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Ontario

OVIN INSIGHTS
Specialized Series

# Leading the Charge: Ontario's Leadership in EV Charging Innovation

Quarterly Specialized Report



OCI
Where Next Happens

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# 1. Executive Summary

The electric vehicle (EV) charging industry has expanded rapidly in recent years, along with global ambitions to decarbonize the transport sector. EV chargers are essential to the development of the EV market – without sufficient charging infrastructure, the electrification of transport would not be able to keep pace with demand. This global expansion is pushing technological innovations, with EV charging organizations exploring opportunities for faster charging, wireless charging, and smart charging, and looking at how charging solutions can unlock opportunities for the sector.

It is predicted by the International Energy Agency that there may be approximately 240M EVs on roads globally by 2030.[1] In Canada alone, Transport Canada predicts there may be 4.6M light-duty EVs on the road by 2030.[2] This trend is supported by the mandatory target set by the Canadian government for 100% of new light-duty car and passenger truck sales to be zero-emission by 2035.[3]

In order to meet this demand, Canada is expected to need up to 469K public EV chargers by 2035.[4] Currently, the federal government's EV charging infrastructure targets are 84,500 chargers to be deployed by 2029.[5] Federal policies related to EVs and their charging infrastructure are building a foundation for a strong industry and robust network across Canada.

Ontario is at the forefront of the EV charging industry, supported by its significant history as a leader in the automotive market. The province has a robust and well-connected ecosystem – including leading Original Equipment Manufacturers (OEMs), manufacturers, service providers, and research institutions – which is driving the implementation of standardized and efficient EV charging solutions, providing significant advantage in the EV revolution.

This report presents an overview of the EV charging industry and examines Ontario's current position and opportunities for growth. This report also highlights emerging EV charging technologies and discusses global trends, current initiatives within the province, and identifies opportunities for Ontario to lead the charge in advancing the EV charging industry.

# 2. An Overview of Charging Technologies

This chapter describes the current state of EV charging technologies, along with emerging technologies in the industry.

EV chargers provide electricity to the on-board batteries of EVs and plug-in hybrid electric vehicles (PHEVs).[6] Available EV chargers fall into three categories:

- Level 1 – slow charging, standard domestic electrical outlet primarily found in residential settings.
- Level 2 – specialized domestic charging infrastructure, also commonly used for workplace and public charging.
- Level 3 – specialized fast chargers, generally found in dedicated public charging stations.[7]

These different charger types have different power ratings and charge times. All EVs, and most PHEVs, are compatible with all charging levels.[8]

## EV charger types[9] [10]

| | Level 1 | Level 2 | Level 3<br>DC Fast Charger |
|---|---|---|---|
| |  |  |  |
| **Input** | 120 V | 208-240 V | 480V |
| **Outlet type** | Standard electrical outlet (phone) | Special electrical outlet (stove or dryer) | DC outlet (not found in homes) |
| **Time to charge*** | 8-50+ hours | 4-10 hours | 25-30 minutes |
| **Range* (per hour of charging)** | 3 km to 8 km | 16 km to 50 km | Up to maximum driving range of vehicles |
| **Typical power output** | 1 kW | 7 kW- 19kW | 50 kW- 350 kW |
| **Typical uses** | Home charging and backup situations | Home charging, at business and public spaces | Charging at dedicated stations, public spaces, and highway |

*The amounts shown are estimates only and assume 80% charging level limit

## Standard Technology

There are currently two main types of EV chargers – alternating current (AC) chargers and direct current (DC) chargers.[11] AC chargers provide electricity through Level 1 and Level 2 chargers, whereas DC chargers, also referred to as Level 3 fast chargers, provide a much faster charging rate.[12]

In addition to the different charger types, there are also a variety of EV charging connectors available. These are dependent on the make and model of the EV. The majority of EV chargers and vehicles have a standard connector known as the Society of Automotive Engineers (SAE) J1772, which is compatible with any Level 1 or Level 2 EV charger in Canada and the United States.[13] For Level 3 fast chargers, there are three connector types available: SAE Combo connector, CHAdeMO (only used by Nissan and Mitsubishi), and the North American Charging Standard (NACS) connector.[14]

There were approximately 2.7M public charging points globally at the end of 2022.[15] Of these, approximately 1M slow chargers and 760K fast chargers were located in China[16] - this equates to around eight electric light duty vehicles (LDV) per charging point, or 3.46 kilowatts (kW) of public charging per electric LDV.[17] In Europe, there were 460K slow chargers. The top three European countries were the Netherlands with 117K slow chargers, France with 74K, and Germany with 64K.[18] There were 70K fast chargers in Europe – 12K of which were in Germany, 9.7K of which were in France and 9K of which were in Norway.[19]

The average public charging capacity per electric LDV globally is around 2.4 kW per EV.[20] Korea, with approximately 7 kW per EV, has the highest ratio.[21] In Canada, there is a ratio of 0.96 kW per EV, with 19 electric LDVs per charging point, and the United States has a ratio of 0.82 kW per EV, with 24 electric LDVs per charging point.[22]

**"Having attracted over $28 billion in automotive investments in the last three years, our province is a leading jurisdiction in the global production and development of EVs. By making it easier to build public charging infrastructure, our government is supporting Ontario's growing end-to-end EV supply chain and ensuring EV drivers can confidently and conveniently power their journeys."[23]**

- The Honourable Victor Fedeli, Ontario Minister of Economic Development, Job Creation & Trade

# Alternative Mobility Types

The EV offering has expanded over the past few years to cover different types of mobility, with different types of EVs having different charging requirements. A selection of these is outlined below.

## Micromobility charging

Electric micromobility refers to any small, low-speed, electric transport device, such as e-bikes and e-scooters.[24] These types of devices are generally charged using household 120 volt (V) AC outlets, with charging times ranging between 2.5 and 9 hours.[25]

## Electric bus charging

Battery electric buses (BEBs) can be categorized as either long/extended range – larger battery packs (250-660 kilowatt-hour (kWh)) which only need to be charged once or twice per day – or fast charge – smaller battery packs (50-250 kWh) that require more frequent high-powered charges.[26]

There are three types of charging infrastructure for BEBs; plug-in charging (both AC and DC options), overhead conductive charging, and wireless inductive charging (via floor-mounted charging pads).[27]

## Heavy-duty vehicle charging

The market for medium- and heavy-duty EVs is expanding, with nearly 840 models on offer.[28] Of these, over 90% are battery electric, and they rely on off-shift charging for the majority of their energy.[29]

For these types of EVs, overnight plug-in charging is the most convenient method due to slow charging being cheaper than fast charging.[30]

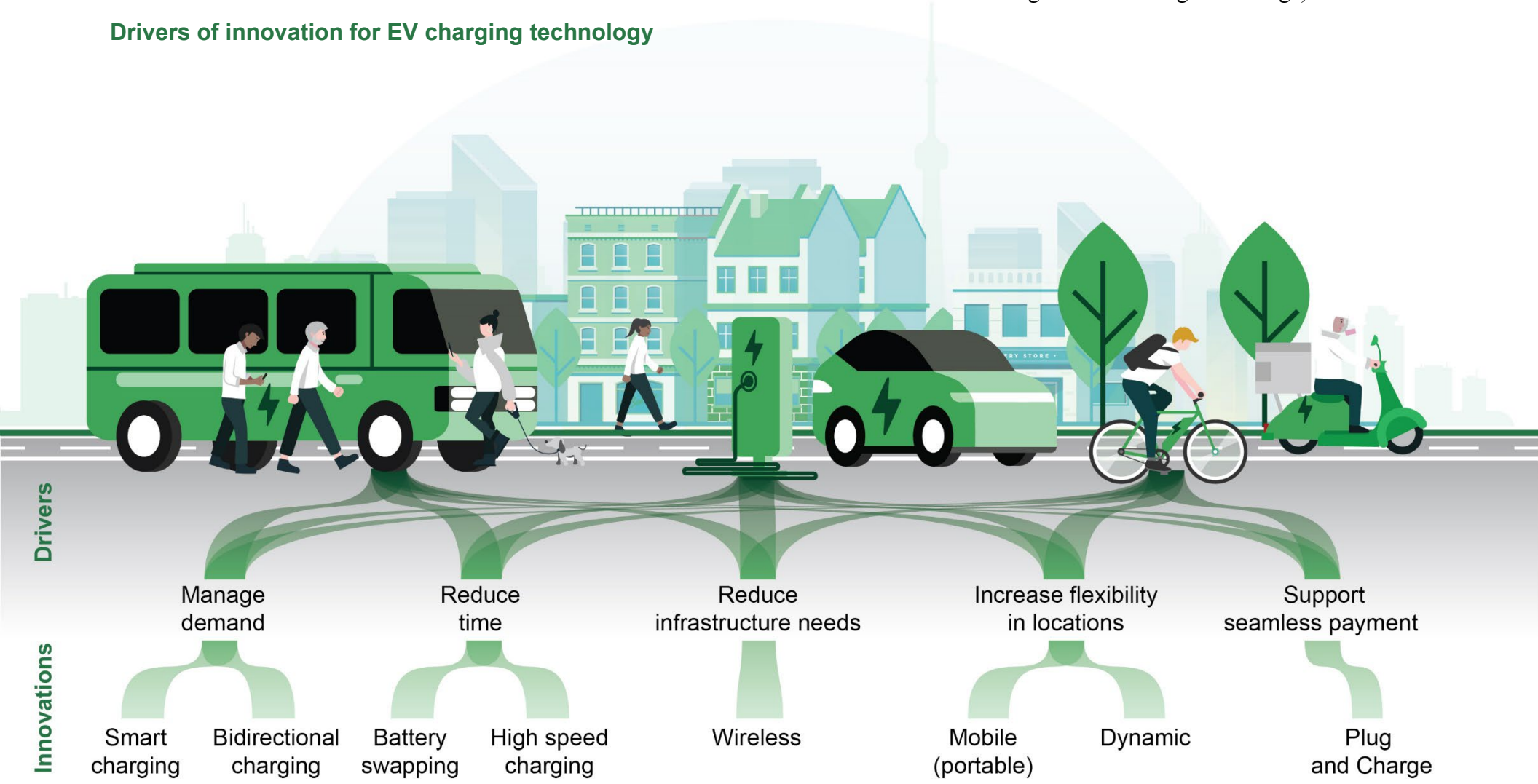
## Train charging

Electric trains currently have three ways in which they can be powered: battery, diesel hybrid engine, and overhead electric lines. Recent innovations in battery technology have resulted in batteries which can be charged whilst a train is running on electricity from overhead lines, and which can harness the energy from a train braking.[31]

## Emerging Technology

An increased demand in EVs and the resultant requirement for charging to meet consumer expectations have led to a surge in technological innovation and emergent charging technologies. Additional factors include the need to manage demand on the electricity grid (through technologies such as smart charging and bidirectional charging), reduce the time taken to charge an EV (through high-speed charging or battery swapping), reduce the need to install charging infrastructure and increase flexibility (through, for example, wireless or portable charging), and support a seamless charging and payment experience (through the introduction of technologies such as Plug and Charge).

### Drivers of innovation for EV charging technology



## Wireless charging

Wireless EV charging uses a process called inductive charging, whereby resonant electromagnetic induction transmits electrical current between a magnetic coil in the charger and a magnetic coil on the underside of the car.[32] This involves installing a wireless charging coil in a designated space, which a wireless-equipped EV would simply need to be parked over to allow for charging.[33]

One example of this technology is undergoing testing and being introduced to the market by North American EV charging company FLO. Working in partnership with WiTricity (a pioneer in wireless charging for EVs), FLO is testing static wireless charging technology at its advanced engineering lab.[34] WiTricity now offers its wireless charging solution to carmakers, suppliers, and car owners.[35] Additionally, American company Plugless Power developed the first wireless charging station to provide 1M charge hours, with installations at Google and Hertz, and installed the first wireless EV charging station on a production fleet of European driverless shuttlebuses.[36]

## Dynamic charging

Dynamic EV charging involves an EV being continuously charged as it is driven, with induction charging built into roadways, for example.[37] This technology would enable EV drivers to travel long distances without having to consider where to stop and charge.[38]

The first dynamic charging public roadway in North America has recently been installed in Detroit, Michigan, and is being used to test and refine the technology for public use.[39]

Dynamic charging can also be via overhead charging. Overhead charging refers to a method of charging most suited to buses and heavy vehicles, which uses a pantograph mounted to the vehicle roof to transfer energy.[40] Dynamic overhead charging involves charging vehicles from overhead wires along the vehicle's route.[41]

Overhead charging can also be static, typically deployed at bus stops or depots, where the vehicle is stationary.[42]

## Portable charging

Portable charging enables EV drivers to charge via a mobile device, removing the need to install charging infrastructure. This can be via a 'roadside assistance' type device which can charge multiple EVs simultaneously and can be recharged in a number of ways, such as through an EV station or by solar generation.[43]

This 'roadside assistance' type technology is already established in Canada, with Portable Electric (a Vancouver based company[44]) and CAFU (based in Montreal[45]) both offering the service.

