large quantities, since fuel and maintenance costs are much lower than for a gasoline-powered vehicle. This is precisely what is happening in China with the entry on the market of the Wuling HongGuang Mini EV battery electric micro car[10], a minimalist four-seater with an estimated range of 120 to 170 km (NEDC cycle) and a top speed of 100 km/h, which sells for US $4,200 to US $5,600. It is the Sino-American joint venture SAIC-GM-Wuling that has been marketed in China since mid 2020. Since October 2020, the number of cars sold per month has exceeded that of the Tesla Model 3 in this country, which is no small feat.

Figure 2.6: Micro electric car Wuling HongGuang Mini EV, commercialized in China in 2020. Source: SAIC-GM-Wuling.

It seems that all the elements of recovery presented are beginning to bear fruit, since the market share of light electric vehicles (BEV & PHEV) in December 2020 in China reached 9.4%. In 2020, China's light-duty electric vehicle market share was 6.3%[11].

EV Market Share in China

December 2020	January - December 2020
9.4 %	6.3 %

Table 2.1 : Light duty EV Market Share in China in 2020. Source: Clean Technica.

[9] Carrie Hampel, *China to Remove Quotas on Licence Plates for NEVs*, Electrive.com, June 9th, 2019 (https://www.electrive.com/2019/06/09/china-to-lift-quotas-on-nev-licence-plates/).

[10] Fred Lambert, *GM-Backed $4,000 Mini Electric Car Has Already Received 50,000 Orders*, Electrek, August 20th, 2020 (https://electrek.co/2020/08/20/gm-mini-electric-car-price-orders/).

[11] Jose Pontes, *China – 9.4% Plugin Vehicle Share in Another Record Month*, Clean Technica, January 24th, 2021 (https://cleantechnica.com/2021/01/24/china-9-4-plugin-vehicle-share-in-another-record-month/).

2.3. Europe, the Challenger, Won in 2020

For several years, China had been selling significantly more electric vehicles on its territory than Europe. But in 2020, as shown in Figure 2.2, Europe overtook China. Furthermore, Figure 2.3 shows that to achieve this, Europe experienced a rapid growth in sales on its territory that year, compared with the growth of previous years. So what happened?

2.3.1. European Fuel Consumption Standards

First of all, it has to be said that fuel consumption standards for internal combustion cars in Europe are becoming more and more stringent, more so than in North America. A document from the International Council on Clean Transportation, published in 2020[12], presents the state of play with regard to the new legislation, which came into force in January 2021 and requires average CO^2 emissions of less than 95 g/km for new passenger cars. It shows that manufacturers must reduce these emissions by 20% to 25% compared to 2019 if they want to comply. Significant penalties are expected for those who do not comply. This is therefore a very strong incentive to accelerate the production and sales of electric vehicles.

2.3.2. European subsidies for New Electric Cars

As far as subsidies for the purchase of an electric vehicle are concerned, France's Bonus-Malus program[13] is still operational and offers up to €7,000 ($10,800 CAN) on the purchase of a new all-electric vehicle until mid-2021 and €6,000 ($9,260 CAN) after that. For those who choose a gasoline or diesel-powered vehicle, a surcharge or malus is imposed, which is all the more significant as the emissions are high. This malus starts at €50 for emissions of 133 g/km and can go up to €30,000 ($46,300 CAN) for emissions of 219 g or more per kilometer.

In Germany, since 2020, the government subsidy is €6,000 ($9,260 CAD) for the purchase of a new electric vehicle and the country is expected to introduce a surtax on internal combustion vehicles in 2021[14].

---

[12] Report of The International Council on Clean Transportation, *CO_2 Emissions from New Passenger Cars in Europe: Car manufacturers' Performance in 2019*, ICCT, August 2020 (https://theicct.org/sites/default/files/publications/CO2-EU-update-aug2020.pdf)

[13] Andy David, *Bonus-Malus 2021: le Fonctionnement, les Détails, les Grilles*, Auto-Moto.com, December 31th, 2020 (https://www.auto-moto.com/actualite/environnement/malus-2021-explications-details-grilles-251986.html).

[14] Fred Lambert, *Germany Boosts EV Incentives to $10,000, Helping Tesla Model 3 and VW ID.*3, Elecctrek, June 4th, 2020 (https://electrek.co/2020/06/04/germany-boost-ev-incentives-9000-euros-helping-tesla-model-3-vw-id-3/).

In the United Kingdom, grants for the purchase of new electric vehicles have been extended until 2023[15] and the amount is £3,000 ($5,230 CAD) since 2020.

2.3.3. Congestion Tax Relief for Electric Cars

More and more major European cities are introducing congestion charges to enter their city centres. This is the case in London, Stockholm and Oslo in particular. The amounts are substantial and can reach several hundred dollars a month for a worker who uses his car five days a week. To give drivers more incentives to buy electric vehicles and reduce pollution in their cities, municipal authorities offer full or partial exemptions from these taxes. This is therefore an additional major incentive to make the transition to an electric vehicle.

2.3.4. Gasoline Prices Higher in Europe

Finally, we should not forget another important incentive for Europeans, the price of gasoline. In fact, the price of gasoline is about twice as high in Europe compared to North America! This means that you can save a lot more on fuel costs with an electric vehicle there.

Gasoline Price per Litre in European Countries
(January 2021, $ CAN)

France	Germany	Norway	Sweden	UK
2.20 $	2.10 $	2.40 $	2.24 $	2.08 $

Table 2.2: Gasoline price in European countries (*GlobalPetrolPrices.com*).

2.3.5. European OEMs Turn on the Steam

The particular European environment we have just described means that both consumers and manufacturers are now taking the purchase and production of electric vehicles seriously. The Volkswagen Group is a leader in this respect and other European manufacturers are following, as the next graph shows with the sales of the main European manufacturers in 2019 and 2020[16].

[15] Chris Randall, *UK Extends but Lowers EV Subsidies*, Electrive.com, March 12th, 2020 (https://www.electrive.com/2020/03/12/uk-extends-but-lowers-ev-subsidies/).

[16] a) Mark Kane, In 2020, *Volkswagen Group Sold 422,100 Plug-In Electric Cars*, InsideEVs, January 14th, 2021 (https://insideevs.com/news/465956/in-2020-volkswagen-group-sales-plugin-cars/),

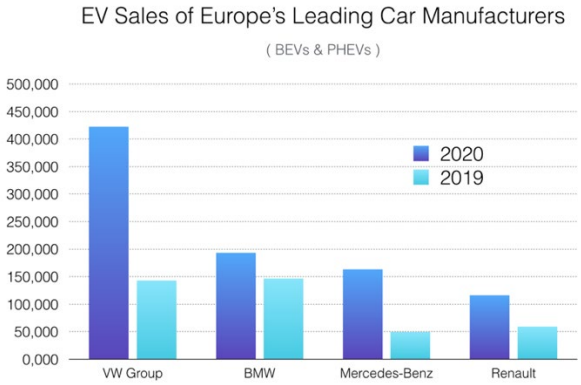


Figure 2.7: Sales of light electric vehicles (EVs) from different European manufacturers for the years 2029 and 2020, including Plug-in Hybrid Electric Vehicles (PHEVs) and Battery Electric Vehicles (BEVs). Source: InsideEVs., ElectricDrive and Europe.AutoNews.

2.3.6. **More Model Choice**

Not only are the sales of European manufacturers important, but the number of models available from them is also significant, as shown in Figure 2.8, which presents the top 20 best-selling electric vehicles in Germany in 2020, as reported by Clean Technica[17].

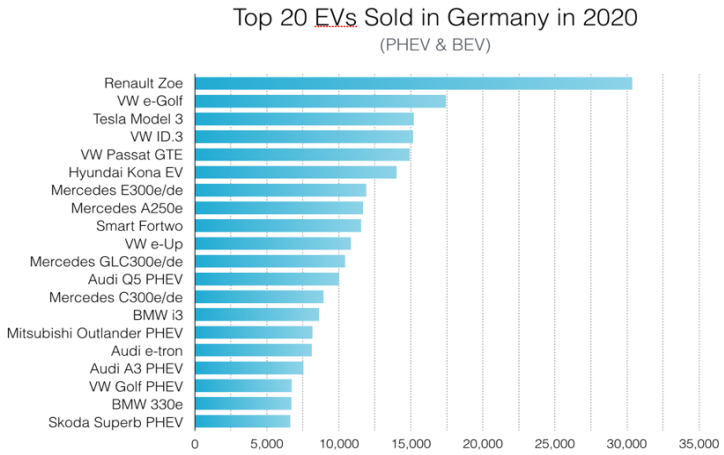


Figure 2.8: The 20 best-selling electric vehicles (EVs) in Germany in 2020. Source: Clean Technica.

b) Chris Randall, *Renault Doubles EV Sales in Europe*, Electrive.com, January 13th, 2021 (https://www.electrive.com/2021/01/13/renault-doubles-ev-sales-numbers-in-europe/),

c) Reuters, *BMW Aims to Double EV Sales this Year*, Automotive News Europe, January 15th, 2021 (https://europe.autonews.com/automakers/bmw-aims-double-ev-sales-year),

d) Mark Kane, *Mercedes-Benz Tripled Plug-In Electric Car Sales in 2020*, Inside EVs, January 8th, 2021 (https://insideevs.com/news/465024/mercedesbenz-plugin-car-sales-2020/).

[17] Jose Pontes, *27% Plugin Vehicle Share in Germany – Open the Plugin Gates!*, Clean Technica, January 20th, 2021 (https://cleantechnica.com/2021/01/20/27-plugin-vehicle-share-in-germany-open-the-plugin-gates/).

For example, this figure shows that the Volkswagen Group (VW, Audi) manufactures eight different models out of the twenty and Daimler (Mercedes, Smart) manufactures five. And a greater choice of electric vehicles necessarily implies more sales. This is another crucial element in the European success equation, which is not found in the United States where the traditional manufacturers GM, Chrysler and Ford are moving more slowly, as will be discussed later in the report.

And this is only the beginning, as the Volkswagen Group's US $41 billion five-year plan for electric vehicles was approved in 2020[18], which should enable it to offer 70 different electric vehicles by 2030 and to produce 26 millions of them from 2020 to 2030. In addition, the Tesla gigafactory in Germany is expected to be operational by the end of 2021, which should give another major boost to European sales in 2022.

2.4. United-States is Lagging Behind Despite California's Efforts

When the case of the United States is discussed, one fact quickly jumps to mind regarding the electrification of transport: California is the leader in the United States. So much so, that it seems appropriate to analyse the situation as if it were two states: California and the rest of U.S..

2.4.1. California, the most proactive state

California has a population of 40 million, which is 12.2% of the US population, or about 1/8 of the US population. There were 145,099 light-duty electric vehicles sold in California in 2020, according to the California Energy Commission[19], whereas we saw in Figure 2.1 that sales for the United States in total were 328,000 light-duty electric vehicles. **EV sales in California therefore represent 44.2% of those of the United States**.

Folowing very acute air pollution problems in the Los Angeles area California decided to take tougher legislative action on emissions from internal combustion vehicles. The state introduced the first version of its zero-emission vehicle standard in 1990, forcing manufacturers to put more and more zero-emission vehicles on the road starting in 1997. Another incentive put in place by this state is the additional US$2,500 rebate in addition to the US$7,500 federal tax credit for the purchase of an electric vehicle with a battery capacity of 16 kWh or more. California is also a hotbed of high-tech. Tesla, who is a global leader in electric vehicle sales, has shown to be a

[18] Steven Loveday, *VW Group New 5-Year Plan Approved: $41 Billion Toward Electric Cars*, InsideEVs, November 13th, 2020 (https://insideevs.com/news/454249/vw-group-5-year-plan-41-billion-evs/).

[19] California Energy Commission, *Zero Emission Vehicle and Infrastructure Statistics – New ZEV Sales in California*, last updated: January 29th, 2021 (https://www.energy.ca.gov/data-reports/energy-insights/zero-emission-vehicle-and-charger-statistics).

popular choice in California. Figure 2.9 presents the 20 top-selling electric vehicles in that state in 2020, according to the California Energy Commission data. It shows that Tesla vehicles accounted for 57.6% of EV sales in California in 2020.

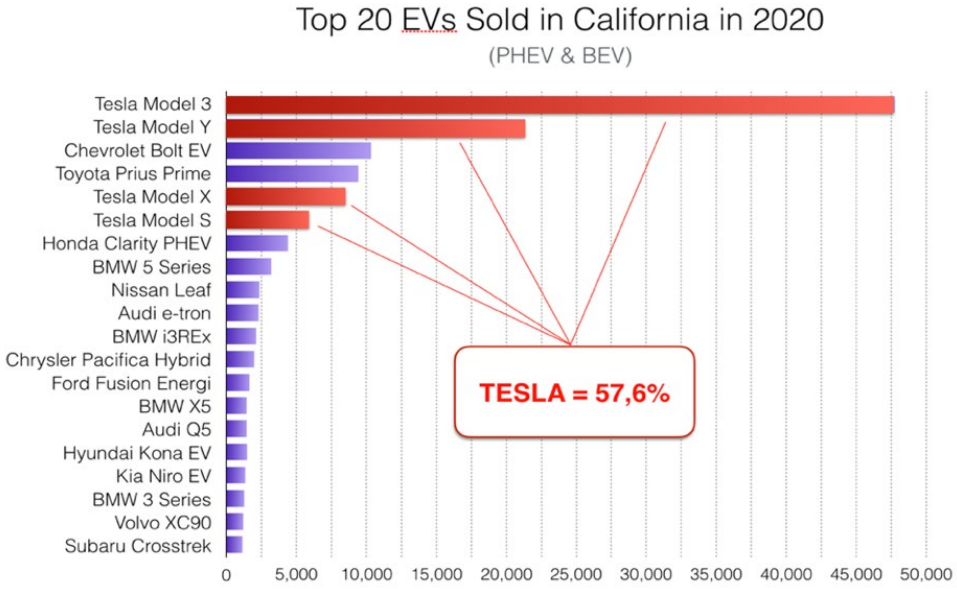


Figure 2.9: The 20 best-selling electric vehicles (EVs) in California in 2020. Source: California Energy Commission.

We would like the other traditional American manufacturers to do the same, but Ford and Chrysler's sales are far behind Tesla's, while GM could do better.

Tesla global sales in 2020 are estimated at 499,550 vehicles and two more gigafactories are expected to go into production at the end of 2021 or the beginning of 2022. For comparison, it is worth noting that as of March 18th 2021 Tesla's market cap was US$628 billions while Toyota, Volkswagen and GM, combined market caps worthed a total of US$440 billions.

As for the EV market share achieved by California in 2020, according to the California Energy Commission (https://www.energy.ca.gov/data-reports/energy-insights), it was 7.8%, whereas the EV market share in the rest of the United States (U.S. 49) was only 1.5%.

EV Market Share in 2020

California	United States	U.S. 49
7.8 %	2.3 %	1.5 %

Table 2.3: Market share of electric vehicle (BEV + PHEV) sales in 2020 for California, U.S. and U.S. 49, i.e., the U.S. minus California. Sources: EVvolumes.com, California Energy Commission, U.S. Bureau of

2.4.2. U.S. 49 Has More Work to Do

The U.S. 49 electric vehicle sales were 182,901 in 2020, corresponding to the 1.5% market share shown in Table 2.3.

A market share of 1.5% for the U.S. 49 is five times less than California. Yet the United States is a major economic power. Let's not forget, as we saw above, that China's market share for 2020 was 6.3% and that it ended in December 2020 at 9.4%. And, still in December 2020, Norway's market share was 87%, Germany's 27%, the United Kingdom's 23% and France's 19% (Figure 2.5). Even if we do the calculations for the whole of the United States, including California, we arrive at a market share of 2.3% for 2020.

2.4.3. How Can We Explain this Situation?

Two points come to mind to explain such a situation: the low cost of gasoline and large vehicles.

According to GlobalPetrolPrices.com, the average price of gasoline in the United States was CAN$0.93 at the beginning of February 2021, while it is above CAN$2.00 just about everywhere in Europe. In addition, a significant portion of Americans use pickup trucks as passenger vehicles. The following chart, based on data from the Bureau of Transportation Statistics, shows the ever-increasing portion of light trucks (pickup trucks, vans and SUVs) sold over the past ten years.

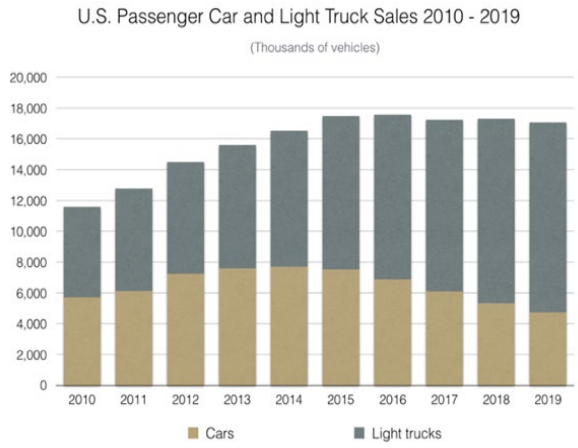


Figure 2.10: Light-duty vehicle sales from 2010 to 2019 in the United States, including all engine/motor types. Source: U.S. Bureau of Transportation Statistics.

In 2010, light trucks accounted for 50% of the light duty vehicle market and cars for the other 50%. By 2019, light trucks had reached a market share of 70%.

Several electric pickup trucks are expected to be on the market by 2022, but there were none in 2020. Similarly, larger electric SUVs will appear in the coming years.

Another factor that has certainly contributed to the low sales of electric vehicles in 2020 in the US is that Tesla and GM are no longer eligible for the US$7,500 federal government tax credit for EV

purchases from Tesla and GM's top sellers[20]. This credit was only available for the first 200,000 EVs sold by a manufacturer.

Finally, the withdrawal of U.S. from the Paris Agreement and the Trump administration's significant retreat from the Corporate Average Fuel Economy (CAFE) standard does not send a clear signal of a desire to have cleaner vehicles on the road. While the average fuel consumption of a manufacturer's fleet was expected to be below 4.3 litres/100 km (55 miles per gallon) in 2025 for cars, it is now expected to fall to 5.9 litres/100 km (40 miles per gallon) in 2026. It is also worth mentioning that the previous administration removed the authority to have ZEV standards in place in California and the Northeast States.

It must also be said that the United States has always had a tradition of having as little state intervention as possible in the functioning of its economy and rather give free rein to the market economy. However, it must be said that the leaders in transport electrification are those who have helped their citizens make the right choice with the right incentives for EVs and demotivating measures for fuel-inefficient internal combustion vehicles, as we have seen with China, European countries and California.

2.4.4. **A Look Forward**

In concluding our analysis on the United States, we should not overlook the plans of American manufacturers for the coming years. First of all, Tesla should have its new Texas-based gigafactory starting to produce its Model Y, an SUV, and its Cybertruck pickup truck by the end of 2021 or early 2022, along with the batteries they will require. Tesla plans to release its semi-trailer truck and Roadster 2 super sports car. The company has also committed to bringing a US$25,000 compact car to market by 2025.

Furthermore, GM presented an ambitious plan for the electrification of its vehicles at CES 2021[21]. With a planned investment of US$27 billion[22], GM intends to market 30 electric vehicles by 2025, including 20 in America. In 2021 the Bolt EUV, larger than the Bolt EV will be introduced, new Cadillac and Buick vehicles will follow, as well as a Hummer, a pickup truck and an electric delivery van. The latter, the EV600, will be marketed by a new GM subsidiary, BrightDrop and built in Canada[23].

---

[20] Edmunds, *Electric Vehicle Tax Credits: What You Need to Know*, August 28th, 2020 (https://www.edmunds.com/fuel-economy/the-ins-and-outs-of-electric-vehicle-tax-credits.html).

[21] General Motors, *GM's CES 2021 Keynote in 10 Minutes*, January12th, 2021 (https://www.youtube.com/watch?v=lDFZqa422nI).

[22] Alisa Priddle, *GM Uses CES to Reveal Virtually All of Its Future EV Plans, Virtually*, Top Gear America, January 12th, 2021 (https://www.motortrend.com/news/2021-ces-gm-chevy-cadillac-buick-hummer-evs-details/).

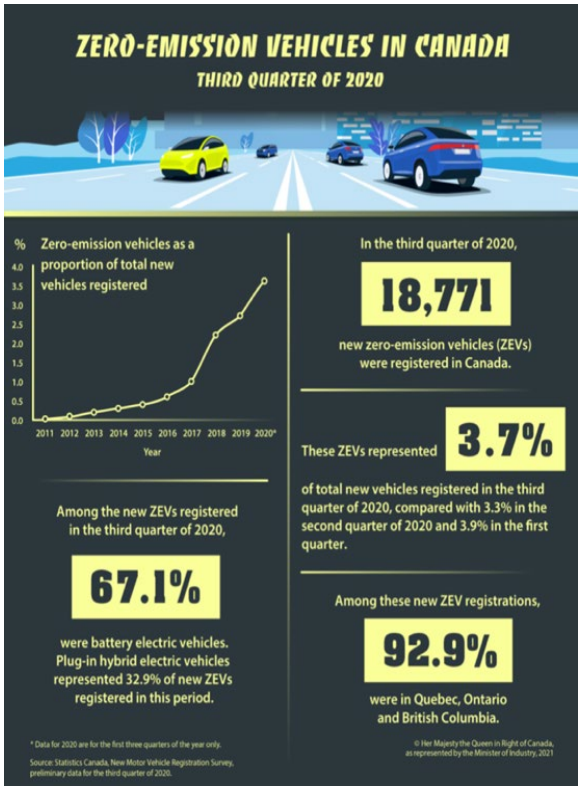
[23] Mark Kane, *GM To Produce BrightDrop EV 600 In Canada*, InsideEVs, January 18th, 2021 (https://insideevs.com/news/466900/gm-produce-brightdrop-ev600-canada/).

For its part, Ford is coming out with its electric SUV Mustang Mach-E in 2021 and announced an electric F-150 pickup truck for 2022, as well as an electric delivery van, the Ford Transit, which should arrive soon. Ford is also talking about building five electric vehicles (full electric or plug-in hybrid electric) in Canada starting in 2025[24].

There is no doubt that U.S. automakers, apart from Tesla, will have to redouble their efforts if they want to stay in the electric mobility race, since Chinese and European manufacturers have already demonstrated their determination in concrete terms.

2.5. Canada: the time is now

For Canada, official EV sales data for new electric vehicles in 2020 was not yet available for the entire year. Unofficially, approximately 55,000 EVs would have been sold last year but this number has yet to be confirmed by StatsCan. On February 11, 2021, Statistics Canada published the data for the first three quarters on its site, and we present the statistics for the third quarter[25], as such, in Figure 2.11.



Although Canada's performance is better than that of the United States, it represents half the market share of California in 2020, about 20 times less than Norway, eight times less than Germany, six times less than the United Kingdom, and five times less than France. When you want to be a leader, you have to compare yourself with the best.

Figure 2.11: Statistics for registrations of new zero-emission vehicles in Canada for the third quarter of 2020, as presented on Statistics Canada site at www150.statcan.gc.ca/n1/pub/11-627-m/11-627-m2021012-eng.htm .

[24] Stephen Edelstein, *Ford Plans to Build 5 Electric Vehicles in Canada, Beginning in 2025*, Green Car Reports, September 23th, 2020 (https://www.greencarreports.com/news/1129696_ford-plans-to-build-5-electric-vehicles-in-canada-beginning-in-2025).

[25] Statistics Canada, Zero-Emission Vehicles in Canada, Third Quarter of 2020, release date: Feb. 11, 2021 (https://www150.statcan.gc.ca/n1/pub/11-627-m/11-627-m2021012-eng.htm).

2.5.1. Polics and Statistics for the Three Main Provinces

It is particularly interesting to note in the Statistics Canada data that 92.9% of the electric vehicles sold in Canada were sold in Quebec, Ontario and British Columbia, the three most populous provinces, two of which have a provincial rebate on the purchase of an electric vehicle (Quebec and British Columbia). It is worth noting that the Yukon government has started to offer a $5000 rebate since Sept, 2020 and the Nova Scotia government announced an up to $3000 rebate in Feb 2021.

Québec has a rebate on the purchase of a zero-emission vehicle (ZEV) of up to $8,000 in addition to the $5,000 rebate from the Canadian government. This provincial rebate is the same since the beginning of the program and is confirmed until March 31, 2022. British Columbia is offering a rebate of up to $3,000 on purchases in addition to the $5,000 federal rebate. It was $5,000 before June 22, 2019. Finally, Ontario already had a provincial rebate on the purchase of a ZEV of up to $14,000 until 2018, which was then abolished by the new government at the time. These differences in the evolution of rebates in these three provinces are correlated with sales, as shown in the following three figures, whose data and charts of the evolution of registrations come from Statistics Canada. The year 2020 in the graphs includes only the first three quarters.

Québec ZEV Registration Statistics	
New ZEV registrations in Q3 2020	**8,885**
New ZEV Market share in Q3 2020	**6.7 %**
Québec Population vs Canada	**22 %**
% of ZEV sold in Canada in Q3	**47 %**

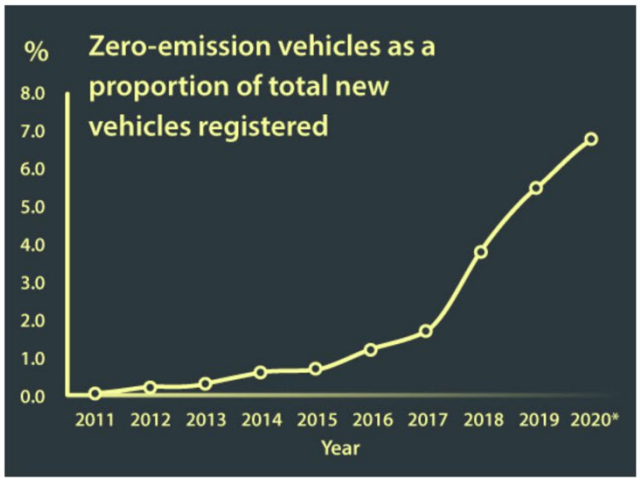


Figure 2.12: Zero emission vehicle statistics for the province of Québec. Source: Statistics Canada https://www150.statcan.gc.ca/n1/pub/11-627-m/11-627-m2021015-eng.htm .

Electric Mobility Canada /Mobilité électrique Canada – www.emc-mec.ca – info@emc-mec.ca
38 place du Commerce, 11-530 Ile des Sœurs, QC H3E 1T8

British Columbia ZEV Registration Statistics	
New ZEV registrations in Q3 2020	4,608
New ZEV Market share in Q3 2020	8.4 %
B.C. Population vs Canada	13.5 %
% of ZEV sold in Canada in Q3	24.5 %

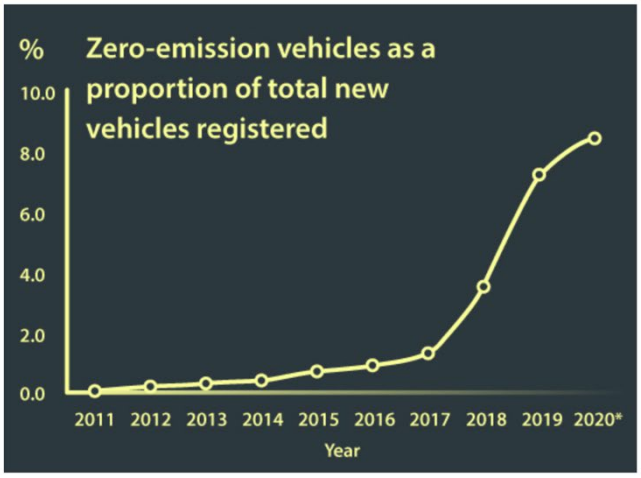


Figure 2.13: ZEV statistics for the province of British Columbia. Source: Statistics Canada https://www150.statcan.gc.ca/n1/pub/11-627-m/11-627-m2021013-eng.htm .

Ontario ZEV Registration Statistics	
New ZEV registrations in Q3 2020	3,947
New ZEV Market share in Q3 2020	2.0 %
Ontario Population vs Canada	39 %
% of ZEV sold in Canada in Q3	21 %

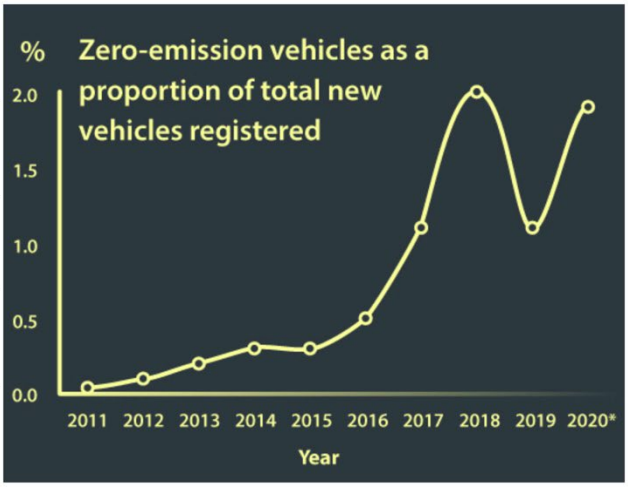


Figure 2,14 : ZEV statistics for the province of Ontario. Source: Statistics Canada https://www150.statcan.gc.ca/n1/pub/11-627-m/11-627-m2021014-eng.htm .

If we look at the last three graphs of the evolution of the ZEV market shares since 2011 in the three provinces, we can see the correlation with the decreases in the purchase discount. When Ontario completely removed its rebate in 2018, sales fell by about 40% in 2019, only to rebound afterwards with the arrival of the federal rebate. With 39% of the Canadian population, Ontario sold only 21% of ZEVs. British Columbia is performing very well, with a market share of 8.4% in the third quarter of 2020. But there is a slowdown on the curve in 2020. Of course there are only three quarters that are counted in 2020, but the same is true for the Québec curve and we see that there is almost no dip in the curve.

Electric Mobility Canada /Mobilité électrique Canada – www.emc-mec.ca – info@emc-mec.ca
38 place du Commerce, 11-530 Ile des Sœurs, QC H3E 1T8

Québec stands out in particular. With only 22% of the Canadian population, 47% of the ZEVs sold in Canada in the third quarter of 2020 were sold in Quebec, which had a market share of 6.7% for this quarter.

It should also be remembered that only British Columbia and Québec have adopted zero-emission standards similar to California's, which gives them more choice for ZEVs. In fact, manufacturers who have a limited number of ZEVs for Canada are motivated to send their vehicles to these provinces on a priority basis to comply with the regulations.

Once again, we see that jurisdictions with better incentives are leading the way. Appropriate government policies are absolutely essential to ensure that countries are credible players in the energy transition.

Electric Mobility Canada /Mobilité électrique Canada – www.emc-mec.ca – info@emc-mec.ca
38 place du Commerce, 11-530 Ile des Sœurs, QC H3E 1T8

3. New Raw Materials for EVs: the Mining Sector and Electromobility

According to the International Organization of Motor Vehicle Manufacturers, more than 90,000,000 new road vehicles (personal cars plus commercial vehicules) were sold each year from 2015 to 2019 worldwide[26]. This requires a lot of raw materials. For traditional internal combustion vehicles, apart from glass, one needs mainly steel, aluminum, copper and organic materials such as plastics, synthetic rubber and fabrics. But for electric vehicles the proportions of these materials vary, some that were scarcely used are now becoming important, such as rare earths in electric motors, and new metals are required for batteries. These substantial changes in the demand for raw materials correspond to the mining resources available in Canada, which is of undeniable economic interest to the country.

In this chapter, we will first look at the new raw material requirements for electric vehicles, pointing out the possible changes in these requirements over the next decade due to the anticipated evolution of batteries primarily. Next, we will present a portrait of the main countries that produce the required resources or control them, situating Canada in the global arena.

3.1. Demand Changes in Raw Materials for EVs

First of all, let's look at the three common metals found in the automotive industry: steel, aluminum and copper.

3.1.1. Usual Metals: Steel, Aluminum and Copper

Due to the heavy weight of batteries in electric vehicles, especially for those with a long range, manufacturers have sought to lighten the structure of EVs as much as possible. Tesla put 661 kg of aluminum in its Model S, according to Reuter[27,] while the Nissan Leaf, with a much shorter range, put 171 kg, and a gasoline-powered VW Golf has 129 kg, according to Reuter. But there's currently a strong competition between aluminum and high-strength steel, which is lighter for the same rigidity as regular steel and cheaper than aluminum. With batteries getting lighter every year, for the same range, and pressure to lower EV costs, Tesla has seen a significant reduction in aluminum in its Model 3[28].

[26] International Organization of Motor Vehicle Manufacturers (OICA) www.oica.net/category/ .

[27] Reuter, *Epic Battle Between Steel and Aluminum as Automakers develop EVs*, Autoblog, May 27th, 2018 (https://www.autoblog.com/2018/03/27/steel-aluminum-automakers-ev-electric/).

[28] Fred Lambert, *Tesla Model 3: Hers's the Alloy Mix of the Model 3 Body*, Electrek, August 22nd,2017 (https://electrek.co/2017/08/22/tesla-model-3-body-alloy-mix/)

Therefore, one should not expect huge changes in the steel-aluminum ratio in EVs relative to conventional vehicles in the coming years. However, in terms of copper, according to Wood Mackenzie[29], a conventional car contains an average of 22 kg of copper, a Plug-in Hybrid Electric Vehicle (PHEV) 55 kg and a Battery Electric Vehicle (BEV) 80 kg. It is therefore an increase of nearly 300% of this metal that is anticipated for BEVs. Copper is mainly found in the winding of electric motors, in the wiring between the battery, power electronics and motors and the various systems (cooling, heating, ventilation, lighting, radio...), as well as in the battery itself. In addition, copper is also needed for the charging stations.

To give a rough estimate of copper requirements for transport electrification, suppose that in 2030 half of the 100 million new vehicles produced are electric (2/3 of BEVS and 1/3 of PHEV), each of the 50 million EVs produced then would need an average of 71 kg of copper, i.e. about 50 kg more than traditional light-duty vehicles. The additional demand for copper would therefore be 2.5 million metric tons in 2030. This is almost equal to the combined mining production of the United States (1.2 Mt), Australia (0.87 Mt) and Canada (0.57 Mt) in 2020[30], and represents 12.5% of current world mining production.

3.1.2. **Battery Materials: Nickel, Cobalt, Lithium and Graphite**

A battery consists of an assembly of cells connected together, cylindrical in shape at Tesla and pocket-shaped at GM. Each cell consists of a cathode, an anode and an electrolyte in between, arranged in the outer container of the cell. The cathode is connected to the positive terminal of the cell and the anode to the negative terminal. In a Li-ion cell, it is the lithium ions that carry the electricity inside the cell, while the electrons travel through the external circuit.

There are several Li-ion battery chemistries, which vary mainly in the composition of the cathode. The main chemistries used for electric vehicles are called NCA, NMC, NMCA, NM and LFP. These various acronyms are composed of the first letters of the various chemical constituents of the cathode: NCA for Nickel, Cobalt and Aluminum; NMC for Nickel, Manganese and Cobalt: NMCA for Nickel, Manganese, Cobalt and Aluminum; NM for Nickel and Manganese; LFP for Lithium, Iron and Phosphate (the chemical symbol of Iron is Fe). Manganese and Aluminum being abundant and not presenting any particular supply problem will not be discussed in the following.

The anode, on the other hand, is generally composed of graphite, a form of carbon. But more and more silicon is being added to it to increase the capacity of the batteries for a given weight. Tesla,

[29] Wood Mackenzie company, *Copper: Powering Up the Electric Vehicle*, News on company site, August 13th, 2019 (www.woodmac.com/news/opinion/copper-powering-up-the-electric-vehicle/#:~:text=EVs%20can%20use%20up%20to,engine%20(ICE)%20passenger%20car.&text=Copper%20is%20used%20in%20every,a%20mile%20of%20copper%20wiring.).

[30] U.S. Geological Survey, National Minerals Information Center, Copper Statistics and Information (www.usgs.gov/centers/nmic/copper-statistics-and-information).

has just announced at its Battery Day[31] on September 22, 2020, that its next generation of battery, around 2023, will have anodes with a lot of silicon. They would have succeeded in solving a technical problem related to the significant swelling of the silicon during recharging which diminished the life of the cells, and to do so at a very affordable price. They thus obtain 20% more mileage for the same battery weight. The young company Enevate (www.enevate.com) has also developed a mainly silicon anode that offers 30% higher energy density. Other companies are also following the silicon path.

Still on the anode side, research on solid state batteries, which are expected to double the range of current Li-ion batteries for the same battery weight, should have a lithium metal anode that will replace graphite. All of this is to say that the high demand for graphite in today's Li-ion batteries could erode by 2030 for electric vehicles. **Because the lighter weight of batteries is less important for the storage of renewable energy on the ground than in cars, heavier graphite anodes could persist longer for these ground applications**.

Let's go back to the materials of the cathode. Currently, Tesla-Panasonic's NCA chemistry gives the lightest batteries (higher energy density). And on the NMC chemistry side, the trend is to increase the proportion of nickel and decrease the cobalt content. This increases the energy density with nickel and decreases the cost because cobalt is expensive. In addition, some cobalt mines in the Democratic Republic of Congo, the main producer, still employ children in unacceptable sanitary conditions, which is an ethical problem that manufacturers are seeking to eliminate. General Motors, with its new Ultium battery[32] (NMCA chemistry) that they developed with LG-Chem, claims to have reduced the cobalt content by 70% compared to their current NMC batteries. This new battery is expected to be in their electric vehicles by 2022-2023. Tesla's next-generation battery, which will also be released in 2022-2023, will be cobalt-free. The use of cobalt in Li-ion batteries for EVs is therefore likely to be largely eliminated by 2030, if all goes according to plan.

Tesla's president Elon Musk has expressed worry about the supply of nickel. This is also confirmed by Caspar Rawles, the director of price assessment at Benchmark Mineral Intelligence, in an interview with Clean Technica[33]. According Mr. Rawles, Li-ion batteries accounted for about 5% of the nickel market in 2020, but demand is growing very rapidly and he predicts that the mining industry will have difficulty meeting demand around 2025-2026, which should push prices up.

As we saw in Chapter 2, 3.2 million EVs were sold worldwide in 2020 with an average market share of 4.2% and exponential growth. If this is to continue, we should expect a market share of

[31] Tesla, *Tesla Battery Day*, YouTube video (www.youtube.com/watch?v=l6T9xIeZTds).

[32] Sam Abuelsamid, *GM Develops Lower Cost Ultium Lithium-ion Batteries To Power New Electric Vehicle Line*, Forbes magazine, March 4, 2020 (www.forbes.com/sites/samabuelsamid/2020/03/04/gm-announces-new-lower-cost-ultium-lithium-ion-batteries-for-new-evs/?sh=eb843474f102).

[33] Caspar Rawles and Zach Shahan, *The EV Battery Supply Chain & Pricing – Nickel, Cobalt, & Lithium Trends (Part 2)*, Clean Technica Interview, February 6th, 2021 (https://cleantechnica.com/2021/02/06/the-ev-battery-supply-chain-pricing-nickel-cobalt-lithium-trends-part-2/).

over 30% in 2030[34] for sales of new EVs worldwide and around 50% in Europe. A few European countries have already exceeded 30% in 2020 and several countries around the world have announced a ban on the sale of light internal combustion vehicles in their territory from 2025 to 2040[35].

Annual sales of light-duty electric vehicles should therefore be expected to be about eight times higher in 2030 than in 2020, which would correspond to monopolizing 40% of the nickel market of 2020. However, for this to occur, the mining sector will have to grow. Setting up a new mine takes 6 to 7 years, whereas building a new electric vehicle plant takes 2 years. **Therefore, the mining sector is likely to be the bottleneck in the electrification of transportation over the coming decade without further rapid and important investments in mining capacity**.

