Electric Vehicle Home and Workplace Charging Study

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Nomenclature

Ampacity: Is the rated current capacity for a piece of electrical equipment. Ampacity refers to the current (measured in amperes) that a conductor can carry continuously without exceeding its temperature reading.

American Wire Gauge (AWG): AWG is a standardized measurement system used for the specification of an electrical conductor's size (gauge). This measurement specifies the diameter of a round, solid, nonferrous, electrically conduction wire.

Electric Vehicles (EV): See below

> **Zero Emission Vehicle:** A vehicle that produces no direct emission from its operation, for example, electric vehicles, where the conversion of electrical energy in the battery to kinetic energy does not result in any emissions. **Zero-emission vehicles do not account for any upstream emissions—i.e., emissions from the electricity source—which should be considered when accounting for emission reductions for ZEVs versus internal combustion engine (ICE) vehicles.**
>
> **Battery Electric Vehicle (BEV):** A vehicle with an electrical drivetrain that is powered by the electrical energy stored in a chemical cell/battery. The vehicle requires an external power source to recharge the battery.
>
> **Plug-In Hybrid Electric Vehicle (PHEV):** A vehicle with both an electric and internal combustion drivetrain; the electric and combustion drivetrains can be in series or parallel. The vehicle has the ability to operate on electricity (typically short capacity compared to BEV) or combustible fuel (gasoline is the most common).
>
> **Fuel-Cell Electric Vehicle (FCEV):** An electric drivetrain vehicle that generates electricity from an onboard fuel cell that converts chemical energy to electrical energy; modern FCEVs typically utilized hydrogen a zero-emission fuel. A small battery system can be used but is typically only charged by the on-board fuel cell.

EV Charging Infrastructure: See below.

> **Partial Infrastructure – Low:** Does not require electrical equipment to be installed during the construction of the building for future EV charging loads. These requirements do specify that sufficient space must be allocated for the installation of requisite electrical equipment (distribution panels, EVEMS, cabling/conduit, etc.) in the future. Wall and floor penetrations are to be completed to accommodate required EV charging cabling and electrical conduit is to be installed as required.
>
> **Partial Infrastructure – High (EV Capable):** Requires that sufficient electrical capacity be available for future EV charging load. This requires that electrical equipment, e.g., distribution panels and EVEMS, be installed and, wall and floor penetrations be completed to accommodate future EV charging cabling (electrical conduit is to be installed as required). The installation of conduit to the individual parking spaces or areas is not required.
>
> **Energized electrical outlets (EV Ready):** Requires that parking spaces have an energized electrical outlet capable of supporting EV charging (e.g., 40 A and 240 V). EV Ready

includes the EV Capable requirements as well as the installation of dedicated/shared branch circuits, breakers, receptacles, and other equipment or controls, such as EV energy management systems.

***EVSE Installation* (Electric Vehicle Supply Equipment Installation):** This includes the *EV Ready* requirements and the installation of the EV charging station.

EVEMS: Electric Vehicle Energy Management System, is piece of hardware or software that is used to control electric vehicle supply equipment loads through the process of connecting, disconnecting, increasing, or reducing electric power to the loads and consisting of any of the following: a monitor(s), communications equipment, a controller(s), a timer(s), and other applicable device(s).

EVSE: Electric Vehicle Supply Equipment is all the equipment that supports and enables the charging of an electric vehicle. This includes conductors, connectors, and devices, apparatus, and fittings, which are for the purpose of transferring electrical power from the electrical supply to the EV.

Standard EV Charger (Non-networked Charger): In this report, this refers to a Level 2 charger with minimal operational features. The charger may have but does not require features for communication with other electrical equipment. The charger provides a single port per charging station and is designed for typical use by a single EV owner or parking space occupant.

Networked EV Charger: Is an EV charger that has built-in networking capabilities (connected to the internet or a local network) that enables wired or wireless communication, which can provide functions such as billing, access control, and real-time updates. These chargers may have the ability for external party control or throttling and can be networked in larger installations for EVEMS operation (load sharing operation).

Commercial EV Charger: A level 2 charger used for multiple charging cycles per day (typical in commercial or high-use locations) where several EV owners may access and use the charger. These chargers are typically larger, they can have built-in payment or restrict user functionality, and can have multiple charging ports per station.

1 Executive Summary

The Electric Vehicle Home and Workplace Charging Study is the culmination of a comprehensive effort to assess opportunities to accelerate the deployment of EV charging infrastructure in the City of Calgary, the City of Edmonton, and across Alberta. The Study builds upon the City of Calgary's Climate Resilience Strategy and the City of Edmonton's Energy Transition Strategy, which calls for increased EV adoption to meet each respective City's climate and economic development goals. EV charging infrastructure at homes and at workplaces is critical for ensuring that drivers have reliable, convenient, and affordable access to electricity as a transportation fuel where they live and work.

From the outset, stakeholder engagement was a core priority for the Study. The research process was shaped by active engagement from city staff and a broad, diverse group of key stakeholders that shared local, regional, and national perspectives on the future of EV charging in the province. These stakeholders included representatives from real estate developer groups, building owners and managers associations, electric utilities, automakers, EV charging service providers, local and provincial governments, electrical contractor associations, and other industries. To ensure stakeholders had sufficient opportunity to share feedback, the project team held a live webinar, hosted multiple in-person stakeholder engagement sessions, and collected input from individual groups. This robust engagement has made the Study more inclusive, transparent, and reflective of stakeholders' perspectives on increasing access to EV charging.

Local and provincial government policy has a significant impact on the ability to efficiently and cost-effectively deploy EV charging infrastructure. The project team explored and compared EV charging policy efforts in selected North American jurisdictions across seven key areas:

- **Building Codes:** regulations that guide building design and associated electrical infrastructure requirements
- **Parking and Zoning Bylaws:** rules that influence vehicle parking and EV charging requirements for various property types
- **Permitting:** a policy that ensures the safe, lawful installation of EV charging equipment
- **Utility Policy:** regulations that govern electric utilities' ability to make investments to support charging infrastructure deployment
- **Load Management:** efforts to integrate EV charging in a manner that generates benefits for the electricity system and utility customers
- **EV Charging Station Incentives:** programs that provide funding for EV charging station deployment
- **Clean Fuel Standards:** market-based regulations that reduce the carbon intensity of transportation fuels

Based on this assessment, the project team found ample opportunity for the Cities to implement effective policies that leverage existing practices from other jurisdictions. To ensure that the project team's perspective was grounded in real-world experience, the project team hosted several in-person stakeholder engagement sessions. These sessions served as a forum to collect input on perceived barriers and opportunities to accelerate EV charging infrastructure deployment, and this input was included in What We Heard forms per the Cities' stakeholder engagement guidance.

The following **core observations** and **key recommendations** synthesize the detailed research and stakeholder feedback collected over the course of the Study.

Core Observations

1. **Increasing access to home and workplace charging is essential for increasing EV adoption.** Home charging is convenient, allowing EV drivers to meet the majority of their fueling needs while vehicles are parked overnight. It also provides access to low cost, predictable residential electricity rates and allows for thermal preconditioning in the colder Alberta climate. Daytime charging at workplaces provides critical range-extending opportunities – particularly for plug-in hybrid electric vehicles. Workplace charging is also a valuable amenity for retaining employees and demonstrating a commitment to sustainability.
2. **Local policies can and should be modified to accelerate EV charging infrastructure deployment.** The City of Calgary and the City of Edmonton have taken initial steps to advance transportation electrification, but barriers to EV charging persist. Sites may have limited existing electrical capacity to support the deployment of charging stations. Equipment and installation costs continue to be a barrier – particularly in more complex charging station deployments at multi-unit residential buildings and workplaces. In some cases, residents installing charging at single-family properties may not obtain a City permit – not only compromising safety and reliability but also preventing the local utility from registering the EV charger load to its database that would have aided in distribution system planning. Finally, multi-unit residential buildings face unique parking, governance, and cost allocation challenges when considering EV charging deployment. There is currently no standard process in place for handling tenant EV charging station installation requests in condominiums.
3. **If managed properly, EV charging can become a grid asset – not a liability.** Left unmitigated, EV charging could create potential challenges for the electric distribution systems in Calgary and Edmonton. However, if properly managed, EV charging will not adversely impact grid operations. Managed EV charging instead could enhance the flexibility and reliability of the grid while reducing fuel costs for EV drivers, avoiding the need for utility distribution system upgrades, and integrating low-carbon electricity generation resources. Experience from other jurisdictions with relatively high levels of EV adoption demonstrates that accommodating EV load in residential settings has not been a significant challenge for distribution utilities.

Key Recommendations

1. **The City of Calgary and the City of Edmonton should amend their parking and zoning bylaws to require more EV ready parking spaces in newly constructed buildings.** A non-trivial portion of EV charging deployment costs stem from the cost of installation rather than the EV charging equipment itself. Installing adequate panel capacity, conduit, and other electrical infrastructure during building construction instead of retrofitting existing buildings can significantly reduce charging station deployment costs and timelines. As noted during the stakeholder engagement sessions, the City of Calgary and the City of Edmonton can leverage local parking and zoning bylaws to require a certain percentage of parking spaces to be "EV ready" in newly constructed buildings – providing tenants and owners with greater flexibility to install EV charging stations as EV adoption increases. Aside from lower future charging station installation costs, EV-readiness provisions can also improve utility distribution system planning around EVs. The recommendations below outline the proposed EV-readiness requirement for various building types:
    - **Single-family Residential:** As the cost and approval barriers are much lower for the retrofit installation of EV charger infrastructure, no EV charging requirements are recommended at this time. The City of Calgary and the City of Edmonton are encouraged to consult with home developers to introduce voluntary developments with EV ready parking spaces/garages.
    - **Multi-Unit Residential:**
        - For condominiums, 100% of parking spaces (excluding visitor parking) designated as EV ready.
        - For apartment buildings, 10% of parking spaces are to be EV ready, and the building will require the remaining 90% of spaces (excluding visitor parking) to be EV-capable.
    - **Workplace/Commercial:**
        - For buildings outside of the downtown core, 100% of spaces are to have considerations in place for future EV charging (partial infrastructure – low).
        - For buildings in the downtown core (focus on high rises) 10% of all parking spaces are to be EV ready and the remaining 90% of spaces are to have considerations in place for future EV charging (partial infrastructure – low).
        - 100% of residential parking spaces at mixed-use buildings are to be EV ready.
    - **Government/Municipal:** 10% of parking spaces designated as EV ready, with at least 5% of spaces equipped with EV charging stations. The remaining 90% of spaces are to be EV capable.