## Battery swapping

Battery swapping is the process of switching a depleted EV battery with a fully charged one, via a battery swapping station.[46] This process is faster than current charging technology, aiming to take a similar amount of time as refuelling an internal combustion engine (ICE) vehicle at a gas station.[47]

American company Ample has launched battery swapping stations in the San Francisco Bay area, specifically for Uber drivers, with the service taking less than 10 minutes.[48]

## Bidirectional charging

Bidirectional charging refers to an EV which can receive charge from a charger and can also discharge energy, when paired with a similarly capable charging device.[49] This enables EVs to provide mobile energy storage, supplementing local energy generation or serving as emergency energy reserves.[50]

There are two types of bidirectional charging – vehicle-to-building (V2B) and vehicle-to-grid (V2G).[51] It is estimated that by 2030 EVs will have more than twice the capacity of Ontario's gas plants.[52] If all cars were electric, their gross discharge capacity would be more than six times Ontario's total peak demand.[53]

This technology has been piloted in Ontario, through the Peak Drive Pilot Project in Toronto. This was one of the largest V2G demonstration projects globally, with the goal of reducing energy bills through targeted discharging.[54]

## Plug and Charge

Currently, for payment purposes, EV drivers often need multiple apps, cards, and accounts to use different charging stations.[55] Plug and Charge technology enables a secure connection between an EV and the charging station, thereby allowing EV drivers to simply plug their vehicle into the charging station without needing a phone app to manage charging and billing.[56]

Plug and Charge uses cryptographic tools to enable secure communications between a vehicle and the charging infrastructure, ensuring the EV driver's personal information is protected, and that data is exchanged in a confidential and authenticated manner.[57] Plug and Charge was initially introduced as a concept by ISO 15118, the international standard for charging EVs.[58] This concept applies to both wired and wireless charging.

In 2021, Electrify Canada introduced Plug and Charge payment technology on all of its chargers across Canada.[59] It was the first company to offer the service to multiple automakers.[60]

## Smart charging

Smart charging relates to a system that allows a charging station owner to optimize energy consumption by monitoring, managing, and restricting the use of their devices remotely.[61] This is often via an app on the charging station owner's phone.

Smart charging can also provide flexibility at the system level; it can facilitate reducing peak demand by controlling EV charging patterns and support real-time balancing of the grid by adjusting charging levels.[62]A number of smart charging pilots have been implemented across Canada, including the Toronto Hydro Smart Charging Pilot Program,[63] and the Nova Scotia Power EV Smart Charging Pilot.[64]

## High-speed charging

High-speed charging, also known as ultra-fast charging, offers the ability to fully charge an EV in under a few minutes.[65] These ultra-fast types of chargers are a sub-category of Level 3 fast chargers, and offer a power output of over 350 kW, making them significantly faster than the current Level 3 chargers available on the market.[66]

The technology for high-speed charging continues to progress, in part due to the demand for heavy-duty application, such as buses and trucks.[67] In response to this, standards have been developed for high-power chargers, offering power outputs up to 600 kW.[68]

# 3. Global Drivers of Change

Demand for EV charging infrastructure is forecast to increase due to its necessity in the expansion of the EV market, and its role in the transition to net zero worldwide. This increased demand may require increased capacity of power grids around the world, with consumers pushing for a faster, more convenient charging experience. Additionally, the emergence of new EV markets and legislation to promote uptake and drive expansion of EV charging infrastructure is having an impact worldwide.

In this context, several overarching trends that are shaping the EV charging industry are detailed below.

## Increasing demand for EVs

Demand for EVs, and the charging infrastructure which enables their use, is expected to grow over the coming years. In 2022, there were over 26M EVs on the road, with EV car sales exceeding 10M – an increase of 55% relative to 2021.[69] It is predicted by the International Energy Agency that there may be approximately 240M EVs on roads globally by 2030.[70] The global EV charging station market was valued at USD $12B in 2022 and is anticipated to expand to USD $141B by 2030.[71] Governments around the world have put in place incentives to further encourage the uptake of EVs, as demonstrated in the policy framework section below. In Canada, the federal government has introduced the Incentives for Zero-Emission Vehicles (iZEV) Program,[72] and the Zero Emission Vehicle Infrastructure Program (ZEVIP),[73] and has set a mandatory target for 100% of new light-duty car and passenger truck sales to be zero-emission by 2035.[74] The federal government also plans to introduce regulations requiring that 100% of certain medium-and heavy-duty vehicles sold be low-emission by 2040.[75]

## Grid capacity

A core strategy in global ambitions to mitigate climate change and achieve net zero is the electrification of vehicles and increasing the percentage of electricity generated from renewable sources.[76] However, it is expected that in order to meet charging demand at peak times, such as in the evening when vehicles are plugged in at the end of the working day, new power plants may be required.[77] New technologies, such as bidirectional charging, can contribute towards making the electricity grid more efficient. An increase in the availability of public charging, particularly at workplaces, could also help distribute pressure on the grid throughout the day.[78]

## Consumer expectations

More and more people are choosing to drive EVs, and the increasing number of public charging stations are helping to enable this. However, consumers have anxieties related to charging which is causing many to delay the switch to an EV.

The time it takes to charge an EV is a concern for many (46%), along with the availability of charging stations (44%).[79] In Canada, nearly 70% of people cite concerns around the availability and reliability of public EV charging stations.[80] Additionally, 78% of Canadians have concerns around the pace at which battery technology is evolving in order to meet low-emission targets.[81] These consumer expectations are pushing for a faster and more convenient charging experience, both in terms of infrastructure investment and vehicle capability.[82]

## Heavy-duty vehicle charging

There is a growing market for electric heavy-duty vehicles. Nearly 66,000 electric buses and 60,000 medium- and heavy-duty EVs were sold worldwide in 2022 – around 4.5% of all bus sales and 1.2% of all medium- and heavy-duty vehicle sales worldwide.[83]

To enable this market to continue to grow, there is a requirement for charging to support long-distance applications through a combination of ‘off-shift’ slow charging, and ‘mid-shift’ fast charging.[84] Heavy-duty EVs are expected to rely on off-shift charging – overnight or other longer periods of downtime – for the majority of their energy needs.[85] However, mid-shift fast charging will be required to extend range, in order for EVs to replace routes currently covered by ICE vehicles.[86] It is estimated that charging power higher than 350 kW – and up to 1 MW – may be needed to fully recharge heavy-duty EVs during a 30- to 45-minute break.[87]

## Access to charging infrastructure

Those who are considered early adopters of EVs tend to live in single-family detached homes, where home charging is more convenient and affordable than public charging.[88] In the United States, 80% of EV owners live in single-family homes.[89]

The majority of EV drivers would prefer to charge their vehicle at home, but for those living in densely populated areas this isn't always an option.[90] In Germany, for example, nearly 90% of people living in rural and suburban areas have access to a home charger, whilst for those living in urban areas it is 77%.[91]

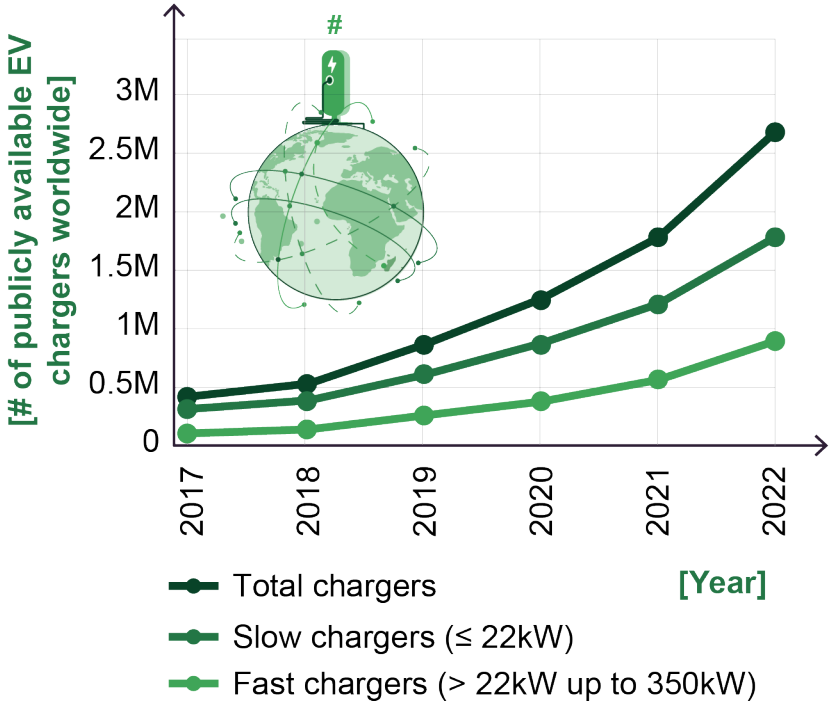
For EVs to be accessible to a wider audience, access to public and workplace charging is imperative.

Globally, the number of public EV chargers has increased significantly; from nearly 315K slow chargers and just over 100K fast chargers in 2017, to nearly 1.8M slow chargers and over 895K fast chargers in 2022.[92]

**~1.8M**
The number of public slow chargers globally in 2022

**895K+**
The number of public fast chargers globally in 2022

**Global public chargers[93]**



# Policy framework

## EV adoption

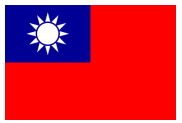
Globally there has been a drive by governments to encourage the uptake of EVs. Policies have been established worldwide to promote their use in order to meet net-zero emissions targets. This section provides a sample of the jurisdictions that have implemented EV policies over recent years. This is not a comprehensive representation but is rather intended to provide an overview of policies from a range of geographies.

**The Glasgow Climate Pact,** agreed by governments at the United Nations Climate Change Conference (COP26), sets out a declaration to accelerate the transition to 100% low-emission cars and vans. Governments agreed to work towards all sales of new cars and vans being low-emission by 2040 or earlier, or by no later that 2035 in leading markets.[94]

The European Union **Clean Vehicles Directive** promotes low-emission vehicles in public procurement tenders. The Directive applies to the purchase, lease, rent, and relevant services contracts of fleet vehicles such as cars, vans, trucks, and buses.[95] National targets for Member States are defined as a minimum percentage of low-emission vehicles in the aggregate public procurement across a Member State.[96]

The Government of Costa Rica has published a **National Decarbonization Plan**, which outlines a target of 100% EV share of LDV sales, 60% EV share of LDV stock, and 100% EV share of bus and taxi stock by 2050. [97]

The Government of Ireland has published a **Climate Action Plan 2023** which sets out targets related to the electrification of its fleet. Targets include 100% EV share of new passenger car sales by 2030, and 30% share of new low-emission heavy-duty vehicles sales by 2030.[98]



The Taiwanese government has announced a **plan to phase out fossil fuel-powered vehicles**, with the aim of a 100% EV share of private vehicles sales by 2040. The phased approach aims to have a 30% EV share of sales by 2030, and a 60% share by 2035.[99]

## EV charging

In addition to policies around the adoption of EVs, governments around the world have also begun to introduce policies related to charging infrastructure. A selection of these policies is summarized below:

- In May 2023, the United States and the European Union Trade and Technology Council published a joint statement around technical recommendations for the government-funded implementation of EV charging infrastructure.[100] The recommendations include: "1) the development of a joint standards support strategy; 2) support for the development and implementation of cost-effective smart charging infrastructure that avoids stranded assets; and 3) identification of the pre-normative research, development and demonstration required to tackle remaining challenges and to support consumers, industry, and the grid".[101]
- In February 2022, the Government of India published a policy for EV charging stations. This policy supports affordable charging for small business owners through setting tariffs, enables the preparation of electrical distribution systems, and outlines the requirement for public charging for long haul heavy-duty vehicles.[102]
- In June 2023, the SAE announced standardization of the NACS connector, developed by Tesla.[103] This standardization ensures that any supplier or manufacturer is able to use, manufacture, or deploy the NACS connector on EVs and at charging stations across North America.[104] Companies which have committed to adopt NACS include Ford, General Motors, Mercedes-Benz, Nissan, and Volvo.[105]

