ZERO EMISSION VEHICLE CHARGING IN MULTI-UNIT RESIDENTIAL BUILDINGS AND FOR GARAGE ORPHANS

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About

Pollution Probe

Pollution Probe is a national, not-for-profit, charitable organization that exists to improve the health and well-being of Canadians by advancing policy that achieves positive, tangible environmental change. Pollution Probe has a proven track record of working in successful partnership with industry and government to develop practical solutions for shared environmental challenges.

The Delphi Group

The Delphi Group is a Canadian strategic consultancy providing innovative solutions in the areas of climate change and corporate sustainability. As a pioneer in sustainability and environmental risk management, The Delphi Group has more than 30 years of experience in helping some of Canada's best-known companies improve the sustainability of their organizations – as well as the local and global communities in which they operate.

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Travis Allan is the Vice President of Public Affairs and General Counsel of AddÉnergie Technologies Inc., the largest Canadian manufacturer of EV charging stations and owner of the FLO EV charging network. Travis has worked for many years to support the development of EV charging standards and policies for multi-unit residential buildings across Canada. He has been selected as a leading Canadian Energy Lawyer by Who's Who, and is the associate Canadian editor of the International Energy Law Review (published by Sweet & Maxwell).

Natural Resources Canada

Natural Resources Canada (NRCan) seeks to enhance the responsible development and use of Canada's natural resources and the competitiveness of Canada's natural resources products. We are an established leader in science and technology in the fields of energy, forests, and minerals and metals and use our expertise in earth sciences to build and maintain an up-to-date knowledge base of our landmass. NRCan develops policies and programs that enhance the contribution of the natural resources sector to the economy and improve the quality of life for all Canadians. We conduct innovative science in facilities across Canada to generate ideas and transfer technologies. We also represent Canada at the international level to meet the country's global commitments related to the sustainable development of natural resources.

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About this Report

The uptake of zero emission vehicles (ZEVs) in Canada presents enormous opportunities for stakeholders across a wide range of sectors. The value of these technologies is often characterized by their potential to reduce the tailpipe emissions that contribute to air pollution and climate change. As the ZEV market continues to grow and evolve, it has become increasingly clear that the value proposition for the technology extends well beyond emissions reductions. There is also the potential for ZEVs to contribute to Canada's clean growth and climate change strategies, to stimulate best practices in energy efficiency and clean technology and to play a critical role in the broadening landscape of renewable distributed energy, storage technology and research, development and demonstration (RD&D). Industry and automakers specializing in ZEV technologies can leverage their early mover advantage to increase revenues from sales of new products and develop export opportunities in this rapidly growing market. However, for ZEVs to become an integral part of successful sustainable transportation systems and continue to contribute to the decarbonisation of the transportation sector, the social, environmental and financial needs of all users should be met, and a number of remaining barriers must be addressed.

ZEVs require infrastructure to charge the vehicle, a fact that necessitates strategic planning to enable their effective deployment. Roughly 80% of all electric vehicle (EV) charging currently occurs at home, and the ability to do so has been tied to optimizing the utility and consumer appeal of ZEVs.[1] While building out additional charging options (e.g., public or workplace) is also important, ensuring that Canadians have access where they live will be critical to supporting widespread ZEV adoption. A significant proportion of the population in major urban centres reside in multi-unit residential condominium and apartment buildings or dwellings without access to a driveway or garage (also known as garage orphans). A number of unique charging-related challenges exist for these residents that will need to be effectively addressed to facilitate further ZEV uptake among this growing segment of the population.

Under the Pan-Canadian Framework on Clean Growth and Climate Change — the federal government's plan to meet emissions reductions targets, grow the economy and build resilience to a changing climate — most provinces agreed to an ambitious target of 30% greenhouse gas (GHG) emissions reductions below 2005 levels by 2030. The Pan-Canadian Framework comprises a suite of actions that jurisdictions can undertake to facilitate the transition to a low-carbon economy. Within the transportation sector, this includes enabling widespread electrification and the uptake of ZEVs.

In early 2019, the Government of Canada announced targets for 10% of vehicle sales to be ZEVs by 2025, 30% by 2030 and 100% by 2040. Budget 2019 proposed a number of actions to support these adoption targets, including $130 million over five years to deploy new ZEV infrastructure, $300 million over three years for a federal purchase incentive for ZEVs that cost $45,000 or less, $5 million over five years to work with automakers to secure voluntary sales targets and a full tax write-off for light-, medium- and heavy-duty ZEVs purchased by businesses.

In support of its commitment to electrification, the Government of Canada convened several ZEV expert working groups in 2016, including one led by Natural Resources Canada (NRCan) specific to informing infrastructure efforts. A recommendation of the infrastructure working group was to incorporate grid readiness into the ongoing dialogue. The name of the working group was changed to the Infrastructure and Grid Readiness Working Group (IGRWG) to reflect this broader focus.[i] Given that a growing proportion of the population in Canadian urban centres reside in multi-unit residential buildings (MURBs) or are without a driveway or garage, a priority issue for the IGRWG over the past year has been addressing the unique challenges associated with charging for these potential ZEV owners.

This report is the result of work undertaken by Pollution Probe and The Delphi Group as part of the study on ZEV Charging in MURBs and for Garage

[i] In addition to the Infrastructure and Grid Readiness Working Group (IGRWG), the Government of Canada has convened the following expert working groups: ZEV Total Costs and Benefits of Ownership Expert Group; Public Awareness and Education Expert Group; Technological Advancement, Clean Growth and Clean Jobs Expert Working Group; and the ZEV Supply Expert Group.

Orphans, conducted in support of NRCan and based on a statement of work developed with input from the IGRWG. The study looked to identify key barriers to ZEV charging in MURBs and for garage orphans and to highlight existing solutions and best practices. Perhaps most importantly, this report maps these barriers to potential solutions and outlines a suite of practical actions that stakeholders can take to address current challenges associated with charging in MURBs and for garage orphans. These actions will support the ongoing development of ZEV deployment strategies as the market continues to expand and evolve, and will serve to bring stakeholders together to move forward in a strategic, cost-effective and collaborative manner.

Objectives and Methodology

Based on a statement of work developed by NRCan's IGRWG, Pollution Probe and The Delphi Group undertook a study to assess and communicate the barriers and opportunities for ZEV charging in MURBs and for garage orphans, in an effort to contribute to accelerating the deployment and adoption of ZEVs in Canada. More specifically, the objectives of the study were to:

- Identify key barriers, opportunities, and potential solutions associated with ZEV charging in MURBs and for garage orphans.
- Communicate best practices and lessons learned for a range of audiences.
- Develop a matrix of actions that will provide a framework for stakeholders to visualize key actions and the potential roles necessary to enable charging in MURBs and for garage orphans.

The research methodology for this study combined an in-depth literature review with a series of interviews with key subject matter experts and stakeholders involved in the deployment of ZEV charging infrastructure in MURBs or for garage orphans. The literature review included an investigation of national and international scholarly and professional resources such as peer-reviewed articles, research reports, policy documents and discussion papers, and allowed for an examination of available evidence about key barriers and the progress made to date in addressing them both within Canada and internationally.

Telephone interviews were conducted with key subject matter experts and stakeholders across Canada to help fill information and data gaps identified through the literature review and to obtain a more targeted understanding of the challenges for ZEV charging in MURBs and for garage orphans. Interviewees included representatives from the following stakeholder groups in Canada:

- Government (federal, provincial/territorial and municipal)
- Electric vehicle supply equipment (EVSE) providers and technology companies
- Residential property developers
- Property managers
- Utilities (local distribution companies and electricity generation companies)
- Academia
- Not-for-profit organizations
- Standards associations
- EV owners and societies
- Automakers and automotive associations
- Energy industry

A total of 33 interviews with 36 stakeholders (some interviews involved more than one person) were conducted between November 2018 and January 2019.

The study also included the development of three separate matrices of action (Existing MURBs, New MURBs and Garage Orphans) that identify opportunities for ongoing capacity building and action related to ZEV charging in MURBs and for garage orphans. The matrices suggest stakeholder groups that could play a role in the implementation of these actions. Members of the IGRWG contributed their time and expertise in reviewing the accuracy and appropriateness of these actions and in identifying any outstanding gaps that should be addressed.

A wide range of stakeholders have been involved in important work related to ZEV charging in MURBs and for garage orphans over the past several years. This study provided an opportunity to engage many of them and where appropriate, to contribute to knowledge-sharing across sectors. Participation of subject matter experts across the country both through interviews and in discussion with the

IGRWG, helped to ensure local and sector-specific perspectives informed the study, enhancing the value and relevance of the findings. It will be critical for stakeholders to continue to work together in developing solutions to support the growing demand for ZEVs among those residing in MURBs and by garage orphans. The study findings outlined in this report constitute a foundation upon which those with a stake in the deployment of ZEVs and the installation of charging infrastructure can base their future actions.

Report Outline

This report is divided into **three** sections that describe the broad context for ZEV charging in MURBs and for garage orphans, identify key barriers and potential solutions to charging for these residents and outline a suite of actions that stakeholders can use as a guide to address challenges.

Section One provides a brief description of ZEVs, charging infrastructure, MURBs and garage orphans, and outlines some of the key benefits associated with ZEV use. This section also introduces the regulatory instruments used by governments, industry, and other organizations to address ZEV charging in MURBs or for garage orphans and provides an overview of relevant initiatives being undertaken by federal, provincial, and municipal governments in Canada.

Section Two describes the barriers, potential solutions and existing best practices associated with ZEV charging in MURBs and for garage orphans based on key findings from this study. This section builds a detailed picture of the broad range of challenges facing potential ZEV owners living in MURBs or without access to a driveway or garage and highlights innovative solutions from a number of leading jurisdictions.

Section Three presents an action-based framework (matrix of actions) that should be considered by relevant stakeholders in Canada to address the challenges associated with ZEV charging in MURBs and for garage orphans. Three matrices of action (Existing MURBs, New MURBs and Garage Orphans) provide an effective visual map of potential future action that will allow stakeholders to identify opportunities where they can make meaningful contributions.

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Executive Summary

The uptake of zero emission vehicles (ZEVs) in Canada presents enormous opportunities for stakeholders across a wide range of sectors. ZEV use can contribute to clean growth and climate change strategies, as well as greenhouse gas (GHG) emissions reduction goals. There is also the potential for ZEVs to play a critical role in the broadening landscape of renewable distributed energy, storage technology and research, development and demonstration (RD&D). While Canada's ZEV sales have increased rapidly over the past several years, they currently represent only 2.2% of the total light-duty vehicle (LDV) market. A number of key barriers must be addressed in order to increase ZEV deployment across the country and to ensure the social, environmental and economic benefits of these vehicles are realized by all potential owners.

Transportation-related GHG emissions in Canada have increased by 42% since 1990 and the sector accounted for 25% of total national GHG emissions in 2016. Significant emissions reductions can be achieved by moving away from the use of fossil-fuel powered vehicles to ZEVs, particularly given Canada's low-carbon electricity mix. ZEVs have no harmful tailpipe emissions and their use contributes to improving local air quality and reducing transportation-related health impacts. The benefits of ZEV use however, extend beyond their contributions to emissions reductions. ZEVs can also provide economic benefits for drivers by way of a reduction in the total cost of ownership (TCO). This is due to the fact that ZEVs have significantly lower operation and maintenance costs when compared to vehicles with a conventional internal combustion engine (ICE). There are also benefits for building owners and cities related to ZEV deployment including the attraction of environmentally-conscious businesses and tenants, creation of new revenue streams and the ability to obtain credit towards environmental performance certification programs.

The Government of Canada has recognized that reducing transportation-related emissions will be critical for meeting its target of 30% GHG reductions below 2005 levels by 2030, as outlined in the Pan-Canadian Framework on Clean Growth and Climate Change. The framework articulates Canada's plan to meet its climate change commitments and identifies increased ZEV use as a priority for addressing emissions from the transportation sector. A range of measures that encourage or support ZEV deployment have been implemented in support of this objective, including several initiatives related to the installation of electric vehicle (EV) charging infrastructure in multi-unit residential buildings (MURBs) and for garage orphans. For example, the federal government is supporting infrastructure installations, pilot projects and demonstrations, working to update relevant legislation and regulations, and providing educational resources specific to MURBs and garage orphans.

In early 2019, the Government of Canada also announced targets for ZEVs to account for 10% of new passenger vehicle sales by 2025, 30% by 2030 and 100% by 2040. Budget 2019 outlined further ways in which the federal government will support these adoption targets, including providing $130 million over five years to deploy new ZEV infrastructure, $300 million over three years for a federal purchase incentive for ZEVs that cost $45,000 or less, $5 million over five years to work with automakers to secure voluntary sales targets and a full tax write-off for light-, medium- and heavy-duty ZEVs purchased by businesses.

ZEV Charging in Multi-Unit Residential Buildings and for Garage Orphans

An increasing proportion of the Canadian population resides in multi-unit residential condominium and apartment buildings or dwellings without access to a driveway or garage. It is estimated that at least one-third of Canadians live in MURBs and in some large metropolitan centres, apartments are more common than single-detached homes. These MURB and garage orphan residents are potential mainstream ZEV adopters but they face a number of unique charging-related barriers that must be effectively addressed to facilitate uptake.

This report is the result of work undertaken by Pollution Probe and The Delphi Group as part of the study on ZEV Charging in MURBs and for Garage Orphans, conducted in support of Natural Resources Canada (NRCan). The study aimed to contribute to the

ongoing development of ZEV deployment strategies by supporting capacity building and stakeholder collaboration related to charging in MURBs and for garage orphans. Key barriers and opportunities for ZEV charging in MURBs were identified and categorized, and potential solutions and best practices were explored. A suite of options for potential future action was also developed, providing a comprehensive framework for stakeholders to visualize practical actions and the potential roles necessary to enable charging in MURBs and for garage orphans.

A wide range of stakeholders have been involved in important work related to ZEV charging in MURBs and for garage orphans over the past several years. This study provided an opportunity to engage many of them and where appropriate, to contribute to knowledge-sharing across sectors. Participation of subject matter experts across the country helped to ensure local and sector-specific perspectives informed the study, enhancing the value and relevance of the findings. It will be critical for stakeholders to continue to work together in developing solutions to support the growing demand for ZEVs by MURB residents and those without access to a garage or driveway. The study findings outlined in this report constitute a foundation upon which those with a stake in the deployment of ZEVs and installation of charging infrastructure can base their future actions.

Barriers and Solutions to EV Charging in MURBs and for Garage Orphans

A range of barriers to EV charging in MURBs and for garage orphans were identified through the review of relevant literature and the interviews conducted as part of this study. These barriers were organized according to the following six broad categories:

- **Grid Preparedness & Charging Infrastructure:** These barriers comprise those related to the electrical grid and EV charging infrastructure (not those specific to building design) as they pertain to MURBs and garage orphans.

- **Building Design & Physical Infrastructure:** Applicable only to MURBs, these barriers include those related to charging infrastructure in and around buildings.
- **Education & Awareness:** Barriers in this category relate to MURBs and garage orphans and focus on consumer, building owner and property manager awareness.
- **Regulatory & Policy:** This category covers barriers related to the regulations and policies (e.g., acts, codes, standards, process policies and bylaws) that impact EV charging in MURBs and for garage orphans.
- **Financial:** Barriers in this category are applicable to MURBs and garage orphans and include installation and operational costs, as well as challenges related to cost-sharing.
- **Other:** These barriers are those that do not fit easily within the other categories.

Table 1 provides a high-level summary of the barriers, the type of dwelling they apply to, and potential solutions.

Table 1. Summary of Barriers and Solutions

Barrier	Brief Description	Existing MURB	New MURB	Garage Orphan	Solutions
Grid Preparedness & Charging Infrastructure Barriers					
Electrical Capacity	Barriers related to the ability of a building's electrical system to accommodate the additional load from EV charging or the capacity of the electrical distribution system at the neighbourhood-level to accommodate EV charging.	✓	✓	✓	• Utility-controlled demand management • Off-peak charging • Electric Vehicle Energy Management Systems (EVEMS) • Energy storage systems • Additional research, development and pilot projects
Metering	Barriers associated with how charging stations are owned, managed and metered in a building and challenges related to customer billing and the distribution of electricity costs.	✓			• EVSE network solutions
Lack of Access to Charging Infrastructure	Barriers faced by garage orphans who do not have access to charging at home because they do not have a garage or dedicated parking space with an electrical outlet.			✓	• Demand or load management • Residential curbside charging • Increased public and workplace charging
Building Design & Physical Infrastructure Barriers					
Parking Supply	Barriers related to a limited number of parking spaces in a building, lack of regular access to a parking space or restrictions on re-assignment of parking spaces.	✓	✓		• Peer-to-peer charging rentals • Public charging (parking lots and curbside charging) • Swapping parking spots • Community or shared charging • Reservations and virtual waiting lists

Barrier	Brief Description	Existing MURB	New MURB	Garage Orphan	Solutions
Design	Barriers related to the physical design of a building, such as space constraints in parking lots and within electrical rooms. Also includes barriers related to the design of EVSE installation.	✓	✓		• Technology solutions (e.g., demand charge controllers, chargers with built-in transformers, energy storage-based charging) • Parking or charging management (i.e., multiple users per charger) • Public charging (parking lots and curbside charging)
Connectivity	Barriers related to poor cellular coverage in underground parking garages.	✓	✓		· Technology solutions (e.g., cellular boosting)
Education & Awareness Barriers					
Consumer Awareness	Barriers related to minimal consumer understanding and experience with EVs or a lack of resources to help properly assess how to implement EV charging.	✓	✓	✓	• Targeted education and outreach • Regulations • Certification programs
Condo Board or Strata Council Decision- Making and Building Owner Awareness	Barriers related to a lack of awareness and resources required by MURB owners or property managers to effectively evaluate and deploy EV charging infrastructure.	✓			• Targeted education and outreach • Regulations (e.g., revising condo acts, bylaws, and regulations, permits triggering EVSE requirements)
Regulatory & Policy Barriers					
Physical Barriers	Regulatory barriers related to physical infrastructure upgrades and the costs associated with installing EVSE.	✓	✓		• Financial support and incentives • Zoning bylaws • EVEMS • Implementing EV supportive standards in national model building code
Condo & Strata Legislation	Regulatory barriers related to the approval process for EVSE installation by a condo board or strata corporation.	✓			• “Right to charge” legislation
Electricity-related Legislative & Regulatory	Regulatory barriers related to cost recovery and the apportionment of electrical costs associated with the use of electricity to charge an EV in a MURB.	✓			• Clarity on recovery of costs for EV charging services without regulation as a public utility
Measurement Rules	Regulatory barriers related to metering requirements for EV charging.	✓	✓		• Approved metering solutions that enable billing for EV charging based on energy usage

Barrier	Brief Description	Existing MURB	New MURB	Garage Orphan	Solutions
Financial Barriers					
Installation Costs	Barriers related to the costs associated with EVSE installation in a MURB or at a residential curbside.	✓	✓	✓	• Technology solutions (e.g., demand charge controllers, charger with a built-in transformer) • Swapping parking spots • Regulations (e.g., EV ready parking requirements or design for 100% in new MURBs and for major renovations) • Funding or support programs
Operation & Maintenance Costs	Barriers related to the cost of operating and maintaining EVSE.	✓	✓		• Funding or support programs • Low-rate charging
Cost Sharing	Barriers related to the inability of MURB owners and property managers to charge for electricity separate from the utility or restrictions on the resale of electricity.	✓	✓		• New financial or operating models (e.g., financial recovery independent of utility costs, utility owned or operated EVSE, privately owned or operated EVSE and networked chargers) • Charging solutions (e.g., flat fee-based charging, rate based charging) • Public charging in parking lots and curbside
Other Barriers					
Rental-specific Barriers	Barriers related to the lack of incentives for renters and landlords to invest in infrastructure upgrades and EVSE installation, as well as challenges associated with liability.	✓	✓	✓	• Regulatory solutions to allow EVSE installation • Public charging in parking lots and curbside

Matrix of Actions

A suite of coordinated actions will be required to effectively address the barriers faced by potential ZEV owners residing in MURBs or those who do not have a dedicated parking spot. Three matrices of action related to new MURBs, existing MURBs, and garage orphans were developed as part of this study to help facilitate capacity building and stakeholder collaboration on addressing these barriers. A clear understanding of the broader interconnections that exist across barriers provides opportunities to determine appropriate and complementary solutions that will not unintentionally create new challenges. The three matrices of action provide an effective visual map that will allow stakeholders to identify opportunities where they can make meaningful contributions.

Potential actions are organized under the following broad categories:

- **Grid Preparedness & Charging Infrastructure:** These barriers comprise those related to the electrical grid and EV charging infrastructure (not those specific to building design) as they pertain to MURBs and garage orphans.
- **Building Design & Physical Infrastructure:** Applicable only to MURBs, these barriers include

those related to charging infrastructure in and around buildings.

- **Education & Awareness:** Barriers in this category relate to MURBs and garage orphans and focus on consumer, building owner and property manager awareness.
- **Regulatory & Policy:** This category covers barriers related to the regulations and policies (e.g., acts, codes, standards, process policies and bylaws) that impact EV charging in MURBs and for garage orphans.
- **Incentives & Support Programs:** This category of actions involves financial and other support programs, such as technical advisory services, and is applicable to MURBs and garage orphans.
- **Complementary Actions:** These actions comprise those that are supportive of the EV sector in general and may not be directly related to facilitating charging in MURBs or for garage orphans.

This study identified that many stakeholders involved in work related to MURBs and garage orphans have no formal means of connection and are therefore unaware of each other's actions, successes and lessons learned. As previously noted, it will be critical for a range of stakeholders to collaborate on the development and implementation of effective solutions to the barriers identified in this report. The following stakeholders have a potential role to play in enabling ZEV charging in MURBs and for garage orphans:

- Government (federal, provincial/territorial and municipal)
- Utilities and electricity providers
- Industry, including technology companies and EVSE providers
- Real estate developers
- Property management and apartment building owners
- Condo and strata boards
- Academia, civil society and advocacy organizations
- EV owners and associations
- Automakers

Each of these stakeholder groups may have specific actions that they are more suited to leading within the matrices. There will also be opportunities for stakeholders to support each other and to form partnerships for effective collaboration related to others.

Matrix of Actions for Zero Emission Charging in Existing Multi-Unit Residential Buildings

GRID PREPAREDNESS & CHARGING INFRASTRUCTURE	BUILDING DESIGN & PHYSICAL INFRASTRUCTURE	EDUCATION & AWARENESS	REGULATORY & POLICY	INCENTIVES & SUPPORT PROGRAMS	COMPLEMENTARY ACTIONS
Investigate and implement distribution system demand management programs	Installation of EV chargers and associated systems for shared use in building common areas	Develop "how to" guidance and web content for EV and building owners, property management and condo boards to reference	Enact provincial "right to charge" regulatory amendments to condo or strata acts to facilitate approval of applications to install EV charging stations	Provide subsidies, tax credits or low-cost loans to condo/strata board or building owners for electrical infrastructure audit or assessment	Develop and implement curriculum at academic institutes related to EV charging
Explore options for demand management at the building level	Explore options for improved cellular connectivity in underground parking areas	Undertake educational campaigns targeting various stakeholder groups based on unique informational needs	Work with federal government to develop approved metering solutions that enable billing for EV charging based on energy usage	Provide financial incentive to MURB residents, building owners or condo/strata boards to purchase and install networked or otherwise energy managed EV charging stations	Installation of public charging infrastructure at workplaces and public locations including in densely populated residential areas to address daytime charging needs
Explore use of technologies capable of augmenting existing electrical capacity	Undertake RD&D and pilot programs that promote use of new technologies that address physical constraints for EV charging in buildings	Develop best practice guidelines and turnkey solutions for condo boards, building owners, property managers and municipalities	Develop condo or strata EV charging station installation policy with a focus on maximizing existing electrical infrastructure and consider EV-supportive upgrades as part of condo/strata board planning processes	Provide financial assistance to building owners or condo/strata boards to support electrical capacity upgrades where demand management solutions are insufficient	Support for RD&D, demonstration and commercialization of EV charging technologies
Prioritize investment in charging infrastructure options that address multiple charging needs (e.g., residential and public charging)	Undertake necessary building upgrades (panel, transformer) where demand management solutions are insufficient	Provide advisory services and workshops on EV charging station installation specific to MURBs	Require municipal departments, building owners, property managers and condo or strata boards to provide information to help consumers make decisions about EV charging installations	Explore the potential to fund the installation of chargers in MURBs or the throughput of kWh through Clean Fuel Standard (CFS) or British Columbia's low carbon fuel standard (LCFS) credits. Note: Parties eligible to generate credits may differ under the standards.	Promotion of electric car share and rideshare services and associated charging infrastructure, as alternative for MURB residents without access to EV charging.
Installation and preferential use of nearby public charging infrastructure to address overnight charging needs of MURB residents	Consider solutions that ensure access to charging infrastructure where parking stalls are deeded (e.g., swapping parking spaces)	Develop materials to communicate business case for EV charging to condo boards, property management and apartment building owners	Provide clarity on ability to recover costs for EV charging services without regulation as a public utility either by utility regulatory decision or provincial legislative exemption	Conduct social equity analysis and consider how to make EV charging stations accessible for underserved neighbourhoods	Develop public education materials to improve general knowledge about EV charging and connect potential buyers with current EV owners

GRID PREPAREDNESS & CHARGING INFRASTRUCTURE	BUILDING DESIGN & PHYSICAL INFRASTRUCTURE	EDUCATION & AWARENESS	REGULATORY & POLICY	INCENTIVES & SUPPORT PROGRAMS	COMPLEMENTARY ACTIONS
Develop program for informing utilities about where EV charging in MURBs currently exists or is planned		Develop training programs for local governments, contractors and other stakeholders related to EV charging installation in MURBs	Develop policy and guidelines that provide clarity on appropriate fee structure for cost recovery on charging infrastructure and ability of utility to rate base installation costs	Preferential parking rate for EV owners in common spaces equipped with chargers	Investigate options for sharing home EV chargers (peer-to-peer charging)
Leverage planned energy retrofits & upgrades to outfit buildings with EV charging infrastructure		Develop a platform and stakeholder network for sharing resources and best practices	Explore potential for requiring installation of EV charging stations when substantial renovations necessitate a permit and/or compliance with building code	Continued research into addressing barriers to charging in MURBs	Develop guidelines and best practices for procurement of public EV charging stations
Undertake RD&D and pilot programs that address grid capacity and demand management related to EV charging		Conduct or host demonstrations and events related to EV charging in MURBs	Require provincial landlord tenant laws to incorporate consideration for EV charging	Provide technical assistance and services for EV charger installation to building owners, property managers and condo boards	Development and use of websites and apps providing real time information on availability and cost of public EV chargers
Ensure EV charging in MURBs is accounted for in long-term load management planning and forecasting		Work together with the real estate sector to list EV charging access as a standard housing attribute in real estate listings	Explore potential for condo or strata boards to use portion of reserve funds to support EV charging station installation or EV-readiness upgrades		Develop supportive policies, electrification targets and incentive programs to signal support for long-term market growth
			Remove requirements for approval from committee of adjustment to install EV charging station in visitor parking		Explore options for enabling utilities to own and operate EV charging infrastructure
			Explore removal of demand charges for purposes of EV charging.		

