AVIN INSIGHTS

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INTRODUCTION TO ELECTRIC VEHICLES AND CHARGING INFRASTRUCTURE

TABLE OF CONTENTS

INTRODUCTION

Transportation is the second-largest source of greenhouse gas emissions in Canada, after the oil and gas sector[1]. With the ever-increasing number of private and commercial vehicles on roads, it is now inevitable to start to decarbonize our means of transportation. As electric vehicles (EVs) can help significantly reduce transportation emissions and reliance on fossil fuels, some countries have announced plans to ban internal combustion engine vehicle (ICEV) sales in the next 10 to 20 years, and most countries have set strict targets for transitioning to zero-emission vehicles (ZEVs). Almost all automakers have also launched EV models and plan for EV production expansion, with more than 250 new models of EVs being introduced in the next two years alone[2]. Due to the huge benefits and positive promises of EVs, some other companies have also joined the EV revolution by expanding their business focus to include vehicle production. For example, Huawei has partnered with the automotive company SERES to launch an extended range electric vehicle[3].

Successful adoption of EVs requires installing charging infrastructure that is widely-available, easy to use, and affordable—whether at home, at work, or in public locations. Significant innovation and investments are being put into the expansion of the EV charging network worldwide, with the goal of addressing customer anxieties and enabling the sustainable growth of EVs.

In this report, we highlight the different types of electric vehicles and their charging infrastructure technologies. We also discuss the major benefits of adopting EVs for both the vehicle owner and the environment, and touch upon the current market dynamics of EV adoption globally and in Canada.

[1] **Government of Canada. Greenhouse gas emissions. Retrieved from** https://www.canada.ca/en/environment-climate-change/services/environmental-indicators/greenhouse-gas-emissions.html

[2] **McKinsey & Company. (2021). How charging in buildings can power up the electric-vehicle industry. Retrieved from** https://www.mckinsey.com/industries/electric-power-and-natural-gas/our-insights/how-charging-in-buildings-can-power-up-the-electric-vehicle-industry

[3] **Huawei Device Co., Ltd. (2021). Huawei Starts to Sell New SERES SF5 Car in its China Flagship Stores. Retrieved from** https://consumer.huawei.com/en/press/news/2021/huawei-starts-to-sell-new-seres-sf5-car-in-its-china-flagship-stores/

TYPES OF ELECTRIC VEHICLES

There are two main types of electric vehicles: fully electric and hybrid. They differ in their reliance on solely batteries, or a combination of a battery and an internal combustion engine (ICE), as detailed below.

In this section:

Fully Electric Vehicles

Fully electric vehicles are also known as all-electric vehicles. These vehicles have no combustion engine and are only powered through electric motors. The electricity comes from a battery for **battery electric vehicles (BEVs)** and a fuel cell for **fuel-cell electric vehicles (FCEVs)**.

Batteries in **BEVs** are charged from an external power supply, typically by plugging into the grid via an EV charger. All energy to run the vehicle comes from the rechargeable battery pack.

FCEVs use fuel cells to power their onboard electric motor. Fuel cells in vehicles generate electricity by combining oxygen from the air and compressed hydrogen, which can be obtained from hydrogen fueling stations. Though, there is limited hydrogen infrastructure currently available worldwide.

BEVs and FCEVs are **zero-emission vehicles (ZEVs)**, which means that they do not generate any harmful tailpipe emissions, compared to the conventional ICEVs. They are the cleanest and most eco-friendly vehicles we can find on roads.

Hybrid Electric Vehicles

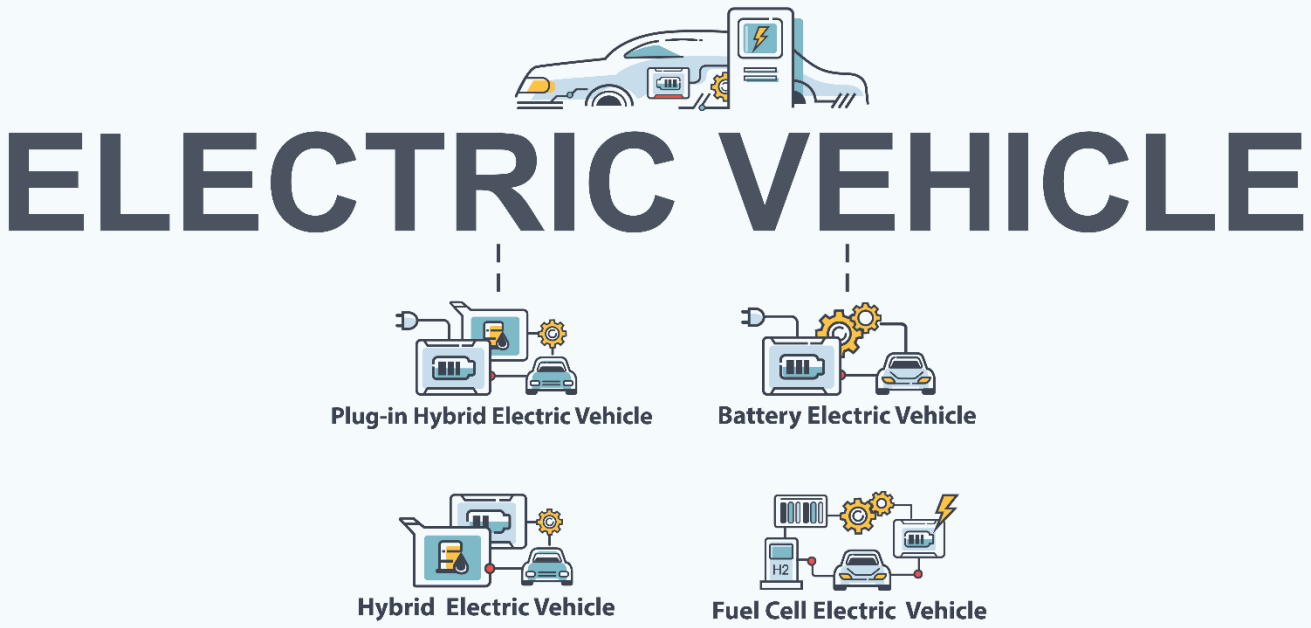
A hybrid electric vehicle contains both an ICE and an electric engine. These middle ground vehicles come in different forms.