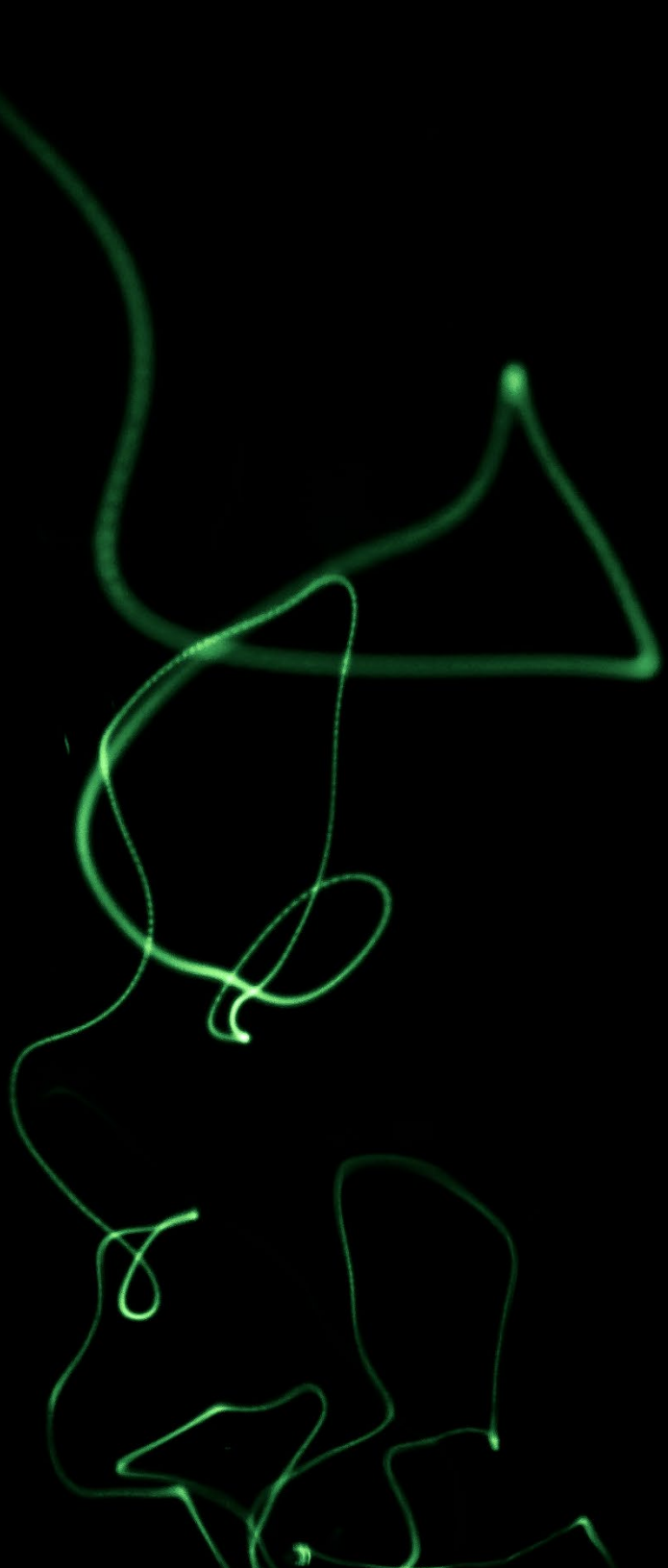
**"Building more public charging stations is part of our government's plan to be a global leader in the electric vehicle industry and provide more travel options for commuters."[106]**

- The Honourable Prabmeet Sarkaria, Ontario Minister of Transportation

# 4. Canada's EV Charging Trends

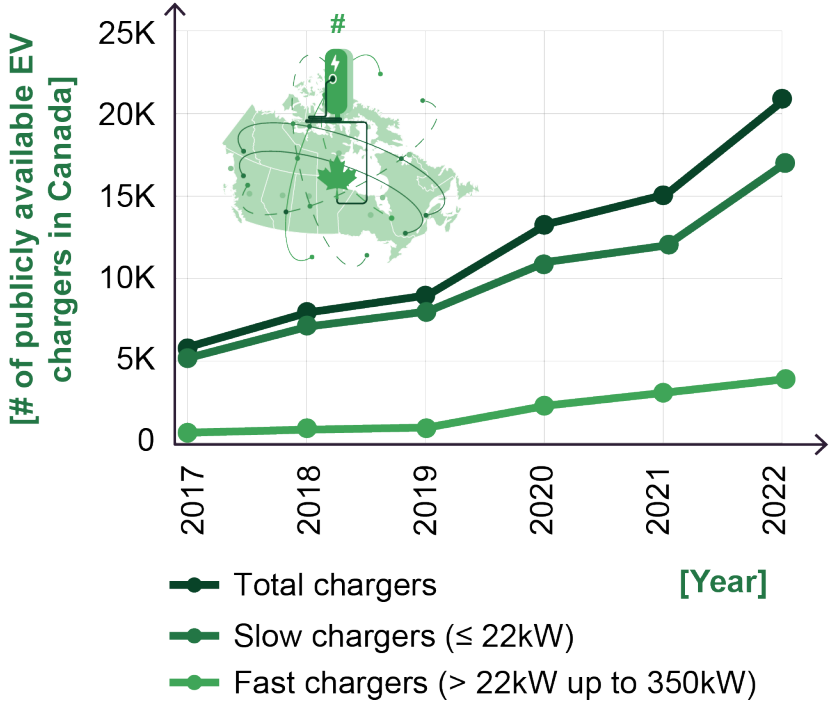
As of December 2023, Canada had over 10K public charging stations which provided access to over 21K Level 2 ports and over 4K Level 3 fast charging ports.[107] The availability of these charging stations varies across provinces. In order to meet demand, Natural Resources Canada estimated that the number of public Level 2 and Level 3 charging ports may need to increase to between 727K and 914K by 2050. [108] Federal policies related to EVs and their charging infrastructure are building a foundation for a strong industry and robust network across Canada.

This section outlines the factors shaping the EV charging industry in Canada.



# State of play

## Public chargers in Canada[109]

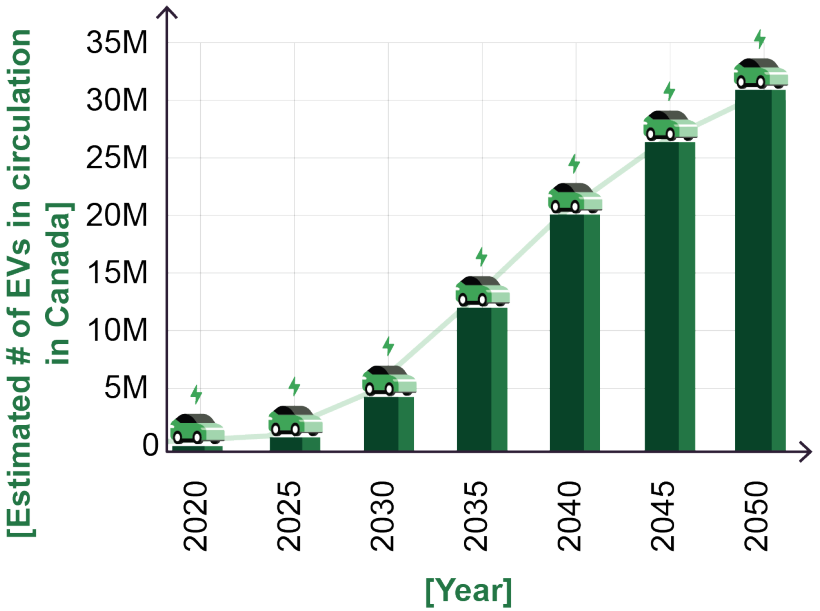





Canada has seen growth in the availability of public EV chargers, with a rise from nearly 6K in 2017 to nearly 21K in 2022.[110]

The number of EVs in circulation in Canada is expected to increase substantially over the coming years, from around 1.02M

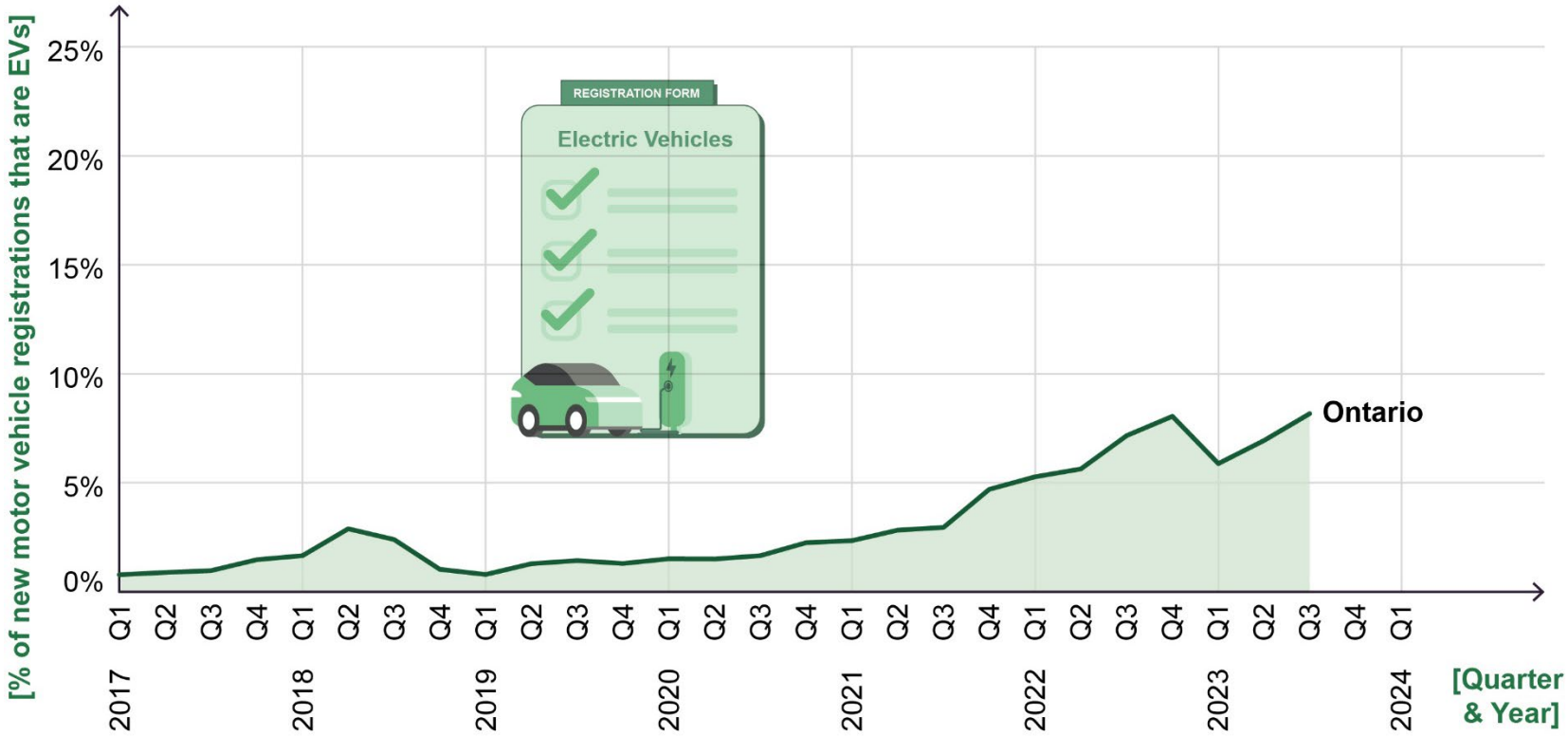
## EVs in Canada[111]






in 2025 – approximately 3.8% of the LDV fleet – to over 31M in 2050 – 90% of the LDV fleet.[112] To enable this rise, sufficient charging infrastructure will need to be in place across all provinces.