LEGEND

- Government actions
- Utility & electricity provider actions
- Industry & EVSE provider actions
- Real estate developer actions
- Property management & apartment building owner actions
- Condo & strata board actions
- Academia, civil society & advocacy organization actions
- EV owners & associations actions
- Automaker actions

Matrix of Actions for Zero Emission Charging in New Multi-Unit Residential Buildings

GRID PREPAREDNESS & CHARGING INFRASTRUCTURE	BUILDING DESIGN & PHYSICAL INFRASTRUCTURE	EDUCATION & AWARENESS	REGULATORY & POLICY	INCENTIVES & SUPPORT PROGRAMS	COMPLEMENTARY ACTIONS
Investigate and implement distribution system demand management programs	Installation of EV chargers and associated systems in private spaces and for shared use in building common areas	Develop "how to" guidance and web content for EV and building owners, property management and condo boards to reference	Include model requirements for EV ready parking spaces and building electrical capacity in National Building Code and work with provinces to establish province-wide standards	Provide subsidies, tax credits or low-cost loans to condo/strata board or building owners for electrical infrastructure audit or assessment and EV-ready upgrades	Develop and implement curriculum at academic institutes related to EV charging
Explore options for demand management at the building level	Explore options for improved cellular connectivity in underground parking areas	Undertake educational campaigns targeting various stakeholder groups based on unique informational needs	Review and update provincial building codes to include requirements for EV-ready parking and building electrical capacity	Explore options for removing barriers in the customer interconnection process (e.g., easing utility expansion deposit requirements for developers who plan to install EV charging infrastructure)	Installation of public charging infrastructure at workplaces and public locations including in densely populated residential areas to address daytime charging needs
Explore use of technologies capable of augmenting existing electrical capacity	Undertake RD&D and pilot programs that promote use of new technologies that address physical constraints for EV charging in buildings	Develop best practice guidelines and turnkey solutions for condo boards, building owners, property managers and municipalities	Where appropriate, use zoning or parking bylaws to require parking spaces be EV ready (either roughed-in or EVSE installed) with minimum charging performance standards	Provide financial incentive for real estate developers to install networked or otherwise energy managed EV charging stations	Support for RD&D, demonstration and commercialization of EV charging technologies
Prioritize investment in charging infrastructure options that address multiple charging needs (e.g., residential and public charging)	Strategic long-term planning related to location of EV ready parking spaces	Provide advisory services and workshops on EV charging station installation specific to MURBs	Work with federal government to develop approved metering solutions that enable billing for EV charging based on energy usage	Explore the potential to fund the installation of chargers in MURBs or the throughput of kWh through Clean Fuel Standard (CFS) or British Columbia's low carbon fuel standard (LCFS) credits. Note: Parties eligible to generate credits may differ under the standards.	Promotion of electric car share and rideshare services and associated charging infrastructure, as alternative for MURB residents without access to EV charging.
Installation and preferential use of nearby public charging infrastructure to address overnight charging needs of MURB residents		Develop a platform and stakeholder network for sharing resources and best practices	Incorporate EV charging station installation needs into building development and planning processes	Conduct social equity analysis and consider how to make EV charging stations accessible for underserved neighbourhoods	Develop public education materials to improve general knowledge about EV charging and connect potential buyers with current EV owners

GRID PREPAREDNESS & CHARGING INFRASTRUCTURE	BUILDING DESIGN & PHYSICAL INFRASTRUCTURE	EDUCATION & AWARENESS	REGULATORY & POLICY	INCENTIVES & SUPPORT PROGRAMS	COMPLEMENTARY ACTIONS
Develop program for informing utilities about where EV charging in MURBs currently exists or is planned		Develop materials to communicate business case for real estate developers	Provide clarity on ability to recover costs for EV charging services without regulation as a public utility either by utility regulatory decision or provincial legislative exemption	Preferential parking rate for EV owners in common spaces equipped with chargers	Investigate options for sharing home EV chargers (peer-to-peer charging)
Undertake RD&D and pilot programs that address grid capacity and demand management related to EV charging		Highlight benefits of EVSE in building certification programs (e.g., LEED).	Require municipal departments, building owners, property managers and condo or strata boards to provide information to help consumers make decisions about EV charging installations	Continued research into addressing barriers to charging in MURBs	Develop guidelines and best practices for procurement of public EV charging stations
Ensure EV charging in MURBs is accounted for in long-term load management planning and forecasting		Conduct or host demonstrations and events related to EV charging in MURBs		Provide best practices, technical assistance and services for EV charger installation to building owners, property managers and condo boards	Development and use of websites and apps providing real time information on availability and cost of public EV chargers
		Work together with the real estate sector to list EV charging access as a standard housing attribute in real estate listings		Explore potential to reduce total number of parking stalls required per building in exchange for EV ready development	Develop supportive policies, electrification targets and incentive programs to signal support for long-term market growth
					Explore options for enabling utilities to own and operate EV charging infrastructure

LEGEND

- Government actions
- Utility & electricity provider actions
- Industry & EVSE provider actions
- Real estate developer actions
- Property management & apartment building owner actions
- Condo & strata board actions
- Academia, civil society & advocacy organization actions
- EV owners & associations actions
- Automaker actions

Matrix of Actions for Zero Emission Charging for Garage Orphans

GRID PREPAREDNESS & CHARGING INFRASTRUCTURE	EDUCATION & AWARENESS	REGULATORY & POLICY	SUPPORT PROGRAMS & INCENTIVES	COMPLEMENTARY ACTIONS
Investigate and implement distribution system demand management programs	Develop "how to" guidance and web content for garage orphans to reference related to potential charging options	Develop bylaws that allow reserved parking for EV charging in residential neighbourhoods	Provide financial incentive for EV charging station installation in public lots, community centres, schools, or churches when preferential parking for garage orphans is provided	Develop and implement curriculum at academic institutes related to EV charging
Explore use of technologies capable of augmenting existing electrical capacity	Undertake educational campaigns targeting various stakeholder groups based on unique informational needs	Develop bylaws that allow for permits for parking in front of house or off-street parking permits (i.e., parking pads) in currently prohibited area	Preferential charging rate or discounted parking for garage orphans at curbside charging stations and parking lots	Installation of public charging infrastructure at workplaces and public locations including in densely populated residential areas to address daytime charging needs
Prioritize investment in charging infrastructure options that address multiple charging needs (e.g., residential and public charging)	Develop a platform and stakeholder network for sharing resources and best practices	Provide clarity on resale of electricity by private entities for EV charging or legislative exemption	Incentivize shared home EV chargers (peer-to-peer charging)	Support for RD&D, demonstration and commercialization of EV charging technologies
Undertake RD&D and pilot programs that address grid capacity and demand management related to EV charging	Conduct or host demonstrations and events related to EV charging for garage orphans	Develop bylaws (including all permitting) that allow for curbside EV charging station installation in residential areas.		Investigate options for sharing home EV chargers (peer-to-peer charging)
Build out network of residential on-street charging stations for use by local owners		Develop policies for tracking EV charging data in curbside residential charging stations		Promotion of car share services as alternative for MURB residents without access to EV charging (garage orphans)
Explore feasibility of EV charging technologies and solutions that work within existing parking bylaws				Develop public education materials to improve general knowledge about EV charging and connect potential buyers with current EV owners
Installation and preferential use of nearby public charging infrastructure to address overnight charging needs of garage orphans				Develop guidelines and best practices for procurement of public EV charging stations
Explore opportunities to install EV charging infrastructure in neighbourhood municipal parking lots, community centres or schools				Development and use of websites and apps providing real time information on availability and cost of public EV chargers

GRID PREPAREDNESS & CHARGING INFRASTRUCTURE	EDUCATION & AWARENESS	REGULATORY & POLICY	SUPPORT PROGRAMS & INCENTIVES	COMPLEMENTARY ACTIONS
Ensure loads associated with EV charging by garage orphans is accounted for in neighbourhood-level distribution system planning ■				Develop supportive policies, electrification targets and incentive programs to signal support for long-term market growth ■
				Explore options for enabling utilities to own and operate EV charging infrastructure ■ ■

LEGEND

■ Government actions ■ Utility & electricity provider actions ■ Industry & EVSE provider actions ■ Real estate developer actions ■ Property management & apartment building owner actions ■ Condo & strata board actions ■ Academia, civil society & advocacy organization actions ■ EV owners & associations actions ■ Automaker actions

1 CANADIAN CONTEXT FOR ZERO EMISSION VEHICLE CHARGING IN MULTI-UNIT RESIDENTIAL BUILDINGS AND FOR GARAGE ORPHANS

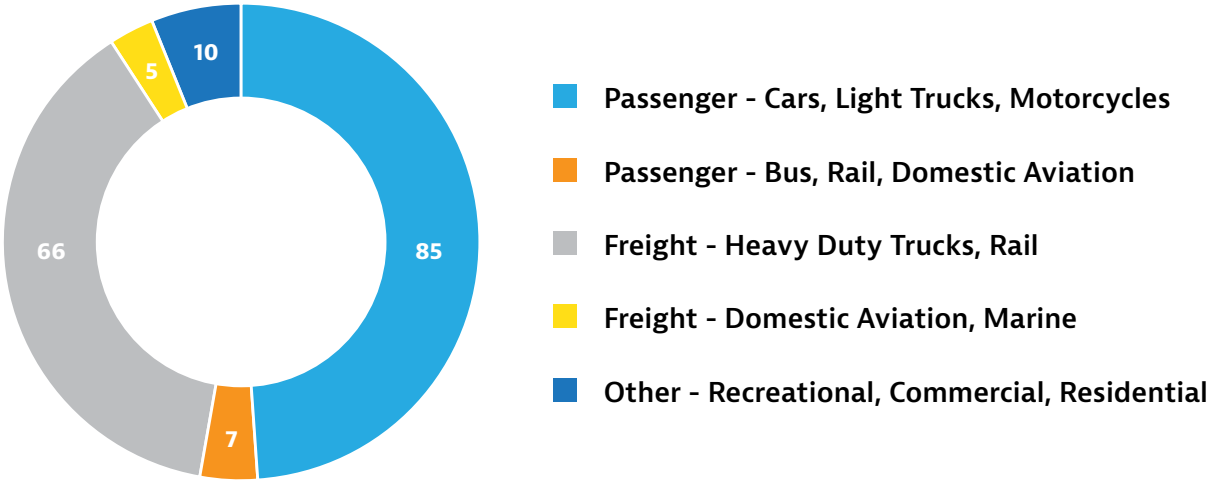
The following section introduces the definitions and concepts that will be referred to throughout this report. It provides background information on ZEVs, charging infrastructure, MURBs and garage orphans in Canada, in an effort to provide context for Section Two and Section Three of the report. Relevant regulatory instruments and initiatives at the federal, provincial/territorial, and municipal level are also explored.

Background

GHG emissions in Canada grew 17% overall between 1990 and 2016. According to Environment and Climate Change Canada (ECCC), this growth was driven primarily by emissions increases in the transportation and oil and gas sectors.[2] Transportation-related GHG emissions have increased 42% since 1990 and accounted for 25% of total national GHG emissions in 2016. Despite improvements in fuel efficiency in the light-duty vehicle sector (i.e., cars and light trucks), vehicle emissions have continued to increase (37% between 1990 and 2016) due to population and economic growth, and the popularity of light trucks and SUVs.[3]

Figure 1 shows GHG emissions sources for Canada's transportation sector in 2016.

Figure 1: Transportation-related Greenhouse Gas Emissions in Canada by Source (173 Mt) [4]



In an effort to reduce GHG emissions, the Government of Canada has adopted several measures to improve energy efficiency, particularly for on-road transportation, which accounts for 80% of the energy consumption in the sector. In 2016, the federal government introduced the Pan-Canadian Framework on Clean Growth and Climate Change which articulates Canada's plan to meet its climate change commitments and grow the economy. Four priority areas for collaborative action with provinces and territories were identified for the transportation sector:

1. Setting emissions standards and improving efficiency
2. Putting more ZEVs on the road
3. Shifting from higher- to lower-emitting modes and investing in infrastructure
4. Using cleaner fuels

A number of transportation-related measures are already underway under the Framework including the development of a national Clean Fuel Standard, federal ZEV sales targets, carbon pricing, the Electric Vehicle and Alternative Fuel Infrastructure Deployment Initiative (EVAFIDI) and efficiency retrofit measures in coordination with provinces and territories.

The majority of the first ZEV owners tended to live in single-family dwellings with access to charging infrastructure at home. A study conducted in 2015 indicated that only 8% of "plug-in [EV] pioneer" respondents (i.e., current EV owners) reported living in an apartment compared to 20% of "mainstream" respondents (i.e., non-EV owners). Over time however, EVs have increased in range and decreased in cost, making them a more attractive option for the broader population, including greater numbers of MURB residents.

At least one-third of Canadians live in MURBs, and in some large metropolitan centres (e.g., Vancouver, Montreal and Toronto), apartments are more common than single-family detached homes. High density neighbourhoods in large urban centres may have greater numbers of residents without a garage or dedicated parking space (i.e., garage orphans). For example, Toronto's transportation services division estimates there are around 53,000 motorists relying on street parking in the city.[5]

The ability to charge at home has been shown to be a key driver for mass ZEV adoption. While early adopters or pioneers of the technology may have been willing to accept challenges associated with charging in their buildings or using only public and workplace charging infrastructure, mainstream adopters will require a lower barrier to entry. MURB residents face some of the greatest challenges related to the installation of charging infrastructure due to issues associated with common property. As the ZEV market continues to grow and evolve over time, addressing these challenges will become increasingly critical as they can ultimately deter drivers from purchasing a ZEV.

What are Zero Emission Vehicles?

Vehicles that do not emit exhaust gas during operations are referred to as ZEVs. While ZEVs have no harmful tailpipe emissions, GHGs and other air pollutants may be emitted when generating the electricity or producing the hydrogen required to power the vehicle.[6] ZEVs include battery electric vehicles (BEVs), plug-in hybrid electric vehicles (PHEVs) and hydrogen fuel cell electric vehicles (FCEVs). While each of these vehicle types is described briefly below, this report focuses on BEVs and PHEVs, as these vehicle types currently face challenges specific to charging in MURBs and for garage orphans. BEVs and PHEVs will be referred to collectively as electric vehicles (EVs).

Battery electric vehicles (BEVs): BEVs use electricity stored in a battery pack as chemical energy to power an electric motor that propels the vehicle. The battery is recharged by plugging into an external electrical outlet. BEV batteries can also be charged through regenerative breaking, where the brakes are applied to slow down the vehicle and kinetic energy is converted into chemical energy that is stored in the battery. BEVs are significantly more efficient at converting energy into motion than comparable conventional vehicles. Around 72% – 94% of the energy to power a BEV is used to propel it down the road,[7] compared to 12% – 30% for a gasoline-powered vehicle.[8]

In 2017, commercially available BEVs had a range of between 150 and 540 kilometres.[9] A Toyota Corolla with an internal combustion engine (ICE) by comparison, can travel approximately 640 kilometres before refuelling, which is about 19% further than the longest range for a BEV.[10]

Plug-in hybrid electric vehicles (PHEVs): PHEVs combine an electric motor, a rechargeable battery and an ICE. The battery can be charged by plugging the vehicle into an external power source, through regenerative braking, and by the ICE.[11] Some PHEVs operate exclusively on electricity until the battery is nearly empty, while others use both systems to power the vehicle simultaneously.[12] Because they also use an ICE, PHEVs typically have smaller battery packs than BEVs and, as a result, less range when in fully-electric mode. Commercially available PHEVs in 2016 had an electric range of between 22 and 85 kilometres.[13]

Fuel cell electric vehicles (FCEVs): FCEVs use a fuel cell and hydrogen gas to power an electric motor. The fuel cell converts hydrogen, which is stored in high pressure tanks, into electricity to power an electric motor that propels the vehicle.[14] This process creates two by-products—heat and water, and no harmful tailpipe emissions. Hydrogen can be produced from methane using steam reforming, or from water via electrolysis. FCEVs take between 3 – 5 minutes to refuel[15,16] and have a range of between 480[17] and 800 kilometres.[18]

Benefits of Electric Vehicle Use

EV use has the potential to realize a range of environmental, economic and social benefits. This section provides a brief overview of some of the key benefits associated with EV adoption.

Environmental Benefits

The combustion process that powers a conventional ICE vehicle emits GHGs (e.g., carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O)) and criteria air contaminants (CACs) including particulate matter (PM), volatile organic compounds (VOCs), nitrogen oxides (NOx) and carbon monoxide (CO). When released through the vehicle's tailpipe, these emissions contribute to air pollution and climate change.[19] Replacing a conventional ICE vehicle with an EV can dramatically reduce these tailpipe emissions.

A number of studies, including one recently undertaken by the National Energy Board[20], suggest that significant GHG emissions reductions can be achieved through the use of EVs, (particularly BEVs), by leveraging low-emitting sources of electricity to charge.[21,22] Canada stands to benefit enormously from widespread EV adoption considering that approximately 81% of the nation's electricity comes from non-GHG emitting sources, such as hydropower, nuclear, and renewables (e.g., solar, wind).[23] Greater emissions reductions from EV use can be realized in provinces with less carbon-intensive electricity grids (e.g., Québec, Manitoba, British Columbia (BC), Prince Edward Island, Newfoundland and Labrador, Ontario and Yukon).[24,25] However, even jurisdictions with more carbon-intensive grids have been shown to benefit from net GHG reductions as a result of increased EV use.[26] Opportunities for powering EVs from renewable and distributed generation sources that are less

dependent on a grid's carbon intensity (e.g., solar photovoltaics) are also being explored.[27]

Economic Benefits

The total cost of ownership (TCO) for a vehicle takes into account a range of factors including purchase price, fuel cost, operating and maintenance costs, annual mileage and depreciation.[28] These costs can vary greatly across jurisdictions, and as a result, the TCO for an individual vehicle is dependent on location. A 2015 study estimating the TCO for conventional, hybrid, plug-in hybrid and BEVs in three industrialized nations — the UK, U.S. and Japan — between 1997 and 2015, found that BEVs had a slightly lower TCO than conventional vehicles. The study noted that vehicle subsidies likely played a key role in determining the lower TCO for an EV.[29]

The initial purchase price of an EV is typically higher than for a comparable ICE vehicle. This is due in part to the cost of an EV's battery pack. Over the past several years however, this cost has decreased significantly. In 2010, the average price of a lithium-ion battery pack was approximately $1,000 per kilowatt hour (kWh),[30] while in 2017, this dropped to $209 per kWh.[31] Bloomberg New Energy Finance predicts that the cost will fall below $100 per kWh by 2025, a rate that has the potential to enable cost-parity between EVs and ICE vehicles as early as 2024.[32] Whether this will happen however, remains to be seen as decreasing battery prices to date, have allowed automakers to focus on increasing range by using larger batteries, rather than lowering the cost of the vehicle.[33]

EVs have significantly lower operation and maintenance costs than ICE vehicles. As previously noted, operation costs will vary by jurisdiction, based on local electricity and gasoline prices. While gasoline prices tend to fluctuate over time, the cost of electricity is more stable.[34] Plug'n Drive suggests that the average EV driver in Canada, travelling 20,000 kilometres per year, can save as much as $2,000 on fuel over the course of a year.[35] EVs also have fewer moving parts and fluids (e.g., oil and transmission fluid) [36] to change than ICE vehicles, which can contribute to savings of hundreds of dollars per year on maintenance.[37]

Depreciation is one of the greatest cost components of vehicle ownership. The first generation of EV models have some of the lowest residual values in the marketplace as their value falls much faster than that of a conventional ICE vehicle.[38] This has been attributed to low demand and the perception that the technology is still unproven.[39] In recent years, depreciation has slowed somewhat and for some models, the value of a used EV can be greater than that of an equivalent gasoline-powered vehicle (e.g., Tesla and Porsche).[40] The high depreciation rate for most EVs however, contributes to used models being a viable option for those who may be unable to afford a new vehicle.[41]

EV deployment also promises economic benefits for industry and automakers including increased revenues from the sale of new products and the potential for new export opportunities in a rapidly growing sector. Developing a market for EVs can help local economies create jobs, attract new businesses and foster cleantech innovation and development. Support for EV deployment may also be a means for automakers to comply with increasingly stringent environmental requirements and regulations.

Social Benefits

EVs do not directly emit any of the air pollutants that contribute to poor air quality, smog formation and associated negative impacts on human health, such as eye, nose or throat irritation, decreased lung function, respiratory effects or cardiac disease.[42] EV use shifts emissions from a vehicle's tailpipe to the power plant, which is typically located far from dense population centres and which is better equipped to control air pollutants than an individual vehicle.[43]

Road traffic has been identified as one of the primary sources of environmental noise pollution. EVs are much quieter than their gasoline-powered counterparts as they do not produce conventional engine noise. Excessive and prolonged exposure to noise has been linked to a range of serious health issues, such as stress, high blood pressure, productivity losses, sleep disturbances, annoyance, cardiovascular disease and cognitive impairment.[44] A recent brain monitoring study commissioned by the London EV Company and led by the University of York in the UK, found that the quieter driving environment of an EV can also have significant mental health benefits. The study examined the link between the acoustic environment and the mood and biophysiological

response of taxi drivers in both a new electric, and a diesel taxi. Participating drivers were found to be more focused, less stressed and happier in the electric taxis than in the diesel models.[45]

Benefits of Electric Vehicle Charging in Buildings

The following are some of the benefits that can be realized by building owners and property managers by installing EV charging stations:[46]

- **Tenant retention or attraction.** Charging stations enable alternative commuting options within cities, thereby attracting and retaining tenants who drive EVs. In addition, building owners and property managers can leverage their environmental choices to positively influence brand perception and appeal, and differentiate themselves in a competitive market.
- **Alternative revenue streams.** Building owners and property managers can tap into alternative revenue streams from advertising products or services on charging stations.
- **Credits or points towards building certification programs.** Installation of charging stations would qualify new and existing buildings for additional credits or points from building environmental performance assessment or certification programs, such as LEED or BOMA BEST. Obtaining such certifications have been shown to help boost a company's image and the desirability of a building.
- **EV charging as an amenity.** When viewed as an amenity, EV charging can augment the overall reputation of the building and parking complex. Similar to when a building provides upgraded exercise or leisure options for residents who value these amenities, EV charging may attract a more environmentally conscious clientele.
- **Convenience.** The ability to charge at home is important to EV owners and they may be willing to pay more to live in a building that provides this convenience.

Electric Vehicle Sales

Number of Electric Vehicles in Canada

Table 2 shows that in 2018, there were approximately 91,693 EVs on the road in Canada. These totals are based on new vehicle sales as reported by the following sources:

1. Inventory of EVs sold in Canada by Matthew Klippenstein
2. Quarterly and annual reports developed by FleetCarma

These sources rely on Statistics Canada's new motor vehicle sales database[47] and IHS Markit — a market research firm — registration data. Differences in data are attributed in part to whether or not limited run and discounted vehicle sales have been accounted for. Data for 2018 found in Table 2 is directly from IHS Markit Catalyst for Insight, as the two data sources used for the previous years were no longer available.

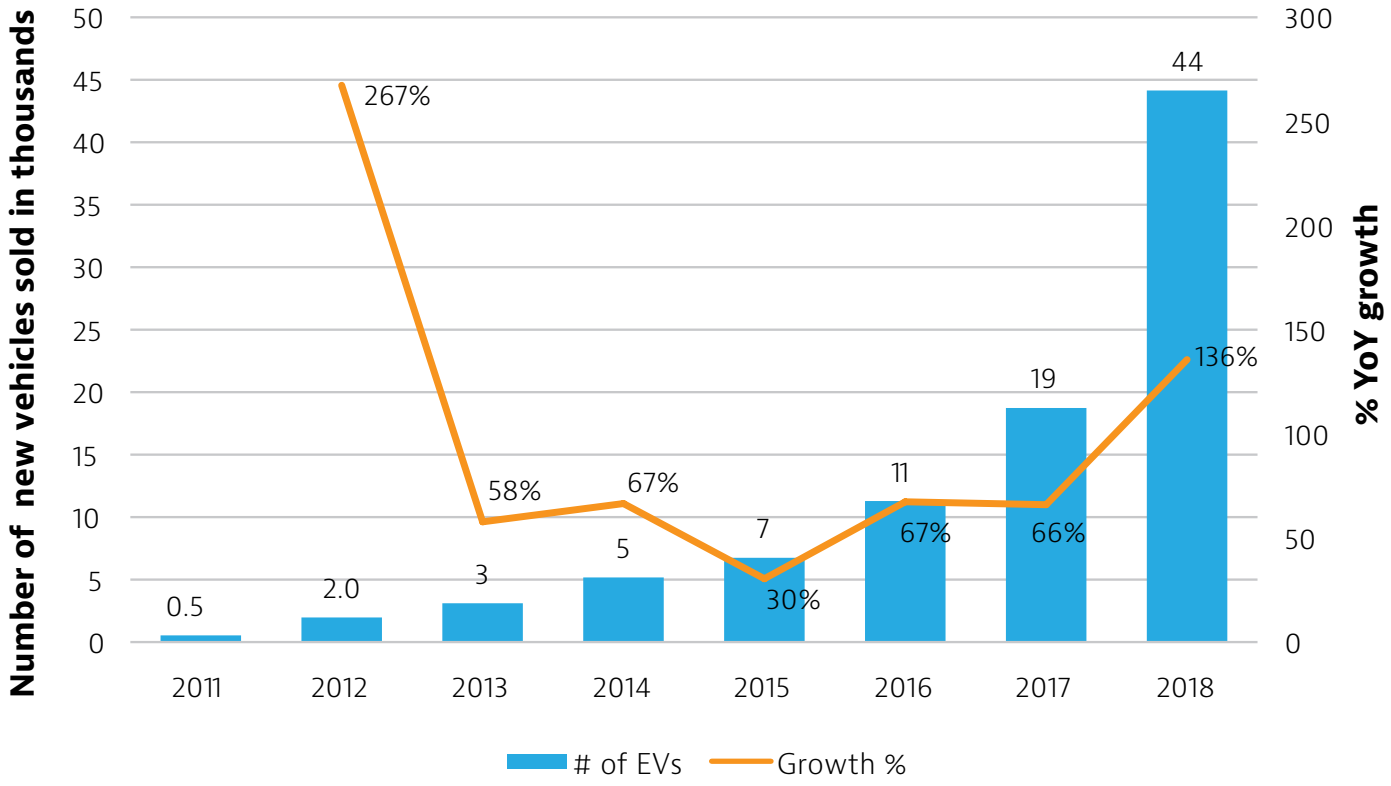
Table 2: Number of Electric Vehicles Sold in Canada

Data Source	2011	2012	2013	2014	2015	2016	2017	2018[ii]	Total
1[48]	536	1,969	3,106	5,172	6,745	11,288	18,734	44,143	91,693
2[49]			3,254	5,356	7,072	11,023	19,236	44,143	90,084

Figure 2 shows the number of EVs sold in Canada between 2011 and 2018, as well as year-over-year (YoY) growth for that timeframe. In 2017, over 2 million light-duty vehicles were sold in Canada,[50] 18,734 of which were EVs (0.9% of the total market).[51] As of December 2018, more than 44,000 ZEVs (2.2% of the total market) were sold, representing a 136% increase over 2017 sales. This figure clearly illustrates the rapid increase in the number of EVs on the road in Canada, despite real and perceived barriers faced by drivers.