The race for raw materials for batteries will be robust and manufacturers will have to invest in partnerships with mining companies and finance part of the required investments.

In anticipation of a nickel shortage, Tesla's president announced that his company would use three different Li-ion battery chemistries, one of which, the LFP chemistry, contains no nickel or cobalt. However, the heavier LFP batteries will only be used for vehicles with an intermediate range of about 400 km. NM batteries, being lighter than LFP batteries, will contain 50% less nickel and will be used for ranges of around 500 km or slightly longer for light vehicles. NCA batteries with a high nickel content, the lightest, will be reserved for Tesla's semi electric truck (range of 800 km) and Cybertruck (range of over 600 km). All these details were revealed by Elon Musk at Battery Day on September 22, 2020[36].

There is another element that makes the supply of nickel more delicate. What Tesla and other manufacturers want is that the extraction be done in a sustainable and responsible way, which is not necessarily the case at present. This was the point made by Caspar Rawles in his interview with Clean Technica, which we mentioned earlier, when he pointed out that the largest nickel producer, Indonesia, was disposing of mine tailings in the sea. Cleaner mining is feasible, but it costs more.

There is still one important raw material for Li-ion batteries that we haven't yet addressed, lithium. Elon Musk doesn't seem too concerned about this light metal because according to him there is enough lithium in Nevada to electrify more than 300 million vehicles, or all the vehicles in the United States. And, assiduous research will discover some everywhere. At least that's what he told Battery Day. In Nevada, lithium is contained in clays, and Tesla has developed a new process to extract it, a cheaper and non-polluting process that doesn't use acids. The company has even

[34] Deloitte, *Deloitte Insights – Electric Vehicles – Setting a Course for 2030*, report published in 2020 (https://www2.deloitte.com/content/dam/insights/us/articles/22869-electric-vehicles/DI_Electric-Vehicles.pdf).

[35] Steve Hanley, *31 Countries, States, And Cities Have Gas/Diesel Car Bans in Place*, Clean Technica, January 2, 2021 (https://cleantechnica.com/2021/01/02/31-countries-states-and-cities-have-ice-bans-in-place/).

[36] Tesla, *Tesla Battery Day*, YouTube video (www.youtube.com/watch?v=l6T9xIeZTds).

acquired the rights to 10,000 acres and plans to become involved in mining, further increasing their vertical integration to reduce costs.

Although this news seems encouraging, we must be cautious because the technology has not yet been demonstrated on a large scale. Traditionally, two different lithium extraction processes are used. The first applies to underground brines resulting from large expanses of salt water from the past and largely evaporated, as in Chile. The second process extracts lithium from rocky ores, of which spodumene is the most common. This is what is done in Australia.

3.2. Magnet Materials: Neodymium and Other Rare Earths

The vast majority of automobile manufacturers use permanent magnet motors for their electric vehicles because they are more compact, more efficient and heat less. Let's not forget that a typical 7% to 8% gain in efficiency means a 7% to 8% smaller and cheaper battery. The magnets of these motors are made of neodymium, iron and boron alloys to which certain rare earths are added to obtain different properties. Neodymium is the main rare earths used, but dysprosium, terbium and gadolinium are often found.

One of the problems with rare earths is that 90% of them were produced and used in China and that China rationed its exports in 2013, which sends a bad signal for the stability of supply. Still in 2020 China was by far the largest producer of rare earth minerals as can be seen in Figure 3.6. Moreover, the extraction and refining of these materials in China has been criticized by many as being very damaging to the environment and the health of workers and local residents[37].

The various countries and manufacturers are therefore seeking to develop magnets with less rare earth minerals. Toyota, for example, has managed to halve the amount of these chemical elements in its electric motors[38].

3.3. Geopolitical Implications

To complete the picture of strategic materials for transport electrification, it is relevant to know where these resources are located and who controls them. To this end, we will mainly use data from the U.S. Geological Survey, which gives the annual production of the main producing countries for each raw material. Below are the graphs obtained for these materials.

---

[37] G. Pitron, *Dirty Rare Metals: Digging Deeper into the Energy Transition*, Green European Journal, September 27th, 2018 (www.greeneuropeanjournal.eu/dirty-rare-metals-digging-deeper-into-the-energy-transition/#:~:text=The%20dirty%20job%20of%20extraction&text=Purifying%20one%20tonne%20of%20rare,of%20China's%20most%20polluting%20industries.).

[38] Toyota Europe Newsroom, *Toyota Develops New Magnets for Electric Motors Aiming to Reduce Use of Critical Rare-Earth Element by Up to 50%*, February 20th, 2018 (newsroom.toyota.eu/toyota-develops-new-magnet-for-electric-motors-aiming-to-reduce-use-of-critical-rare-earth-element-by-up-to-50/).

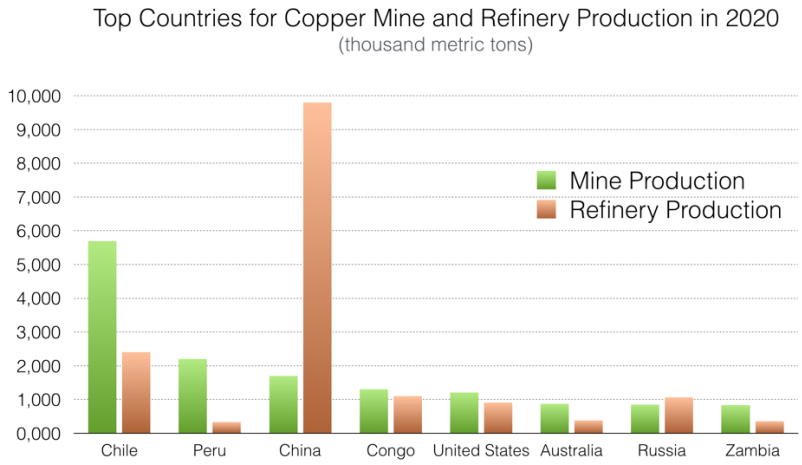


Figure 3.1: Mine and refinery production of copper for the top producing countries. Source: U.S. Geological Survey (USGS.gov) data.

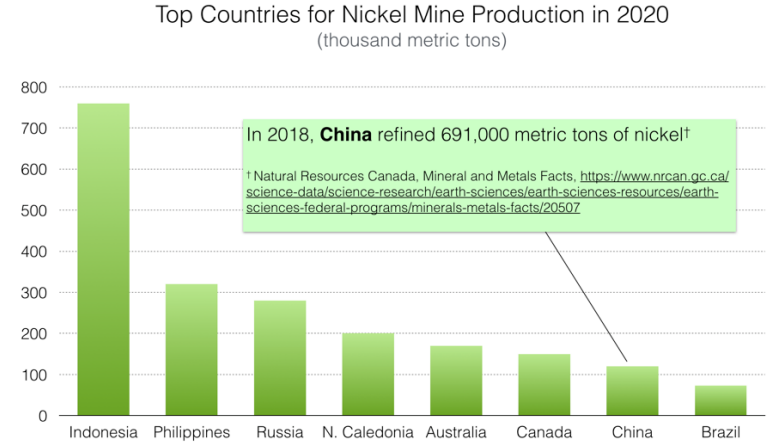


Figure 3.2: Mine production of nickel for the top producing countries. Source: U.S. Geological Survey (USGS.gov) data.

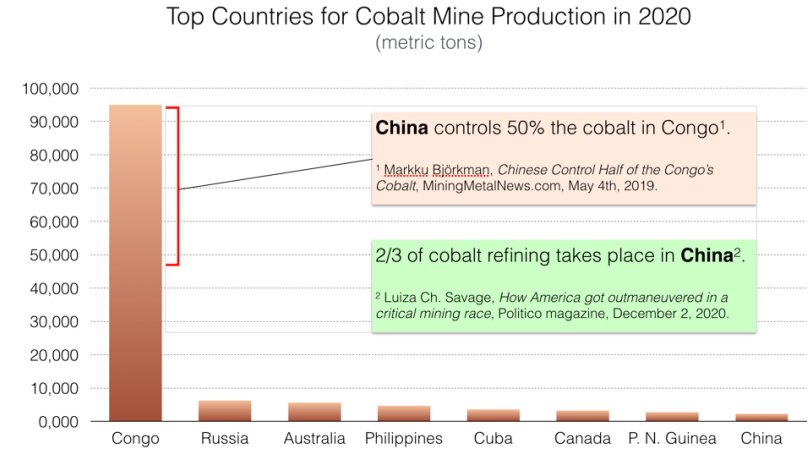


Figure 3.3: Mine production of cobalt for the top producing countries. Source: U.S. Geological Survey (USGS.gov) data.

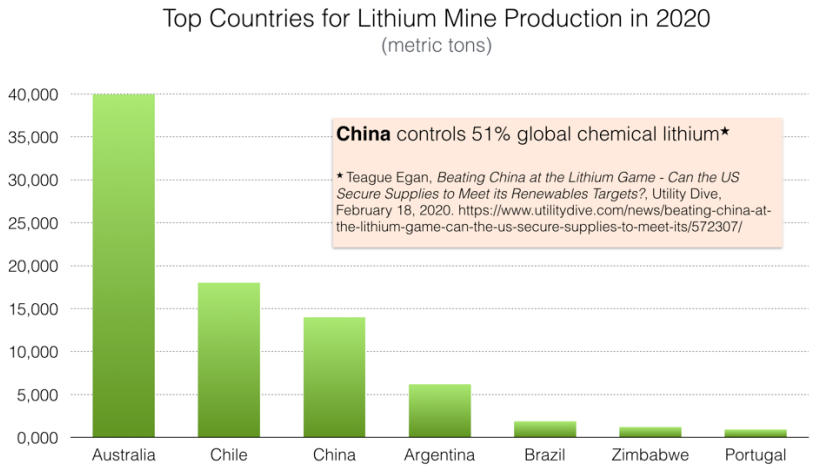


Figure 3.4: Mine production of lithium for the top producing countries. Source: U.S. Geological Survey (USGS.gov) data.

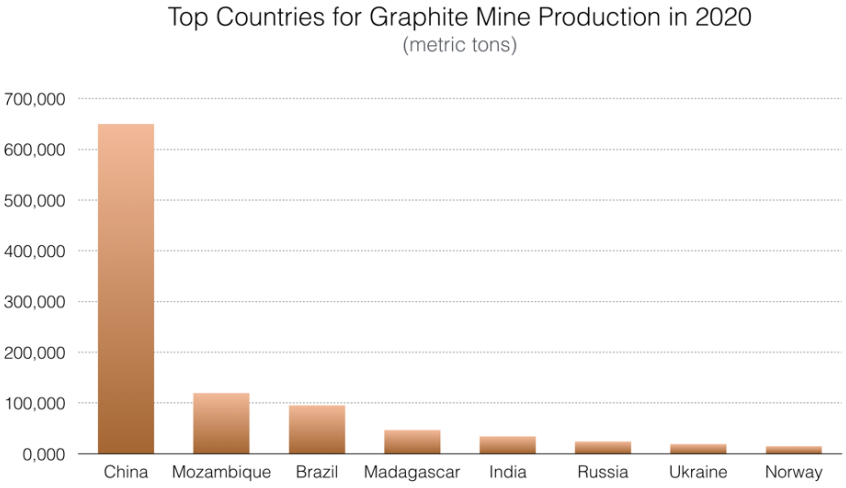


Figure 3.5: Mine production of graphite for the top producing countries. Source: U.S. Geological Survey (USGS.gov) data.

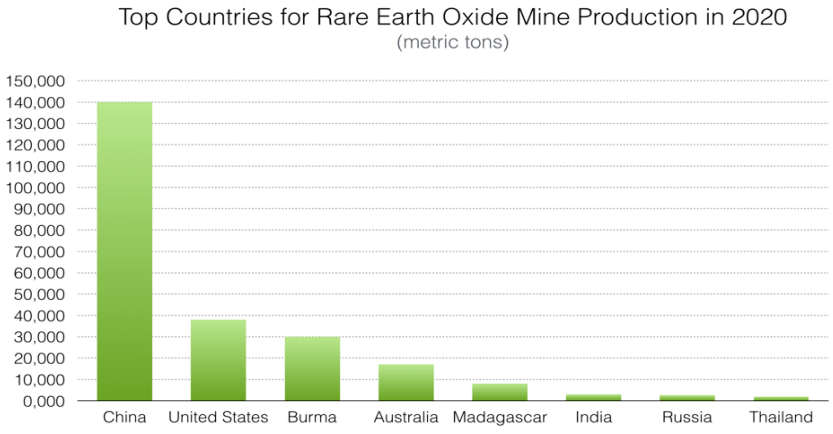


Figure 3.6: Mine production of rare earth oxides for the top producing countries. Source: U.S. Geological Survey (USGS.gov) data.

As can be seen in the graphs above, and in the boxes therein, China generally controls the supply chain of strategic materials needed for electric vehicles. According to Bloomberg NEF, China controls 80% of the refining of these materials and 77% of the world's battery cell manufacturing capacity[39]. Having control does not necessarily mean having the mines in one's own country, but having invested in the mines of other countries as well. It has to be said that China has been far-sighted in its long-term investments.

Moreover, China has cheaper labor and lower costs for extracting and refining minerals due to reduced environmental constraints on companies, as reported in various surveys[40]. All of this makes competing with China not easy.

3.4. An Opportunity for Canada

Increasingly, electric vehicle manufacturers are asking their suppliers to ensure that materials are produced with minimal pollution and greenhouse gases and that they provide their employees with healthy and ethical (no children) working conditions. This is what sustainable development is all about. It's not just about replacing a gasoline engine with an electric motor. Elon Musk of Tesla is the first to ask for clean nickel, and clean lithium, because that's what he wants, and he's the world leader.

Canada has the advantage of having very low-emission power grid in most provinces. We have a lot of hydro and nuclear power, as well as wind and solar farms. In fact, 82% of electricity production comes from non-emitting sources. Even geothermal plants are making their debut in Canada, with the expertise of the oil industry to drill deep. The DEEP project in Saskatchewan is expected to produce 20 MW of electricity in 2021[41].

Canada would therefore benefit using this asset for greening its mines to help build a more environmentally responsible supply chain for electric vehicle batteries. It goes without saying that it would be much more profitable for our economy to process the raw materials, right up to the manufacturing of the batteries, in the country as well.

Already, Glencore's Onaping Depth nickel mine project[42] near Sudbury, Ontario, is part of this trend towards cleaner mines. All rolling stock and machine tools will be electric, reducing greenhouse gases

[39] Mining.com Editor, *Canada ranked 4th, US 6th in Lithium-Ion.Battery Supply Chain*, Mining.com, September 16th, 2020 (https://www.mining.com/new-ranking-has-canada-4th-us-6th-in-lithium-ion-battery-supply-chain/).

[40] Earth.org, *How Rare-Earth Mining Has Devastated China's Environment*, July 14th, 2020 (https://earth.org/rare-earth-mining-has-devastated-chinas-environment/).

[41] Alexander Richter, *Successful Tests Allow DEEP to Plan 20 MW Geothermal Power Plant in Saskatchewan*, Think Geoenergy, September 10th, 2020 (https://www.thinkgeoenergy.com/successful-tests-allow-deep-to-plan-20-mw-geothermal-power-plant-in-saskatchewan/).

[42] Emma Jarratt, *Deep Secrets : How Canada's Mining Sector Grabbed the Global Lead in Mining Electrification*, Electric Autonomy, November 19th, 2020 (https://electricautonomy.ca/2020/11/19/canada-mining-electrification/#).

by 44%. In fact, it was the only solution for mining the ore at a depth of 2.6 km, as diesel or gasoline-powered equipment would have required costly ventilation infrastructures. The mine is scheduled to open in 2024.

The young Ontario company Canada Nickel (canadanickel.com), for its part, is proposing for its Crawford nickel, cobalt and iron project to use extraction and first refining technologies that will emit almost no greenhouse gases. They are betting, among other things, on the use of hydroelectricity and the absorption of CO2 by the serpentine rocks that will make up most of the mine tailings. The company has launched a subsidiary, NetZero Metals Inc. to validate the concept.

In Quebec, two start-up projects are also aimed at producing strategic materials more cleanly. Nouveau Monde Graphite (https://nouveaumonde.group) has just received the environmental authorizations to go ahead with the construction of the largest graphite mine in the Western Hemisphere. The company intends to electrify all its rolling stock and machine tools, which will be powered by clean hydroelectricity. The other project, Nemaska Lithium (https://nemaskalithium.com/en/), after restructuring and new investments, will focus on a plant to transform spodumene ore into battery-grade lithium hydroxide using a new patented process using electrolysis and clean Quebec electricity. The pilot plant is in Shawinigan and management is lining up for a commercial plant that will initially import the ore for clean processing. In a second phase, spodumene deposits in Northern Quebec could be exploited, in particular the Wabouchi deposit in the James Bay territory.

Canada has a definite interest in contributing to the development of cleaner mines and refineries for strategic materials, if it wants to play a relevant role in the supply chain for materials essential to electric vehicles. This is an opportunity that should not be missed.

4. The Value Chain of Batteries

For starters, let's mention that the Quebec government has already funded a study on lithium-ion batteries in 2019, which deals with their value chain, through the organization Propulsion Québec[43]. Here are some extracts from the summary of the study.

> "***Quebec has a unique set of competitive advantages***. *Quebec can build on its strengths to establish a foothold in this strategic market. Quebec already has the raw materials required for battery production, readily available technological and industrial expertise, access to clean and abundant energy, relatively low operating costs for North America, and proximity to automobile manufacturers."*
>
> ***"Quebec's most promising options for development***: *a) Implementing stronger vertical integration of the sector by strengthening the capacities of resource and material producers. b) Working to attract strategic partners and establish partnerships with them to develop a lithium-ion battery-cell or component manufacturing plant. c) Developing a lithium-ion battery recycling industry based on reliable hydrometallurgical processes (as yet undeveloped). d) Adapting current recycling facilities so they can handle end-of-life lithium-ion batteries.*"
>
> *"**Speed of action is crucial, and the window of opportunity is short**, given the rapid transformation of the global industry."*

The Li-ion battery value chain begins in the mines we discussed in the previous chapter. Once the ores are extracted, they are purified and transformed into salts or oxides, such as lithium hydroxide, lithium carbonate or iron phosphate. Then there are two steps to arrive at finished battery cells: the production of cathode and anode materials and finally the manufacture of the cells themselves, that will be assembled in battery packs and integrated in cars. These steps will be discussed in section 4.1. The geopolitics of battery factories will be discussed in section 4.2. There are a few small battery plants in Canada, but at this point in time they are much smaller than what is being done elsewhere. It is in Canada's best interest to stimulate the development of larger plants. To this end, Section 4.3 provides a brief overview of the battery research sector in Canada. Finally, battery recycling in the value chain should not be overlooked, a sector in which Canada is already well positioned, as discussed in Section 4.4.

[43] Propulsion Québec, Cluster for Electric and Smart Transportation, *Lithium-Ion Battery Sector – Developing a Promising sector for Quebec's Economy*, April 2019 (https://propulsionquebec.com/wp-content/uploads/2019/09/RAPPORT-BATTERIES-LITHIUM-ION-EN-2.pdf?download=1).

4.1. From Battery Materials to Battery Factories

After the ore concentrates leave the mines, a purification plant transforms them into purified chemicals. For example, Nemaska Lithium's lithium ore purification plant in Shawinigan, Quebec (nemaskalithium.com) produces battery-grade lithium hydroxide. Such purified chemicals are then purchased by the plants to produce the cathode and anode materials for the batteries. Cathodes are generally made, as we have seen, from a mixture of chemicals that are often reduced to fine particles and coated with certain materials[44] to increase conductivity or prevent harmful chemical reactions when in contact with the electrolyte. In Canada, we have Jonhson Matthey (matthey.com/en/products-and-services/battery-materials) and Nano One (nanoone.ca), for example, who produce cathode materials. As far as the anode is concerned, it is often silicon particles that are coated with a substance that allows lithium ions to pass through but prevents the particles from disintegrating during discharge-recharge cycles (due to the large volume variations of silicon as the ions enter and leave it).

Some battery manufacturers purchase these materials for the cathode and anode, and others, such as Tesla, are moving towards in-house production of these materials, in whole or in part.

It comes down to the battery factories themselves. The factories of the big battery manufacturers are usually very large. A good example is the Tesla gigafactory in Nevada, a partnership with Panasonics. In Canada, there are a few small manufacturers, such as Electrovaya (https://electrovaya.com/), Blue Solutions (https://blue-solutions.ca/en/) and Lithium Battery Solution (https://lithium.fit/).

Figure 4.1: Tesla-Panasonic's gigafactory in Nevada, opened in 2016. It was the largest building in the world when it opened, in terms footprint. Source : Wikimedia Commons, December 2019 (https://commons.wikimedia.org/wiki/File:Tesla_Gigafactory_1_-_December_2019.jpg).

[44] AZO Materials Team, *Particle-Level Cathode Coating Increases Life and Safety of Li-Ion Batteries*, AZO Materials, July 9th, 2020 (https://www.azom.com/news.aspx?newsID=54101).

4.2. Geopolitics of Batteries

After seeing, in the last chapter, China's control of strategic raw materials for Li-ion battery manufacturing, it will come as no surprise that the same is true for battery plants worldwide. This is shown in the next graph, whose data comes from Benchmark Mineral Intelligence (https://www.benchmarkminerals.com/) via an article by Clean Technica[45] .

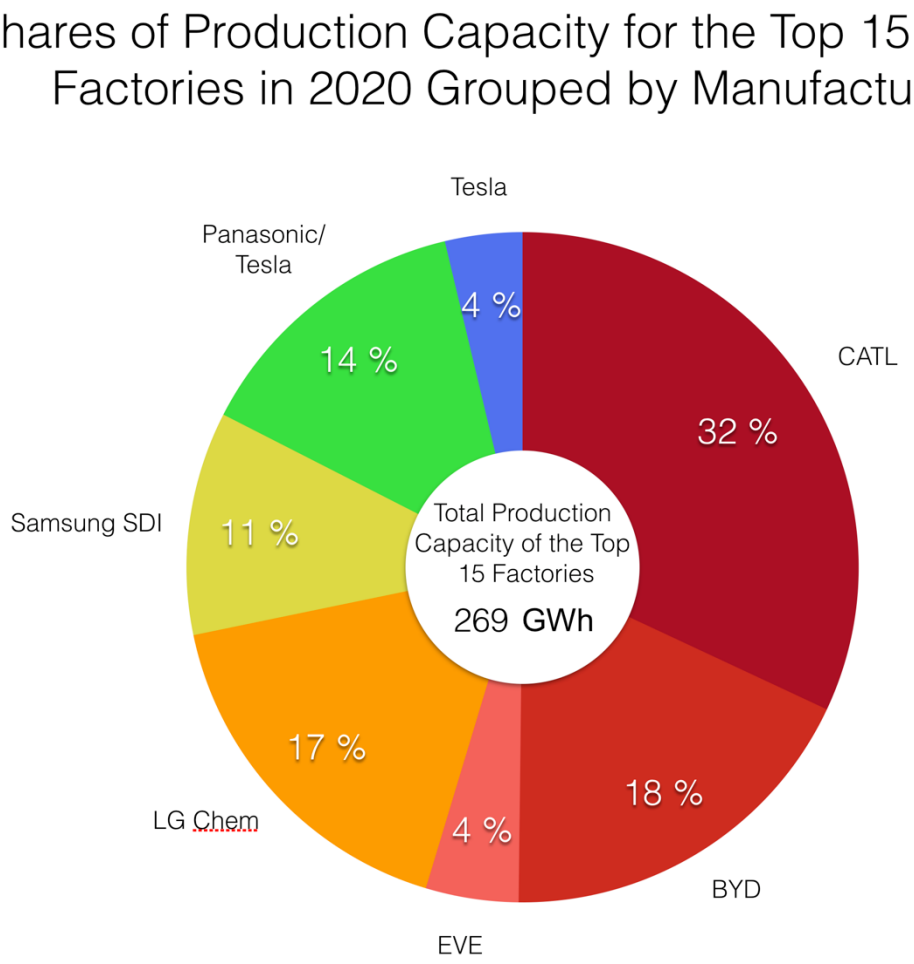


Figure 4.2: Breakdown of the production capacities of the 15 largest battery plants grouped by manufacturer. The red tones correspond to Chinese companies, the yellow and orange tones to South Korean manufacturers, the green color to a Japanese manufacturer and the blue color to a U.S. manufacturer (10 GWh pilot plant in California). The green portion actually corresponds to a partnership between Panasonic and Tesla for the Nevada gigafactory, but the technology is Panasonic's own. The building belongs to Tesla. Data Source : Benchmark Mineral Intelligence.

[45] Zachary Shahan, *Tesla "Pilot" Battery Factory = 13th Largest Battery Factory in World*, Clean Technica, September 24th, 2020 (https://cleantechnica.com/2020/09/24/tesla-pilot-battery-factory-13th-largest-in-world/).

In total, China controls 54% of the production capacity of the world's 15 largest battery plants, followed by South Korea at 28% and Japan at 14%. This means that 96% of their production capacity is owned by Asian companies.

Of course, production capacity shares will evolve in the coming years, especially with Tesla, who plans to produce batteries at its gigafactory in Berlin which is under construction and also at its gigafactory in Texas, also under construction. There is also NorthVolt in Sweden (northvolt.com) who is thinking big with its battery gigafactory which opens in 2021 and should reach a production of 32 GWh in 2024. Northvolt has also entered into a 50/50 partnership with Volkswagen[46] to build a battery plant in Germany which is expected to open in 2024 with an initial production capacity of 16 GWh.

The battery ecosystem also includes a multitude of startup companies with interesting innovations, some of which may have surprises in store for us in the next few years. The Energy Startups site www.energystartups.org/top/battery/ lists 70 of them. It includes, among others, Northvolt, Sila Nanotechnologies, QuantumScape, StoreDot and Solid Power.

Needless to say, before we get to the point of producing batteries in factories, we need considerable R&D efforts.

4.3. The R&D Sector

Research is very important both to train qualified researchers and to grow the economy through the acquisition of intellectual property. As we have just seen, China, South Korea and Japan have a huge lead in the lithium-ion battery value chain. We mentioned that the development of a clean mining sector could allow Canada to take a reasonable market share in strategic base materials. But if we want to move up the value chain for batteries, innovation must play an important role. By designing and manufacturing cathode materials that perform better than others, or a complete cell that performs better than others, patents will give us leverage to either negotiate licenses or partnerships with other players, including a clause for manufacturing in Canada.

In the value chain, there are also sophisticated devices required for battery research. This is a good example where Canadian innovation has led to the development of an ultra-accurate battery life duration testing system, which has greatly shortened testing times and allowed us to make much faster progress in improving battery chemistries. The work took place at Dalhousie University in Nova Scotia, in the battery laboratory of Professor Jeff Dahn, a leading authority in his field. From these developments, the new company Novonix (www.novonix.ca/) was born in Halifax to commercialize these systems worldwide.

[46] Volkswagen Group News Press Release, *Volkswagen and Northvolt Form Joint Venture for Battery Production*, September 6th, 2019 (https://www.volkswagen-newsroom.com/en/press-releases/volkswagen-and-northvolt-form-joint-venture-for-battery-production-5316).

4.3.1. Larger Laboratories and Research Centers

The advent of the new wave of electric vehicles is fairly recent and Canada has yet to make strides in this area. The same is true for research on lithium-ion batteries. However, some university and public government laboratories are doing well in this area.

Center of Excellence in Transportation Electrification and Energy Storage[47]. This research organization is housed at the Institut de recherche d'Hydro-Québec (IREQ), which has been working for nearly 40 years on the development of lithium batteries. It is there, among other things, that the iron phosphate LFP battery has been greatly improved in terms of power and longevity, thanks to multiple patented innovations. Today, this center of excellence is a world-class center of innovation in the field of battery materials and has unique equipment for both material analysis and controlled atmosphere pilot lines for the production of the two main types of cells on the market, cylindrical and pouch cells.

PMG Technologies[48]. Located in Blainville, north of Montreal, it is the largest and most advanced automotive testing and research center in Canada, with a collision laboratory, large environmental chambers that can accommodate heavy buses and trucks, 25 kilometers of outdoor tracks and a well equipped test laboratory. This allows batteries and electric vehicles to be tested under real-world conditions before they are commercialized. They also handle certifications and approvals.

Jeff Dahn Research Group, Dalhousie University[49]. This Halifax-based research group has been particularly notable for significant innovations in battery longevity testing systems. This work has significantly reduced the time required for testing and has helped speed up their research. This has enabled them to double the life of certain types of NMC lithium-ion batteries. The group has about ten well-equipped rooms at Dalhousie University and employs more than twenty people. Tesla funds some of their research.

The Waterloo Center for Automotive Research (WatCAR)[50]. This research center at the University of Waterloo focuses on collaborative research by facilitating relationships between the automotive industry and researchers at the University of Waterloo. It consists of 125 active faculty members with expertise in connectivity, cyber security, advanced propulsion systems, artificial intelligence, autonomous driving and lightweight materials. Their team includes 7 professors in the battery sub-sector[51]. They have worked on lithium-sulphur and rechargeable zinc-air batteries as well as high-silicon content anodes for lithium-ion batteries, among other things.

---

[47] See internet site at www.hydroquebec.com/ce-transportation-electrification-energy-storage/ .

[48] See internet site at www.pmgtest.com .

[49] See internet site at www.dal.ca/diff/dahn.html .

[50] See internet site at https://uwaterloo.ca/centre-automotive-research/ .

[51] See relevant page of their site at https://uwaterloo.ca/centre-automotive-research/about/people/group/44 .

NRC's LiBTec Industrial Research Group[52]. This research group is a multi-stakeholder, pre-competitive industrial R&D initiative that aims to develop and support the Canadian supply chain for value-added materials such as graphite and lithium, particularly for lithium-ion battery applications. The Group brings together raw material suppliers, processors, battery and original equipment manufacturers, and other players from all parts of the supply chain, to which it provides leading-edge technologies.

NRC's Battery Performance and Safety Evaluation Research Facility[53]. The National Research Council's Battery Performance and Safety Evaluation Group has become a leader in battery safety evaluation and has developed unique expertise in this field. With this experience, they are able to provide support to government regulators, manufacturers and suppliers. The group has specific tools that allow them to advise clients on how to improve the design of batteries tested for various situations and operational conditions.

Institute for Innovative Vehicles (IVI)[54]. The IVI, located in Saint-Jérôme north of Montreal, was founded in 2015 following the merger between the Centre National du Transport Avancé (CNTA) and the Institut du Transport Avancé du Québec (ITAQ), which gives them more than 20 years of experience in transportation electrification. They have participated, among others, in the development of the Lion electric school bus, an electric farm robot, electric trucks and have worked with more than 120 companies. Their three main sectors of activity are electric vehicles, autonomous vehicles and connected vehicles, with sub-sectors for each of them. The IVI received a grant of $12.7 million from the Quebec Ministry of Economy and Innovation in 2019 for the construction of a new building.

4.3.2. Smaller University Laboratories

With the electrification of transportation and the lithium-ion battery sector having become synonymous with the next great technological revolution, many Canadian universities are researching these exciting topics with the promise of economic benefits for Canada. We will name just a few, in addition to the University of Waterloo and Dalhousie University, mentioned above.

University of Toronto Electric Vehicle (UTEV) Research Centre[55]. This center is a university-industry partnership for the development of innovative technologies for electric vehicles. Founded in 2016, the organization is supported by several professors from different departments at the

[52] See the relevant page of NRC's site at https://nrc.canada.ca/en/research-development/research-collaboration/industrial-rd-groups/libtec-industrial-rd-group .

[53] See the relevant page of NRC's site at https://nrc.canada.ca/en/research-development/nrc-facilities/battery-performance-safety-evaluation-research-facility .

[54] See the IVI internet site at www.ivisolutions.ca/ .

[55] See the UTEV internet site at www.ece.utoronto.ca/research/centres/university-toronto-electric-vehicle-utev-research-centre/ .

University of Toronto, and has received $9.1 million in funding from the National Sciences & Engineering Research Council (NRSERC) and Havelaar Canada over five years. UTEV will focus on electronic converters for propulsion systems, recharging infrastructure, and energy storage and autonomous operation systems for electric vehicles.

University of Western Ontario in London[56]. The Advanced Materials for Clean Energy Group led by Professor Andy Xueliang Sun has three areas of focus on batteries: 1) solid state batteries, 2) nanoscale and atomic structures, and 3) advanced characterization techniques. An example of realization is undoubtedly the development of a process allowing to reduce by a factor 300 the price of black phosphorus which offers the possibility of storing seven times more lithium in the anode than the graphite used today[57], which could make it possible to recharge one's smart phone only once a week.

University of Montreal[58]. Professor Michaël Dollé, principal researcher at the university's Solids Chemistry and Electrochemistry Laboratory, has been actively involved in a battery recycling project in collaboration with the Centre national en électrochimie et en technologies environnementales (CNETE) and Nemaska Lithium, since 2018. They have developed a new patented process and obtained a $3.9M grant for 5 years from the governments of Canada and Quebec.

University of British Columbia[59]. Dr. Liu is in charge of the Advanced Materials for Energy Storage Lab, where battery research focuses on sodium-ion batteries, whose key element, sodium, is much more abundant than lithium. However, because sodium ions are larger than lithium ions, this makes intercalation in the electrodes more problematic. The team is working to remedy this.

McGill University. Professor Demopoulos' research group is working to remove cobalt from lithium-ion batteries using a lithium iron silicate cathode. These materials are abundant, non-toxic and theoretically have the potential to store a lot of energy. However, the results of previous research have been disappointing. McGill researchers have greatly improved the performance of such batteries by encapsulating the nanocrystals of the cathode with a new and very promising coating[60]. They are working closely with Hydro-Québec.

---

[56] See the internet site at www.eng.uwo.ca/nanoenergy/home/index.html .

[57] Sean Irvine, *Want a 7-Day Charge on your Smartphone? Western U Research Finds Low-Cost Way to Do It*, CTV News, August 19th, 2020 (https://london.ctvnews.ca/want-a-7-day-charge-on-your-smartphone-western-u-research-finds-low-cost-way-to-do-it-1.5070728).

[58] Editor, *Vers le recyclage des batteries de véhicules électriques*, UDEM nouvelles, July 10th, 2019 (https://nouvelles.umontreal.ca/article/2019/07/10/vers-le-recyclage-des-batteries-de-vehicules-electriques//).

[59] See the internet site at http://nesc.ok.ubc.ca// .

[60] Christopher Minasians, *Development of a Sustainable Battery Is Underway for Electric Vehicles*, Totally EV, June 24th, 2020 (https://totallyev.net/development-of-a-sustainable-battery-is-underway-for-electric-vehicles/).

4.4. The Circular Economy

According to IHS Markit (https://ihsmarkit.com), a leader in strategic information and analysis in critical areas of business, more than 500,000 tons of Li-ion batteries will reach the end of their life in 2020, 1.2 million tons in 2025 and 3.5 million tons in 2030[61]. The battery recycling industry will more than triple its capacity by 2030, according to IHS Markit. And the tonnage to be recycled will increase even more after that date.

In addition to being an essential element in reducing the ecological footprint of electric vehicles, via a circular economy, it is also a business opportunity. The major electric vehicle manufacturers have understood this. Tesla's co-founder, J.B. Straubel, started Redwood Materials in 2017 in Nevada (www.redwoodmaterials.com) and intends to work closely with Tesla to meet this challenge. Similarly, Volkswagen has set up a pilot battery recycling plant for their electric vehicles in Salzgitter, Germany[62].

4.4.1. A Second Life

But before recycling the batteries of electric vehicles one can give them a second life for energy storage on the ground. Their life in a vehicle is generally defined as the time when the electrical energy storage capacity has decreased by 20%. But the battery is still good at this stage and can be used to store solar energy for the night or to support the fast charging stations by recharging the battery at night and releasing energy during the grid rush hour during the day. However, we will not elaborate further on this aspect and will instead focus on recycling, in this report.

4.4.2. Battery Recycling Already Well Underway in Canada

It is interesting to note that the recycling of Li-ion batteries is well underway in Canada, with three companies already in operation or starting up, with patented processes.

Retriev Technologies (www.retrievtech.com). This British Columbia company has been recycling Li-ion batteries for over 20 years, in addition to other types of batteries. For electric vehicle batteries, they first dismantle them by hand and recover the metal and plastic structures as well as the wiring and printed circuit boards of the battery management system. Then they send the cells for recycling. Their process recovers aluminum and copper on one side and a black paste containing nickel, cobalt and manganese on the other. These metals correspond to 75% of the weight of the cells. Lithium and electrolyte are not recovered. Retriev sends their metals to smelters

[61] DeAnne Toto, *IHS Markit : Lithium-Ion Battery Recycling Industry Poised for Substantial Growth*, Recycling Today, December 9th, 2020 (https://www.recyclingtoday.com/article/lithium-ion-battery-recycling-growth/).

[62] Steve Hanley, Volkswagen Begins Battery Recycling Pilot Project in Salzgitter, Clean Technica, February 1st, 2021(https://cleantechnica.com/2021/02/01/volkswagen-battery-recycling-pilot-project-salzgitter/).

and refineries for final separation. In a Radio-Canada Découverte report[63], Vice-President Kathy Bruce says that they are beginning to think that eventually they could manage the final recovery of their cathode metals themselves instead of sending their black paste (mixed metals) to smelters and refineries. But she also argues that this process will need to be economically viable if the company is to take it on, as the materials in some types of batteries are less valuable than others. Ideally the manufacturer should not have to pay more for the recovered materials than they can get on the market.

Li-Cycle (https://li-cycle.com). This Kingston Ontario-based company, founded in 2016, is making great strides. Their technology uses mechanical processes to initially shred the cells and pre-treat them at several local plants that send the recovered but unseparated metals to a regional plant for final treatment using hydrometallurgy. In this way, they can recover up to 95% of the material from the cells. This is a new generation plant. In 2019, their first local plant in Kingston was commissioned with a capacity to receive 2,500 tons of batteries per year. A regional hydrometallurgy plant has also been built there. A second local primary processing plant is under construction in Rochester U.S.A., and more are planned. They have already signed agreements with some 40 customers, including the largest electric vehicle manufacturer (Tesla?). An interview with President and CEO Ajay Kochhar is available on Bloomberg[64].

Recyclage Lithion (www.lithionrecycling.com). Montreal-based start-up Lithion, founded in 2018, has also developed a new hydrometallurgy-based Li-ion battery recycling process that can recycle 95% of battery components with a significantly smaller carbon footprint than conventional pyrometallurgy processes. They formed a consortium that received $3.8 million in funding from Sustainable Development Technology Canada (SDTC) and a $4.8 million grant from the Quebec government to build a 200-ton-per-year pilot plant that began operations in 2020. They are currently using it to refine their processes and plan to build a first commercial plant able to recycle 2,000 tons of batteries in 2023. An important part of their intellectual property is the automatic dismantling of the battery packs in minutes instead of several hours manually. In addition, their business model is to license the technology so that many partners can build and operate their own plants around the world. The benefit is that this greatly reduces Lithion's financing requirements and speeds up deployment. Their corporate video is available on YouTube[65].

[63] Tobie Lebel and Eric Lemyre, *Voitures électriques: le défi du recyclage des batteries*, Découverte program, Radio-Canada, Avril 29th, 2018 (https://ici.radio-canada.ca/tele/decouverte/site/segments/reportage/69715/voiture-electrique-recyclage-batterie-environnement).

[64] Interview with Li-Cycle CEO Ajay Kochhar, Bloomberg Quicktake "Take the Lead" Program, at 51 minutes from the beginning (https://li-cycle.com/news/quicktake-take-the-lead-02-17-2021/).