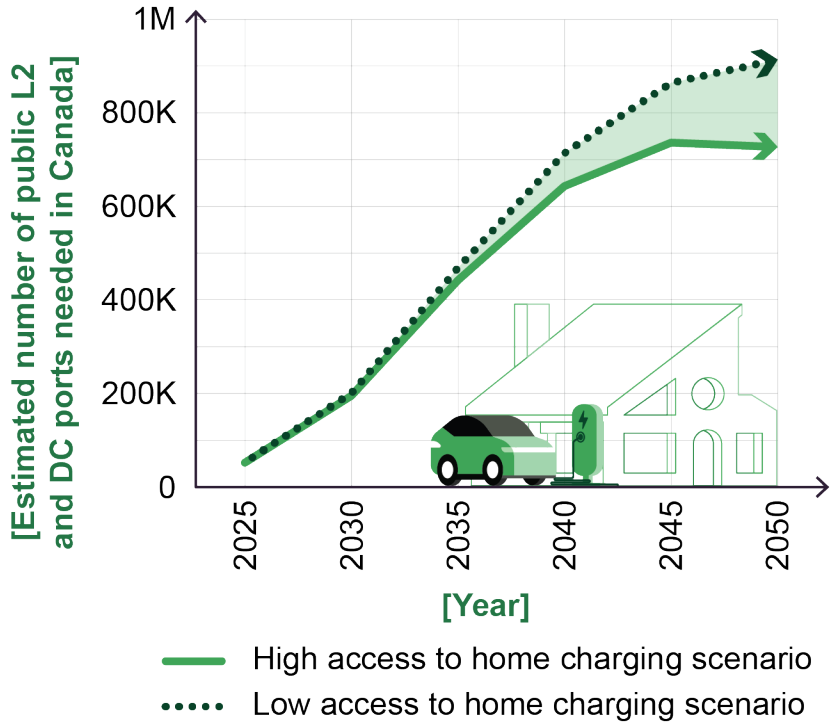
## New EV registrations[113]






In line with the increase in EV chargers, Canada has seen an increase in new motor vehicle registrations that are EVs across all provinces since 2017, and these numbers are expected to continue to rise. Between 2017 and 2023, the percentage of new motor vehicle registrations that are EVs increased in Ontario from approximately 1% to approximately 8%.[114]

### Estimated charger need[115]






Based on a scenario where people across Canada have a high level of access to home charging, it is anticipated that the number of public Level 2 and DC charging ports will need to increase from around 52K in 2025 to around 727K in 2050.[116] Under a scenario where there is a low level of access to home charging for people across Canada, these numbers would be higher – from 53K in 2025 to 914K in 2050.[117]

## Federal policies

Across Canada, several policies and programs have been put in place to further the uptake of EVs and make charging more accessible. A selection of these is outlined below:

- Zero Emission Vehicle Infrastructure Program (ZEVIP) – provides funding for owners/operators of charging infrastructure, delivery organizations, and Indigenous organizations towards the deployment of EV chargers and hydrogen refuelling stations across Canada.[118]
- Incentives for Zero Emission Vehicles Program (iZEV) – provides point-of-sale incentives up to $5K for individuals and businesses who buy or lease an EV.[119]
- Incentives for Medium- and Heavy-Duty Zero Emission Vehicles Program (iMHZEV) – provides point-of-sale incentives up to $200K for businesses and organizations who buy or lease medium- and heavy-duty EVs.[120]
- Canada's Electric Vehicle Availability Standard – requires auto manufacturers and importers to meet annual zero-emission vehicle regulated sales targets.[121]
- Measurement Canada kWh Billing Temporary Dispensation – allows Level 1, Level 2, and Level 3 operators to bill EV drivers for energy supplied rather than the time spent charging.[122]

## Network expansions

There has already been a substantial amount of investment across Canada to develop the EV charging network, with plans in place to invest significantly more to develop the network further.

In May 2023, the federal government announced a partnership with the United States government to designate a binational EV charging corridor.[123] This corridor is planned to extend between Kalamazoo, Michigan and Quebec City, Quebec, with Level 3 fast chargers approximately every 80 km.[124]

In Ontario, the government of Ontario launched the EV ChargeON program in 2023, which will enable thousands of new charging stations to be built across the province.[125]

**$36.7B**

The amount vehicle owners in Canada are estimated to save in energy costs by switching to an EV, from 2024 to 2050.[126]

**360M tonnes**

Projected greenhouse gas emissions reduction by 2050 by phasing in 100% new EV sales across Canada by 2035.[127]

**"Ontario is at the heart of the EV revolution, and…new EV fast chargers will help people and businesses more conveniently access charging on the go as we continue to build Ontario's end-to-end EV supply chain."[128]**

- The Honourable Victor Fedeli, Ontario Minister of Economic Development, Job Creation & Trade

# 5. Ontario's Unique Position in the EV Charging Industry

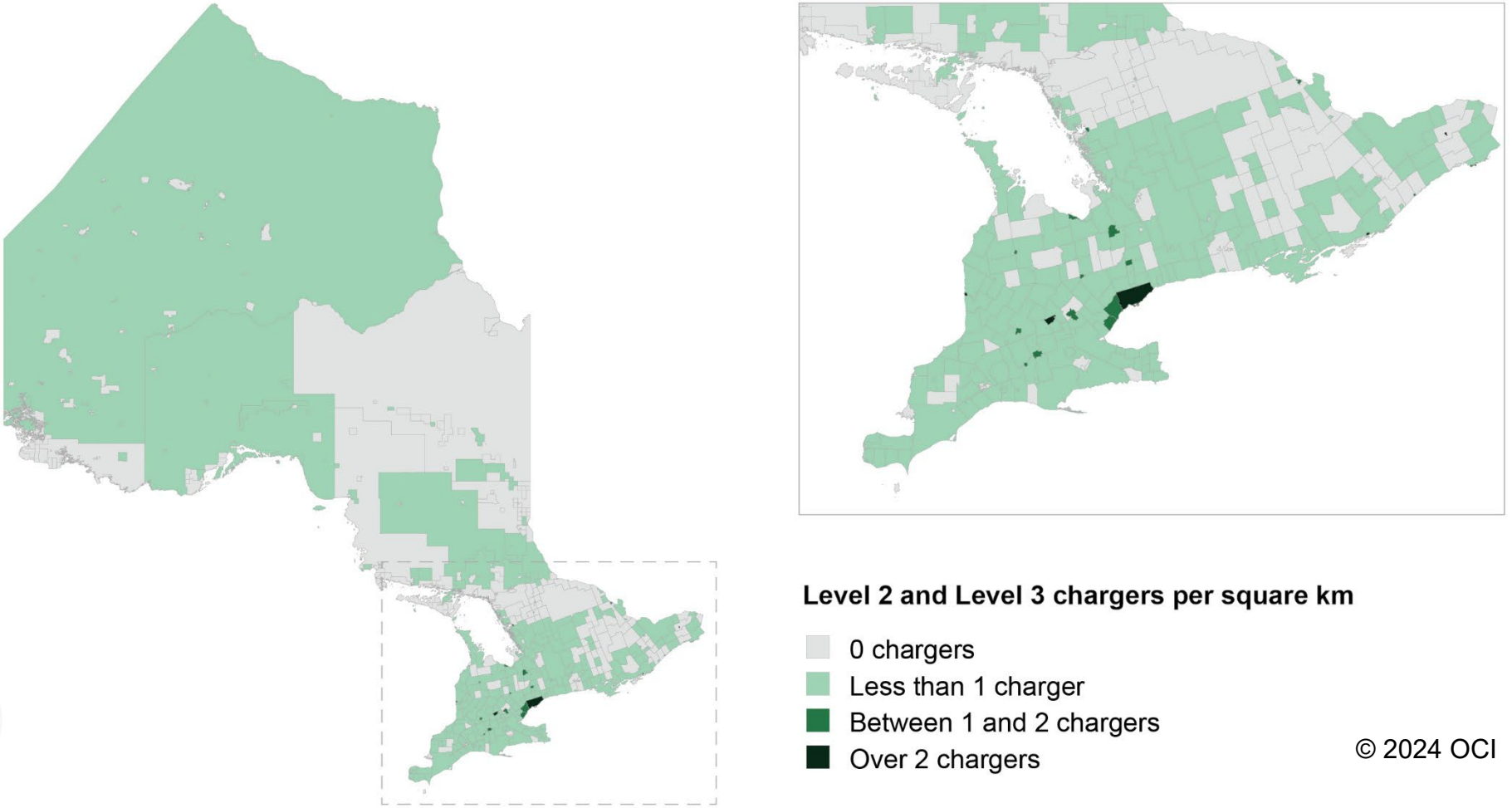
Ontario is at the forefront of the EV charging industry, supported by its significant history as a leader in the automotive market. The province has a robust and well-connected ecosystem – including leading Original Equipment Manufacturers (OEMs), manufacturers, service providers, and research institutions – which is driving the implementation of standardized and efficient EV charging solutions, providing significant advantage in the EV revolution.

This section summarizes the current state of Ontario's EV charging industry, outlining key players, and highlighting the research and development (R&D) innovations taking place in the province.

## State of play

There are approximately 135K EVs registered in Ontario, and the Ontario government estimates that there will be more than 1M by 2030.[129] As of December 2023, there were more than 3K public charging stations in the province, with over 7K Level 2 charging ports, and over 1K Level 3 fast charging ports.[130] Ontario's network of public chargers is currently concentrated in higher density, urban areas such as Toronto, with a smaller network distributed throughout more rural, lower density areas.[131] There is potential to expand the network throughout much of northern Ontario.

### Chargers in Ontario[132]



# OVIN Advanced Charging and V2G R&D Partnership Fund Stream

The Ontario Vehicle Innovation Network (OVIN) has launched a new Advanced Charging and V2G Stream under its R&D Partnership Fund. Through OVIN, the Ontario Government will provide small- and medium-sized enterprises (SMEs) up to $1M to develop advanced charging and V2G technologies and solutions that are critical to electrification and the transition to EVs. This new investment in Ontario's SMEs is essential to support the province's adoption of EVs while driving economic growth and exporting solutions across the globe. This stream includes technologies in the following Priority Areas:

- Advanced charging technologies, including wireless charging, high-speed charging, bidirectional charging, dynamic charging, and smart charging.
- V2G technologies, including technologies to support interoperability and scalability. Examples include vehicles equipped with bidirectional charging technology that enables EVs to discharge energy back into the grid when not in use, supporting grid stability and managing fluctuations in energy supply and demand.
- Energy demand and grid management systems. Examples include time-of-use pricing, off-peak charging, and smart charging software.
- Zero-emissions technologies relating to the integration of renewable energy within charging infrastructure, to potentially enhance the reliability and sustainability of the grid, such as solar, wind, small-scale hydroelectric systems and geothermal power technologies.
- Technologies that support system operability across the grid, vehicle and charging infrastructure, including cybersecurity solutions (e.g. network security and device authentication), connectivity and smart device solutions (e.g. anomaly detection, network management and preventative maintenance), and blockchain solutions (e.g. access management and transaction systems).
- Energy storage and transmission technologies relating to energy management and grid capacity. Examples include batteries for grid storage applications, hydrogen storage technologies including compressed hydrogen for grid integration, pumped hydro storage systems for large-scale and long-duration storage, and flywheels for rapid response times.

This program is structured to achieve multifaceted objectives for eligible projects, applicants, and partners. It aims to facilitate the commercialization of Ontario-made technologies and demonstrate them to potential customers, fostering relationships with researchers to extend company R&D efforts. Additionally, it seeks to promote marketable solutions and technologies, particularly in the realms of advanced charging and energy management systems, while fostering public/private partnerships. Beyond the immediate stakeholders, the program also aims to benefit society at large by promoting cleaner transportation, reducing environmental and carbon footprints, and realizing efficiencies and cost-savings in energy systems and infrastructure.

# Spotlight:

# EV ChargeON

Originally announced in 2022, the Ontario Ministry of Transportation (MTO) EV ChargeON program – a $91M investment program – opened for applications in October 2023. The program received a significant number of applications, with funding decisions to be announced in spring 2024. OVIN is working with MTO to support and promote this initiative.

The program consists of a Community Sites Stream and a Government Sites Stream. The Community Sites Stream provides grant funding to eligible private and public sector entities to build thousands of new EV charging stations in communities with less than 170K people, as well as in any Indigenous community in Ontario.[133] The Government Site Stream will build more EV chargers on government-owned land, such as highway rest areas, carpool parking lots, and tourist destinations such as Ontario Parks.[134]

The aim of the program is to:

- increase the number of public EV charging stations throughout Ontario;
- make public chargers more accessible and affordable; and
- encourage more people to switch to EVs.[135]

Those eligible to apply within small and medium-sized communities included businesses, not-for-profit corporations, municipalities, Indigenous communities, and broader public sector organizations such as hospitals and universities.[136]

“

### In conversation with MTO

A key focus for MTO in delivering the EV ChargeON program is reliability, and taking a cautious and considered approach to ensure the right solutions are applied in the right settings. This includes considering current consumer needs alongside long-term planning for the future of the transport network.

Reducing range anxiety for Ontarians living in rural, remote, and northern communities was identified as a key area of focus. MTO hopes that the EV ChargeON program will result in increased confidence for consumers – particularly those in rural and remote areas – and that they will have access to a reliable charging network, enabling them to travel via EV without concern.

A key learning from this program – as identified by MTO – is the importance of working with partners. In designing the program, MTO worked closely with the Ministry of Energy and key stakeholders in electrical generation and transmission to ensure the charging network would be supported by a reliable supply, in recognition of the fact that much of the charging infrastructure would be installed in locations that are challenging to access with the existing grid.

MTO sees a key opportunity for Ontario in the innovation and testing of cold weather technologies and in developing a holistic, sustainable EV supply chain through its access to ethically sourced critical minerals within the province, via the Critical Minerals Strategy. MTO will be taking lessons from the delivery of EV ChargeON and is committed to exploring opportunities for future EV charging programs.