    The Cities can also explore using EV-readiness requirements above parking bylaw minimums as a mechanism to offset parking space minimums. Using EV-readiness to reduce parking space minimums can also bolster the Cities' efforts to increase walking, biking, and transit ridership.

2. **The City of Calgary and the City of Edmonton should explicitly require the procurement of a permit prior to the installation of EV charging stations and set targets for permit approval turnaround times.** City permits should be required prior to any safe and lawful installation of EV charging infrastructure where electrical outlets are not currently available. This requirement will only become more important as EV charging station deployments increase over time across all market segments. As permit requests grow, the Cities of Calgary and Edmonton should strive to establish efficient "turnaround" targets for permit approvals.

3. **The City of Calgary and the City of Edmonton should pursue an array of options to expand financial support for EV charging station deployment.** Reducing charging station costs through incentives can help address a key barrier to home and workplace charging. Cities should explore utility partnerships that could offset the cost of charging infrastructure deployment. Additionally, Cities could authorize property assessed clean energy (PACE) loans for EV charging equipment for potential prospective EV charging site hosts. PACE loans could ensure that residents face low to no upfront costs associated with charging station deployment and costs are repaid over time while EV drivers realize potential fuel cost savings from electricity. Finally, the Cities themselves can implement EV charging station incentive programs to support charging station growth across several key market segments – including public and workplace charging.

4. **The Cities of Calgary and Edmonton should pursue a comprehensive education and outreach strategy to increase awareness of EV benefits among local stakeholders.** Lack of education and awareness remains a barrier to EV charging deployment. The City of Calgary and the City of Edmonton can pursue a public-facing campaign to increase EV charging awareness – especially among large potential site hosts within the Cities' jurisdictions. The campaign should include a dedicated website, visual content on publicly accessible EV charging station locations in the Cities, and information on complementary City programs and initiatives. Understandably, increasing EV literacy is vital in gaining the support of both the public and building developers. It is important to make it clear why the electrification of transportation is expected to increase and how building the infrastructure today, with the additional cost of EV charging provisions, can improve the value of building developments tomorrow.

The study also explored the potential for Community Charging Hubs – publicly accessible clusters of charging stations meant to serve City residents. Community Charging Hubs have been widely adopted in other jurisdictions and could provide a critical, highly-visible refuelling opportunity for EV drivers – particularly for those with limited access to residential charging. It is recommended that Community Charging Hub, if adopted, be situated in well-visited urban locations such as grocery stores, municipally owned parking lots, recreation centers and shopping centres.

Finally, the study developed user-friendly guides to help decision makers in single-family, multi-family, and commercial market segments navigate the EV charging station installation process. The guides are intended to increase awareness of basic electrical infrastructure requirements, outline necessary steps taken to deploy charging stations, and ensure that stations are safely installed by qualified electrical contractors.

The Cities of Calgary and Edmonton have established ambitious greenhouse gas emissions reduction and economic development goals that encourage the adoption of new, clean energy technologies. Scaling EV adoption is a critical strategy for reducing transportation sector emissions, and a focus on home and workplace EV charging is necessary to grow the EV market in a manner consistent with the Cities' goals. Fortunately, Calgary and Edmonton can leverage the experiences of other leading jurisdictions in developing tailored EV charging policies that meet community needs. With bold, strategic action, the Cities are well-positioned to accelerate EV adoption in support of a more sustainable, resilient future.

2 Introduction

The City of Calgary and the City of Edmonton have established a series of commitments to reduce greenhouse gas (GHG) emissions, encapsulated in a variety of strategic planning exercises, including in Calgary's Climate Resilience Strategy and Edmonton's Community Energy Transition Energy Strategy. The deployment of electric vehicles (EVs) has the potential to reduce petroleum consumption and GHG emissions dramatically and increase energy independence through the utilization of locally produced energy. However, the success of long-term decarbonization of the transportation sector will depend in part on the near-term deployment of vehicles and fueling infrastructure, and the associated planning required by stakeholders. The transition towards higher rates of EV adoption and deployment of the corresponding charging infrastructure requires a broad range of stakeholders to prepare and plan for deployment.

Calgary and Edmonton's current EV strategies provide a critical foundation for understanding policy drivers, barriers, and opportunities for EV charging deployment. Homes and workplaces form the backbone of the robust charging network needed to support widespread EV adoption, and the City of Calgary and the City of Edmonton have clearly identified these as key opportunities to scale EV charging sustainably at these locations in their EV Strategy reports. In instances where obstacles preclude the deployment of EV charging at residences (including multi-family dwellings), community charging hubs may also play an important role in creating a broader, more diverse EV market.

Despite the emerging success of EVs as a viable option for consumers, many questions remain for policymakers and stakeholders. Most notably, there is a lack of understanding of where, when, and for how long consumers will charge their EVs. There is a broad understanding that most charging occurs at single-family homes, whereas other segments may currently be underserved in the market today. As such, deploying EV charging infrastructure to support at-home and workplace charging requires a confluence of multiple stakeholders, all of whom come to the market with vastly different interests and technical understanding of key issues. These stakeholders include but are not limited to general consumers that lease or own EVs, electrical contractors, EV charging providers, employers, the residential and commercial development industries, building code officials, and municipal planning staff.

Electrification is a growing trend that impacts virtually every level of the transportation sector. In response to market signals, policy shifts, and technological advancements, automakers have publicly committed to invest $300 billion in electric vehicles (EVs) worldwide over the next five to ten years [1]. These investments will provide automakers with the battery and manufacturing capabilities to produce EVs at scale. Cumulative global light-duty EV sales have already surpassed 5 million units – bolstered by strong Chinese, European, and North American markets [2]. Moreover, many major automakers have set internal goals for EV sales: The International Council on Clean Transportation estimates that, in aggregate, these commitments would generate annual global EV sales of 15 million units in 2025 [3].

Driven by government incentive programs, legal settlements[i], and private investment and partnerships, EV charging infrastructure availability is also steadily growing to meet the charging demands of a growing EV fleet. The dynamics of refuelling EVs differ from those of internal combustion engine (ICE) vehicles, creating new opportunities and challenges for the deployment of charging stations – also known as electric vehicle supply equipment (EVSE). Several larger EV charging service providers (EVSPs) have been acquired by or received significant investment from established multinational energy companies [4,5]. However, lack of EV charging infrastructure is regularly cited as a barrier to widespread transportation electrification; without reliable access to electricity as a transportation fuel where people live, work, and play, light-duty EVs will continue to face headwinds in the market. Overcoming these barriers requires sustained coordination between government actors, developers, utilities, automakers, EVSPs, non-governmental organizations (NGOs), and other stakeholders.

Alberta has an opportunity to take advantage of the shift toward transportation electrification to meet economic and environmental goals. This report examines national and local EV markets, reviews existing federal, provincial, local, and utility policies that impact EV adoption, and outlines emerging EV load management policies and programs. Although the report is focused on Alberta, initiatives from other leading jurisdictions are included to contextualize the local policy landscape.

2.1 EV Market

The EV market is still nascent in Canada. As of the first quarter of 2019, cumulative sales surpassed 100,000 units, with the majority of sales concentrated in Quebec, Ontario, and British Columbia [6]. According to Statistics Canada, approximately 23 million light-duty vehicles were registered in 2018 [7]. Although EVs comprise a small fraction of total vehicles on the road, the momentum behind EVs is growing. Annual sales increased 125 percent between 2017 and 2018 (albeit from low initial sales figures), and Transport Canada has announced that more than 14,000 EVs have been purchased as of early August 2019 with support from the federal government's recent iZEV point of sale incentive program – effective May 1, 2019 [8].

Alberta EV sales have been limited to date. Electric Mobility Canada estimates that cumulative EV sales in the province amounted to 2,269 units as of the first quarter of 2019 – about 2 percent of national cumulative sales, while 191 EVs were sold in Alberta in the same quarter [9]. The growth in EV sales in both Calgary and Edmonton is exponential, and if the trend were to hold, there could be a large amount of EVs in both cities; see **Figure 1**.

[i] Companies like Volkswagen Group of America and NRG were required to make investments in EV charging infrastructure as a result of legal settlements for various violations in the United States and Canada.