The most popular form of hybrid vehicle is the **plug-in hybrid electric vehicle (PHEV)**. These vehicles can depend on their on-board battery to cover in-city traveling distances and can also switch to their combustion engine to cover long distances without worrying about electricity re-charge. Same as BEVs, PHEVs can have their batteries recharged via plugging into the power grid. PHEVs are considered a bridging technology between conventional ICEVs and fully electric ones.

Another form of hybrid electric vehicle is the range-extended electric vehicle, or **range extender (REx)** for short. These vehicles mostly act as BEVs with wheels only driven by electric motors. The on-board ICE can be used as a generator to recharge the battery in case a charging power supply is not available. The ICE can never directly drive the wheels, compared to PHEVs.

A **full hybrid electric vehicle (HEV)** is another form of hybrid vehicle that can run on a battery, an ICE, or a combination. However, compared to PHEVs and REx, HEV batteries can only be charged by on-board operations, not by plugging into the grid. All electricity for the battery is obtained through regenerative braking and the on-board ICE.

As the cleanest electric vehicles with ease of charging through the power grid, BEVs are expected to have the largest market share in EV sales by 2030. Although PHEVs have been attractive to consumers due to their major advantage of a long driving range, they have started to face regulatory concerns for being less eco-friendly than fully electric options. The driving range of BEVs has also been constantly increasing; rising by 55 percent from 2017 to 2020, according to McKinsey[4].



[4] **McKinsey & Company. (2020). McKinsey Electric Vehicle Index: Europe cushions a global plunge in EV sales. Retrieved from** https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/mckinsey-electric-vehicle-index-europe-cushions-a-global-plunge-in-ev-sales

CHARGING INFRASTRUCTURE

As sales of and interest in EVs grow, consumer demands grow subsequently to secure and easily access EV charging infrastructure.

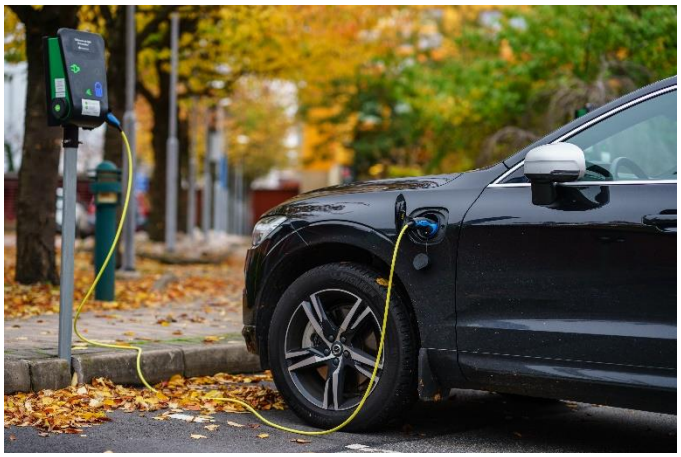
In this section:

McKinsey estimates that $110 - $180 billion must be invested from 2020 to 2030 to meet global demand for EV charging infrastructure, both in public and private spaces[2]. By 2025, 22-27 million combined charging points and stations will be needed in China, the EU plus the UK, and the US, and upward of 55 million charging points will be needed by 2030. These demands need to be addressed and charging infrastructure deployments need to be facilitated to eventually have EVs as the mainstream option on our roads.

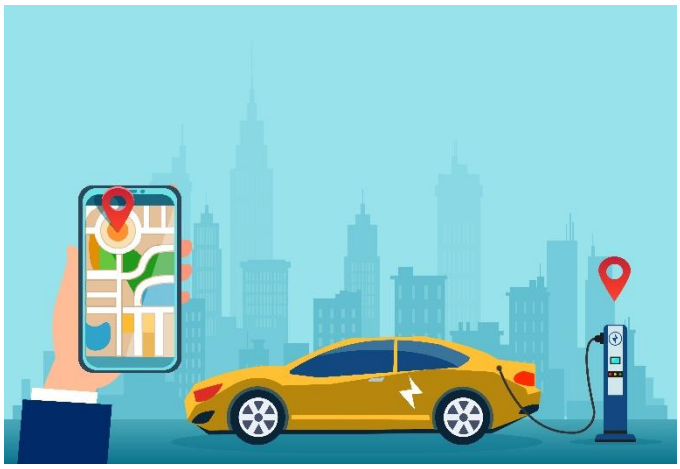
Where to charge?