## Provincial policies

There are a number of policies unique to Ontario which are helping to shape the EV charging industry and encourage uptake of EVs. These include:

- Driving Prosperity Phase 1 and Phase 2 – positions Ontario as a leader in developing and building the car of the future through emerging technologies and advanced manufacturing processes.[137]
- Green Licence Plate Program – provides individuals, businesses, and commercial fleets with green vehicle licence plates for EVs and PHEVs weighing under 3,000 kg, allowing them to drive in High Occupancy Vehicle (HOV) lanes with any number of occupants, and High Occupancy Toll (HOT) lanes at no cost with any number of occupants.[138]
- Ontario Job Creation Investment Incentive – allows businesses to write off specified clean energy equipment, including EV charging equipment.[139]
- Reserved Parking for Electric Vehicle Act 2019 – created a provision which restricts non-EVs and non-charging EVs from parking in EV charging stations.[140]

## Ontario's network

Ontario's charging network has grown significantly over recent years, with plans in place to continue its development. Hydro One and Ontario Power Generation (OPG) further developed the existing Ivy Charging Network – a fast charging network with 150 chargers across over 60 locations[141] – by installing Level 3 chargers at all 20 renovated ONroute stations along the 400 and 401 highways.[142] Additionally, in October 2023, the government of Ontario launched the EV ChargeON program.[143] This program provides funding to build thousands of new EV charging stations in small and medium-sized communities.[144]

## Key players in Ontario

There are a number of organizations providing EV charging products and services which are based in Ontario. A selection of these is outlined below.

- Jule – A Toronto based company (previously know as eCamion) which specializes in smart energy management and battery storage systems, while providing integrated DC fast charging technology.[145]
- Autochargers.ca – a Markham based company which specializes in the sale, installation, and maintenance of home and commercial EV charging equipment across Canada.[146] It is a subsidiary of United Chargers – one of the few EV charger manufacturers in the province.[147]
- Gbatteries – an Ottawa based company which specializes in the development of intelligent battery management technology to enable e-mobility.[148]
- SWTCH – with its Canadian headquarters in Toronto, this North American company provides EV charging solutions for multi-tenant properties, including an EV charging management platform.[149]
- Daymak – based in Toronto, this company specializes in the development and distribution of light electric vehicles (LEVs) in Canada. It has also developed a patented wireless charging technology – Ondata. [150]

- BluWave-ai – with its headquarters in Ottawa, this company specializes in artificial intelligence (AI) and renewable energy. It has developed a system called EV Everywhere, which uses real-time data to predict energy demand, and "provides optimal dispatch for intelligent scheduling of EV charging and available battery energy storage".[151]
- Stromcore Energy Inc. – a Mississauga based company which specializes in the design and manufacture of lithium-ion battery systems for forklift trucks.[152]
- metroEV – based in Markham, this company specializes in the installation of EV charging equipment for residential, commercial, and institutional sectors.[153]
- TROES – also based in Markham, this company offers a 'Microgrid-in-a-Box' modular battery energy storage system solution, integrating advanced microgrid controllers and optimizers.[154]
- Ettractive Inc. – based in Oldcastle, Ontario, this company specializes in vehicle integration, and supports new and bespoke charging and infrastructure solution for motorsport.[155]

## Research in Ontario

Ontario is at the forefront of research in the EV charging domain. The University of Toronto EV Research Centre (UTEV), which is a university-industry partnership, is one example of an Ontario research institution with a focus on next generation EV technologies.[156] A key area of research focus at UTEV is ubiquitous charging – a charging network comprised of on-board, off-board, wireless, and battery-assisted stationary chargers that can alleviate range anxiety for EV owners.[157]

Additionally, the Ontario Tech University Automotive Centre of Excellence (ACE) – which is part of OVIN's Durham Regional Technology Development Site (RTDS) – provides partners with access to full-scale EV bidirectional charging research stations, along with test labs for aerodynamic, climatic, and structural research and development, and automotive software testing and development.[158]

Furthermore, the University of Windsor and McMaster University have both conducted research around the cybersecurity of charging infrastructure,[159] and early detection of cyberattacks on fast charging stations.[160] McMaster University's Institute for Transportation and Logistics (MITL) also has a research area focused on EVs, with projects such as optimization analysis for the locations of public charging infrastructure, and economic impact analysis of EV adoption.[161]

# Spotlight: OVIN's Durham RTDS

OVIN's Durham RTDS, namely Ontario Tech University's ACE, collaborated with Jule (previously known as eCamion) - a technology provider for flexible battery storage, electric vehicle charging, and energy management solutions – to develop end-to-end energy storage and fast charging technology.[162]

The Durham RTDS provided Jule with the ability to test battery and power electronics performance under a multitude of conditions, such as extreme temperatures, humidity, and icy conditions.[163] This allowed for the identification of necessary design alterations to ensure reliability for consumers.[164]

Additional research projects being undertaken in partnership with Jule and the Durham RTDS include:

- High-power wireless fast charging.
- Thermal modelling micro-grids for TransCanada Highway deployment.
- Mechatronic autonomous charging system.[165]

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### In conversation with Ontario Tech University

New charging technologies are imminent, and so they need to undergo thorough research and development, and a rigorous testing phase. The Durham RTDS provides a crucial opportunity for the university to work closely with industry partners to test the effectiveness, efficiency, and practicality of charging methods – as demonstrated through the project with Jule.

Some of the key factors considered by the university – in close collaboration with industry partners – include charging speed, customer convenience, safety, and cost effectiveness. It was noted that a key aim is to ensure that research and findings are relevant and applicable to the current market landscape. The university sees reliability as foundational to the uptake of EVs, with a need for reliable, robust EV charging and battery technology.

From the university's perspective, Ontario is in an excellent position to be a world leader in the development of EV charging. The scale of research and innovation taking place in the province was noted as a key factor, along with the established presence of battery manufacturing, and the opportunity to lead the way in mitigating climate change via access to clean energy sources.

## Innovation in Ontario

Ontario is leading the way in EV charging technology advances, with numerous pilot projects and innovations taking place in the province. A selection of these is outlined below:

- **Blackstone Energy Services V2G pilot** – working in partnership with Natural Resources Canada, this Toronto based organization is testing the V2G concept, which will enable EV drivers to get paid for sharing power from their EV battery with the facility they are parked at during peak electricity demand. They have bi-directional test chargers across the province, located at Fanshawe College, Brock University, and Georgian College.[166]
- **eLeapPower** – based in Toronto, this tech company delivers a range of power conversion solutions to the mobility industry. In 2021, with support from OVIN, eLeapPower held a successful project demonstration of their wireless charging technology.[167]
- **BluWave-ai and Hydro Ottawa EV Everywhere pilot** – in 2022, with support from the Independent Electricity System Operator (IESO) and the Ontario Energy Board (OEB), this Ottawa-based pilot used an AI software platform – EV Everywhere – to manage EV charging during peak demand periods.[168]
- **TTC and PowerON Energy Solutions eBus charging pilot** – in 2023, Toronto Transit Commission (TTC) announced the installation of 10 eBus charging pantographs as part of a proof of concept at its Birchmount Garage in Scarborough. Delivered in partnership with the Ontario Power Generation subsidiary PowerON Energy Solutions, the pantographs enable overhead charging for the eBus fleet.[169]
- **Blockchain-based EV charging pilot** – delivered in partnership between SWTCH Energy and Opus One Solutions, this demonstration involved two office buildings in downtown Toronto being used as a testing ground for two technologies – turning EVs into a power source for building residents and tracking energy usage and billing with blockchain technology.[170]
- **HydroOne heavy-duty truck charging pilot** – in 2021, HydroOne received $4.95M via Natural Resources Canada's Green Infrastructure – EV Infrastructure Demonstration Program to develop a heavy-duty electric truck charging station pilot project. The aim of this pilot was to establish a model that could be used by other utilities and businesses.[171]
- **Stromcore e-forklift charging investment** – the federal government invested $4.8M in Stromcore to launch two new products, including Turbo Bank – an advanced AI-powered charger with improved efficiency – and Electric Cart – a low-emission e-forklift. Both products have a fast-charging capability and the ability to work in cold environments.[172]
- **Toronto Hydro Smart Charging Pilot Program** – in 2022 Toronto Hydro launched a pilot for residents of Toronto, in partnership with Plug'n Drive and Elocity Technologies Inc. Participants were given a free Hyper Integrated Electric Vehicle (HIEV™) EVPlug smart charging device, allowing them to control their EV charging schedule using a smartphone app. The overall goal of this pilot was to understand EV charging patterns and behaviours in Toronto, including duration, frequency, and time of charging.[173]

# Spotlight: Peak Drive V2G Pilot

In 2019, Peak Power – a cleantech company with headquarters in Toronto offering energy storage development and optimization – delivered one of the largest V2G pilot projects globally in downtown Toronto.[174] The demonstration featured 21 bidirectional chargers and Nissan LEAF vehicles in three commercial office buildings. The pilot employed EVs and energy storage systems to reduce the buildings' demand charges.[175]

The objectives of this pilot included:

- Reducing the buildings' energy bills with targeted discharging of the Nissan LEAF EV batteries.
- Combining an energy-based use case with a mobility use case and providing valuable data around driving patterns and charging behaviour.

The project found that there could be an estimated $8K in energy savings per EV per year.[176]

At the beginning of 2024 the sites were decommissioned following a successful four-year delivery.

### In conversation with Peak Power

V2G presents an opportunity to support neighbourhood electricity grids, keeping them up and running and providing back up power in the case of a power outage. Peak Power sees a role for V2G in alleviating the need for installing infrastructure in places that may not be connected to the grid, through a V2B or V2H (vehicle-to-home) model. The V2H model is considered to be an ideal use case in rural areas, by increasing electricity reliability.

Range convenience was also raised as a key concept, whereby charging your EV becomes second nature, rather than having to plan ahead and identify locations with chargers. By improving the reliability and accessibility of the network, convenience for drivers can be improved.

Ontario has a unique position in this field due to its leading role in automotive manufacturing, the availability of a local supply chain for battery production, and the presence of an electricity and clean tech sector that is supportive of startups, innovation, and pioneering new technologies.

From Peak Power's perspective, the key challenges that currently face the EV charging industry include a lack of policy support for electrification and limited buyer power. The organization sees opportunities for consumer incentivization and collaboration between sectors in order to develop the industry in the province. They are in discussions to progress a number of future pilot projects.

# OVIN supported projects

### Jule: Fast Charging System for Autonomous Vehicles

Through the OVIN Talent Development Internship/Fellowship Program, OVIN supported Jule in its efforts to increase its intake of electrical / software engineers in order to continue the production development and rollout of Autonomous Vehicle (AV) Fast Charging stations. This project supported the growth of the EV charging industry for AVs in Ontario.

### eLeapPower: Wireless AV / EV Charging Project

As part of another Talent Development Internship/Fellowship Program, OVIN sponsored eLeapPower to explore the potential for accelerating electric connected vehicle (CV) and AV growth and market entry for advanced CV / AV technology. This project focused on the last mile infrastructure challenge associated with electric commercial vehicles, enabling EVs to charge wirelessly and autonomously.

### SWTCH: Smart EV Charging for Multi-unit Residential Buildings

OVIN is currently supporting SWTCH, through the Talent Development Internship/Fellowship Program, to enable development of an innovative EV charging platform. This platform allows for intelligent EV charging management in multi-unit residential buildings, whilst managing EV charging loads to improve grid efficiency.

### TROES and Day & Night Solar: Validation and Demonstration of Transportable EV Charging Station

Delivered via OVIN's R&D EV Stream fund by TROES and Day & Night Solar – an American company – this project is developing a new type of high-capacity, fully portable, DC fast charging station, with batteries recharged from a 60 kW solar array. The Battery Energy Storage System (BESS) collapses to the cubic size of a standard 53-foot flatbed trailer and is designed to stay within road weight limits, and the microgrid controller will operate through an algorithm that will manage the optimal power flow of the system. The proposed system can be in fast DC fast charging service as soon as it arrives at its site; it can also be grid tied for grid support and charging.

### SmartONE, Conqora Capital and SWTCH: Smart EV Charging in Multi-Family Communities

Working in partnership, SmartONE Solutions Inc. (an Ontario-based company which specializes in smart buildings), Conqora Capital Partners Inc. (a private equity firm headquartered in Toronto), and SWTCH are delivering this project at the newly developed 16 Hamilton rental community in Ottawa, via OVIN's R&D EV Stream funding. They are combining technologies to develop a smart EV charging solution that will address the unique demands of multi-family developments. The smart charging feature will be made available through the SmartONE community app, where residents can actively view and manage the charging of their vehicle. In addition, the community will be equipped with charging stations which can be shared by residents and offered to visitors.