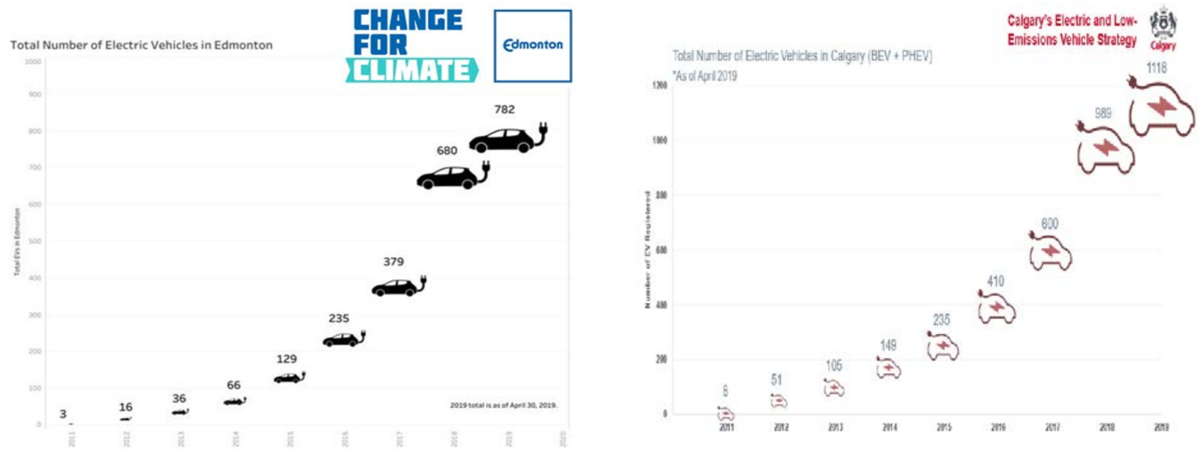

Figure 1: Cumulative number of electric vehicles (BEV and PHEV) registered in the City of Calgary and the City of Edmonton as of April 2019.

2.2 EVSE Market

Current EV charging technologies fall into three primary categories: **Level 1 (L1)**, **Level 2 (L2)**, and **Direct Current Fast Charging (DCFC)** stations.

Figure 2 illustrates the characteristics of L1, L2, and DCFC stations.

Level 1 (L1) charging stations use a standard 120V outlet and provide about 1.1 kilowatts (kW) of power, refuelling an EV at a rate of 3-7 km per hour of charging.

Level 2 (L2) stations use a 208V/240V outlet and typically provide 3.3 to 19.2 kW of power, providing 16 to 40 km of range per hour of charging.

Level 3 (DCFC) stations require 480V service; current stations provide power at 25 kW up to 350 kW. Typically, **DCFC** stations provide 50 kW of power. These 50 kW plugs can add more than 4.8 km of range per minute. Newer DCFC chargers are capable of power ratings of 350 kW and can add 32 km per minute; compared to the peak charging rates of 0.1 km per minute and 0.7 km per minute for level 1 and level 2, respectively.

TYPES OF EV CHARGING STATIONS

AC LEVEL ONE	AC LEVEL TWO	DC FAST CHARGE
VOLTAGE 120V 1 - PHASE AC	**VOLTAGE** 208V or 240V 1 - PHASE AC	**VOLTAGE** 208V or 480V 3 - PHASE AC
AMPS 12 - 16 Amps	**AMPS** Typically 32 Amps	**AMPS** <125 Amps (Typ. 60 Amps)
CHARGING LOADS 1.4 to 1.9 kW	**CHARGING LOADS** Typically 3.6 kW to 7.2 kW	**CHARGING LOADS** 50 kW to 350 kW
CHARGE TIME FOR VEHICLE 5 - 8 km of Range per Hour	**CHARGE TIME FOR VEHICLE** 30 km of Range per Hour	**CHARGE TIME FOR VEHICLE** 80% Charge in 15 - 60 minutes

Figure 2: EVSE Technology Basics [10]

Natural Resources Canada (NRCan) estimates that Canada has 4,987 public charging stations with 11,537 charging outlets or plugs [11], where 84 percent of these charging outlets are Level 2 (L2) chargers, and 14 percent are Direct Current Fast Charging (DCFC) stations. The remaining two percent of chargers are Level 1 (L1). Approximately 90 percent of all public charging stations in Canada are in the Provinces of Quebec, Ontario, and British Columbia.[ii]

Presently, Alberta has a total of 224 public EV charging stations with 490 charging outlets;

- **Level 2:**[iii] 182 stations and 392 of these outlets are L2 chargers,
- **DCFC charger:**[iv] 42 stations and 98 outlets [11].

The majority of stations are located in the metropolitan areas of Calgary and Edmonton. Outside of the City of Calgary and the City of Edmonton, there is limited DCFC infrastructure, but installations are steadily increasing. **Figure 3** and **Figure 4** illustrate the locations of L2 stations and DCFC stations in Alberta.

A suite of diverse policy areas influences the EV charging landscape at the municipal, provincial, and federal level. The following section introduces these policy concepts and expands on progressive policies in place across Canada and the U.S. to facilitate EVSE deployment.

[ii] NRCan does not track deployment of residential EV charging stations and site hosts with private EV charging stations (e.g. private workplaces) are not required to report them to the NRCan.
[iii] 22 Stations and 121 outlets are Tesla Level two chargers. While Tesla has an adapter to use the J1772 or CHAdeMO other EVs cannot use the Tesla chargers.
[iv] 9 of the stations and 58 of the outlets are Tesla Superchargers. Tesla employs a proprietary DCFC plug standard, meaning that only Tesla vehicles can use these stations.

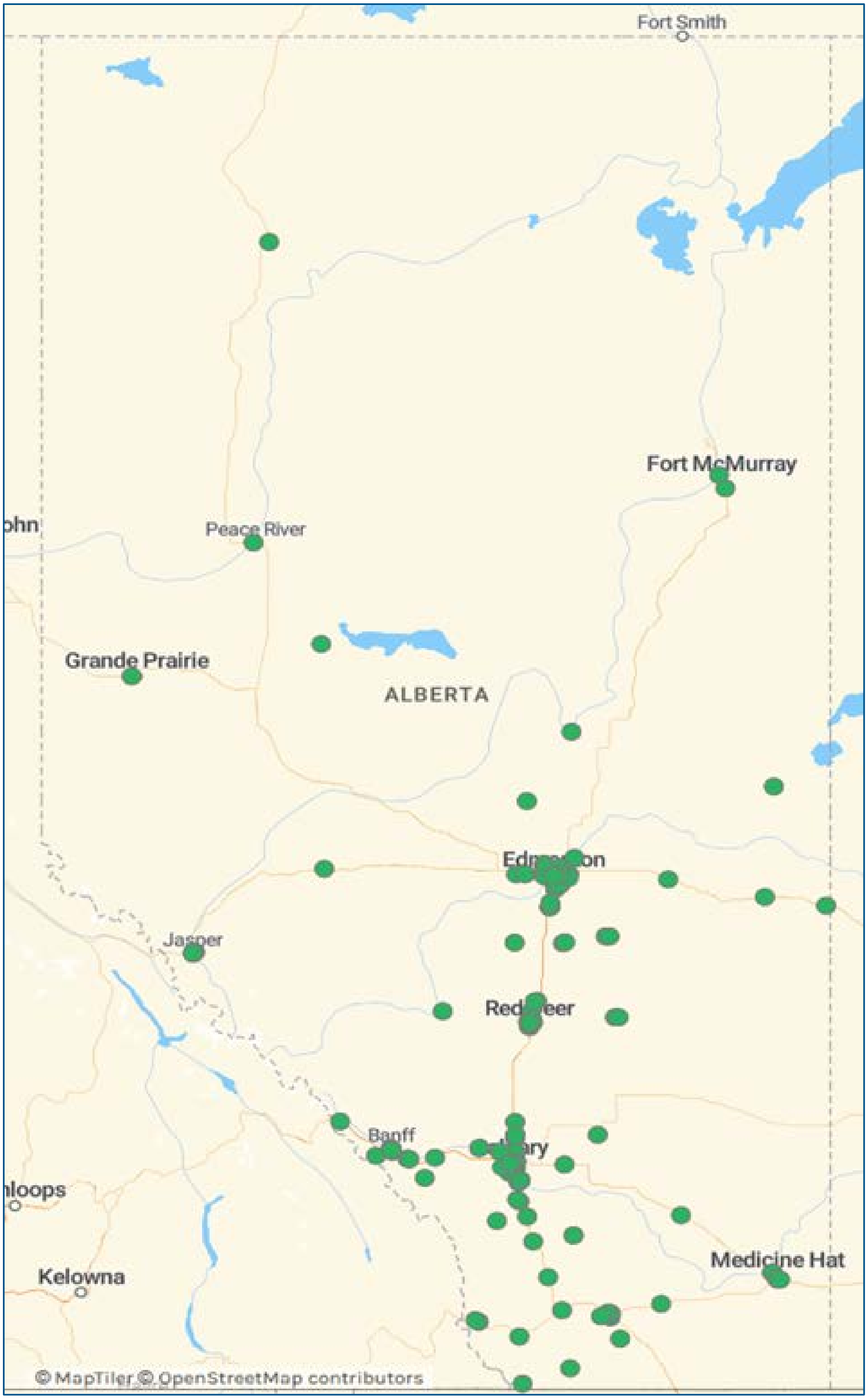

Figure 3: Current Alberta L2 Station Locations [12]