[ii] IHS Markit Catalyst for Insight data as of December 31, 2018. Data sources used for previous years were no longer available.

Figure 2: Number of Electric Vehicles Sold in Canada from 2011 to 2018 and % Year-over-Year Growth



Projected Electric Vehicles Sales in Canada

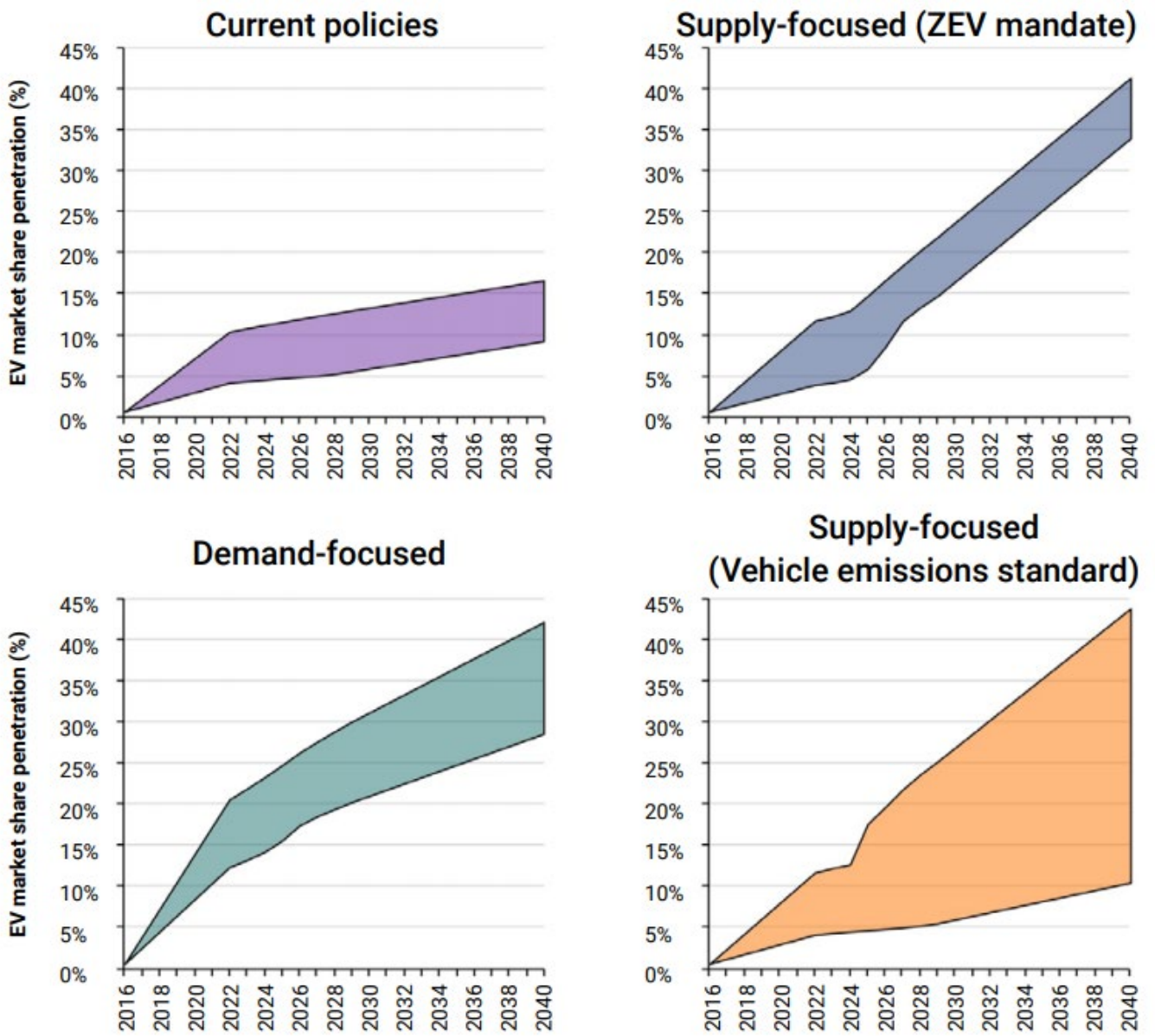
Global EV sales are expected to increase with improvements in battery technology, availability of new makes and models from manufacturers and the development of supportive policy.[52] Bloomberg predicts that the demand for EVs will increase from 1.1 million in 2017, to 11 million in 2025 and 30 million in 2030. It is predicted that by 2040, 55% of all new car sales and 33% of the global fleet will be electric.[53]

To improve understanding of EV forecasts, the Sustainable Transportation Action Research Team (START) at Simon Fraser University (SFU) developed the Canadian REspondent-based Preference and Constraint (REPAC) model which simulated new market share based on EV supply, demand and relevant policy.[54] Four policy scenarios were considered to estimate EV market share penetration out to 2040:

1. **Current policy:** No change to current policies.
2. **Demand-focused policy:** A $6,000 purchase incentive per EV for 20 years.
3. **Supply-focused policy (EV mandate):** EV sales target of 40% by 2040 + $6,000 purchase incentive per EV for 2 years.
4. **Supply-focused policy (vehicle emission standard):** A national vehicle emission standard of 71g CO_2e by 2040 (combined average for light-duty trucks and cars) + $6,000 purchase incentive per EV for 2 years.

Figure 3 shows that EV market share would increase gradually over time under the current policy scenario. Results from the other three scenarios were modelled to reach the 40% EV sales target by 2040 (upper band) with the likelihood of achieving this target differing between scenarios (lower band). The START study found that a 40% market share outcome is most certain using the supply-focused approach that relies on an EV mandate. This is because the EV mandate prescribes that EVs account for a specific share of vehicle sales whereas the other scenarios rely on consumer response (demand-focused scenario) or automaker strategies (supply-focused relying on vehicle emissions standards), such as selling a mix of ICE, hybrid and EVs, to meet the fleet average emissions standard.

Figure 3: Predicted Electric Vehicle Market Share in Canada based on Four Different Policy Scenarios [55]



Electric Vehicle Charging

Electric vehicle supply equipment (EVSE), commonly known as an EV charger, is the intermediary equipment between a power source and the vehicle's charging port.[56] The term EVSE refers to the cables, connectors and other devices that function to safely transfer power and enable the exchange of information between the electric circuit and the vehicle.[57]

Charging levels determine the rate at which electrical energy is drawn when an EV battery is being charged. The three main charging levels for EVs are Level 1, Level 2, and Level 3 or direct current fast charging (also known as DCFC or DC fast charging).

Level 1 Charging: This type of charging involves a standard electrical outlet, a 120 volt (V) alternating current (AC), and a standard 3-prong household plug.[58] This is the slowest type of charging and generally takes between 8 - 30 hours to fully recharge an EV battery, making it most suitable for locations where a vehicle will be parked for long periods of time (e.g., home or work).[59] A study prepared for the City of Richmond, BC, estimated that installation costs[iii] for a dedicated Level 1 charger range from $126 per parking

[iii] Cost estimate assumes 100% of parking stalls are EV ready (i.e., energized outlets).

stall in a townhouse, to between $847 and $881 in a mid-rise building, and $1,443 per parking stall in a high-rise building.[60]

Level 2 Charging: This type of charging requires the use of a 240V, AC plug. Depending on the vehicle's battery size, it can take between 4 - 10 hours to fully recharge the battery.[61] Level 2 charging stations are practical for charging at home, the workplace and in public locations, such as restaurants, parks or parking lots and can also be programmed to charge during off-peak periods. The City of Richmond study estimated that the installation costs of a dedicated Level 2 charger range from $2,655 per parking stall in a townhouse, to between $2,314 and $2,448 in a mid-rise building, and $3,023 per parking stall in a high-rise building.[iv] The estimate for retrofits was between $4,000 and $8,000. These costs, however, were found to be significantly lower when load-sharing systems were installed.[v]

Direct Current Fast Charging (DCFC): This type of charging is also known as a quick charge and power is supplied through a 480V, direct current plug. DCFC stations can charge a BEV to 80% in 25 - 30 minutes.[62] The use of a DCFC station is best suited to driving applications where recharging in a short period of time is necessary, such as along major highways. Most EVs today can charge at up to 50 kW; however, new EVs are entering the market with the ability to charge at greater rates. DCFC solutions are being developed to support ultra-fast charging at up to 350 kW or more.[63] There is no single standard for DCFC stations. Tesla has its own Supercharger network, while other EV models use either the CHAdeMO or the Combined Charging System (CCS). The purchase, installation and labour costs associated with DCFC stations are influenced by a number of factors but in general, are estimated to range from approximately $50,000 – $120,000.[64,65,66] Specific purchase costs vary by manufacturer and charger specifications, while installation costs are dependent on the availability of a suitable three-phase power supply, the amount of civil work required on site, aesthetic considerations, the time of year when installation occurs and the company managing the project.[67]

Electric vehicle energy management systems (EVEMS) refer to a variety of technologies that enable multiple EVs to charge on the same circuit. Also known as "load sharing", "power sharing", or "smart charging", one circuit can supply power to multiple vehicles by controlling the rate and timing of the charge. The use of EVEMS reduces the need for additional infrastructure and electrical supply to power multiple EVSE. In addition, EVEMS can be valuable for shared parking situations, including in MURBs, because they allow for the tracking of electricity usage and billing by individual users.[68]

Electric Vehicle Charging Station Distribution

As of March 2019, there were 4,236 public Level 2 and DCFC stations across Canada with 8,736 charging outlets.[69] Charging stations may have more than one charging outlet however, it should be noted that fast charging stations can only be used to charge one vehicle at a time, even when the station has different types of connectors.[70]

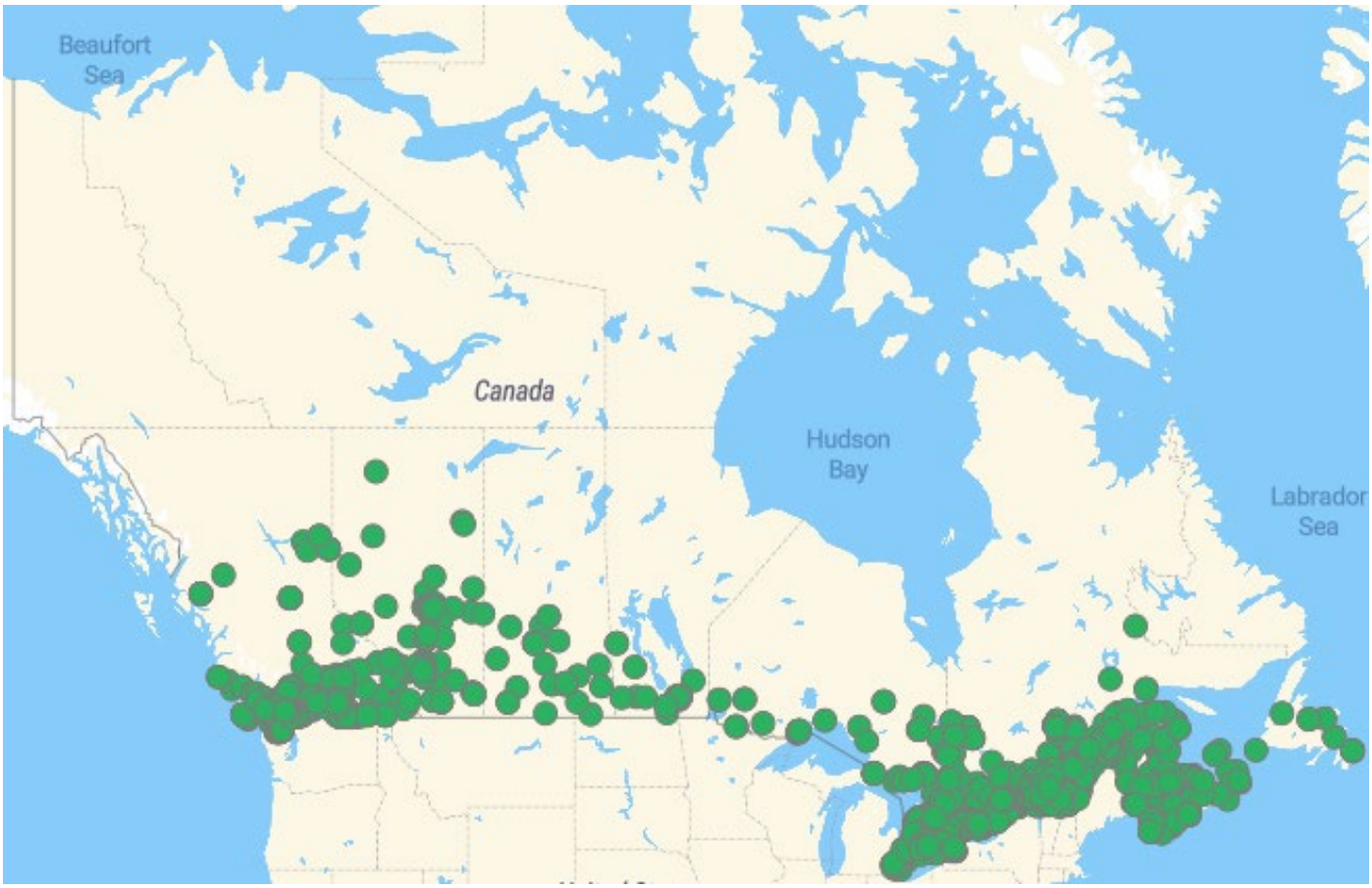
Table 3 provides a breakdown of the geographic distribution of Level 2 and DCFC stations across Canada by province and territory. Figure 4 depicts the location of these charging stations.

Table 3: Distribution of Public Electric Vehicle Charging Stations across Canada

Region	# Charging Stations	# Charging Outlets	Charger Type (stations/outlets)	
			# Level 2	# DCFC
Canada	4,663	9,342	4,079/8,448	554/894
AB	185	333	171/298	14/35
BC	869	1,776	765/1,568	104/208
MB	43	62	39/57	4/5
NB	107	164	107/138	26/26
NL	11	14	11/14	
NS	83	118	69/104	14/14
NT	0	0		
ON	1,257	2,913	1,050/2,565	207/348
PE	25	35	25/35	
QC	1,992	3,864	1,807/3,606	185/258
SK	35	63	35/63	
YT	0	0		
NU	0	0		

[iv] Cost estimate assumes 100% of parking stalls are EV ready (i.e., energized outlets).
[v] Depends on the type: 4-way load shared and load managed or 18-way load shared, 80A.

Figure 4: Map of Electric Vehicle Charging Stations in Canada[71]



What are Multi-Unit Residential Buildings and Garage Orphans?

Multi-unit residential building (MURB): MURBs are buildings with a common entrance and separate units. The Canadian Census uses this term to describe owned or rented apartments and condominiums constructed for dwelling purposes. MURBs must have one primary exterior door for access, with each of the apartments connected by an interior door.[72] This definition does not apply to hotels, residence halls or dormitories, senior care communities, single-family homes or other types of lodging or residential facilities.

Categories for MURBs include:

- **Low-rise (two to three floors):** The building must have a minimum of two floors located above ground and four apartment (dwelling) units.
- **Mid-rise (four to nine floors)**
- **High-rise (10 + floors)**

In this report, MURBs are further differentiated as new MURBs and existing MURBs. New MURBs are those that are being planned (i.e., yet to be built) or that are in the early stages of being built. Existing MURBs are those that have already been built or that are nearing completion (i.e., no further changes to the building's design or infrastructure are possible).

Garage orphan: A garage orphan is a vehicle owner that does not have access to a garage or driveway in a single-family home. The term also applies to those EV owners without full ownership of a private parking spot and the necessary space to install charging-related electrical infrastructure in a MURB.[73]

Geographic Distribution of Multi-Unit Residential Buildings and Garage Orphans

The 2016 Canadian Census classifies private dwellings according to the following structure types:

1. Single-detached house
2. Semi-detached house
3. Row house
4. Apartment (owned or rented apartment or condo) or flat in a duplex

5. Apartment in a building with fewer than five storeys (MURB$_-$)
6. Apartment in a building with five or more storeys (MURB$_+$)
7. Other single-attached house
8. Movable dwelling

Table 4 shows the distribution of private dwellings by structure type nationally and for each province and territory. It shows that in Canada, the majority (53.6%) of private dwellings are single-detached houses. This is also the case for each individual province and territory. Québec, Ontario and BC have the greatest number of residents living in MURBs while Newfoundland has the least.

Table 4: Percentage of Private Dwellings by Structure Type in Canada[74]

Region	Private Dwellings by Structure Type							
	Single-detached	MURB ≥ 5 stories	MURB < 5 stories	Row house	Semi-detached	Duplex	Other	Movable dwelling
Canada	53.6	9.9	18	6.3	5	5.6	0.3	1.3
NL	73.3	0.3	5.3	4.8	3.9	11.5	0.2	0.7
PE	69.2	0.1	15.2	3.7	5.6	1.7	0.2	4.3
NS	65.5	5.3	14.5	2.5	5.1	3.1	0.2	3.7
NB	69.3	1.2	13.8	2.8	3.9	4.2	0.4	4.3
QC	45.4	5.3	32.7	2.6	5.3	7.5	0.5	0.7
ON	54.3	17.2	10.1	8.9	5.6	3.4	0.2	0.3
MB	67.8	8	13.7	3.5	3.2	1.4	0.2	2.1
SK	72.7	2.4	13.2	4.3	2.9	2.2	0.2	2.2
AB	61.9	4.1	14.6	7.6	5.7	2.8	0.1	3.1
BC	44.1	9.4	20.5	7.9	3	12.2	0.2	2.6
YK	61.9	0.3	11.6	6.2	7.6	4	0.5	7.8
NT	57.6	3	15.9	10.6	6.5	2.6	0.4	3.4
NU	44.3	1.1	13.3	30.1	9	1.8	0.2	0.2

Appendix A provides additional information on dwelling types and their age, distribution (e.g., rural vs. urban) and turnover rates.

Regulatory Landscape for Charging in Multi-Unit Residential Buildings and for Garage Orphans

There are a number of regulatory instruments used by governments, industry and other organizations to address EV charging in MURBs or for garage orphans. This section provides a brief introduction to some of the codes, standards, acts and bylaws that are discussed within this report. Further detail about regulatory and policy-related barriers and solutions is found in Section Two.

Codes and Standards

National Building Code of Canada

In Canada, provinces and territories have jurisdiction to enact and enforce their own building laws and codes. The National Building Code of Canada (National Building Code) is provided as a model to Canada's provinces and territories, but adoption is not mandatory. The National Building Code is one of three key national model codes relevant to the installation of EV charging stations in Canadian MURBs.[75,76] The Canadian Commission on Building and Fire Codes (CCBFC) is an independent, volunteer committee established by the National Research Council of Canada (NRC) to develop and oversee updates to the National Building Code, along with four other national codes (see also National Energy Code of Canada for Buildings).

The National Building Code addresses issues including the health, safety, accessibility, and protection of buildings from fire and structural damage and applies to the construction of new buildings or the demolition of existing ones. It is also intended to be applied to buildings that have been substantially renovated.[77] During consultations for this report, numerous stakeholders pointed out that the scope of the National Building Code can be expanded to include matters related to the environment and energy efficiency, particularly given the contribution of buildings to Canada's GHG emissions. Similar expansions have already taken place elsewhere in Canada (such as Ontario) and internationally, including in California and Oregon.

Many provinces and territories use portions of the National Building Code in the development of their own building codes or, in the case of Saskatchewan, adopt it in its entirety (in a previous version).[vi] A number of Canadian cities (e.g., Toronto and Vancouver) have been provided with jurisdiction over some or most aspects related to building, based on a special relationship with their respective provinces. Some provinces (e.g., Ontario, excluding Toronto), favour a high degree of provincial consistency within their building codes,[78] providing for limited exceptions related to regional safety. In the case of Ontario, the province has already added EV charging requirements in the provincial building code intended to apply to the whole province (for non-multi-unit residential and commercial buildings). Other provinces have provided more latitude for municipalities to address matters related to building, and in particular, EV charging. For example, in the case of BC, the provincial government provided municipalities with the ability to regulate EV charging standards outside of BC's *Building Act*.[79]

Canadian Electrical Code

The Canadian Electrical Code (CE Code), published by the Canadian Standards Association, is another key national model code relevant to the installation of charging infrastructure in MURBs. The CE Code covers installation and maintenance of electrical equipment and seeks to ensure installers and consumers are kept safe from harm. The code is updated every three years to reflect the latest advances in technology and their safe implementation.[80] As with the National Building Code, the CE Code may be adopted by provinces and territories in whole or in part and modifications can be made to meet the needs of different jurisdictions.

Section 86 of the CE Code outlines requirements for installation of EVSE. Until recently, the code required that EVSE be supplied by a separate branch circuit which would support no additional loads (with the exception of ventilation equipment) and that for the purposes of load calculation, EV charging must be considered a continuous load (i.e., vehicle is charging at 100% continuously). In 2018, the CE Code was updated to permit load management and as a result, EVSE equipment may now be installed on a branch circuit that supplies other loads, provided that an EVEMS is also installed, in accordance with the code.[81]

National Energy Code of Canada for Buildings

The National Energy Code of Canada for Buildings (NECB) is a national model code that sets out technical requirements for the energy efficient design and construction of new buildings and substantial renovations to existing buildings. The NECB was designed to complement the other national building codes and it can be adopted by provincial and territorial, as well as some municipal, governments in its entirety or with modifications to suit local needs. It can also be used as a guideline for construction of new and energy-efficient buildings.[82]

The NECB establishes requirements for monitoring the energy usage of electrical distribution systems, sets limits on the size of conductors to minimize voltage drops, and establishes standards to govern the selection of transformers and electrical motors.[83]

[vi] For example, Subsection 31(1) states that Ontario's *Building Code Act, 1992* (OBCA) supersedes all municipal bylaws respecting the construction or demolition of buildings.

Because of its coverage of energy elements, the NECB has been discussed as an alternative location for EV charging requirements for MURBs. Some restrictions have been noted however, including the fact that the NECB is not yet broadly adopted by Canadian provinces.

Condominium and Strata Acts

The regulation of condominiums and stratas falls within provincial jurisdiction. Provincial condominium or strata acts create condominium or strata corporations and govern the interactions between condominium or strata owners and their condo board or strata councils. With regards to the installation of charging infrastructure, these acts set out the process that must be followed in order to run electrical cabling from a building's electrical rooms or sub-panels to parking spaces, and other modifications required during installation. This is done via their jurisdiction of changes to what are often referred to as "common elements" (i.e., property owned on behalf of all condominium or strata owners).

Zoning and Parking Bylaws

The purpose of zoning bylaws is to set out rules to govern land use and to regulate how a property may be used for building and other purposes. This typically includes elements such as building size, placement, dimensions such as height, and requirements for amenities such as parking.[84] Parking bylaws are often used to regulate on- and off-street parking, including the number of parking spaces required for different land uses. Changes to parking can also be advanced through amendments to the parking sections of local government zoning bylaws.[85] These bylaws tend to be passed at the municipal level, although they may be directly or indirectly impacted by provincial legislation, such as planning legislation. In some cases, zoning and parking bylaws may be a source of authority relating to EVSE installation requirements, although this depends on whether this area is subject to provincial building code authority. Stakeholders noted that, in many cases, municipal zoning and parking bylaws are subject to negotiation during development processes, meaning that they may not create consistent obligations depending on individual development negotiations.

Public Utilities Acts

Provincial public utility legislation broadly governs the provision of electricity and other regulated "monopoly" services (such as natural gas distribution) to the public. With few exceptions, these acts limit the ability of entities, other than regulated public utilities, to sell electricity. Ontario Energy Board staff argued that selling EV charging services is distinguishable from the act of electricity retailing, and therefore does not trigger equivalent regulatory governance from the Ontario Energy Board.[86] Most Canadian provincial utilities commissions (other than BC's[87]) have not found that provision of EV charging services constitutes the sale of electricity; however most have also not yet considered the issue as part of a formal proceeding. Even in BC, the BCUC provided a clear suggestion to the provincial government that it consider some form of ministerial action to ensure that entities providing EV charging services are not subject to full regulation as public utilities, recognizing the many differences between providing EV charging services and the role of a traditional public utility. Stakeholders are anticipating a response from the BC government on this point. Therefore, while it could create barriers to cost recovery if other provinces follow the BCUC's decision without some form of exemption or exclusion from applicable utility legislation, most stakeholders hope that this will not create a major barrier across Canada going forward.

Federal Measurement Statutes

In many cases when EVSE are installed in MURBs, they do not have a dedicated utility meter, meaning that a condo corporation or strata council needs to individually bill electricity to EVSE users to ensure fair recovery of costs of electricity consumed in EV charging. While most new networked EVSE are designed with measurement systems to record the amount of energy dispensed, they must be approved by Measurement Canada — the federal body with jurisdiction over ensuring accuracy in the selling of measured goods — if they are being used to sell electricity on the basis of energy (such as electricity).[88] In situations where meters are not Measurement Canada approved, EV owners may be charged a flat rate, a time-based rate, or a blended rate (e.g., billed for parking and time) to charge their vehicle.[89]

Residential Tenancy Acts

Provincial landlord tenant laws govern the relationship between landlords and tenants and set out the obligations of landlords, including for apartments. Until EV use becomes more common, landlords may be hesitant to install EV charging infrastructure and typically, residential tenancy acts do not address EV charging, despite the fact that tenants may wish to install chargers. Under the BCUC's governing legislation, landlords are permitted to resell electricity to their tenants, but only if their tenancy is within certain time limits (e.g., less than five years) and it is not resold to others.[90] Because in most other provinces EV charging has not been found to be retailing electricity, this has not been a major issue outside of BC.