Availability of EV charging infrastructure expands from private charging **at home** or **at work** to charging **at public stations** while traveling and/or at specific destinations. Unsurprisingly, most of EV charging currently takes place at EV owner's homes, where vehicles usually remain parked for 8 to 12 hours at night. Aside from the ultimate convenience, home charging comes with another major benefit: it tends to be cheaper compared

to work and public stations as, in most countries, residential electricity is lower priced than commercial electricity, and most home charging can happen overnight, benefiting from off-peak much lower prices[5]. Consumers can plug in their EVs overnight and wake up to a full battery of low-cost electricity.



Despite being the dominant option, home charging needs to be complemented by charging stations en route and at popular destinations to support EV charging on the go. In countries like China, where there are a few areas with single-family houses compared to highly dense urban residences and facilities, public charging is also expected to dominate over time with availabilities at on-street and commercial parking spots, in addition to well-visited public places[5]. The search for these public charging stations is usually supported by mobile or web apps that display the location of these stations, and possibly, the wait times. The most popular app is PlugShare[6], which shows the locations and details of more than 300,000 charging stations worldwide. It relies on users to supply up-to-date information about EV charging stations.



[5] **McKinsey & Company. (2018). Charging ahead: Electric-vehicle infrastructure demand. Retrieved from** https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/charging-ahead-electric-vehicle-infrastructure-demand

[6] **Recargo, Inc. PlugShare. Accessed through** https://www.plugshare.com/

For consumers in multiple occupancy residences, such as apartment buildings, and those with access to commercial buildings at work, some property management companies have also started to deploy EV charging points on site. However, it is not as easy as deploying an EV charger in a single-family house since this usually requires revisiting and adapting the whole building electricity capacity and equipment. Therefore, recommendations have been made to urban planners, building developers, and electrical-equipment suppliers to integrate EV charging infrastructure into standard building-design plans[2].

What are the types of EV chargers?

Beyond where to charge their EVs, the next question that consumers ask is what type of charger they should use. Currently, there are three types of wired EV chargers available. The kilowatt capacity of a charger determines the speed at which the battery receives electricity.

Level 1 chargers

These are alternating current (AC) slow chargers that plug into a standard North

American household 120V outlet. They provide the slowest speed of charging, compared to the other two types.

AC chargers require an in-car inverter that converts alternating current to direct current (DC), which then charges the battery.

Level 2 chargers

Similar to Level 1 chargers, these are AC chargers. Yet, they use 208V or 240V power outlets, like the ones used for clothes dryers. They can charge a vehicle battery up to four times faster than a Level 1 charger[7]. They are the most common EV chargers in use.

Level 3 chargers

These are direct current fast chargers (DCFCs). They convert the AC obtained from the power grid to DC, supplying the vehicle directly with DC to charge the battery without the need for an inverter. Since DCFCs bypass the use of an EV inverter, they can deliver much higher levels of electrical power.

Level 1 and Level 2 chargers are suitable for home and workplace use, since they are relatively slow and require longer time for a charge, compared to Level 3 ones. They are also more affordable than Level 3 chargers, which are more suited for on-the-go stations to offer fast public charging when time matters. Level 2 chargers are also common at retail and public parking facilities. According to a recent report by McKinsey[2], an EV charger's cost can be as low as $400 for home charging points, $2,400 for public AC Level 2 charging points, and more than $30,000 for lower-end Level 3 charging points.

According to a recent study by the Boston Consulting Group (BCG)[8], two-thirds of the electricity demand for EV charging is currently coming from private charging points, whether at home or in company parking lots. The study forecasts however that the proportion of EV charging from public stations will be boosted over the next ten years. It is expected that the share of electricity demand from public charging will be close to that of private charging by 2030.

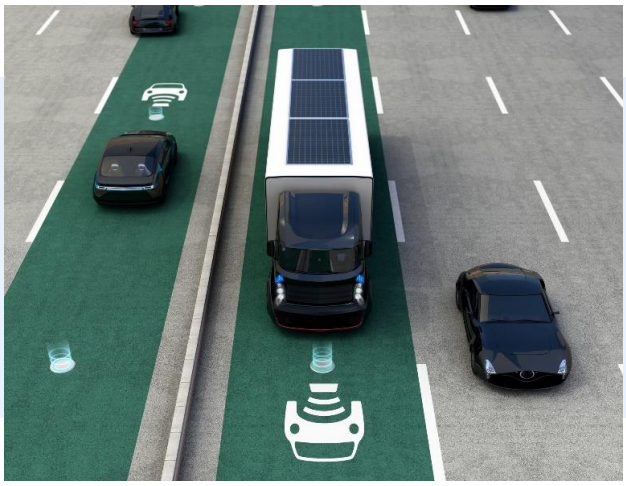
[7] **The Standing Committee on Environment and Sustainable Development. (2021). The road ahead: Encouraging the production and purchase of zero emission vehicles in Canada. Retrieved from** https://www.ourcommons.ca/Content/Committee/432/ENVI/Reports/RP11209745/envirp03/envirp03-e.pdf

[8] **Boston Consulting Group. (2021). Winning the Battle in the EV Charging Ecosystem. Retrieved from** https://www.bcg.com/publications/2021/the-evolution-of-charging-infrastructures-for-electric-vehicles

What about wireless charging?