**“Under the Advanced Charging and V2G Stream, Ontario SMEs will have a unique opportunity to shape the future of vehicle charging, from the vehicle to the grid. Companies will partner to develop, validate, test, and demonstrate, new technologies to drive commercialization, and deployment of solutions such as wireless charging, high-speed charging, bidirectional charging, dynamic charging, and smart charging; energy demand and grid management systems; the integration of renewable energy with charging infrastructure; and energy storage and transmission.”**

- The Honourable Victor Fedeli, Ontario Minister of Economic Development, Job Creation & Trade

# 6. Future Opportunities

The EV charging industry is still in its early stages, continuing to grow and develop, hence there are many opportunities for governments and organizations to play a role in shaping its future. This not only includes through technological development, but also through improving the customer experience, increasing accessibility, and managing demand.

The following section calls attention to some of the immediate and ongoing opportunities for Ontario to continue building on its leading role in the EV charging industry.

## Continue to encourage technological development and commercialization

Ontario is in a prime position to leverage it's influence in the EV charging industry, particularly through the OVIN RTDS network and programs, including the advanced charging and V2G stream of the R&D partnership fund. The RTDS network supports SMEs to develop, test and prototype advanced technologies and leverage expertise around key focus areas, such as EV charging.[177]

Ontario has already demonstrated that it can lead the way in technological advancements in Canada, through Project Arrow. This was an initiative launched by the Automotive Parts Manufacturers' Association in partnership with OVIN, to develop and build the first all-Canadian low-emission vehicle.[178] In November 2023, Project Arrow 2.0 was announced, which aims to build 20 more fully functional prototype vehicles by 2026.[179]

In addition to existing innovations in the province, Ontario can leverage the tech, battery, and EV focused organizations that call it home. As noted in the previous chapter, there are several companies doing important work in the EV charging sphere – conducting research and running pilots. Ontario can continue supporting these organizations in bringing their concepts and products to market and becoming commercially viable.

## Simplify charging payment technologies

Consumers don't only want faster charging technology; they also want a simplified, consistent charging and payment experience. Currently a typical EV driver has to navigate a range of apps, cards, and accounts to use public chargers in different locations.[180] Plug and Charge technology has begun to gain momentum as the solution to this, but there needs to be agreement between a range of actors – from OEMs to electricity networks, and EV station owners – before it can be universally adopted.[181]

Ontario has the opportunity to promote, and make a reality, EV roaming – allowing EV drivers to access a wide range of public charging stations using their preferred payment method.[182] Steps have already been taken across Canada to enable this, with several of North America's largest networks – Greenlots, CharePoint, EV Connect, and FLO – signing a roaming agreement across their networks of 54,000 chargers in 2021.[183] This was taken further in 2023 by the Agora initiative. This is a national campaign jointly led by ChargeHub, BC Hydro, Circuit Electric, and 12 industry partners – including a number of Ontario based organizations, such as the Electric Vehicle Council of Ottawa, SWTCH (which has its Canadian headquarters in Toronto) and the Ivy Charging Network – to enable EV roaming through a single, secure account.[184]

## Ensure equitable distribution

EV charging networks tend to be concentrated in urban areas, meaning those living in more remote, rural areas do not have the same level of access to infrastructure. There is an opportunity for Ontario to bridge this gap, by installing more charging stations across the province, ensuring that all residents – no matter how remote their home is – have access to a public EV charger. Steps have already been made to address this issue with the ChargeON program offering a Community Sites Stream of funding.[185] This funding stream is available to small- and medium-sized communities, including Indigenous communities, and aims to make public chargers more accessible and affordable, to encourage more people to make the switch to EVs.[186]

A Natural Resources Canada study found that Canada will need one charger for every 20 EVs by 2025.[187] For densely populated, urban areas – such as southern Ontario – this presents a challenge due to the number of people living in multi-use residential buildings (MURBs).[188] There is not currently national or provincial building codes which specify EV charging requirements for these types of residential buildings. Local governments can implement such performance standards, but there is an opportunity for Ontario to implement this on a provincial basis, which would make it the first to do so.[189]

In May 2022, the municipal government of Toronto published the Toronto Green Standard Version 4 performance standards.[190] These standards specify that "all residential parking spaces provided for dwelling units located in an apartment building, mixed use building, multiple dwelling unit building, excluding visitor parking spaces, must include an energized outlet capable of providing Level 2 charging or higher to the parking space".[191]

## Expand guidance and incentives

In order to ensure that a range of charging types are available and to encourage technological innovation, there is an opportunity for governments to support the implementation of desired forms of public and private charging infrastructure. This could include, for example, incentives for public sector organizations that encourage the installation of fast public chargers or for homeowners to install smart private chargers.

An example of this in action comes from the UK; the national government incentivizes smart charging technology by only making funding available to homeowners who install private chargers that use smart technology.[192]

In addition to incentivizing different technologies, there is also an opportunity to create guidance which promotes the adoption of best practice or streamlines implementation. To this end, the Ontario Energy Board recently launched their new EV Charging Connections Procedures, a landmark initiative to consolidate procedures, timelines, and other key information and materials to guide and facilitate the process of connecting public EV chargers.[193]

## Manage demand on the grid

More broadly, considering the impact increased levels of EV charging is expected to have on the electricity grid, there are opportunities to expand clean energy provision and manage demand. It is estimated that rising demands on electricity could put Ontario's grid under strain by 2026 and possibly trigger chronic shortages by 2030.[194]

In order to overcome pressure on the grid and meet federal net zero targets, there is an ongoing opportunity for Ontario to promote flexible demand and energy efficiency through leveraging technologies such as smart and bidirectional charging.[195] The province has already set a standard in smart energy use – it is one of the only jurisdictions in the world where nearly every home has a smart meter installed.[196] The new Advanced Charging and V2G Stream of OVIN's R&D Partnership Fund will accelerate the development and commercialization of additional energy demand and grid management systems that regulate demand on the grid.[197]

Encouraging consumers to change their consumption habits to times of lower demand could also play a key part in managing a power grid which is increasingly reliant on variable renewable power.[198]

**"Our government is paving the way towards an electric future by building the infrastructure needed to support the electrification of transportation across Ontario."[199]**

- The Honourable Todd Smith, Ontario Minister of Energy

# 7. Interviewee List

The list of interviewees is presented below:

- Mabel Fulford, Peak Power Inc.
- Prof. Sheldon Williamson, Ontario Tech University
- Mike DeRuyter, Ontario Ministry of Transportation
- Tori Prouse, Ontario Ministry of Transportation

# 8. Glossary

| | |
|---|---|
| **AC** | Alternating Current |
| **ACE** | Automotive Centre of Excellence |
| **AI** | Artificial Intelligence |
| **AV** | Autonomous Vehicle |
| **BEB** | Battery Electric Bus |
| **BESS** | Battery Energy Storage System |
| **CV** | Connected Vehicle |
| **DC** | Direct Current |
| **EV** | Electric Vehicle |
| **HIEV™** | Hyper Integrated Electric Vehicle |
| **HOT** | High Occupancy Toll |
| **HOV** | High Occupancy Vehicle |
| **ICE** | Internal Combustion Engine |
| **IESO** | Independent Electricity System Operator |
| **iMHZEV** | Incentives for Medium- and Heavy-Duty Zero Emission Vehicles Program |
| **iZEV** | Incentives for Zero-Emission Vehicles Infrastructure Program |
| **kW** | Kilowatt |
| **kW-h** | Kilowatt-hour |
| **LDC** | Local Distribution Companies |
| **LDV** | Light Duty Vehicle |
| **MITL** | McMaster University's Institute for Transportation and Logistics |
| **MTO** | Ontario Ministry of Transportation |
| **MURB** | Multi-Use Residential Building |
| **NACS** | North American Charging Standard |
| **OEB** | Ontario Energy Board |
| **OEM** | Original Equipment Manufacturer |
| **OPG** | Ontario Power Generation |
| **OVIN** | Ontario Vehicle Innovation Network |
| **PHEV** | Plug-in Hybrid Electric Vehicle |

| | |
|---|---|
| **R&D** | Research & Development |
| **RTDS** | Regional Technology Development Sites |
| **SAE** | Society of Automotive Engineers |
| **SME** | Small- and Medium-sized Enterprises |
| **TTC** | Toronto Transit Commission |
| **UTEV** | University of Toronto EV Research Centre |
| **V** | Volt |
| **V2B** | Vehicle-to-Building |
| **V2G** | Vehicle-to-Grid |
| **V2H** | Vehicle-to-Home |
| **ZEVIP** | Zero Emission Vehicle Infrastructure Program |

# 9. About OVIN

OVIN is a key component of Phase Two of Driving Prosperity, the Government of Ontario's ambitious plan that positions Ontario as a North American leader in developing and building the car of the future through emerging technologies and advanced manufacturing processes. The Government of Ontario has committed an additional $56.4 million, for a total investment of over $141 million to date, through OVIN's innovative programming to support research and development (R&D) funding, talent development, technology acceleration, business and technical supports, and testing and demonstration.

OVIN, 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 OVIN programs are:

- Research and Development Partnership Fund
- Talent Development
- Regional Technology Development Sites
- Demonstration Zone
- Project Arrow

The OVIN 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.

To find out the latest news, visit www.ovinhub.ca or follow OVIN on social media @OVINhub

# 10. OVIN Objectives

| | |
|---|---|
|  | Foster the development and commercialization of Ontario-made advanced automotive technologies and smart mobility solutions. |
|  | Showcase the Province of Ontario as the leader in the development, testing, piloting and adoption of the latest transportation and infrastructure technologies |
|  | Drive innovation and collaboration among the growing network of stakeholders at the convergence of automotive and technology |
|  | Leverage and retain Ontario’s highly skilled talent, and prepare Ontario’s workforce for jobs of the future in the automotive and mobility sector |
|  | Harness Ontario’s regional strengths and capabilities, and support its clusters of automotive and technology |

# 11. Meet the OVIN Team

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# 12. Disclaimers

This report was commissioned by the Ontario Centre of Innovation (OCI) through a Request for Proposals titled “Ontario Vehicle Innovation Network (OVIN) – Annual Comprehensive Sector Report & Quarterly Specialized Reports,” dated August 25, 2023, and has been prepared by Arup Canada Inc. It is one of five reports covering an analysis of Ontario’s automotive technology, electric vehicle and smart mobility landscape while incorporating implications for the sector’s skills and talent landscape.

This report contains general information only, and by means of this communication, OCI is not rendering professional advice or services. Accordingly, readers are cautioned not to place undue reliance on this report and to perform their due diligence, investigations, and analysis before making any decision, relying on the report, or taking any action that may affect readers’ finances or business.

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# 13. References


[1] International Energy Agency. (2023, April). Global EV Outlook 2023. https://www.iea.org/reports/global-ev-outlook-2023

[2] Transport Canada. (2022, December). Canada's Action Plan for Clean On-Road Transportation. Government of Canada. https://tc.canada.ca/en/road-transportation/publications/canada-s-action-plan-clean-road-transportation

[3] Government of Canada. (2023, May). 2030 Emissions Reduction Plan – Sector-by-sector overview: Transportation. https://www.canada.ca/en/services/environment/weather/climatechange/climate-plan/climate-plan-overview/emissions-reduction-2030/sector-overview.html#sector6

[4] Dunsky Energy & Climate. (2022, March). Canada's Public Charging Infrastructure Needs. Natural Resources Canada. https://natural-resources.canada.ca/sites/nrcan/files/energy/cpcin/2022-ev-charging-assesment-report-eng.pdf

[5] Natural Resources Canada. (2023, November). Zero Emission Vehicle Infrastructure Program. Government of Canada. https://natural-resources.canada.ca/energy-efficiency/transportation-alternative-fuels/zero-emission-vehicle-infrastructure-program/21876

[6] Natural Resources Canada. (2023), Electric vehicle charging. Government of Canada. https://natural-resources.canada.ca/energy-efficiency/transportation-alternative-fuels/electric-vehicle-charging/25049

[7] Ibid.

[8] Ibid.

[9] US Department of Transportation. (2023, June). Charger Types and Speeds. United States Government. https://www.transportation.gov/rural/ev/toolkit/ev-basics/charging-speeds

[10] Natural Resources Canada. (2023), Electric vehicle charging. Government of Canada. https://natural-resources.canada.ca/energy-efficiency/transportation-alternative-fuels/electric-vehicle-charging/25049

[11] Ibid.

[12] Ibid.

[13] Ibid.

[14] Ibid.

[15] International Energy Agency. (2023, April). Global EV Outlook 2023 – Trends in charging infrastructure. https://www.iea.org/reports/global-ev-outlook-2023/trends-in-charging-infrastructure

[16] Ibid.

[17] Ibid.

[18] Ibid.

[19] Ibid.

[20] Ibid.

[21] Ibid.

[22] Ibid.