Charging-Related Initiatives for Multi-Unit Residential Buildings and Garage Orphans

Federal Initiatives

The Government of Canada has committed to undertaking a number of initiatives that encourage or support the installation of EV charging infrastructure in MURBs and for garage orphans. Expanding the number of ZEVs on the roads has been identified by the federal government as a key strategy to advance low-carbon transportation systems in Canada. In early 2019, new ZEV sales targets were announced for 10% of vehicle sales by 2025, 30% by 2030 and 100% by 2040.

The federal government's Budget 2019 committed $130 million over five years to NRCan to deploy new ZEV infrastructure (e.g. Level 2 chargers) in workplaces, public parking spots, commercial buildings, MURBs and remote locations.[91] NRCan will seek to deploy up to 20,000 Level 2 chargers however, program details are still being finalized. Budget 2019 also provided $300 million over three years to Transport Canada (TC) for a federal purchase incentive of up to $5,000 for ZEVs that cost $45,000 or less, and $5 million over five years for TC to work with auto manufacturers to secure voluntary ZEV sales targets. In addition, the budget also committed to an accelerated capital cost allowance for light-, medium- and heavy-duty ZEVs purchased by businesses, including electric battery, plug-in hybrid (with a battery capacity of at least 15 kWh) or hydrogen fuel cell vehicles for the years in use.[92] While Budget 2019 did not propose specific measures to address consumer awareness, a key barrier to ZEV adoption, NRCan will continue to provide Canadians with information and tools to assist in their vehicle purchasing decisions.

Infrastructure and Grid Readiness Working Group

NRCan's Infrastructure and Grid Readiness Working Group (IGRWG) explores and informs infrastructure and grid readiness efforts and was convened to help support the federal government's commitment to increasing the number of ZEVs on the road. The IGRWG discusses barriers and opportunities related to ZEV charging in MURBs and for garage orphans, shares information on solutions and best practices, and facilitates the development of materials and products to advance the implementation of solutions.

Codes and Standards Working Group

The federal government's Alternate Fuels Technical Advisory Committee includes representatives from key sectors including EVs/EVSE, propane, hydrogen and natural gas (manufacturers and service providers). The committee's mandate is to identify gaps and issues related to industry codes and standards that create barriers to greater adoption of low emissions vehicles (LEV) in Canada. In addition, the working group helps to identify challenges and opportunities for federal and provincial government support for local authorities in the implementation of codes and standards related to LEV charging. The participation and collaboration of the authorities that have jurisdiction over alternative fuel vehicle regulations at the provincial and federal levels, standards development organizations and alternative fuel vehicles industry associations are important to the success of the committee.

Demonstrations and Pilot Projects

The federal government has provided support for a number of demonstration and pilot projects that aim to address barriers to the adoption of EV charging infrastructure in MURBs and for garage orphans. The Energy Innovation Program (EIP) received $46.1 million in funding over two years through Budget 2016 to support demonstration projects that advance next generation ZEV infrastructure technologies.[93] Under the Electric Vehicle Infrastructure Demonstration component of the program, NRCan contributed $6.7 million to a project that involves the installation and

demonstration of curbside charging infrastructure in cities across Canada. FLO, a subsidiary of AddÉnergie Technologies, will install 100 new urban charging stations in municipalities including London, Kitchener, Waterloo, Cambridge, Edmonton, Vancouver, and Surrey. The project aims to increase access to EV charging for those living in urban areas with on-street parking. Installations have been completed in Vancouver and the remaining stations will be installed in 2019.

In addition, NRCan provided funding for a pilot project led by FleetCarma. The project seeks to improve the operation and deployment of charging infrastructure for EVs by demonstrating charging based on real-world, vehicle-side data. The data obtained will provide utilities and governments with a better understanding of how EVs are driven and charged in Canada. It will also support the strategic deployment of new charging stations and help to identify potential grid upgrades. In addition, the project will test a charge reimbursement system for MURBs that is less onerous, lower cost and which will provide more value to EV drivers and building owners than installing sub-meters.[94]

Clean Fuel Standard

The Government of Canada is developing a Clean Fuel Standard (CFS) that will aim to reduce GHG emissions by 30 million tonnes annually by 2030 through the increased use of lower carbon fuels, energy sources and technologies. This will be achieved by setting lifecycle carbon intensity reduction requirements for liquid, gaseous and solid fossil fuels. Fossil fuel primary suppliers who are subject to the regulations will generate CO_2e exceedances annually based on the amount (expressed in megajoule (MJ) of energy) of each fossil fuel they produce and import for use in Canada. The sum of the CO_2e exceedances from each fuel will form their annual carbon intensity compliance obligation. Each CO_2e exceedance will represent one tonne of carbon dioxide equivalent (t CO_2e). At the end of each compliance period, each fossil fuel primary supplier will need to cancel their carbon intensity compliance obligation for that year with an equal number of credits. Each CFS credit will represent one tonne of avoided carbon dioxide equivalent (t CO_2e).

Credits can be generated through a number of flexible, performance-based compliance pathways, including actions throughout the lifecycle that reduce the carbon intensity of the fossil fuel (e.g., process improvements in refineries, upgraders and oil sands), supplying low-carbon fuels (e.g., producing ethanol for use in Canada) or some types of end-use fuel switching (e.g., electricity used by vehicles as a substitute to gasoline or diesel). Credits may be generated by fossil fuel primary suppliers or by the voluntary credit generators that undertake these actions. These voluntary credit generators are parties other than fossil fuel primary suppliers (i.e., no obligation to reduce carbon intensity) that choose to generate credits under the CFS. For example, distribution utilities will generate credits for EV charging at home, while EV charging network operators will generate credits for EV public charging and site hosts will generate credits for the private or commercial charging of EVs.

In the CFS regulatory design paper published in December 2018, ECCC noted that it is considering whether the standard should allow actors other than distribution utilities, site hosts and network operators, to generate credits. The consultations on the CFS are currently ongoing, with draft regulations for the liquid fuel stream planned for publication in the Canada Gazette, Part I in spring/summer of 2019.

Other Initiatives

The federal government has commissioned a study that will examine different approaches to encouraging the installation of EVSE in buildings by leveraging existing legislative and other instruments within federal jurisdiction. The study will include a review of regulatory instruments in Canada, the U.S. and other jurisdictions, including the National Building Code and NECB, among others. The study will explore how these codes can be used to mandate the installation of EVSE in parking lots and enable EV charging in MURBs, and will help to inform the federal government's actions moving forward.

NRCan has also signed a contribution agreement with CSA Group to develop or update standards related to EV infrastructure, natural gas vehicles and devices, hydrogen vehicle systems and infrastructure, and propane autogas. The agreement supports the CSA Group's work at the bi-national and international level

to harmonize relevant standards. Other ongoing and planned initiatives include the submission of a Change Code Request to be included in the 2020 edition of the NECB related to EV infrastructure and the development of an Installation Guide for EVSEs.

Provincial and Territorial Initiatives

The provincial and territorial landscape for EV charging in MURBs and for garage orphans varies significantly across Canada. Several jurisdictions have begun to directly address barriers by updating relevant legislation, providing financial incentives for charging infrastructure, developing educational resources and supporting infrastructure installations, pilot projects and demonstrations. A number of others have identified EV charging in MURBs and for garage orphans as an important consideration in provincial strategies or action plans but have yet to implement specific measures and actions. Some provinces have also implemented initiatives that indirectly support the installation of EV charging infrastructure in MURBs and for garage orphans.

The following are some of the current provincial and territorial actions and initiatives related to EV charging in MURBs and for garage orphans.

Province of Ontario

In its 2016 Climate Action Plan, the Government of Ontario set a province-wide electric and hydrogen passenger vehicle sales target of 5% by 2020. To help achieve this target, the government announced a number of programs that aimed to reduce barriers and increase adoption of ZEVs across the province, including those specific to MURBs. Proposed initiatives included an extension of the rebate program for the purchase and installation of home charging stations (up to $1,000 per station) to 2020, a four-year, free overnight EV charging program for residential customers, investment in the installation of charging stations in MURBs and workplaces and requirements for the installation of charging stations in existing condominiums and apartment buildings.[95] The free overnight EV charging program and support program for the installation of chargers in MURBs were not implemented. The rebate programs for the purchase and installation of home charging stations (Electric Vehicle Charging Incentive Program) and for workplace chargers (Workplace Electric Vehicle Charging Incentive Program) were both cancelled by the provincial government in 2018.

Changes to the Condominium Act

Changes to *Ontario Regulation 48/01* under the *Condominium Act, 1998*, related to EVs came into effect on May 1, 2018. The changes streamlined the requirements that need to be met by condominium owners and corporations to install EV charging infrastructure and prevent condo boards from rejecting an owner's application if specific requirements are met. Under the new regulations, corporations are able to install an EV charging station on 60-day notice to owners if the following conditions are met: (1) the cost of installation is not greater than 10% of the annual budgeted common expenses, and (2) in the reasonable opinion of the board, owners would not regard the installation as causing a material reduction or elimination of the use or enjoyment of units or of common elements or assets of the corporation. In addition, no vote by owners is required.[96]

In a situation where an EV owner wishes to install a charging station, they are required to submit an application and their condo board must respond in writing within the specified timeframe with its decision. The board may reject an application where a professional has indicated that the proposed installation would be contrary to relevant legislation, would adversely affect the structural integrity of the property, or would pose a health and safety risk to the individuals or the property. Under the revised regulation, condo boards may request that an EV owner make changes to their proposed installation or that the installation be carried out in an alternate location.[97]

Changes to the Building Code

In 2017, the Ontario Ministry of Municipal Affairs consulted on changes to the Ontario Building Code related to requiring EV charging infrastructure installation for apartment buildings, where parking is provided inside the building.[98] While EVSE is not currently required in new MURBs, the province introduced a number of building code requirements for EVSE installation in commercial buildings which could benefit MURB residents and EV owners without a garage or driveway, by providing alternative charging options.

Province of BC

BC has well-established financial and non-financial incentive and support programs for EVs, including a number that specifically address barriers to EV charging in MURBs. The provincially funded Charging Solutions and Incentives Program is administered by Plug In BC, an initiative of the Fraser Basin Council.[99] The program provides online resources related to EV charging, including information on relevant incentives, policies and charging solutions, and a list of local EVSE suppliers and public charging locations. Educational resources are geared towards a range of audiences, including MURB residents and strata councils (see pluginbc.ca). In addition, the program offers onsite presentation and education programming on charging station installation processes and guidelines for strata councils and MURB residents, and provides an initial consultation with an expert to help assess site specific charging options.

The Charging Solutions and Incentives Program also offers financial incentives for MURB charging infrastructure and installation to cover up to 75% of eligible costs for a Level 2 station (up to $4,000 per station).[100] Eligible charging stations can be networked or installed with a revenue grade meter on a circuit that includes the charger. Eligible costs include the purchase of the charging station and revenue-grade electricity meter, labour, construction, electrical and other permit costs, parking and electrical design related costs to accommodate charging infrastructure and EV parking signage.[101] A maximum of two stations per building are eligible for funding and the program is currently waitlisted as interest exceeded the initial funding availability.

While the program does not require a design that enables available capacity to be considered for future use by all parking stalls, it does specify that oversized conduit be installed and meet certain requirements, including that it must:

- Allow for wiring of a total of six Level 2 chargers (rated at 40A each) or the total number of parking stalls (whichever comes first)
- Run to provide future service to all parking stalls or 30 metres into the parking area (whichever comes first)
- Enable the installation of junction boxes at intervals for future runoffs

The Province of BC offers a number of other incentives that indirectly benefit MURB residents and garage orphans including workplace charging incentive under the Charging Solutions and Incentives program and a point-of-sale incentive for EVs under the Clean Energy Vehicle (CEV) Program. The BC SCRAP-IT Program is a voluntary early vehicle retirement program that offers financial incentives to recycle older ICE vehicles. Led by a not-for-profit organization, the program provides $6,000 towards the purchase of a new EV, or $3,000 for a used one.[102] BC SCRAP-IT has also partnered with Foreseeson Technologies and ChargePoint on the ZAPBC program which offers an incentive of $1,100 to BC residents in designated service areas to put towards the purchase and installation of a charging station.[103]

In 2016, the provincial government clarified that EVSE requirements, including the number, location and type of charging stations in a building, as well as wiring for EVs, are "out of scope" of the B.C. *Building Act*.[104] The Act has therefore allowed municipal governments to implement policies related to the use of EV charging in new developments within their jurisdictions.

Province of Québec

The Province of Québec has implemented a range of initiatives and programs that support the electrification of transportation, including an EV mandate, purchase or lease rebates, a used vehicle pilot project rebate, charging station rebate and the implementation of the Electric Circuit — a network of public charging stations.[105] In 2015, the Québec government released its Transportation Electrification Action Plan 2015 – 2020, which outlines measures to support the adoption of EVs in the province. The

government committed an initial $420.75 million (to which an additional $166.7 million was added in the 2017 and 2018 budgets) in funding for the government's electrification priorities.[106] The Plan identifies the need for practical solutions to address the challenge of accessing charging in densely populated urban neighbourhoods. The Plan also allocates $5.4 million to support the installation of charging stations in MURBs, new office buildings and for on-street parking.[107]

The government has also explored amending the provincial building code to ease the installation of Level 2 charging stations in all newly constructed residential buildings, including homes, duplexes and condos.[108] Regulatory amendments to the provincial building code were implemented on October 1st, 2018, with a six-month transition period.[109] The provisions specify that for each individual dwelling that has access to a garage, carport or dedicated parking space, a conduit or cable must be installed in anticipation of a separate branch dedicated to supplying power to an EVSE.[110] The infrastructure required must be adapted for Level 2 charging stations operating at 240 V. According to stakeholders consulted for this study, this applies to the construction of new single-family homes, as well as duplexes, triplexes and quadruplexes.

To support EV adoption in the province, Hydro-Québec published a technical guide on the basics of installing EV charging stations aimed at master electricians, retailers, municipalities and the general public.[111]

Province of Alberta

The Government of Alberta does not address charging for MURBs or garage orphans in existing legislation or regulations. However, the government is undertaking a number of initiatives that encourage or support the installation of EV charging infrastructure. In 2015, the Province introduced its Climate Leadership Plan, which focuses on addressing Alberta's high-emitting sectors including oil and gas and electricity.[112] While the plan does not target the transportation sector as a key focus for emissions reductions, it does identify transit and infrastructure projects as one of the areas for carbon levy revenue spending.

The Province has prioritized EV-related transit initiatives through the Alberta Community Transit Fund, which provides $215 million over five years to municipalities to support regional transit projects, including the purchase of electric or hydrogen-electric buses.[113] The Alberta government also supports EV deployment through the Green Building Standards, which require that all new builds and major renovation projects are certified as Leadership in Energy and Environmental Design (LEED®) Silver.[114] Under the LEED rating system, one credit toward the Silver certification is allocated for the designation of preferred green vehicle parking in 5% of parking spaces and installing EVSE (Level 2 networked) in 2% of all parking spaces.

Province of Saskatchewan

The Province of Saskatchewan released it's Prairie Resilience: A Made-in-Saskatchewan Climate Change Strategy in December 2017. The Strategy identifies a number of measures to reduce transportation emissions, including a commitment to evaluate government fleet vehicles for lower-carbon technology opportunities.[115] There is no reference to EV charging in MURBs or for garage orphans, however, in 2018, the province initiated stakeholder consultations to refine the strategy and to implement relevant regulations and measures.[116]

Province of Manitoba

The Government of Manitoba has implemented, or is considering a number of initiatives that are supportive of EV deployment and charging infrastructure. The Made-in-Manitoba Climate and Green Plan was released in 2017, and identifies electrification as one of the greatest opportunities for reducing emissions from transportation. While the plan does not include strategies specific to EV charging in MURBs or for garage orphans, it acknowledges that Manitobans already have a culture of plugging in due to the cold climate and that there are more than 500,000 existing plug points (e.g., for block heaters) at home and at work.[117] The idea is that the existing infrastructure for block heaters could also be used for charging EVs. A stakeholder consulted for this study noted that block heaters are generally not designed for EV charging, and while it may be possible for some types of receptacles to support Level 1 charging, for the most part, they are insufficient for EV use.[118,119] The plan also highlights EVs as a means of greening government operations and infrastructure. This includes exploring opportunities for installing EV charging infrastructure at government-

owned buildings, increasing the number of EVs in the government fleet and support for the electrification of public transit.

The Province of Manitoba has also supported the deployment of EVs by collaborating on EV technology demonstrations related to Manitoba's specific climatic conditions, the establishment of The Electric Vehicle Technology & Education Centre (EVTEC) at Red River College and the creation of Drive Electric Manitoba, a website providing public information on EVs.[120,121,122]

Province of Nova Scotia

A number of provincial initiatives in Nova Scotia are supportive of EV deployment and the installation of charging infrastructure. The Province released its Choose How You Move: Sustainable Transportation Strategy in 2013. The strategy identifies "cleaner vehicle technologies and cleaner renewable fuels" as a means of moving towards more sustainable transportation systems and commits to 28 actions to support this transition, many of which are specific to EVs. The Province has committed to examining options for public EV charging infrastructure, promoting off-peak charging and assessing the viability of integrating EVs and the electrical grid.[123] Provincial investments of $3.7 million to date have supported projects that improve active transportation infrastructure, transit services, data collection and EV integration.[124] In addition, the government provided a $100,000 grant to Efficiency Nova Scotia Corporation for innovative projects that encourage EV use.[125]

In 2018, Nova Scotia Power, a wholly owned subsidiary of Emera, completed the installation of the province's first EV fast-charging network.[126] A total of 12 DCFC stations, funded by NRCan's EVAFIDI, were installed in strategic locations to enable EV drivers to travel across the province. The stations are part of a pilot project to study the usage of the network and its potential impacts on the electrical system.[127] The Government of Nova Scotia also contributed $120,000 in funding for the installation of an additional 12 Level 2 chargers at the same locations to provide an option for plug-in hybrids that are unable to use DCFC stations.[128] Nova Scotia Power also has a webpage that provides general information on EVs, including available models, charging options and costs.[129]

Province of New Brunswick

The Province of New Brunswick developed its Transitioning to a Low-Carbon Economy: New Brunswick's Climate Change Action Plan in 2016. The plan set a target for 2,500 EVs on the road by 2020, and 20,000 by 2030.[130] It also includes a commitment to develop and implement an EV strategy that will clarify the incentives, regulations, policies, programs and charging infrastructure required to achieve these targets.

A stakeholder consulted for this study stated that a draft EV strategy for New Brunswick has been developed and that it will be presented to the new provincial government for review in early 2019. The draft strategy identifies key drivers and priorities for EV adoption with a focus on achieving the 2020 target. Charging in MURBs or for garage orphans is not considered to be a key priority for the province in the short-term due to the fact that a high percentage of its residents live in single-family homes and most have access to a driveway. The number of EVs registered in the province is also low (somewhere between 100 – 150 vehicles in total). The stakeholder consulted noted that charging in MURBs may be a bigger priority for the province in meeting its 2030 targets because within this longer timeframe, EVs are expected to reach price parity with ICE vehicles.

NB Power operates the eCharge Network, consisting of Level 2 charging stations located throughout the province, and a network of 29 DCFC stations, funded through NRCan's EVAFIDI, located along the TransCanada Highway and throughout the northern part of the province.[131,132]

Province of Prince Edward Island

Prince Edward Island developed its 10-year Provincial Energy Strategy 2016/17 in 2016. The strategy identifies the electrification of transportation as an opportunity to assist with the province's ability to showcase technology and address long-term GHG emissions reductions goals. The strategy proposes a number of measures to support EV deployment and includes provisions specific to charging in MURBs. More specifically, the government commits to examining the feasibility of requiring outdoor parking in new MURB developments to be equipped with EV chargers.[133] The Government of Prince Edward Island

will also consider mandating that new homes are pre-wired for EV charging through the provincial building code.

The strategy also indicates that a provincial transportation committee will be established to examine and implement energy saving policies, such as incentives for the purchase of an EV and the installation of public charging stations. In addition, the strategy notes that government will work with utilities to explore options to leverage federal funding to deploy public charging infrastructure. The strategy states that only utilities can sell electricity in the province under current regulations and acknowledges that this is a barrier to further developing charging infrastructure. In an effort to mitigate this barrier, the government has committed to implementing regulations that would either allow for additional parties to sell electricity in limited ways, or for utilities to become involved in charging infrastructure and then charge for the electricity withdrawn.[134]

Province of Newfoundland and Labrador

The Government of Newfoundland and Labrador's Charting Our Course: Climate Change Action Plan 2011 identifies a number of measures to reduce GHG emissions in the transportation sector, including through EV and infrastructure requirements.[135] The province's 2015 report, titled "*An Examination of Electric Vehicle Technology, Infrastructure Requirements and Market Developments*" identifies a number of relevant considerations, such as the resale of electricity, availability of public charging infrastructure and potential grid impacts related to EV charging. The provincial government provided $52,000 through the Newfoundland and Labrador Green Fund to install residential and commercial EV charging stations and launched a Vehicle Efficiency and Cost Calculator that estimates the costs and GHG emissions associated with various vehicle types, including EVs.[136,137]

The sale of electricity in Newfoundland and Labrador is governed by the *Electrical Power Control Act 1994* (EPCA), and the *Public Utilities Act* (PUA).[138] The EPCA grants Newfoundland and Labrador Hydro the exclusive right to sell electricity to retailers on the island portion of the province. Retailers are defined as public utilities whose primary business is the sale or resale of power to customers. Under the regulations, an EV charging station provider whose primary business is the sale or resale of power could be considered a retailer and as a result, would be subject to certain legislative and regulatory provisions.

Northwest Territories

The Government of Northwest Territories' 2030 Energy Strategy includes a strategic objective to reduce GHG emissions related to transportation by 10% on a per person basis, and outlines short- and long-term actions to help achieve this goal.[139] These actions include piloting a grant program for the purchase of low-emission or ZEVs in communities that are serviced by hydroelectricity. The program will provide a subsidy for eligible vehicles and for the installation of EV charging stations. The government has also partnered with the Arctic Energy Alliance (AEA) on an EV pilot and committed to assessing the feasibility of a ZEV transportation corridor in the Northwest Territories.[140]

Yukon

The Government of Yukon is currently developing a new strategy with a focus on climate change, energy and the green economy. Transportation is identified as an area of interest for the new strategy.[141] Public consultations on the strategy are underway and it is slated to be released in 2019.

As part of its work to update its 20-Year Resource Plan, Yukon Energy commissioned a study to assess the technical feasibility of EVs in the territory.[142] The study identified a number of technological barriers to EV adoption, including a lack of available makes and models to meet consumer demand for larger vehicles, and battery performance limitations in a cold climate. The study identified the widespread availability of outlets for block heaters at businesses and homes in Yukon as a potential opportunity for integrating EV charging infrastructure.[143] While the study concluded that the potential for EV adoption in Yukon is still low, Yukon Energy continues to monitor the EV market, recognizing the rapid development of the technology over the past several years.[144]

Nunavut

Nunavut's energy strategy, Ikummatiit (2007), focuses on reducing the costs for and improving efficiency of transportation services.[145] The strategy commits to piloting a number of initiatives which may

include testing to better understand the impact of hybrid vehicles on transportation energy use in the Arctic.[146] Nunavut has also published a transportation strategy, titled Ingirrasiliqta (Let's Get Moving), which outlines the government's approach to improving the transportation system. EV deployment is not considered in the strategy.[147]

Municipal Initiatives

Municipalities across Canada have begun preparing for a transition towards electric mobility as part of broader sustainability strategies and a move towards low-carbon transportation systems. Municipalities play a critical role in enabling EV use for their residents and have a number of mechanisms through which to support a wide range of actions aimed at accelerating EV charging in MURBs and for garage orphans. As previously noted, the relevance of addressing barriers to charging in MURBs and for garage orphans in the near-term for a specific municipality will be highly dependent on its population size and the number of residential buildings located within its boundaries. While it is critical for large urban centres to begin developing a strategy to address challenges for MURB residents and garage orphans, some smaller municipalities may have more time to determine the most effective path forward.

Policy Options

A number of policy options can be leveraged by municipalities including requirements for EV ready parking spaces in new MURBs, support for EV charging in existing MURBs and providing on-street charging options for garage orphans. EV supportive requirements can also be included in community and environmental sustainability plans, and other high-level framing documents.[148] Municipalities can support EVSE installations in MURBs through language in an EV action plan or strategy or through a stand-alone charging policy that could act as a guide for how to navigate the development and permitting process.[149]

To complement high-level policy language in framing documents, municipalities can also require that some level of EVSE be provided in new residential construction as part of rezoning, or that requirements are included in specific residential land use designation in a zoning bylaw. Three basic readiness options for EV infrastructure requirements can be pursued[150]:

1. **EVSE installation:** This option includes the provision of all required infrastructure for EV charging at the parking spot, including electrical equipment (e.g., meters and transformers), cabling, raceways, connections and at a minimum, a Level 2 charger.
2. **EV ready:** Also referred to as energized, this option involves equipping parking spots with all required infrastructure for EV charging to enable easy installation of at a minimum, a Level 2 charger.
3. **EV capable:** This option involves partial provision of supporting infrastructure for EV charging, such as electrical panel capacity and conduit. Pursuing this option would require that additional EVSE infrastructure be installed at a later date.[151]

The City of Richmond adopted amendments to the Richmond Zoning Bylaw, requiring the provision of an energized outlet for Level 2 EV charging in all residential parking in new buildings (excluding visitor parking). This requirement can be met by providing a dedicated circuit that can supply Level 2 charging to an outlet at each parking stall or by using EVEMS, which enable multiple EVSE to use a single electrical circuit simultaneously without exceeding its capacity.[152] As part of it's EV Ecosystem Strategy, Vancouver amended it's Parking Bylaw to require every parking space in new MURBs (except visitor parking) be equipped with an energized outlet capable of supporting Level 2 EVSE installation.[153]

The need for harmonization and standardization across municipalities was discussed by a number of stakeholders consulted for this study. Many noted that standardization is important for supporting municipalities who may not have sufficient resources to develop their own EV-related bylaws or strategies. One stakeholder noted that in the Metro Vancouver area, standardization is already underway and that it has been helpful in terms of providing guidance to smaller communities without the bandwidth to address these issues. However, another stakeholder consulted for this study stated that standardization of EV-related regulations between adjacent municipalities or larger regional development areas may not be necessary and that such matters should be at the discretion of the local municipality based on an assessment of specific needs. Stakeholders were in agreement that wherever possible, harmonization across different standards and regulations will be

important to ensure EV charging requirements are not being pursued at cross purposes.