Many solutions have been introduced to the market to facilitate charging EVs wirelessly. According to a recent market research report by Meticulous Market Research[9], the wireless EV charging systems market is expected to reach a value of $827.03 million by 2027. These wireless systems use electromagnetic waves to charge batteries. Typical systems consist of a charging pad installed at the wireless charging station and another pad attached to the vehicle. The most popular provider of wireless EV charging is the US-based Plugless Power Inc.[10], which began selling its Plugless L2 wireless charging system to the public in 2014 and is now offering its systems in many EV models.

With the continuing rise of autonomous vehicles, wireless charging techniques that can accommodate vehicles with no human on board have also been worth exploring and investing in. One of these techniques is the "charging on motion" concept. This includes the use of in-road charging plates that can transmit wireless energy to in-vehicle batteries[11,12].



[9] **Meticulous Market Research. (2021). Wireless Electric Vehicle (EV) Charging Systems Market. Retrieved from** https://www.meticulousresearch.com/product/wireless-electric-vehicle-charging-systems-market-5178

[10] **Plugless Power Inc. EV Unplugged - Wireless Electric Vehicle Charging. Accessed through** https://www.pluglesspower.com/

[11] **Knoss, T. (2018, March). Future electric cars could recharge wirelessly while you drive. Retrieved from** https://www.colorado.edu/today/2018/03/27/future-electric-cars-could-recharge-wirelessly-while-you-drive

[12] **Nutt, D. (2021). Research paves way for wireless charging of electric vehicles. Retrieved from** https://news.cornell.edu/stories/2021/04/research-paves-way-wireless-charging-electric-vehicles

Roads electrified through tracks of rail exemplify another promising solution. These electric rails transfer energy wirelessly to vehicles driving on them. This solution was deployed in Sweden for a distance of about 2 km, with plans by the government for future expansion[13]. Along with Sweden, Germany is also leading the development of electric roads. Recently, a €1.9 million project has been funded by the Roads Innovation Program of the German Federal Highway Research Institute (BASt) to test a wireless charging technology suitability to the Highway Network of Germany[14].

What about EV charging offerings in Ontario?

According to Natural Resources Canada[15], there are currently 13,634 EV chargers available at 6,115 stations across Canada. Among them, there are 1,596 EV charging stations with over 4,000 charging outlets in Ontario. There are many initiatives to expand the EV charging networks in the province. For instance, Ontario Power Generation (OPG), the largest energy provider in Ontario, is massively supporting EV charging offerings. In a joint venture with Hydro One, they have been developing the Ivy Charging Network[16], Ontario's largest, most connected fast-charger network with more than 70 locations and 160 fast chargers across the province. OPG has also expanded its attention to support public fleet electrification. Recently, the Toronto Transit Commission (TTC) board has approved a framework with OPG and Toronto Hydro to electrify TTC's bus fleet, North America's largest battery electric bus fleet[17]. OPG, through a subsidiary, will

[13] **The Guardian (2018, Apr). World's first electrified road for charging vehicles opens in Sweden. Retrieved from** https://www.theguardian.com/environment/2018/apr/12/worlds-first-electrified-road-for-charging-vehicles-opens-in-sweden

[14] **Cision US Inc. (2021). Electreon Wins a Tender to Provide Road Charging Technology for a Project Funded by the German Government. Retrieved from** https://www.prnewswire.com/il/news-releases/electreon-wins-a-tender-to-provide-road-charging-technology-for-a-project-funded-by-the-german-government-301221202.html

[15] **Natural Resources Canada. Electric Charging and Alternative Fuelling Stations Locator. Retrieved from** https://tinyurl.com/452jhr9e

[16] **Ontario Charging Network LP. Ontario, meet Ivy. Accessed through** https://ivycharge.com/

[17] **Ontario Power Generation. (2021). OPG building better ways to charge the Province's transit. Retrieved from** https://www.opg.com/media_releases/opg-building-better-ways-to-charge-provinces-transit/

> **" By providing more environmentally friendly transit options, the TTC, OPG and Toronto Hydro are contributing to our government's efforts to build healthier communities across our province.[17] "**
>
> The Hon. Caroline Mulroney, Ontario's Minister of Transportation and Francophone Affairs

design, build, operate and maintain the charging infrastructure to power the electric bus fleet.

Many other companies and organizations, such as Tesla, ChargePoint, Canadian Tire, Electrify Canada, and FLO, have been actively deploying national EV charging networks across Canada, including Ontario[18]. GM has also recently announced its plan to offer about 60,000 EV charging points across Canada and US, in partnership with seven charging network providers[19].

In April 2021, the Government of Canada announced a more than $235,000 investment for SWTCH Energy Inc.[20], a charging and energy management solution provider headquartered in Toronto, to install 61 EV chargers in Ontario and Quebec to provide EV consumers with more public options to charge their vehicles[21]. This funding is provided through Natural Resources Canada's Zero-Emission Vehicle Infrastructure Program[22].