[65] See Lithion Recycling Corporate Video at https://www.youtube.com/watch?v=Gsoy8lhUzJk .

4.4.3. Motivations to Recycle the Batteries

Urban mine Faster to Commissioning. Recycling centers can be seen as urban mines that take 1 to 2 years to operate, unlike real mines that can take 7 to 8 years to enter in production. However, towards the end of the 2020s, there may be a lot of pressure and delays in sourcing strategic materials, hence the interest of recycling for manufacturers.

Consumers Want Greener Products. One of the incentives for a consumer to buy an electric vehicle is the feeling that it contributes to improving our environment. Therefore, they expect not to add to their vehicle's environmental footprint by disposing of the battery.

Government Regulations. Finally, governments must ensure that they put in place strict regulations to force battery recycling.

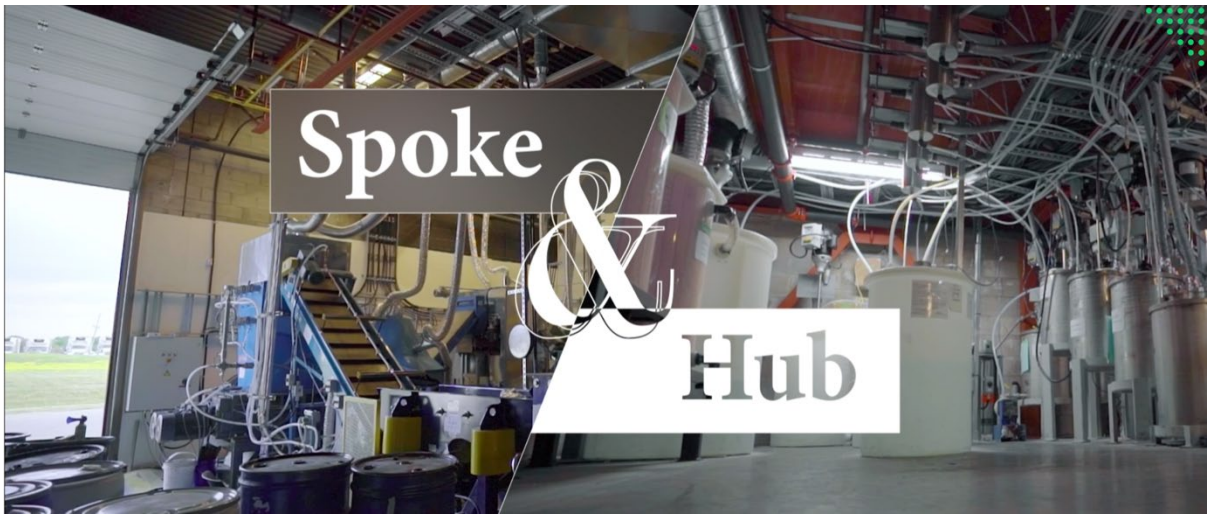


Figure 4.3: The spoke & hub concept of Li-Cycle battery recycling process uses several spoke facilities in a region to make the first mechanical treatment (disassembly, shredding of batteries and sorting of the residues). The cathode and anode materials are then sent ro a central hub facility that complete the separation and refining of the different metals using hydrometallurgy. Source: Li-Cycle (li-cycle.com).

Electric Mobility Canada /Mobilité électrique Canada – www.emc-mec.ca – info@emc-mec.ca
38 place du Commerce, 11-530 Ile des Sœurs, QC H3E 1T8

5. A Larger Perspective on the EV Ecosystem

The first step in the electrification of transportation, in the early 2010s, was to electrify cars with a battery giving a range of 130 km to 160 km only, due to the high cost of batteries in that time period. Some luxury cars had a larger battery, such as the Tesla Model S, but their price was too high for the vast majority of people. We had to wait to electrify trucks, which require larger batteries, until the price of these batteries dropped enough. But things have evolved quickly.

a) Rapid evolution of EV range

In 2012, the average range of an electric vehicle, excluding Tesla, was around 110 km. In 2016, around 150 km. In 2020, most EVs offer an average range of 400 km for less than half the price of a 2012 Tesla with the same range. By 2025, an EV range should be between 600 to 1000 km, which will be greater than the range of many gasoline-powered vehicles. Let's not forget that 90% of Canadians travel less than 60 km each day to and from work. So for the vast majority of drivers, a 400 kilometer range is already more than enough for daily commutes and likely longer trips.

b) Rapid decrease in charging time

In 2012, due to the lack of fast charging stations, recharging time was 4 to 6 hours for 100 kilometers. In 2016, on a 50 kW fast charger, it was about 1 hour per 250 km. In 2020, new ultra- fast charging stations are shortening the charging time to 20-30 minutes for 400 km, making traveling long distances with an EV no longer an issue. By 2025, the charging time is expected to be at approximately 10-15 minutes for 600 km.

5.1. From Scooters to Cars to Trucks to Buses to Boats

According to Bloomberg NEF[66], the average price of lithium-ion battery packs has decreased by a factor of 8 from 2010 to 2020. According to them, the average price was more than $1,100 per kilowatt-hour in 2010, dropping to $137/kWh in 2020. Price is expected to be $100/kWh by 2023. The electric vehicle ecosystem is therefore expected to expand considerably in the 2020s.

[66] Bloomberg NEF, *Battery Pack Prices Cited Below $10/kWh for the First Time in 2020, While Market Average Sits at $137/kWh*, December 16th, 2020 (https://about.bnef.com/blog/battery-pack-prices-cited-below-100-kwh-for-the-first-time-in-2020-while-market-average-sits-at-137-kwh/).

5.1.1. Passenger vehicles

Scooters and motorcycles. Two-wheeled electric vehicles are becoming increasingly popular, especially personal or self-service scooter rentals, with removable batteries like those from Gogoro (www.gogoro.com/). Recharging can be done at home, by bringing the battery inside or through a subscription to a network of charging stations where empty batteries can be swapped for full ones. In Taiwan there are already more than 2,000 stations. With a self-service rental, such as Cityscoot in Europe (www.cityscoot.eu), the manager takes care of exchanging the batteries. Electric motorcycles have better performance than scooters but are also more expensive. The Canadian company LITO Motorcycles, south of Montreal, manufactures its luxury superbike SORA GEN2, with a range of 290 km.

Figure 5.1: Electric scooter and charging/swapping stations of Gogoro. Source : Gogoro.

Microcars. Scooters and motorcycles, however, have the disadvantage that they do not provide protection from the weather. There is, in fact, a new type of electric vehicle that bridges the gap between a two-wheeled electric vehicle and an electric car, it is a three-wheeled micro electric vehicle, with a cabin that protects the driver from the rain. The Vancouver-based company Electra Meccanica (electrameccanica.com) has developed one, the Solo, which carries only one passenger with very low power consumption. The Toronto company Daymak Avvenire (daymakavvenire.com) also plans to dive into this adventure and market its three-wheeled electric micro cars in 2022-2023.

Cars and light duty trucks. With lower battery prices, more and more large electric cars and full-size electric SUVs will appear. The number of models will also increase significantly in the coming years, allowing more consumers to find a vehicle that suits them. As far as the Canadian automotive industry is concerned, Ford announced in September 2020 that it will transform its Oakville, Ontario assembly plant to manufacture all-electric vehicles[67] starting in 2024. The

[67] Fred Lambert, *Ford Announces $1.8 Billion Investment to Produce 'Fully Battery Electric Vehicles' in Canada*, Electrek, September 28th, 2020 (https://electrek.co/2020/09/28/ford-investment-produce-battery-electric-vehicles-canada/).

company plans to invest C$1.8 billion to make this happen and reached an agreement with Unifor and the Ontario and Canadian governments. GM, for its part, also plans to build an electric vehicle in Ontario, a delivery van, which we will discuss a little later in the section on electric trucks.

On a global scale, Tesla has announced that it plans to sell an affordable small car at US$25,000 by 2023-2024 with an expected range of about 400 km. Other manufacturers are expected to follow suit as well, which will really democratize electric vehicles.

Finally, by 2025, a new category of light-duty vehicles will appear. These are autonomous vehicles, which will revolutionize the transportation of people. Most studies agree that, in the long term, it will cost two to three times less to subscribe to a robotaxi service than to own a private car. More and more people will buy kilometers from a transportation service instead of buying vehicles. Robotaxis have the potential to be safer and far less numerous on the roads than personal vehicles, for the same door-to-door service, thus reducing congestion in our cities. Another advantage of these vehicles is that there will not be a need to go to repair shops or to look and pay for parking. Electric cars are good, but autonomous electric cars are much better for the environment and the economy. Instead of sending our money out of the country to buy the vehicles, robotaxi fleet managers will buy a lot of Canadian electricity.

5.1.2. **Electric Buses**

Although electric buses are not yet widely available in Canadian cities, most major cities have committed to replacing their diesel buses with electric buses in the coming years, with several cities no longer purchasing diesel buses after 2025. The purchase price is still high, but the fuel and maintenance savings will help recover the extra cost at the time of purchase. However, with the COVID-19 pandemic, public transport ridership has declined and several public transport companies have a significant revenue shortfall. Government support will therefore be needed. Bus electrification is essential to reduce air and noise pollution in our cities.

China is well aware of this and there are more than 500,000 electric buses in China, making up about 98% of the world's fleet[68]. The city of Shenzhen has already eliminated all of its diesel buses and has more than 16,000 electric buses, plus 22,000 electric cabs, which shows that electrifying public transportation is possible. The Fully Charged program devoted a 21-minute report[69] to the electric public transit of Shenzhen.

The future looks bright for electric buses in Canada, judging by the number of manufacturers offering electric versions for either school or city transit or both. From east to west, in Quebec, there is Nova Bus (novabus.com/) in St-Eustache, Lion (thelionelectric.com/en) in St-Jérôme and

[68] Wood Mackenzie News release, *China's e-Bus Stock to Surpass 1 Million Mark by 2023*, September 16th, 2019 (https://www.woodmac.com/press-releases/chinas-e-bus-stock-to-surpass-1-million-mark-by-2023/).

[69] Mark Kane, *Shenzhen: The City With 16,000 Electric Buse and 22,000 Electric Taxis*, February 13th, 2021 (https://insideevs.com/news/487869/shenzhen-city-16000-electric-buse-22000-taxis/).

Girardin (girardinbluebird.com/en/) in Drummundville; BYD Canada (en.byd.com/) which has established an assembly plant in Newmarket, Ontario; in Manitoba New Flyer (newflyer.com/) is based in Winnipeg; and finally Green Power Motor (greenpowermotor.com/) is in Vancouver, British Columbia. Interestingly, half of these manufacturers use the high-powered electric motors from Quebec manufacturer Dana-TM4 (danatm4.com) in Boucherville, much of whose technology was developed at Hydro-Québec's research institute in the 1990s.

Figure 5.2: The new generation electric bus Xcelsior CHARGE NG from New Flyer. Source: New Flyer.

5.1.3. **Electric Trucks**

Now that battery prices are low enough, electric trucks can take off. GM announced in January 2021[70] that it would invest $1 billion to transform their CAMI assembly plant in Ingersoll, Ontario, after signing an agreement with Unifor who represents the plant's employees. GM, under the name of its new subsidiary BrightDrop, will build an electric delivery van, the EV600, at the plant beginning in late 2021. It will have a range of up to 400 km.

Canadian companies are also starting to sell electric trucks developed domestically. In Quebec, there is The Lion Company (thelionelectric.com/en) from St-Jérôme that markets the Lion8, a class 8 electric truck that can travel up to 400 km. The Nordresa company (nordresa.com) of Laval

[70] Jasmin Legatos, *GM's New Electric Delivery Vans Will Be Made in Canada*, Electric Autonomy, January 18th, 2020 (https://electricautonomy.ca/2021/01/18/gm-electric-delivery-van-made-in-ontario/).

markets an electric delivery van with a range of 240 km. In British Columbia, Green Power Motor (greenpowermotor.com/) of Vancouver markets one that can also travel 240 km. All three companies use Canadian Dana-TM4 engines. Ecotuned (ecotuned.com/en/) of Varennes, Quebec, for its part, offers and installs electric conversion kits for gas-powered pickup trucks.

All these electric trucks can go on roads and highways. There are also Canadian manufacturers of small low-speed trucks, made mainly for industrial and institutional off-road use. In the East we have the Kargo company (kargo-ev.com/) in Alma, Quebec and in the West we have the Canadian Electric Vehicles Ltd (canev.com/) in Parksville, British Columbia.

Elsewhere in the world, there are several electric trucks coming. Tesla's semi-trailer truck (tesla.com/semi) is without a doubt the most awaited, with its 800 km range when fully loaded. It should arrive in 2022. Tesla's Cybertruck (tesla.com/cybertruck), a pickup truck with a futuristic look is also eagerly awaited by those who have made reservations, in 2022. The new U.S. company Rivian (rivian.com) offers light electric trucks with a successful design and well-thought-out amenities. They are expected to be on the road in 2022. In addition, Ford promises to release its electric F-150 for soon. In short, electric trucks are coming!

5.1.4. **Water Sports, Short Cruise Boats and Ferries**

Electrification is not only for land vehicles; water sports enthusiasts can now enjoy their activities without polluting lakes or rivers. In Canada, LTS Marine (ltsmarine.com/english/) has developed electric boats for water skiing and Vision Marine Technologies (visionmarinetechnologies.com) manufactures electric boats for cruising that can carry up to 10 passengers. Both companies are from the Montreal area. Similarly, Templar Electric (templarmarine.com/) of Kelowna, British Columbia offers promenade boats including a 12-passenger water cab. Finally, Taiga Motors (taigamotors.ca/watercraft/) of Montreal specializes in personal watercraft and electric snowmobiles.

Another niche market for electric boats is short cruise ships. Marc Marine of Gatineau has built an electric cruise boat for Ottawa Boat Cruise (www.ottawaboatcruise.com/) which offers cruises on the Rideau Canal. The boat, which can carry 100 people, is even equipped with solar panels on its roof.

Norway surprised the world in 2015 when the country inaugurated the world's first large-capacity electric ferry, the Ampere, capable of crossing the Sognefjord over a distance of 6 km, with 360 passengers and 120 cars. Recharging is done in 10 minutes at the docks. By 2016, its owner estimated that it had reduced greenhouse gases by 95% and operating costs by 80%[71]. This success earned the Norwegian shipyard that built them, Fjellstrand, several new ferry orders.

[71] Fred Lambert, *World's Largest All-Electric Ferry Completes its Maiden Trip,* August 21th, 2019 (https://electrek.co/2019/08/21/worlds-largest-electric-ferry/).

Seeing this, BC Ferries of British Columbia ordered hybrid electric ferries[72] to replace old ones that served the islands. Once the mega-chargers are sufficiently powerful, the boats will be able to run on pure electric power for the vast majority of the time. Two ferries were delivered in 2020, with a capacity of 47 vehicles each, and four more are expected to arrive in 2022. All six ships are built in the Netherlands. Similarly, Ontario ordered two all-electric ferries in 2018 to shuttle between Wolfe and Amherst Islands across from Kingston. One will carry 300 passengers and the other 400[73]. The builder, Damen in the Netherlands, is the same as for the ferries delivered to British Columbia.

Knowing that a ferry can last 60 years, this is a strong motivation to go for electric propulsion now and not wait 60 years. It would certainly be appropriate for at least one Canadian shipyard to take a closer look at it.

5.2. Feedback from Electric Mobility Actors

Electric Mobility Canada asked different organizations to comment on how they see the future of electric mobility, with some questions related to their particular field of expertise and interests. We asked:

- Light duty OEMS: GM, Nissan, Tesla and Toyota
- Heavy Duty OEMs: Girardin, Lion, NewFlyer
- APMA
- Unifor
- A transit fleet manager: EXO
- NGOs: Pembina Institute, Clean Energy Canada, Plug'n Drive

A summary of the Q&A is presented in the sections below. The detailed questions and answers are given in Appendix 2.

[72] Site of BC Ferries at https://www.bcferries.com/in-the-community/projects/introducing-island-class-ferries#Island-Class-design .

[73] Luke Sarabla, *As Electric Boats Push Off, Where Does Canada Stand?*, Electric Autonomy, February 11th, 2020 (https://electricautonomy.ca/2020/02/11/as-electric-boats-push-off-where-does-canada-stand/).

5.2.1. **Feeedback from automakers**

EV Sales in Canada. The four auto manufacturers that answered our questionnaire did not give forecasts for their EV sales in Canada in the next few years.

Number of models available in Canada in 2021-2023. Nissan only confirmed one, the Leaf, and mentioned that the new Ariya electric crossover should arrive in Canada at a later date, yet to be announced. GM confirmed that their battery electric vehicles (BEVs), the Bolt EV & EUV models will be available in Canada in 2021 and mentioned that it is on its way to an all-electric future, with a commitment to 30 new electric vehicles by 2025, including an electric Hummer and pickup truck. Toyota said that they will continue to sell two plug-in hybrid electric vehicle (PHEV) models in Canada in 2021, the Prius Prime and the RAV4 Prime. Tesla, for its part, will continue selling its four BEVs models: Model S, Model X, Model 3 and Model Y in 2021, and the Cybertruck (pickup truck) as well as the Semi (Class 8 semi-trailer truck) BEV should arrive at the end of 2021-beginning 2022.

What the Government of Canada could do to help? Here are the OEMs' recommendations where there is consensus:

- Continue the financial incentives for the purchase of an EV and a home or work charger, see what can be done for the Provinces without their own rebate and EV strategy,

- Help utilities and private sector put in place charging infrastructure particularly for multi-unit residential buildings,

- Educate the consumers with respect to EVs.

Other recommendations lack consensus, and rather reflect the type of light-duty vehicles manufacturers sell, i.e. only BEVs (Tesla), BEVs and gasoline vehicles (GM, Nissan) or PHEVs and gasoline vehicles (Toyota). For example, Tesla suggests that financial incentive rules arbitrarily penalize long range BEVs and favor PHEVs due to their lower prices. They also whish that a Canadian Clean Fuel Standard and a Canadian ZEV Standard come into effect as soon as possible. On the other end, Toyota says: "the true challenge is overall carbon reduction - not simply selling more battery electric vehicles. A comprehensive approach to powertrain technologies is necessary – one that includes BEVs, PHEVs, FCEVs, and HEVs… not everyone can afford a battery electric vehicle. They're also not always suited to everyone's lifestyle (i.e. urban dwellers with only street parking)". As for GM, they recommend that financial incentive adjusted upward to accommodate BEVs with larger batteries like pickup trucks and Hummer which typically havea higher price.

Intention to manufacture EVs in Canada? GM mentioned that they recently announced plans to bring production of its BrightDrop electric light commercial vehicle, the EV600, to its CAMI manufacturing plant in Ingersoll, Ontario. Nissan and Tesla do not intend presently to manufacture EVs in Canada. Toyota mentioned that it is already building hybrid vehicles in Canada and " ensure

Toyota's Canadian plants are well-positioned to build any vehicle the company asks to build – including the most advanced electrified models that will be coming to our market over the next few years".

5.2.2. Feeedback from bus manufacturers

Manufacturing of BEV and PHEV buses in Canada? **Lion Electric** answered that they are already manufacturing seven purpose-built all-electric models, a mix of medium-duty and heavy-duty trucks and buses that demonstrate a great commonality across the platforms. They also pointed out that in the next two years Lion Electric expect to reveal seven new truck models and one school bus, for a total of 15 all electric vehicles made in Canada. **Girardin** specified that they have eight BEV bus models available for sale in Canada for commercial or school use. Only the BEV minibuses are manufactured in Canada, in Drummondville and they are planning to build 200-250 units in 2022-2023. The large BEV buses come from their United States partner Blue Bird. Finally, **New Flyer** does not plan to manufacture electric buses in Canada. They start with the bodies in Winnipeg and complete the production in the U.S., where they install the electric power train, including the battery.

Sales forecasts in 2021. The sales objectives of **Lion Electric** for 2021 are 400 BEV trucks and 250 BEV buses. **Girardin** and **New Flyer** did not give sales forecasts for 2021.

What the Government of Canada could do to help? All three manufacturers ask for **financial incentives** to reduce the purchase price difference between an EV bus and a diesel bus. They also point out the need of **subsidies for charging infrastructure**, overnight charging at the garages or fast charging at route ends. Lion Electric insists that a **Buy Canadian Act** should be impose for electric buses and trucks purchases in Canada. New Flyer raises the importance to train the workers on the new electric technologies as well as the operational differences to manage routes, range and charging times.

5.2.3. Feeedback from the public transport company EXO

EXO has 650 buses serving the public around Montréal. They do not have electric buses yet. The challenges they see to electrify their fleet are:

- The high purchase price of electric buses
- the garage adaptation with charging infrastructure for hundreds of buses,
- keeping up with battery technology evolving when the buses last 16 years

5.2.4. Feeedback from NGOs

Most challenging issues regarding EV adoption in Canada? **Plug'n Drive** and **Clean Energy Canada** (CEC) mentioned the lack of EV supply and the lack of knowledge/familiarity with respect to EVs. CEC added also the higher upfront cost and perceived range anxiety, while **AQLPA** (Association Québécoise pour la Lutte contre la Pollution Atmosphérique) pointed out the difficulty to adopt a ZEV standard.

How can Canada become a leader in EV industry? **AQLPA** answered that Canadian government should provide adequate support to Canadian equipment manufactures and Canadian manufacturers of electric buses and trucks. **Plug'n Drive** suggests to maximize capability in mining and manufacturing and at the same time encouraging adoption through usual incentives: EV rebates, infrastructure deployment, education and ZEV standard. **Clean Energy Canada** says that one should take the opportunity offered by the Joint Action Plan on Critical Materials between U.S. and Canada to add value beyond material extraction and work towards battery self-reliance by 2030. They also recommend to accelerate mineral production and processing with a focus on nickel and lithium, while establishing one or two national battery manufacturing champions to support a robust supply chain. CEC also suggest to better promote Canada's clean and responsible battery brand abroad to attract foreign investment and a large scale battery cell producer.

5.2.5. Feeedback from UNIFOR

How do you view the future of electric mobility as a union? **Unifor** points out that Canada needs an industrial strategy that develops new green manufacturing capacity that includes a "National Auto Strategy" that includes aggressive incentives to capture manufacturing investments for electric vehicles.

What are your concerns regarding Canadian jobs as we shift towards electric vehicles? **Unifor** stresses the importance of having true and well-planned labor market impact assessments developed well ahead of the changes as well as retraining & skills upgrading.

What do you think the governments can do to help in that transition? **Unifor** suggests to put in place a Just Transition Minister and bring together sector experts to advise on the development of a National Just Transition Action Plan. They continue by saying that we have a rich inventory of natural resources, a lot of emissions-free electricity together with well-trained labour, and that we should build on these assets to maximize Canadian employment. Instead of just mining and exporting our resources, we should make local transformations like making EV batteries in Canada. Unifor suggests the introduction of a national vehicle trade-in program with a one-time financial incentive to car owners who trade-in older, higher polluting vehicles and purchase newer, more efficient alternatives, thus boosting sales that have fallen to their lowest levels since 2009.

Do you have any data regarding potential future jobs for Canadian workers in electric mobility? **Unifor** reminds that auto bargaining commitments in 2020 and 2021 between the Detroit 3 will bring a total investment of nearly $6 billion in manufacturing to Canada.

5.2.6. **Feeedback from APMA**

To what extent are the auto parts manufactured in Canada for zero-emission vehicles produced either in Canada or abroad? APMA: "Some parts but nothing strategic like batteries, motors, BMS for now: aluminum, parts, etc"

What are you concerns regarding Canadian jobs as we shift towards electric vehicles (LDVs and HDVs)? How are your members preparing for this transition? APMA: "Concerns are that massive OEM investment is taking place with very small volumes on the horizon (by 2025 in North America estimates are 1.4 million EVs in production compared on average 16-18 million vehicles produced) – most suppliers have business models based on volume production vs value-add per vehicle produced which is fine even in low volume environments. We have to make sure that, has we pull people on board, the members are ready for the transition. Our members are worried that Canadian parts manufacturers will be worth less comparatively to the battery suppliers and other high tech companies. Tesla is a perfect example of that fact."

Do you have any data regarding potential future jobs for Canadian workers in the auto parts manufacturing as we transition towards electrification of transportation?

APMA: "What we do know is that any part of mobility will become more and more commoditized."

6. Electrical Infrastructures - A New Paradigm

Canada is expected to have around ≈ 35 million vehicles on the road by 2050[74], and the electrification of these vehicles will prove to be a major challenge for the provision of electricity in Canada and will induce strong growth in electricity generation and transmission infrastructure.

This increase must take into account 2 "layers" which superpose on each other:

- different "service topologies" from one province/territory to another
- the structure of the electricity market in each of the provinces or territories, the markets being regulated or deregulated according to the option chosen by the respective governments.

Service topology refers to the integration - or lack of integration - of generation/transmission/distribution units from generating stations up to the end users. For instance, in most of the provinces, the electrical system is fully "connected" together contrary to the territories where a lack of transmission system leads to an "uncoupled" service topology, e.g. where decentralized units act locally without being integrated in the whole system.

Finally, special attention should be paid to sparsely populated territories covening large areas ("Yukon, Northwest Territories and Nunavut") which present particular challenges in the electrification of vehicles.

Figure 6.1 : Electric vehicle charging in front of le Rocher Percé-Gaspésie. Source: Daniel Breton.

[74] For the purpose of analyzing the number of vehicles involved in the electrification of transport, only passenger vehicles and " light " trucks of less than 4.5 tons will be considered

Thus, a major increase in the electricity supply & distribution - induced by the electrification of transport - must take into account the fact that the energy sector is a sector of provincial or territorial jurisdiction. Therefore, the measures put forward by the federal government should not interfere in this area of jurisdiction but rather offer "incentives" to support the choices that will be implemented in each jurisdiction, while presenting "varied options" in order to take into account the particularities of each of the targeted territories.

6.1. Electrical service - Topologies of service

Canada is made up of 10 provinces and 3 territories, each with its own particularities. Thus, 5 provinces[75] present a population level such that the electrification of road transport will enjoy a "critical mass" which has allowed, to date, the development of a well integrated and diversified electricity generation/transmission network.

In addition, 5 other provinces[76] have less densification with population concentrated around main agglomerations and have therefore - in some cases - an extended territory to cover, a challenge for transport electrification across their territories. And, finally, the 3 territories located in the northern part of Canada present characteristics typical of remote regions, namely no integrated transmission networks are available throughout the territories to allow the exchange of energy between the different zones. Appendix 3 presents the different topologies found on Canadian territory based on information available on this site[77] and other sites.

6.1.1. Provinces/territories with integrated topologies

All provinces in Canada have "integrated" transmission networks to provide free flow of energy across their territories. These "integrated" transmission networks make it possible to pool the various electricity generation sites and route the energy to areas with a greater concentration of the population.

By way of illustration, the Prince Edward Island offers a fully integrated electricity transmission service across the province[78].

[75] New Brunswick, Ontario, Quebec, Alberta and British Columbia

[76] Newfoundland and Labrador, Prince Edward Island, Nova Scotia, Manitoba and Saskatchewan

[77] www.cer-rec.gc.ca/fr/donnees-analyse/marches-energetiques/profils-energetiques-provinces-territoires

[78] Maritime Electric Company Limited -2020 Integrated System Plan

Electric Mobility Canada /Mobilité électrique Canada – www.emc-mec.ca – info@emc-mec.ca
38 place du Commerce, 11-530 Ile des Sœurs, QC H3E 1T8

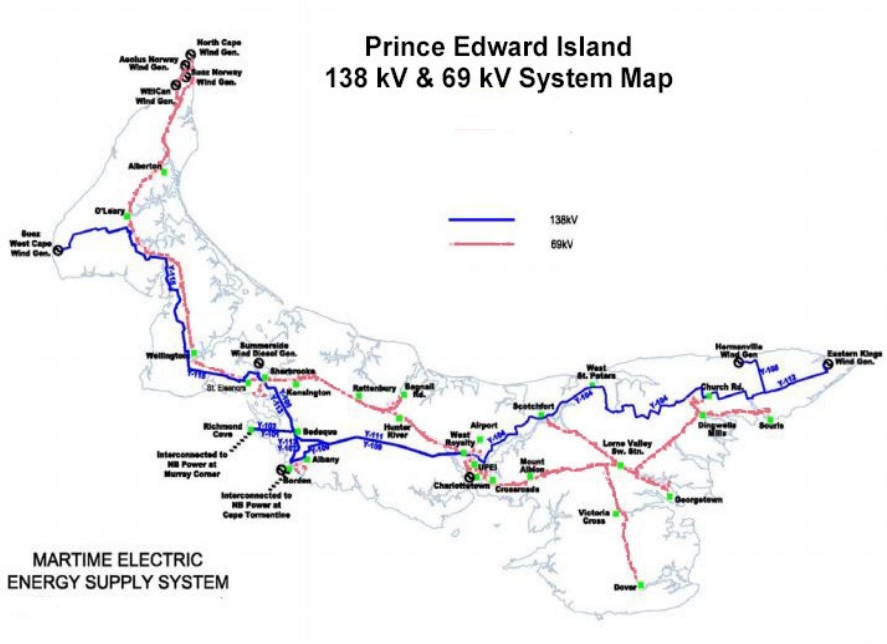


Figure 6.2 : Prince Edward Island System Map
Source: Maritime Electric Company 2020 Integrated System Plan - September 2020.

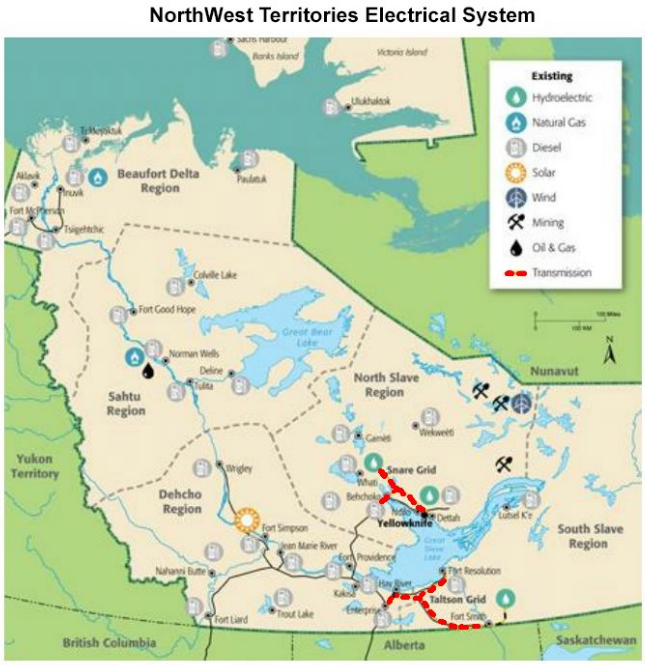
Provinces/territories with topologies partially or with no integration

In the northern zone, only the Yukon has a "partially integrated" network for the transmission of electricity allowing the transit of electricity across a limited area of the territory[79].

Figure 6.3 : Yukon Electrical System
Source: Report on the State of Alternative Energy in the Artic - Polar Knowledge Canada - September 2015.

[79] Report on the State of Alternative Energy in the Artic - Cherniak et Al - 2015-09-21

As for the Northwest Territories, two "regional" transmission networks are located near the Great Slave Lake ("Snare Grid & Taltson Grid") and are used to route energy from the Taltson hydroelectric station and those along the Snare River to cover limited areas around these networks.



Source: (NT Energy, 2013)

Figure 6.4 : NorthWest Territories Electrical System Source: Electrical Generation in the NWT - Government of Northwest Territories

As far as Nunavut is concerned, this territory has a unique topology since no transmission network to transit electricity across the territory is available, each municipality is equipped with a local generating station that feeds power within the limits of each municipality.

6.2. Serving electricity - Market regulation

In terms of market structures operating in each of the provinces and territories, again each province and territory is distinguished by an electricity market where generation and supply are regulated by "central entities" or where generation and distribution are left to the free competition of private providers, with government only intervening to regulate the prices charged to customers.

Thus there is no doubt that the type of market structure set up in each of the jurisdictions will be important on the options governments will have in hand to implement a challenging electrifying transport program in their respective territories.

6.2.1. **Provinces/territories with market regulation ("vertical integration")**

As far as the existence of a "wholesaler" integrating electricity generation from different suppliers with distributors which supply end clients through distribution agreements ("resale to local or regional clients") is concerned, 9 jurisdictions provide “vertical integration” for the supply of electricity in their respective territories:

- Nova Scotia
- New Brunswick
- Quebec
- Ontario
- Manitoba
- Saskatchewan
- British Columbia
- Yukon
- Nunavut

And, beyond this “vertical integration” in the supply of electricity, governments ensure a “fair price” for customers through regulatory bodies responsible for setting the prices granted by distributors to their customers.

6.2.2. **Provinces/territories with market deregulation**

Some provinces and territories have implemented an electricity market structure where no wholesaler ensures integration of electricity generation and where distribution agreements - in each of the territories concerned - are negotiated by mutual agreement. Between the producers and the distributors, prices granted to distributors being nevertheless framed by control agencies. These jurisdictions are :

- Newfoundland & Labrador
- Prince Edward Island
- Alberta
- Northwest Territories

6.3. Future development of the vehicle fleet

Estimating the future demand for energy and power required for the generation, transmission and distribution of electricity, resulting from the electrification of road transport, requires an assessment on the growth of the vehicle fleet in the years to come.

Henceforth, it is "reasonable" to estimate that the entire fleet of vehicles in Canada will have been converted to the use of electricity by 2050, which allows the proper planning and implementation of new means of electricity generation over the next 30 years.

In addition, based on the average annual growth of the automobile fleet during the period 2009-2019, this average growth was used to estimate the size of the vehicle fleet for each of the provinces and territories by 2050. This synthesis is presented in appendix 4 and it is estimated, at the Canadian level, a fleet of vehicles $\approx$ 35 million vehicles by 2050.

6.4. Daily and annual variation in electricity demand

In estimating the future demand for energy and power required for the generation, transmission and distribution of electricity for recharging the electric vehicle fleet, it is important to make a distinction between generating stations which provide "power & energy" from those guaranteeing mostly the availability of "energy" and no guarantee of “power” when demand requires the delivery of “power” during peak conditions.

Thus, the electrification of transport will have a significant impact on the needs to fill energy demand, but also at the power level needed in order to avoid power outages or avoid load shedding. And the daily and annual variations in demand will require strategies that take into account the profiles in the demand and in the supply of electricity, for each of the provinces and territories, according to their specific characteristics.

6.4.1. Daily variations in electricity demand

The following graphs show the variation in electricity demand in various locations.

Electric Mobility Canada /Mobilité électrique Canada – www.emc-mec.ca – info@emc-mec.ca
38 place du Commerce, 11-530 Ile des Sœurs, QC H3E 1T8

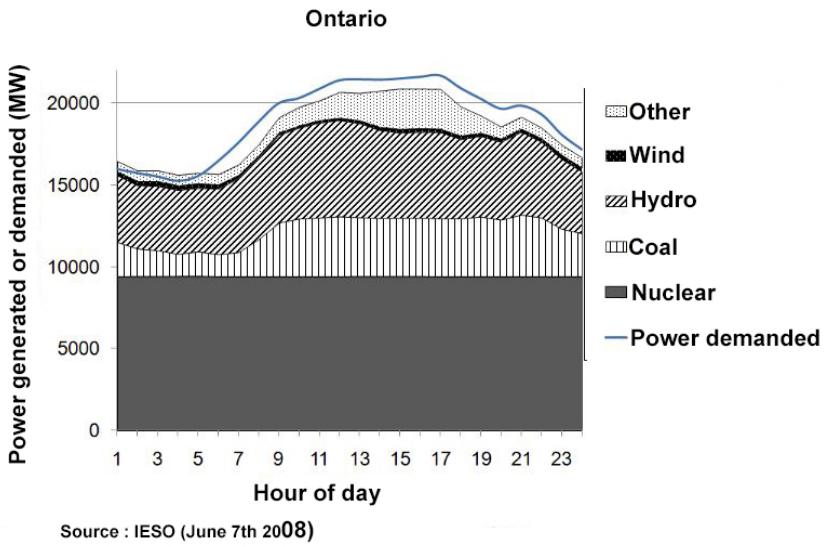


Figure 6.5 : Ontario Daily Load Pattern & Sources of generation
Source: Towads the assessment of a residential electric storage system - Saldanha & Al – 2010

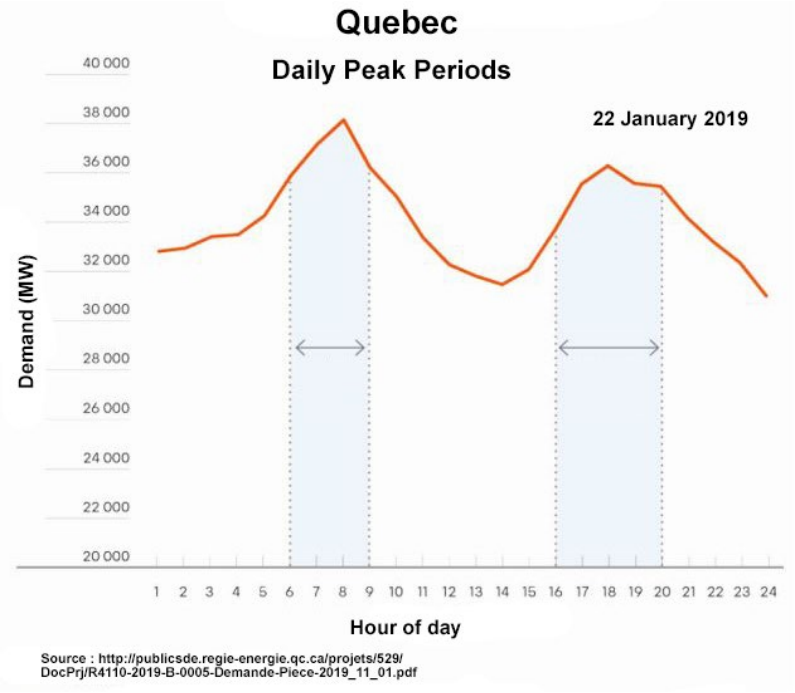


Figure 6.6 : Quebec daily peak periods
Source: Électrification efficace, pointes électriques et flexibilité de nos clients - Séminaire Chaire de recherche en géothermie, septembre 2020

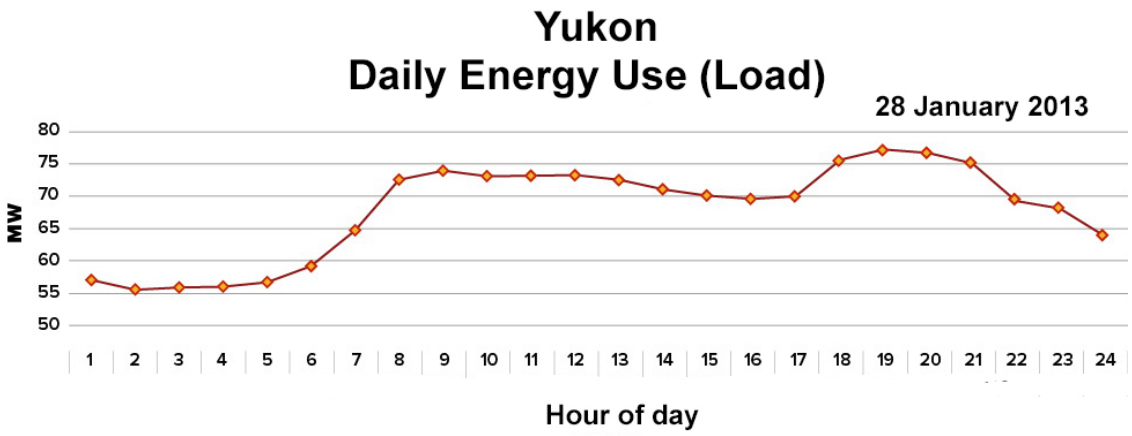


Figure 6.7 : Yukon Daily Energy Use
Source: Load - How we Use Energy, Next Generation Hydro

Thus, notwithstanding specificity for the case of Quebec, insofar as heating in all provinces and territories is not provided by electricity but by fossil energy sources, the profiles in electricity demand are relatively "flat" and recharging of electric vehicles, if it is carried out in the period following return from work, should not induce a "demand peak" out of proportion to the power level provided during daily conditions.