Education and Awareness

Municipalities can also play an important role as a credible source of information related to EV charging in MURBs and for garage orphans. For example, Metro Vancouver created an online resource (www.evcondo.ca) that includes information for EV owners, strata councils and property managers. The website guides these audiences through typical steps required to set up EV charging in stratified buildings.[154] A number of stakeholders consulted for this study noted that while knowledge about EVs is growing among consumers, there is still a long way to go. There was also agreement that the development of resources that provide specific guidance for local governments including staff, departments and politicians, would be helpful for municipalities looking to address challenges related to EV charging in MURBs and for garage orphans.

Public Charging

Partnerships and support for innovative pilot projects that address charging barriers are effective means for municipalities to support the uptake of EVs for their residents. In Montreal, the City has prioritized increased public EV charging infrastructure, in part to ensure garage orphans have more options. The City's Transportation Electrification Strategy commits the city to installing 1,000 public curbside charging stations by 2020 (600 have been installed to date).[155] Vancouver also has a curbside charging pilot where a total of 15 EV owners can apply for a licence to charge at the curb. The City of Toronto has partnered with Toronto Hydro on a number of EV-related pilot projects including one to install 14 EV charging stations on electrical wires and street light poles at up to seven locations throughout the city in an effort to provide on-street charging options for garage orphans in residential permit parking areas. In addition, the City will collaborate with Toronto Hydro and the Toronto Parking Authority (TPA) to install over 200 public charging stations in TPA-operated parking garages. Many of these charging stations will be located in neighbourhoods with high concentrations of MURBs and garage orphans.[156]

Appendix B provides an overview of some of the current activities relevant to EV charging in MURBs and garage orphans being undertaken in municipalities and districts across Canada.

2 | BARRIERS, SOLUTIONS AND BEST PRACTICES

Section Two describes key barriers, potential solutions and current best practices associated with EV charging in MURBs and for garage orphans as identified through the literature review and interviews conducted for this study. While it is beyond the scope of this report to explore every barrier and potential solution, the following builds a detailed picture of the broad range of challenges facing potential EV owners living in MURBs or without access to a driveway or garage, and highlights innovative potential solutions from a number of leading jurisdictions.

The following broad categories have been used to organize key barriers to EV charging in MURBs and for garage orphans:

- **Grid Preparedness & Charging Infrastructure:** These barriers comprise those related to the electrical grid and EV charging infrastructure (not those specific to building design) as they pertain to MURBs and garage orphans.
- **Building Design & Physical Infrastructure:** Applicable only to MURBs, these barriers include those related to charging infrastructure in and around buildings.
- **Education & Awareness:** Barriers in this category relate to MURBs and garage orphans and focus on consumer, building owner and property manager awareness.
- **Regulatory & Policy:** This category covers barriers related to the regulations and policies (e.g., acts, codes, standards, process policies and bylaws) that impact EV charging in MURBs and for garage orphans.
- **Financial:** Barriers in this category are applicable to MURBs and garage orphans and include installation and operational costs, as well as challenges related to cost-sharing.
- **Other:** These barriers are those that do not fit easily within the other categories.

Overview

Table 5 presents a high-level summary of the barriers explored in this section, along with the type of dwelling they apply to, and a number of potential solutions identified through this study.

Table 5: Summary of Barriers and Solutions

Barrier	Existing MURB	New MURB	Garage Orphan	Solutions
Grid Preparedness & Charging Infrastructure Barriers				
Electrical Capacity	✓	✓	✓	• Utility-controlled demand management • Off-peak charging • Electric Vehicle Energy Management Systems (EVEMS) • Energy storage systems • Additional research, development and pilot projects
Metering	✓			• EVSE network solutions
Lack of Access to Charging Infrastructure			✓	• Demand or load management • Residential curbside charging • Increased public and workplace charging
Building Design & Physical Infrastructure Barriers				
Parking Supply	✓	✓		• Peer-to-peer charging rentals • Public charging (parking lots and curbside charging) • Swapping parking spots • Community or shared charging • Reservations and virtual waiting lists
Design	✓	✓		• Technology solutions (e.g., demand charge controllers, chargers with built-in transformers, energy storage-based charging) • Parking or charging management (i.e., multiple users per charger) • Public charging (parking lots and curbside charging)
Connectivity	✓	✓		• Technology solutions (e.g., cellular boosting)
Education & Awareness Barriers				
Consumer Awareness	✓	✓	✓	• Targeted education and outreach • Regulations • Certification programs
Condo-Strata Decision Making/ MURB Owner Awareness	✓			• Targeted education and outreach • Regulations (e.g., revising condo acts, bylaws, and regulations, permits triggering or EVSE requirements)
Regulatory & Policy Barriers				
Physical Barriers	✓	✓		• Financial support and incentives • Zoning bylaws • EVEMS • Implementing EV supportive standards in national model building code
Condo & Strata Legislation	✓			• “Right to charge” legislation
Electrical-related Legislative & Regulatory	✓			• Clarity on recovery of costs for EV charging services without regulation as a public utility
Measurement Rules	✓	✓		• Approved metering solutions that enable billing for EV charging based on energy usage

Barrier	Existing MURB	New MURB	Garage Orphan	Solutions
Financial Barriers				
Installation Costs	✓	✓	✓	• Technology solutions (e.g., demand charge controllers, charger with a built-in transformer) • Swapping parking spots • Regulations (e.g., EV ready parking requirements or design for 100% in new MURBs and for major renovations) • Funding or support programs
Operation & Maintenance Costs	✓	✓		• Funding or support programs • Low-rate charging
Cost Sharing	✓	✓		• New financial or operating models (e.g., financial recovery independent of utility costs, utility owned or operated EVSE, privately owned or operated EVSE and networked chargers) • Charging solutions (e.g., flat fee-based charging, rate based charging) • Public charging in parking lots and curbside
Other Barriers				
Rental-specific Barriers	✓	✓	✓	• Regulatory solutions to allow EVSE installation • Public charging in parking lots and curbside

Barriers, Solutions and Best Practices

Grid Preparedness and Charging Infrastructure

The electricity distribution system's ability to respond to the power demand for EV charging plays a critical role in the adoption of the technology, particularly in the broader market. In a MURB context, planning is required in both new and existing buildings to ensure electrical capacity is managed in a way that will effectively accommodate charging for potential EV owners. The following barriers relate to grid capacity and charging infrastructure in MURBs and for garage orphans, and highlight potential solutions and current best practices. The purpose of exploring the following barriers and solutions is to introduce high-level concepts related to the challenges associated with electrical capacity in MURBs and for garage orphans from an EV perspective only. In no way should it take the place of input from an electrical engineer related to electrical design, planning and implementation when pursing the installation of charging infrastructure.

Barrier: Electrical Capacity

Applies to: Existing MURBs, New MURBs, Garage Orphans

A building's distribution system comprises a series of components that transmit electricity safely and efficiently to its end use. The capacity and baseload of each building varies and the specific system configuration in terms of common area wiring, location and metering will determine the ability of the building's electrical system to accommodate the additional load from EV charging.[157] The capacity of the electrical distribution system at the neighbourhood-level to accommodate EV charging is also a potential challenge for garage orphans. Potential solutions to address garage orphans' lack of access to charging infrastructure include installing charging stations on existing neighbourhood-level transformers. The rated capacity of these assets would need to be evaluated before installing additional EVSE.

The charging level of the EVSE (e.g., Level 1, 2 or DCFC) and the capacity of the vehicle's on-board charger play a role in the number of EVs that can charge before creating challenges for a building's

distribution system. Electricity delivered through an EV charging station is converted to battery power by a small charger on board the vehicle. The EVSE and the charger determine the rate at which electrical energy is drawn when an EV battery is being charged. Many of the current EVs on the market contain an on-board charger rated at 6.6 kW when charging at 240 V. However, some EV models have more powerful on-board chargers, in some cases, rated up to 20 kW, which is a much more significant load for the distribution system. Depending on the available capacity of the building's electrical system, a number of vehicles charging simultaneously with more powerful on-board chargers could potentially exceed the rated capacity of the building's infrastructure assets.[158] A stakeholder consulted as part of this study noted that all loads connected to the building's electrical supply must be included in the calculated load and if EVs with greater on-board chargers were anticipated, they would be accounted for in the design of the building's electrical installation.

The demand for electricity fluctuates over the course of a day, meaning that the time at which an EV is plugged in will have implications for a building's distribution system capacity. EV charging during periods of peak electricity demand in a building would have a greater risk of overload than if charging occurred off-peak. Non-networked or non-smart chargers — often referred to as "dumb chargers" — do not collect data and are incapable of responding to electricity price fluctuations over the course of a day. When an EV owner charges their vehicle with a non-networked charging station and without concern for the time of day or electricity price, it can contribute to an increased demand for power during peak load periods should a number of EV owners wish to charge at the same time.

Stakeholders consulted for this study had differing opinions about whether electrical capacity in MURBs was a critical issue, particularly in the near-term. Some noted that most MURBs have spare capacity, and even at peak load times, a building may only be operating at 30% of its electrical capacity. Others felt that current EV penetration rates in MURBs, combined with the use of power-sharing technologies and other means of demand management, ensure enough capacity exists to accommodate the charging needs of EV owners. Energy conservation efforts over the past several years have also shifted the demand profile in buildings, freeing up some of the existing load from other services (e.g., TVs, electronics, appliances).

The need to address electrical capacity in existing MURBs to support EV charging requires evaluation on a case-by-case basis and would benefit from a study of existing building stock, age and capacity.[159] Stakeholders consulted for this study noted that a number of smart charging options — the intelligent charging of EVs to optimize charging infrastructure by creating and distributing available power in an efficient and flexible manner based on grid loads and in accordance with an owner's needs — on the market also have the potential to link to a building's energy management system to help address capacity at the building level, in addition to the individual EVSE level.

Solutions and Best Practices

While in the majority of cases it is possible to increase a building's electrical capacity through service upgrades in collaboration with the local utility, this process can be complex and prohibitively expensive. As a result, a number of more cost-effective technologies and demand management solutions are being explored in an effort to optimize existing electrical capacity in MURBs and for garage orphans.

Demand Management

Utility-controlled load management: If the demand for power to charge EVs in a MURB were actively managed behind the meter by the utility, the risk of exceeding electrical capacity could potentially be mitigated. By managing the power supplied to each EV, a full charge could be provided to a greater number of EVs without additional costs to the utility through an increase in infrastructure costs for the building. This could also help to level the overall load on the system which fluctuates over a 24-hour period, minimizing potential grid constraints for utilities. Utility-controlled load management would require less control on the part of the EV owner, building owner or property manager to determine when or how charging occurs. It should also be noted that this approach would likely require the use of smart or networked EVSE. While in general, utilities may not be overly concerned with what is behind the meter, stakeholders consulted for this study noted that some are already testing acceptance for utility-controlled demand management for EVs and pursuing behind the meter investigations prior to installing EVSE in

MURBs. Others have plans to pursue work in this area in the future.

In addition, utilities may not know where EV charging is occurring. As a result, load management solutions would require the utility to be aware of either where EV owners are located or where someone may be planning to charge in future. Having a clear understanding of how EVs change the profile for power demand within a building will therefore, be critical for making informed, strategic and effective investments in the technology and infrastructure required to maintain quality of service for MURB residents.

Off-peak charging: Off-peak charging mitigates the demand for power during the peak load period. Most EVs and EVSE have the ability to pre-program start times for charging and as a result, can charge outside of peak demand times. Some EVSE also have the ability to program charging to respond to price signals from their utility.[160] With an adequate price differential, time-of-use pricing — rates determined based on the time of day that electricity is consumed — and other rate designs (e.g., demand charges) in some jurisdictions have been shown to effectively encourage charging during off-peak periods. Strategic planning is required however, because if a number of EVs program their vehicle to begin charging at the beginning of the off-peak time, there would be a spike in the demand for power. A stakeholder consulted for this study indicated that because off-peak charges would only apply to a specific window of time (e.g., overnight), this would reduce the number of hours within a day that EV owners would likely choose to charge their vehicle. A number of vehicles charging during this reduced timeframe, rather than spread across a full day, could require additional capacity at the building-level to accommodate.

Electric Vehicle Energy Management Systems (EVEMS): Similar to utility-controlled demand management, EVEMS can be an effective technological means of addressing electrical capacity issues at a building-level. Also called load sharing or smart charging, EVEMS refer to a wide range of technologies that allow for multiple vehicles to charge on the same electrical circuit. Instead of a dedicated EVSE where one circuit provides power to one parking stall, a single circuit is able to service a number of stalls simultaneously by controlling the rate and timing of the charge. This reduces the peak capacity needed to charge multiple EVs.

EVEMS have the ability to significantly increase the number of vehicles that can charge in a MURB by making efficient use of available electrical installations. It should be noted however, that power can typically be managed at a circuit, panel or even building level and condo boards or strata corporations can establish an energy management policy with their residents that describes exactly how power will be shared when all vehicles are plugged in. A stakeholder consulted as part of this study noted that because EVEMS have the ability to reduce or limit peak power, while increasing overall energy consumption, reduced rates could be provided to incentivize their use.

For further information about the specifics of EVEMS and options for installation refer to the City of Richmond and BC Hydro's report entitled *Residential Electric Vehicle Charging: A Guide for Local Governments*.

Augmenting Existing Electrical Capacity

Energy storage systems: Technology companies and EVSE providers have begun to explore options for addressing electrical system capacity challenges with energy storage solutions. For example, eCAMION offers a battery-supported EV charging system that draws power slowly from the grid when the demand is low. The system can supply power to a number of charging stations at the same time and is able to provide power through a slow or fast charge. The company's pole-mounted battery storage systems are also being piloted in Toronto in partnership with Toronto Hydro. Battery solution provider Koben Systems announced an integrated system design for large-scale Level 2 charging installations in the U.S. in October 2018.[161] The system captures energy from the grid during low demand periods for use during peak times. The company indicates that demand savings can be as great as 80% through use of their system which can be scaled based on the needs of the building.

Additional research, development and pilot projects: Stakeholders consulted for this study discussed a BC Hydro pilot project that is exploring the use of EVSE combined with a small transformer that bypasses the building's transformer. EverCharge, a U.S.-based EV charging solutions provider, is

currently piloting a solution developed specifically for MURBs in Toronto. EverCharge installs transformers on every level of a parking garage and provides the conduit for EV charging only as it is required for a new vehicle. The company's SmartPower system allocates power based on vehicle demand and the company indicates that its system can significantly increase charging capacity.[162] Other EVSE providers (e.g., ChargePoint) offer panel load managed systems that can reduce capacity requirements.

Stakeholders were in agreement that planning for electrical capacity during the design phase for a building should include considerations for future EV charging, particularly considering that retrofitting can be considerably more expensive. Some utilities require property developers to pay a load deposit based on their planned electrical distribution system requirements. Stakeholders indicated that this deposit may not be returned if capacity is not fully used, further highlighting the importance of strategic planning to clearly understand and forecast future EV-related loads.

Barrier: Metering

Applies to: Existing MURBs, New MURBs

The way in which charging stations in a building are owned, managed and metered can present a number of challenges for EV deployment. Many older buildings are bulk metered, which means that electricity costs are equally distributed among residents based on the total electricity consumption for the entire building. This configuration can create challenges for a potential EV owner as other residents may have misconceptions about how much it costs to charge a vehicle. Many residents have argued that the provision of electricity to power an EV in such buildings is comparable to providing gasoline to residents to power a conventional vehicle.[163] Stakeholders consulted for this study felt strongly that EV drivers should be the ones to pay to charge their vehicle.

Buildings that are sub-metered or suite-metered also face challenges. Each unit in a sub-metered building has its own meter and is charged for electricity based on consumption per unit rather than it being shared among the entire building. Even buildings that are already sub-metered may not have meters in parking areas, and installing a new one can be expensive. Stakeholders consulted for this study noted that early bylaws related to the installation of EV charging infrastructure did not include requirements for meters and as a result, some EVSE has gone unused because there is not an appropriate means of billing. It was also noted that a common meter for all EVSEs could be used to resolve this issue as it would allow EV owners to allocate costs through networked systems that either separately meter or use a flat rate.

Solutions and Best Practices

A number of EVSE service providers have full-service solutions that address issues associated with metering. These types of services can be particularly useful for property management companies or condo boards that do not want the hassle or responsibility of managing customer service and billing. Some utilities are also exploring the feasibility of providing similar solutions. Stakeholders consulted for this study noted that the proprietary nature of these systems and ongoing networking fees should be considered when determining the most appropriate system to use. One stakeholder indicated that the Open Charge Alliance has developed an Open Charge Point Protocol (OCPP) which offers a uniform solution for the method of communication between the charge point and the central system. This uniform standard approach may prevent coordination challenges as it ensures that a central system can be connected to any charge point, regardless of the vendor.[164]

Barrier: Lack of Access to Charging Infrastructure

Applies to: Garage Orphans

While the majority of single-family homes have access to a 120V 15A shared outlet for reduced Level 1 charging, garage orphans are without a garage or dedicated parking space and as a result, a means of charging their vehicle. Encroachment bylaws in many municipalities restrict the installation of charging stations at curbside. In some municipalities these bylaws restrict extension cords from running over or underneath sidewalks. At the same time, the installation of additional charging infrastructure solutions that tie into existing neighbourhood-level transformers may contribute to electrical capacity issues. A number of vehicles charging on the same local transformer can lead to potential overloading, particularly at periods of peak demand.[165]

Solutions and Best Practices

FleetCarma's ChargeTO pilot program uses vehicle-side data on a range of models to demonstrate how paired smart charging can meet the needs of EV owners and the utility. The project looked to determine the most appropriate load management solution for a specific utility by gathering different data points from customers (e.g., commute cycles, proportion of city versus highway driving, available rate structures and incentives, etc.).[166]

Residential curbside charging infrastructure programs are being explored by many municipalities as a means of addressing the charging needs of garage orphans, while also providing additional public charging for EV owners. The City of Montreal has installed hundreds of curbside stations as part of their electrification strategy. FLO, a subsidiary of AddÉnergie Technologies, is leading the large-scale demonstration and installation of charging infrastructure in municipalities across Canada through support from the Electric Vehicle Infrastructure Demonstrations component of NRCan's Energy Innovation Program.[167] These charging stations have been designed for curbside installation on city streets and will increase access for EV owners living in urban areas. Installations have already been completed in Vancouver with stations in additional municipalities slated to be in operation in 2019.

As previously noted, the City of Toronto has partnered with Toronto Hydro on a pilot project involving the installation of 14 EV charging stations on electrical wires and street light poles at up to seven locations throughout the city in an effort to provide on-street charging options for garage orphans in residential permit parking areas.

Increasing the availability of public charging infrastructure outside of residential areas and at workplaces can also help to temporarily address the lack of at-home charging options for garage orphans. A recent study found that drivers are more likely to own an EV if there is an option to charge within one kilometre of their home.[168] A stakeholder consulted for this study indicated that the location of vehicle owners without garages should be a key consideration when determining where to install public infrastructure.

Building Design and Physical Infrastructure

The following barriers relate to the physical design constraints of buildings, including the location of electrical infrastructure (e.g., electrical service rooms).

Barrier: Parking Supply

Applies to: Existing MURBs, New MURBs

Existing MURBs, particularly older buildings, may have little or no parking, meaning their residents are garage orphans.[169] It is also possible for residents of existing and new MURBs with parking not to have regular access to an assigned or unassigned space, making them garage orphans as well. These garage orphans in MURBs, may choose to park curbside or in nearby lots.

When parking spaces are deeded to a unit, it limits the building owner or condo board's ability to re-assign spaces to accommodate EV charging, since parking spaces are legally bound to the unit's title.[170] If the assigned parking space is common property but held pursuant to a lease between the developer and the original owner, the ability to re-assign the space depends on the provisions of the lease. Some leases may specifically state that owners can trade spaces, while others will not, thus limiting the potential for re-assignment.[171] A charging station tied to a deeded space could be seen as added value to a future tenant with an EV but it may be unattractive to someone who does not own one.[172]

Solutions and Best Practices

Shared and public charging: Shared economy websites and apps (web-based platforms) allow EV owners to rent charging time from privately-owned stations (e.g., Bookmycharge[173] in the UK and EVMatch[174] in the Los Angeles area, as well as Toronto start-up SWTCH[175]). Peer-to-peer charging station rentals could be considered an interim solution for garage orphans assuming there are nearby neighbours participating in the app.[176]

Community or shared EV charging stations in MURB visitor parking spaces may provide a solution where installations in dedicated spots are not possible. For example, ChargePoint offers a solution that tracks usage and manages billing for shared charging stations and also provides EV drivers with other features including information about real-time station

availability, virtual waitlists and notifications to help coordinate access to shared charging.[177]

Another potential solution would be to provide EV owners with preferential use of charging stations in public lots. Many parking lots located near MURBs (e.g., those used by schools, churches, businesses, etc.) are full during the workday and remain relatively empty at night. Arrangements could be made to accommodate EV owners charging in these lots during the evening or at night.[178] The feasibility of this solution would depend on how close the parking lot is to the MURB and if the EV owner would be required to pay for both parking and charging, making it prohibitive as a long-term solution.

EV chargers could also be installed in park and ride lots. In general, vehicles in these lots are parked for at least 8 hours. As a result, it might be sufficient to install Level 1 chargers, making it a less expensive option. It should be noted however, that a greater number of spots for EV charging would need to be made available in park and ride lots as most drivers may not return midday to move their car and free up the charging station.

Addressing parking supply: Strata corporations and condo boards have the authority to reassign parking spaces that are located in common areas (i.e., not registered on a title). Re-assigning these types of spaces can be advantageous in order to group EV charging stations closer to the electrical room or in a dedicated area of the parking lot, thereby maximizing the use of available parking space and capacity. Where possible and legal, condo boards could also facilitate negotiations between residents to find solutions that would address the lack of EV accessible parking supply in their building.[179] They could also provide guidance and support to EV owners wishing to negotiate a parking space swap independent of the board, as a stopgap measure. A stakeholder consulted for this study noted that with a national target of 100% ZEVs by 2040, swapping parking stalls should not be considered a long-term solution. The re-assignment of parking spaces in MURBs does not contribute to the overall development of the infrastructure required to support EV adoption in the long-term.[180]

EV charging could also be offered as one of the finishes or as a requirement when purchasing a unit in a new MURB. It should be noted, however, that if the new MURB is not designed to be 100% EV ready, this could limit the buyer's options in terms of the location of their parking space.

Barrier: Design

Applies to: Existing MURBs, New MURBs

There are a number of barriers for EV charging in MURBs related to the design of the building. In existing MURBs, the number of EV charging stations that can be installed is dependent on the building's existing electrical capacity. In addition, while the installation of dual Level 2 EV charging stations can help to reduce costs, space constraints or certain parking lot designs can make sharing a station impossible. Space constraints can also be an issue in the building's electrical service room, creating challenges when looking to upgrade electrical panel capacity or install additional sub-meters.

New MURBs also face challenges related to building design. For example, increased transformer capacity to accommodate EV readiness requires more space in the electrical service room when dedicated circuits are used. As a result, prime square footage may need to be used to accommodate EVSE infrastructure. This could be particularly costly in municipalities with expensive housing markets, such as Vancouver and Toronto.

Due to the costs associated with EVSE installation, many building owners or property managers may choose to take an incremental approach, installing them as demand requires in common areas for shared charging or in assigned parking spaces for private use. Alternatively, a decision may be made to install multiple EVSE in only one section of the parking garage. While these approaches may contribute to keeping costs low in the short-term, as the demand for EVs in MURBs increases, future EVSE installation will be prohibitively expensive.

Solutions and Best Practices

Technology solutions: Space constraints within an electrical room can be addressed by the use of a load management solution known as a demand charge controller (DCC). The DCC is installed between the condo owner's meter and electric panel and diverts some of the power to the EV charging station while

monitoring the overall electricity consumption of the panel. This technology can enable condo owners with low capacity electrical panels to accommodate a charging station with 30-60 amp capacity. The DCC will cut power to the EV charging station to prevent exceeding the panel's capacity if total usage exceeds 80%. It is worth noting however, that when the DCC cuts power to the EVSE, some EVs may stop charging. While some will not attempt to restart for up to 15 minutes, assuming a power failure, others will not start again without manual intervention.

Tapping into the common electric panel is not required with the use of a DCC and because it is small in size, it can fit easily into electrical rooms with space constraints. The DCC, which costs approximately $1,100 for the hardware, can be used with any Level 1 or Level 2 charging station. Installation costs vary depending on specific installation requirements (e.g., the distance between the DCC and the parking space). Because the DCC is linked directly to the condo unit, it can add resale value.[181]

As previously noted, BC Hydro is currently piloting an EV charging station with a built-in transformer. This would eliminate the need for increased transformer capacity, and therefore the need for increased space in the electrical room. eCAMION's battery storage solution requires no additional electrical service capacity and the battery system can be installed on the roof of the parking garage. This eliminates the need for extra space in the electrical room, or ground space in the parking garage, for installation. An eCAMION pilot project is currently underway in Toronto that involves the installation of DCFC stations in high-rise condo buildings in partnership with the Low Carbon Innovation Fund.

Parking or charging management: Installing EVSE in a location that intersects several parking spaces can accommodate the shared use of the charging station by multiple vehicles. Where valet parking is available in MURBs, parking management or attendants could move vehicles around to facilitate the shared use of EV charging stations and to take advantage of off-peak charging rates.[182] Online reservation systems can also be used to book charging time at shared spots.[183] To encourage EV owners to only park in common spaces for the duration of the charge, the EVSE could be set up to bill for the time the vehicle is connected, rather than for the time when it is actively charging. It is important to note however, that charging based on time, rather than electricity consumption, could result in cost inequities, as older EV models can be slower to charge.

For new MURBs that are being built EV ready, property developers could consider installing a small number of EVSE at the time of construction. Additional EVSE units could then be added as required, and at the expense of the tenant or unit owner. Managing installation in this way would help defer some of the upfront costs for developers.

Public charging: If there are no viable means of addressing building design and installation constraints within the MURB's parking infrastructure, public EV charging could be made available to EV owners within close proximity. To minimize barriers to using public chargers, the California Health and Safety Code does not allow EVSE service providers to charge a subscription fee or require membership for use of public charging stations. They must also post the actual fees for using the station at the point of sale and allow for two payment options.[184]

Barrier: Connectivity

Applies to: Existing MURBS, New MURBs

Underground parking garages may have poor cellular coverage, which is required to operate some networked EV charging stations.[185]

Solutions and Best Practices

There are two main options for improving cellular coverage in parking garages: an active distributed antenna system (DAS) or a cell phone signal booster (i.e., a passive DAS). An active DAS distributes its own cellular signal and as a result, is beneficial for parking areas that are greater than 500,000 square feet. They are expensive however, and require infrastructure-intensive installation. For this reason, most parking garages use a passive DAS to improve cellular coverage. Passive DASs (also known as cell boosters) are relatively inexpensive, as they work to boost existing cellular signals. They are easy to install and useful in areas of less than 500,000 square feet.[186] The cost for a passive DAS ranges from between 37 and 90 cents per square foot.[187] Alternatively, a wireless system using Ethernet is an option used in some products. A stakeholder consulted for this study

noted that improving cellular coverage has the added benefit of increasing safety in underground parking lots as it enables people to make emergency calls.