[18] **Electric Autonomy Canada. (2021). Canadian EV charging networks post double-digit growth since start of pandemic. Retrieved from** https://electricautonomy.ca/2021/02/04/canadas-ev-charging-networks-2021/

[19] **Reuters. (2021). GM partners up to offer about 60,000 EV charging points across Canada, U.S. Retrieved from** https://www.reuters.com/business/autos-transportation/gm-partners-up-offer-about-60000-ev-charging-points-across-canada-us-2021-04-28/

[20] **SWTCH Energy Inc. Scalable, end-to-end EV charging & energy management solutions. Accessed through** https://swtchenergy.com/

[21] **Government of Canada. (2021). More than 60 New Electric Vehicle Chargers Coming to Ontario and Quebec. Retrieved from** https://www.canada.ca/en/natural-resources-canada/news/2021/04/more-than-60-new-electric-vehicle-chargers-coming-to-ontario-and-quebec.html

[22] **Natural Resources Canada. Zero Emission Vehicle Infrastructure Program. Accessed through** https://www.nrcan.gc.ca/energy-efficiency/transportation-alternative-fuels/zero-emission-vehicle-infrastructure-program/21876

ADVANTAGES OF ELECTRIC VEHICLES

Compared to gasoline vehicles, electric vehicles come with huge benefits to their owners and the environment, as we discuss below.

In this section:

Electric Vehicles Save You Money

When purchasing a new vehicle, consumers should not only consider the price of the vehicle, but also the cost of ownership over the long term. Since EVs use electricity instead of fossil fuels, the cost of using them is lower than those of conventional ICEVs. More savings can be gained when EV users charge their vehicles overnight at off-peak hours. According to Plug 'N Drive, a Canadian non-profit organization committed to accelerating the adoption of EVs, the average Canadian driver, travelling 20,000 km per year, can save about $2,000 per year on fuel cost alone[23]. According to Natural Resources Canada's Fuel Consumption Ratings Search Tool[24], on average, a typical BEV costs less than $530 per year, or about $1.45 per day to charge at night. A typical PHEV costs about $700 per year, or $1.92 per day for both gasoline and electricity costs. Comparable gasoline cars can cost about $2,500 per year to fuel.

EVs have lower lifetime maintenance costs as well. A recent analysis[25] by Consumer Reports finds that owners of EVs are spending half as much on maintenance and repair as the owners of comparable ICEVs. According to this analysis, the average maintenance/repair costs over vehicle lifetime for a BEV or PHEV is $0.03/mile, compared to $0.06/mile for an ICEV.

Electric Vehicles are Eco-Friendly

The global transportation sector accounts for one of the largest portions of greenhouse gas (GHG) emissions. Global GHG emissions from the transportation sector totaled 8.26 billion metric tons of carbon dioxide equivalent in 2018, with an increase of almost 80 percent since 1990[26]. One of the major benefits that come with the use of EVs is the significant reductions in such GHG emissions generated from burning fuel to power ICE-based transportation. These pollutants have major harmful impacts on air quality and climate change, that can be greatly reduced, and eventually avoided, through the use of EVs. According to Plug 'N Drive, by switching to EVs, the average Canadian

[23] **Plug 'N Drive. Electric Car Benefits. Retrieved from** https://www.plugndrive.ca/electric-vehicle-benefits/
[24] **Natural Resources Canada. Fuel Consumption Ratings Search Tool. Retrieved from** https://fcr-ccc.nrcan-rncan.gc.ca/
[25] **Consumer Reports, Inc. (2020). Electric vehicle owners spending half as much on maintenance compared to gas-powered vehicle owners, finds new CR analysis. Retrieved from** https://advocacy.consumerreports.org/press_release/electric-vehicle-owners-spending-half-as-much-on-maintenance-compared-to-gas-powered-vehicle-owners-finds-new-cr-analysis/
[26] **Statista. (2021). Greenhouse gas emissions from the transportation sector worldwide from 1990 to 2018. Retrieved from** https://www.statista.com/statistics/1084096/ghg-emissions-transportation-sector-globally/

driver can reduce their vehicle's GHG emissions by as much as 90 percent, since most of Canada's electricity comes from hydroelectric and nuclear power[23]. This is not only the case in Canada. A 2020 study by the universities of Exeter, Nijmegen, and Cambridge found that driving an EV is better for the climate than conventional ICEVs in 95 percent of the world[27]. The greater the proportion of renewables in a country's electricity generation mix, the more the environmental benefits of EVs are.

Electric Vehicles as a Source of Energy

One of the very promising advantages of EVs is that they can give energy back to the grid, in a type of communication known as vehicle-to-grid (V2G)[28].

In situations where EVs are parked with unneeded electricity, their batteries could be used to let electricity flow from these vehicles to the electric distribution network. This V2G concept brings a source of revenue to the owners of these vehicles by selling electricity back to the grid during times of peak demand. V2G can also help stabilize the power grid when its main electricity sources are fluctuating and potentially work as a residential back-up power supply when there is a power outage.

As a partnership between SWTCH and Opus One Solutions, with additional technical support from the University of Waterloo's Cheriton School of Computer Science, a couple of office buildings in downtown Toronto will be a testing and demonstration ground for V2G technologies in the next three years[29]. EV owners can choose to opt-in to participate and their per kilowatt hour rate will be pre-negotiated. This project represents an opportunity to prove that EVs are not just cars, but "batteries on wheels" with many useful applications even when they are not being driven.

[27] **ScienceDaily. (2020). Electric cars better for climate in 95% of the world. Retrieved from** https://www.sciencedaily.com/releases/2020/03/200323125602.htm
[28] **Bonnici, D. (2020). Vehicle-to-grid technology explained. Retrieved from** https://www.whichcar.com.au/car-advice/what-is-vehicle-to-grid-charging

[29] **Electric Autonomy Canada. (2021). SWTCH Energy to lead new blockchain-based EV charging pilot. Retrieved from** https://electricautonomy.ca/2020/11/11/swtch-ev-charging-blockchain-buildings/

MARKET DYNAMICS

So, what are the current market dynamics and consumer trends for these EV technologies?