6.4.2. **Annual variations in electricity demand**

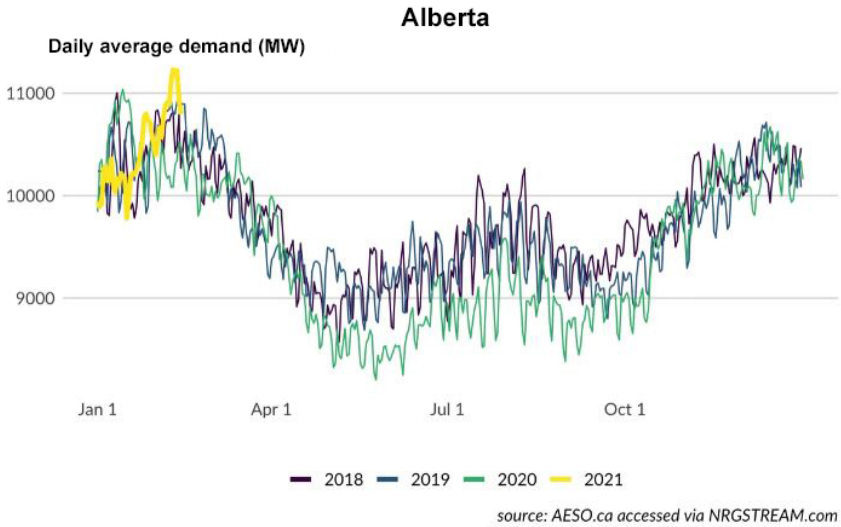


Figure 6.8 : Alberta Daily average demand
Source: Electricity in Alberta - Alberta Electric System Operator

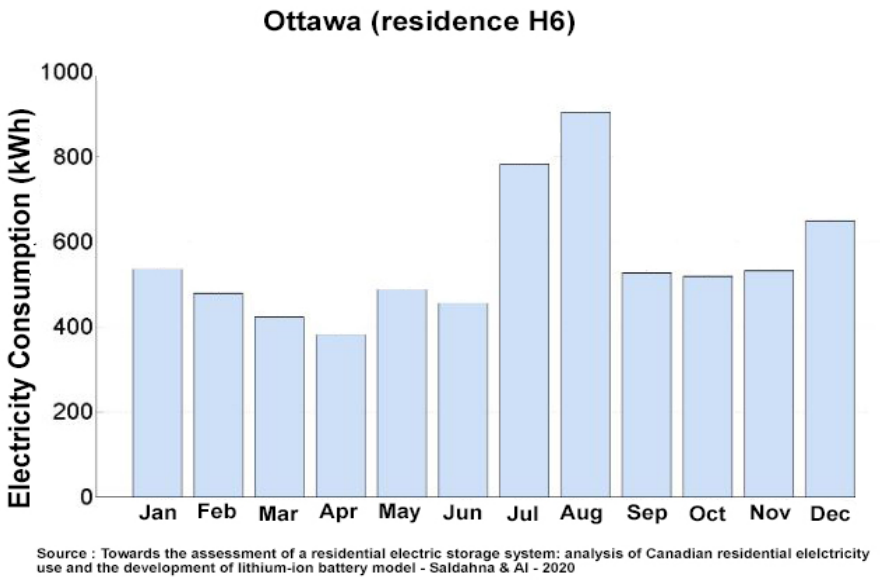


Figure 6.9 : Ottawa Residence H6 Monthly Energy Usage
Source: Towads the assessment of a residential electric storage system - Saldanha & Al – 2010

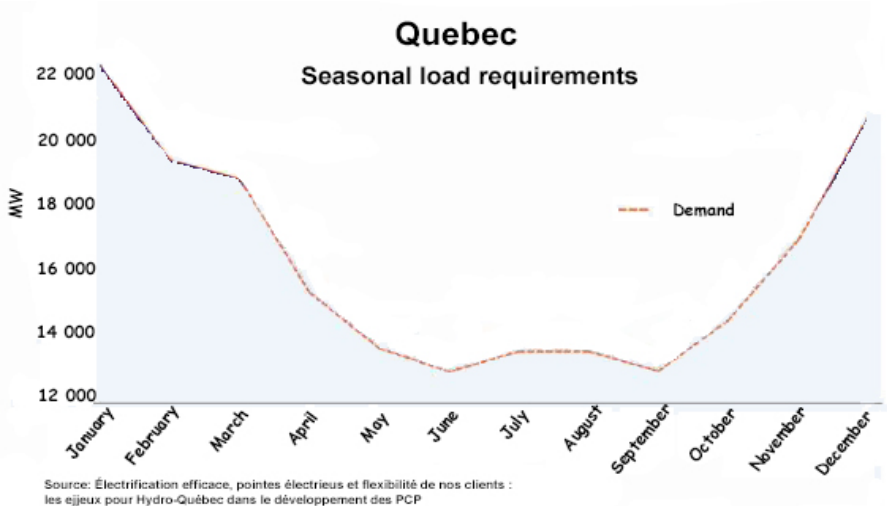


Figure 6.10 : Quebec Seasonal Load Requirements
Source: Électrification efficace, pointes électriques et flexibilité de nos clients - Séminaire Chaire de recherche en géothermie, septembre 2020

Thus, again notwithstanding a specific situation for Quebec, insofar as heating is provided by fossil energy sources in all the provinces and territories, the profiles in electricity demand are relatively "constant" on a yearly basis and the recharging of electric vehicles should not induce a “demand peak” out of proportion to the average power produced during any given year.

6.5. Wind energy and photovoltaic panels - Sources of energy ... but not delivering power when conditions require the delivery of electricity during peak periods

Unlike popular belief, electricity generated via wind or via solar panels happens to be a source of energy useful to meet energy needs every day - such as heating hot water or power electric stoves - but not a source of power to be relied on at times when demand for electricity peaks during the day or year.

Thus, relying on these energy sources to meet a specific "demand" requirement may turn out to be a decision with unintended consequences. This was the case in February 2021 when Germany, subjected to a major cold spell spanning several days, was forced to restart its coal-fired power stations in order to avoid shortages or to carry out load shedding for customers and in order to meet the strong demand for electricity during this period[80].

So to invest in "energy sources" - wind and solar - to replace the "base units" providing "energy & power" - nuclear power stations and coal power plants - lead Germany in a situation of "energy precariousness" which raises the comments of many specialists anxious to ensure a stable and predictable power supply for the years to come.

Thus, this comment from Professor Schwarz concerning the recent "critical situation" experienced by Germany during the period of extreme cold:

Physical reality "totally neglected" by policymakers

According to Prof. Schwarz:

> ***"With this supply of wind and photovoltaic energy, it's between 0 and 2 or 3 percent - that is de facto zero. You can see it in many diagrams that we have days, weeks, in the year where we have neither wind or PV. Especially this time for example - there is no wind and PV, and there are often times when the wind is very miniscule. These are things, I must say, that have been physically established and know for centuries, and we've simply totally neglected this during the green energies discussion."***

Will have to rely on foreign energy in the future

[80] https://21stcenturywire.com/2021/02/09/achtung-baby-its-cold-outside-germanys-green-energy-fail-rescued-by-coal-and-gas/

Electric Mobility Canada /Mobilité électrique Canada – www.emc-mec.ca – info@emc-mec.ca
38 place du Commerce, 11-530 Ile des Sœurs, QC H3E 1T8

6.5.1. Future requirements of electricity from an "energy" point of view

Thus, taking into account the growth of the Canadian automobile fleet and the energy needs required to ensure the recharging of electric vehicles, a simulation of the future energy demand, by 2050, was carried out for the purposes of estimating the additional needs that electricity suppliers and distributors will have to meet over the next 30 years.

This simulation was based on the following assumptions:

- annual increase in the vehicle fleet, during the period 2020 @ 2050, based on the average growth in the vehicle fleet during the years 2009 @ 2019
- an annual vehicle usage estimated at 16,000 km per year
- an electrical recharge level set at 20 kWh for each 100 km traveled

All analyses are available in appendix 4 and the following table presents the summary of this compilation.

Electric energy demand recharging Cars + Trucks < 4500 kg			
	2018	2050	
	Annual GWh @ 100 % home recharging	Annual GWh @ 100 % home recharging	%
Newfounland & Labrador	7 800	9 453	3,9%
Prince Edward Island	562	1 084	93,0%
Nova Scotia	9 600	12 108	26,1%
New Brunswick	12 200	14 603	19,7%
Quebec	248 700	273 771	11,7%
Ontario	151 100	190 957	26,4%
Manitoba	36 900	40 862	10,7%
Saskatchewan	24 300	27 836	14,6%
Alberta	81 000	96 510	19,1%
British Columbia	74 200	89 636	20,8%
Yukon	500	697	39,5%
NorthWest Territories	400	491	22,8%
Nunavut	200	227	13,7%
Canada	647 462	758 236	17,1%

Note

Churchill Falls : included in the 2018 Quebec's energy balance sheet (35000 MWh) and reported in the 2050 Newfouldland's energy balance sheet

Prince Edward Island : Based solely on energy contribution from the island's wind farms & excluding all energy input derived from New Brunswick undersea links

Thus, notwithstanding Prince Edward Island, government authorities and energy regulators will have to increase the required energy generation, by 2050, within a range of between 10% and 30% of the annual volume of energy produced in 2018.

6.5.2. **Future requirements of electricity from a "power" point of view**

As for the future demand in electricity, by 2050, a simulation was carried out in order to estimate the additional needs that electricity suppliers and distributors will have to implement during the next 30 years.

This simulation was carried out according to the following assumptions :

annual increase in the vehicle fleet, during the period 2020 @ 2050, based on the average growth in the vehicle fleet during the years 2009 @ 2019

power of electric charging stations at 7.5 kilowatts provided by Level II charging stations installed in residences

recharging scenarios where the simultaneous number of vehicles being charged is set at 20%, 33% or 50% of the vehicle fleet, each of these levels commanding very different power requirements.

All analyses are also available in appendix 4 and the following table presents the summary of this compilation.

Electric power demand for Automobiles + Trucks < 4500 kg recharging*							
	2018	2050					
		Low charging scenario (%)		Medium charging scenario (%)		High charging scenario (%)	
		20%		33%		50%	
	MW	MW	%	MW	%	MW	%
Newfounland & Labrador	2 394	3 169	9,9%	3 673	16,3%	4 331	24,8%
Prince Edward Island	100	345	244,9%	504	404,1%	712	612,3%
Nova Scotia	3 061	4 237	38,4%	5 001	63,4%	6 000	96,0%
New Brunswick	4 521	5 647	24,9%	6 379	41,1%	7 337	62,3%
Quebec	46 176	57 928	28,8%	65 567	47,6%	75 557	72,1%
Ontario	40 671	59 354	45,9%	71 498	75,8%	87 378	114,8%
Manitoba	5 690	7 547	32,6%	8 754	53,8%	10 332	81,6%
Saskatchewan	4 533	6 191	36,6%	7 268	60,3%	8 677	91,4%
Alberta	16 332	23 602	44,5%	28 328	73,5%	34 508	111,3%
British Columbia	14 210	21 446	50,9%	26 149	84,0%	32 299	127,3%
Yukon	124	217	74,7%	277	123,2%	355	186,6%
NorthWest Territories	208	251	20,6%	279	33,9%	315	51,4%
Nunavut	78	91	16,5%	99	27,2%	110	41,2%
Canada	138 098	190 024	37,6%	223 775	62,0%	267 912	94,0%

Note

Churchill Falls : included in the 2018 power input to Quebec (5 428 MW) and included in the 2050 power input to Newfoundland

Prince Edward Island : Based solely on power input from New Brunswick's undersea links and excluding power input contribution from the island's wind farms

Electric Mobility Canada /Mobilité électrique Canada – www.emc-mec.ca – info@emc-mec.ca
38 place du Commerce, 11-530 Ile des Sœurs, QC H3E 1T8

Thus, notwithstanding Prince Edward Island, government authorities and managers of generating stations will have to increase the power generating capacity, at the 2050 horizon, in a range of between 10% and 75% of the current power levels of 2018, on the condition that the simultaneous charging of electric vehicles is limited to 20% of the vehicle fleet.

On the basis of the estimated growth of the Canadian vehicle fleet by 2050, given the objective of electrifying the entire vehicle fleet within this horizon, it can be deduced that significant investments will have to be made in order to meet the "energy & power requirements" in the generation and distribution of electricity for recharging vehicle purposes.

In this regard, it will be up to the respective governments, taking into account the market structure in force in each of the provinces and territories, to establish a plan which takes into account this orientation aimed at converting the entire fleet of vehicles that will be electrified by 2050.

And it will be up to the Canadian government to put in place “facilitating” conditions in order to support the provincial and territorial governments in the implementation of this important energy transition while ensuring a certain “fairness” so as not to unduly favor some regions to the detriment in particular of northern regions where a transport electrification strategy must be developed which will have to take into account the constraints specific to these regions.

Figure 6.11 : Electric vehicle at a Petro-Canada charging station. Source: Daniel Breton.

Electric Mobility Canada /Mobilité électrique Canada – www.emc-mec.ca – info@emc-mec.ca
38 place du Commerce, 11-530 Ile des Sœurs, QC H3E 1T8

7. Role of Governments, Utilities and Private Companies in the Transition to Electric Vehicles

The transition of land transport to electric vehicles will require close coordination between users of electric vehicles, on the one hand, and governments who will have to promote this transition through an appropriate legislative framework, while ensuring that the electric service in each of these territories is able to meet future demand for energy and power.

Thus, without a "strong demand" created by consumers to encourage manufacturers to develop vehicles well suited to their needs and without the availability of "abundant and inexpensive" electricity to ensure vehicle recharging, the transition to an electrified vehicle fleet, across Canada, could result in a failure of this program or become a " difficult " transition for provincial and territorial authorities to manage.

7.1. The citizen - The "Prime Mover" in the transition to electric vehicles

So regardless of the will of governments to transition to electric vehicles, if the citizen at first did not participate "with enthusiasm" to the transition, it will prove a failure and will only bring mixed results.

In this regard, notwithstanding the environmental dimension to value - reducing greenhouse gas emissions -, a constant financial incentive should be offered to not only lower the cost of purchasing an electric vehicle but also make it more advantageous compared to a conventional vehicle.

Furthermore, maintaining a subsidy for the purchase and installation of home charging stations will also prove to be a powerful incentive to purchase such vehicles. And, for individuals residing in urban environments that do not allow the installation of individual charging stations, an abundance of charging stations installed along streets will complete the "incentive" offer intended for individuals.

7.2. Businesses and municipal governments - Secondary actors for the transition to electric vehicles

Whether private or state-owned enterprises, companies also have an important role to partner, too, as actors in the transition to electric transportation.

Thus, notwithstanding SMEs which have a reduced fleet of vehicles and limited financial means, large and medium-sized companies could be encouraged to become active in this transition by establishing a "merit recognition" awarded to the most dynamic companies in this sector, as tax options are already available to accelerate their transition.

Although such a program would provide a rather small incentive for large and medium-sized companies to move forward on electrification, it would nonetheless signal the commitment of the federal government in achieving this goal although these initiatives fall under the jurisdictions of governments of provinces and territories.

Thus, to the extent that medium and large companies have sufficient financial means to ensure this transition, the organization of merit galas and distinctive recognitions to the best performers could prove to be powerful incentives to bring about the mobilization of companies to this orientation.

7.3. Municipal Governments

Since municipalities report directly to provincial and territorial governments, these governments should direct municipalities to electrify their fleets as a signal that they are supportive of these initiatives and promote the electrification of vehicles to their

Moreover, insofar as such a transition does not involve substantial outlays and insofar as they have direct taxation power over residents, the simple adoption of a decree should prompt municipalities to convert gradually all of their vehicle fleet to electric vehicles.

7.4. The companies offering car-sharing vehicles and are companies holding rental fleets

Buying or leasing a car only to use it occasionally is not very profitable. In these cases, there is a wonderful solution: car-sharing. Car-sharing allows one to borrow a car on an ad hoc basis for a short period of time. For example, a person could borrow a car for an hour while he/she does their grocery shopping.

Moreover, it is important to emphasize the fact that car sharing is a concept that has been very successful among the younger and more urban population. The current trend is to move away from traditional models - car(s) owned by family and by residence - and to move towards ways of doing things that provide greater freedom and flexibility for this segment of the population.

"As of January, 2018, Canada had 20 car sharing services in operation with more than 336,000 members and 5,200 vehicles. In 2017, there were 3,300 car-sharing vehicles operating in the city of Vancouver alone, dubbed the 'car-sharing capital of North America.' A recent Vancity survey has revealed that 95% of 'Vancouverites' choose car-sharing services for the convenience, 62% to save money and 58% due to the concern for the environment.[81]"

In terms of car-sharing companies well established in Canada, we should point out the presence of the companies Communauto , Turo , Carshare , Zipcar , Modo and Evo, among others.

[81] https://movmi.net/shared-mobility-canada/

Thus, these car-sharing companies should benefit from incentive programs for the purchase (in volume) of a large number of electric vehicles but also benefit from "discount" pricing for the use of public charging stations. Just like for car-sharing companies, car rental companies should benefit from incentive programs for the purchase (in volume) of a large number of electric vehicles and should benefit from subsidies for installation of charging stations in rental depots.

Car rental companies in Canada include Thrifty, Enterprise, Avis, Hertz, National, Budget, Sunnycars and Discount among others.

7.5. The role of utilities

Electricity companies will play a key role in the transition to the massive use of electric vehicles. This challenge will be mainly at the level of electricity generation but also will involve reinforcing electricity grids as well as an upgrade of the low voltage distribution networks in order to feed electricity to residences and public charging stations.

Thus, it will be essential to put into operation power plants / production units in order to provide the energy necessary for recharging vehicles. And, as to the supply of "power" to meet daily or annual "demand peaks", appropriate equipment to meet this constraint must be implemented, in particular with the deployment of recharging units that can be remotely controlled so as to postpone vehicle recharging outside peak periods.

Furthermore, to limit the "peak demand" on power systems and notwithstanding the installation of remote modules in charging units, particular emphasis should be carried on the technology "V2G" ("Vehicle to G rid") adapted / installed in level III charging stations so as to use the energy stored in the batteries to "reinject power" it into the network at times of high demand[82].

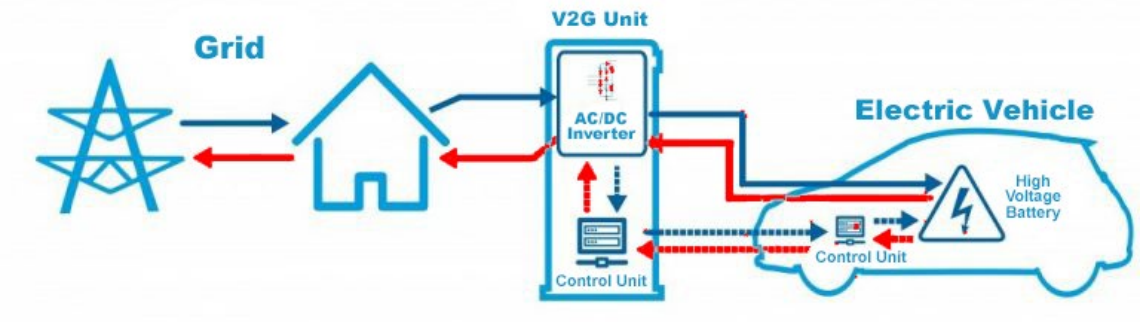


Figure 7.1 : V2G systems to level off peak demand
Source : www.cleantech.com/ev-charging-software-and-grid-services.

[82] https://www.cleantech.com/ev-charging-software-and-grid-services/

This being so, and especially for the northern territories where the electricity supply is carried out by diesel units supplying isolated municipalities, insofar as we choose to develop the electrification of vehicles in such communities, such a technology would avoid the replacement of the existing units by oversized units and increase the effectiveness of units already installed and in operation[83].

7.6. Role of provincial and territorial governments

To the extent that the supply of electricity in each of the provinces and territories falls under the jurisdiction of the governments concerned, they will have a decisive role to play in the transition from the gasoline vehicle fleet to an electrified vehicle fleet. In this sense, these governments will assume the role of "orchestra conductors" in order to ensure a gradual and smooth transition of user needs with the constraints that will be imposed on electricity producers.

In addition, these governments will have to support the transition through financial incentives for the purchase of electric vehicles and for the setting up of charging stations. And, with regard to electricity generation and managers of electricity transmission and distribution networks, to adopt appropriate fiscal measures to support the investments that have to be made since such large investments might be out of reach for utilities operating in the territories.

Thus, the provincial and territorial governments, notwithstanding the structure of the electricity market specific to each territory, will have to :

a) establish an overall plan for the transition to the electrification of transport and :

- agree on a "deadline" when the entire fleet will have been converted to electricity
- set the annual and multi-annual horizon for the growth of the electric vehicle fleet
- configure the evolution of the means of generation and transmission of electricity so that it accompanies the pace chosen in the transition towards the electrification of the vehicle fleet within the determined horizon
- set up financial incentives for individuals, car-sharing fleet managers and rental vehicle managers
- set up tax measures for private companies operating electricity generation units / plants or operating electricity transmission and distribution networks

b) adopt legislation to support the deployment plan that will have been agreed by the parties

c) set up a mechanism for monitoring the intervention plan and, if necessary, modify its parameters and financial and fiscal incentives to ensure harmonious convergence of the whole.

[83] Fuel Saving on Diesel Genset using PV / Battery Spike - Dwi Atmaja & Al - 2018

7.7. Role of the federal government

The federal government, without interfering in a field of provincial or territorial jurisdictions, can nevertheless support these governments by proposing orientations and proposing financial incentives which would make it possible to "level" the conditions of access to the electrification of transport road, regardless of the type of territory to be served and the specific conditions in each of them.

As a result, a harmonious integration of provincial and territorial initiatives would allow the Government of Canada to:

- claim the achievement of the objectives and commitments made within the framework of the Paris agreements
- and, alternatively, contribute to the improvement of the commercial balance of Canada by reducing imports of fossil energy sources

Thus, the federal government could set up and propose:

- financial incentives for the purchase of electric vehicles for individuals as well as for car-sharing companies and car rental fleet managers
- financial incentives for the purchase and installation of remote-controlled charging stations and V2G- type charging stations
- the installation of charging stations - with level III charging units - along the TransCanada Highway, every 100 km from one charging station to another

a set of measures that would confirm the federal government's unconditional support for ensuring the transition to electric road vehicles by 2040.

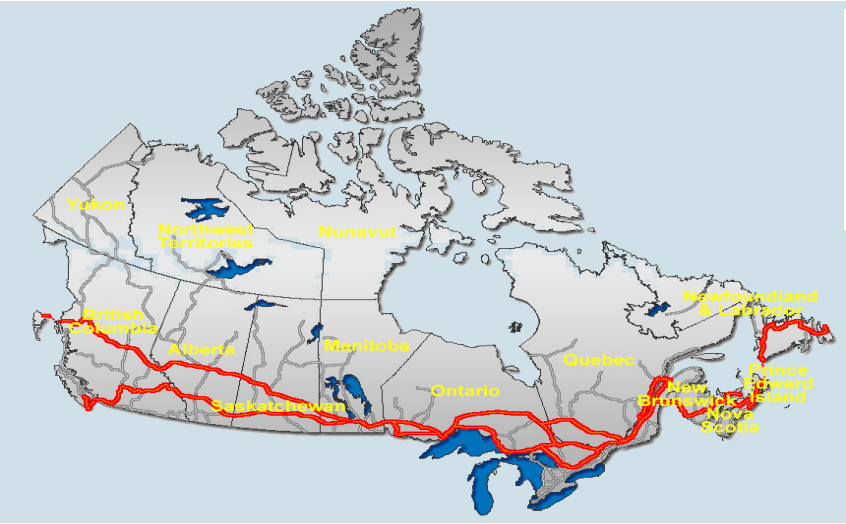


Figure 7.2 : Trans-Canada Highway
Source: https://en.wikipedia.org/wiki/Trans-Canada_Highway

The transition from land transport using fossil fuels to electric vehicles will require close coordination of all the actors involved in this "profound change" in our land transport needs.

Such a transition will involve consultation and close collaboration of all the actors targeted by this transition, whether they are individuals who will migrate to the use of electric vehicles, whether they are companies that offer car-sharing services, whether municipal governments who will have to adapt - if necessary - their urbanization standards and finally both the federal and provincial and territorial governments to be active promoters in the electrification of transport.

And, to the extent that the desired electrification would be achieved by 2050, by acting in concert and with the firm intention of making this transition a success, there is no doubt that Canada will be able to position itself as a leader in the electrification of transport in its territory.

Figure 7.3 : Lion 8 electric truck. Source : Lion Electric .

Electric Mobility Canada /Mobilité électrique Canada – www.emc-mec.ca – info@emc-mec.ca
38 place du Commerce, 11-530 Ile des Sœurs, QC H3E 1T8

8. Public Procurement of EVs, Charging Infrastructures and Related Products/Services in Canada: An Analysis Under the Rules of International Trade

In this chapter, we look at the impact of international free trade agreements on EV related companies that build vehicles, infrastructure and other products and the positive effect that "greener procurements" could have on Canadian jobs in this sector. It is a trend that has been seen elsewhere in the world and that could inspire Canadian governments.

Document prepared for EMC by:

Geneviève Dufour, Ph. D., a lawyer called to the Quebec Bar in 2002 and professor for the Faculty of Law at the University of Sherbrooke. She heads the Master of International Law and Applied International Policy degree and chairs the BAJI, the Office of International Legal Assistance, where she acts as advisor to various international organizations and intervenes before international tribunals. She is the President of the Société québécoise de droit international and a member of the Board of Directors of the Canadian Council on International Law. Her research focuses on public international law and international economic law. In 2018, she was awarded the Tremplin prize for her exceptional contribution to research. She frequently appears as an expert in local and international media. In addition, she is a consultant for several organizations and companies in international trade matters and has participated in WTO ministerial conferences as an expert for the government of Benin.

David Pavot, Ph, D., is the Assistant Professor of International Law at the School of Management of the University of Sherbrooke and the Research Chair for Anti-Doping in sports. He holds a Doctorate in International Law (2016), a Master and a DESS from the University of Nice Sophia Antipolis. His work focuses on international sports law and international economic law. He is regularly invited to instruct at universities and speak at conferences, here in Canada, and also abroad. In addition, he is a consultant in international law.

8.1. Introduction

In the majority of European countries and in several other countries of the world, public procurement has undergone an ecological transformation. Public buyers are called upon to demand more environmentally friendly products and services from suppliers. These buyers not only care about the final products and services, but increasingly pay attention to the processes and methods of production.

In other words, the supply chain and the lifecycle of products and services are increasingly considered in tenders.

In Canada, public buyers can demand products and services that are environmentally friendly. The legislative framework does not prohibit this. From this perspective then, greater consideration of the environment in public procurement could benefit the transportation electrification industry.

Free Trade Agreements are often seen as hindering the ability to restrict trade for environmental reasons. The revised World Trade Organization Agreement on Government Procurement, to which Canada is a party, expressly allows states to include environmental requirements in tenders. No free trade agreement to which Canada is a party prohibits this.

In this context, public buyers should be encouraged to include environmental requirements. This would certainly favor the electric vehicle and charging station industry and any other business related to transportation electrification.

These environmental requirements must, however, respond to a need to achieve environmental protection objectives. In other words, they should not be pretexts to favor a domestic industry. The use of concrete national, provincial or municipal greenhouse gas reduction targets can certainly justify the use of environmental requirements in calls for tenders, since there is no doubt that the electrification of transport contributes to a reduction in greenhouse gases. The use of international standards or certification standards also provides a scientific and consensual basis for greener calls for tenders.

Public buyers benefit from a wide range of tools to help them achieve a more environmentally friendly public procurement. In terms of transport electrification, it seems that 1) the insertion of technical specifications, 2) the use of contractual performance clauses, and 3) the evaluation of quality according to certain attributing criteria, are the most important tools. A call for tenders can select the tool best suited to the target market, or combine two or three such tools. In all cases, public buyers should be bound by the principle of non-regression.

If public buyers were required to take into account the environmental impact of their purchases, or, if at the very least, governments strongly encouraged their entities to do so, it would certainly have the effect of benefiting the electrification of transport industry.

8.2. The Context for 'Greening' Public Procurement in Canada

Traditionally, government procurement has been governed by the rule of the lowest bidder. If buyers were allowed to impose certain technical requirements, these had to adhere to the strict specifications of the product. However, since the end of the 2000s, certain considerations not necessarily linked to the intrinsic characteristics of products are becoming commonplace. This is the case for the criteria and requirements related to environmental protection which contribute to the phenomenon of 'greenifying' public procurement.

In concrete terms, when drafting calls for tenders, public buyers include environmental requirements. These can of course relate to the product or service to be purchased (therefore, its specific characteristics), but can also relate to the production chain, or even the entire life cycle of the product or service.

The legislative framework is the responsibility of each level of the federal, provincial and municipal governments. Regardless of individual differences, it is important to mention that none of them prevent procuring entities from including environmental criteria in tenders in Canada. Of course, it would be appropriate for these different legislative frameworks to be revised in order to explicitly authorize environmental criteria, but even more so and as is already done elsewhere[84], public buyers must be obliged to impose environmental criteria.

The Canadian industry on the electrification of transportation could certainly benefit from this 'greening' of public markets. In order for States, such as the State of California[85], to meet their target for reducing greenhouse gas emissions, governments could be tempted to speed up electrification of transportation, which would lead to an increase in purchases made in this sector. On the other hand, Canadian production in the field may offer comparative advantages that could allow the industry to position itself advantageously in the context of calls for tenders and to become even more competitive in international markets[86], which could lead to an increase in Canadian purchases.

[84] For example, California is forcing its public buyers to prioritize goods with less health and environmental impacts over competing products (Executive Order, B-18-12, April 25, 2012). The city of Berlin requires its public buyers to include environmental criteria, as well as an analysis of the cost of living (Decree on the Application of Regulation for Environmentally-Friendly Purchases and other Placements for Deliveries, Construction Work and Services, 2013). Spain has set time targets to force buyers to enforce the greening of public markets. For example, 50% of the paper purchased was to be recycled in 2010, while 90% of the paper was to be recycled in 2015. In Massachusetts, public buyers must consider the environmental impact of a purchase (Executive Order 515 Establishing an Environmental Purchasing Policy, Mass register n1143).

[85] Since 2012, the state of California ordered its agencies to provide electric vehicle charging stations in employee parking lots of existing and new buildings (Executive Order, B-18-12, April 25, 2012).

[86] The draft European regulation on batteries aims among other things to encourage local producers to become more competitive. Kate Abnett, « With green battery standards, EU seeks a competitive edge », The Telegram, December 10th 2020, online: https://www.thetelegram.com/business/reuters/with-green-battery-standards-eu-seeks-a- competitive-edge-529553/?mc_cid=32955fdac4&mc_eid=d90b0e714f.

Electric Mobility Canada /Mobilité électrique Canada – www.emc-mec.ca – info@emc-mec.ca
38 place du Commerce, 11-530 Ile des Sœurs, QC H3E 1T8

8.3. The Inclusion of Environmental Considerations: A Practice Already Well Established Abroad

For many years, several countries around the world have explicitly allowed or required their public buyers to consider impacts on the environmental. Some even go so far as to support their public buyers by providing them with software detailing the type of environmental criteria that can be easily added to a call for tenders, depending on the targeted sector, product or service to be acquired. This is the case for European countries and several American states. Their calls for tenders must increasingly focus on considerations of sustainable development.

The following is a non-exhaustive summary of the principles being applied abroad:
• At the national level, some governments allow or explicitly impose to take into account the life cycle of products[87]; others impose environmental technical specifications[88]; some recognize the possibility of including environmental criteria[89]

At the provincial level, some governments adopt public procurement policies aimed at protecting the environment, taking into account life-cycle[90]; encouraging the use of preferential margins in order to favor green purchases[91]; imposing the use of specifications on environmental techniques[92];

---

[87] In Chile, Article 6 of the Public Procurement Act, number 19886, stipulated that the award criteria must make it possible to establish the most advantageous combination between the goods or services purchased and their costs, past, present or future. In Japan, the texts specify that the goods and services selected in a call for tenders must be done so by considering their ability to respect the environment throughout their life cycle (Basic Policy for the Promotion of an Ecologically Responsible Public Purchase ", p. 4).

[88] In Tunisia, Law 2003-72 of August 2, 2004 indicated that new public buildings are subject to "technical specifications aimed at saving energy consumption" (Art. 10).

[89] Japan, *Basic Policy for Promoting Environmentally Responsible Public Purchasing*, p. 2.

[90] Massachusetts, *Section 2, Executive order 414.*

[91] Several neighboring American states have already adopted this practice for many years. For example, we can mention that the Massachusetts Public Purchasing Guide (2014) allows preferential margins of between 5 and 10% to be allocated for green products and services. Connecticut also explicitly allows the public purchaser to allocate up to 10% preferential margin (Chap. 58: *Procedures Promoting the Procurement and Use of Recycled Products and Environmentally Preferable Products and Services by State Agencies*, para. 4a-67h, 2014). Vermont does the same (*Vermont Statutes, Title 29, para. 93*).

[92] Connecticut, *Chap. 58: Procedures Promoting the Procurement and Use of Recycled Products and Environmentally Preferable Products and Services by State Agencies*, para. 4a-67h, 2014: with respect to cleaning products. For its part, the Basque government has operated in stages. In 2016, it suggested the inclusion of technical specifications to its buyers. 50% of all calls for tenders in 10 categories of contracts had to include technical specifications in 2018, and in 2020, 20 categories of contracts had to include such specifications, *Green Public Procurement Program of the Basque Country 2020*, online: http://www.oneplanetnetwork.org /sites/default/files/gpp-programme-basque-country-2020_eng.pdf .

At the municipal level, some municipalities require that the environment be taken into account by their public buyers[93] through environmental criteria[94] and a life-cycle analysis[95].

A recent initiative of the European Commission proposes to modernize the European legislative framework on batteries in order to impose sustainable production taking into account the whole life cycle[96]. The new regulation, applicable to all types of batteries marketed in Europe, would require the "use of responsibly sourced materials with restricted use of hazardous substances, minimum content of recycled materials, carbon footprint, performance and durability and labelling"[97].

8.4. International Legal Framework Governing the Action of Public Buyers

The international legal framework relating to public procurement is fragmented. Indeed, many treaties are likely to apply to a call for tenders. Among the most important is *The Revised Agreement on Government Procurement* of the World Trade Organization, but also all other free trade agreements that the government of Canada or the provinces enter into.

In order to determine whether an agreement is applicable, it is first and foremost necessary to verify whether the procuring entity is covered by the agreement and whether the amount of the invitation to tender meets the thresholds established by the agreement.

---

[93] In 2013, the city of Berlin, adopted the *Beschaffung und Umwelt* (the Public Procurement and the Environment) Program, online: : <www.umweltbundesamt.de/en/topics/economics-consumption/green-procurement/incorporating-green- procurement-into-your>.

[94] City of Berlin, *Decree on the application of regulations for environmentally friendly purchases and order placements for deliveries, construction work and services* (2013). See also, the city of Pamplona Fisseha Tessema and Cecile Marsille (2009) Practical insights and illustrative examples on Sustainable Public Procurement, Case Studies from Europe, SuPP-Urb-China Paper No. 3, online: https://www.scpcentre.org/wpcontent/uploads/2016/05/32_Tessema_Marsille__2009___SPP_in_Urban_Admi nis trations_in_Chia_en.pdf.

[95] City of Berlin, *Decree on the application of regulations for environmentally friendly purchases and order placements for deliveries, construction work and services,* 2013.

[96] European Commission, Green Deal: Sustainable batteries for a circular and climate neutral economy, December 10th, 2020, online: : https://ec.europa.eu/commission/presscorner/detail/en/ip_20_2312.

[97] *Ibid*. With respect to recycling, the draft regulation states that "all collected batteries have to be recycled and high levels of recovery have to be achieved, in particular of valuable materials such as cobalt, lithium, nickel and lead". In addition, the regulation wishes to facilitate « repurposing of batteries from electric vehicles so that they can have a second life, for example as stationary energy storage systems, or integration into electricity grids as energy resources".

For example, Canada has agreed to be bound by the rules of the World Trade Organization's *Revised Agreement on Government Procurement*. However, this Agreement only covers calls for tenders issued by the federal government, some of its entities and provincial governments. It therefore does not apply to calls for tenders launched by municipalities, schools or even urban transportation companies. In addition, calls for tenders are subject to international trade rules only if the thresholds are met. These differ depending on the target entity and whether the nature of the contract is one of goods, services or construction.

It is also possible that more than one agreement is applicable. In this case, the call for tenders must respect the terms of each of the international agreements. However, negotiators reproduce much the same rules from one agreement to another. When they apply, they provide for rules of openness, non-discrimination, fairness and transparency in the award of public contracts.

More specifically, as far as we are concerned, these agreements prohibit States from discriminating in favor of their products, their services or their national suppliers. In other words, when a call for tenders is launched and an international agreement is applicable, the public purchaser cannot write the call for tenders in such a way as to favor local products, services or suppliers. This rule may appear frustrating, but it has been the basis of the multilateral trading system for at least 70 years. There are some exceptions, but these are extremely narrow and only apply in very specific cases.

For example, the Canadian government typically excludes contracts for urban transit equipment and systems and highway projects from the scope of government procurement agreements. It can also relativize certain obligations, such as in the case of the obligation of non-discrimination, by providing that part of the contract can be given to national suppliers.

8.5. Protection of the Environment in Calls for Tenders: an authorization by international agreements

International agreements do not prevent buyers from including technical requirements of an environmental nature in a tender. The World Trade Organization's *Revised Agreement on Government Procurement* explicitly mentions that states may "prepare, adopt or apply technical specifications to promote the conservation of natural resources or protect the environment." (Art. X: 6) . Some free trade agreements have adopted the language of this provision[98], or, at the very least, have provided that a country can derogate from the principles of free trade for environmental reasons.[99]

This permission should not be aimed at discriminating in favor of local products or creating unnecessary obstacles to trade. As a general rule, therefore, a technical specification cannot mention

[98] For example, the *Comprehensive Economic and Trade Agreement*, article 19.9, par. 6 and the Comprehensive and Progressive Agreement for Trans-Pacific Partnership, article 15.12, par. 6.

[99] *Comprehensive Economic and Trade Agreement*, article 19.3, par. 2 and the Comprehensive and Progressive Agreement for Trans-Pacific Partnership, article 19.3, par. 2.

the origin of the product to be purchased or require that the product come from a particular territory.[100] Writing the technical requirements obviously requires special know-how and knowledge of the target market, but must also demonstrate real sincerity. In other words, the inclusion of a requirement aimed solely for the purpose of discriminating Canadian products over foreign ones would not pass the tests of international trade law. The protection of the environment must remain the objective pursued by the inclusion of a requirement. The fact remains that such a requirement may have the effect of discriminating in favor of national or local products. In such a situation, which is called *de facto* discrimination, the buyer's sincerity may be called into question. Legal tests have been developed by the dispute settlement bodies to determine the underlying motivations that led to the inclusion of the technical criteria.