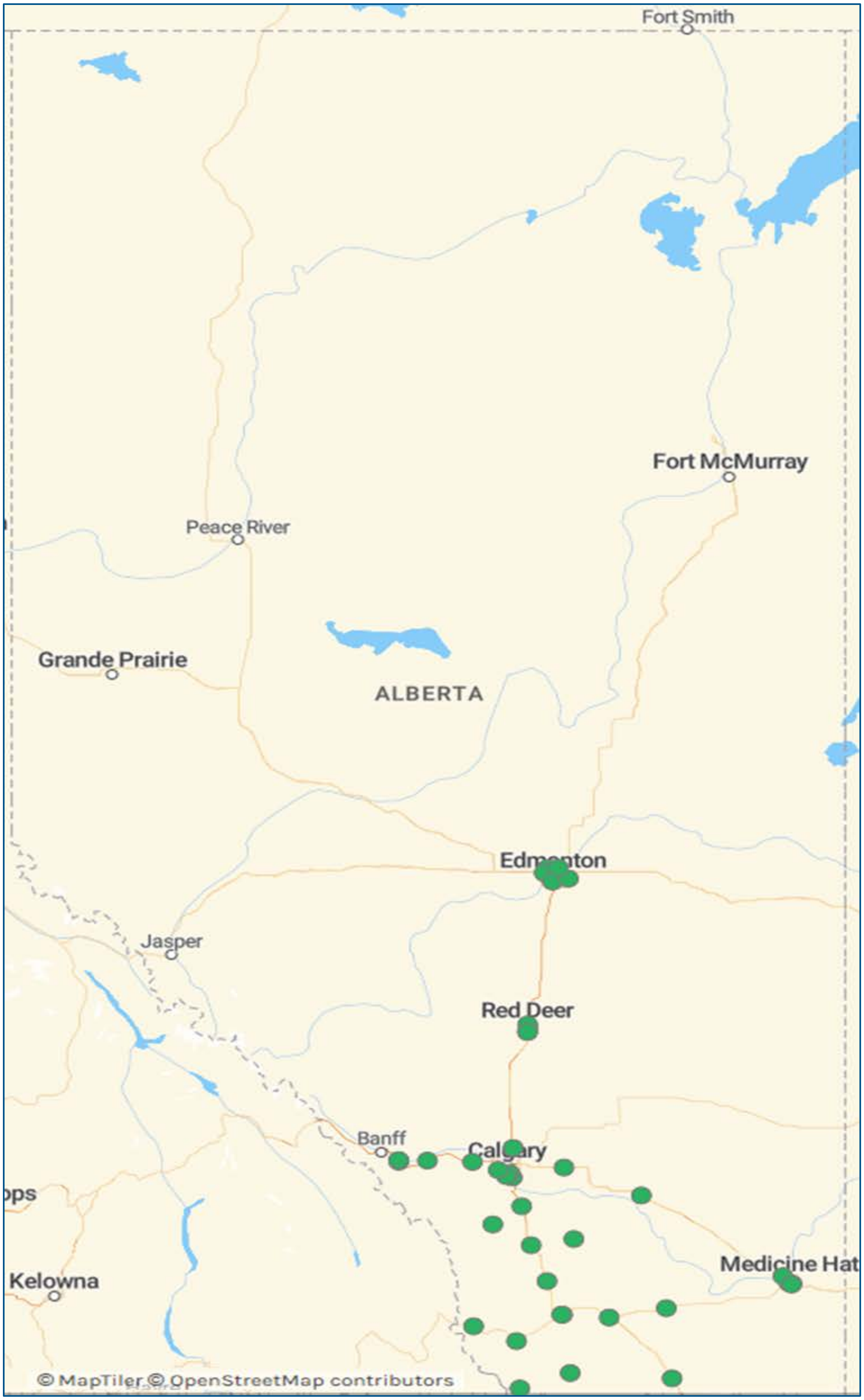

Figure 4: Current Alberta DCFC Station Locations [13]

3 Market Overview of Policy and Implementation for EV Infrastructure

As part of the City of Calgary's and City of Edmonton's evaluation of the role in which home and workplace EV infrastructure will play as part of their overall EV Strategy, a robust understanding of existing implementations throughout North America is required. Items examined are as follows:

1. Codes and Standards
2. Municipal Policy and Parking Zoning
3. Municipal Electrical Permitting
4. Utility Electric Vehicle Service Equipment Regulations
5. Electric Vehicle Energy Management Systems
6. EV and Electric Vehicle Service Equipment Programs and Incentives
7. Clean Fuel Standards

These topics have been selected to provide an overview of the requirements for the installation of EV charging infrastructure, outline what neighbouring jurisdictions have achieved and implemented, and lastly understand the policy and market forces that are driving EV adoption, which in turn can be used to estimate the growing need for EV charging infrastructure.

3.1 Codes and Standards

3.1.1 Overview

It is paramount that EVSE deployment is completed within the requirements of provincial and federal codes and standards. These baseline requirements help ensure that an EVSE is installed safely, integrated into broader building planning, and accessible throughout the equipment's useful life. Understanding the applicable codes and standards will enable the development of EV ready guidelines, which can significantly lower costs, time, and ensure compliance for EVSE deployments.

3.1.2 The Canadian Electrical Code

The main Standard relevant to electrical work completed in Canada for residential, commercial, and industrial spaces is Code C22.1 - The Canadian Electrical Code (CEC), which is published by the Canadian Standard Association (CSA). The CEC is currently updated every 3 years, with the latest version released in 2018 (C22.1-18). The CEC 2018 was formally adopted in Alberta on February 1, 2019 and replaced the 2015 (C22.1-15) version of the Code. In addition to the codebook, the CEC also includes a handbook that provides detailed explanations, clarifications, and examples for the codebook. Key sections that are relevant to EV charging from the CEC included Section 8, Section 84, and Section 86.

3.1.2.1 Section 8 – Circuit Loading and Demand Factors, Rule 8-106 Subrules 10) and 11)

Electric Vehicle Energy Management Systems (EVEMS) are systems that can be utilized for charge management of multiple EVs. The change introduced in 2018, (Rule 8-106 10)) clarifies that the rated load for EVs plugged into the EVEMS is the rated load of the system and not the number of EVs plugged into the EVEMS, which by design is installed to cap the current draw of the vehicles plugged in to ensure that peak loading is minimized and charging loads are distributed over an extended period of time. These systems are of particular interest for multi-unit residential buildings (MURBs) where a higher density of EVs can be located. The change in the Code makes it clear for inspectors and installers to understand the breaker sizing and power requirements for this equipment.

In Rule 8-106 11), with the use of an EVEMS that manages the EV charger current draw to operate below the rated limits of the EV owners electrical service and feeders limits the load from the EV does not need to be considered as part of the feeder sizing calculation as outlined in Rule 8-200 below.[v]

3.1.2.2 Rule 8-200 (Single dwellings) and 8-202 (Apartment and similar buildings) Calculated Load for Service and Feeders

These rules outline the minimum feeder (distribution panel) power rating based on a building or unit living area, electric heating, electric range/oven, electric domestic hot water, swimming pools or hot tubs, electric vehicle charger, any other large electrical equipment located in the home.

For example, 90 m^2 home or apartment with electric home heating and hot water, and electric range, and EV would have the following feeder requirements as shown in **Table 1**.[vi]

While technologies are available to manage the load of a home, the CEC does allow for systems that manage home electrical draw to be used to reduce the required size of your home electrical panel/feeder size (see Rule 8-106 summarized above).

Table 1: 90 m^2 Home Minimum Feeder Sizing

Loads Type	Load [W]
Basic Load	5,000
Space Conditioning	3,900
Electric Range	6,000
Domestic Hot Water	1,500
Electric Vehicle	7,600
Total Load	**24,000**
Minimum Ampacity [A @ 240 V]	**100**

[v] From the CEC 2018, Rule8-106 Subrule 11:
"*where an electric vehicle energy management system as described in Subrule 10) monitors the consumer's service and feeders and controls the electric vehicle supply equipment loads in accordance with Rule 8-500, the demand load for the electric vehicle supply equipment shall not be required to be considered in the determination of the calculated load*."

[vi] NOTE: The loads listed have demand factors of 100%, some additional loads have reduced demand factors, for example 40% for an any load in excess of 12,000 W for an electric range.

3.1.2.3 Rule 8-500

This rule outlines what functions an EVEMS is permitted to complete, which includes monitoring and controlling EV charging loads. The EVEMS can be controlled remotely and must ensure that the current draw does not exceed the designed branch circuit current.

3.1.2.4 Section 26-500 Storage Batteries

Section 26 applies to general electrical equipment, but the key area of interest is Section 26-500. This section applies to storage batteries, which are defined as "a battery consisting of more than one rechargeable cell of the lead-acid, alkaline, or another electrochemical type." It is not uncommon for this section to be used when evaluating the requirements for EV chargers, as some battery chemistries (e.g., lead-acid batteries), when charged, can lead to significant levels of hydrogen (H_2) gas formation.

The CEC outlines the requirements for ventilation of batteries to limit the level of hydrogen gas such that an explosive/hazardous atmosphere does not occur; for hydrogen, the volume of gas must be below 2% by volume, as hydrogen is explosive at concentrations of 4% to 74% by volume. Lead-acid batteries are not used in current EVs, as was the case with early EVs such as the GM EV1, with most battery-electric vehicles (BEV) using lithium-ion batteries and some hybrid electric using nickel-metal hydride batteries (Toyota Prius), see **Part 3.1.3.1**.