[23] Government of Ontario. (2024, February). Ontario Making it Easier to Build Electric Vehicle Charging Stations. https://news.ontario.ca/en/release/1004197/ontario-making-it-easier-to-build-electric-vehicle-charging-stations

[24] US Department of Transportation. (2023, May). Electric Micromobility Basics. United States Government. https://www.transportation.gov/rural/electric-vehicles/ev-toolkit/electric-micromobility

[25] Ibid.

[26] US Department of Transportation. (2023, June). Electric Bus Basics. United States Government. https://www.transportation.gov/rural/electric-vehicles/ev-toolkit/electric-bus-basics

[27] Ibid.

[28] International Energy Agency. (2023, April). Global EV Outlook 2023. https://iea.blob.core.windows.net/assets/dacf14d2-eabc-498a-8263-9f97fd5dc327/GEVO2023.pdf

[29] Ibid.

[30] Ibid.

[31] Hannah Brown. (2023, July). Inside the factory making 'tri-brid' electric trains that could revolutionise transport in Europe. https://www.euronews.com/green/2023/07/04/inside-the-factory-making-tri-brid-electric-trains-that-could-revolutionise-transport-in-e

[32] EV Charging Summit. (n.d.). Everything You Need to Know About Wireless EV Charging. https://evchargingsummit.com/blog/everything-you-need-to-know-about-wireless-ev-charging/

[33] Ibid.

[34] FLO. (2023, September). FLO Develops Technology for the Future of EV Charging Including Wireless Charging and Plug & Charge. https://www.flo.com/en-ca/news/flo-develops-technology-for-the-future-of-ev-charging-including-wireless-charging-and-plug-charge/

[35] WiTricity. (n.d.). Wireless EV charging for automotive. https://witricity.com/automotive/automotive-solutions

[36] Plugless Power. (n.d.). EV Unplugged. https://pluglesspower.com/

[37] EV Charging Summit. (n.d.). Everything You Need to Know About Wireless EV Charging. https://evchargingsummit.com/blog/everything-you-need-to-know-about-wireless-ev-charging/

[38] Ibid.

[39] Corey Williams. (2023, November). New technology installed beneath Detroit street can charge electric vehicles as they drive. CTV News. https://www.ctvnews.ca/autos/new-technology-installed-beneath-detroit-street-can-charge-electric-vehicles-as-they-drive-1.6666109

[40] Cenex. (2021, August). An Introduction to Innovative Electric Vehicle Charging Infrastructure. https://www.cenex.co.uk/app/uploads/2021/08/Intro-to-Innovative-charging.pdf

[41] Ibid.

[42] Ibid.

[43] Portable Electric. (2021, April). Teck Partners to Bring Canada's Largest Mobile EV Charger to the East Kootenays. https://portable-electric.com/canadas-largest-mobile-ev-charger/

[44] Ibid.

[45] Electric Autonomy Canada. (2023, June). Cafu buying Lion5 electric trucks to expand its mobile charging service; other operators aren't far behind. https://electricautonomy.ca/2023/06/15/cafu-lion-electric-mobile-charging-service/

[46] Casey Crownhart. (2023, May). How 5-minute battery swaps could get more EVs on the road. MIT Technology Review. https://www.technologyreview.com/2023/05/17/1073265/how-5-minute-battery-swaps-could-get-more-evs-on-the-road/

[47] Ibid.

[48] Lora Kolodny. (2021, March). Ample is trying to make battery swapping for EVs a reality, starting with Uber drivers in the Bay Area. CNBC. https://www.cnbc.com/2021/03/03/ample-opens-5-ev-battery-swapping-stations-for-bay-area-uber-drivers.html

[49] Federal Energy Management Program. (n.d.). Bidirectional Charging and Electric Vehicles for Mobile Storage. US Department of Energy. https://www.energy.gov/femp/bidirectional-charging-and-electric-vehicles-mobile-storage

[50] Ibid.

[51] Ibid.

[52] Ontario Clean Air Alliance. (2021, November). Vehicle-to-Building/Grid Integration. https://www.cleanairalliance.org/wp-content/uploads/2022/01/Vehicle-to-Building-and-Grid-for-Peak-Needs-November-22-2021.pdf

[53] Ibid.

[54] Peak Power. (n.d.). Peak Drive Pilot Project. https://peakpowerenergy.com/project/peak-drive-pilot-project/

[55] Electric Autonomy Canada. (2021, November). Plug and Charge: easier, faster and more secure charging for the future. https://electricautonomy.ca/2021/11/29/plug-and-charge/

[56] Ibid.

[57] Driivz. (n.d.). Electric Vehicle Plug & Charge. https://driivz.com/glossary/plug-and-charge/

[58] Marc Multin. (2020, November). The basics of Plug & Charge. https://www.switch-ev.com/blog/basics-of-plug-and-charge

[59] Electrify Canada. (2021, June). Electrify Canada to Debut Plug&Charge Payment Technology for Simplified Charging Experience. https://media.electrify-canada.ca/en-ca/releases/26

[60] Ibid.

[61] Virta. (n.d.). Smart Charging of Electric Vehicles. https://www.virta.global/smart-charging

[62] IRENA. (2019). Innovation Outlook: Smart Charging for Electric Vehicles. https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/May/IRENA_EV_smart_charging_2019_summary.pdf

[63] Toronto Hydro. (n.d.). Smart Charging. https://www.torontohydro.com/electric-vehicles/smart-charging

[64] Nova Scotia Power. (n.d.). Electric Vehicle Smart Charging Pilot. https://www.nspower.ca/cleanandgreen/innovation/electric-vehicle-network/electric-vehicle-smart-charging-pilot

[65] Suwaiba Mateen, Mohmmad Amir, Ahteshamul Haque, Farhad Ilahi Bakhsh. (2023, September). Ultra-fast charging of electric vehicles: A review of power electronics converter, grid stability and optimal battery consideration in multi-energy systems. Sustainable Energy, Grids and Networks, Volume 35. https://www.sciencedirect.com/science/article/abs/pii/S2352467723001200

[66] Ibid.

[67] IEA. (2019, May). Global EV Outlook 2019. https://www.iea.org/reports/global-ev-outlook-2019

[68] Ibid.

[69] International Energy Agency. (2023). Trends in electric light-duty vehicles. https://www.iea.org/reports/global-ev-outlook-2023/trends-in-electric-light-duty-vehicles

[70] International Energy Agency. (2023, April). Global EV Outlook 2023. https://iea.blob.core.windows.net/assets/dacf14d2-eabc-498a-8263-9f97fd5dc327/GEVO2023.pdf

[71] Globe News Wire. (2023, July). EV Charging Station Market Size [2023-2030] Worth USD 141.08 Billion | Exhibit a CAGR of 36.0%. https://www.globenewswire.com/en/news-release/2023/07/12/2703351/0/en/EV-Charging-Station-Market-Size-2023-2030-Worth-USD-141-08-Billion-Exhibit-a-CAGR-of-36-0.html

[72] Ibid.

[73] Government of Canada. (2023, January). Government of Canada Launches New Intake Model for Zero-Emission Vehicles Infrastructure Funding. https://www.canada.ca/en/natural-resources-canada/news/2023/01/government-of-canada-launches-new-intake-model-for-zero-emission-vehicles-infrastructure-funding.html

[74] Government of Canada. (2023, May). 2030 Emissions Reduction Plan – Sector-by-sector overview: Transportation. https://www.canada.ca/en/services/environment/weather/climatechange/climate-plan/climate-plan-overview/emissions-reduction-2030/sector-overview.html#sector6

[75] Ibid.

[76] David L. Chandler. (2023, March). Minimizing electric vehicles' impact on the grid. https://news.mit.edu/2023/minimizing-electric-vehicles-impact-grid-0315

[77] Ibid.

[78] Ibid.

[79] S&P Global Mobility. (2023, November). Affordability tops charging and range concerns in slowing EV demand. https://www.spglobal.com/mobility/en/research-analysis/affordability-tops-charging-and-range-concerns-in-slowing-ev-d.html

[80] KPMG. (n.d). KPMG's 2023 auto poll: The road ahead. https://kpmg.com/ca/en/home/insights/2023/02/kpmg-2023-auto-poll.html

[81] Ibid.

[82] Ibid.

[83] International Energy Agency. (2023, April). Global EV Outlook 2023 - Trends in electric heavy-duty vehicles. https://www.iea.org/reports/global-ev-outlook-2023/trends-in-electric-heavy-duty-vehicles

[84] International Energy Agency. (2023, April). Global EV Outlook 2023 – Trends in charging infrastructure. https://www.iea.org/reports/global-ev-outlook-2023/trends-in-charging-infrastructure

[85] Ibid.

[86] Ibid.

[87] Ibid.

[88] International Energy Agency. (2023, April). Global EV Outlook 2023. https://iea.blob.core.windows.net/assets/dacf14d2-eabc-498a-8263-9f97fd5dc327/GEVO2023.pdf

[89] Ibid.

[90] Boston Consulting Group. (2023, January). What Electric Vehicle Owners Really Want from Charging Networks. https://www.bcg.com/publications/2023/what-ev-drivers-expect-from-charging-stations-for-electric-cars

[91] Ibid.

[92] International Energy Agency. (2023, April). Global EV Data Explorer. https://www.iea.org/data-and-statistics/data-tools/global-ev-data-explorer

[93] IEA. (2023). Global EV Data Explorer. https://www.iea.org/data-and-statistics/data-tools/global-ev-data-explorer

[94] UK Government. (2022, November). Policy paper: COP26 declaration on accelerating the transition to 100% zero emission cars and vans. https://www.gov.uk/government/publications/cop26-declaration-zero-emission-cars-and-vans/cop26-declaration-on-accelerating-the-transition-to-100-zero-emission-cars-and-vans

[95] European Commission. (n.d.). Clean Vehicles Directive. European Union. https://transport.ec.europa.eu/transport-themes/clean-transport/clean-and-energy-efficient-vehicles/clean-vehicles-directive_en

[96] Ibid.

[97] Government of Costa Rica. (2019). Decarbonization Plan. https://2050pathways.org/wp-content/uploads/2019/02/Decarbonization-Plan-Costa-Rica.pdf

[98] Government of Ireland. (2023). Climate Action Plan 2023. https://www.gov.ie/pdf/?file=https://assets.gov.ie/243585/9942d689-2490-4ccf-9dc8-f50166bab0e7.pdf#page=null

[99] ZEV Transition Council. (2023, August). Phase-out targets: LDV. https://zevtc.org/tracking-progress/light-duty-vehicle-map/

[100] European Commission. (2023, May). Joint Statement EU-US Trade and Technology Council of 31 May 2023 in Lulea, Sweden. European Union. https://ec.europa.eu/commission/presscorner/detail/en/statement_23_2992

[101] Ibid.

[102] Ministry of Power. (2022, February). Government of India sets policy for Electric Vehicle charging stations. Government of India. https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1797350

[103] SAE. (2023, June). SAE International Announces Standard for NACS Connector, Charging PKI and Infrastructure Reliability. https://www.sae.org/news/press-room/2023/06/sae-international-announces-standard-for-nacs-connector

[104] Ibid.

[105] Digital Trends. (2023, July). Tesla's charging connector is taking over. Here's every company that will switch. https://www.digitaltrends.com/cars/ev-companies-using-tesla-nacs-charging-connector/

[106] Government of Ontario. (2023, October). Ontario Building More Electric Vehicle Charging Stations. https://news.ontario.ca/en/release/1003677/ontario-building-more-electric-vehicle-charging-stations

[107] Government of Canada. (2023). Electric Charging and Alternative Fuelling Stations Locator. https://natural-resources.canada.ca/energy-efficiency/transportation-alternative-fuels/electric-charging-alternative-fuelling-stationslocator-map/20487#/analyze?country=CA&region=CA-ON&fuel=ELEC&ev_levels=all

[108] Dunsky Energy & Climate. (2022, March). Canada's Public Charging Infrastructure Needs. Natural Resources Canada. https://natural-resources.canada.ca/sites/nrcan/files/energy/cpcin/2022-ev-charging-assesment-report-eng.pdf

[109] IEA. (2023). Global EV Data Explorer. https://www.iea.org/data-and-statistics/data-tools/global-ev-data-explorer

[110] Ibid.

[111] Dunsky Energy & Climate. (2022, March). Canada's Public Charging Infrastructure Needs. Natural Resources Canada. https://natural-resources.canada.ca/sites/nrcan/files/energy/cpcin/2022-ev-charging-assesment-report-eng.pdf

[112] Ibid.

[113] Statistics Canada. (2023, December). Table 20-10-0024-01 New motor vehicle registrations, quarterly. https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=2010002401

[114] Ibid.

[115] Dunsky Energy & Climate. (2022, March). Canada's Public Charging Infrastructure Needs. Natural Resources Canada. https://natural-resources.canada.ca/sites/nrcan/files/energy/cpcin/2022-ev-charging-assesment-report-eng.pdf

[116] Ibid.