Legal tests have not been developed with regard to the inclusion of environmental requirements in calls for tenders, but rather within the framework of environmental law which has an impact on international trade. The idea remains the same: when an environmental requirement is imposed which has the effect of limiting access to the national market and which, in fact, disadvantages local products or suppliers, the environmental requirement must be rationally founded. In this matter, case law tends to resort to international standards based on scientific consensus or, failing that, on a scientific basis justifying the need to adopt such a requirement to protect the environment.

The use of international technical standards, such as those issued by ISO or other standardization organizations, can provide a solid basis for justifying an environmental requirement. The more the requirements are based on established scientific standards, the easier they will be to justify. For example, the ISO 26000 standard on social responsibility can easily be used as a guide or inspiration when drafting calls for tenders. This standard does not give rise to certification, but rather provides guidelines aimed, among other things, at contributing to sustainable development and provides information on best practices of companies throughout the life cycle.

Certification standards can also be taken into account in the development of calls for tenders in order to justify the use of environmental requirements. The public purchaser may either refer to the standard as such, which contains a series of requirements, or they may select the environmental criteria that best suits the contract to be awarded and, above all, the status of the bid in a given market.[101]

---

[100] Subject to some exceptions, for example, a call for tenders aimed at purchasing products covered by designations of origin or geographical indications, such as Champagne, Marseille soap or Laguiole knives, which directly refers to the origin of the product.

[101] This clarification is important since calls for tenders must take into account the market offer. In other words, an overly demanding tender could simply be unsuccessful if no product or supplier meets the criteria. In addition, a public purchaser cannot add criteria for the sole reason that he wishes to restrict the market to less than three suppliers, or even to a single supplier.

8.6. Tools Allowing Buyers to 'Green' Public Procurement

Several tools are available to public buyers to 'green' public markets. These can be used as desired or be combined within a single call for tenders. It all depends on the product or service being purchased, and the state of the market. Every public buyer needs to know the market, the level of competition, and the ability of suppliers to meet the requirements. A public purchaser could therefore decide to impose very few environmental requirements in response to the fact that certain suppliers are not ready for such measures. A buyer could also assess that a call for tenders is likely to encourage, in the short term, suppliers to change their actions.

In this context, public purchasers may become a driver for social change insofar as the requirements that they choose to add in a call for tenders reasonably obliges suppliers to evolve and to offer more sustainable products or services. If the first call for tenders includes one or two environmental requirements, the next call for tenders could raise the level of requirement, again encouraging the industry to expect a higher level of environmental protection. Ultimately, the industry acquires an enviable specificity not only at the national or local level, but at the international level. It becomes more respectful toward the environment, but also becomes more competitive in international markets.

Here is a non-exhaustive list of the tools available to public buyers which allow them to include environmental requirements. These can be used to directly encourage the purchase of electric vehicles or charging stations and could have the effect of indirectly encouraging the purchase of domestically produced products.

1. Include technical specifications for sustainable development in calls for tenders, whether or not based on recognized certifications. As such, as part of a call for tenders for the replacement of vehicles, a public purchaser could require that these vehicles be electric. The invitation to tender could also specify a more environmentally friendly type of material in the design of vehicles, batteries, terminals, etc. The technical specification may relate to the production chain and provide for the use of renewable energy for certain percentage of inputs or of certain products in particular. The technical specification can also cover the entire life cycle of the product, for example, by including requirements for recycling end- of-life products. The specification may also require that the products be subject to a carbon market. Given the highly technical nature of these specifications, governments should develop an accounting system that allows for the proper evaluation of long-term costs.[102]

   Although the public purchaser cannot require a supplier to obtain a specific certification, they may refer to a certification in order to clarify the technical specifications that are required.

[102] This is often a major obstacle to green purchasing for public buyers: F. Testa, E Annunziata and M Frey, "Drawbacks and opportunity of green public procurement: An effective tool for sustainable production" (2016) 112 Journal of Cleaner Production 1893-900. Vidal Rosario and Nuria Pantoja have developed a method for evaluating projects according to requirements (technical specifications, award criteria, etc.) and the cost related to the product life cycle: "Method bases on life cycle assessment and TOPSIS to integrate environmental award criteria into green public procurement "(2018) 44 Journal of sustainable cities and society 464-474.

Electric Mobility Canada /Mobilité électrique Canada – www.emc-mec.ca – info@emc-mec.ca
38 place du Commerce, 11-530 Ile des Sœurs, QC H3E 1T8

They can also be inspired by it and select the technical specifications that best illustrate the state of the current offer.

2. Require that contracts contain performance clauses that reduce the impact on the environmental. This tool is one of the most interesting in terms of the electrification of transportation as it can target all sectors, and thereby encourage the sector of electric vehicles and charging stations. For example, a public purchaser could require that the contract be performed by deliveries made by means of electric vehicles. For example, to win a contract for food supplies to schools, hospitals, daycares or government departments, the supplier would have to be able to demonstrate that the delivery will be made using electric vehicles. Public buyers could, follow the example of other European countries, and provide for the addition of bonuses in the event of compliance with these requirements and of penalties in the event of failure to comply with a contractual clause.

3. Evaluating the quality of bids through award criteria related to sustainable development, while allowing to pay 10% more in order to achieve this result. When a public purchaser considers that the state of the market does not allow the imposition of detailed technical specifications, as this would risk reducing competition and producing an unsuccessful call for tenders, he can resort to a common tool for public procurement: quality assessment. By adding award criteria relating to environmental protection, the public purchaser indicates to industries that they do not have to meet environmental standards but that those that do achieve them may be given preference. The public purchaser may even pay up to 10% more to favor industries that are more environmentally friendly.

4. Public buyers can impose a principle of non-regression, so that if a call for tenders includes sustainable development criteria, the next call cannot be less demanding.

   Public buyers have several tools at their disposal for green public procurement. These tools can be used individually, at the choice of the public purchaser, or they can also be combined in the context of a call for tenders. For example, it would be possible for a market requiring glass to offer a preferential margin of up to 10% for suppliers able to demonstrate the use of a wastewater treatment system. It would also be possible for the same market to additionally require, as a technical specification, that glass be produced from recyclable energy. In the latter case, only glass suppliers using recyclable energy will be selected and a preferential margin will be granted to suppliers treating their wastewater.

8.7. The Impact on the Electrification of transportation in Canada when Taking Better Consideration of the Environment

If public buyers were required to take into account the environmental impact of their purchases, or if at the very least, governments strongly encouraged their entities to do so, it would certainly have the effect of benefiting the manufacturing of the electrification of transportation industry.

For example, public buyers could be required, where possible, to renew the vehicle fleet with electric cars, trucks or buses. Such a measure would have the effect of increasing the demand for electric vehicles and charging stations.

With a view to preserving the environment and natural resources, public buyers of electric vehicles and charging stations should be encouraged to take into account the complete life cycle of a product, taking into account, for example, the impacts of the production of inputs into the finished product (and most importantly, the extraction of minerals). In doing so, companies manufacturing environmentally friendly products, using renewable energy or following strict specifications for the treatment of waste and wastewater, could be favored. Clearly, companies using renewable energy would be one step ahead. Measures targeting sectors not necessarily linked to the production of electric vehicles or charging stations could nevertheless also benefit the transport electrification sector. For example, public buyers could demand that the delivery of tender products be made by electric vehicles, or that the supplier using this type of transport be given priority in the quality assessment.

These measures would obviously respond to the urgent need for action to ensure that Canada meets its greenhouse gas reduction targets, but would also, very likely, have the effect of benefiting businesses in the sector in a number of areas. The electrification of transportation sector certainly is no exception.

Electric Mobility Canada /Mobilité électrique Canada – www.emc-mec.ca – info@emc-mec.ca
38 place du Commerce, 11-530 Ile des Sœurs, QC H3E 1T8

9. The role of Government Incentives in Canadian EV Industry Strategy

The role of governments is essential in reorienting the population towards more sustainable solutions in transportation and other areas. There is still some resistance to making significant changes in our lifestyles. This is human nature. It is legislation on greenhouse gases, on pollution or fuel consumption of vehicles, on clean fuels or on a zero-emission standard for automobile manufacturers that will make the electrification of transportation a success or a failure. It is one minute to midnight and we can no longer put off the right and necessary actions until later.

As discussed in chapter 2, leaders in transport electrification are those who have put in place appropriate regulations, incentives, or disincentives, often penalizing those who want to buy large gasoline- or diesel-powered fuel-inefficient vehicles. Of course, there are exceptions for those who really need them for their work.

Significantly reducing greenhouse gas emissions in transportation will not happen by itself and will be difficult. Indeed, the strong trend is that consumers are moving away from lighter cars to heavier, more fuel-inefficient SUVs. This is confirmed by Statistics Canada's visualization tool for motor vehicle registration data[103] from 2011 to 2019. The graph below is derived from this data. It is clear that this is not at all a step in the right direction. A big push is needed to change course.

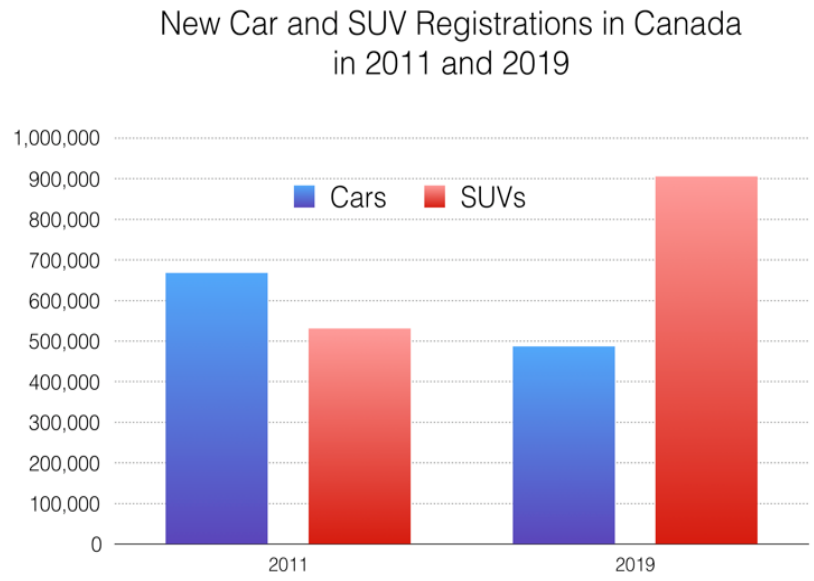


Figure 9.1: In 2019, new car registrations are down 27% from 2011, while new SUV registrations are up 70%. Source : Statistique Canada.

[103] See this web page www150.statcan.gc.ca/n1/pub/71-607-x/71-607-x2019028-eng.htm .

9.1. ZEV rebates

The most important incentive for zero emission vehicles (electric vehicles) is undoubtedly the rebate or tax credit at the time of purchase, to reduce the extra cost. We know that in many cases, the owner can recoup this extra cost with the fuel and maintenance savings, but paying an additional C$8,000 to C$12,000 to buy an electric vehicle with a range of 400 km can turn potential buyers off of this vehicle, even if the costs are recouped over the life of the vehicle through fuel and maintenance savings. It's like asking someone to pay 75% of the gas they will consume in 10 years when buying a gas vehicle. It's not a win-win situation. Instead, the consumer is going to buy a vehicle for which he or she does not have to pay for fuel when buying the vehicle.

Most experts agree that parity in the purchase price of electric vehicles with those in the same gasoline-powered category should arrive in the mid-2020s. Already Tesla is announcing a compact electric car at US$25,000 by 2024, while the cheapest of its vehicles, the Model 3 Standard Range Plus, currently sells for US$37,000 in 2021, with a range of 420 km. It must be said, however, that the future car will be in a lower category than the Model 3 and will certainly be produced in larger quantities.

The importance of purchase rebates for EV sales is clearly seen for China in Figure 2.3. Indeed, we learned in Chapter 2 that China cut its purchase subsidies in half in 2019, which led to higher EV sales in 2018 and significantly slowed sales in 2019, a slowdown that continued into 2020. For Ontario, which completely removed its rebates overnight in 2018, the change in the sales curve in Figure 2.14 shows that in 2019 EV sales fell by almost 40%, and began to grow again when the Government of Canada introduced its own rebate.

The rebates are therefore still essential to ensure that sales of electric vehicles grow at a rate adequate to meet our objectives and stimulate the energy transition. Rebates should continue at the same level until 2023 and gradually decrease until 2025, with the possibility of revaluation every two years, depending on the evolution of vehicle purchase prices.

And for those who would complain about these subsidies for electric vehicles, they may need to be reminded that oil has still been subsidized for more than a hundred years.

Alternatively, **rebates can be offered at zero cost to the taxpayer by imposing a surcharge on fuel-inefficient vehicles, which should grow with fuel consumption. In this way, the surcharges pay for the rebates on electric vehicles. This is called a Bonus-Malus system**. France and Norway are two examples of countries that have implemented it. Without going as far as a surtax of more than C$40,000 as in France, there would certainly be a step to be taken in this direction to accelerate the penetration of electric vehicles and the achievement of our greenhouse gas reduction objectives.

9.2. Reducing Greenhouse Gas of Internal Combustion Vehicles

Realistically, it can be said that the electrification of all road vehicles can continue until 2045 - 2050, given the 12 to 15 year lifespan of the vehicles. It is then essential, in order to reduce greenhouse gases

and air pollution from internal combustion vehicles, to put in place regulations to reduce emissions from these vehicles.

There are two ways to do this: 1- reduce the fuel consumption of vehicles, 2- reduce the amount of greenhouse gases (GHG) emitted by fuels over their life cycle (extraction, refining, transportation, distribution and combustion). To do so, governments must implement two types of standards: a fuel consumption standard for vehicles and a cleaner fuel standard.

9.2.1. **Fuel Consumption Standards**

Traditionally, Canada has aligned itself with the U.S. Corporate Average Fuel Economy (CAFE) standard. However, with the withdrawal of the Paris Agreement and the Trump Administration's significant reduction in stringency of the CAFE standard[104], the average fuel economy of a manufacturer's fleet, which was expected to be below 4.3 litres/100 km (55 miles per gallon) in 2025, is now reduced to 5.9 litres/100 km (40 miles per gallon) in 2026. Let's hope that the Biden Administration corrects the situation and returns to the standard set by the Obama Administration.

Let's not forget, as we saw in section 2.3.1, that the European standard in effect in 2021 requires that the manufacturers' car fleet have an average CO^2 emission of less than 95 g/km, at use (not life cycle).

Since the Toyota Corolla displays 101 gCO^2/km in France with a consumption of 4.5 L/100 km (WLTP), the standard to be met, 95 gCO^2/km, corresponds to a consumption of 4.3 L/100km. However, it should not be forgotten that the EPA test cycle estimates, on which the CAFE standard is based, are approximately 10% higher than those of the WLTP cycle. The final result is that the average fuel consumption of European car fleets should be less than 4.7 L/100 km in 2021, according to the EPA test cycle. And, as we saw in the previous paragraph, the CAFE standard in the United States currently requires a fuel consumption of less than 5.9 L/100 km in 2026, according to this test cycle.

No wonder many electric vehicle (EV) manufacturers send their vehicles to Europe and not to America. So, there are many more EV choices in Europe than in America.

It is therefore in Canada's best interest to align itself with a more stringent fuel consumption standard than the one that currently prevails in the United States.

[104] Rebecca Beitsch, *Trump Administration Rolls Back Obama-Era Fuel Efficiency Standards*, The Hill, March 31, 2020 (https://thehill.com/policy/energy-environment/490318-trump-administration-rolls-back-obama-era-fuel-efficiency-standards .

9.2.2. Lower Emission Fuel Standards

In the following we will compare the clean fuel standard put in place by California in 2009 to that proposed by the Government of Canada for adoption in late 2021.

1) California Low Carbon Fuel Standard

California pioneered the introduction of its Low Carbon Fuel Standard (LCFS) in 2009. The California Air Resources Board (CARB) has posted an explanatory document[105] on this standard, from which the next two figures are taken. Figure 9.2 explains the different stages in the life cycle of a fuel. GHG emissions are accounted for in gCO^2/MJ of fuel available at the pump. The MJ (mega-Joule) is a unit of energy corresponding to that found in about 31 cl of gasoline. Note that **the total GHG emissions for gasoline in California are 101 gCO^2/MJ**.

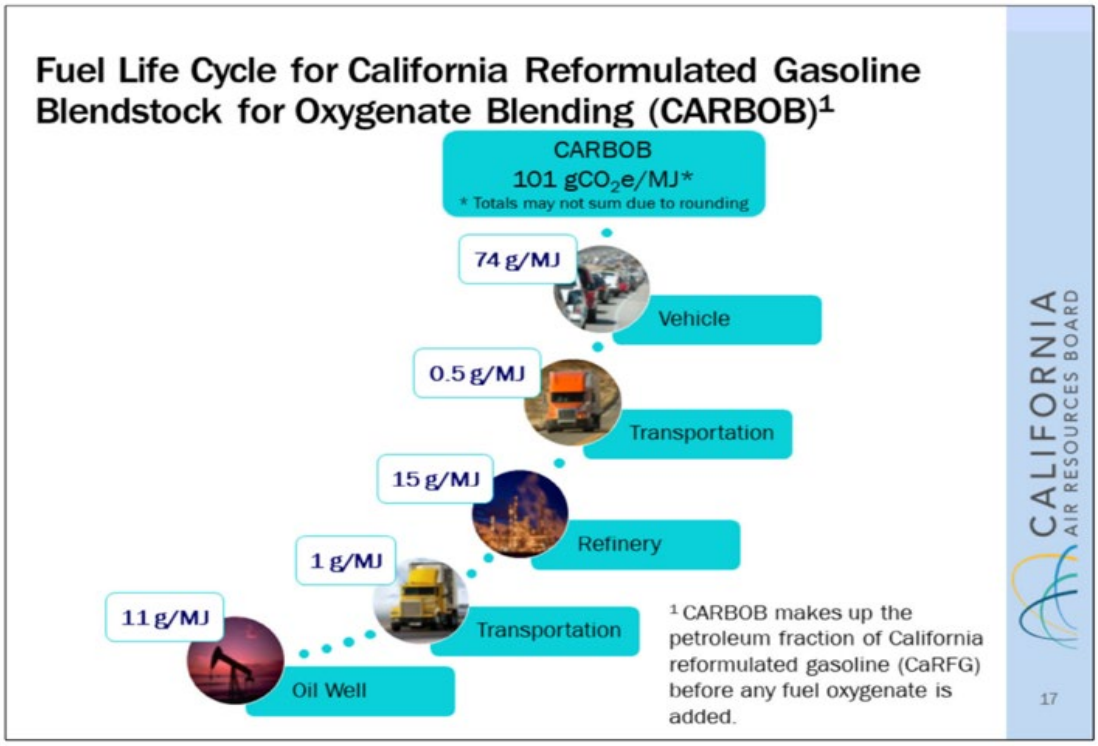
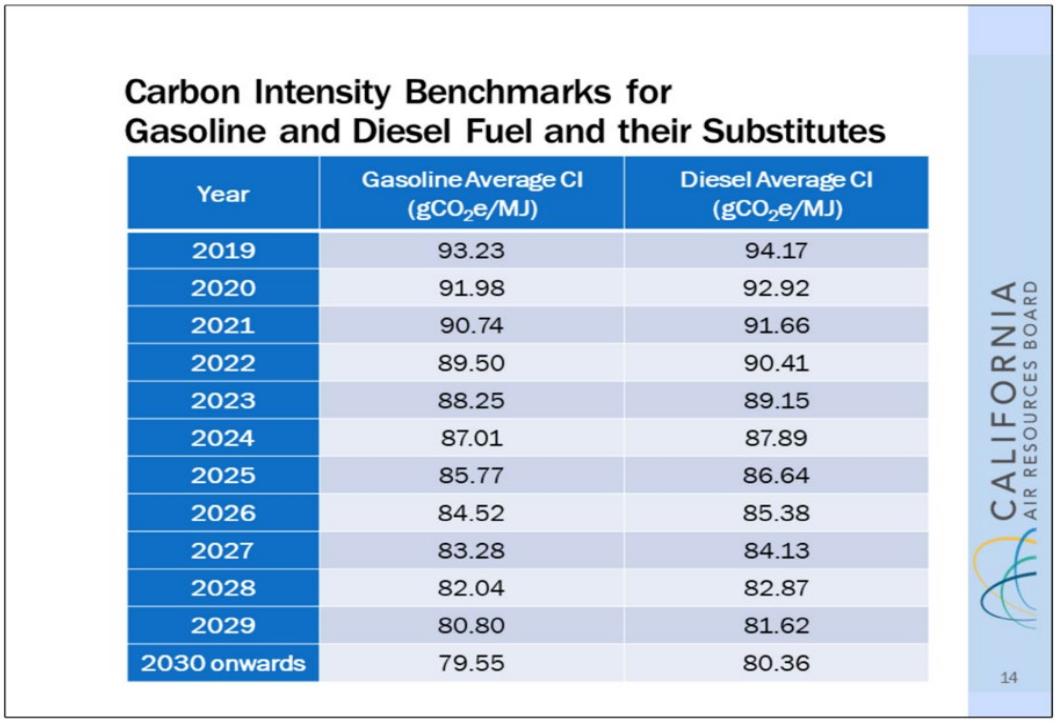


Figure 9.2: An example of GHG emissions over the life cycle of a fuel. Source: California Air Resources Board.

[105] More information about the Low Carbon Fuel Standard of California is given on the California Air Resources Board site here https://ww2.arb.ca.gov/resources/documents/lcfs-basics .

Figure 9.3 shows a table of allowable emission caps for gasoline and diesel from 2019 to 2030.



Carbon Intensity Benchmarks for Gasoline and Diesel Fuel and their Substitutes

Year	Gasoline Average CI (gCO_2e/MJ)	Diesel Average CI (gCO_2e/MJ)
2019	93.23	94.17
2020	91.98	92.92
2021	90.74	91.66
2022	89.50	90.41
2023	88.25	89.15
2024	87.01	87.89
2025	85.77	86.64
2026	84.52	85.38
2027	83.28	84.13
2028	82.04	82.87
2029	80.80	81.62
2030 onwards	79.55	80.36

Figure 9.3: Emission caps allowed each year for gasoline and diesel fuel in California. Source: California Air Resources Board.

Oil companies will therefore have to ensure that the life-cycle GHG emissions of the gasoline they will sell in California have decreased by 13.5% from 2020 to 2030. They can do this by improving their extraction and/or refining processes or by blending petroleum gasoline with lower-emission biofuels or synthetic fuels.

If the fuel supplier achieves the required reductions and exceeds them, it obtains credits, calculated in metric tons of CO^2e avoided in addition, and if it does not achieve them, it obtains deficits. The fuel supplier can make up the shortfall by purchasing credits from other companies or from a government credit bank, which amounts to a financial penalty.

In this way, California ensures that all of its gasoline sources are cleaner because the emissions caps are absolute and the same for everyone.

2) Clean Fuel Standard Proposed By Canada

The Government of Canada has initiated a process to put in place a clean fuel standard to come into effect on December 1, 2022[106]. The proposed approach is to require oil companies to reduce the emission intensity of their fuels by 2.4 gCO^2e/MJ in 2022 and increase this threshold each year to reach 12 gCO^2e/MJ in 2030 compared to the Canadian average value in 2016.

However, it should not be forgotten that in 2016 more than 60% of the oil produced in Canada came from the oil sands[107], and that there was also oil produced from tight oil, two types of operations that are more polluting and emit more GHGs than conventional light oil. As a result, **we should expect the emission caps in the Canadian standard to be higher than those in California**.

For the rest of the modus operandi of the Canadian clean fuel standard, in terms of credits and company deficits it is similar to California, with sales and purchases of credits.

9.3. A Zero Emission Vehicle (ZEV) Standard

While purchase rebates stimulate demand for electric vehicles, a standard for zero-emission vehicles (ZEVs) stimulates supply from manufacturers, forcing them to sell an ever-increasing percentage of ZEVs over the years. ZEVs include battery electric vehicles, plug-in hybrid electric vehicles and fuel cell/hydrogen electric vehicles.

Importantly, according to a report prepared for Transport Canada in April 2020[108], 67% of Canadian car dealerships did not have a single electric vehicle in inventory and the majority of people who bought one waited 3 to 6 months! We can therefore see that there is a supply problem in Canada.

California was the first jurisdiction to implement a ZEV standard in 1990, followed by 10 other states, then Quebec[109], British Columbia and China.

Quebec and British Columbia are aligning their ZEV standard with California's ZEV regulations. According to California's ZEV regulations, each ZEV is awarded a number of credits based on the

---

[106] See the page *Clean Fuel Standard* of Government of Canada site here https://www.canada.ca/en/environment-climate-change/services/managing-pollution/energy-production/fuel-regulations/clean-fuel-standard.html .

[107] See the page *Crude oil facts* of Government of Canada site here www.nrcan.gc.ca/science-data/data-analysis/energy-data-analysis/energy-facts/crude-oil-facts/20064#L6 .

[108] Dunsky Energy Consulting, *Plug-iIn Electric Vehicle Availability*, prepared for Transport Canada, April 2020 (www.dunsky.com/wp-content/uploads/2020/07/DunskyZEVAvailabilityReport_Availability_20200805.pdf).

[109] See more details on the Quebec Government information document here https://www.environnement.gouv.qc.ca/changementsclimatiques/vze/feuillet-vze-reglement.pdf

vehicle's electric range. The number is capped at 4 credits for a range of 350 miles in the UDDS cycle, or approximately 245 miles (392 km) in the EPA cycle. Since most electric vehicles coming out in 2021 have a range of more than 400 km EPA, these vehicles will be entitled to a maximum of 4 credits. Plug-in hybrid electric vehicles, on the other hand, are limited to 1.3 credit for an electric range of 90 km or more. The average credits per ZEV for the coming years should approach 3 credits.

Now, under California's ZEV regulations, manufacturers must accumulate a minimum number of credits in a year expressed as a percentage of the total number of vehicles sold by that manufacturer. Specifically, assume a manufacturer has earned 900 credits from ZEV sales and sold a total of 10,000 vehicles in the State during the year. This corresponds to a percentage of credits for that manufacturer of 9%. But what is important to note here is that the manufacturer did not sell 9% of ZEV vehicles. In fact, if each ZEV sold gave them an average of 3 credits, they sold 300 ZEVs, or 3% of the total number of vehicles sold.

With this clarification, the figure below shows the minimum percentage of credits required by the California ZEV regulations. The acronym TZEV refers to transitional (T) ZEV, such as plug-in hybrid electric vehicles.

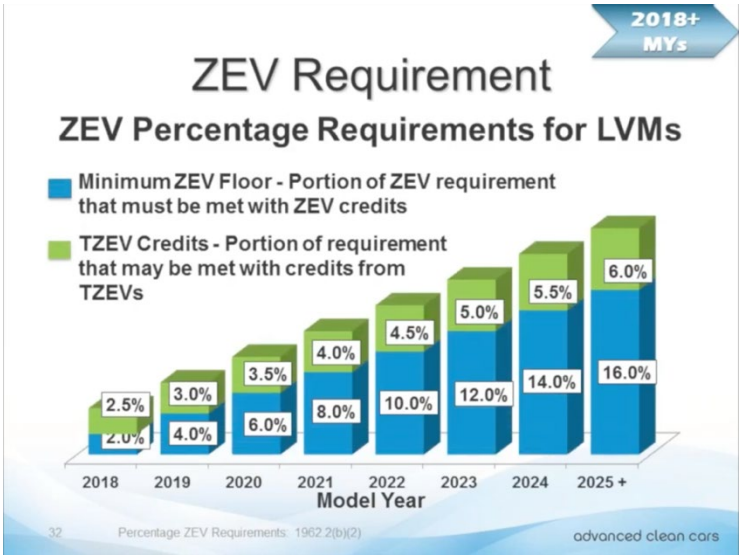


Figure 9.4: Minimum credit percentage required by California's ZEV regulations.
Source : California Air Resources Board.

It shows that by 2025, manufacturers will need to accumulate 22% of ZEV credits, which could represent approximately 8% to 10% of ZEVs sold.

This is too little, because if we refer to Chapter 2 we realize that in 2020 California had achieved a 7.8% market share of new vehicle sales for its ZEVs for the year, and that British Columbia and Quebec had achieved 8.4% and 6.7% respectively for the third quarter of 2020. In Germany, the United Kingdom and France, market shares for December 2020 were even higher, at 28%, 23% and 19%

respectively for the month of December. We should aim for a market share of at least 20% in 2025, not 9%, otherwise we won't replace enough internal combustion vehicles to meet our greenhouse gas reduction targets.

Now, to conclude on California ZEV regulations, those who do not reach their credit minimum can carry it forward for one year to try to accumulate more credits the following year, otherwise manufacturers must buy the missing credits from those who have a surplus or from the government. This is the equivalent of a monetary penalty.

9.4. Other means

There are a number of measures, other than those just discussed, that can stimulate faster adoption of electric vehicles. They focus on free access or rights that drivers of gasoline or diesel cars do not have. These are listed below:

- Exemption from tolls on highways or for crossing bridges
- Free access to ferries
- Free access to municipal parking lots
- Authorization to use reserved lanes for public transit and cabs during peak traffic hours
- Exemption from congestion charges to enter city centers in metropolises such as London or Stockholm
- Reduced annual registration fees.

A strong gesture to stimulate manufacturers is to stop the sale of light-duty petroleum vehicles in any country, state, province or large city from a certain year onward. According to a January 2021 article[110], there were already 31 countries, states and cities that have proclaimed such a ban from 2025 to 2050. Of the 31, 18 have set a deadline of 2025 to 2035. This is a very clear signal that the time for internal combustion engines is over.

Another strong incentive that should not be overlooked is the development of a proper charging network that will allow motorists to travel across the country. This infrastructure will take some time to pay for itself with few electric vehicles to begin with. It is therefore a major role for governments to provide financial assistance for the establishment of this essential recharging network. If the network is not up to the task, potential future customers will be reluctant to buy an electric vehicle.

In closing this chapter, it is important to specify that the incentive measures, standards or regulations put in place will be all the more effective if they have **sufficiently binding objectives**.

[110] Steve Hanley, *31 Countries, States, And Cities Have Gas/Diesel Car Bans in Place*, Clean Technica, January 2, 2021 (https://cleantechnica.com/2021/01/02/31-countries-states-and-cities-have-ice-bans-in-place/).

10. Conclusion: The Time is Now

As a developed and highly industrialized country, Canada can profit from its many advantages to become a leader in electric mobility. In fact, it is very well positioned with:

- An abundance of critical minerals and metals;
- A thriving and experienced mining industry;
- 82% of non emitting electricity production in Canada… that will keep getting cleaner
- Many Canadian companies involved in electric mobility: OEMs, infrastructure manufacturers and providers, utilities, mining companies, etc;
- A network of research centers and universities involved in electric mobility from BC to Atlantic Canada;
- A Federal government and more and more provincial governments pushing to accelerate electric mobility;
- National organizations such as Electric Mobility Canada, Unifor, APMA, Clean Energy Canada and others that want to accelerate electric mobility in Canada;
- The upcoming Canadian ZEV supply Chain Alliance that will work on establishing the best ways to create a complete Canadian ZEV supply chain, from mining to mobility;
- The newly announced Roadmap for a Renewed U.S.-Canada Partnership where Prime Minister Trudeau and President Biden agreed to work together to build the necessary supply chains to make Canada and the United States global leaders in all aspects of battery development and production and to strengthen the Canada-U.S. Critical Minerals Action Plan to target a net-zero industrial transformation, batteries for zero-emissions vehicles, and renewable energy storage.

Electric Mobility Canada /Mobilité électrique Canada – www.emc-mec.ca – info@emc-mec.ca
38 place du Commerce, 11-530 Ile des Sœurs, QC H3E 1T8

10.1. 559,400 clean jobs by 2030: Almost 50% in clean transport.

According to *The Fast Lane, tracking the energy revolution 2019*[111] from Clean Energy Canada, demand for clean energy and clean transportation jobs will keep growing at a very fast rate. "That's jobs like manufacturing electric cars, buses, and trucks that are forecast to hit our roads in record numbers. In fact, several transit authorities have committed to buying only electric buses over the next decade"

10.2. Economic impact of air pollution in Canada: $120 billions a year[112]

According to a 2021 report published by Health Canada titled Health Impacts of Air Pollution in Canada : Estimates of morbidity and premature mortality outcomes, the "total annual economic value of health outcomes associated with air pollution is approximately $120 billion. Health Canada estimates the number of annual mortalities in Canada that can be attributed to air pollution from human sources in North America to be 15,300 deaths per year based on 2016 population counts."It represents 8 times the death toll of motor vehicle accidents, which was 1,922 in 2018. Considering the fact that Transportation is a major source of air pollution in Canada, accounting for 31% of black carbon emissions , 33% of carbon monoxide emissions and 41% of nitrogen oxide emissions[113], accelerating the transition to zero emission vehicles will therefore end up saving thousands of lives and billions of dollars for Canadians every year.

10.3. Over $190 billions in potential sales revenue

According to a 2020 analysis from Electric Mobility Canada titled *The case for a Canadian EV industry & a ZEV standard*[114], if Canada decides to implement regulatory policies inspired by jurisdictions like BC, Québec or California, Canada could see EV related sales revenue of more than

---

[111] https://cleanenergycanada.org/wp-content/uploads/2019/10/Report_TER2019_CleanJobsFuture_20191002_FINAL-FOR-WEB.pdf

[112] http://publications.gc.ca/collections/collection_2019/sc-hc/H144-51-2019-eng.pdf

[113] https://www.canada.ca/content/dam/hc-sc/documents/services/publications/healthy-living/2021-health-effects-indoor-air-pollution/hia-report-eng.pdf

[114] *https://emc-mec.ca/wp-content/uploads/EMC-The-case-for-the-EV-industry-and-a-ZEV-standard-DEC-6-2020.pdf*

$190 Billions between 2021 and 2030, from electric LDVs to HDVs, from utilities growing revenue to charger sales and installation revenue.

10.4. The need for regulation

Although Canada already has its own ZEV adoption targets, Canada won't be able to reach them without a comprehensive strategy and voluntary measures alone likely won't be enough. Third party modeling by *Navius Research* shows even less optimistic projections: Under current policies, ZEVs are projected to account for only 3.7% of new light-duty vehicle sales by 2025, 7.3% by 2030, and 14% by 2040.

Let's not forget that, according to a 2019 study by the *International Energy Agency*[115], Canada is the #1 country in the world for GHG emissions per kilometer driven by its light duty vehicle fleet, in front of the United States. It's also the largest and the second heaviest in the world.

10.5. Canada and California

Two years ago, Environment Minister Catherine McKenna[116] announced that the Canadian and Californian governments would work together on regulations to cut greenhouse gases from vehicles. Since Canada's new Climate Plan says the we would "Work to align Canada's Light-Duty Vehicle regulations with the most stringent performance standards in North America post-2025, whether at the United States federal or state level"[117], it therefore only makes sense that Canada adopts California's LDV and HDV regulations for fuel economy and ZEV standard… since California is in fact the North-American leader.

10.6. A Canadian Electric Mobility Strategy

Other countries in the world have embraced or are embracing electric mobility right now. Because of that, competition is fierce to attract investment and qualified people from around the world. For all the reasons mentioned before, from jobs to revenue to health impact, Canada needs to move forward with a comprehensive electric mobility strategy that involves 5 pillars to handle present and future challenges in electric mobility:

[115] https://www.iea.org/reports/fuel-economy-in-major-car-markets
[116] https://www.cbc.ca/news/business/canada-california-vehicle-emissions-1.5190619
[117] https://www.canada.ca/content/dam/eccc/documents/pdf/climate-change/climate-plan/healthy_environment_healthy_economy_plan.pdf

1- Infrastructure deployment to make sure that all Canadians have access to charging everywhere in the country;

2- Education for consumers and training-retraining for present and future workers of the EV industry since there still are many misconceptions about EVs and EV use on a daily basis

3- EV rebates and financial support to make light, Medium- & Heavy-Duty affordable until the reach price parity (like we have seen in other economic sectors);

4- Investment in a Canadian ZEV supply chain, from mining to mobility, from R & D to commercialization to create jobs in Canada instead of just importing EV components, batteries, vehicles and technologies;

5- EV regulation to secure enough EV access to Canadian consumers across the country and for Canada to reach its climate and EV adoption targets.

While Canada is well positioned to create jobs and develop a thriving electric mobility industry, other countries won't wait.

That's why **the time is now**.

Electric Mobility Canada /Mobilité électrique Canada – www.emc-mec.ca – info@emc-mec.ca
38 place du Commerce, 11-530 Ile des Sœurs, QC H3E 1T8

Appendix 1 : Lessons From the Past

Since 2008, Canada has missed some important opportunities to help develop a thriving electric mobility industry. There are lessons to be learned from that last major crisis in the way we will collectively want to emerge from the present crisis. Not only are we presently dealing with a historic public healt and economic crisis, but Canada, and the world, also have to deal with the climate crisis.

So if we want an economic recovery that will not only create jobs in the short term, but also help the environment, there are some key sectors that can be supported by all the major stakeholders, from governments to the private sector, from institutions to consumers and from BC to the Maritimes and to the North. And electric and smart transportation is certainly one of them.

A1.1. The 2008 EV Roadmap

In 2008, "The Electric Vehicle Technology Roadmap for Canada"[118] was published by a group of different stakeholders, including Electric Mobility Canada, CAW/TCA, OEMs such as Ford and GM, utilities and other groups specialized on the topic in order to propose a vision of what could be done to reach the target of 500 000 Zero Emission Vehicles by 2018.

In the executive summary we could read:

"By 2018, there will be at least 500 000 highway-capable plug-in electric-drive vehicles on Canadian roads, as well as what may be a larger number of hybrid-electric vehicles. All these vehicles will have more Canadian content in parts and manufacture than vehicles on the road in Canada in 2008.

Electricity as an alternative to traditional transportation energy is becoming a near-term reality for many countries, including Canada. Electric vehicles (EVs = Battery Electric Vehicles (BEV) + Plug-in Hybrid Electric Vehicles (PHEV)) will contribute to promoting sustainable energy development while addressing air quality and climate change. The market for EVs in Canada is growing as Canadians look for cleaner, more efficient vehicles. Research confirms that consumers in North America are willing to pay more for an EV if the environmental benefits are significant. In Canada, it is expected that these benefits can be achieved because the majority of our electricity is generated from renewable and low-emission sources.

With our significant amounts of clean electricity and a growing EV industry, Canada is well positioned to capitalize on this form of clean transportation. Our industry is well placed to be a major supplier of EV components and vehicles, not only in Canada but also internationally. Canada has the opportunity

[118] "The Electric Vehicle Technology Roadmap for Canada": https://emc-mec.ca/wp-content/uploads/ElectricVehicleTechnologyRoadmap_e.pdf

Electric Mobility Canada /Mobilité électrique Canada – www.emc-mec.ca – info@emc-mec.ca
38 place du Commerce, 11-530 Ile des Sœurs, QC H3E 1T8

to link our efforts with those of the United States because of the integrated North American automotive industry.

To achieve the timely and effective commercialization of EVs, governments and industry must work together on ensuring that the necessary steps are taken. These steps include many activities, such as the development of advanced batteries, a charging infrastructure, electricity storage devices, codes and standards, and policies, as well as public education and consumer acceptance.

The most important of these topics is energy storage. Progress toward widespread use of the vehicles covered by the Electric Vehicle Technology Roadmap for Canada (the Roadmap) depends above all on one factor: increasing the amount of electrical energy that can be stored in a given volume or weight on board a vehicle, thereby extending electric traction's range. This Roadmap is intended to provide the strategic direction to ensure the development and adoption of EVs in Canada, while building a robust industry."