As a useful example, calculations were completed for EV batteries assuming that they were lead-acid. The analysis is completed for the typical parking space and ignores any surrounding space around or near the vehicle parking space. Using the example calculations for a lead-calcium grid battery with 2.2 V per cell, and the battery pack from a Tesla Model 3 (75 kWh) would yield the following results:

Equation 1: Baseline EVSE Hydrogen Gas Emissions Calculation

$$\dot{V_{H_2}} = \frac{V_{gas}}{day} \times AH \times n_{cells} \times \frac{I_{float}}{AH_{rated}} \times \frac{min}{day}$$

$$= 7.6 * 10^{-6} \frac{m^3}{min} \times \frac{75\ kWh}{350\ V} \times 60\ \times 6 * 10^{-4} \frac{A}{AH} * 1440 \frac{min}{day}$$

$$= 0.00844 \frac{m^3}{day}$$

$$V_{parking\ Stall} = 2.5\ m \times 5.4\ m \times 1.6\ m = 21.6\ m^3$$

$$n_{days} = \frac{\dot{V_{H_2}}}{V_{parking\ stall} \times \%H_{2_{max}}} = \frac{0.00844\ m^3/day}{21.6\ m^3 \times 2\%} = 51.7\ \ days$$

Adjusting for the higher voltage of the Tesla Model 3 than the grid storage battery (thus increased number of cells per battery) yields the following:

Equation 2: High Voltage EVSE Hydrogen Gas Emissions Calculation

$$\dot{V_{H_2}} = \frac{V_{gas}}{day} \times AH \times n_{cells} \times \frac{I_{float}}{AH_{rated}} \times \frac{min}{day}$$

$$= 7.6 * 10^{-6} \frac{m^3}{min} \times \frac{75\ kWh}{350\ V} \times \frac{350\ V}{2.1\ V/Cell} \times 6 * 10^{-4} \frac{A}{AH} * 1440 \frac{min}{day}$$

$$= 0.023 \frac{m^3}{day}$$

$$V_{parking\ Stall} = 2.5\ m \times 5.4\ m \times 1.6\ m = 21.6\ m^3$$

$$n_{days} = \frac{\dot{V_{H_2}}}{V_{parking\ stall} \times \%H_{2_{max}}} = \frac{0.023\ m^3/day}{21.6\ m^3 \times 2\%} = 18.4\ days$$

In both cases, the number of air changes required by other codes (see **Part 3.1.3.1**), the probability of hydrogen gas accumulation in a parking lot exceeding safe levels even with lead-acid batteries, is highly improbable.

3.1.2.5 Section 84 – Interconnection of Electric Power Production Sources

This section sets the requirements for the interconnection of the power distribution grid with power generation or energy sources (energy storage such as electrical batteries). At the time of this report, no production EVs were identified for the Canadian market[vii] that enables the end-user to use the batteries in the EV as a backup power supply or energy storage device for non-vehicle energy-related applications (e.g., home backup power system similar to an uninterruptable power supply (UPS)) [14,15,16]. Currently, EV manufacturers do not allow the batteries to have bi-directional flow with the grid—avoids adverse charging cycles that could damage the batteries or lead to reduced operating cycle life. Although this section is not currently applicable, it is important to consider the impact of future EVs that may introduce this functionality and the additional protective equipment and measures that are currently required to ensure the safety of personnel and equipment connected to an EV, these include system isolation (anti-islanding), disconnecting means, overcurrent protection for load and source applications, and warnings identifying the bi-directional nature of the power flow to and from the EV. For more details on vehicle-to-grid, see **Part 3.5.3** and **Part 3.5.5.2**.

3.1.2.6 Section 86 – Electric Vehicle Charging Systems

This section applies specifically to EV charging with a nominal AC voltage of less than 750 V, which covers Level I and Level II EV chargers that would be typically installed at home and workplace locations, and currently covers Level III or Direct Current Fast Charging (DCFC) systems with operating DC voltages of 500 V (AC voltage less than 350 V).

This section outlines the ampacity and protection requirements, signage, and appropriate indoor and outdoor installation locations. This section is subject to all other rules of the CEC, and those items as identified above. Key items in this section are the need for dedicated circuits for EV chargers, clear labelling, and rules for when EVEMS are required.

3.1.3 National Building Code of Canada and Alberta Building Code (ABC)

The National Building Code of Canada (NBC) is published by Natural Resources Canada and developed by the Canadian Commission on Building and Fire Codes. The Code sets out the technical provisions for buildings, including design, construction, alternations, change of use, and demolition. The NBC can be adopted in part, or wholly by Provinces, and thus unless adopted by the Provincial authorities is a non-binding document. This was the case in Alberta,

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[vii] In 2018 Nissan has received approval from the German Government/utility operator to introduce interactive capabilities for the Nissan Leaf in 2019 [14]. In July 2019, Nissan did deploy a demonstration installation in Chile, [15] and Nissan is working with utilities for pilot programs for the Lead and e-NV200 models, but that the availability of this functionality is limited to the charger infrastructure and local utility/market [16].

where the Alberta Building Code 2014 edition was used since May 1, 2015. As of April 1, 2019, the new building code has now been modified and adopted in Alberta, and this version of the Code is formally the National Building Code (NBC) – 2019 Alberta Edition.

The NBC focuses on the structural requirements for building construction and is not directly concerned with the requirements for EV charging infrastructure. By and large, the NBC covers Fire Protection, Structural Design, Heating, Ventilation, and Air Conditioning (HVAC), Plumbing Services and Health, and Safety Measures for Construction and Demolition Sites. One section that was explored further was section 6.3 Ventilation, as this requirement was relevant to the analysis completed for battery storage.

3.1.3.1 Section 6.3 Ventilation Systems

This section provides the minimum air changes for various building and/or location types, which was discussed in **Part 3.1.2.4** of this report. This is applicable to the ventilation requirements for battery storage. The ventilation requirements for the NBC are to be at a minimum of those set out in ANSI/ASHRAE 62 “Ventilation for Acceptable Indoor Air Quality,” with the exception of Article 6.3.1.4 pertaining to storage garages. ASHRAE requires a minimum of 4-6 air changes per hour, while the NBC requirement is a minimum of 3.9 L/s (14.0 m^3/hr) per square meter of floor space and requires carbon monoxide and nitrogen dioxide detection to ensure levels are below 100 ppm and 3 ppm respectively. As shown for a single parking stall, this would require a minimum air change rate of 8.75 times per hour.

Equation 3: Air Changes required per parking stall

$$A_{parking} = 2.5\,m \times 5.4\,m = 13.5\,m^2$$

$$V_{parking\ Stall} = 2.5\,m \times 5.4\,m \times 1.6\,m = 21.6\,m^3$$

$$\dot{V}_{req} = 14.0\frac{m^3}{hr \cdot m^2} \times 13.5 \ = 189\frac{m^3}{hr}$$

$$n_{air\ changes} = \frac{189\frac{m^3}{hr}}{21.6\,m^3} = 8.75\ \frac{air\ changes}{hr}$$

3.1.4 National Fire Code

The Alberta Fire Code (NFC) 2014 Edition in effect since May 1, 2015, and was replaced effective April 1, 2019, with the National Fire Code – 2019 Alberta Edition. The code provides requirements for facilities with the stated objectives of ensuring safety, health, and fire protection of buildings and facilities. Similar to the NBC, the fire code is a guideline document which may be formally adopted by the respective Provincial authorities.

The NFC includes several provisions for the storing and handling of liquid fuels and highlights additional requirements for battery charging installations for battery-powered industrial trucks. Currently, there are no provisions directly applicable to light-duty EVs outside of the requirements established in the CEC.

While not covered in the NFC, batteries used in EVs can contain a large amount of energy, and it is important to understand the battery chemistry and how those would interact with fire suppression equipment or strategies. According to the National Fire Protection Association (NFPA) and their Alternative Fuel Vehicle Safety Training Program – Emergency Field Guide 2018 Edition “hybrid and electric vehicles do not require special equipment for fire suppression/extinguishment.” Water can be safely used to extinguish an EV fire, and an unplugged vehicle does not pose an electrical hazard. According to the NFPA, a large amount of water may be needed to suppress a battery fire, with testing showing that over 9000 litres of water was required; this amount will vary depending on the battery size. If a fire involves an EV charger/charging station, as would be the case in a fire with other electrical equipment, the power source should be shut down, and the charger is to be isolated prior to attempting to suppress or extinguish the fire.

For fire prevention, the primary concern for EV chargers or charging stations, it is important to ensure that the system was installed properly and that all proper installation requirements, as set in the Electrical Code, are met. As part of the inspection process, inspections should review the installation to ensure the project was properly permitted, that it was completed by qualified personnel, the electrical equipment was bonded and/or grounded, and that overcurrent protection is in place. These strategies can minimize the risk of incident and greatly reduce the amount of electrical energy available to cause or fuel a potential fire.

3.1.5 National Energy Code for Buildings

The National Energy Code for Buildings (NECB) is self-defined as a document that “sets out technical provisions to address the energy efficiency of the requirements in design and construction in new buildings as well as additions to existing buildings.” The 2017 edition was declared in force in Alberta on April 1, 2019.

The NECB is concerned with ensuring that buildings are designed such that their energy use is less than the metrics set in the code. The building energy use does not include energy used for external means, e.g., EV charging, and cannot be offset by on-site energy generation, e.g., solar PV. As per the calculations completed in **Part 3.1.3.1**, the existing ventilation requirements far exceed the requirements to ensure EV battery technology would not create a hazardous environment. As such, existing EV technology will not lead to an increase in air change requirements for parking garages, and thus it is not expected that there will be any impact on HVAC requirements for the facilities with EV vehicles and chargers.

3.1.6 National Fire Protection Agency (NFPA) 70 – National Electrical Code

The National Electrical Code (NEC) or NFPA 70 is the US equivalent of the CEC (see **Part 3.1.2**). This code is published by the National Fire Protection Agency (NFPA) and according to their website “throughout the United States and around the world, NFPA 70®, National Electrical Code® (NEC®), sets the foundation for electrical safety in residential, commercial, and industrial occupancies.” Similar to the CEC, the NEC is updated every 3 years, with the current version being the 2017 edition. The 2020 edition to be released on September 6, 2019.