Education and Awareness

This section explores barriers related to education and awareness for different stakeholder groups, including consumers, condo boards and strata councils.

Barrier: Consumer Awareness

Applies to: Existing MURBs, New MURBs, Garage Orphans

A lack of consumer awareness and experience with EVs can be a significant barrier to the deployment of the technology. A number of studies have found that there is a general lack of knowledge about EVs, including available makes and models, purchase cost and charging requirements. This is of particular relevance for MURB residents who may not have a full understanding of the complexities involved with the installation of an EV charging station in their building. A stakeholder consulted for this study noted that some consumers even go so far as to purchase an EV before discovering that they are unable to install a charger. In addition, some condo boards may require that a potential EV owner do all of the leg work to determine installation requirements before a decision is made about whether to grant their request for a charging station. For this reason, MURB residents require resources specific to the unique challenges they face related to EV charging at home.

Solutions and Best Practices

Targeted education: Targeted education campaigns are necessary to address misconceptions or a lack of information about EV charging stations. Governments and other stakeholders have developed online resources to provide support for potential EV owners in MURBs. As previously noted, Metro Vancouver hosts a website that includes information for EV owners, strata councils and property managers on how to set up EV charging in stratified buildings.[188] In the City of Richmond, Plug-in Richmond, an independent organization, hosts a webpage dedicated to providing information and highlighting important considerations for home charging in MURBs.[189] The California Energy Commission, together with Public Utilities Commission, have been mandated to maintain a website with detailed information to help consumers make decisions related to the installation of EVSE.[190]

In some jurisdictions, utilities are also playing a critical role in educating consumers about EV charging. For example, San Diego Gas & Electric (SDG&E) holds quarterly workshops on EVSE installations for MURBs, participates in national and statewide efforts to facilitate charging in residential buildings and serves as a resource for property owners, local governments and residents.[191] Seattle City Light developed an information sheet for MURB building owners and property managers about how to get their buildings "plug-in ready"[192]. Most Canadian utilities maintain webpages dedicated to EV charging, and some (e.g., BC Hydro) include information specific to MURBs.[193] Hydro Québec published a technical installation guide for EV charging stations intended for master electricians, retailers, municipalities, and the general public.[194]

Not-for-profit organizations also have a role to play in consumer education and awareness related to EV charging. Plug'n Drive, a champion for electrified transportation, operates the Electric Vehicle Discovery Centre (EVDC), the first facility of its kind dedicated to experiential learning.[195] Visitors can learn about EV charging and the benefits of EV use while taking a test drive in a sales-free, no-pressure environment. As previously noted, Plug In BC provides online resources related to EV charging, including information on relevant incentives, policies and charging solutions.

Regulations: San Francisco goes one step further to involve building owners themselves in the education and awareness process. As part of San Francisco's EV Ready ordinance, owners of EV ready buildings, including homeowners associations, must annually notify all residents (including renters) of the remaining electrical service capacity and the rights of tenants to install EV charging stations. They must also provide information on currently available financing or incentive opportunities for EVSE installations. Warnings and fines are issued to building owners who do not comply.[196,197]

Certification programs: Another potential avenue for disseminating information about EV charging in MURBs is through building certification programs like the Green Building Council's LEED program.

Barrier: Condo Board or Strata Council Decision-Making and Building Owner Awareness

Applies to: Existing MURBs

In most jurisdictions, condo boards or strata councils have the right to reject requests by EV owners to install charging stations. There are a variety of reasons why a condo board may choose to deny such a request. Condo boards may prefer not to make decisions that appear to give preferential treatment to an EV owner over other residents, or they may not see the value of EV charging for the condominium as a whole. A lack of understanding of the complexities of EV charging station installation in a MURB may also deter condo boards from delivering an affirmative response.[198] This lack of awareness extends to building owners, property managers and any other parties in a position to evaluate the feasibility of installing EV charging stations in MURBs.[199]

Solutions and Best Practices

Targeted education and training: Engagement and education are important tools for addressing misinformation. Training programs for local contractors and government employees aimed at increasing understanding about EV charging in MURBs could in turn, provide additional support for building owners, condo boards and strata councils seeking out guidance.[200][201] Not-for-profit organizations could play a role in developing training materials to address the specific interests of condo boards or strata councils including permitting, legislation and infrastructure requirements.

Stakeholders consulted for this study noted that government funding could be provided for EV infrastructure assessments conducted by experts.[202] This would help to address the knowledge barrier by ensuring that building owners, condo boards and strata councils are better equipped to make informed decisions related to EV charging station installation. As previously noted, the Charging Solutions and Incentives Program administered by Plug In BC offers onsite presentations and educational programming on charging station installation processes and guidelines for strata councils and MURBs residents. An initial consultation with an expert is also offered to help assess site specific charging options.

Regulations: There is precedence for mandating the provision of information related to EV charging station installation in MURBs. As part of San Francisco's EV Ready ordinance, the Department of the Environment must notify owners of EV ready buildings annually of their responsibilities and provide information on currently available financing or incentive opportunities for EV charger installations.[203]

Condominium and strata acts or their equivalent in other jurisdictions can also be amended to prevent condo boards from restricting or prohibiting EV owners from installing EVSE. In California, Senate Bill 880 mandates that homeowners associations cannot prohibit or restrict the installation of EVSE.[204] On January 1, 2019, California amended Civil Code Section 4745, which was the first statute designed to nullify a homeowners associations' ability to prohibit the installation and use of EV charging stations. This amendment expands the scope of rights homeowners have related to installing EV charging stations, and adds a section to address dedicated time of use meters.[205]

Mandating that major renovations that require a permit trigger requirements to make associated parking spaces at a minimum, EV ready could contribute to increasing the number of charging stations in MURBs. It should be noted however, that this incremental approach may lead to future challenges. While the installation of the first number of EV charging stations would be easily accommodated, subsequent requests may be denied based on a building's reduced electrical capacity.

Regulatory and Policy Barriers

MURB residents hoping to install EVSE in parking spaces tend to face two categories of regulatory barriers in Canada, which can be broadly categorized into physical barriers and legal and governance barriers.

Barrier: Physical barriers

Applies to: All non-EV Ready MURBs

Most existing Canadian MURBs were not designed with EVSE installation in-mind, meaning that significant civil and electrical costs may be required to allow for EVSE installation in a parking spot. For example, connecting an EVSE to an existing electrical

panel can involve drilling through concrete. This is in addition to costs such as obtaining an electrical permit, materials, labour, and the cost of the EVSE itself. The full cost of EVSE installation in an existing MURB varies by building, but some experts have provided a typical range of between $4,000 and $8,000 per unit.[206] Costs can increase dramatically if building electrical service requires an upgrade to support increased electrical load. Costs can be dramatically lower if EVSE electrical infrastructure is installed in new construction or major renovation.[207]

Legislative approaches using building codes typically apply at the point of new construction or substantial renovation (i.e. times at which a building permit application is submitted). They do not typically require changes to existing buildings that are not otherwise applying for building permits. This means that a building code change alone will not resolve issues with the existing stock of MURBs.

Solutions and Best Practices

One of the leading policy approaches to support installation in existing MURBs has been to provide special funding targeted at MURB residents or, in some cases, buildings, recognizing that the costs are much higher than in detached homes. One Canadian example is the Plug In BC Charging Solutions and Incentives Program, funded by the Province of BC, which provided a maximum of 75% of the project costs up to $4,000 per Level 2 EVSE up to a maximum of 2 stations per MURB property.[208]

An alternative approach to subsidizing individual units is to provide condo boards or strata corporations with a subsidy that supports an electrical audit and investment in certain recommended actions. For example, electrical panel upgrades and bringing dedicated EV-charging sub-panels to parking areas, along with support for condo or strata bylaw updates and development of an EV charging policy could help make it cheaper and easier for each condo or strata owner who wants to install EVSE. Suitable bylaw changes and a charging policy can address who bears electrical costs, timing and installation requirements. It can also require participation in building energy management programs, while reducing the application costs for individual unit owners seeking to install charging by providing a standard process and documents. This approach is attractive, because it could substantially reduce the per-unit cost of installation, while also providing for electrical capacity for more residents as EV uptake increases, especially if a building requires residents to participate in charging station energy management, which allows more users to charge using available electrical capacity. This approach overcomes the cost and timing barriers that typically exist when applications are considered on a case-by-case basis, which is the default under most provincial regulatory frameworks for stratas and condominiums.

Barrier: Physical barriers

Applies to: New MURBs and Existing (renovated) MURBs

Regulators have additional mechanisms with respect to new buildings and substantial renovations, which are typically regulated at a provincial and municipal level through building codes, electrical safety codes and zoning bylaws. Stakeholders consulted for this report typically agreed that it is important to set requirements for new and renovated buildings relating to: (1) ensuring sufficient building electrical capacity, typically assuming that EVSEs use some form of energy management and (2) providing for cost-effective electrical connection of EVSE to a building's electrical systems. If these are in place, they will typically greatly reduce the cost of installing EVSE after a building has been constructed or renovated.

Solutions and Best Practices

Some of the strongest Canadian examples of EV-supportive MURB regulation can be found in BC, where municipalities were given wide discretion to regulate EVSE through their zoning bylaws (subject to conformity with other applicable laws). A guide prepared on behalf of the City of Richmond, a Canadian leader on the subject, sets out sample requirements including (1) an energized outlet for each parking space capable of servicing a Level 2 EVSE, (2) labelling (to support later installation), and (3) a "performance standard" specified by the City. This performance standard, which the City of Richmond set via a Technical Bulletin, sets out more specific electrical requirements to ensure enough electrical capacity is in place to allow for sufficient overnight charging, while also setting rules for the use of EVEMS.[209] Other BC municipalities following Richmond's lead have improved on this bylaw and

bulletin, creating 'best practices' that are being reviewed with interest by governments across North America.

EVEMS are "a means used to control EVSE loads through the process of connecting, disconnecting, increasing, or reducing electric power to the loads and consisting of any of the following: monitor(s), communications equipment, controller(s), timer(s), and other applicable device(s)."[210] They allow more EVSE to be added, even if the calculated or demonstrated load of the EVSE would otherwise exceed the rating of the electrical distribution equipment, feeders, or services. EVEMS are preferred by developers in many cases because they allow for more efficient use of available electrical capacity. These work in a MURB application because a typical EV does not require the full electrical capacity for which a standard Level 2 EVSE is rated for an entire overnight charging period based on normal Canadian driving ranges.

Stakeholders consulted for this study broadly agreed on the scope of EV-supportive requirements for EV-readiness in new MURBs. They also agreed that municipal action on EV-readiness requirements, led largely by BC has been strongly positive for the development of the industry. For example, stakeholders noted that, in BC, where the province determined that municipalities could lead regulation on the basis that EVSE are "out of scope" of BC's *Building Act*[211] municipal experimentation has permitted the development of strong policies that have led the way for the rest of Canada. They note that BC municipal leadership has resulted in coverage of many new BC MURB developments and is unimpeded by five year building code development cycles and even longer adoption cycles. Supporters of a zoning approach also note that it allows flexibility in performance requirements to address different power requirements that may be warranted in different municipalities or regions based on different distances travelled, environmental conditions (temperatures) and typical vehicle types. Some stakeholders argued that specific performance standards could reduce the risk of "over-building" electrical capacity that could result in a national standard that applies to all new MURBs.

While recognizing the important work done at the municipal level, the vast majority of stakeholders felt that it is also important to encourage broader, more consistent uptake of policies via national model building code amendments that could be adopted across Canada, particularly now that good models have been proven in a number of BC's municipalities. The majority of stakeholders argued that broader standardization, if correctly developed to address regional differences, will reduce compliance costs and uncertainty for the development community, while also supporting municipalities (and the MURB residents who live in them) who do not have sufficient expertise and/or resources to develop their own EV-supportive bylaws. Finally, while BC chose to allow for municipal experimentation, municipalities in other provinces may not have the same ability to regulate the availability of EVSE within MURBs because their municipal bylaw making authority is or could be superseded by provincial building code authority.[vii]

To address these concerns and future-proof the many MURBs to be built across Canada in the coming decades, stakeholders felt that the federal government should consider implementing EV-supportive model building code standards in the National Building Code. Stakeholders also referred to the possibility of including standards in the model National Energy Code, but noted that, so far, this code has not been widely adopted in Canada,[212] meaning that changes may not achieve the standardization objectives that are vital to broader EV adoption in MURBs. While provinces would not be required to adopt these model standards,[213] they would be able to use them as a starting point to develop their own, jurisdiction specific building code, energy code, or zoning requirements. Such standards would be consistent with federal policies targeted at increasing EV uptake and those targeted at improving the sustainability of buildings more broadly.[214]

Some stakeholders also suggested considering expanding the scope of Canada's model codes to address existing buildings similar to codes adopted by the City of Marin, the City of Menlo Park and the City and County of San Francisco.[215] These stakeholders suggested that codes can be applied during targeted building alterations and additions that provide cost-

[vii] For example, Subsection 31(1) states that Ontario's *Building Code Act, 1992* (OBCA) supersedes all municipal bylaws respecting the construction or demolition of buildings.

effective opportunities to install EV infrastructure based on the number of parking spaces that are added or modified; changes to electrical systems; and/or the total dollar value of the renovation compared to the cost of new construction.

Barrier: Condominium and Strata Legislation

Applies to: Existing MURBs

Typically, condominium or strata legislation, as well as condominium or strata agreements, create fairly lengthy and expensive processes to modify parts of the building that are owned on behalf of all condominium or strata owners (often called "common elements"). These can be triggered when individual condominium owners need to run electrical wiring from an electrical room to their parking space. Other rules can impact a condominium corporation or strata council's ability to make modifications and investments that would enable many or all owners to install EVSE in the future (including panel and electrical room upgrades) and bringing dedicated electrical sub-panels to parking areas. These rules can require formal notice periods, votes of a significant proportion of unit owners and legal amendments to the agreements that provide for the governance of the condominium or strata, all of which can create delay, risk of non-approval and add cost.[viii] Reports by EV owners or prospective owners that their requests to install EVSE were denied by condo or strata boards for various reasons, including fear of cost to other owners, are widespread across Canada.[216]

Solutions and Best Practices

The leading Canadian regulatory response to this issue is from Ontario, which enacted a regulatory reform commonly referred to as a "right to charge" in O. Reg. 48/01 under the *Ontario Condominium Act, 1998*. Broadly, a "right to charge" can include a number of features that support EVSE installation including:

- The process by which a condo owner can apply for installation
- The content of a complete application (including any drawings required)
- Default allocation of cost between the condo/strata owner and board or council considering both installation, use of electricity and maintenance/removal
- The deadline and rules regarding a condominium board or strata council's response
- A requirement to approve a complete application except under certain circumstances (typically associated with safety or legitimate negative impacts on other residents)
- Acceptable requirements related to insurance, maintenance and removal
- The ability of a condo board or strata council to propose modifications to an application, for example to require the use of energy management (which can help future owners install EVSE using existing electrical capacity)
- Dispute resolution procedures

It is also advisable to consider provisions allowing a condo board or strata council to initiate and expedite its own changes to support EVSE installation, within certain cost limitations, so that proactive buildings can make investments that will support multiple owners' installation and also develop policies that support efficient use of building electrical resources.

Stakeholders agreed that a "right to charge" regulation is a high priority for all Canadian provinces, but noted that any "right to charge" regulation does not remove the importance of providing condominium corporations and strata councils with financial support to make investments that will reduce the costs for each condo owner.

Barrier: Electricity-Related Legislative and Regulatory Barriers

Applies to: Existing MURBs

A secondary issue associated with EVSE installation in MURBs across Canada relates to the apportionment of electrical costs. As noted above, Ontario Energy Board (OEB) staff argued that selling EV charging services is distinguishable from the act of electricity retailing, and therefore does not trigger equivalent regulatory governance from the OEB.[217] Most Canadian provincial utilities commissions (other than BC's[218]) have not found that provision of EV charging services constitutes the sale of electricity; however most

[viii] For an excellent summary of the requirements that BC stratas can face, see City of Richmond. *Residential Electric Vehicle Charging*. Starting at Section 3.2.

have not yet considered the issue as part of a formal proceeding. Even in BC, the British Columbia Utilities Commission (BCUC) provided a clear suggestion to the provincial government that it consider some form of ministerial action to ensure that entities providing EV charging service are not subject to full regulation as public utilities, recognizing the many differences between providing EV charging services and the role of a traditional public utility. Stakeholders are anticipating a response from the BC government on this point. Therefore, while it could create barriers to cost recovery if other provinces follow the BCUC's decision without some form of exemption or exclusion from applicable utility legislation, most stakeholders hope that this will not create a major barrier across Canada going forward.

Solutions and Best Practices

Under the BCUC's recent Phase 1 Report in respect of its inquiry into the regulation of EV charging service,[219] the BCUC found that, because of the plain wording of the governing provincial legislation (the *Utilities Commission Act)* "a person who provides EV charging services for compensation is a "public utility" and therefore subject to regulation.[220] The BCUC went on to find, however, that most of the regulation that would typically apply is not required for persons (including strata councils) who are not "otherwise public utilities"[221] and to recommend that the province provide an exemption from the Act for such persons.[222] Not all regulatory bodies or staff across Canada have taken this position. OEB staff, for example, have argued that selling EV charging services is distinguishable from the act of electricity retailing, and therefore does not trigger equivalent regulatory governance from the OEB.[223]

The challenge is that every provincial act governing utility regulation has slightly different wording, and different administrative interpretation. Therefore, many stakeholders would prefer that provinces take proactive steps to clarify that the sale of electricity for EV charging purposes in a MURB context, at least, be exempted from provincial utility regulation.

Barrier: Measurement Rules

Applies to: Existing MURBs, New MURBs

A second issue that arises when common utility meters are used in MURBs relates to the measurement of electricity consumed. Most condo boards and strata corporations seek to recover the cost of electricity used by an EV-charging resident, to avoid a subsidy from other owners. The federal body with jurisdiction over ensuring accuracy in the selling of measured goods (including electricity), Measurement Canada, takes the position that any meter used as the basis for billing a person based on cost of electricity delivered based on energy (kWh) or power (kW) must be Measurement Canada-certified.[ix] Meters used for time-based charges only (minutes or hours charging) do not require measurement Canada certification.[224]

Solutions and Best Practices

While most new networked EVSE are designed with measurement systems to record the amount of energy dispensed, none are currently certified by Measurement Canada. Recently, Measurement Canada has advised that an interim certification approach is available, but many (if not all) EVSE currently in use in MURBs are not certified. Stakeholders have indicated that further progress on this issue is important for MURB residents in Canada. In the interim, some condo boards are charging flat monthly fees or time-based fees, to avoid contravening Measurement Canada regulations; however, many stakeholders advised that some form of energy or power-based billing is preferable for reasons of fairness to EV users, who may have different driving patterns (meaning some may be over- or under-charged using fixed fees or time-based models).

Financial Barriers

This section explores the range of costs associated with EV charging in MURBs and for garage orphans including those related to EVSE installation, operation and maintenance, and cost sharing between parties.

[ix] Some stakeholders also noted that, while current EVSE available for MURB applications typically concentrate on unidirectional energy delivery (to EVs), if bi-directional flow is used (i.e. "vehicle-to-grid" applications) additional requirements related to net metering devices would be applicable. See Measurement Canada. *E-27 Policy on the use of electricity meters in net metering applications*. Retrieved from: https://www.ic.gc.ca/eic/site/mc-mc.nsf/eng/lm00030.html#Section2.0

Barrier: Installation Costs

Applies to: Existing MURBs, New MURBs, Garage Orphans

The capital costs associated with the installation of EVSE and the ability to recover these costs, are key barriers for charging in MURBs and for garage orphans.[225] EVSE installation costs typically include permitting, inspections, engineering (review, drawings), electrical work, construction and labour. Costs increase as the distance between the electrical service and the parking space increases. In fact, some of the highest costs associated with EVSE installations are due to the distance between the electrical panel and the location of the EV charging station. Excavation, trenching or boring through parking garage walls and floors significantly increases the total installation cost. Transformer or service capacity upgrades can also dramatically affect overall installation costs. In this case, utilities would work together with building owners to determine if upgrades are required.[226]

Installation costs vary greatly and on a case-by-case basis. In addition, studies have presented differing cost estimates. For example, a study prepared for the City of Richmond estimated that the installation of a Level 1 charging station costs in the range of $126 for a townhouse and $1,443 for a high-rise MURB (assuming that all stalls are EV ready). The same study estimated that the installation of a Level 2 charging station would cost between $2,655 and $3,023 for EV ready stalls, and $4,000 to $8,000 for retrofits.[227]

By comparison, Metro Vancouver estimated that the installation of a Level 1 charging station would cost between $300 to $2,500, depending on whether a dedicated circuit or new outlet needs to be installed, the distance to the electrical room and if an upgrade to the electrical system is required. It was estimated that the installation of a Level 2 charging station would range from between $6,000 and $20,000. The cost of the EVSE varies depending on the type of charger ($400 to $4,000 for a single user; $2,200 to $16,000 for multiple users) and power output, whether it will be located indoors or outdoors, portable or hard-wired, networked or non-networked and single or dual port. Installation costs range between $4,000 and $16,000 depending on factors such as the number of circuits, distance to electrical room, building age and modifications, and electrical upgrades.[228] The City of Vancouver estimated that the cost for curbside EVSE installations can range from $5,500 to $10,200 for single units or $9,500 to $12,200 for dual units.[229]

Solutions and Best Practices

Electrical upgrades: Load management technologies (e.g., DCCs) can alleviate many of the installation costs related to electrical service upgrades. While it is less expensive to have multiple EV owners install EVSE at the same time, the use of load management technologies can offer an affordable solution for individual EV owners who want to charge in their own parking space.[230]

New MURBs that are required to be EV ready face challenges related to the need to plan for future transformer capacity to accommodate EV charging that far exceeds the building's current needs. The capital investment in transformer capacity could take decades to fully realize and usable real estate is lost to EVSE infrastructure before it is needed. As building for EV readiness is considered to be best practice, there may be opportunities to develop and use new technologies (e.g., built-in transformers) to help alleviate some of the associated challenges.

Existing MURB installations: The greater the distance between the electrical panel and the location of the EV charging station, the more costly the installation. Strategic planning should therefore involve ensuring that EV charging stations are initially located as close to the electrical room as possible. Parking space swaps could be pursued to support this goal. Where it is not possible to obtain a parking spot close to the electrical room, the use of surface mounted conduit may be an option in a parking garage to reduce costs related to trenching or boring.[231] If there is interest from a small number of EV owners to install charging stations, building owners and condo boards should consider surveying all residents to gauge future interest. Planning ahead for electrical capacity upgrades can result in considerable savings.[232]

New MURB installations: As previously noted, where possible, new MURBs should be designed to be EV ready as it is considerably more expensive to retrofit a building after the fact.[233] As previously noted, the City of Richmond study estimates that a retrofit installation would cost between $4,000 and $8,000.[234]

Funding programs: A number of leading jurisdictions provide funding for programs that target charging curbside and in MURBs.[235] Under BC's Clean Energy Vehicle Program, a 75% rebate, up to a maximum of $4,000, was available for the purchase and installation of a Level 2 charging station in MURBs on a first-come, first-serve basis. The program offered consultation on EV charging solutions in MURBs, as well as incentives for the installation of charging infrastructure. The program was popular and quickly oversubscribed.[236,x] Stakeholders consulted for this study suggested that governments could also consider providing incentives specific to rental apartments. The business case is not strong for installing EV charging stations in these buildings, due primarily to high tenant turnover rates.

The Tokyo Metropolitan Government provides subsidies for the cost and installation of charging infrastructure in MURBs and recognizes the importance of support and outreach to increase EV uptake in these buildings. Oslo, Norway provides funding for charging in apartment buildings, covering 20% of the costs (up to about $600) per charge point. Paris, France offers 50% of the costs for charging stations (up to 4,000 euros), per building.[237] In California, multiple utilities deliver incentive programs for the installation of EV charging stations in MURBs.[238] The Sacramento Municipal Utility District (SMUD) in California offers the Multifamily Charger Incentive, which offers financial incentives for each Level 2 hardwired wall or pedestal mounted EV charger port, up to a maximum of 20 charge ports per property.[239,240]

Barrier: Operation and Maintenance Costs

Applies to: Existing MURBs, New MURBs

Operation and maintenance costs can include electricity consumption and demand charges, EVSE network subscription, management time, billing transaction costs, and maintenance and repairs.[241] To facilitate load management and address barriers such as installation costs, some building owners, property managers or condo boards decide to install EV charging stations in common areas for use by all residents. These stations may also be used by the public in some cases.[242] In these circumstances, it is typical for building owners, property managers or

[x] Additional incentives and rebates are offered under the program for workplace and single-family home charging infrastructure and installation. Support and consultation on EV charging solutions are also offered for workplaces. More details available at: https://pluginbc.ca/incentives/charging-solutions-incentives/

condo boards to commit to a long-term contract with an EVSE service provider that handles all aspects related to EV charging station operation, maintenance and customer billing.[243] There are however, ongoing fees associated with these types of services (e.g., session fee + incremental fee on electricity costs).

Solutions and Best Practices

If the installation of EVSE by an EV owner is not possible, there is a need to incentivize condo boards, property developers and building owners to do so. This will require that the installation of EVSE makes economic sense (i.e., where costs in addition to those related to electricity use are minimized for EV owners). For example, the California Air Resources Board (CARB) incentivizes the installation of public chargers through the Low Carbon Fuel Standard (LCFS) regulation. Developers could contract with EVSE service providers to get a percent of LCFS credit value based on throughput of kWh, and both parties can sell the credits to high carbon fuel providers (e.g., oil companies) who are obligated to comply with the regulation. However, for some entities, directly generating and selling credits is not feasible, as they would need to aggregate several thousand credits in order to find counterparties.[244]

Stakeholders consulted for this study noted that other considered entities (e.g., utilities) may not have access to the quality of EV charging data needed to accurately count power consumption, and they may have limited direct interaction with EV consumers to communicate benefits and return value. This challenge could potentially be resolved by including mechanisms in the regulation that enable credit generation in aggregate by entities that have actual charging data (e.g., automakers, charging station operators including utilities, fleet owners) and require that credit proceeds go to support EV adoption and more charging infrastructure deployment. In California, regulators decided that the majority of residential charging credit value should be used as an upfront statewide vehicle incentive provided to consumers at the point-of-sale.