Other EVs that were not considered in the Roadmap include fuel-cell-based vehicles, vehicles with two or three wheels, low-speed and off-road vehicles, military vehicles, and vehicles such as trolley buses that are powered from the grid while in motion.

The following are recommendations from the 2008 report:

"Technology

- Improve energy storage through basic and applied research, including improvements in:
  a) manufacturing techniques—with the goals of adding scale, improving efficiency and reducing costs
  b) energy density—to reduce costs, increase range and achieve smaller, lighter systems
  c) management and control electronics—for more efficient use of available energy storage
  d) system packaging—to optimize thermal, electrical, mechanical and safety elements.
- Reduce the cost of EV components by a factor of two to three so they can be competitive with equivalent ICE components.
- Reduce the weight of the components.
- Test options for the charging infrastructure in each major region of Canada, including smart charging and vehicle-to-home and vehicle-to-grid arrangements. Recommend changes and improvements, noting impacts of multiple chargers on power quality.
- Demonstrate vehicle use in real-world operation to assess the reliability and durability of energy storage and other components.

Codes, standards, regulations and infrastructure readiness

- Review national, provincial/territorial and municipal regulations that impact the manufacture and use of EVs in Canada. Ensure that the regulations support EV development without compromising safety and other concerns.

- Harmonize North American standards and practices concerning the integration of EV components, including charger interfaces.
- Develop harmonized standards for the conversion of used vehicles to electric traction.

- Amend building codes and other regulations to require that at least the rough-in for outlets for charging EVs is included in all new buildings. Provide model codes and regulations.
- Develop action plans for infrastructure readiness.

Studies and assessments

- Assess the merits of, and develop a mandate for, an Electric Transportation Institute as a Canadian focus of applied EV research and development and other activities required to accelerate widespread use of EVs.
- Assess the potential impacts of incentive programs for the purchase of EVs on EV penetration and the impacts of battery warranty and lease programs.
- Estimate how much EVs will increase the demand for national and regional electrical energy and power over several periods and at several levels of market penetration. Take into account the reduced block heater loads and the additional battery conditioning loads. Assess the current and expected future ability to handle these demands, noting additions that would be required to the generation and distribution infrastructure.
- Estimate the lifetime savings that will result from the shift to EVs from ICE-based vehicles, anticipating changes in electricity rates and fossil fuel prices.
- Identify the effects on government revenue from the shift to EVs from ICE-based vehicles.
- Assess if renewable sources of electricity will be able to support use of the proposed 500 000 or more EVs by 2018.
- Assess the prospects for battery leasing models and the viability of battery "repurposing."
- Compare the social benefits and costs of electric traction with ICE-based traction that uses fossil fuels.
- Identify the feasibility, costs and benefits of creating a Canadian brand of highway-capable EVs.
- Identify new business opportunities for Canadian electrical utilities that could arise from growth in the EV industry.
- Identify and assess the challenges and opportunities for Canada's EV industry posed by the *American Recovery and Reinvestment Act of 2009* and other such measures.
- Identify potential early adopters of EVs, particularly fleets, and how they may be encouraged to become early adopters.

Education and outreach

- Assess the resource requirements for training, education and certification in skills related to the emerging EV industry. Provide this information to organizations that can develop:

Electric Mobility Canada /Mobilité électrique Canada – www.emc-mec.ca – info@emc-mec.ca
38 place du Commerce, 11-530 Ile des Sœurs, QC H3E 1T8

a) technical courses on EV repair, service and maintenance and on the conversion of ICE-based vehicles to EVs
b) courses to help graduates of universities and colleges secure employment in high-paying jobs in the emerging EV industry in areas such as battery engineering, power systems engineering, power electronics, manufacturing processes and development of new business models.

- Develop educational and public relations programs that increase awareness across Canada of the benefits of EVs and associated technologies.

The basic message of this Roadmap was clear: early action, mainly by governments and industry, could sustain Canada's strong position in electric transportation and enhance it for the benefit of all Canadians.

13 years later, Canada has not reached the 500 000 EV target for 2018 as proposed by this group. In early 2021, we are closer to 200 000 EVs on Canadian roads with more than 9 EVs out 10 found in Québec, British Columbia and Ontario.

It's worth noting that in 2008, the world was in the middle of a financial crisis the likes of which we had not seen since the Great Depression. Its effects on all the countries was deep and had a major influence on governments and the private sector.

A1.2 GM and Chrysler support in 2008-2009: A missed opportunity for the transition in Canada

In 2009, the 3 major North American OEMs were in deep trouble. Through 2009 and 2010, GM endured a government-backed Chapter 11 bankruptcy in the US, reorganized its leadership, stopped producing Saturn, Saab, Pontiac, and Hummer. Chrysler was in even deeper trouble than GM, even shutting down all vehicle production in December 2008 and enduring a 42-day period of bankruptcy. After accepting a $4 billion dollar federal loan in the US, Chrysler accepted to marry with with Fiat Automobiles S.p.A., of Italy in June 2009.

In 2009, Barack Obama, the newly elected President of the United States proposed a bail-out plan to these 2 OEMs. The U.S. government's $80.7 billion bailout of the auto industry lasted between December 2008 and December 2014 and helped save the US auto industry. The US government ended up recuperating $70, 5 billions.

In addition to the successful bridge loans there were five other major Obama administration policies that helped the auto industry and the US by creating jobs, reducing oil use, saving families money, and cutting pollution:

1- Fuel-economy and carbon-pollution standards for 2012 to 2016 model cars sparked job growth in automobile manufacturing and increased automobile sales.
2- Fuel-economy and carbon-pollution standards for 2017 to 2025 model cars were projected to double their fuel economy and reduce oil use by 2 million barrels per day.
3- The Recovery Act invested in fuel-efficient vehicle research and development to spur job growth and increase international competitiveness.
4- Federal loans helped convert factories to the production of fuel-efficient vehicles.

5- A "Cash for Clunkers" program that increased vehicle efficiency and helped save the auto industry by jump starting demand during the depths of the Great Recession.

Meanwhile, in Canada…

During that same period, the Canadian and Ontario governments decided to help the Canadian auto industry with a $13,7 billions bailout plan… that included no requirement for investments in more fuel-efficient vehicle research, development and production of these vehicles in Canada. As a result, Canada saw plant closures and therefore job losses in the Canadian automotive sector.[119]

A1.3. The Automotive Innovation Fund[120]

When we look at the archives from the government of Canada, we can read the following:
"In 2008 the federal government introduced the Automotive Innovation Fund (AIF), providing $250 million over five years to support strategic, large scale research and development projects in the automotive sector that support innovative, greener and more fuel-efficient vehicles. In 2016, changes were made to provide both payable and non-repayable contributions, expanding the list of eligibility costs to include land and buildings, and increase the maximum amount of contribution from $250 million to $500 million for greenfield investments.

The AIF will support Canada's environmental agenda in advancing Canadian capabilities in fuel-efficient automotive technologies, greenhouse gas reduction and clean technologies. It demonstrates the government's commitment to implementing Canada's Science and Technology (S&T) Strategy in an automotive context. The AIF also provides an important complement to the Government's agenda to support industry competitiveness, outlined in a plan called *Advantage Canada: Building a Strong Economy for Canadians.*

Under the AIF, Innovation, Science and Economic Development Canada will consider funding proposals that provide for private sector investment in Canada of more than $75 million until March 31, 2021. Eligible projects will include vehicle and powertrain assembly operations associated with significant automotive innovation and R&D initiatives. Other large-scale automotive innovation and R&D initiatives will also be considered, provided they meet the $75 million threshold.

Proposals will be assessed based on their contribution to:

- automotive R&D capacity and knowledge-based jobs in Canada;
- the government's S&T Strategy and environmental agenda;
- the development of innovative, fuel-efficient technologies or processes;
- the long-term economic benefit to Canada, including significant job creation/retention; and
- their potential to attract further investments to foster Canadian competitiveness.

---

119 "GM plant closure stirs questions about massive 2009 government bailout": https://www.thestar.com/politics/federal/2018/11/26/gm-plant-closure-stirs-questions-of-massive-2009-government-bailout.html

120 : https://www.ic.gc.ca/eic/site/auto-auto.nsf/eng/am02257.html

Support under the AIF will be provided for major automotive innovation and R&Dinitiatives to develop and build greener, more fuel-efficient vehicles, inclusive of:

- new product development (e.g., advanced emissions technologies, energy-efficient engines and transmissions, advanced materials, including engineered plastics, and lightweight components and materials);
- leading-edge engineering and design, and prototype development;
- advanced product testing that ensures cleaner, more efficient automotive performance, and reduces greenhouse gases;
- the development of new production methods and process technologies, including advanced flexible manufacturing techniques;
- new or expanded facilities to produce leading-edge and more energy efficient vehicles and powertrains;
- substantive investments in new flexible manufacturing processes; and
- introduction of other new transformative production technologies to substantially increase productivity and efficiency (e.g., robotics and advanced IT systems).
- Individual proposals will be evaluated in consideration of the strength of the business case, including with respect to R&D and innovation, environmental and economic benefits."

While interesting, the AIF had two important flaws:

a) **No support for SMEs working in electric mobility:** The AIF did not provide any financial support for Canadian SMEs invested in developing cleaner vehicles such as hybrid, plug-in hybrid and 100% electric vehicles since no SME could come up with $75 million. It therefore did not help startups in electric mobility which have demonstrated over the recent years that they could lead the innovation race.

b) **No obligation to offer the products for Canadians:** In 2011, the government of Canada, through the AIF, and the Ontario government each provided funding of $70.8 million for the assembly of the Toyota RAV4 EV in Woodstock, Ontario.[121] Since there was no obligation for Toyota to make these electric vehicles available to Canadians, all the RAV4 EVs produced in Ontario were shipped to California where there was a ZEV sales regulation. As a result, Canadians could not purchase these Canadian built EVs whose assembly had been financed by Canadian taxpayer's money.

[121] Ontario Puts A Charge Into Electric Vehicle Production: https://news.ontario.ca/en/release/19194/ontario-puts-a-charge-into-electric-vehicle-production

Electric Mobility Canada /Mobilité électrique Canada – www.emc-mec.ca – info@emc-mec.ca
38 place du Commerce, 11-530 Ile des Sœurs, QC H3E 1T8

Appendix 2 : Feedback from Electric Mobility Actors

Different OEMs Points of View

We have asked different organizations on how they saw the future of electric mobility with some questions related to their particular field of expertise and interest. We asked:

- Light duty OEMS: GM, Nissan, Tesla and Toyota
- Heavy Duty OEMs: Girardin, Lion, NewFlyer
- APMA
- Unifor
- A transit fleet manager: EXO
- NGOs: Pembina Institute, Clean Energy Canada, Plug'n Drive

Answers from General Motors:

a) How many different models of plug-in electric vehicles does your company sell globally?

GM: Unfortunately, we don't share global sale numbers for competitive advantage concerns. However, I can tell you that General Motors wants to put everyone in an EV. GM is on its way to an all-electric future, with a commitment to 30 new electric vehicles by 2025 and plans for additional models taking us beyond that.

b) How many do you expect to make available in Canada in 2021, and in which vehicle segments?

GM: In addition to the all-new 2022 Bolt EV & EUV, GM have moved up 12 EV vehicles programs, including the GMC HUMMER EV, three other GMC Ultium variants, including an EV pickup, four Chevrolet, including a pickup, and compact crossovers and four Cadillac.

c) How many plug-in electric vehicles in total does your company plan to sell in Canada in 2021?

GM: Unfortunately, we don't share forecast sales. The answer will depend on consumer demand, which is hard to predict at this time.

d) What are the main challenges you see for increasing electric vehicle sales in Canada?

GM: We would need strong consumers incentives, more charging infrastructures for urban people (i.e condominium) and more consumer education on EV. If we look at the Norwegian success story is first and foremost due to a substantial package of consumer incentives developed to promote zero-emission vehicle in the market. Things like sales tax exemption, free municipal parking, access to bus lanes, road toll reductions etc. Also, I can tell you that GM and EVgo in the U.S are collaborating to build out more than 2,700 public fast chargers over the next five years to help

make charging more accessible and convenient to consumers. GM Canada is also working on some innovative ways to get people to adopt EV's.

e) Do you plan to manufacture electric vehicles in Canada? If so, how many per year in 2022-2023?

GM: General Motors recently announced plans to bring production of its **BrightDrop** electric light commercial vehicle, the EV600, to its CAMI manufacturing plant in Ingersoll, Ontario. The approximately C$1 billion investment will support GM's timing to deliver BrightDrop EV600 in late 2021. The investment will enable GM to make CAMI into Canada's first large-scale auto plant converted to produce electric delivery vehicles in Canada. Work already began to transform the CAMI plant to support electric vehicle production.

f) What could the Government of Canada do to help you accelerate the penetration of electric vehicles in Canada?

GM: Part of this question was answered above (#4) but in addition to the existing federal incentives, we need all Canadian provinces to expend their EV infrastructures. We think that the government of Quebec is doing a good job regarding consumer education, infrastructures and incentives for over 10 years now and we are looking into the other provinces to replicate the different actions we see in Quebec. Also, the new EV models (not only GM) will soon come with larger batteries (i.e HUMMER or future GM EV pickup) so the government will need to adjust the incentives appropriately. It's time that zero emission vehicles be truly zero emission vehicles (i.e incentives exclusively for full electric models, no plug-in)

Answers from Nissan

a) How many different models of plug-in electric vehicles does your company sell globally?

Nissan: We sell the LEAF in 51 countries. We also sell the eNV200 in selected markets. There are also EVs that are sold by our other companies (DFAC, DF Nissan, DF Venucia, ZNA) for the Chinese market only.

b) How many do you expect to make available in Canada in 2021, and in which vehicle segments?

Nissan: One, the Nissan LEAF (in the compact segment). On a related note, we are looking forward to the arrival of the all-new Nissan Ariya electric crossover to Canadian showrooms - timing for that will be announced at a later date.

c) How many plug-in electric vehicles in total does your company plan to sell in Canada in 2021?

Nissan: Not applicable

Electric Mobility Canada /Mobilité électrique Canada – www.emc-mec.ca – info@emc-mec.ca
38 place du Commerce, 11-530 Ile des Sœurs, QC H3E 1T8

d) What are the main challenges you see for increasing electric vehicle sales in Canada?

Nissan: The main challenges in Canada are EV awareness, stable/significant rebate in more than 2 provinces and the limited charging infrastructure

e) Do you plan to manufacture electric vehicles in Canada? If so, how many per year in 2022-2023?

Nissan: none

f) What could the Government of Canada do to help you accelerate the penetration of electric vehicles in Canada?

Nissan: Invest in Customer Awareness Campaign; continue Purchasing Incentives for new EVs - $5,000 Federal Rebate; fiscal Incentives: GST and PST Exemption on the purchase of new and all-electric pre-owned EVs; fast Charging Infrastructure for EVs; financial Incentives for the purchase and installation of an EV charger (at work or at home); focus on the provinces with no EV strategy; Keep an open line of communication with the Manufactures to ensure the demand is met.

Answers from Tesla

a) **How many different models of plug-in electric vehicles does your company sell globally**?

Tesla: 4 BEV models : Model 3, Model Y, Model S, Model X

b) How many do you expect to make available in Canada in 2021, and in which vehicle segments?

Tesla: We expects to deliver its first Semi by the end of 2021 (Heavy-duty vehicle). Deliveries of Cybertruck are expected to start in late 2021/early 2022 (expected to be a light-duty truck).

c) How many plug-in electric vehicles in total does your company plan to sell in Canada in 2021?

Tesla : N/A

d) What are the main challenges you see for increasing electric vehicle sales in Canada?

Tesla: 1. Limited supply (growing steadily). 2. Incentive eligibility rules which arbitrarily penalize long range BEVs (especially those equipped with AWD) and favour PHEVs, due to their lower MSRP.

e) Do you plan to manufacture electric vehicles in Canada? If so, how many per year in 2022-2023?

Tesla : N/A

Electric Mobility Canada /Mobilité électrique Canada – www.emc-mec.ca – info@emc-mec.ca
38 place du Commerce, 11-530 Ile des Sœurs, QC H3E 1T8

f) What could the Government of Canada do to help you accelerate the penetration of electric vehicles in Canada?

Tesla:

1- Move away from tax-funded EV purchase incentives and towards a new non-tax, revenue-neutral, regulatory charge program (a feebate).
2- Provide medium/long-term visibility into the future of EV incentives, to help manufacturers plan vehicle supply, and consumers plan their purchase.
3- Bring the Clean Fuel Standard into effect as soon as possible, to unleash private sector funding to augment public investments in charging and incentives, and ensure 100% of electricity used in transportation is counted.
4- Focus charging infrastructure efforts on existing multi-unit residential buildings: rental apartments and condominiums/strata. Enable power capacity for at least 100,000 multi-unit residential parking stalls by 2025.
5- Establish a national Zero Emission Vehicle (ZEV) Standard backstop with equivalency. Exclude provinces which already have their own ZEV Standards, if those standards meet or exceed the federal standard.

Answers from Toyota:

a) How many different models of plug-in electric vehicles does your company sell globally?

Toyota: Globally, we sell four plug-in hybrid electric models (Corolla PHV, Levin PHV, Prius Prime and RAV4 Prime). We also sell BEVs in Europe and Asia.

b) **How many do you expect to make available in Canada in 2021, and in which vehicle segments?**

In Canada, we sell the plug-in hybrid electric Prius Prime (Compact car) and the plug-in hybrid electric RAV4 Prime (Compact SUV).

c) How many plug-in electric vehicles in total does your company plan to sell in Canada in 2021?

Toyota: We don't share our sales forecasts.

d) What are the main challenges you see for increasing electric vehicle sales in Canada?

Toyota: Toyota is the number one seller of electrified vehicles in Canada. Since the launch of the Toyota Prius in 2000, Toyota Canada has sold more than 250,000 hybrid electric vehicles. In 2020 alone, we sold more than 35,000. While Toyota shares the goal of Canadian governments to reduce carbon/GHG emissions, and we're working with governments to help bring more advanced technologies to market, we believe the true challenge is overall carbon reduction - not simply selling more battery electric vehicles. A comprehensive approach to powertrain

Electric Mobility Canada /Mobilité électrique Canada – www.emc-mec.ca – info@emc-mec.ca
38 place du Commerce, 11-530 Ile des Sœurs, QC H3E 1T8

technologies is necessary – one that includes BEVs, PHEVs, FCEVs, and HEVs. Each of these technologies will have a unique role to play in reducing our overall GHG emissions.

Ultimately, each consumer will decide which technology is right for their lifestyle and budget, and we will continue to provide a portfolio of options, including plug-in hybrid electric, fuel cell electric, hybrid electric, and battery electric vehicles. Currently, battery electric vehicles are still generally expensive compared to other powertrains and not everyone can afford a battery electric vehicle. They're also not always suited to everyone's lifestyle (i.e. urban dwellers with only street parking).

As relative cost decreases and structural concerns related to battery electric vehicles (charging infrastructure, charging time, range, cold weather performance, impact on lifestyle, etc.) improve, consumer demand will also improve. And, as customer adoption rates increase, Toyota will be prepared to meet the demand. Meanwhile, because BEVs and PHEVs can't currently meet everyone's needs, we are also deploying other technologies to further reduce carbon emissions. We are bolstering our efforts with the deployment of zero-emission FCEVs into high-use fleet applications - such as our recently launched KINTO Share proof-of-concept program with Lyft in B.C. - and we look forward to continuing to grow this space. As a result, Toyota is now taking a leadership role in advancing the adoption of three of the four electrified options currently available to Canadians, and we'll soon have products in the fourth category (BEV).

e) Do you plan to manufacture electric vehicles in Canada? If so, how many per year in 2022-2023?

Toyota: Toyota has been producing high-tech electrified vehicles in Canada for almost a decade. We also already have a track record of producing EVs in Canada and, therefore, are well positioned for the future as the market evolves and as the supply chain builds out. Today, we build North America's best-selling hybrid electric SUV, the Toyota RAV4 hybrid, and best-selling luxury hybrid electric SUV, the Lexus RX hybrid. Starting in 2022, we'll also be building the Lexus NX hybrid in Canada. Our recent investments ensure Toyota's Canadian plants are well-positioned to build *any* vehicle the company asks us to build – including the most advanced electrified models that will be coming to our market over the next few years. But we don't comment on future production plans before they are announced.

f) What could the Government of Canada do to help you accelerate the penetration of electric vehicles in Canada?

While Toyota shares the goal of Canadian governments to reduce carbon emissions, and we're working with governments to help bring more advanced technologies to market, we don't believe governments should focus their energy on "accelerating the penetration of electric vehicles". Since the true challenge is overall carbon reduction - not simply selling more battery electric vehicles – we believe governments should focus on a broad-based strategy for reducing overall carbon emissions from transportation. It's very possible to increase battery electric vehicle adoption while also seeing an *increase* in overall emissions, particularly as consumer preferences continue to trend toward larger pickup trucks and SUVs.

Focusing on only one potential solution will not lead us to a successful outcome. A comprehensive approach to powertrain technologies is necessary – one that includes BEVs, PHEVs, FCEVs, and HEVs. Each of these technologies will have a unique role to play in reducing our overall GHG emissions

Answers from APMA:

a) **How do you view the future of electric mobility as an association?**

APMA: It's critical because the fact is that our members are suppliers to OEMs, so it's critical for us BECAUSE it's critical for them. The value equation will increase because of the value of the technology.

b) **To what extent are the auto parts manufactured in Canada for zero-emission vehicles produced either in Canada or abroad?**

APMA: Some parts but nothing strategic like batteries, motors, BMS for now: aluminum, parts, etc
.

c) **What are you concerns regarding Canadian jobs as we shift towards electric vehicles (LDVs and HDVs)? How are your members preparing for this transition?**
APMA: Concerns are that massive OEM investment is taking place with very small volumes on the horizon (by 2025 in North America estimates are 1.4 million EVs in production compared on average 16-18 million vehicles produced) – most suppliers have business models based on volume production vs value-add per vehicle produced which is fine even in low volume environments. We have to make sure that, has we pull people on board, the members are ready for the transition. Our members are worried that Canadian parts manufacturers will be worth less comparatively to the battery suppliers and other high tech companies. Tesla is a perfect example of that fact.

d) **Do you have any data regarding potential future jobs for Canadian workers in the auto parts manufacturing as we transition towards electrification of transportation?**

APMA: What we do know is that any part of mobility will become more and more commoditized.

Answers from Girardin buses

a) **How many different models of plug-in electric vehicles does your company sell globally? How many do you expect to make available in Canada in 2021, and in which vehicle segments?**

Girardin: 8 models, 4 type ''A'' 100% electric buses made in Quebec (2 School bus type and 2 commercial type), 2 type ''C'' electric buses (1 School bus type and 1 commercial type) and 2 type ''D'' electric buses (1 School bus type and 1 commercial type)

Electric Mobility Canada /Mobilité électrique Canada – www.emc-mec.ca – info@emc-mec.ca
38 place du Commerce, 11-530 Ile des Sœurs, QC H3E 1T8

b) **How many plug-in electric vehicles in total does your company plan to sell in Canada in 2021?**

Girardin: 8 models, 4 type ''A'' 100% electric buses made in Quebec (2 School bus type and 2 commercial type), 2 type ''C'' electric buses (1 School bus type and 1 commercial type) and 2 type ''D'' electric buses (1 School bus type and 1 commercial type)

c) **What are the main challenges you see for increasing electric vehicle sales in Canada?**

Girardin: To get better autonomy range and get more funding for the acquisition and electric charging infrastructure.

d) **Do you plan to manufacture electric vehicles in Canada? If so, how many per year in 2022-2023?**

Girardin: We are building electric buses since 2017 in Drummondville Quebec, the quantity for 2022-2023 will be around 200-250 units.

e) **What could the Government of Canada do to help you accelerate the penetration of electric vehicles in Canada?**

Girardin: To get more funding for the acquisition and electric charging infrastructure.

Answers from Lion Electric :

a) **How many different models of plug-in electric vehicles does your company sell globally? How many do you expect to make available in Canada in 2021, and in which vehicle segments**

Lion: I would like to highlight the unmatched line-up of seven purpose-built all-electric models that Lion has available for sale today, a mix of medium-duty and heavy-duty trucks and buses that demonstrate a great commonality across the platforms, which eases our production challenges and provides increased economies of scale. Furthermore, within the next two years, we expect to reveal seven new truck models and one new school bus, for a total of 15 all-electric vehicles, representing a full line-up from class 5 to class 8 electric trucks and a full line-up of electric school buses.

b) **How many plug-in electric vehicles in total does your company plan to sell in Canada in 2021?**

Lion: I cannot provide that number at this moment since we are in the process of going public, we can only publish what's available, objectives for 2021 are 400 trucks and 250 buses for a total of 650 vehicles globally.

c) **Do you expect to sell electric trucks in Canada by the end of 2022?**

Lion: I cannot provide that number at this moment since we are in the process of going public, we can only publish what's available, objectives for 2021 are 1800 trucks and 675 buses for a total of 2475 vehicles globally.

d) **What are the main challenges you see for increasing electric vehicle sales in Canada?**

Lion: Legislation, incentives and we need a Buy Canadian Act, Education.

e) **Do you plan to manufacture electric vehicles in Canada? If so, how many per year in 2022-2023?**

Lion: Yes, 2500

f) **What could the Government of Canada do to help you accelerate the penetration of electric vehicles in Canada?**

Lion: Legislation to favor electric, incentives for the next 5 to 7 years to reduce price difference between electric and diesel. We need a Buy Canadian Act, growth of the supply chain in Canada, volume will reduce prices on our components the Lion is buying from Canadian suppliers, Education.

Answers from NewFlyer

a) **How many different models of plug-in electric vehicles does your company sell globally? How many do you expect to make available in Canada in 2021, and in which vehicle segments?**

NewFlyer: NA

b) **How many plug-in electric vehicles in total does your company plan to sell in Canada in 2021?**

NewFlyer: We are very cautious with forecasts.

c) **Do you expect to sell electric buses in Canada by the end of 2022?**

NewFlyer: Yes, we sell electric vehicles in Canada 'today' and will continue into 2022 and beyond

d) **What are the main challenges you see for increasing electric vehicle sales in Canada?**

NewFlyer: Education on both the technology & the operational differences to manage routes, range and charging times; the cost of infrastructure and the cost of high voltage batteries; scaling infrastructure to support a whole garage of ZE buses

e) **Do you plan to manufacture electric vehicles in Canada? If so, how many per year in 2022-2023?**

Electric Mobility Canada /Mobilité électrique Canada – www.emc-mec.ca – info@emc-mec.ca
38 place du Commerce, 11-530 Ile des Sœurs, QC H3E 1T8

NewFlyer: No. We will start the production of Electric bus 'bodies' in Canada but will finish that production including the installation of the batteries and electric motors in the US.

f) What could the Government of Canada do to help you accelerate the penetration of electric vehicles in Canada?

NewFlyer: Like in the US mandate ZEV fleets by 'a date' but support that mandate with funding for both vehicles and infrastructure; retail is a vary different market place – I cannot comment at this time. Other than to state, cost is always a barrier no matter how much the public claim they want to go electric.

Answers from Unifor

a) How do you view the future of electric mobility as union?

Unifor: Canada needs an industrial strategy that develops new green manufacturing capacity. This must include a "National Auto Strategy" that includes aggressive incentives to capture manufacturing investments for electric vehicles. Our auto assembly plants are hubs for advanced technological innovation, critical research and development, and thousands of local supply-chain jobs. Every auto assembly line job supports 10 others throughout the economy.

The auto sector is a critical sector in Unifor's representation of workers, with more than 40,000 members involved in vehicle and powertrain assembly, component parts manufacturing and working in auto dealerships. Electric mobility is the future for all modes of transportation. Unifor is fully engaged with business and government to ensure Canadian workers are part of those investments.

b) What are your concerns regarding Canadian jobs as we shift towards electric vehicles (LDVs and HDVs)?

Unifor: Our goal is to ensure that there are true and well-planned labour market impact assessments developed well ahead of these changes. We are committed to ensure our collective bargaining agreements support fair and respectful worker transitions to work as closely aligned with original worker skills as possible including defined income, security and safety.

This would include retraining & skills upgrading (including apprenticeships). Preferential hiring agreements would be a critical part of any realized job reduction that may be transferred to component part manufacturing.

c) What do you think the governments can do to help in that transition?

Unifor: The Federal government has an opportunity to build back better following the COVID crisis. The establishment of a Just Transition Minister would provide opportunity to bring together the sector experts to advise on the development of a National Just Transition Action Plan.

Canada has a rich inventory of natural resources, world-class researchers, a well-established history of auto making and unparalleled access to emissions-free electricity. Our governments at the federal and provincial level have the tools at their hands to manage these resources in a manner that can maximize Canadian employment. For example, we can manufacture the EV batteries in Canada rather than simply mining and exporting those natural resources to another country.

The federal government can also allocate appropriate funding toward a Zero Emission Vehicle Industrial Strategy Council, responsible for identifying and mapping Canada's supply chain capacity (and gaps), coordinating dialogue among key stakeholders (including workers), forecasting future product development and needs and advising government on strategic action; and

In the upcoming federal budget, Unifor is also calling on the federal government to introduce a national vehicle trade-in program that provides a one-time financial incentive to car owners who trade-in older, higher polluting vehicles and purchase newer, more fuel-efficient alternatives. Such a program will boost sales that have fallen to their lowest levels since 2009 (and nearly 20% below pre-pandemic levels) and stimulate economic activity.

d) Do you have any data regarding potential future jobs for Canadian workers in electric mobility?

Unifor: Unifor auto bargaining commitments in 2020 and 2021 between the Detroit 3 will bring a total investment of nearly $6 billion in manufacturing to Canada.

The Ford deal reached in September included $1.95 billion to bring battery electric vehicle production to Oakville Ontario. The Fiat Chrysler agreement included more than $1.5 billion for a state-of-the-art platform to build both Plug-In Hybrid Vehicles and Battery Electric Vehicles in Windsor Ontario. General Motors agreed to invest $1 billion dollars to begin large-scale commercial production of EV600, an all-electric van, to be built in Ingersoll Ontario.

Answers from EXO

a) How many light-duty passenger vehicles are in your fleet?

EXO: 0

b) How many buses and motor coaches are in your fleet?

EXO: 650

c) How many all-electric vehicles do you have in each of the 3 categories?

d) EXO:

0

Electric Mobility Canada /Mobilité électrique Canada – www.emc-mec.ca – info@emc-mec.ca
38 place du Commerce, 11-530 Ile des Sœurs, QC H3E 1T8

e) How many do you expect to have in 2025, for each of the 3 categories?

EXO: 30

f) How many plug-in hybrids do you have in each of the three categories?

EXO: 0

g) How many do you think you will have in 2025, for each of the 3 categories?

EXO: 0

h) Have you experienced any difficulties to date with all-electric or plug-in hybrid vehicles? If so, please elaborate briefly.

EXO: We don't have any Hybrid or Electric yet

i) What barriers or challenges do you see in electrifying your fleet?

EXO: Garage adaptation or construction, length of transition because of natural life cycle of diesel bus (16 years for us), funding, technical expertise for maintenance, electrical equipment, planification of service regarding autonomy limitations, how to keep up with battery technology evolving when our bus are supposed to last 16 years?

j) What measures would you like the government of Canada to put in place to facilitate the penetration of electric vehicles?

Reduce the duration of funding so we can amortize the diesel buses quicker and therefore accelerate the full transition

k) When do you plan to complete the electrification of your fleet?

EXO: 2040

Answers from NGOs :

Plug'n Drive

a) What could the Government of Canada do to help you accelerate the penetration of electric vehicles in Canada? a) EV rebates b) Infrastructure deployment c) Education d) ZEV sales mandate e) other

Plug'n Drive: All of the above! Rebates on new and used. Also the model building code changed to require all new multi unit buildings be built to be ev ready (rough in).

b) What are the most challenging issues regarding EV adoption in Canada?

Plug'n Drive: Lack of supply and lack of knowledge.

c) How can Canada become a leader in EV industry?

Plug'n Drive: Maximize capabilities in mining and manufacturing, at the same time encouraging adoption through mechanisms in 1 above.

Clean Energy Canada

a) What could the Government of Canada do to help you accelerate the penetration of electric vehicles in Canada? EV rebates b) Infrastructure deployment c) Education d) ZEV sales mandate e) other

CEC: All of the above. Ambitious vehicle emission standards are another.

b) What are the most challenging issues regarding EV adoption in Canada?

CEC: Higher upfront cost, perceived range anxiety, lack of ZEV supply, lack of familiarity with EVs/education.

c) How can Canada become a leader in EV industry?

1- Pursue a North American battery strategy that builds on the Canada-U.S. Joint Action Plan on Critical Minerals, carves out specific opportunities for Canada to add value beyond material extraction, and works towards battery self-reliance by 2030.
2- Grow domestic demand for batteries in a variety of vehicle segments and end uses.
3- Accelerate mineral production and processing, with a focus on nickel and lithium.
4- Establish one or two national battery manufacturing champions to support a robust supply chain up- and downstream
5- Better promote Canada's clean and responsible battery brand abroad to attract foreign investment and land a large-scale battery cell producer.

Answers from AQLPA

a) What could the Government of Canada do to help you accelerate the penetration of electric vehicles in Canada? EV rebates b) Infrastructure deployment c) Education d) ZEV sales mandate e) other

AQLPA: The Government of Canada needs to stimulate the market by investing heavily to support the deployment of the necessary infrastructure in the short and long term, while at the same time requiring all automakers to offer enough plug-in electric and hybrid vehicles to meet demand more quickly. The Government of Canada could perhaps provide tax deductions for a period of 3 to 5 years to taxpayers/individuals who switch from a gasoline-powered vehicle to an electric vehicle based on the GHG reductions achieved based on the price per tonne of carbon credits.

b) What are the most challenging issues regarding EV adoption in Canada?

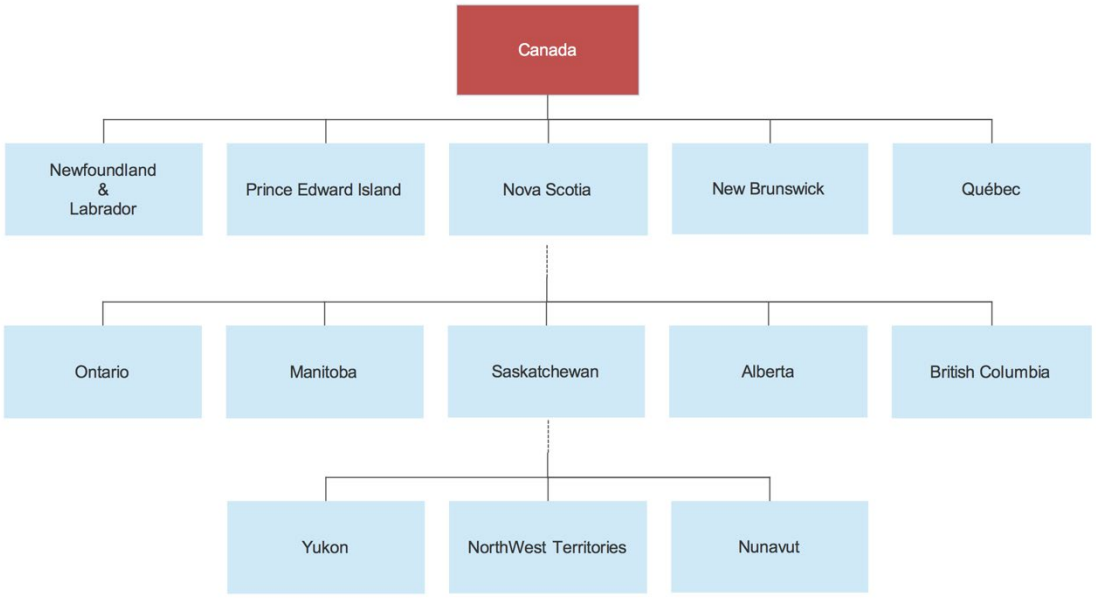
AQLPA: - Green and renewable electricity supply + Adoption of a ZEV mandate

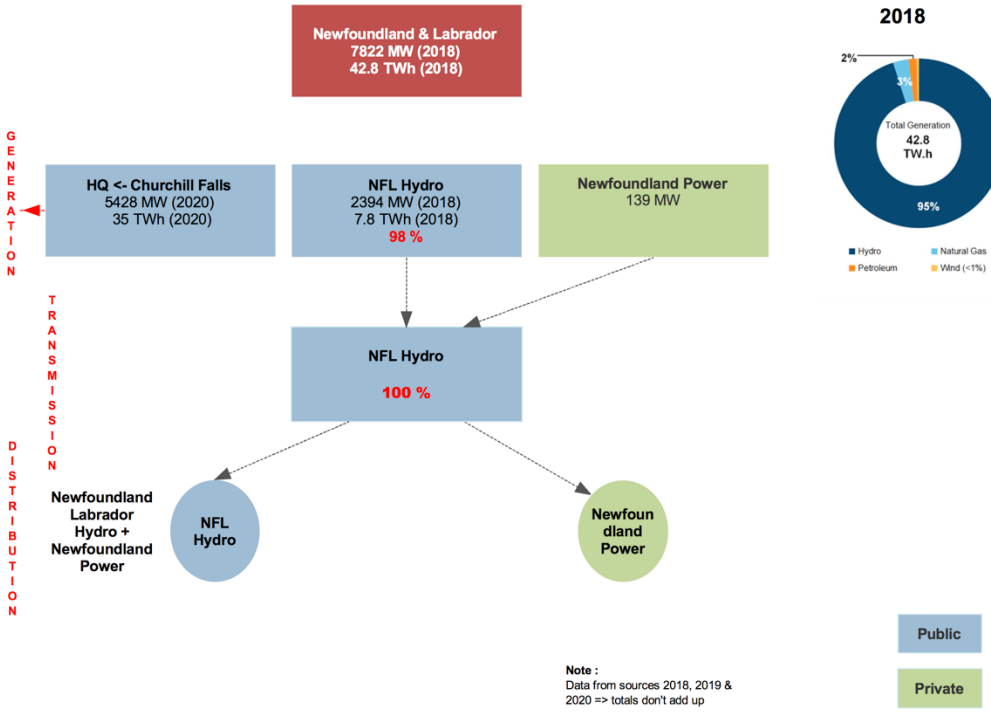
c) How can Canada become a leader in EV industry?