Next, we walk you through this globally and in Canada.

In this section:

Global Dynamics

Consideration and adoption of EVs have significantly increased over the past few years, as consumers have started to recognize and appreciate their major benefits. By 2030, it is anticipated to have as many as 130 million EVs on the road globally, with more than 250 new EV models likely to be unveiled by manufacturers in the next two years, according to McKinsey[2].

The adoption curve for EVs varies by market, depending primarily on the cost of owning an EV, the local cost of electricity versus fossil fuels, and the incentives available to consumers to switch to EVs. China and Europe play a major role in shaping the global EV trends. The Chinese government's incentives, along with the low electricity costs compared to gas prices, have made China the leading market for EVs for many years[30]. With the tough emission targets and fines for not meeting them, sales of EVs in Europe more than doubled in 2020 to about 1.3 million units - topping China for the first time[31]. Norway has come at the top of the list. In 2020, BEVs made up 54.3 percent of all new vehicles sold in Norway, a global record up from 42.4 percent in 2019 and from a 1 percent of the overall market a decade ago[32]. Meanwhile, EV sales in the US fell behind China and Europe. This is attributed to many factors including the relatively low cost and taxes of fuel that make ICEVs cheaper than EVs to operate in the US[33].

The overall consumer demand for EVs remained strong globally even through the COVID-19 pandemic. According to a recent study by BCG[34], the global market share of light EVs grew from 8 percent in 2019 to 12 percent in 2020 and has shown continued strength in early 2021. The share of the light vehicle market occupied by PHEVs and BEVs rose to 2.2 percent in 2020 in the US, 5 percent in China, and 9.3 percent in the EU where sales of plug-ins in the fourth

[30] **Boston Consulting Group. (2020). Who Will Drive Electric Cars to the Tipping Point? Retrieved from** https://www.bcg.com/publications/2020/drive-electric-cars-to-the-tipping-point

[31] **Automotive News Europe. (2021). The next electric-car battery champion could be European. Retrieved from** https://europe.autonews.com/suppliers/next-electric-car-battery-champion-could-be-european

[32] **World Economic Forum. (2021). Norway sets electric vehicle record. Retrieved from** https://www.weforum.org/agenda/2021/01/electric-cars-record-market-share-norway-2020/

[33] **McKinsey & Company. (2020). Electric mobility after the crisis: Why an auto slowdown won't hurt EV demand. Retrieved from** https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/electric-mobility-after-the-crisis-why-an-auto-slowdown-wont-hurt-ev-demand

[34] **Boston Consulting Group. (2021). Why Electric Cars Can't Come Fast Enough. Retrieved from** https://www.bcg.com/publications/2021/why-evs-need-to-accelerate-their-market-penetration

quarter grew by 230 percent over the same period in 2019. Tesla's sales in particular rose approximately 36 percent to 499,550 vehicles in 2020. The company's full year revenue climbed to $31.5 billion, up from $24.6 billion in 2019[35].

BCG predicts that, by 2026, EVs will account for more than half of light vehicles sold globally[34]. Cheaper batteries and longer-range vehicles, in addition to government incentives and regulations, are driving this growth. The study projects that, by 2030, the global market share of BEVs will rise to 28 percent. The forecast also sees ZEVs replacing ICEVs for new light-vehicle sales globally just after 2035. This powertrain shift will be most notable in Europe and China where BEV penetration is anticipated to reach 43 percent and 40 percent, respectively. Meanwhile, PHEV penetration may begin to decline as government incentives for hybrid vehicles expire and targets for zero-emission transportation get stronger. While the EV market share in the US will likely increase with President Biden Administration's goal to accelerate and deploy electric vehicles and charging stations[36], the pace of its growth is expected to be slower than those in China and Europe.

By 2026, EVs are expected to account for more than half of light vehicles sold globally.[34]

[35] **The New York Times Company. (2021). Tesla Has First Profitable Year, but Competition Is Growing. Retrieved from** https://www.nytimes.com/2021/01/27/business/tesla-earnings.html

[36] **The White House. (2021). FACT SHEET: Biden Administration Advances Electric Vehicle Charging Infrastructure. Retrieved from** https://www.whitehouse.gov/briefing-room/statements-releases/2021/04/22/fact-sheet-biden-administration-advances-electric-vehicle-charging-infrastructure/

Market Dynamics and Developments in Canada

The Government of Canada has set ambitious targets[37], aiming for ZEVs to make up 10 percent of new light-duty vehicle sales per year by 2025, 30 percent by 2030, and 100 percent by 2040. These targets are coupled with plans by the federal and provincial governments to increase support for ZEV infrastructure and vehicle purchase incentives. For example, in the 2021 budget[38], the federal government announced that $17.6 billion will go towards a "green recovery" for the country, which includes expedited decarbonization of the automobile sector and development of a battery supply chain.

According to Statistics Canada[39], there were 54,353 new ZEVs registered in Canada in 2020, down slightly from 2019 and accounting for 3.5 percent of new vehicle registration in the country. Out of these 2020 ZEV registrations, 95.4 percent were in Canada's three largest provinces. Promisingly, according to a recent survey by KPMG Canada, the next new vehicle purchase for nearly 70 percent of Canadians will be an EV, of which over 62 percent intend to make their purchase in the next one-to-five years[40].