In addition, it should be noted that incentivizing EVSE installations through a Clean Fuel Standard approach will not be economically sufficient when the installation costs are on the higher end of the range (e.g., when power upgrades are required in the building).

Barrier: Cost-sharing

Applies to: Existing MURBs, New MURBs

As previously noted, in many jurisdictions there are restrictions on the resale of electricity by entities other than regulated utilities. This is particularly relevant for MURBs where building owners or condo boards may seek to recover installation costs by establishing a financial recovery model for EV charging independent of the electricity costs charged by the utility.[245]

Solutions and Best Practices

Building owners or condo boards have the option to install EV charging stations in common areas and recoup costs through a built-in billing system. Where feasible, EV charging stations in MURBs can be made accessible to the public to allow for a larger revenue stream.[246] In California, EV supply providers (EVSPs) and MURBs have special permission under California law to establish financial recovery models for EV charging, independent of the electricity costs charged by the utility.[247] In addition, the California Public Utilities Commission (CPUC) allows investor-owned utilities to own and operate charging stations.[248] For example, SDG&E Power Your Drive, a fully subscribed program, installed 3,500 chargers in apartment buildings, condos, and workplaces.[249] ChargePoint, in collaboration with the City of San Diego, the California Energy Commission (CEC) and other partners, installed 206 charging stations in MURBs as part of their ChargePoint MultiCharge program. Property owners applied for free EV charging stations but were responsible for the installation costs.[250] Powertree, a private company that installs EVSE in MURBs at no cost to the unit owners, rents the space from the building owner, providing a new source of revenue.[251]

Electrify America is a program born from the Volkswagen diesel emission scandal that is investing $2 billion in infrastructure, access and education for EV charging stations in workplaces and MURBs in Sacramento, Fresno, San Francisco, Boston, Seattle, and New York.[252] Electrify America covers all installation costs for the EV charging stations and then charges for their use.[253] Electrify Canada is currently focused on deploying DCFC near major highways and in big cities. There is no indication that MURBs will be included as part of this initiative.

Other Barriers

Barriers in this section are those that do not fit into any of the other categories.

Barrier: Rental-specific Barriers

Applies to: Existing MURBs, New MURBs, Garage Orphans

In 2015, 33.5% of Canadians rented.[254] Regardless of income level, homeowners are more likely than renters to own EVs as there are a number of additional charging barriers specific to rental properties. For example, renters are unlikely to invest in immobile property upgrades that they would not own.[255] In general, renters may not value energy-related investments made by landlords.[256] They are also more likely to live in MURBs where parking spots may not be assigned or available at all.

At the same time, landlords may be concerned about assuming liability for resident-owned EVSE located in common areas, including parking garages.[257] The installation of EV charging infrastructure is likely to be low on the list of priorities for capital expenditures for most property developers and building owners.[258] If a landlord makes the investment for a current tenant with an EV and then charges higher rent for the amenity, they may not be able to maintain the increased rent for the next tenant should they not own an EV.[259]

Solutions and Best Practices

Regulatory solutions: Building owners of existing MURBs are unlikely to see EV charging station investment as a priority without significant financial incentives.[260] As a result, it is likely that EV owners would be required to take on the full cost of EVSE installation. In California, Assembly Bill 2565 affords renters the ability to install chargers in their parking spots.[261,262] Senate Bill 880 makes it illegal to prohibit or restrict EV charging station installation in a designated parking spot in a MURB and provides for certain conditions if the charging station is installed in a common area.[263,264]

Public charging: Improved access to public charging in and around MURBs and for garage orphans is another means of addressing the inability of many renters to make a capital investment in EV charging infrastructure that is not their own. Some jurisdictions have addressed this issue by strategically installing public infrastructure in areas where the demand is greatest. Public EV charging stations installed at workplaces, institutions, retail locations and municipal parking lots may help alleviate some of need for at home charging.[265]

California is investing in public charging stations ($2.5 billion for 250,000 chargers by 2025), with a focus on serving EV owners without access to private charging.[266] Much of the funding will go toward communities known to have greater numbers of renters. Assembly Bill 1452 authorizes jurisdictions in California to dedicate on-street parking spaces for the purpose of EV charging.[267] The City of Berkeley has run a pilot project to allow homeowners without garages to install curbside chargers. Costs ranged from $4,000 to $10,000 USD. While only the homeowner can access the EV charging station, the parking spot itself is not reserved so anyone can park there. Working out arrangements with kind neighbours can help alleviate potential competition for parking spaces.[268,269]

In Amsterdam, public EV charging is critical, as a large percentage of the city's residents (renters and owners) are garage orphans. EV owners are given priority on the parking permit waiting list and they can also request the installation of an EV charging station, free of charge from Nuon/Heijmans (Nuon is an energy company and Heijmans is the installation partner).[270] EVBox is the key supplier of these charging stations.[271]

The Chinese government plans to build a nationwide charging network that can support up to 5 million EVs by 2020. Charging spots will be located in residential and business districts, as well as public areas and inter-city highways.[272] In addition, EV charging networks are planned for urban districts in East China's Zhejiang province, with the goal of one charging station for every 2 kilometres.[273]

In Canada, the City of Montreal aims to install a network of 1,000 charging stations for EVs (on- and off-street) by 2020. The network, which will be the first on this scale in the country, will serve the entire municipal territory, including densely built urban areas and boroughs.[274]

3 | MATRIX OF ACTIONS

What is the Matrix of Actions and How is it Used?

In 2016, as part of its approach to supporting the deployment of electric and hydrogen vehicles within the province, the Government of Ontario looked to international best practices for inspiration and conducted consultations with a range of stakeholders to test a matrix of actions aimed at addressing barriers to ZEV uptake. The purpose of the matrix was to create a framework for the actions that should be considered by relevant stakeholders within the province to promote ZEV adoption.

In 2017, Pollution Probe and The Delphi Group leveraged this matrix of actions during a series of regional workshops and included it as part of the resulting report, "*Accelerating the Deployment of Zero Emission Vehicles: Atlantic Canada and the Prairies.*"

The use of the matrix as part of the ZEV workshop series allowed for the testing of its effectiveness as a framework for helping stakeholders identify and visualize key actions and potential roles required to enable ZEV adoption. Given its effectiveness as a tool for shaping thinking about future actions, a similar framework approach was taken for this study to identify means of addressing barriers specific to charging in MURBs and for garage orphans.

Pollution Probe and The Delphi Group also used this matrix approach to support the development of their Framework for Municipal Zero Emission Vehicle Deployment, a generic municipal ZEV deployment framework which can be used by local and regional governments, along with other organizations, to accelerate the deployment of ZEVs. The development of the municipal framework was supported by NRCan.

For the purposes of this report, the following three matrices of actions were developed:

- Existing MURBs
- New MURBs
- Garage Orphans

The use of these three separate matrices will allow for greater exploration of the specific actions needed to address the unique barriers associated with each dwelling type. A clear understanding of the broader interconnections that exist across barriers, provides opportunities to determine appropriate and complementary solutions that do not unintentionally introduce new challenges. The three matrices of actions provide an effective visual map of potential future action that will allow stakeholders to identify opportunities where they can make meaningful contributions.

Stakeholder Involvement

This study identified that many key stakeholders involved in efforts related to MURBs and garage orphans, have no formal means of connection or collaboration and they may be unaware of each other's actions, successes and lessons learned. It will be critical however, for the full range of stakeholders to work together to develop and implement effective solutions to the barriers identified in Section Two of this report.

Table 6 shows the stakeholder groups included in the matrices of action and provides examples of the types of activities they may find value in contributing to. While different groups may have specific actions that they are more suited to leading, there will also be opportunities to partner and to support the actions of other stakeholders. The matrices of action are not meant to assign specific actions to different stakeholders or to indicate who should lead any related efforts.

Table 6: Stakeholders for Multi-Unit Residential Building and Garage Orphan Charging

Stakeholder	Relevant Areas for Participation	Other Potential Activities of Interest
Government (federal, provincial/ territorial and municipal)	• Regulatory or policy (all) • Funding or incentives (federal and provincial/territorial) • RD&D (federal) • Local scale infrastructure (municipal)	• Strategy/targets (all) • Funding/incentives (municipal) • Education/awareness/advisory services/training (all) • RD&D (provincial) • Regional scale infrastructure (federal and provincial) • Support for sharing economy (all) • Host sharing network (federal and provincial)
Utilities & Electricity Providers	• Funding or incentives • RD&D • Grid capacity and charging infrastructure • Load management planning • Metering and rate base solutions	• Education/awareness/advisory services/training • Support for real time data sharing • Strategic long-term planning
Industry including Technology Companies & EVSE Providers	• RD&D • Charging infrastructure • Technology availability	• Education/awareness/advisory services/training • Strategic long-term planning • Support for metering and rate base solutions • Support for sharing economy • Incentives
Real Estate Developers	• Electrical and charging infrastructure • Strategic long-term planning	• Education/awareness • RD&D • Host sharing network

Stakeholder	Relevant Areas for Participation	Other Potential Activities of Interest
Property Management & Apartment Building Owners	• Education and awareness • Electrical and charging infrastructure • Building plans and strategies	• R&D • Support for sharing economy • Incentives • Support for metering and rate base solutions • Strategic long-term planning
Condo & Strata Boards	• Building plans and strategies • Education and awareness • Electrical and charging infrastructure	• R&D • Support for sharing economy • Incentives • Support for metering and rate base solutions • Strategic long-term planning
Academia, Civil Society & Advocacy Organizations	• Education/awareness/advisory services/training • Host sharing network	• Funding or incentives, typically as partners • Infrastructure, typically as partners • R&D • Support for metering and rate base solutions • Support for sharing economy
EV Owners & Associations	• Education and awareness	• Contribute to R&D
Automakers	• Funding or incentives • RD&D • Charging infrastructure	• Education/awareness • Support for sharing economy

Matrix of Actions

The following broad categories have been used to organize potential actions related to addressing barriers to EV charging in MURBs and for garage orphans:

- **Grid Preparedness & Charging Infrastructure:** These barriers comprise those related to the electrical grid and EV charging infrastructure (not those specific to building design) as they pertain to MURBs and garage orphans.
- **Building Design & Physical Infrastructure:** Applicable only to MURBs, these barriers include those related to charging infrastructure in and around buildings.
- **Education & Awareness:** Barriers in this category relate to MURBs and garage orphans and focus on consumer, building owner and property manager awareness.
- **Regulatory & Policy:** This category covers barriers related to the regulations and policies (e.g., acts, codes, standards, process policies and bylaws) that impact EV charging in MURBs and for garage orphans.
- **Incentives & Support Programs:** This category of actions involves financial and other support programs, such as technical advisory services, and is applicable to MURBs and garage orphans.
- **Complementary Actions:** These actions comprise those that are supportive of the EV sector in general and may not be directly related to facilitating charging in MURBs or for garage orphans.

Note that the actions in the matrices may apply to more than one of the barrier categories outlined in Section Two. For example, regulatory and policy actions may be used to address regulatory and policy barriers, as well as those related to building design and physical infrastructure, or education and awareness.

The purpose of the matrices is not to recommend any one action over another. It is anticipated that specific jurisdictions and stakeholders will determine which actions are most appropriate to support or pursue based on their own priorities.

Matrix of Actions for Zero Emission Charging in Existing Multi-Unit Residential Buildings

GRID PREPAREDNESS & CHARGING INFRASTRUCTURE	BUILDING DESIGN & PHYSICAL INFRASTRUCTURE	EDUCATION & AWARENESS	REGULATORY & POLICY	INCENTIVES & SUPPORT PROGRAMS	COMPLEMENTARY ACTIONS
Investigate and implement distribution system demand management programs	Installation of EV chargers and associated systems for shared use in building common areas	Develop "how to" guidance and web content for EV and building owners, property management and condo boards to reference	Enact provincial "right to charge" regulatory amendments to condo or strata acts to facilitate approval of applications to install EV charging stations	Provide subsidies, tax credits or low-cost loans to condo/strata board or building owners for electrical infrastructure audit or assessment	Develop and implement curriculum at academic institutes related to EV charging
Explore options for demand management at the building level	Explore options for improved cellular connectivity in underground parking areas	Undertake educational campaigns targeting various stakeholder groups based on unique informational needs	Work with federal government to develop approved metering solutions that enable billing for EV charging based on energy usage	Provide financial incentive to MURB residents, building owners or condo/strata boards to purchase and install networked or otherwise energy managed EV charging stations	Installation of public charging infrastructure at workplaces and public locations including in densely populated residential areas to address daytime charging needs
Explore use of technologies capable of augmenting existing electrical capacity	Undertake RD&D and pilot programs that promote use of new technologies that address physical constraints for EV charging in buildings	Develop best practice guidelines and turnkey solutions for condo boards, building owners, property managers and municipalities	Develop condo or strata EV charging station installation policy with a focus on maximizing existing electrical infrastructure and consider EV-supportive upgrades as part of condo/strata board planning processes	Provide financial assistance to building owners or condo/strata boards to support electrical capacity upgrades where demand management solutions are insufficient	Support for RD&D, demonstration and commercialization of EV charging technologies
Prioritize investment in charging infrastructure options that address multiple charging needs (e.g., residential and public charging)	Undertake necessary building upgrades (panel, transformer) where demand management solutions are insufficient	Provide advisory services and workshops on EV charging station installation specific to MURBs	Require municipal departments, building owners, property managers and condo or strata boards to provide information to help consumers make decisions about EV charging installations	Explore the potential to fund the installation of chargers in MURBs or the throughput of kWh through Clean Fuel Standard (CFS) or British Columbia's low carbon fuel standard (LCFS) credits. Note: Parties eligible to generate credits may differ under the standards.	Promotion of electric car share and rideshare services and associated charging infrastructure, as alternative for MURB residents without access to EV charging.
Installation and preferential use of nearby public charging infrastructure to address overnight charging needs of MURB residents	Consider solutions that ensure access to charging infrastructure where parking stalls are deeded (e.g., swapping parking spaces)	Develop materials to communicate business case for EV charging to condo boards, property management and apartment building owners	Provide clarity on ability to recover costs for EV charging services without regulation as a public utility either by utility regulatory decision or provincial legislative exemption	Conduct social equity analysis and consider how to make EV charging stations accessible for underserved neighbourhoods	Develop public education materials to improve general knowledge about EV charging and connect potential buyers with current EV owners

GRID PREPAREDNESS & CHARGING INFRASTRUCTURE	BUILDING DESIGN & PHYSICAL INFRASTRUCTURE	EDUCATION & AWARENESS	REGULATORY & POLICY	INCENTIVES & SUPPORT PROGRAMS	COMPLEMENTARY ACTIONS
Develop program for informing utilities about where EV charging in MURBs currently exists or is planned		Develop training programs for local governments, contractors and other stakeholders related to EV charging installation in MURBs	Develop policy and guidelines that provide clarity on appropriate fee structure for cost recovery on charging infrastructure and ability of utility to rate base installation costs	Preferential parking rate for EV owners in common spaces equipped with chargers	Investigate options for sharing home EV chargers (peer-to-peer charging)
Leverage planned energy retrofits & upgrades to outfit buildings with EV charging infrastructure		Develop a platform and stakeholder network for sharing resources and best practices	Explore potential for requiring installation of EV charging stations when substantial renovations necessitate a permit and/or compliance with building code	Continued research into addressing barriers to charging in MURBs	Develop guidelines and best practices for procurement of public EV charging stations
Undertake RD&D and pilot programs that address grid capacity and demand management related to EV charging		Conduct or host demonstrations and events related to EV charging in MURBs	Require provincial landlord tenant laws to incorporate consideration for EV charging	Provide technical assistance and services for EV charger installation to building owners, property managers and condo boards	Development and use of websites and apps providing real time information on availability and cost of public EV chargers
Ensure EV charging in MURBs is accounted for in long-term load management planning and forecasting		Work together with the real estate sector to list EV charging access as a standard housing attribute in real estate listings	Explore potential for condo or strata boards to use portion of reserve funds to support EV charging station installation or EV-readiness upgrades		Develop supportive policies, electrification targets and incentive programs to signal support for long-term market growth
			Remove requirements for approval from committee of adjustment to install EV charging station in visitor parking		Explore options for enabling utilities to own and operate EV charging infrastructure
			Explore removal of demand charges for purposes of EV charging.		

LEGEND

- Government actions
- Utility & electricity provider actions
- Industry & EVSE provider actions
- Real estate developer actions
- Property management & apartment building owner actions
- Condo & strata board actions
- Academia, civil society & advocacy organization actions
- EV owners & associations actions
- Automaker actions

Matrix of Actions for Zero Emission Charging in New Multi-Unit Residential Buildings

GRID PREPAREDNESS & CHARGING INFRASTRUCTURE	BUILDING DESIGN & PHYSICAL INFRASTRUCTURE	EDUCATION & AWARENESS	REGULATORY & POLICY	INCENTIVES & SUPPORT PROGRAMS	COMPLEMENTARY ACTIONS
Investigate and implement distribution system demand management programs	Installation of EV chargers and associated systems in private spaces and for shared use in building common areas	Develop "how to" guidance and web content for EV and building owners, property management and condo boards to reference	Include model requirements for EV ready parking spaces and building electrical capacity in National Building Code and work with provinces to establish province-wide standards	Provide subsidies, tax credits or low-cost loans to condo/strata board or building owners for electrical infrastructure audit or assessment and EV-ready upgrades	Develop and implement curriculum at academic institutes related to EV charging
Explore options for demand management at the building level	Explore options for improved cellular connectivity in underground parking areas	Undertake educational campaigns targeting various stakeholder groups based on unique informational needs	Review and update provincial building codes to include requirements for EV-ready parking and building electrical capacity	Explore options for removing barriers in the customer interconnection process (e.g., easing utility expansion deposit requirements for developers who plan to install EV charging infrastructure)	Installation of public charging infrastructure at workplaces and public locations including in densely populated residential areas to address daytime charging needs
Explore use of technologies capable of augmenting existing electrical capacity	Undertake RD&D and pilot programs that promote use of new technologies that address physical constraints for EV charging in buildings	Develop best practice guidelines and turnkey solutions for condo boards, building owners, property managers and municipalities	Where appropriate, use zoning or parking bylaws to require parking spaces be EV ready (either roughed-in or EVSE installed) with minimum charging performance standards	Provide financial incentive for real estate developers to install networked or otherwise energy managed EV charging stations	Support for RD&D, demonstration and commercialization of EV charging technologies
Prioritize investment in charging infrastructure options that address multiple charging needs (e.g., residential and public charging)	Strategic long-term planning related to location of EV ready parking spaces	Provide advisory services and workshops on EV charging station installation specific to MURBs	Work with federal government to develop approved metering solutions that enable billing for EV charging based on energy usage	Explore the potential to fund the installation of chargers in MURBs or the throughput of kWh through Clean Fuel Standard (CFS) or British Columbia's low carbon fuel standard (LCFS) credits. Note: Parties eligible to generate credits may differ under the standards.	Promotion of electric car share and rideshare services and associated charging infrastructure, as alternative for MURB residents without access to EV charging.
Installation and preferential use of nearby public charging infrastructure to address overnight charging needs of MURB residents		Develop a platform and stakeholder network for sharing resources and best practices	Incorporate EV charging station installation needs into building development and planning processes	Conduct social equity analysis and consider how to make EV charging stations accessible for underserved neighbourhoods	Develop public education materials to improve general knowledge about EV charging and connect potential buyers with current EV owners

GRID PREPAREDNESS & CHARGING INFRASTRUCTURE	BUILDING DESIGN & PHYSICAL INFRASTRUCTURE	EDUCATION & AWARENESS	REGULATORY & POLICY	INCENTIVES & SUPPORT PROGRAMS	COMPLEMENTARY ACTIONS
Develop program for informing utilities about where EV charging in MURBs currently exists or is planned		Develop materials to communicate business case for real estate developers	Provide clarity on ability to recover costs for EV charging services without regulation as a public utility either by utility regulatory decision or provincial legislative exemption	Preferential parking rate for EV owners in common spaces equipped with chargers	Investigate options for sharing home EV chargers (peer-to-peer charging)
Undertake RD&D and pilot programs that address grid capacity and demand management related to EV charging		Highlight benefits of EVSE in building certification programs (e.g., LEED).	Require municipal departments, building owners, property managers and condo or strata boards to provide information to help consumers make decisions about EV charging installations	Continued research into addressing barriers to charging in MURBs	Develop guidelines and best practices for procurement of public EV charging stations
Ensure EV charging in MURBs is accounted for in long-term load management planning and forecasting		Conduct or host demonstrations and events related to EV charging in MURBs		Provide best practices, technical assistance and services for EV charger installation to building owners, property managers and condo boards	Development and use of websites and apps providing real time information on availability and cost of public EV chargers
		Work together with the real estate sector to list EV charging access as a standard housing attribute in real estate listings		Explore potential to reduce total number of parking stalls required per building in exchange for EV ready development	Develop supportive policies, electrification targets and incentive programs to signal support for long-term market growth
					Explore options for enabling utilities to own and operate EV charging infrastructure

LEGEND

- Government actions
- Utility & electricity provider actions
- Industry & EVSE provider actions
- Real estate developer actions
- Property management & apartment building owner actions
- Condo & strata board actions
- Academia, civil society & advocacy organization actions
- EV owners & associations actions
- Automaker actions

Matrix of Actions for Zero Emission Charging for Garage Orphans

GRID PREPAREDNESS & CHARGING INFRASTRUCTURE	EDUCATION & AWARENESS	REGULATORY & POLICY	SUPPORT PROGRAMS & INCENTIVES	COMPLEMENTARY ACTIONS
Investigate and implement distribution system demand management programs	Develop "how to" guidance and web content for garage orphans to reference related to potential charging options	Develop bylaws that allow reserved parking for EV charging in residential neighbourhoods	Provide financial incentive for EV charging station installation in public lots, community centres, schools, or churches when preferential parking for garage orphans is provided	Develop and implement curriculum at academic institutes related to EV charging
Explore use of technologies capable of augmenting existing electrical capacity	Undertake educational campaigns targeting various stakeholder groups based on unique informational needs	Develop bylaws that allow for permits for parking in front of house or off-street parking permits (i.e., parking pads) in currently prohibited area	Preferential charging rate or discounted parking for garage orphans at curbside charging stations and parking lots	Installation of public charging infrastructure at workplaces and public locations including in densely populated residential areas to address daytime charging needs
Prioritize investment in charging infrastructure options that address multiple charging needs (e.g., residential and public charging)	Develop a platform and stakeholder network for sharing resources and best practices	Provide clarity on resale of electricity by private entities for EV charging or legislative exemption	Incentivize shared home EV chargers (peer-to-peer charging)	Support for RD&D, demonstration and commercialization of EV charging technologies
Undertake RD&D and pilot programs that address grid capacity and demand management related to EV charging	Conduct or host demonstrations and events related to EV charging for garage orphans	Develop bylaws (including all permitting) that allow for curbside EV charging station installation in residential areas.		Investigate options for sharing home EV chargers (peer-to-peer charging)
Build out network of residential on-street charging stations for use by local owners		Develop policies for tracking EV charging data in curbside residential charging stations		Promotion of car share services as alternative for MURB residents without access to EV charging (garage orphans)
Explore feasibility of EV charging technologies and solutions that work within existing parking bylaws				Develop public education materials to improve general knowledge about EV charging and connect potential buyers with current EV owners
Installation and preferential use of nearby public charging infrastructure to address overnight charging needs of garage orphans				Develop guidelines and best practices for procurement of public EV charging stations
Explore opportunities to install EV charging infrastructure in neighbourhood municipal parking lots, community centres or schools				Development and use of websites and apps providing real time information on availability and cost of public EV chargers

GRID PREPAREDNESS & CHARGING INFRASTRUCTURE	EDUCATION & AWARENESS	REGULATORY & POLICY	SUPPORT PROGRAMS & INCENTIVES	COMPLEMENTARY ACTIONS
Ensure loads associated with EV charging by garage orphans is accounted for in neighbourhood-level distribution system planning ■				Develop supportive policies, electrification targets and incentive programs to signal support for long-term market growth ■
				Explore options for enabling utilities to own and operate EV charging infrastructure ■ ■

LEGEND

■ Government actions ■ Utility & electricity provider actions ■ Industry & EVSE provider actions ■ Real estate developer actions ■ Property management & apartment building owner actions ■ Condo & strata board actions ■ Academia, civil society & advocacy organization actions ■ EV owners & associations actions ■ Automaker actions

Next Steps

Study on ZEV Charging in Multi-Unit Residential Buildings and for Garage Orphans

This report will be broadly disseminated with the intent of targeting a range of audiences including, but not limited to, MURB owners, garage orphans, developers, tenants, municipalities and utilities. It will also be made available to the general public, as all Canadians stand to benefit from the information found herein. In order to further assist stakeholders and raise awareness among MURB residents, NRCan is also developing a set of factsheets that will complement this report. The factsheets will summarize the main findings and tangible actions that can be taken to address barriers to EV charging in MURBs and for garage orphans. It is anticipated that these factsheets will be published in the spring or summer of 2019 and they will be made available online.

Decarbonizing Transportation in Canada

NRCan, together with the U.S. Department of Energy, is committed to developing and aligning codes and standards for low-carbon vehicles and refueling infrastructure. NRCan has established a working group for electrification that meets on a bi-monthly basis, with a current focus on the regulatory framework around EV charger installation, including municipal bylaws and the resale of electricity. The group will also meet on a semi-annual basis to address other fuel types (e.g. natural gas, propane and hydrogen) as part of a low-carbon vehicle codes and standards community of practice that will discuss common regulatory barriers, as well as possible solutions.

First Ministers have agreed to collaborate on ways to promote clean growth while growing the economy. As a next step, First Ministers will lead a discussion on the development of a framework for a clean electric future, including hydroelectricity, aimed at using clean, reliable and affordable electricity and to promote access to domestic and international markets.

The IGRWG, convened by NRCan in 2017, and expanded and re-launched in 2018, will continue to explore issues related to the electrification of transportation. The group will also investigate how barriers to mass adoption of ZEVs can be addressed, and how clean growth opportunities can be realized. NRCan's Consumer Awareness Expert Group, which was launched at the same time as the IGRWG, will be re-engaged in 2019.

Conclusion

The deployment of EVs presents an important opportunity to contribute to achieving Canada's GHG reduction targets and to realize a range of environmental, economic, and social benefits. Canada has seen a major uptake of EVs over the past several years, however, in order to accelerate the deployment of EVs, a number of remaining barriers need to be addressed, particularly those related to charging in MURBs and for garage orphans.