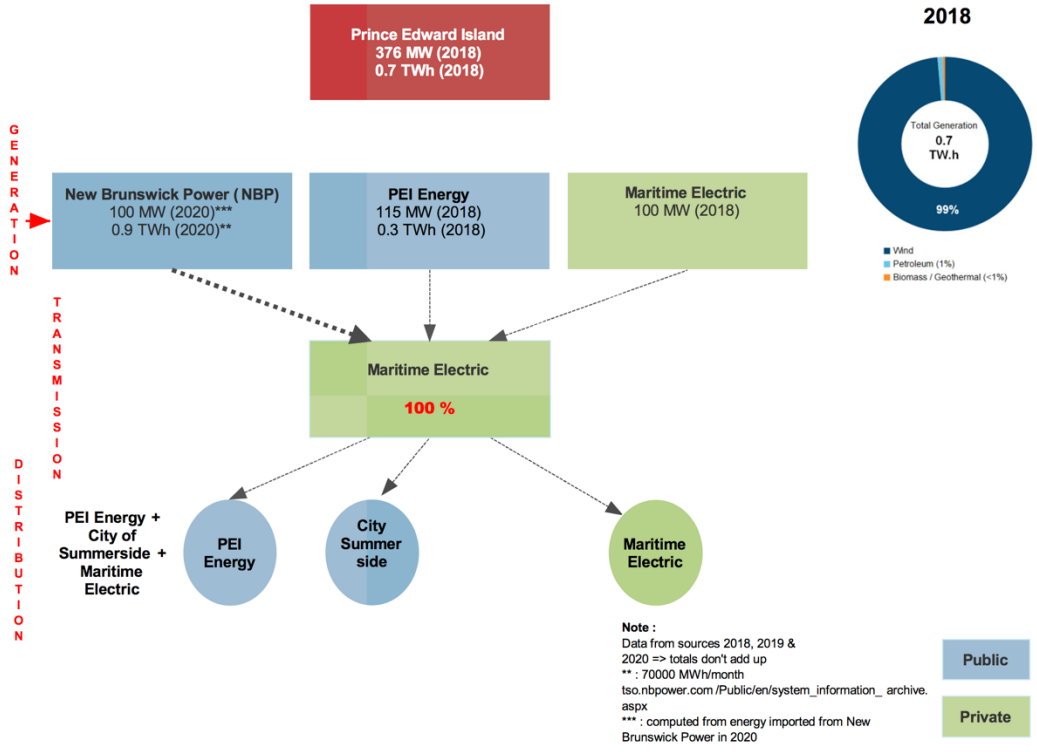
By providing more convincing support to Canadian equipment manufacturers and Canadian manufacturers of electric buses and trucks.

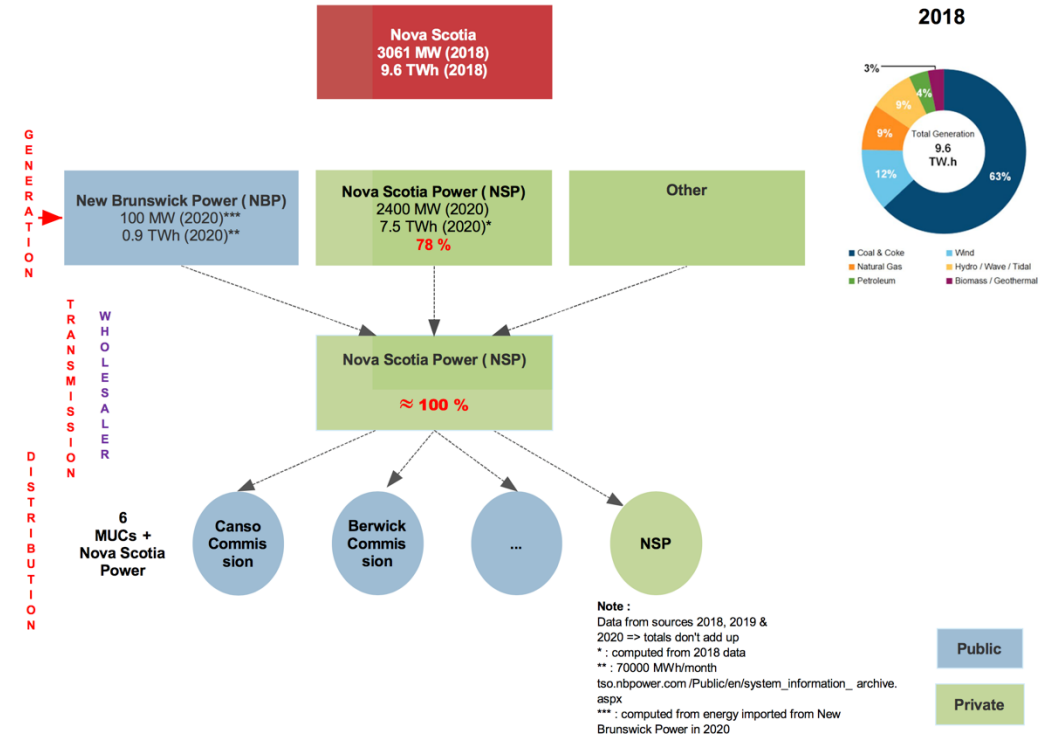
Electric Mobility Canada /Mobilité électrique Canada – www.emc-mec.ca – info@emc-mec.ca
38 place du Commerce, 11-530 Ile des Sœurs, QC H3E 1T8

Appendix 3 : Flowcharts for the Requirements on Electric Grids

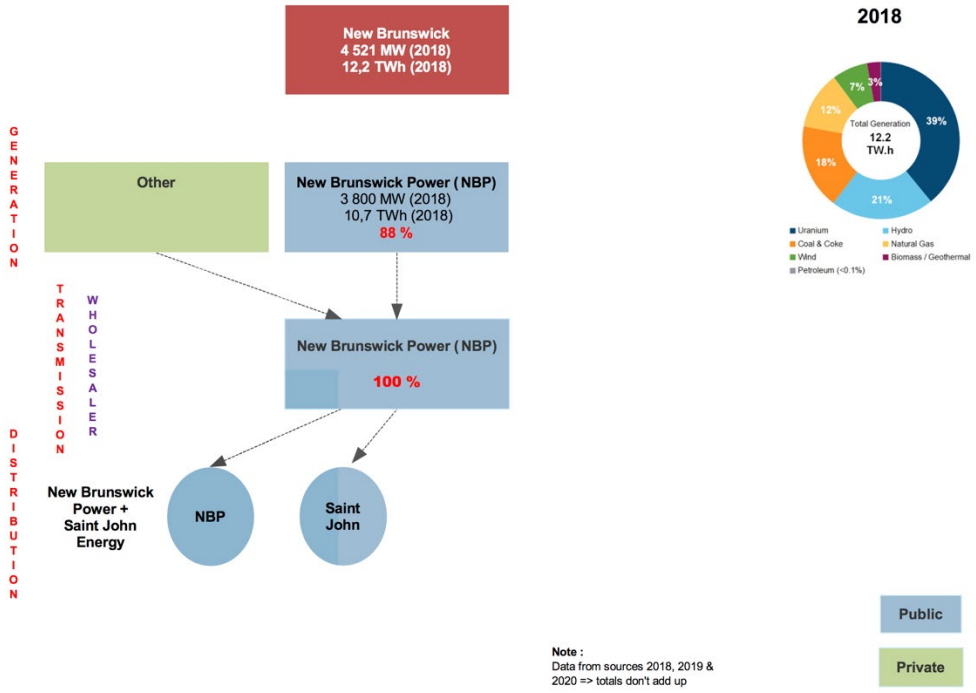


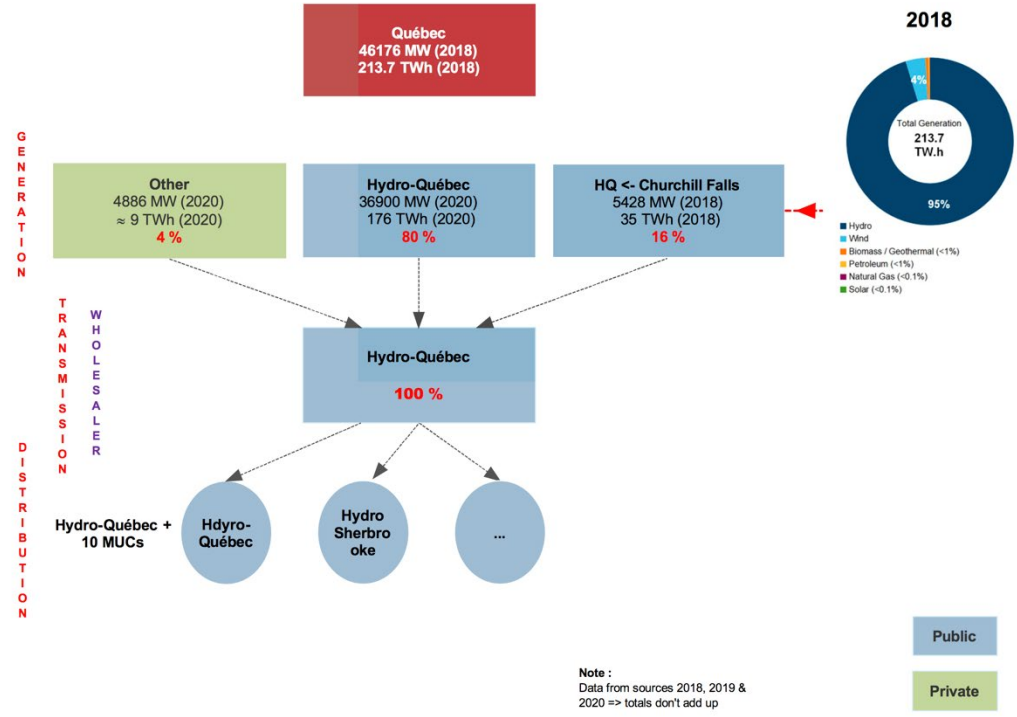




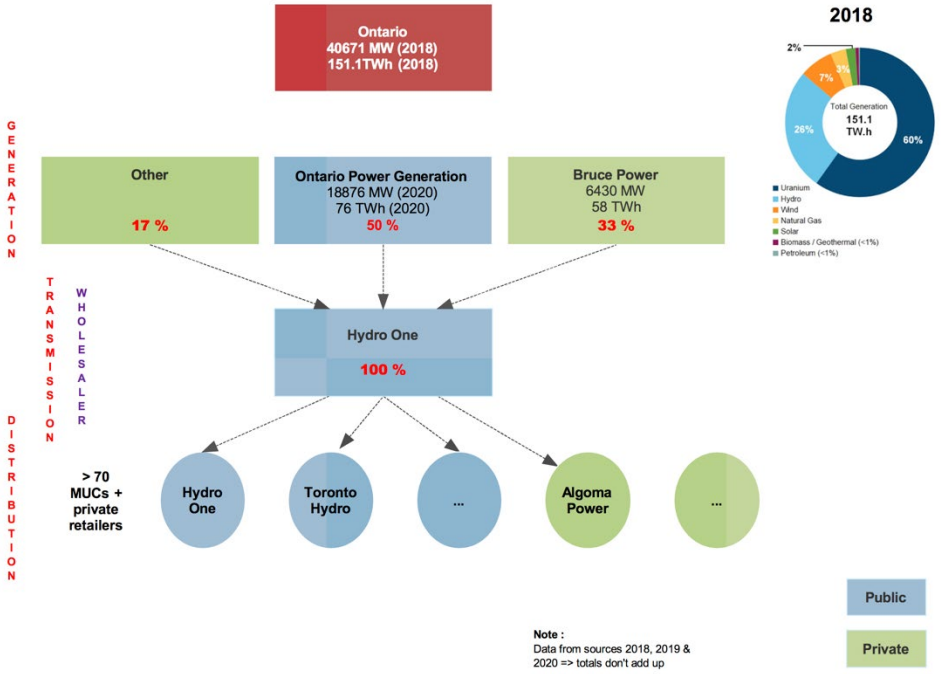


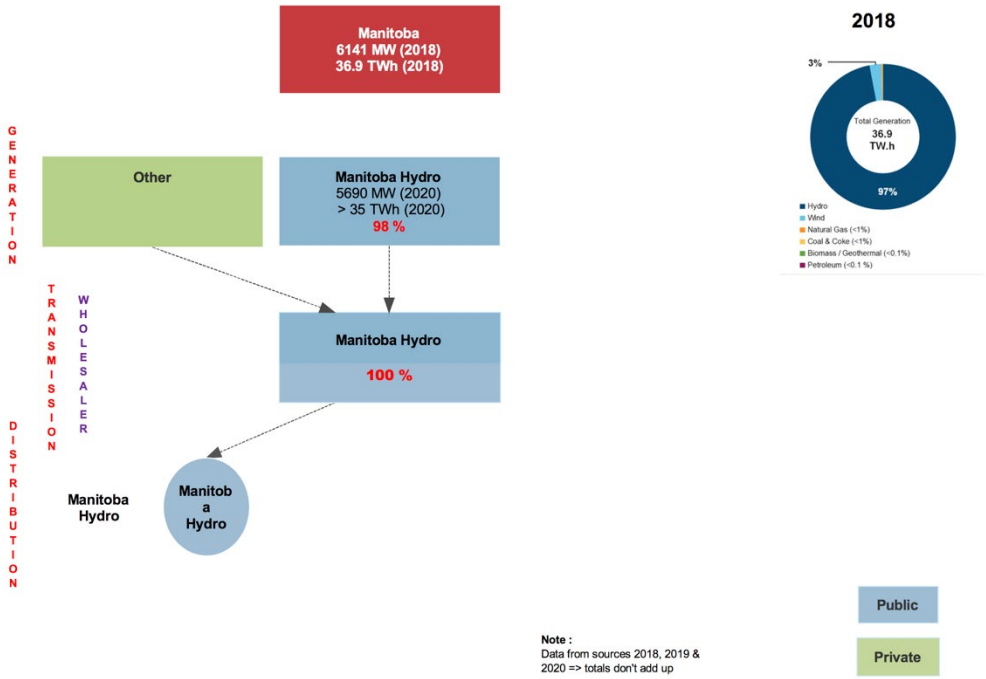
Electric Mobility Canada /Mobilité électrique Canada – www.emc-mec.ca – info@emc-mec.ca
38 place du Commerce, 11-530 Ile des Sœurs, QC H3E 1T8



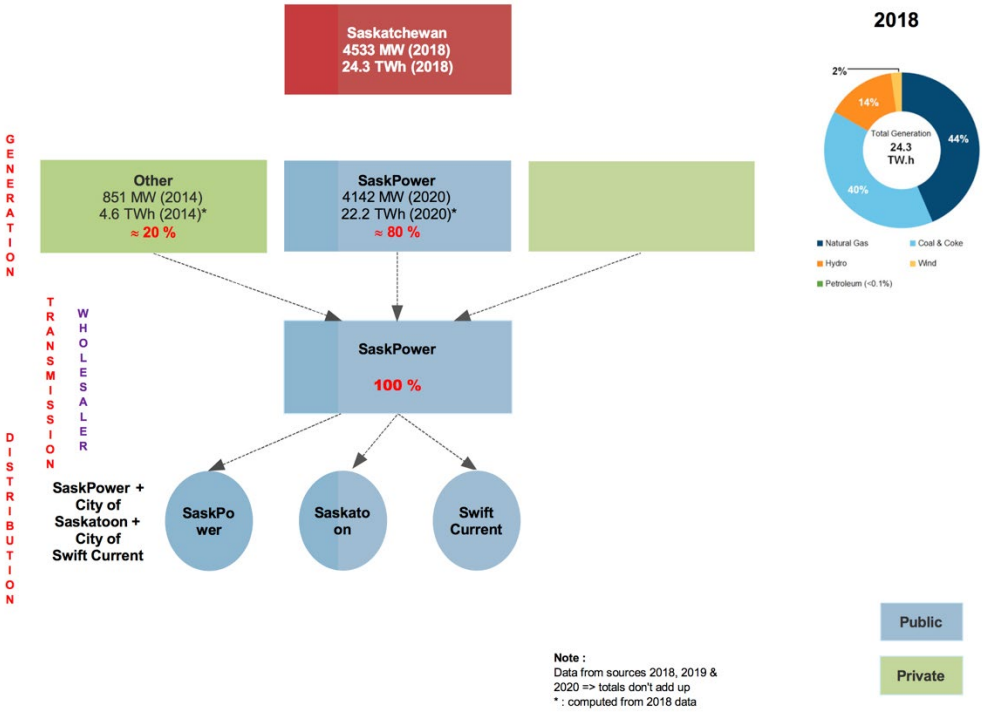


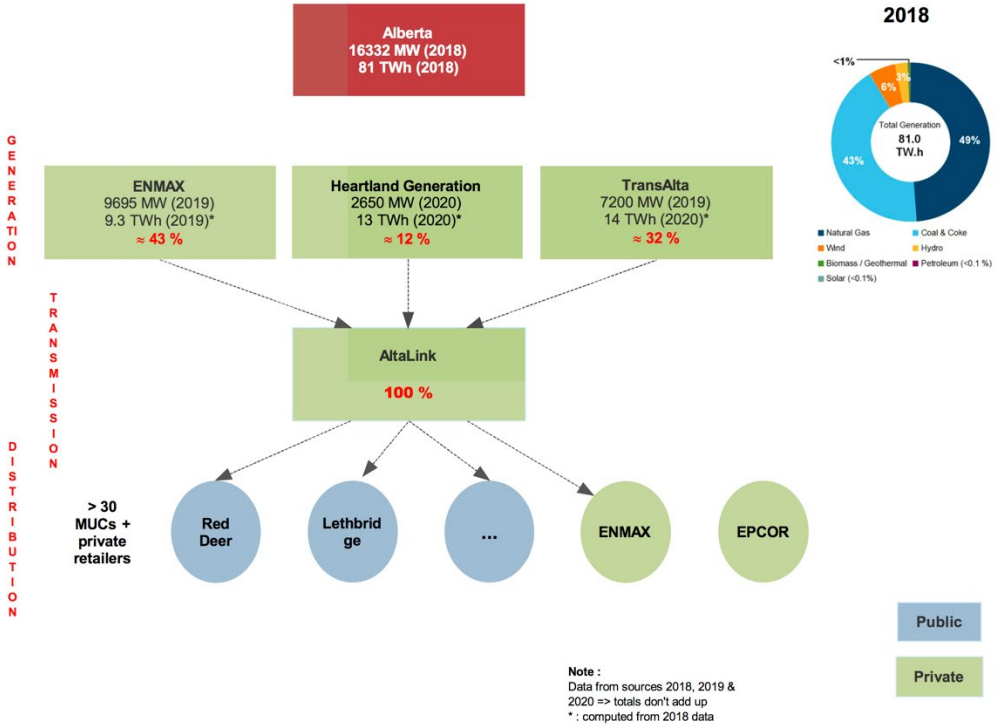
Electric Mobility Canada /Mobilité électrique Canada – www.emc-mec.ca – info@emc-mec.ca
38 place du Commerce, 11-530 Ile des Sœurs, QC H3E 1T8

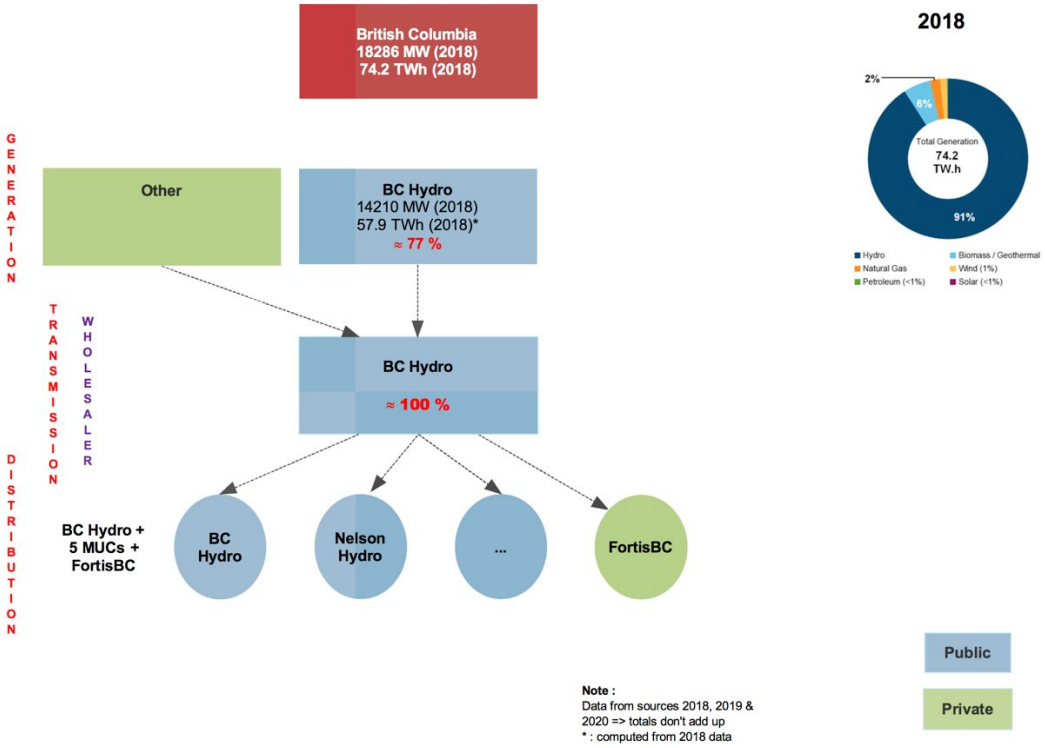


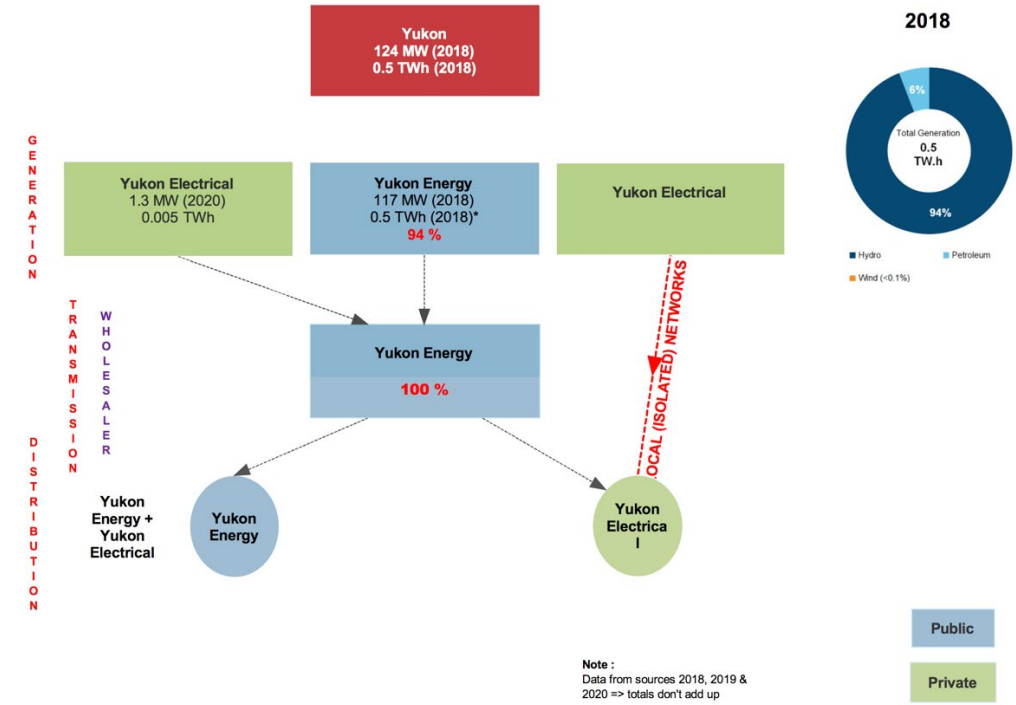


Electric Mobility Canada /Mobilité électrique Canada – www.emc-mec.ca – info@emc-mec.ca
38 place du Commerce, 11-530 Ile des Sœurs, QC H3E 1T8

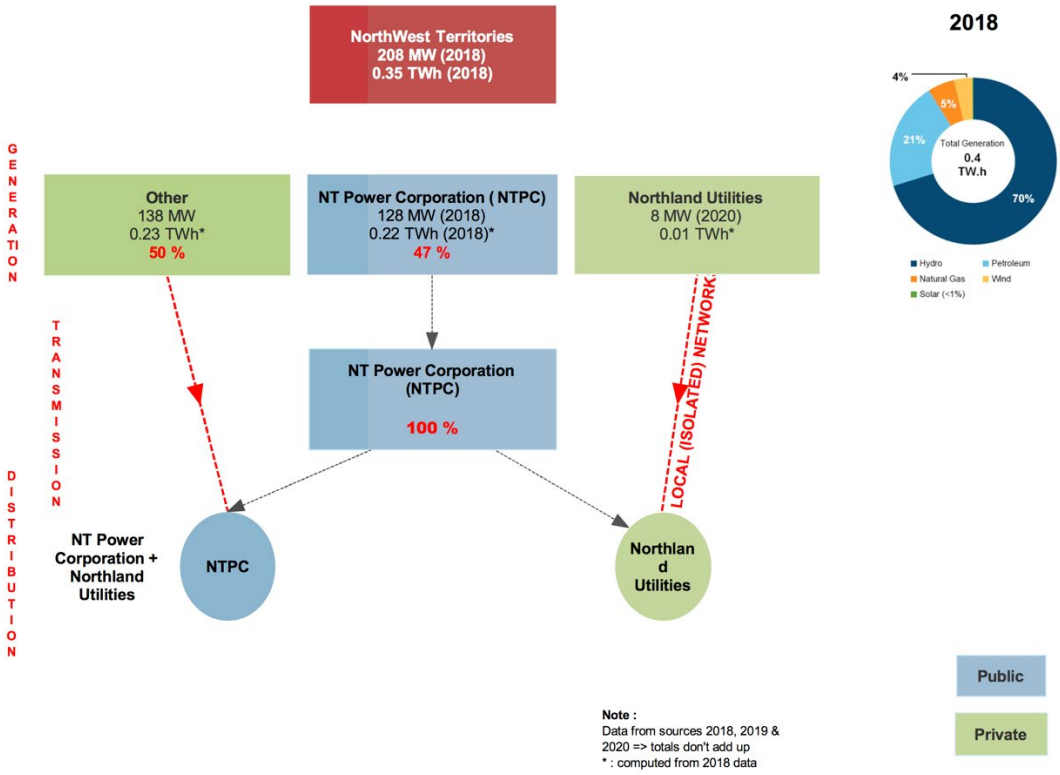

Saskatchewan
4533 MW (2018)
24.3 TWh (2018)
GENERATION
Other
851 MW (2014)
4.6 TWh (2014)*
≈ 20 %
SaskPower
4142 MW (2020)
22.2 TWh (2020)*
≈ 80 %
TRANSMISSION
WHOLESALER
SaskPower
100 %
DISTRIBUTION
SaskPower + City of Saskatoon + City of Swift Current
SaskPower
Saskatoon
Swift Current
2018
2%
14%
44%
40%
Total Generation
24.3
TW.h
Natural Gas
Coal & Coke
Hydro
Wind
Petroleum (<0.1%)
Public
Private
Note :
Data from sources 2018, 2019 & 2020 => totals don't add up
* : computed from 2018 data

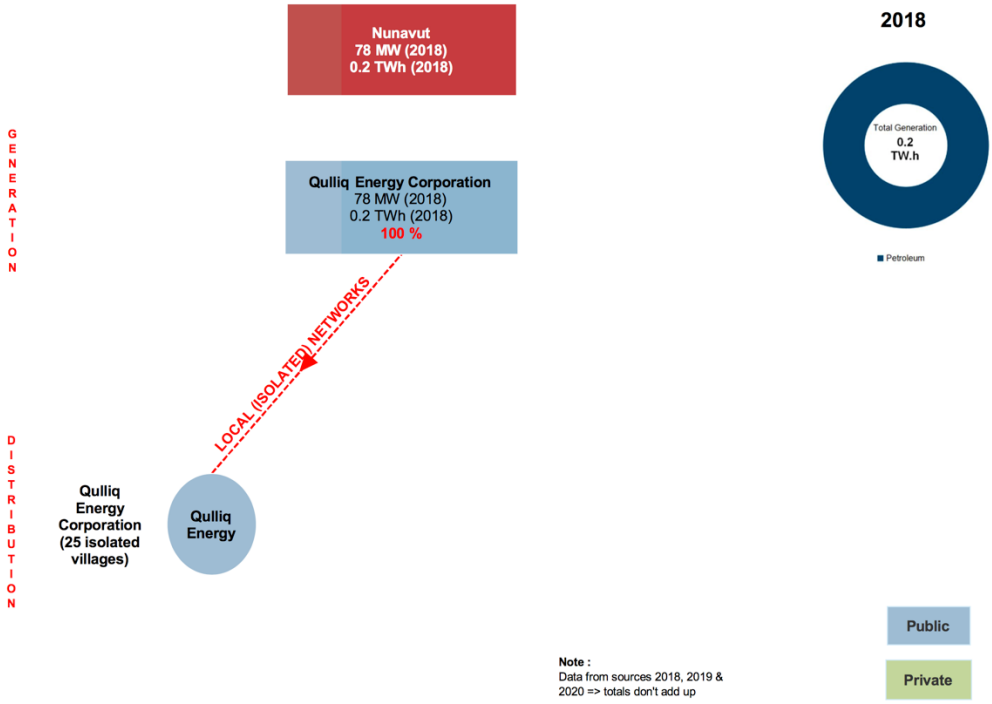

Alberta
16332 MW (2018)
81 TWh (2018)
GENERATION
ENMAX
9695 MW (2019)
9.3 TWh (2019)*
≈ 43 %
Heartland Generation
2650 MW (2020)
13 TWh (2020)*
≈ 12 %
TransAlta
7200 MW (2019)
14 TWh (2020)*
≈ 32 %
TRANSMISSION
AltaLink
100 %
DISTRIBUTION
> 30 MUCs + private retailers
Red Deer
Lethbridge
...
ENMAX
EPCOR
2018
<1%
3%
6%
49%
43%
Total Generation
81.0
TW.h
Natural Gas
Coal & Coke
Wind
Hydro
Biomass / Geothermal
Petroleum (<0.1 %)
Solar (<0.1%)
Public
Private
Note :
Data from sources 2018, 2019 & 2020 => totals don't add up
* : computed from 2018 data





Electric Mobility Canada /Mobilité électrique Canada – www.emc-mec.ca – info@emc-mec.ca
38 place du Commerce, 11-530 Ile des Sœurs, QC H3E 1T8





Electric Mobility Canada /Mobilité électrique Canada – www.emc-mec.ca – info@emc-mec.ca
38 place du Commerce, 11-530 Ile des Sœurs, QC H3E 1T8

Appendix 4 : Tables for the Requirements on Electric Grids

Automobiles + Trucks < 4500 kg													
Year	Newfounland & Labrador	Prince Edward Island	Nova Scotia	New Brunswick	Quebec	Ontario	Manitoba	Saskatchewan	Alberta	British Columbia	Yukon	NorthWest Territories	Nunavut	Canada
2000	242 706	72 604	513 030	431 284	3 835 380	6 344 239	583 721	619 932	1 926 497	2 221 457	21 149	17 857	2 326	16 832 182
2001	241 925	72 559	518 472	433 600	3 856 620	6 443 516	592 211	613 622	1 998 767	2 245 015	17 753	18 089	2 645	17 054 794
2002	249 639	73 390	519 875	442 703	4 056 125	6 559 352	601 942	634 980	2 089 420	2 271 267	22 907	19 260	2 793	17 543 653
2003	252 911	74 197	526 583	442 259	4 147 586	6 626 804	605 113	638 148	2 107 517	2 301 051	23 777	19 947	2 874	17 768 767
2004	253 182	75 162	518 429	442 592	4 224 895	6 679 102	616 014	642 053	2 148 694	2 343 020	23 904	19 939	2 927	17 989 913
2005	253 025	75 929	532 253	450 489	4 245 268	6 775 882	623 382	657 115	2 223 822	2 389 628	24 670	20 725	3 082	18 275 270
2006	258 127	76 675	525 214	459 671	4 373 402	6 918 914	631 516	665 169	2 339 251	2 442 248	24 957	20 574	3 217	18 738 935
2007	268 190	77 873	548 111	471 013	4 464 896	7 038 695	643 580	683 507	2 453 491	2 499 237	25 815	21 451	3 095	19 198 954
2008	281 656	79 134	539 006	484 797	4 525 950	7 176 013	659 493	708 247	2 558 244	2 548 212	26 800	22 068	3 310	19 612 930
2009	297 249	81 699	541 748	489 507	4 613 923	7 243 898	670 511	719 577	2 605 008	2 561 329	27 244	21 539	3 752	19 876 984
2010	311 393	86 618	552 572	501 145	4 697 001	7 327 772	706 901	740 394	2 646 210	2 644 087	28 546	21 499	3 844	20 267 982
2011	330 263	87 976	562 996	508 423	4 787 638	7 424 967	721 021	756 623	2 702 591	2 670 522	29 552	21 580	3 949	20 608 101
2012	335 359	89 382	559 689	521 925	4 579 435	7 514 137	737 271	766 017	2 789 795	2 702 059	30 381	22 451	4 092	20 651 993
2013	341 745	87 177	575 341	525 614	4 887 622	7 625 689	748 009	778 069	2 895 686	2 738 785	30 928	22 685	4 310	21 261 660
2014	349 436	83 295	585 968	527 213	5 082 180	7 710 424	759 003	787 428	2 998 455	2 787 750	31 066	22 710	4 668	21 729 596
2015	354 811	77 723	588 807	533 082	5 086 519	7 866 332	771 944	794 478	3 074 733	2 859 463	31 960	23 051	4 875	22 067 778
2016	361 096	74 795	595 895	538 760	5 186 844	8 037 343	783 273	805 898	3 063 493	2 901 758	32 711	23 237	4 927	22 410 030
2017	362 839	71 683	606 346	545 094	5 200 910	8 199 865	794 440	809 975	3 060 649	2 964 236	33 795	23 569	4 927	22 678 328
2018	353 735	100 276	615 897	549 514	5 309 654	8 357 600	803 282	811 246	3 104 880	3 067 762	34 787	23 643	4 927	23 137 203
2019	350 761	101 594	600 756	553 244	5 399 507	8 514 952	808 918	813 605	3 151 829	3 113 125	35 651	23 242	4 927	23 472 111
2020	356 112	103 584	606 657	559 618	5 478 065	8 642 057	822 759	823 008	3 206 511	3 168 305	36 492	23 412	5 045	23 831 624
2021	361 463	105 573	612 558	565 991	5 556 624	8 769 163	836 599	832 411	3 261 193	3 223 484	37 332	23 583	5 162	24 191 136
2022	366 815	107 563	618 458	572 365	5 635 182	8 896 268	850 440	841 813	3 315 875	3 278 664	38 173	23 753	5 280	24 550 649
2023	372 166	109 552	624 359	578 739	5 713 741	9 023 374	864 281	851 216	3 370 557	3 333 843	39 014	23 923	5 397	24 910 162
2024	377 517	111 542	630 260	585 113	5 792 299	9 150 479	878 122	860 619	3 425 240	3 389 023	39 855	24 094	5 515	25 269 675
2025	382 868	113 531	636 161	591 486	5 870 857	9 277 584	891 962	870 022	3 479 922	3 444 203	40 695	24 264	5 632	25 629 187
2026	388 219	115 521	642 062	597 860	5 949 416	9 404 690	905 803	879 425	3 534 604	3 499 382	41 536	24 434	5 750	25 988 700
2027	393 571	117 510	647 962	604 234	6 027 974	9 531 795	919 644	888 827	3 589 286	3 554 562	42 377	24 604	5 867	26 348 213
2028	398 922	119 500	653 863	610 607	6 106 533	9 658 901	933 484	898 230	3 643 968	3 609 741	43 217	24 775	5 985	26 707 725
2029	404 273	121 489	659 764	616 981	6 185 091	9 786 006	947 325	907 633	3 698 650	3 664 921	44 058	24 945	6 102	27 067 238
2030	409 624	123 479	665 665	623 355	6 263 649	9 913 111	961 166	917 036	3 753 332	3 720 101	44 899	25 115	6 220	27 426 751
2031	414 975	125 468	671 566	629 728	6 342 208	10 040 217	975 006	926 439	3 808 014	3 775 280	45 739	25 286	6 337	27 786 263
2032	420 327	127 458	677 466	636 102	6 420 766	10 167 322	988 847	935 841	3 862 696	3 830 460	46 580	25 456	6 455	28 145 776
2033	425 678	129 447	683 367	642 476	6 499 325	10 294 428	1 002 688	945 244	3 917 378	3 885 639	47 421	25 626	6 572	28 505 289
2034	431 029	131 437	689 268	648 849	6 577 883	10 421 533	1 016 529	954 647	3 972 061	3 940 819	48 262	25 797	6 690	28 864 802
2035	436 380	133 426	695 169	655 223	6 656 441	10 548 638	1 030 369	964 050	4 026 743	3 995 999	49 102	25 967	6 807	29 224 314
2036	441 731	135 416	701 070	661 597	6 735 000	10 675 744	1 044 210	973 453	4 081 425	4 051 178	49 943	26 137	6 925	29 583 827
2037	447 083	137 405	706 970	667 971	6 813 558	10 802 849	1 058 051	982 855	4 136 107	4 106 358	50 784	26 307	7 042	29 943 340
2038	452 434	139 395	712 871	674 344	6 892 117	10 929 955	1 071 891	992 258	4 190 789	4 161 537	51 624	26 478	7 160	30 302 852
2039	457 785	141 384	718 772	680 718	6 970 675	11 057 060	1 085 732	1 001 661	4 245 471	4 216 717	52 465	26 648	7 277	30 662 365
2040	463 136	143 374	724 673	687 092	7 049 233	11 184 165	1 099 573	1 011 064	4 300 153	4 271 897	53 306	26 818	7 395	31 021 878
2041	468 487	145 363	730 574	693 465	7 127 792	11 311 271	1 113 413	1 020 467	4 354 835	4 327 076	54 146	26 989	7 512	31 381 390
2042	473 839	147 353	736 474	699 839	7 206 350	11 438 376	1 127 254	1 029 869	4 409 517	4 382 256	54 987	27 159	7 630	31 740 903
2043	479 190	149 342	742 375	706 213	7 284 909	11 565 482	1 141 095	1 039 272	4 464 199	4 437 435	55 828	27 329	7 747	32 100 416
2044	484 541	151 332	748 276	712 586	7 363 467	11 692 587	1 154 936	1 048 675	4 518 882	4 492 615	56 668	27 500	7 865	32 459 929
2045	489 892	153 321	754 177	718 960	7 442 025	11 819 692	1 168 776	1 058 078	4 573 564	4 547 795	57 509	27 670	7 982	32 819 441
2046	495 243	155 311	760 078	725 334	7 520 584	11 946 798	1 182 617	1 067 481	4 628 246	4 602 974	58 350	27 840	8 100	33 178 954
2047	500 595	157 300	765 978	731 708	7 599 142	12 073 903	1 196 458	1 076 883	4 682 928	4 658 154	59 191	28 010	8 217	33 538 467
2048	505 946	159 290	771 879	738 081	7 677 701	12 201 009	1 210 298	1 086 286	4 737 610	4 713 333	60 031	28 181	8 335	33 897 979
2049	511 297	161 279	777 780	744 455	7 756 259	12 328 114	1 224 139	1 095 689	4 792 292	4 768 513	60 872	28 351	8 452	34 257 492
2050	516 648	163 269	783 681	750 829	7 834 817	12 455 219	1 237 980	1 105 092	4 846 974	4 823 693	61 713	28 521	8 570	34 617 005

https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=2310006701&pickMembers%5B0%5D=1.1&cubeTimeFrame.startYear=2000&cubeTimeFrame.endYear=2019&referencePeriods=20000101%2C20190101