The adoption of EVs in Canada is anticipated to surge with the investments and EV manufacturing expansion happening in the country, and particularly in Ontario, by many leading vehicle manufacturers and EV technology providers. In September 2020, Ford Canada announced a plan to build BEVs at Ford's Oakville Assembly Complex in Oakville, ON, in addition to ICEVs. This project is valued at $1.8 billion and will include contributions of $295 million from each of the provincial and federal governments[41]. In October 2020, Fiat Chrysler Automobiles (FCA), which recently merged with Groupe PSA as Stellantis, reached an agreement[42] on a $1.5 billion venture to build plug-in

[37] **Natural Resources Canada. (2021). Zero Emission Vehicle Awareness Initiative. Retrieved from** https://tinyurl.com/uh6p7d5as
[38] **Government of Canada. Budget 2021. Accessed through** https://www.budget.gc.ca/2021/report-rapport/p2-en.html
[39] **Statistics Canada. (2021). Zero-emission vehicles in Canada, 2020. Retrieved from** https://www150.statcan.gc.ca/n1/pub/11-627-m/11-627-m2021033-eng.htm
[40] **Cision. (2021). The next new vehicle purchase for nearly 70 per cent of Canadians will be an electric model: KPMG in Canada survey. Retrieved from** https://tinyurl.com/fdsk8ca6
[41] **Government of Ontario. (2020). Historic Ford Canada Investment Transforming Ontario into Global Electric Vehicle Manufacturing Hub. Retrieved from** https://news.ontario.ca/en/release/58736/historic-ford-canada-investment-transforming-ontario-into-global-electric-vehicle-manufacturing-hub
[42] **Cision. (2020). Deal with Fiat Chrysler secures $1.5 billion electric vehicle investment. Retrieved from** https://www.newswire.ca/news-releases/deal-with-fiat-chrysler-secures-1-5-billion-electric-vehicle-investment-864517412.html

" Together with our federal partners, we are proud to invest almost $300 million to support the production of next-generation, made-in-Ontario vehicles and secure thousands of good-paying jobs across the province for years to come.[43] "

The Hon. Doug Ford, Premier of Ontario

hybrid and fully electric vehicles in Windsor, ON. In January 2021, General Motors announced plans to invest $1 billion to manufacture the BrightDrop EV600 electric commercial vehicles at its CAMI plant in Ingersoll, ON[44].

Moreover, some EV auto part suppliers have great presence and contributions in the country. For example, Dana has widespread EV operations in Ontario and Quebec, including the company's global battery R&D centre in Oakville, ON, and a manufacturing plant in Cambridge, ON[45]. Magna International, the Canadian auto parts supplier headquartered in Aurora, ON, has also been a pioneer in the EV industry. In December 2020, Magna announced the launch of a joint venture with LG Electronics, tentatively called LG Magna e-Powertrain and valued at $1 billion, to make key components for EVs[46].

To further promote EV design, manufacturing, and adoption in Canada, the Automotive Parts Manufacturers Association (APMA) launched the first,

[43] **Cision. (2020). New commitment to battery-electric vehicle manufacturing in Ontario. Retrieved from** https://www.newswire.ca/news-releases/new-commitment-to-battery-electric-vehicle-manufacturing-in-ontario-833966689.html

[44] **General Motors Canada. (2021). General Motors to Invest C$1 billion to Convert CAMI into Canada's First Large-Scale Commercial Electric Vehicle Manufacturing Plant. Retrieved from** https://media.gm.ca/media/ca/en/gm/home.detail.html/content/Pages/news/ca/en/2021/Jan/0115_brightdrop.html

[45] **FMA Communications Canada, Inc. (2021). Canada jumps into electric vehicle industry. Retrieved from** https://www.canadianmetalworking.com/canadianmetalworking/article/madeincanada/canada-jumps-into-electric-vehicle-industry

[46] **Reuters. (2020). LG and Magna announce billion dollar joint venture in electric car gear. Retrieved from** https://www.reuters.com/article/lg-elec-magna-intl-jv-idINKBN28X0EU

original, zero-emission concept vehicle named Project Arrow[47]. The vehicle will be designed, engineered, and built exclusively by Canadian automotive manufacturers and post-secondary institutions.

Furthermore, the Government of Ontario is investing $56.4 million over the next four years to create the Ontario Vehicle Innovation Network (OVIN)[48]. OVIN will build on successful elements of the Autonomous Vehicle Innovation Network (AVIN), accelerating the development of next generation electric, connected, and autonomous vehicle and mobility technologies. OVIN will encourage innovation and collaboration in the auto industry and battery sector as well, including critical minerals development in Ontario's North. The Ontario government, through the Ministry of Northern Development, Mines, Natural Resources and Forestry, is also developing a Critical Minerals Strategy to support relevant technologies, including EVs[49].

$56.4 million

of further support over the next four years by the Government of Ontario to create the Ontario Vehicle Innovation Network (OVIN) that will help foster the next generation of electric, connected, and autonomous vehicle and mobility technologies in Ontario.