3.1.6.1 Article 625 – Electric Vehicle Charging System

Similar to the CEC, the NEC outlines the requirements for charging cable types, installation locations, overcurrent protection, and ventilation. The NEC does require manufacturers to clearly identify if the electrical equipment in accordance with 625.15(B) and 625.15(C) requiring a clear marking stating “Ventilation Not Required” and “Ventilation Required,” respectively. The air change rate is to be identified or calculated, but based on the method 625.52(B)(1), the air change rate for Level II 30 A system is 7.2 m^3/min or 432 m^3/hr, which is significantly higher than other methods. As noted in the summary of the CEC and NBC, lithium-ion batteries do not require ventilation and should be marked as such. Due to the proximity to the US, it is likely that many vehicles sold in Canada may carry marking to this effect for the Canadian and US models.

3.2 Parking Bylaws

3.2.1 Overview

Parking regulations can have a significant impact on the site host's ability to deploy and utilize EVSE. Many cities and municipalities have minimum parking requirements that govern the number of spaces that developers need to provide for different land uses. Real estate developers may be resistant to deploy charging infrastructure in new and existing buildings if parking spaces equipped with EVSE are not counted toward parking requirements – particularly in urban areas with limited land availability. Modifying parking policies, as required, to recognize EVSE-equipped parking stalls could potentially mitigate concerns about deploying EVSE at multi-family buildings and workplaces.

Residents living in buildings with condo boards may also face additional barriers or restrictions in deploying EVSE. Condo boards may be averse to permitting the use of EV charging infrastructure for certain tenants[viii] or may not have an established governance structure to determine how EVSE would be installed, owned, operated, and maintained. Laws that prevent condo boards from unreasonably blocking tenants' ability to install EV charging stations can help ensure that they have access to residential charging.

Finally, without proper enforcement, internal combustion engine (ICE) vehicles may park in spaces dedicated to EV charging use only. This situation not only prevents current EV drivers from utilizing existing EV charging infrastructure but potentially discourages prospective vehicle buyers from purchasing EVs. Cities can implement parking requirements and regulations that ensure that spaces equipped for EV charging at workplaces and other public locations fulfill their purpose of charging EVs.

However, in anticipation of the growing demand for EV charging, some jurisdictions have taken a more proactive, efficient approach to EVSE deployment by incorporating "EV ready" building codes, policies, or bylaws, which require the installation of electrical equipment needed to support EV charging. For example, this can include updated requirements for parking zoning bylaws, updates to local building codes, or policies or programs to incentivize EVSE installations. There are three levels of EV-readiness for Level 2 stations that vary in terms of upfront infrastructure requirements and investment [17].

> **Partial Infrastructure – Low:** Does not require electrical equipment to be installed for future EV charging loads during the construction of the building. These requirements do specify that sufficient space must be allocated for the installation of electrical equipment (distribution panels, EVEMS, cabling/conduit, etc.) to support EV charging in the future.

[viii] While the unit occupant would be the end user of the EV charger, the installation may be requested by the Unit owner.

Wall and floor penetrations are to be completed to accommodate required EV charging cabling and electrical conduit is to be installed as required.

Partial Infrastructure – High (EV Capable): Requires that sufficient electrical capacity be available for future EV charging load. This requires that electrical equipment, e.g., distribution panels and EVEMS, be installed and, wall and floor penetrations be completed to accommodate future EV charging cabling (electrical conduit is to be installed as required). The installation of conduit to the individual parking spaces or areas is not required.

Energized electrical outlets (EV Ready): Requires that parking spaces have an energized electrical outlet capable of supporting EV charging (e.g., 40 A and 240 V). EV Ready includes the EV Capable requirements as well as the installation of dedicated/shared branch circuits, breakers, receptacles, and other equipment or controls, such as EV energy management systems.

***EVSE Installation* (Electric Vehicle Supply Equipment Installation):** This includes the *EV Ready* requirements and the installation of the EV charging station.

Category / Requirements	Partial Infrastructure – Low	*Partial Infrastructure – High (EV Capable)*	*Energized electrical outlets (EV Ready)*	*EVSE Installation*
EVSE installed				✓
Cabling / Conduit			✓	✓
Wall & Floor penetrations	✓	✓	✓	✓
Electrical Equipment, e.g. panels, breakers		✓	✓	✓

3.2.2 Policies in Alberta

The City of Calgary defines EV charging stations in its land-use bylaws and clarifies that signage must be provided to indicate parking spaces equipped with EV charging. However, the bylaws do not appear to clarify whether EV charging spaces count toward minimum parking requirements for various land uses or whether the City enforces EV-only parking for these spaces[ix].

The City of Edmonton does not appear to address EVSE-equipped parking spaces in the City's zoning bylaw.

The Government of Alberta also has not considered EV charging infrastructure needs for residential or commercial buildings in current legislation or regulations [18].

3.2.3 Policies in British Columbia

British Columbia has become a leader in Canada on the adoption of EVs and the requirements for EV infrastructure. Provincial and municipal governments have undertaken various strategies to encourage and support EVs, including Provincial Acts, edits to building codes, and municipal bylaws for parking as summarized below.

[ix] Enforcement would vary with municipal authority and the individual or entity that owns and operates the building. Most cities do not and would not enforce parking rules in private buildings.

- **Government of British Columbia** –Provincial legislation Bill 28 -2019: Zero-Emissions Vehicles Act (ZEVA) was passed in May 2019 and came into effect in August 2019 [19]. The act sets sales targets for ZEVs of 10% of new sales by 2025 and 100% by 2040. This Act, however, does not provide any requirements for infrastructure required to support the ZEVs, nor does this or any other Act outline requirements for EV infrastructure or provide any legal authority for EV owners to access or install the supporting infrastructure—commonly referred to as Right to Charge Legislation. An attempt was made to mirror the legislation passed in Ontario (see **Part 3.2.4**) with Resolution B132, which was seeking a similar amendment to the BC Strata Property Act. The Provincial Ministry of Municipal Affairs & Housing did not agree at the time that this was the most effective means of addressing issues with EV Charging within existing multi-dwelling units, and the full response is included in **Appendix B Resolution Text**. Many BC municipal governments have made changes to their bylaws, in particular to new builds, which will require buildings to be EV ready or include charging stations once construction is complete.
- **City of Burnaby** – Amended their Zoning Bylaw 1965, with Amendment Bylaw No. 24, 2018, which added Section 800.8 Provisions of Electric Vehicle Charging Infrastructure. This bylaw change requires an energized electrical outlet for Level 2 EV charging at all applicable parking spaces in new residential buildings.
- **City of Richmond** – Zoning Bylaw 8500, Amendment Bylaw 9756: Was adopted December 18, 2017, and added Section 7.15 Provisions of Electric Vehicle Charging Infrastructure, all new residential parking spaces, excluding visitor parking are to be equipped with an energized outlet to support Level 2 or higher EV charging.
- **City of Vancouver** – Has adopted and amended the National Building Code 2014 as By-law 10908 – Building Code Bylaw. The bylaw was amended to include provisions for Level 2 EV charging infrastructure at all applicable parking stalls [20]; this includes 1 EV ready stall for single-family residential, 100% of parking stalls to be EV Ready for MURBs, and 10% of parking stalls are to be EV ready for commercial buildings. The By-law is set to be replaced on November 1, 2019, with the new Building By-law 12511, which is based on the 2018 BC Building Code (BCBC) [21].
- **City of Port Coquitlam** – As part of amendment Bylaw, 2017, No. 4035 passed on January 23, 2018, the "Zoning Bylaw, 2008, No. 3630" amended Section II (Zones and Regulations) Sub-Section 2 (Residential Zones) Item 2.5 (Additional Regulations), and Sub-Section 3 (Commercial Zones), Item 3.5 (Additional Regulations) to include sub-item 10 (Electric Vehicle Infrastructure). This amended required new buildings to include *roughed-in electrical vehicle charging infrastructure*[x] or a separate utility meter and distribution panel to support future EV charging infrastructure depending on whether the building has common parking or not.
- **District of North Vancouver** – On December 15, 2014, the District approved an Administrative and Operational Policy called the *Implementation of Electric Vehicle Infrastructure with Development,* which requires 20% of multi-family homes to be ready for Level 1 charging and provisions to install Level 1 chargers at the remaining parking

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[x] means a Level 2 service including a 208 V or 240 V circuit breaker on an energized electrical panel connected by a raceway to an outlet.

stalls. Commercial and industrial require 10% of parking stalls to wired for Level 2 Charging. The District also requires Level 1 charging for all secure bicycle storage to support the charging of electric bicycles [22].

- **District of Squamish** – As part of the District's Zoning Bylaw 2200, 2011 (Consolidated July 2019), Section 41 (Off-Street Parking), Item 41.11(f) requires 30% of off-street parking spaces for MURBs to have Level 2 chargers, and the remaining spaces to have provisions for Level 2 charging [23].
- **The City of Surrey** – Effective February 25, 2019, the City of Surrey updated its requirements for EV charging requirements in new developments. The City amended the *Surrey Zoning By-Law 12000, Part 5: Parking and Loading/Unloading, A.7. Provisions of Electric Vehicle Charging Infrastructure* for a new building or a building containing a new use, 100% of residential parking spaces, and 50% of visitor parking spaces are to be EV ready for Level 2 or higher EV charging. For commercial buildings, 20% of parking spaces are to be Level 2 or higher EV ready.
- **District of Saanich** – On September 2019, the District of Saanich has introduced a detailed set of proposed changes for EV charging requirements for most building types in the district. While the changes have yet to be formally adopted, but the district has completed the early stages of stakeholder engagements and surveys. For example, single-family homes should have a minimum of EV energized outlet to support Level 2 charging, MURBS are to be 100% EV ready (excluding visitor parking), and institutional, commercial, and industrial are to have 0% to 5% of parking spaces EV ready based on the building use [24]. The proposed requirements can be found in the self-published report by the district *Electric Vehicle Infrastructure Requirement - Engagement Summary: September 2019,* in Appendix A (pages 15 to 22).