Annual growth rate 2020 -> 2050 : mean value 2009 @ 2019

Electric energy demand recharging Cars + Trucks < 4500 kg

Année	Newfounland & Labrador	Prince Edward Island	Nova Scotia	New Brunswick	Quebec	Ontario	Manitoba	Saskatchewan	Alberta	British Columbia	Yukon	NorthWest Territories	Nunavut	Canada
	Annual GWh @ 100 % home recharging													
2000														
2001														
2002														
2003														
2004														
2005														
2006														
2007														
2008														
2009														
2010														
2011														
2012														
2013														
2014														
2015														
2016														
2017														
2018														
2019														
2020	1 140	331	1 941	1 791	17 530	27 655	2 633	2 634	10 261	10 139	117	75	16	76 261
2021	1 157	338	1 960	1 811	17 781	28 061	2 677	2 664	10 436	10 315	119	75	17	77 412
2022	1 174	344	1 979	1 832	18 033	28 468	2 721	2 694	10 611	10 492	122	76	17	78 562
2023	1 191	351	1 998	1 852	18 284	28 875	2 766	2 724	10 786	10 668	125	77	17	79 713
2024	1 208	357	2 017	1 872	18 535	29 282	2 810	2 754	10 961	10 845	128	77	18	80 863
2025	1 225	363	2 036	1 893	18 787	29 688	2 854	2 784	11 136	11 021	130	78	18	82 013
2026	1 242	370	2 055	1 913	19 038	30 095	2 899	2 814	11 311	11 198	133	78	18	83 164
2027	1 259	376	2 073	1 934	19 290	30 502	2 943	2 844	11 486	11 375	136	79	19	84 314
2028	1 277	382	2 092	1 954	19 541	30 908	2 987	2 874	11 661	11 551	138	79	19	85 465
2029	1 294	389	2 111	1 974	19 792	31 315	3 031	2 904	11 836	11 728	141	80	20	86 615
2030	1 311	395	2 130	1 995	20 044	31 722	3 076	2 935	12 011	11 904	144	80	20	87 766
2031	1 328	401	2 149	2 015	20 295	32 129	3 120	2 965	12 186	12 081	146	81	20	88 916
2032	1 345	408	2 168	2 036	20 546	32 535	3 164	2 995	12 361	12 257	149	81	21	90 066
2033	1 362	414	2 187	2 056	20 798	32 942	3 209	3 025	12 536	12 434	152	82	21	91 217
2034	1 379	421	2 206	2 076	21 049	33 349	3 253	3 055	12 711	12 611	154	83	21	92 367
2035	1 396	427	2 225	2 097	21 301	33 756	3 297	3 085	12 886	12 787	157	83	22	93 518
2036	1 414	433	2 243	2 117	21 552	34 162	3 341	3 115	13 061	12 964	160	84	22	94 668
2037	1 431	440	2 262	2 138	21 803	34 569	3 386	3 145	13 236	13 140	163	84	23	95 819
2038	1 448	446	2 281	2 158	22 055	34 976	3 430	3 175	13 411	13 317	165	85	23	96 969
2039	1 465	452	2 300	2 178	22 306	35 383	3 474	3 205	13 586	13 493	168	85	23	98 120
2040	1 482	459	2 319	2 199	22 558	35 789	3 519	3 235	13 760	13 670	171	86	24	99 270
2041	1 499	465	2 338	2 219	22 809	36 196	3 563	3 265	13 935	13 847	173	86	24	100 420
2042	1 516	472	2 357	2 239	23 060	36 603	3 607	3 296	14 110	14 023	176	87	24	101 571
2043	1 533	478	2 376	2 260	23 312	37 010	3 652	3 326	14 285	14 200	179	87	25	102 721
2044	1 551	484	2 394	2 280	23 563	37 416	3 696	3 356	14 460	14 376	181	88	25	103 872
2045	1 568	491	2 413	2 301	23 814	37 823	3 740	3 386	14 635	14 553	184	89	26	105 022
2046	1 585	497	2 432	2 321	24 066	38 230	3 784	3 416	14 810	14 730	187	89	26	106 173
2047	1 602	503	2 451	2 341	24 317	38 636	3 829	3 446	14 985	14 906	189	90	26	107 323
2048	1 619	510	2 470	2 362	24 569	39 043	3 873	3 476	15 160	15 083	192	90	27	108 474
2049	1 636	516	2 489	2 382	24 820	39 450	3 917	3 506	15 335	15 259	195	91	27	109 624
2050	1 653	522	2 508	2 403	25 071	39 857	3 962	3 536	15 510	15 436	197	91	27	110 774

Electric power demand for Automobiles + Trucks < 4500 kg recharging*

Percentage of recharges during peak period — MW

Année	Newfounland & Labrador 20%	Newfounland & Labrador 33%	Newfounland & Labrador 50%	Prince Edward Island 20%	Prince Edward Island 33%	Prince Edward Island 50%	Nova Scotia 20%	Nova Scotia 33%	Nova Scotia 50%	New Brunswick 20%	New Brunswick 33%	New Brunswick 50%
2000												
2001												
2002												
2003												
2004												
2005												
2006												
2007												
2008												
2009												
2010												
2011												
2012												
2013												
2014												
2015												
2016												
2017												
2018												
2019												
2020	534	881	1 335	155	256	388	910	1 501	2 275	839	1 385	2 099
2021	542	895	1 355	158	261	396	919	1 516	2 297	849	1 401	2 122
2022	550	908	1 376	161	266	403	928	1 531	2 319	859	1 417	2 146
2023	558	921	1 396	164	271	411	937	1 545	2 341	868	1 432	2 170
2024	566	934	1 416	167	276	418	945	1 560	2 363	878	1 448	2 194
2025	574	948	1 436	170	281	426	954	1 574	2 386	887	1 464	2 218
2026	582	961	1 456	173	286	433	963	1 589	2 408	897	1 480	2 242
2027	590	974	1 476	176	291	441	972	1 604	2 430	906	1 495	2 266
2028	598	987	1 496	179	296	448	981	1 618	2 452	916	1 511	2 290
2029	606	1 001	1 516	182	301	456	990	1 633	2 474	925	1 527	2 314
2030	614	1 014	1 536	185	306	463	998	1 648	2 496	935	1 543	2 338
2031	622	1 027	1 556	188	311	471	1 007	1 662	2 518	945	1 559	2 361
2032	630	1 040	1 576	191	315	478	1 016	1 677	2 540	954	1 574	2 385
2033	639	1 054	1 596	194	320	485	1 025	1 691	2 563	964	1 590	2 409
2034	647	1 067	1 616	197	325	493	1 034	1 706	2 585	973	1 606	2 433
2035	655	1 080	1 636	200	330	500	1 043	1 721	2 607	983	1 622	2 457
2036	663	1 093	1 656	203	335	508	1 052	1 735	2 629	992	1 637	2 481
2037	671	1 107	1 677	206	340	515	1 060	1 750	2 651	1 002	1 653	2 505
2038	679	1 120	1 697	209	345	523	1 069	1 764	2 673	1 012	1 669	2 529
2039	687	1 133	1 717	212	350	530	1 078	1 779	2 695	1 021	1 685	2 553
2040	695	1 146	1 737	215	355	538	1 087	1 794	2 718	1 031	1 701	2 577
2041	703	1 160	1 757	218	360	545	1 096	1 808	2 740	1 040	1 716	2 600
2042	711	1 173	1 777	221	365	553	1 105	1 823	2 762	1 050	1 732	2 624
2043	719	1 186	1 797	224	370	560	1 114	1 837	2 784	1 059	1 748	2 648
2044	727	1 199	1 817	227	375	567	1 122	1 852	2 806	1 069	1 764	2 672
2045	735	1 212	1 837	230	379	575	1 131	1 867	2 828	1 078	1 779	2 696
2046	743	1 226	1 857	233	384	582	1 140	1 881	2 850	1 088	1 795	2 720
2047	751	1 239	1 877	236	389	590	1 149	1 896	2 872	1 098	1 811	2 744
2048	759	1 252	1 897	239	394	597	1 158	1 910	2 895	1 107	1 827	2 768
2049	767	1 265	1 917	242	399	605	1 167	1 925	2 917	1 117	1 843	2 792
2050	775	1 279	1 937	245	404	612	1 176	1 940	2 939	1 126	1 858	2 816

Année	Quebec 20%	Quebec 33%	Quebec 50%	Ontario 20%	Ontario 33%	Ontario 50%	Manitoba 20%	Manitoba 33%	Manitoba 50%	Saskatchewan 20%	Saskatchewan 33%	Saskatchewan 50%
2000												
2001												
2002												
2003												
2004												
2005												
2006												
2007												
2008												
2009												
2010												
2011												
2012												
2013												
2014												
2015												
2016												
2017												
2018												
2019												
2020	8 217	13 558	20 543	12 963	21 389	32 408	1 234	2 036	3 085	1 235	2 037	3 086
2021	8 335	13 753	20 837	13 154	21 704	32 884	1 255	2 071	3 137	1 249	2 060	3 122
2022	8 453	13 947	21 132	13 344	22 018	33 361	1 276	2 105	3 189	1 263	2 083	3 157
2023	8 571	14 142	21 427	13 535	22 333	33 838	1 296	2 139	3 241	1 277	2 107	3 192
2024	8 688	14 336	21 721	13 726	22 647	34 314	1 317	2 173	3 293	1 291	2 130	3 227
2025	8 806	14 530	22 016	13 916	22 962	34 791	1 338	2 208	3 345	1 305	2 153	3 263
2026	8 924	14 725	22 310	14 107	23 277	35 268	1 359	2 242	3 397	1 319	2 177	3 298
2027	9 042	14 919	22 605	14 298	23 591	35 744	1 379	2 276	3 449	1 333	2 200	3 333
2028	9 160	15 114	22 899	14 488	23 906	36 221	1 400	2 310	3 501	1 347	2 223	3 368
2029	9 278	15 308	23 194	14 679	24 220	36 698	1 421	2 345	3 552	1 361	2 246	3 404
2030	9 395	15 503	23 489	14 870	24 535	37 174	1 442	2 379	3 604	1 376	2 270	3 439
2031	9 513	15 697	23 783	15 060	24 850	37 651	1 463	2 413	3 656	1 390	2 293	3 474
2032	9 631	15 891	24 078	15 251	25 164	38 127	1 483	2 447	3 708	1 404	2 316	3 509
2033	9 749	16 086	24 372	15 442	25 479	38 604	1 504	2 482	3 760	1 418	2 339	3 545
2034	9 867	16 280	24 667	15 632	25 793	39 081	1 525	2 516	3 812	1 432	2 363	3 580
2035	9 985	16 475	24 962	15 823	26 108	39 557	1 546	2 550	3 864	1 446	2 386	3 615
2036	10 102	16 669	25 256	16 014	26 422	40 034	1 566	2 584	3 916	1 460	2 409	3 650
2037	10 220	16 864	25 551	16 204	26 737	40 511	1 587	2 619	3 968	1 474	2 433	3 686
2038	10 338	17 058	25 845	16 395	27 052	40 987	1 608	2 653	4 020	1 488	2 456	3 721
2039	10 456	17 252	26 140	16 586	27 366	41 464	1 629	2 687	4 071	1 502	2 479	3 756
2040	10 574	17 447	26 435	16 776	27 681	41 941	1 649	2 721	4 123	1 517	2 502	3 791
2041	10 692	17 641	26 729	16 967	27 995	42 417	1 670	2 756	4 175	1 531	2 526	3 827
2042	10 810	17 836	27 024	17 158	28 310	42 894	1 691	2 790	4 227	1 545	2 549	3 862
2043	10 927	18 030	27 318	17 348	28 625	43 371	1 712	2 824	4 279	1 559	2 572	3 897
2044	11 045	18 225	27 613	17 539	28 939	43 847	1 732	2 858	4 331	1 573	2 595	3 933
2045	11 163	18 419	27 908	17 730	29 254	44 324	1 753	2 893	4 383	1 587	2 619	3 968
2046	11 281	18 613	28 202	17 920	29 568	44 800	1 774	2 927	4 435	1 601	2 642	4 003
2047	11 399	18 808	28 497	18 111	29 883	45 277	1 795	2 961	4 487	1 615	2 665	4 038
2048	11 517	19 002	28 791	18 302	30 197	45 754	1 815	2 995	4 539	1 629	2 689	4 074
2049	11 634	19 197	29 086	18 492	30 512	46 230	1 836	3 030	4 591	1 644	2 712	4 109
2050	11 752	19 391	29 381	18 683	30 827	46 707	1 857	3 064	4 642	1 658	2 735	4 144

Année	Alberta 20%	Alberta 33%	Alberta 50%	British Columbia 20%	British Columbia 33%	British Columbia 50%	Yukon 20%	Yukon 33%	Yukon 50%
2000									
2001									
2002									
2003									
2004									
2005									
2006									
2007									
2008									
2009									
2010									
2011									
2012									
2013									
2014									
2015									
2016									
2017									
2018									
2019									
2020	4 810	7 936	12 024	4 752	7 842	11 881	55	90	137
2021	4 892	8 071	12 229	4 835	7 978	12 088	56	92	140
2022	4 974	8 207	12 435	4 918	8 115	12 295	57	94	143
2023	5 056	8 342	12 640	5 001	8 251	12 502	59	97	146
2024	5 138	8 477	12 845	5 084	8 388	12 709	60	99	149
2025	5 220	8 613	13 050	5 166	8 524	12 916	61	101	153
2026	5 302	8 748	13 255	5 249	8 661	13 123	62	103	156
2027	5 384	8 883	13 460	5 332	8 798	13 330	64	105	159
2028	5 466	9 019	13 665	5 415	8 934	13 537	65	107	162
2029	5 548	9 154	13 870	5 497	9 071	13 743	66	109	165
2030	5 630	9 289	14 075	5 580	9 207	13 950	67	111	168
2031	5 712	9 425	14 280	5 663	9 344	14 157	69	113	172
2032	5 794	9 560	14 485	5 746	9 480	14 364	70	115	175
2033	5 876	9 696	14 690	5 828	9 617	14 571	71	117	178
2034	5 958	9 831	14 895	5 911	9 754	14 778	72	119	181
2035	6 040	9 966	15 100	5 994	9 890	14 985	74	122	184
2036	6 122	10 102	15 305	6 077	10 027	15 192	75	124	187
2037	6 204	10 237	15 510	6 160	10 163	15 399	76	126	190
2038	6 286	10 372	15 715	6 242	10 300	15 606	77	128	194
2039	6 368	10 508	15 921	6 325	10 436	15 813	79	130	197
2040	6 450	10 643	16 126	6 408	10 573	16 020	80	132	200
2041	6 532	10 778	16 331	6 491	10 710	16 227	81	134	203
2042	6 614	10 914	16 536	6 573	10 846	16 433	82	136	206
2043	6 696	11 049	16 741	6 656	10 983	16 640	84	138	209
2044	6 778	11 184	16 946	6 739	11 119	16 847	85	140	213
2045	6 860	11 320	17 151	6 822	11 256	17 054	86	142	216
2046	6 942	11 455	17 356	6 904	11 392	17 261	88	144	219
2047	7 024	11 590	17 561	6 987	11 529	17 468	89	146	222
2048	7 106	11 726	17 766	7 070	11 666	17 675	90	149	225
2049	7 188	11 861	17 971	7 153	11 802	17 882	91	151	228
2050	7 270	11 996	18 176	7 236	11 939	18 089	93	153	231

Année	NorthWest Territories 20%	NorthWest Territories 33%	NorthWest Territories 50%	Nunavut 20%	Nunavut 33%	Nunavut 50%	Canada 20%	Canada 33%	Canada 50%
2000									
2001									
2002									
2003									
2004									
2005									
2006									
2007									
2008									
2009									
2010									
2011									
2012									
2013									
2014									
2015									
2016									
2017									
2018									
2019									
2020	35	58	88	8	12	19	35 747	58 983	89 369
2021	35	58	88	8	13	19	36 287	59 873	90 717
2022	36	59	89	8	13	20	36 826	60 763	92 065
2023	36	59	90	8	13	20	37 365	61 653	93 413
2024	36	60	90	8	14	21	37 905	62 542	94 761
2025	36	60	91	8	14	21	38 444	63 432	96 109
2026	37	60	92	9	14	22	38 983	64 322	97 458
2027	37	61	92	9	15	22	39 522	65 212	98 806
2028	37	61	93	9	15	22	40 062	66 102	100 154
2029	37	62	94	9	15	23	40 601	66 991	101 502
2030	38	62	94	9	15	23	41 140	67 881	102 850
2031	38	63	95	10	16	24	41 679	68 771	104 198
2032	38	63	95	10	16	24	42 219	69 661	105 547
2033	38	63	96	10	16	25	42 758	70 551	106 895
2034	39	64	97	10	17	25	43 297	71 440	108 243
2035	39	64	97	10	17	26	43 836	72 330	109 591
2036	39	65	98	10	17	26	44 376	73 220	110 939
2037	39	65	99	11	17	26	44 915	74 110	112 288
2038	40	66	99	11	18	27	45 454	75 000	113 636
2039	40	66	100	11	18	27	45 994	75 889	114 984
2040	40	66	101	11	18	28	46 533	76 779	116 332
2041	40	67	101	11	19	28	47 072	77 669	117 680
2042	41	67	102	11	19	29	47 611	78 559	119 028
2043	41	68	102	12	19	29	48 151	79 449	120 377
2044	41	68	103	12	19	29	48 690	80 338	121 725
2045	42	68	104	12	20	30	49 229	81 228	123 073
2046	42	69	104	12	20	30	49 768	82 118	124 421
2047	42	69	105	12	20	31	50 308	83 008	125 769
2048	42	70	106	13	21	31	50 847	83 897	127 117
2049	43	70	106	13	21	32	51 386	84 787	128 466
2050	43	71	107	13	21	32	51 926	85 677	129 814

* : scenarios   Boston Consulting Group   www.bcg.com/publications/2019/costs-revving-up-the-grid-for-electric-vehicles

Automobiles + Trucks < 4 500 kg			Electric energy demand recharging Cars + Trucks < 4500 kg														
Year	Canada		Year	Newfounland & Labrador	Prince Edward Island	Nova Scotia	New Brunswick	Quebec	Ontario	Manitoba	Saskatchewan	Alberta	British Columbia	Yukon	NorthWest Territories	Nunavut	Canada
	Vehicules on the road	Yearly increase ("growth of vehicle fleet")		Annual vehicle mileage (km) -> 16000													
				EV recharge requirement (kWh/100 km) -> 20													
				Annual GWh @ 100 % home recharging													
2000	16 832 182		2000														
2001	17 054 794	222 612	2001														
2002	17 543 653	488 859	2002														
2003	17 768 767	225 114	2003														
2004	17 989 913	221 146	2004														
2005	18 275 270	285 357	2005														
2006	18 738 935	463 665	2006														
2007	19 198 954	460 019	2007														
2008	19 612 930	413 976	2008														
2009	19 876 984	264 054	2009														
2010	20 267 982	390 998	2010														
2011	20 608 101	340 119	2011														
2012	20 651 993	43 892	2012														
2013	21 261 660	609 667	2013														
2014	21 729 596	467 936	2014														
2015	22 067 778	338 182	2015														
2016	22 410 030	342 252	2016														
2017	22 678 328	268 298	2017														
2018	23 137 203	458 875	2018	7 800	562	9 600	12 200	248 700	151 100	36 900	24 300	81 000	74 200	500	400	200	647 462
2019	23 472 111	334 908	2019														
2020	23 831 624	359 513	2020	1 140	331	1 941	1 791	17 530	27 655	2 633	2 634	10 261	10 139	117	75	16	76 261
2021	24 191 136	359 513	2021	1 157	338	1 960	1 811	17 781	28 061	2 677	2 664	10 436	10 315	119	75	17	77 412
2022	24 550 649	359 513	2022	1 174	344	1 979	1 832	18 033	28 468	2 721	2 694	10 611	10 492	122	76	17	78 562
2023	24 910 162	359 513	2023	1 191	351	1 998	1 852	18 284	28 875	2 766	2 724	10 786	10 668	125	77	17	79 713
2024	25 269 675	359 513	2024	1 208	357	2 017	1 872	18 535	29 282	2 810	2 754	10 961	10 845	128	77	18	80 863
2025	25 629 187	359 513	2025	1 225	363	2 036	1 893	18 787	29 688	2 854	2 784	11 136	11 021	130	78	18	82 013
2026	25 988 700	359 513	2026	1 242	370	2 055	1 913	19 038	30 095	2 899	2 814	11 311	11 198	133	78	18	83 164
2027	26 348 213	359 513	2027	1 259	376	2 073	1 934	19 290	30 502	2 943	2 844	11 486	11 375	136	79	19	84 314
2028	26 707 725	359 513	2028	1 277	382	2 092	1 954	19 541	30 908	2 987	2 874	11 661	11 551	138	79	19	85 465
2029	27 067 238	359 513	2029	1 294	389	2 111	1 974	19 792	31 315	3 031	2 904	11 836	11 728	141	80	20	86 615
2030	27 426 751	359 513	2030	1 311	395	2 130	1 995	20 044	31 722	3 076	2 935	12 011	11 904	144	80	20	87 766
2031	27 786 263	359 513	2031	1 328	401	2 149	2 015	20 295	32 129	3 120	2 965	12 186	12 081	146	81	20	88 916
2032	28 145 776	359 513	2032	1 345	408	2 168	2 036	20 546	32 535	3 164	2 995	12 361	12 257	149	81	21	90 066
2033	28 505 289	359 513	2033	1 362	414	2 187	2 056	20 798	32 942	3 209	3 025	12 536	12 434	152	82	21	91 217
2034	28 864 802	359 513	2034	1 379	421	2 206	2 076	21 049	33 349	3 253	3 055	12 711	12 611	154	83	21	92 367
2035	29 224 314	359 513	2035	1 396	427	2 225	2 097	21 301	33 756	3 297	3 085	12 886	12 787	157	83	22	93 518
2036	29 583 827	359 513	2036	1 414	433	2 243	2 117	21 552	34 162	3 341	3 115	13 061	12 964	160	84	22	94 668
2037	29 943 340	359 513	2037	1 431	440	2 262	2 138	21 803	34 569	3 386	3 145	13 236	13 140	163	84	23	95 819
2038	30 302 852	359 513	2038	1 448	446	2 281	2 158	22 055	34 976	3 430	3 175	13 411	13 317	165	85	23	96 969
2039	30 662 365	359 513	2039	1 465	452	2 300	2 178	22 306	35 383	3 474	3 205	13 586	13 493	168	85	23	98 120
2040	31 021 878	359 513	2040	1 482	459	2 319	2 199	22 558	35 789	3 519	3 235	13 760	13 670	171	86	24	99 270
2041	31 381 390	359 513	2041	1 499	465	2 338	2 219	22 809	36 196	3 563	3 265	13 935	13 847	173	86	24	100 420
2042	31 740 903	359 513	2042	1 516	472	2 357	2 239	23 060	36 603	3 607	3 296	14 110	14 023	176	87	24	101 571
2043	32 100 416	359 513	2043	1 533	478	2 376	2 260	23 312	37 010	3 652	3 326	14 285	14 200	179	87	25	102 721
2044	32 459 929	359 513	2044	1 551	484	2 394	2 280	23 563	37 416	3 696	3 356	14 460	14 376	181	88	25	103 872
2045	32 819 441	359 513	2045	1 568	491	2 413	2 301	23 814	37 823	3 740	3 386	14 635	14 553	184	89	26	105 022
2046	33 178 954	359 513	2046	1 585	497	2 432	2 321	24 066	38 230	3 784	3 416	14 810	14 730	187	89	26	106 173
2047	33 538 467	359 513	2047	1 602	503	2 451	2 341	24 317	38 636	3 829	3 446	14 985	14 906	189	90	26	107 323
2048	33 897 979	359 513	2048	1 619	510	2 470	2 362	24 569	39 043	3 873	3 476	15 160	15 083	192	90	27	108 474
2049	34 257 492	359 513	2049	1 636	516	2 489	2 382	24 820	39 450	3 917	3 506	15 335	15 259	195	91	27	109 624
2050	34 617 005	359 513	2050	1 653	522	2 508	2 403	25 071	39 857	3 962	3 536	15 510	15 436	197	91	27	110 774
			Differential 2050 vs 2018 (%) ->	21,2%	93,0%	26,1%	19,7%	10,1%	26,4%	10,7%	14,6%	19,1%	20,8%	39,5%	22,8%	13,7%	17,1%
			Churchill Falls	3,9%				11,7%									

Source https://www.cer-rec.gc.ca/en/data-analysis/energy-markets/provincial-territorial-energy-profiles/provincial-territorial-energy-profiles-canada.html
https://en.wikipedia.org/wiki/Churchill_Falls_Generating_Station

Note Churchill Falls : included in the 2018 Quebec's energy balance sheet (35000 MWh) and reported in the 2050 Newfouldland's energy balance sheet

Automobiles + Trucks < 4 500 kg — **Electric power demand for Automobiles + Trucks < 4500 kg recharging*** (MW)

Year	Canada – Vehicules on the road	Canada – Yearly increase ("growth of vehicle fleet")	Year	Newfounland & Labrador – Percentage of recharges during peak period			Prince Edward Island – Percentage of recharges during peak period			Nova Scotia – Percentage of recharges during peak period			New Brunswick – Percentage of recharges during peak period		
				20%	33%	50%	20%	33%	50%	20%	33%	50%	20%	33%	50%
2000	16 832 182		2000												
2001	17 054 794	222 612	2001												
2002	17 543 653	488 859	2002												
2003	17 768 767	225 114	2003												
2004	17 989 913	221 146	2004												
2005	18 275 270	285 357	2005												
2006	18 738 935	463 665	2006												
2007	19 198 954	460 019	2007												
2008	19 612 930	413 976	2008												
2009	19 876 984	264 054	2009												
2010	20 267 982	390 998	2010												
2011	20 608 101	340 119	2011												
2012	20 651 993	43 892	2012												
2013	21 261 660	609 667	2013												
2014	21 729 596	467 936	2014												
2015	22 067 778	338 182	2015												
2016	22 410 030	342 252	2016												
2017	22 678 328	268 298	2017												
2018	23 137 203	458 875	2018		2 394			100			3 061			4 521	
2019	23 472 111	334 908	2019												
2020	23 831 624	359 513	2020	534	881	1 335	155	256	388	910	1 501	2 275	839	1 385	2 099
2021	24 191 136	359 513	2021	542	895	1 355	158	261	396	919	1 516	2 297	849	1 401	2 122
2022	24 550 649	359 513	2022	550	908	1 376	161	266	403	928	1 531	2 319	859	1 417	2 146
2023	24 910 162	359 513	2023	558	921	1 396	164	271	411	937	1 545	2 341	868	1 432	2 170
2024	25 269 675	359 513	2024	566	934	1 416	167	276	418	945	1 560	2 363	878	1 448	2 194
2025	25 629 187	359 513	2025	574	948	1 436	170	281	426	954	1 574	2 386	887	1 464	2 218
2026	25 988 700	359 513	2026	582	961	1 456	173	286	433	963	1 589	2 408	897	1 480	2 242
2027	26 348 213	359 513	2027	590	974	1 476	176	291	441	972	1 604	2 430	906	1 495	2 266
2028	26 707 725	359 513	2028	598	987	1 496	179	296	448	981	1 618	2 452	916	1 511	2 290
2029	27 067 238	359 513	2029	606	1 001	1 516	182	301	456	990	1 633	2 474	925	1 527	2 314
2030	27 426 751	359 513	2030	614	1 014	1 536	185	306	463	998	1 648	2 496	935	1 543	2 338
2031	27 786 263	359 513	2031	622	1 027	1 556	188	311	471	1 007	1 662	2 518	945	1 559	2 361
2032	28 145 776	359 513	2032	630	1 040	1 576	191	315	478	1 016	1 677	2 540	954	1 574	2 385
2033	28 505 289	359 513	2033	639	1 054	1 596	194	320	485	1 025	1 691	2 563	964	1 590	2 409
2034	28 864 802	359 513	2034	647	1 067	1 616	197	325	493	1 034	1 706	2 585	973	1 606	2 433
2035	29 224 314	359 513	2035	655	1 080	1 636	200	330	500	1 043	1 721	2 607	983	1 622	2 457
2036	29 583 827	359 513	2036	663	1 093	1 656	203	335	508	1 052	1 735	2 629	992	1 637	2 481
2037	29 943 340	359 513	2037	671	1 107	1 677	206	340	515	1 060	1 750	2 651	1 002	1 653	2 505
2038	30 302 852	359 513	2038	679	1 120	1 697	209	345	523	1 069	1 764	2 673	1 012	1 669	2 529
2039	30 662 365	359 513	2039	687	1 133	1 717	212	350	530	1 078	1 779	2 695	1 021	1 685	2 553
2040	31 021 878	359 513	2040	695	1 146	1 737	215	355	538	1 087	1 794	2 718	1 031	1 701	2 577
2041	31 381 390	359 513	2041	703	1 160	1 757	218	360	545	1 096	1 808	2 740	1 040	1 716	2 600
2042	31 740 903	359 513	2042	711	1 173	1 777	221	365	553	1 105	1 823	2 762	1 050	1 732	2 624
2043	32 100 416	359 513	2043	719	1 186	1 797	224	370	560	1 114	1 837	2 784	1 059	1 748	2 648
2044	32 459 929	359 513	2044	727	1 199	1 817	227	375	567	1 122	1 852	2 806	1 069	1 764	2 672
2045	32 819 441	359 513	2045	735	1 212	1 837	230	379	575	1 131	1 867	2 828	1 078	1 779	2 696
2046	33 178 954	359 513	2046	743	1 226	1 857	233	384	582	1 140	1 881	2 850	1 088	1 795	2 720
2047	33 538 467	359 513	2047	751	1 239	1 877	236	389	590	1 149	1 896	2 872	1 098	1 811	2 744
2048	33 897 979	359 513	2048	759	1 252	1 897	239	394	597	1 158	1 910	2 895	1 107	1 827	2 768
2049	34 257 492	359 513	2049	767	1 265	1 917	242	399	605	1 167	1 925	2 917	1 117	1 843	2 792
2050	34 617 005	359 513	2050	775	1 279	1 937	245	404	612	1 176	1 940	2 939	1 126	1 858	2 816
			Differential 2050 vs 2018 (%) ->	32,4%	53,4%	80,9%	244,9%	404,1%	612,3%	38,4%	63,4%	96,0%	24,9%	41,1%	62,3%
			Churchill Falls	9,9%	16,3%	24,8%									

Year	Quebec – Percentage of recharges during peak period			Ontario – Percentage of recharges during peak period			Manitoba – Percentage of recharges during peak period			Saskatchewan – Percentage of recharges during peak period			Alberta – Percentage of recharges during peak period		
	20%	33%	50%	20%	33%	50%	20%	33%	50%	20%	33%	50%	20%	33%	50%
2000															
2001															
2002															
2003															
2004															
2005															
2006															
2007															
2008															
2009															
2010															
2011															
2012															
2013															
2014															
2015															
2016															
2017															
2018		46 176			40 671			5 690			4 533			16 332	
2019															
2020	8 217	13 558	20 543	12 963	21 389	32 408	1 234	2 036	3 085	1 235	2 037	3 086	4 810	7 936	12 024
2021	8 335	13 753	20 837	13 154	21 704	32 884	1 255	2 071	3 137	1 249	2 060	3 122	4 892	8 071	12 229
2022	8 453	13 947	21 132	13 344	22 018	33 361	1 276	2 105	3 189	1 263	2 083	3 157	4 974	8 207	12 435
2023	8 571	14 142	21 427	13 535	22 333	33 838	1 296	2 139	3 241	1 277	2 107	3 192	5 056	8 342	12 640
2024	8 688	14 336	21 721	13 726	22 647	34 314	1 317	2 173	3 293	1 291	2 130	3 227	5 138	8 477	12 845
2025	8 806	14 530	22 016	13 916	22 962	34 791	1 338	2 208	3 345	1 305	2 153	3 263	5 220	8 613	13 050
2026	8 924	14 725	22 310	14 107	23 277	35 268	1 359	2 242	3 397	1 319	2 177	3 298	5 302	8 748	13 255
2027	9 042	14 919	22 605	14 298	23 591	35 744	1 379	2 276	3 449	1 333	2 200	3 333	5 384	8 883	13 460
2028	9 160	15 114	22 899	14 488	23 906	36 221	1 400	2 310	3 501	1 347	2 223	3 368	5 466	9 019	13 665
2029	9 278	15 308	23 194	14 679	24 220	36 698	1 421	2 345	3 552	1 361	2 246	3 404	5 548	9 154	13 870
2030	9 395	15 503	23 489	14 870	24 535	37 174	1 442	2 379	3 604	1 376	2 270	3 439	5 630	9 289	14 075
2031	9 513	15 697	23 783	15 060	24 850	37 651	1 463	2 413	3 656	1 390	2 293	3 474	5 712	9 425	14 280
2032	9 631	15 891	24 078	15 251	25 164	38 127	1 483	2 447	3 708	1 404	2 316	3 509	5 794	9 560	14 485
2033	9 749	16 086	24 372	15 442	25 479	38 604	1 504	2 482	3 760	1 418	2 339	3 545	5 876	9 696	14 690
2034	9 867	16 280	24 667	15 632	25 793	39 081	1 525	2 516	3 812	1 432	2 363	3 580	5 958	9 831	14 895
2035	9 985	16 475	24 962	15 823	26 108	39 557	1 546	2 550	3 864	1 446	2 386	3 615	6 040	9 966	15 100
2036	10 102	16 669	25 256	16 014	26 422	40 034	1 566	2 584	3 916	1 460	2 409	3 650	6 122	10 102	15 305
2037	10 220	16 864	25 551	16 204	26 737	40 511	1 587	2 619	3 968	1 474	2 433	3 686	6 204	10 237	15 510
2038	10 338	17 058	25 845	16 395	27 052	40 987	1 608	2 653	4 020	1 488	2 456	3 721	6 286	10 372	15 715
2039	10 456	17 252	26 140	16 586	27 366	41 464	1 629	2 687	4 071	1 502	2 479	3 756	6 368	10 508	15 921
2040	10 574	17 447	26 435	16 776	27 681	41 941	1 649	2 721	4 123	1 517	2 502	3 791	6 450	10 643	16 126
2041	10 692	17 641	26 729	16 967	27 995	42 417	1 670	2 756	4 175	1 531	2 526	3 827	6 532	10 778	16 331
2042	10 810	17 836	27 024	17 158	28 310	42 894	1 691	2 790	4 227	1 545	2 549	3 862	6 614	10 914	16 536
2043	10 927	18 030	27 318	17 348	28 625	43 371	1 712	2 824	4 279	1 559	2 572	3 897	6 696	11 049	16 741
2044	11 045	18 225	27 613	17 539	28 939	43 847	1 732	2 858	4 331	1 573	2 595	3 933	6 778	11 184	16 946
2045	11 163	18 419	27 908	17 730	29 254	44 324	1 753	2 893	4 383	1 587	2 619	3 968	6 860	11 320	17 151
2046	11 281	18 613	28 202	17 920	29 568	44 800	1 774	2 927	4 435	1 601	2 642	4 003	6 942	11 455	17 356
2047	11 399	18 808	28 497	18 111	29 883	45 277	1 795	2 961	4 487	1 615	2 665	4 038	7 024	11 590	17 561
2048	11 517	19 002	28 791	18 302	30 197	45 754	1 815	2 995	4 539	1 629	2 689	4 074	7 106	11 726	17 766
2049	11 634	19 197	29 086	18 492	30 512	46 230	1 836	3 030	4 591	1 644	2 712	4 109	7 188	11 861	17 971
2050	11 752	19 391	29 381	18 683	30 827	46 707	1 857	3 064	4 642	1 658	2 735	4 144	7 270	11 996	18 176
Differential 2050 vs 2018 (%) ->	25,5%	42,0%	63,6%	45,9%	75,8%	114,8%	32,6%	53,8%	81,6%	36,6%	60,3%	91,4%	44,5%	73,5%	111,3%
Churchill Falls	28,8%	47,6%	72,1%												

Year	British Columbia – Percentage of recharges during peak period			Yukon – Percentage of recharges during peak period			NorthWest Territories – Percentage of recharges during peak period			Nunavut – Percentage of recharges during peak period			Canada – Percentage of recharges during peak period		
	20%	33%	50%	20%	33%	50%	20%	33%	50%	20%	33%	50%	0%	33%	50%
2000															
2001															
2002															
2003															
2004															
2005															
2006															
2007															
2008															
2009															
2010															
2011															
2012															
2013															
2014															
2015															
2016															
2017															
2018		14 210			124			208			78			138 098	
2019															
2020	4 752	7 842	11 881	55	90	137	35	58	88	8	12	19	35 747	58 983	89 369
2021	4 835	7 978	12 088	56	92	140	35	58	88	8	13	19	36 287	59 873	90 717
2022	4 918	8 115	12 295	57	94	143	36	59	89	8	13	20	36 826	60 763	92 065
2023	5 001	8 251	12 502	59	97	146	36	59	90	8	13	20	37 365	61 653	93 413
2024	5 084	8 388	12 709	60	99	149	36	60	90	8	14	21	37 905	62 542	94 761
2025	5 166	8 524	12 916	61	101	153	36	60	91	8	14	21	38 444	63 432	96 109
2026	5 249	8 661	13 123	62	103	156	37	60	92	9	14	22	38 983	64 322	97 458
2027	5 332	8 798	13 330	64	105	159	37	61	92	9	15	22	39 522	65 212	98 806
2028	5 415	8 934	13 537	65	107	162	37	61	93	9	15	22	40 062	66 102	100 154
2029	5 497	9 071	13 743	66	109	165	37	62	94	9	15	23	40 601	66 991	101 502
2030	5 580	9 207	13 950	67	111	168	38	62	94	9	15	23	41 140	67 881	102 850
2031	5 663	9 344	14 157	69	113	172	38	63	95	10	16	24	41 679	68 771	104 198
2032	5 746	9 480	14 364	70	115	175	38	63	95	10	16	24	42 219	69 661	105 547
2033	5 828	9 617	14 571	71	117	178	38	63	96	10	16	25	42 758	70 551	106 895
2034	5 911	9 754	14 778	72	119	181	39	64	97	10	17	25	43 297	71 440	108 243
2035	5 994	9 890	14 985	74	122	184	39	64	97	10	17	26	43 836	72 330	109 591
2036	6 077	10 027	15 192	75	124	187	39	65	98	10	17	26	44 376	73 220	110 939
2037	6 160	10 163	15 399	76	126	190	39	65	99	11	17	26	44 915	74 110	112 288
2038	6 242	10 300	15 606	77	128	194	40	66	99	11	18	27	45 454	75 000	113 636
2039	6 325	10 436	15 813	79	130	197	40	66	100	11	18	27	45 994	75 889	114 984
2040	6 408	10 573	16 020	80	132	200	40	66	101	11	18	28	46 533	76 779	116 332
2041	6 491	10 710	16 227	81	134	203	40	67	101	11	19	28	47 072	77 669	117 680
2042	6 573	10 846	16 433	82	136	206	41	67	102	12	19	29	47 611	78 559	119 028
2043	6 656	10 983	16 640	84	138	209	41	68	102	12	19	29	48 151	79 449	120 377
2044	6 739	11 119	16 847	85	140	213	41	68	103	12	19	29	48 690	80 338	121 725
2045	6 822	11 256	17 054	86	142	216	42	68	104	12	20	30	49 229	81 228	123 073
2046	6 904	11 392	17 261	88	144	219	42	69	104	12	20	30	49 768	82 118	124 421
2047	6 987	11 529	17 468	89	146	222	42	69	105	12	20	31	50 308	83 008	125 769
2048	7 070	11 666	17 675	90	149	225	42	70	106	13	21	31	50 847	83 897	127 117
2049	7 153	11 802	17 882	91	151	228	43	70	106	13	21	32	51 386	84 787	128 466
2050	7 236	11 939	18 089	93	153	231	43	71	107	13	21	32	51 926	85 677	129 814
Differential 2050 vs 2018 (%) ->	50,9%	84,0%	127,3%	74,7%	123,2%	186,6%	20,6%	33,9%	51,4%	16,5%	27,2%	41,2%	37,6%	62,0%	94,0%

Note: Churchill Falls : included in the 2018 power input to Quebec (5 428 MW) and included in the 2050 power input to Newfoundland
Prince Edward Island : Based solely on power input from New Brunswick's undersea links and excluding power input contribution from the island's wind farms
* according to selected scenarios from the Boston Consulting Group www.bcg.com/publications/2019/costs-revving-up-the-grid-for-electric-vehicles