An increasing proportion of the Canadian population resides in multi-unit residential condominium and apartment buildings or dwellings without access to a driveway or garage. These MURB and garage orphan residents are potential mainstream EV adopters, however, they face a number of unique charging-related challenges. MURB residents in particular, face some of the greatest barriers related to the installation of charging infrastructure due to the challenges associated with common property. Effectively addressing these challenges and ensuring that MURB residents and garage orphans have convenient access to charging, will be critical to supporting widespread EV adoption in Canada.

Stakeholders have begun to address challenges associated with EV charging, including those specific to MURBs and for garage orphans, however, strategies, actions and approaches to date have varied significantly across the country due to different regulatory environments, availability of resources, levels of awareness and unique regional needs. However, a number of coordinated actions by a range of stakeholders will be required to effectively address the challenges associated with charging in MURBs and for garage orphans.

To contribute to knowledge-building and awareness-raising, this study aimed to identify and categorize key barriers and opportunities for EV charging in MURBs and for garage orphans and to communicate potential solutions and best practices. While a number of useful reports on charging in MURBs and for garage orphans exist, this study's focus on research gathered through an in-depth literature review and series of interviews with key subject matter experts and stakeholders, have contributed to a first-of-its kind, comprehensive, multi-sectoral report that addresses the full spectrum of barriers and suggests a suite of options for potential future action.

Three matrices of actions were developed for this study, highlighting the unique challenges facing existing MURBs, new MURBs, and garage orphans. The matrix of action framework provides an effective visual mapping of potential future actions. As a result, each of the matrices of actions enables stakeholders to easily identify opportunities where they can make meaningful contributions. The matrices present practical actions that will support ongoing EV deployment in Canada, as the market continues to expand and evolve. This report and more specifically, the matrices of actions, will help facilitate capacity building and stakeholder collaboration, resulting in a holistic, strategic, and cost-effective path toward mass EV adoption and integration.

Appendix A: Dwelling Types and Distribution

Population Distribution and Dwelling Type

In general, the majority of high-rise MURBs and garage orphans are found in urban centres and more specifically, urban cores, where land is generally more expensive. In dense urban residential neighbourhoods, on-site parking (e.g., driveways, garages, parking pads) is typically limited. The majority of high-rise MURBs located in urban centres have their own dedicated underground parking, while many residents of single-family homes depend on on-street parking.

Population centres with at least 1,000 people and a population density of 400 people or more per square kilometre, are classified as one of the following three groups, determined by Statistics Canada, depending on population size:

- Small population centres, with a population of between 1,000 and 29,999
- Medium population centres, with a population of between 30,000 and 99,999
- Large urban population centres, with a population of 100,000 or more.

All areas outside of population centres are classified as rural. Taken together, population centres and rural areas cover all of Canada. Almost 60% of Canadians live in large urban population centres while approximately 19% live in rural communities (see Table 7). Residents in rural areas are not typically constrained by space and have fewer MURBs or garage orphans compared to large urban population centres.

Table 7: Distribution of Population in 2016[275]

Population classification	Count	Percentage
Rural area	6,575,373	18.7
Small population centre (1,000 to 29,999)	4,458,766	12.7
Medium population centre (30,000 to 99,999)	3,179,294	9
Large urban population centre (100,000 or greater)	20,938,295	59.6
Total	35,151,728	100

Table 8 presents the distribution of dwelling types in seven large urban population centres in Canada. The table shows that apartments (i.e., apartment or condo units in duplexes, low- or high-rise buildings) were more common than single-detached houses in Vancouver, Montreal, Québec City, and Toronto.[276] Toronto had the greatest number of high-rise buildings (i.e., five or more storeys) at approximately three in 10 dwellings. In Montreal, four in 10 dwellings were apartments with fewer than five storeys.[277] Outside of large urban population centres, the majority (73%) of dwellings in 2016 were single-detached houses.[278]

Table 8 Types of Dwellings in Major Cities in Canada[279,280]

City	Apartments	Single-detached houses
Vancouver	58%	29%
Montréal	58%	33%
Québec City	49%	41%
Toronto	44%	40%
Ottawa-Gatineau	31%	45%
Edmonton	27%	57%
Calgary	25%	58%

Note: Apartments include dwellings or units in low- and high-rise buildings, as well as duplexes.

Dwelling Age and Turnover Rate

Typical buildings have a lifespan of 50 to 100 years. Based on a survey of 227 commercial and residential buildings in Canada and the U.S., the top four reasons for building demolition include:

- No longer suitable for needs
- Area redevelopment
- Physical condition
- Fire damage

Of those buildings where physical conditions were the reason for demolition, 65% were between 76 and 100

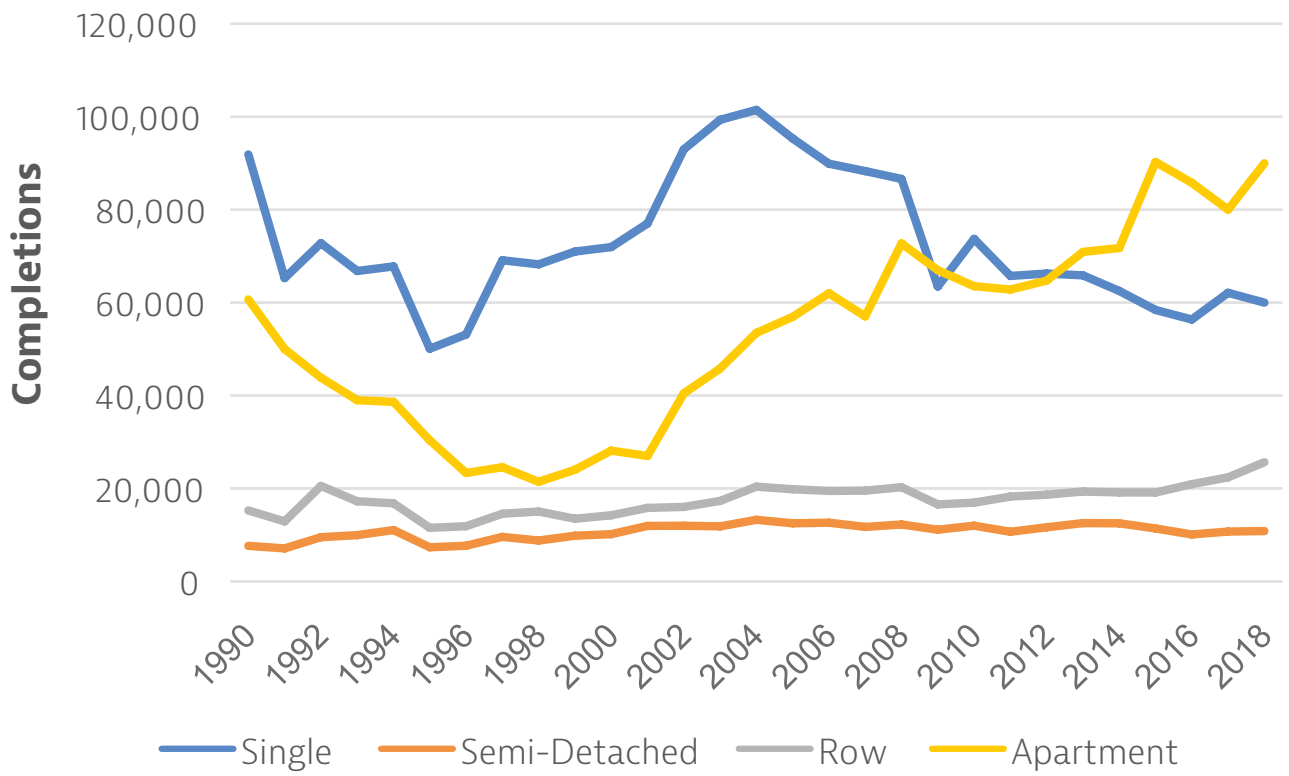
years old.[281] Table 9 shows Canada-wide building stock by dwelling type and vintage.[282] The table provides an idea of the percentage of older MURBs that may be nearing the end of their useful life, requiring new buildings to be constructed in their place that could accommodate EV charging with fewer barriers. Approximately half the apartment building stock (including apartment or condo units in duplexes, low- and high-rise buildings) in Canada was built 40 or more years ago.

Table 9: Building Stock and Vintage

Dwelling Type	Before 1946	1946 - 1960	1961 - 1980	1981 - 2000	2001 - 2016	Total Number
Apartment (in a building with 5+ stories)	3%	7%	36%	26%	28%	1,390,770
Apartment (in a flat or duplex)	17%	20%	29%	20%	13%	771,670
Apartment (in a building with <5 stories)	12%	12%	32%	25%	19%	2,539,325
Other attached dwelling	11%	11%	30%	26%	22%	4,949,585
Semi-detached house	10%	8%	28%	26%	28%	706,135
Row house	3%	3%	26%	33%	34%	897,645
Other single-attached house	33%	18%	24%	16%	10%	34,850
Single-detached house	11%	13%	28%	27%	20%	7,541,555

The construction of apartments and condominiums in Canada continues to accelerate and as of 2012, it has surpassed the growth of single-detached houses.[283] Figure 5 shows building completions over time for census metropolitan areas, census agglomerations,[xi] and other selected municipalities with at least 10,000 people.[284]

Figure 5: Historical Building Completions by Dwelling Type



[xi] Census metropolitan areas (CMA) and census agglomerations (CA) are areas consisting of one or more neighbouring municipalities centred around a core. CMAs must have a population of at least 50,000 in the core and at least 100,000 overall. CAs must have a population of at least 10,000 in the core.

Appendix B: Municipal and District Initiatives and Activities Related to Multi-Unit Residential Buildings and Garage Orphans

Alberta	Activity Area	Activity Description
City of Calgary	EV Action Plan or Strategy (including Community Plans)	• Developing EV Strategy as part of Climate Resilience Plan that will examine cost-effective opportunities to address charging in MURBs and for garage orphans (e.g., extra space in electrical rooms to allow for future capacity, enabling condos to provide communal EV charging in visitor stalls, planning for community charging hubs and public charging on-street or at community destinations)
City of Edmonton	EV Action Plan or Strategy (including Community Plans)	Edmonton's Electric Vehicle Strategy being developed with strategic objective for improving opportunities for residential EV charging and addressing barriers in MURB context. Strategy also includes the following: • Provide non-permanent financial incentives, aimed at residents, to reduce the cost of EV charging infrastructure • Leverage municipal regulations and processes to better support the advancement of EVs • Undertaking public education and marketing activities to create awareness and build support for EVs among Edmontonians
	Pilot Project	• Curbside charging pilot project with ATCO Energy to install five Level 2 dual-port charging stations at on-street City parking spaces (likely in business areas)
		• Installation of curbside charging stations with AddÉnergie (support from NRCan)
British Columbia	**Activity Area**	**Activity Description**
City of Burnaby	Infrastructure Requirements for New MURBs	• Adopted zoning bylaw requirement for every dwelling unit: every required parking space, excluding visitor and secondary suite, provided with energized outlet for Level 2 charging. Previously: Multi-unit residential buildings: negotiated ~10% of parking stalls EV-ready or EVSE installed.
Capital Region District (CRD)	Education & Awareness	• CRD's Infrastructure Planning Guide identifies strategies for local governments, electoral areas and private developers to expand EV and E-Bike charging infrastructure in the Capital Region. Strategies include policy options and opportunities to increase EV charging infrastructure in new developments and approaches for retrofitting existing MURBs. • The Capital Region EV + E-Bike Infrastructure Planning "Backgrounder" complements the Infrastructure Planning Guide, providing a summary of EV and E-Bike research undertaken by CRD. Both documents are the outcomes of the EV and E-Bike Infrastructure Planning Project, which was undertaken to understand and assess opportunities to advance EV and E-Bike charging infrastructure in public and private locations throughout the region. "

City of Coquitlam	Infrastructure Requirements for New MURBs	• Adopted zoning bylaw requirement for one energized, Level 2 outlet per dwelling unit for apartment, townhouse, and street-oriented village home. Coquitlam is considering a zoning bylaw amendment that will clarify definitions for EVEMS and EV supply equipment, require that 100% of residential parking spaces be equipped with an energized outlet capable of Level 2 charging or higher where the minimum number of parking spaces required is less than the number of dwelling units and exclude visitor parking spaces from the EV charging requirements.
City of Port Coquitlam	Infrastructure Requirements for New MURBs	• Zoning bylaw requirement for one stall per residential unit for all dwelling types is roughed-in for Level 2 charging (all electrical infrastructure other than wire)
Corporation of Delta	Infrastructure Requirements for New MURBs	• Delta Zoning Bylaw No. 7600, 2017 requires that a minimum of 20% of parking spaces in all MURBs or mixed use buildings with more than 6 dwelling units are provided with: • a 40A Level 2 EV charging station, or • a rough-in electrical raceway or cable, electrical panel capacity and physical space for equipment at the parking space and in the electrical room to accommodate 40A Level 2 EV charging station • parking spaces should be separately metered and clearly labeled."
District of Squamish	Infrastructure Requirements for New MURBs	• Zoning bylaw requirement for 30% of off-street parking stalls in shared parking areas of MURBs have shared access to Level 2 EV charging receptacles. District of Squamish is considering a zoning bylaw amendement for the provision of EV charging infrastructure in 100% of the off-street parking stalls in shared parking areas for MURB resident use.
City of New Westminster	Infrastructure Requirements for New MURBs	• Zoning bylaw requires an energized outlet for EV Charging in 100% of new residential construction. The City's Development Permit Area guidelines recommend providing EV charging infrastructure in visitor parking in MURBs
City of Langley	Infrastructure Requirements for New MURBs	• City of Langley prepared a draft zoning bylaw that requires at least two of the parking spaces to be provided with EV charging equipment, where 50 or more resident parking spaces are provided for an apartment residential use
Township of Langley	Infrastructure Requirements for New MURBs	• The Township of Langley initiated work to update zoning bylaw to make EVSE mandatory in new residential construction. Township is proposing that one parking space per dwelling in new residential construction be equipped with an energized outlet capable of providing Level 2 charging.
City of Maple Ridge	Infrastructure Requirements for New MURBs	• A proposed zoning bylaw amendment required 100% of off-street residential parking spaces in new MURBs to be energized (Level 2) and 50% of visitor parking to be wired for a minimum of Level 2 charging. City Council has instructed staff to examine the potential to require only rough-in for EV charging stations.

City of North Vancouver	EV Action Plan or Strategy (including Community Plans)	City of North Vancouver EV Strategy proposes the following related to MURBs and garage orphans: • Incorporating into Zoning Bylaw, a requirement for 100% of residential parking spaces outfitted with energized outlets capacble of Level 2 charging, allowing for load management systems (currently 20% of parking spaces are supplied by 40A 240V branch circuit and capacity in electrical room for 100% of parking spaces) • Retrofit Incentives for MURBs to improve access to home charging for resident • Advocate for provincial regulations that require strata corporations to allow installation of EV charging infraastructure where safe and feasible • Provide education to stratas, landlords, property managers to facilitate EV charging retrofits in existing MURBs and promoting resources available through www.evcondo.ca
	Infrastructure Requirements for New MURBs	• Zoning bylaw requires that a minimum of 20% of all residential visitor parking spaces include energized outlet capable of providing minimum Level 2 charging level for EVs. Bylaw amendment requiring 10% of parking spaces for residential use (except visitor parking) have an energized outlet capable of minimum Level 2 charging will come into effect on June 1st, 2019. Where an EVEMS is implemented, the Director of Planning can require a minimum performance standard to ensure sufficient rate of charging.
District of North Vancouver	Infrastructure Requirements for New MURBs	• Requires 20% of MURB parking spaces are EV-ready (wired for Level 1) and conduit for 100% of spaces.
Regional District of Nanaimo	Residential EV Charging Station Incentive	• Offers residential Level 2 EV Charging Station rebate of $250
City of Port Moody	EV Action Plan or Strategy (including Community Plans)	• The 2014 Official Community Plan states that the City will encourage the provision of EV charging stations as part of new development
	Infrastructure Requirements for New MURBs	• The City is considering a zoning bylaw amendment to require that parking spaces for all new dwelling units (excluding visitor parking spaces, secondary suite parking spaces and new parking spaces servicing existing dwelling units), are equipped with an energized outlet capable of providing Level 2 charging. EVEMS can be used to meet the requirements.
City of Richmond	Education & Awareness	Developed the following resources to support EV charging in MURBs: • Electric Vehicle Charging Infrastructure in Shared Parking Area: Resources to Support Implementation & Charging Infrastructure Requirements - Assists developers, designers, property managers, and others interested in EV charging installation in MURB • Residential Electric Vehicle Charging: A Guide for Local Governments - to provide guidance on establishing EV charging infrastructure requirements for new developments and support in existing residences.
		• Commissioned costing study from AES Engineering to study the total cost of various construction scenarios for EV charging including capital costs for construction and future retrofit costs for MURBs
	Infrastructure Requirements for New MURBs	• Richmond Zoning Bylaw requires every residential parking space, excluding visitor parking, be equipped with energized outlet (Level 2)

District of Saanich	EV Action Plan or Strategy (including Community Plans)	• Saanich is exploring opportunities and actions to support uptake of EVs, including strategies such as a requirement for EV-ready new developments and supporting retrofits to install EV charging infrastructure in existing buildings
	Infrastructure Requirements for New MURBs	• Considering zoning bylaw requirement for energized outlets for EV charging in 100% of new residential construction
City of Surrey	Pilot Project	• Installation of curbside charging stations with AddÉnergie (support from NRCan)
	Infrastructure Requirements for New Builds	• In the process of passing zoning bylaw amendment to require an energized outlet for EV charging in 100% of new residential construction
City of Vancouver	EV Action Plan or Strategy (including Community Plans)	Vancouver's EV Ecosystem Strategy includes the following: • Proposes to develop programs that encourage retrofitting in MURBs • Advocates for more clarity and exemptions to enable private sector station hosts to charge fees for electricity under the BC Utilities Commission Act • Develop in-building "Innovation Zones" that link incentives for car-share parking with creation of EV charging at car-share parking stalls • Advocates for provincial regulations to require strata corporations allow the installation of EV charging infrastructure where it is technically feasible and safe • Require cellular repeaters in all underground parking levels to enable networked stations • Work with BC Hydro to determine how best to mitigate impacts to distribution system
		• Vancouver Parking By-law requires every parking space in MURB, excluding visitor must have energized outlet for Level 2 charging (previously 20% of parking stalls)
	Pilot Project	• Installation of curbside charging stations with AddEnergie (support from NRCan)
		• Curbside Electric Vehicle (EV) Pilot program will include 15 stations installed on the City boulevard in residential areas
	Education & Awareness	• Promotes EV resources, including information specific to MURBs and garage orphans available through Metro Vancouver's www.evcondo.ca
		• Offers charging station installation tips specific to MURBs
City of Victoria	EV Action Plan or Strategy (including Community Plans)	• Victoria's Official Community Plan (2012) includes policy objectives to consider the provision of EV charging stations in new multi-unit residential and mixed use development
	Infrastructure Requirements for New MURBs	• Considering zoning bylaw requirement for energized outlets for EV charging in 100% of new residential construction
District of West Vancouver	Infrastructure Requirements for New MURBs	• The District's 2018 Sustainable Buildings Policy 02-80-386 requires that all residential parking spaces (excluding visitor parking) in new buildings New buildings should demonstrate that all residential parking spaces, have an energized outlet capable of Level 2 EV charging. Energy management system that controls the rate and timing of EV charging is considered to be sufficient for this purpose.
City of White Rock	Infrastructure Requirements for New MURBs	• One energized parking space for every 10 spots in addition to one "roughed-in"(Level 2) spot for every parking spot for future use

Ontario	Activity Area	Activity Description
City of Cambridge	Pilot Project	• Installation of curbside charging stations with AddÉnergie (support from NRCan)
City of Kingston	EV Action Plan or Strategy (including Community Plans)	• Forecast and assess implications of future EV charging demands by residential and commercial customers and future building code requirements
City of Kitchener	Pilot Project	• Installation of curbside charging stations with AddÉnergie (support from NRCan)
City of London	Pilot Project	• Installation of curbside charging stations with AddÉnergie (support from NRCan)
City of Toronto	Pilot Project	• The Residential On-Street EV Charging Station pilot will provide EV charging stations at six locations to serve a total of eleven EV parking spaces in residential parking areas • A second pilot will involve deploying five EV charging stations at three downtown locations to serve short-term (up to three hours) charging in public on-street space
	Infrastructure Requirements for New MURBs	• Tier 1 of the Toronto Green Standard Version 3 (mandatory) requires 20% of all parking spaces (residential and non-residential) in large buildings are provided with Level 2 charging and remaining spaces provided with rough-in conduits. Tier 2 (voluntary) involves 25% as charged parking spaces and the remaining roughed-in. • All building developments governed by Waterfront Toronto should meet the Minimum Green Building Requirements (MGBR), which mandates EV infrastructure be provided for 2% of tenant parking spaces in residential buildings. Remaining residential and commercial parking spaces must be EV-ready to enable future installation of Level 2 chargers
City of Waterloo	Pilot Project	• Installation of curbside charging stations with AddÉnergie (support from NRCan)
Québec	**Activity Area**	**Activity Description**
City of Dorval	Residential EV Charging Station Incentive	• Offers a subsidy to cover 50% of the purchase and installation costs of a residential charging station for electric vehicle, up to a maximum of $500 per station.
City of Joliette	Residential EV Charging Station Incentive	• Offers financial assistance for the purchase and installation of a residential charging station. The rebate covers 25% of the total costs, up to $250.
City of Montreal	Pilot Project	• Pilot project to install curbside Level 2 chargers in downtown expanded to total of 1,000 in all boroughs by 2020
City of Sherbrooke	Residential EV Charging Station Incentive	• Offers financial assistance of up to $500 for the purchase and installation of a residential charging station.
Town of Granby	Residential EV Charging Station Incentive	• Offers a rebate covering 25% of the purchase and installation costs of a residential charging station for electric vehicle, up to $250 per station.
Town of Prévost	Residential EV Charging Station Incentive	• Offers a rebate of $100 to its residents for the purchase and installation of a residential charging station for electric vehicle.

Appendix C: Selected Resources, Guides and Websites

AddÉnergie Technologies. https://addenergietechnologies.com/en/multi-residential

Addressing Challenges to Electric Vehicle Charging in Multifamily Residential Buildings. (US). https://luskin.ucla.edu/sites/default/files/EV_Multifamily_Report_10_2011.pdf

Alectra Utilities. https://www.powerstream.ca/innovation/electric-vehicles-and-charging-stations.html

BC Hydro. https://www.bchydro.com/powersmart/electric-vehicles/charging.html

Capital Region Local Government Electric Vehicle (EV) + Electric Bike (E-Bike) Infrastructure Planning Guide. https://www.highlands.ca/DocumentCenter/View/7075/Electric-Vehicle-Bike-Project

ChargePoint. https://www.chargepoint.com/en-ca/businesses/apartments-and-condos

Charging Solutions and Incentives Program. https://pluginbc.ca/incentives/charging-solutions-incentives/

CSA Group. https://www.csagroup.org/testing-certification/product-areas/power-generation-energy-storage/vehicle-power-fueling/electric-charging/

Drivetricity https://www.drivetricity.com

eCAMION. http://www.ecamion.com/products

Electric Vehicle Charging Infrastructure in Shared Parking Areas: Resources to Support Implementation & Charging Infrastructure Requirements. https://www.bchydro.com/content/dam/BCHydro/customer-portal/documents/power-smart/electric-vehicles/ev-charging-infrastructure-in-shared-parking-areas.pdf

Electric Vehicle Charging Stations for Multi-Unit Residential and Mix-Use Commercial/Residential Buildings. https://www.boma.bc.ca/media/19602/EVCS%20Info%20Booklet%20For%20MURBs%20-%20BOMA%20BC%20.pdf

Electric Vehicle Charging Stations. Technical Installation Guide. http://www.hydroquebec.com/data/electrification-transport/pdf/technical-guide.pdf

Electric Vehicle Service Equipment for Multi-Family Housing. (U.S). http://www.seattle.gov/light/electricvehicles/docs/Electric_Vehicle_Service_Equipment_for_Multi.pdf

Enabling Electric Vehicle Charging in Condominiums. http://www.plugndrive.ca/wp-content/uploads/2017/05/Enabling-EV-Charging-in-Condominiums.pdf

EV Society. https://evsociety.ca/

EverCharge. https://evercharge.net

FleetCarma. https://www.fleetcarma.com/smartcharge-manager

FLO. https://flo.ca/business/multi-unit-residential-buildings

Fraser Basin Council. https://www.fraserbasin.bc.ca/ccaq_plug_in_bc.html

Greenlots. https://greenlots.com/industries/apartments-condos

Hydro Québec. http://www.hydroquebec.com/transportation-electrification/electric-vehicles

Installation of Electric Vehicle Charging Stations on Strata Properties in British Columbia. http://www.westcoastelectricfleets.com/wp-content/uploads/CHOA-report.pdf

Koben Systems. https://kobensystems.com

Make Your Condo EV Ready. 2018 Guide for Condo Owners, Boards and Managers. https://www.plugndrive.ca/wp-content/uploads/2018/08/Make-Your-Condo-EV-Ready-Guide.pdf

Metro Vancouver. http://www.metrovancouver.org/services/air-quality/climate-action/transportation-programs/ev-strata-condo/Pages/default.aspx

MultiHousingCharging.com. (U.S.). http://www.multihousingcharging.com

Natural Resources Canada. Electric Charging and Alternative Fuelling Stations Locator https://www.nrcan.gc.ca/energy/transportation/personal/20487#/find/nearest

Plug In BC. https://pluginbc.ca/charging-stations

Plug-in Electric Vehicle Charging Infrastructure Guidelines for Multi-unit Dwellings. (U.S.). http://www.veloz.org/wp-content/uploads/2017/08/MUD_Guidelines4web.pdf

Plug-in Richmond. http://pluginrichmond.ca/index.html

Plug'n Drive. https://www.plugndrive.ca/condo-charging

Powertree. http://www.powertreeservices.com

Residential Electric Vehicle Charging: A Guide for Local Governments. https://pluginbc.ca/wp/wp-content/uploads/2018/10/Residential-EV-Charging-A-Guide-for-Local-Governments.pdf

Signature Electric. https://signatureelectric.ca/services/ev-chargers-for-condos

Strata Bylaw Templates for EV Charging. https://pluginbc.ca/resource/strata-bylaw-templates-ev-charging

SWTCH E-Car Inc. https://swtchev.com/home.html

Tesla. https://www.tesla.com/en_CA

Toronto Hydro. http://www.torontohydro.com/sites/electricsystem/electricityconservation/Pages/ElectricVehicles.aspx

Vancouver Electric Vehicle Association. https://veva.ca

U.S. Green Building Council. https://www.usgbc.org/credits/homes-mid-rise/v4/bdc-lt-credit

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