3.2.4 Policies in Ontario

In Ontario, the Provincial Government has not undertaken any formal legislation for requiring EV charging infrastructure, but as outlined below, they have provided changes to the Condominium Act to provide residents with a Right to Charge; i.e., install EV chargers. In comparison to BC few Ontario municipalities as of August 2019 Changes to local bylaws that were identified include the following:

- **Government of Ontario** – Passed changes to the Condominium Act with the Government of Ontario modifying the act Ontario Regulation 48/01 (O. Reg. 48/01) sections 24.4 to 24.7, which provides owners or occupants within MURBs with the legal authority to push for the installation of EV charging infrastructure. The change to the regulation provides the homeowner with the legal exception to request and install an EV charger, as well as the application process, the agreement required for installation, and mediation and arbitration outlines.
- **Government of Ontario** – The changes to the requirements in Ontario for EV infrastructure has undergone some changes recently. For context, the Ontario Building Code is Ontario Regulation 332 (O. Reg. 332/12 was modified with O. Reg. 139/17 and O. Reg. 563/17 set the conditions and requirements for the effective date of January 1, 2018, that would require "no less than 20% of parking spaces needed to be supplied with electric vehicle supply equipment". This amendment applied to Division B, Part 3

and Part 9, specifically subsections. 3.1.21 and 9.34.4. This amendment applied to all buildings excluding apartments/MURBs or houses, and the EV charger could be Level 1 or Level 2 based on the building needs. Effective May 2, 2019, O. Reg. 88/19 was passed, which revoked subsections 3.1.21 and 9.34.4 from the Ontario Building Code; as such, these requirements are no longer valid in Ontario.

- **City of Toronto** – The Green Standard has been updated to reflect the changes to the Ontario Building Code (Ontario Regulation 331/12). According to the Toronto Green Standard Version 3 (May 2, 2018), Tier 1 (mandatory requirement) requires 20% of all parking spaces to have Level 2 chargers with the remaining to have installed provisions for future chargers. With the voluntary requirement (Tier 2) being 25% installed and 75% with provisions. As part of the recommendations of the recent City of Toronto's EV Strategy released in December 2019, it is recommended that the City required 100% EV Ready in Mid to High-rise Commercial buildings and City-Owned facilities [25].

3.2.5 Other Jurisdictions

Many cities have taken steps to clarify and strengthen parking regulations to support EV charging. For example, the Cities of Santa Barbara and West Hollywood specify that parking spaces equipped with EV charging stations count as one space toward their respective minimum parking requirements [26]. Some cities and counties go further to incentivize EVSE deployment in their zoning bylaws: in some cases, Sacramento County and the City of Stockton allow individual EVSE-equipped spaces to count as *two* spaces for the purposes of meeting local minimum parking requirements.[xi]

Several provincial and state governments have taken steps to clarify condo owners and boards' ability to deploy EVSE in so-called "right to charge" legislation. California passed Senate Bill 880 (2012), which affirms owners' ability to deploy EV charging stations and prevents associations from placing unreasonable restrictions on property owners' ability to install EVSE at their designated parking space [27]. The legislation also permits associations to install EVSE in common areas and requires associations to develop reasonable terms for the use of charging stations. Oregon, Colorado, and Florida also have a similar "right to charge" laws [28]. Examples include of EV Charging legislation includes:

- New York Bill S5157A [29];
- Florida Statutes Section 718.113 – Section 3, Subsection (8) [30];
- Oregon Statutes 94.550, 94.762, 100.005, and 100.627 [31,32,33,34];
- Colorado Statutes 38-12-601 and 38.33.3-106.8 [35, 36];
- Hawaii Statutes 196-7.5 [37];
- California Civil Code 4745 and 6713 [38, 39, 40];
- Massachusetts Bill H.4069 [[41]].

[xi] The City of Stockton allows developers to utilize this incentive to reduce up to 10% of the parking spaces required for new developments. In contrast in Sacramento, this policy would enable the developer/builder to reduce the required parking spaces by 50% [27].

Moreover, some jurisdictions have taken action to prevent “ICE-ing”: a situation where an internal combustion engine (ICE) vehicle is parked in a space intended for EV charging only. For example, the City of Montreal requires that EVs parked in on-street, EVSE-equipped spaces must be actively charging.[xii] Ten U.S. states and Washington, D.C. have similar laws that prohibit the use of EV parking spaces by ICE vehicles; in the event that an ICE vehicle is found in an EV-only space[xiii], local law enforcement is typically given authority to cite the offending driver with a traffic violation [42]. Some states specify the fines that may be levied, including Quebec, Vancouver, and Ontario in Canada [43].

3.3 Municipal Electrical Permitting

3.3.1 Overview

In nearly all cases, the relevant authorities having jurisdiction (AHJs) must issue permits before EVSE can be installed. Station developers or site hosts typically submit permit applications that are reviewed for compliance with building, electric, energy, and fire codes. Public safety and engineering reviews may also be required depending on the AHJ [44]. If a permit application complies with all relevant codes and standards, the permit would be approved, and installation can begin. However, if the application is out of compliance, the AHJ may ask the applicant to revise their proposed installation design and documentation prior to approval.

Although permits are important for ensuring that EVSE is deployed safely and reliably, protracted permitting processes can discourage entities from installing EV charging infrastructure and act as a barrier to achieving broader EV adoption goals. Streamlined permitting processes can reduce time and financial costs associated with installation, and these processes will only become more important as more entities seek approval for EVSE deployments.

3.3.2 Alberta

Within Alberta, the governing legislation is the Alberta Safety Codes Act: Permit Regulation (Alberta Regulation 204/2007), which is the current act as of April 1, 2019. As outlined in the Act, Section 8.1, “A permit in the electrical discipline is required to install, alter, or add to an electrical system,” with the exceptions as outlined in the Act in Section 8.2 including communication systems, extra-low voltage (excluding safety control, hazardous area installations, electro-medical purposes, and lighting), and the replacement electrical equipment (must not modify ratings or characteristics of the electrical installation).

> **NOTE: Level 2 Chargers are readily available in stores and online, and many models of Level 2 chargers can be plugged into standard outlets (e.g., NEMA 6-50R or NEMA 14-50R, see Figure 5). This can lead to several installations occurring in homes being completed by residents/landowners, and the City and/or utility would not be made aware of the intent to install EV chargers. For work requiring the installation of the receptacle or hard wiring, the charger will require**

[xii] Communication, Eric MacNaughton, City of Calgary, August 23, 2019.
[xiii] This applies to publicly accessible parking spaces only.

an electrical permit, which is outlined for both Calgary and Edmonton in the subsequent sub-sections.

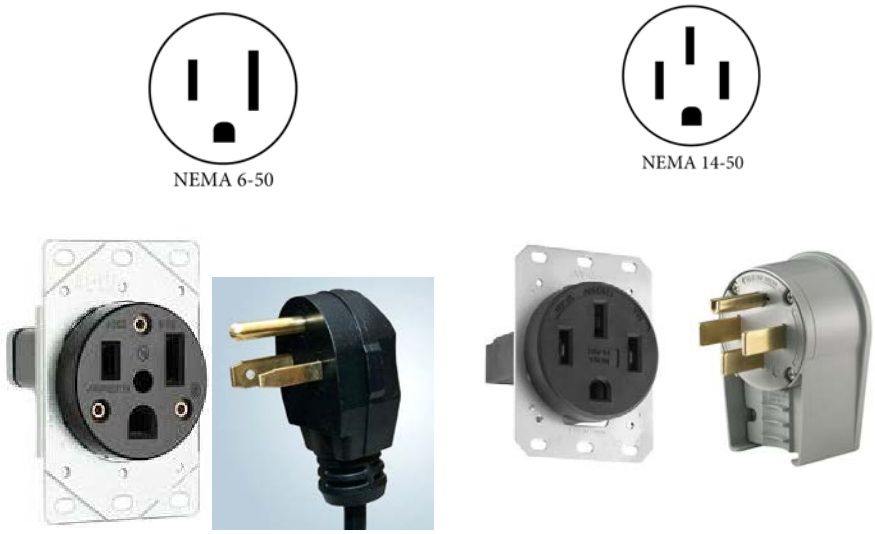

Figure 5: NEMA 6-50 and 14-50 receptacle and plugs commonly used for Level 2 Chargers

3.3.3 Calgary

In Calgary, there are two types of electrical permits, those for homeowners [45] and those for electrical contractors [46]. Homeowners, subject to limitations outlined by the City, are permitted to tie into their main electrical panel for the installation of equipment. For EV chargers, this would require a 50 A breaker to be installed and unused within the panel, which is unlikely as Alberta does not have any provisions for homes to be EV charging ready. In the likely case that a 50 A breaker is not installed in the panel, a certified contractor will be required to complete the installation. A contractor will need to pull a permit for the installation of a charger and need to identify if the charger is greater than or less than 50 kW.[xiv] Homeowners and contractors should refer to the City of Calgary permit webpages, "Homeowner electrical and plumbing permits," and "Electrical Permits for Contractors," respectively.