[47] **Automotive Parts Manufacturers Association (APMA). Project Arrow. Accessed through** https://projectarrow.ca/

[48] **Government of Ontario. (2021). Ontario's Action Plan: Protecting People's Health and Our Economy. Retrieved from** https://budget.ontario.ca/2021/pdf/2021-ontario-budget-en.pdf

[49] **Government of Ontario. (2021). Ontario Developing First-Ever Critical Minerals Strategy. Retrieved from** https://news.ontario.ca/en/release/60622/ontario-developing-first-ever-critical-minerals-strategy

HIGHLIGHTS FROM ONTARIO

ECAMION

eCAMION Inc., based in Toronto, ON, is a technology provider for flexible battery storage, electric vehicle charging, and energy management solutions. The company's "Jule" charging stations provide power for electric cars, trucks, vans, and buses. The company has installed energy storage systems in Toronto, Michigan, Ottawa, Sudbury, and the York Region in Ontario, as well as EV fast-charging stations in Ontario, Michigan, and Manitoba.

Link: https://www.ecamion.com/

EBERSPAECHER

Eberspaecher Vecture Inc., headquartered in Vaughan, ON, specializes in Battery Management System (BMS) solutions for a variety of industries as well as being at the forefront of BMS development for green energy storage, smart grid, and electric vehicle power applications. The company possesses one of the largest intellectual property libraries of BMS designs for the latest Lithium based systems.

Link: https://www.eberspaecher-vecture.com/

FLEETCARMA

FleetCarma is a division of Geotab and based in Kitchener, ON. The company designs solutions for electric utilities to understand and manage electric vehicle charging. With customers in North America and Europe, the company provides telematics for hybrid and electric vehicles as well.

Link: http://www.fleetcarma.com/

ELEAPPOWER

eLeapPower is a Toronto, ON-based startup that was founded in 2016. The company has developed a suite of technologies for powering e-mobility. Their powertrain technology aims for optimizing battery performance and significantly cutting charging time. It also allows for bidirectional charging, as well as charging directly from renewable energy sources like wind and solar. eLeapPower powertrains work across all manufacturers, vehicle types, and batteries.

Link: https://www.eleappower.com/

Note: The companies highlighted above are only a few examples of the success stories in Ontario in the vehicle electrification space.

CONCLUSIONS

In this report, we have shed light on the types of electric vehicles and the key differences among them. We have also touched upon the EV charging infrastructure, highlighting the different types of EV chargers and some of the EV charging offerings in Ontario. We have reviewed the immense advantages of electric mobility and, finally, highlighted the current market dynamics and consumer trends regarding EV adoption globally and in Canada.

Despite the promising market dynamics that have surpassed many of the forecasts, EV adoption is still in its infancy. EVs will thrive and spread only if they become affordable to buy, easy and fast to recharge, and capable of longer ranges with a single charge, as compared to conventional ICEVs. Fortunately, a lot of research and innovation is currently happening worldwide, especially in terms of energy efficiency and its impact on the vehicle cost.

Major benefits also extend beyond EV users and the environment. By supporting the production of EVs, their batteries, and charging infrastructure, countries can attract investments, create sustainable jobs, and make their automotive sector more competitive[7]. Advances and innovation in EV developments can also help related sectors, such as manufacturing and critical minerals, to flourish. Governments as well as companies in the automotive sector need to be forward-looking and interpret the need to decarbonize their transportation offerings as an opportunity to lead globally and reap huge environmental, social, and economic benefits.

With Ontario's access to an abundance of critical materials needed for EV battery production, in addition to a plethora of innovative companies, world-class research institutes, and highly skilled workers, the province is poised to lead the future of electric vehicle production[50].

[50] **Invest Ontario. (2021). 5 reasons Ontario is poised to lead the future of electric vehicle production. Retrieved from** https://www.investontario.ca/spotlights/5-reasons-ontario-poised-lead-future-electric-vehicle-production

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ABOUT AVIN

The **Autonomous Vehicle Innovation Network (AVIN)** is a key component of Driving Prosperity, the Government of Ontario's initiative to ensure that the automotive sector remains competitive and continues to thrive. The Government of Ontario has committed $85 million in innovative programming to support research and development (R&D) funding, talent development, technology acceleration, business and technical support, and testing and demonstration sites. AVIN programs support small- and medium-sized enterprises (SMEs) to develop, test, and commercialize new automotive and transportation products and technologies, and cultivate the capacity of a province-wide network to drive future mobility solutions, reinforcing Ontario's position as a global leader.

AVIN, led by Ontario Centre of Innovation (OCI), is supported by the Government of Ontario's Ministry of Economic Development, Job Creation and Trade (MEDJCT) and Ministry of Transportation (MTO).

The initiative comprises five distinct programs and a central hub. The AVIN programs are:

- AV Research and Development Partnership Fund
- WinterTech
- Talent Development
- Demonstration Zone
- Regional Technology Development Sites

The AVIN Central Hub is the driving force behind the programming, province-wide coordination of activities and resources, and Ontario's push to lead in the future of the automotive and mobility sector globally. Led by a dedicated team, the Central Hub provides the following key functions:

- A focal point for all stakeholders across the province;
- A bridge for collaborative partnerships between industry, post-secondary institutions, broader public sector agencies, municipalities, and the government;
- A concierge for new entrants into Ontario's thriving ecosystem; and
- A hub that drives public education and thought leadership activities and raises awareness around the potential of automotive and mobility technologies and the opportunities for Ontario and for its partners.

We would like to thank the Government of Ontario for supporting AVIN programs and activities.

We would also like to thank the partner organizations that work with OCI to deliver AVIN programs, including the Regional Technology Development Sites and the Demonstration Zone.