[117] Ibid.

[118] Government of Canada. (2024, January). Zero Emission Vehicle Infrastructure Program. https://natural-resources.canada.ca/energy-efficiency/transportation-alternative-fuels/zero-emission-vehicle-infrastructure-program/21876

[119] Government of Canada. (2023, December). Zero-emission vehicles incentives. https://www.canada.ca/en/services/transport/zero-emission-vehicles/zero-emission-vehicles-incentives.html

[120] Ibid.

[121] Government of Canada. (2023, December). Canada's Electric Vehicle Availability Standard (regulated targets for zero-emission vehicles). https://www.canada.ca/en/environment-climate-change/news/2023/12/canadas-electric-vehicle-availability-standard-regulated-targets-for-zero-emission-vehicles.html

[122] Government of Canada. (2022, October). Temporary dispensation program for electric vehicle supply equipment. https://ised-isde.canada.ca/site/measurement-canada/en/temporary-dispensation-program-electric-vehicle-supply-equipment

[123] US Department of Transportation. (2023, May). U.S. Transportation Secretary Buttigieg Joins Canadian Minister of Transport Alghabra, Michigan Governor Whitmer and Mayor Duggan to Announce the First U.S.-Canada Electric Vehicle Corridor. United States Government. https://www.transportation.gov/briefing-room/us-transportation-secretary-buttigieg-joins-canadian-minister-transport-alghabra

[124] Ibid.

[125] Government of Ontario. (2023, October). Ontario Building More Electric Vehicle Charging Stations. https://news.ontario.ca/en/release/1003677/ontario-building-more-electric-vehicle-charging-stations

[126] Government of Canada. (2023, December). New Electric Vehicle Availability Standard will give Canadians better access to more affordable cars and cleaner air. https://www.canada.ca/en/environment-climate-change/news/2023/12/new-electric-vehicle-availability-standard-will-give-canadians-better-access-to-more-affordable-cars-and-cleaner-air.html

[127] Ibid.

[128] Government of Ontario. (2023, June). Ontario Expands Electric Vehicle Charging Stations. https://news.ontario.ca/en/release/1003146/ontario-expands-electric-vehicle-charging-stations

[129] Government of Ontario. (2023, October). Ontario Building More Electric Vehicle Charging Stations. https://news.ontario.ca/en/release/1003677/ontario-building-more-electric-vehicle-charging-stations

[130] Government of Canada. (2023). Electric Charging and Alternative Fuelling Stations Locator. https://natural-resources.canada.ca/energy-efficiency/transportation-alternative-fuels/electric-charging-alternative-fuelling-stationslocator-map/20487#/analyze?country=CA&region=CA-ON&fuel=ELEC&ev_levels=all

[131] Ibid.

[132] Ibid.

[133] Electric Autonomy Canada. (2023, October). Ontario opens application process for EV ChargeON funding. https://electricautonomy.ca/2023/10/27/ev-chargeon-funding-ontario-ev-chargers/

[134] Ibid.

[135] Government of Ontario. (2023, October). Electric vehicle (EV) ChargeON Program. https://www.ontario.ca/page/ev-chargeon-program

[136] Electric Autonomy Canada. (2023, October). Ontario opens application process for EV ChargeON funding. https://electricautonomy.ca/2023/10/27/ev-chargeon-funding-ontario-ev-chargers/

[137] Government of Ontario. (2022, September). Driving Prosperity: The Future of Ontario's Automotive Sector. https://www.ontario.ca/page/driving-prosperity-future-ontarios-automotive-sector

[138] Government of Ontario. (2023, October). Get a green licence plate. https://www.ontario.ca/page/get-green-licence-plate#section-1

[139] Government of Ontario. (2019, April). Annex: Details of Tax Measures. https://budget.ontario.ca/2019/annex.html?_ga=2.85516378.2181788.1578408984-989871658.1578408984#section-7

[140] Government of Ontario. (2019). Reserved Parking for Electric Vehicle Charging Act, 2019, S.O. 2019, c. 18 - Bill 123. https://www.ontario.ca/laws/statute/s19018#:~:text=part%20iii.1,-Electric%20vehicle%20charging&text=30.2%20No%20person%20shall%20park,to%20the%20station's%20charging%20equipment.

[141] Ivy Charging Network. (n.d.). Get to know Ivy. https://ivycharge.com/about-ivy/

[142] Government of Ontario. (2023, June). Ontario Expands Electric Vehicle Charging Stations. https://news.ontario.ca/en/release/1003146/ontario-expands-electric-vehicle-charging-stations

[143] Government of Ontario. (2023, October). Ontario Building More Electric Vehicle Charging Stations. https://news.ontario.ca/en/release/1003677/ontario-building-more-electric-vehicle-charging-stations

[144] Ibid.

[145] Jule. (2023, January). Battery Storage and EV Charging Leader Jule, Unveils Rebrand to Support Growth Goals. https://www.julepower.com/blog-post/battery-storage-and-ev-charging-leader-jule-unveils-rebrand-to-support-growth-goals

[146] Autocharger.ca. (n.d.). Company. https://www.autochargers.ca/about.html

[147] United Chargers. (n.d.). About United Chargers. https://grizzl-e.com/ca/about/

[148] Gbatteries. (n.d.). Company. https://www.gbatteries.com/about

[149] SWTCH. (n.d.). Smart Charging for Busy Buildings. https://swtchenergy.com/

[150] Daymak. (2021, April). Daymak announces wireless charging system for new series of Avvenire electric vehicles. https://daymak.com/wireless-charging-system.html

[151] BluWave-ai. (n.d.). Manage the Transition to High EV Penetration – EV Everywhere. https://www.bluwave-ai.com/ev-everywhere

[152] Stromcore. (n.d.). Turbo Charger. https://www.stromcore.com/turbo-charger

[153] metroEV. (n.d.). About metroEV. https://www.metroev.ca/about

[154] TROES. (n.d.). Modular Battery Energy Storage Systems. https://troescorp.com/

[155] Ettractive Inc. (n.d.). Electric Vehicle Development. https://ettractive.com/electric-vehicle-capabilities/

[156] UTEV. (n.d.). UTEV Research Centre. https://utev.utoronto.ca/

[157] UTEV. (n.d.). Ubiquitous Charging. https://utev.utoronto.ca/index.php/ubiquitous-charging/

[158] Melissa Nowakowski. (2023, March). Accelerating Innovation for the Communities of Tomorrow. The Spark Magazine. https://thesparkmagazine.ca/2023/03/15/the-early-days-of-electrification/

[159] University of Windsor. (2019). Driving cybersecurity evolution. https://www.uwindsor.ca/engineering/2019-12-12/driving-cybersecurity-evolution

[160] Z.S. Warraich, W.G. Morsi. (2023, June). Early detection of cyber–physical attacks on fast charging stations using machine learning considering vehicle-to-grid operation in microgrids. Sustainable Energy, Grids and Networks. https://www.sciencedirect.com/science/article/abs/pii/S2352467723000358

[161] McMaster University. (n.d.). About MITL. https://mitl.mcmaster.ca/about/

[162] Ontario Tech University. (n.d.). Electric Vehicles. https://ace.ontariotechu.ca/autonomous/index.php

[163] Ibid.

[164] Ibid.

[165] Ibid.

[166] Blackstone Energy Services. (n.d.). Vehicle to Grid. https://blackstoneenergy.com/electricvehicletogrid/

[167] OVIN. (2023). Annual Comprehensive Sector Report – Ontario in the Driver's Seat: Shaping the Future of Smart Mobility and the Automotive Industry. https://www.ovinhub.ca/wp-content/uploads/2023/08/ACSR_Report_OCI-AODA-updates.pdf

[168] IESO. (2022, April). Artificial Intelligence Pilot to Support EV Electricity Demand in Ottawa. https://www.ieso.ca/en/Corporate-IESO/Media/News-Releases/2022/04/Artificial-Intelligence-Pilot-to-Support-EV-Electricity-Demand-in-Ottawa

[169] TTC. (2023, April). TTC and PowerON unveil innovative eBus charging system. https://www.ttc.ca/news/2023/April/TTC-and-PowerON-unveil-innovative-eBus-charging-system

[170] Electric Autonomy Canada. (2020, November). SWTCH Energy to lead new blockchain-based EV charging pilot. https://electricautonomy.ca/2020/11/11/swtch-ev-charging-blockchain-buildings/

[171] Today's Trucking. (2021, July). Hydro One's heavy-duty truck charging pilot included in new EV funds. https://www.trucknews.com/equipment/hydro-ones-heavy-duty-truck-charging-pilot-included-in-new-ev-funds/1003152578/

[172] Government of Canada. (2023, May). Government of Canada invests $4.8 million to support scale up of Mississauga-based clean technology innovator. https://www.canada.ca/en/economic-development-southern-ontario/news/2023/05/government-of-canada-invests-48-million-to-support-scale-up-of-mississauga-based-clean-technology-innovator.html

[173] Toronto Hydro. (n.d.). Electric Vehicle (EV) Smart Charging Pilot Program. https://www.torontohydro.com/electric-vehicles/smart-charging

[174] Peak Power. (n.d.). Peak Drive Pilot Project. https://peakpowerenergy.com/project/peak-drive-pilot-project/

[175] Ibid.

[176] Ibid.

[177] OVIN. (n.d.). Regional Technology Development Sites. https://www.ovinhub.ca/ecosystem/regional-technology-development-sites/

[178] OVIN. (n.d.). Project Arrow. https://www.ovinhub.ca/project-arrow/

[179] Jil McIntosh. (2023, November). Canadian Project Arrow 2.0 to spawn 20 more prototypes. https://driving.ca/auto-news/industry/project-arrow-2-0-automotive-parts-manufacturers-association

[180] Electric Autonomy Canada. (2021, November). Plug and Charge: easier, faster and more secure charging for the future. https://electricautonomy.ca/2021/11/29/plug-and-charge/

[181] Ibid.

[182] Agora. (n.d.). FAQ. https://agoracharge.com/faq

[183] Electric Autonomy Canada. (2021, July). Major EV charging networks sign roaming agreement, opening door for more flexibility. https://electricautonomy.ca/2021/07/16/ev-charging-networks-roaming-agreement/

[184] Electric Autonomy Canada. (2023, November). Sixteen companies launch campaign to boost EV charger roaming in Canada. https://electricautonomy.ca/2023/11/17/ev-charger-roaming-campaign-canada/

[185] Electric Autonomy Canada. (2023, October). Ontario opens application process for EV ChargeON funding. https://electricautonomy.ca/2023/10/27/ev-chargeon-funding-ontario-ev-chargers/

[186] Ibid.

[187] Natural Resources Canada. (2022, March). Updated Projections of Canada's Public Charging Infrastructure Needs. Government of Canada. https://natural-resources.canada.ca/energy-efficiency/transportation-alternative-fuels/resource-library/updated-projections-canadas-public-charging-infrastructure-needs/24504

[188] Carter Li. (2022, October). Canada Needs EV Charging Infrastructure to Transition to a Clean Economy. The Future Economy.ca. https://thefutureeconomy.ca/op-eds/canada-needs-ev-charging-infrastructure-to-transition-to-a-clean-economy/

[189] Electric Autonomy Canada. (2022, May). High-rise headaches: EV charging in Canada's condos, apartments and MURBs a mixed experience. https://electricautonomy.ca/2022/05/16/ev-charging-canada-murbs/

[190] Ibid.

[191] City of Toronto. (n.d.). Air Quality. https://www.toronto.ca/city-government/planning-development/official-plan-guidelines/toronto-green-standard/toronto-green-standard-version-4/mid-to-high-rise-residential-non-residential-version-4/air-quality/

[192] IRENA. (2019). Innovation Outlook – Smart Charging for Electric Vehicles. https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/May/IRENA_EV_smart_charging_2019_summary.pdf

[193] Ontario Energy Board. (2024, February). Electric Vehicle Charging Connection Procedures. https://engagewithus.oeb.ca/derandevchargingconnections

[194] Colin Guldimann. (2023, June). Power Shift: How Ontario Can Cut Its $450-Billion Electricity Bill. RBC Capital Markets. https://www.rbccm.com/en/story/story.page?dcr=templatedata/article/story/data/2023/06/power-shift

[195] Ibid.

[196] Ibid.

[197] OVIN. (n.d.). R&D Partnership Funds – Advanced Charging and Vehicle-to-Grid (V2G) Stream. https://www.ovinhub.ca/programs/rd-partnership-fund-advanced-charging-and-vehicle-to-grid-v2g-stream/

[198] Ibid.

[199] Government of Ontario. (2023, October). Ontario Building More Electric Vehicle Charging Stations. https://news.ontario.ca/en/release/1003677/ontario-building-more-electric-vehicle-charging-stations