Applications must be completed by a certified electrical contractor holding an Alberta Master Electrician Certificate and a City of Calgary business license and completed the City Qualified Trade Application process. For residential electrical permits, the City of Calgary has a separate process that enables applicants to apply for permits online. The City also encourages permit applicants to contact ENMAX prior to beginning installation to reduce delays and ensure that the utility has sufficient distribution system capacity to accommodate new electrical demand. Once a permit is processed by the City, it is automatically forwarded to ENMAX to notify them of anticipated installations.[xv]

[xiv] Permits for EVSE capable of 50 kW or greater are typically not installed at residences.
[xv] As per city official

3.3.4 Edmonton

Although the City of Edmonton does not explicitly designate a permit requirement for EVSE, “any addition to an electrical system” requires a permit – including new circuits and wiring for EVSE.[47] The installation of the EV charger can be completed by the homeowner or by a qualified electrical contractor. Permit fees are based on the estimated electrical installation cost of the project. The City of Edmonton encourages applicants to review EPCOR’s Power Connection Process guide to ensure that interconnection processes are handled efficiently.

For more information on permits, homeowners and contractors can visit their respective permit webpage on the City of Edmonton website, “Electric Permits – Residential” and “Commercial Electrical Permits.”

3.3.5 Other Jurisdictions

Despite deploying more EVSE than any other state or province in North America, California continues to struggle with streamlining permitting processes at the municipal level. Electrify America (EA), the Volkswagen Group of America subsidiary is required to invest $2 billion on EV charging networks across the U.S., identifies permitting as a challenge to successfully installing EVSE in a timely manner [48]. The company notes that permitting duration in California on average takes 66 business days (25 more business days than the national average) and that the company’s California DCFC station design, permitting, and construction costs are 32 percent higher than the national average [49]. To address permitting issues related to EVSE installations, California passed Assembly Bill 1236 (AB 1236, 2015), which requires all cities and counties to develop expedited permitting processes for all EVSE “to achieve the timely and cost-effective installation of electric vehicle charging stations” [50]. Specifically, the legislation stipulates that a jurisdiction’s review of a permit application shall be limited to whether the application meets all relevant health and safety requirements, as opposed to whether the application meets aesthetic or other additional standards of review.

Moreover, the law requires AHJs to develop an accessible, on-line checklist of all requirements needed to be eligible for an expedited review. The California Governor’s Office of Business and Economic Development (GO-Biz) suggests that once a permit application is submitted, a “best practice” duration for permit approval is one day for Level 2 stations in single-family homes, 15 days for Level 2 stations in multi-family buildings and workplaces, and 15 days for DCFC stations [51]. GO-Biz also developed a table of provisions required by AB 1236 as well as general best practices for AHJs involved in EVSE permitting [52]. The table is available in Appendix A of this report.

Although some areas within California have faced difficulties in complying with AB 1236, some AHJs have met and exceeded the law’s requirements. For example, the City of Los Angeles enabled projects with EVSE installations that require less than 400 amps of service to use the City’s Express Permit, which allows applicants to receive permits automatically online and use their EVSE immediately after inspection [53] The City of Anaheim waives the $147.67 fee for approved residential EVSE permit applications [54]. Outside of California, some states like Oregon and New Jersey have moved to classify EVSE installations as “minor work” – meaning that projects are able to advance more efficiently or at less cost than standard permit applications [55].

For more complex projects that require electrical metering upgrades or distribution system upgrades, electric utility engagement is required to ensure the EVSE installation occurs safely and efficiently. The most advanced utilities have dedicated internal EV teams that are responsible for handling interconnection requests and EVSE deployments. Although dedicated teams and processes help ensure that installations happen efficiently, installation timelines are ultimately dependent on the complexity of the EVSE deployment. Pacific Gas & Electric (PG&E), the utility serving much of Northern California, estimates that the most sophisticated EVSE deployments can take up to one year to schedule and complete [56].

3.4 Utility-EVSE Regulation

In most North American jurisdictions, electrical utilities are regulated, and there exist specific rules as to how electricity can be purchased, sold, and priced. It has been observed that there are potential challenges for EV charging when charging station operators attempt to capture increased fees on the electrical power they sell. In Canada, the BC Utility Commission examined regulating EV charging, whereby charging for power sold from chargers could be considered "public utilities" under the Utilities Commission Act. As of 2018, they ruled that they would not regulate EV Chargers.

In Alberta, "the Alberta Utilities Commission (AUC) regulates Alberta's investor-owned electric, gas, water utilities and certain municipally owned electric utilities to ensure that customers receive safe and reliable service at just and reasonable rates." Currently, it does not regulate rural electrification associations (REAs), municipally-owned utilities (excluding ENMAX and EPCOR, which are regulated), or competitive retailers. At this time, AUC has not brought out any regulation pertaining to EV charging.

> **NOTE: In Alberta, the AUC does not have any regulations on EVs and EV chargers; this would include Vehicle-to-Grid (V2G) interactions and how EV chargers can bill consumers for use.**

3.5 EV Energy Management Systems and Vehicle-Grid Integration

3.5.1 Overview

3.5.2 Electric Vehicle Energy Management Systems

Multiple EVSE deployments located in close proximity can create challenges for existing electrical infrastructure at residences and workplaces – leading to potentially costly upgrades. EV Energy Management Systems (EVEMS) describe various technologies employed to modify EV charging in a manner that increases the utilization of existing electrical capacity and mitigates the need to make new infrastructure investments. These systems may either slow, cycle, or delay EV charging to prevent capacity overloading when multiple EVSEs are drawing power from the same circuit or electrical panel. In other words, EVEMS may be ideal for long dwell-time locations such as homes and workplaces where load management may not impede an EV's ability to reach a desired state of charge in a given period. However, EVEMS may not be appropriate for modifying load where EV charging needs are time-sensitive, such as at DCFC stations, or when pricing is time-based (e.g. cents per minute).

Given that EVEMS are deployed "behind the meter" at the point furthest downstream in the electricity system, EVEMS can be an important strategy to manage potential EV charging installation costs incurred by site hosts as well as mitigate upstream electric distribution system upgrades that utilities may incur from increased EV charging. Figure 6 illustrates where EVEMS fit into the broader distribution system.

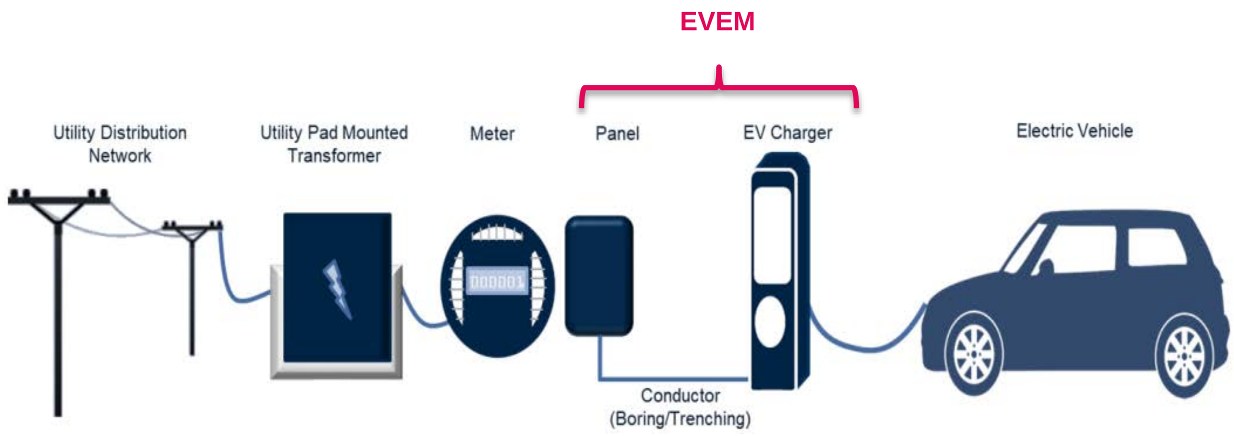

Figure 6: Illustration of EV Charging Infrastructure Requirements (Source: M.J. Bradley and Associates)

There is an array of EVEMS configurations that each offer various advantages, disadvantages, and technical requirements. However, the Canadian Standards Association Group (CSA Group) identifies two primary schemes: time allocation and power allocation [57]. Time allocation, or "rotational charging," refers to the assignment of power to different charging stations based on time. Power allocation, in its simplest form, describes the scenario where power is split between two or more vehicles to ensure that circuits are not overloaded. In both cases, power supplied to EV charging stations should not exceed the circuit demand rating at any point in time.

An important consideration for the EVEMS design is to factor the minimum charge requirement for a vehicle. This will vary greatly based on the following factors: typical driving distances, weekday versus weekend driving habits, building occupant/vehicle density, vehicle make and model, typical duration period for which the EV is plugged in, and seasonal weather variations; all of which can greatly vary EV charging requirements. Due to the high level of variance, it would be prudent for the installation of EVEMS systems to be based on a site-specific analysis that considers the typical behaviour of the building occupants and regional weather that would influence the minimum charge requirements. Based on conversations with the City of Vancouver personnel, the number of EV chargers per EVEMS is typically less than five to ensure adequate time for an EV to charge.

3.5.3 Vehicle-Grid Integration

EVEMS is one tool to mitigate potential adverse electricity system impacts from EV charging, but there are several additional strategies available to achieve broader load management goals. Vehicle-grid integration (VGI), as defined by the California Public Utilities Commission (CPUC), refers to "the many ways in which a vehicle can provide benefits or services to the grid, to society, the EV driver, or parking lot site host by optimizing plug-in EV interaction with the electrical grid" [58]. VGI encompasses active EV load management strategies (e.g., demand response and ramping of EV charging) based on active grid conditions and passive load management strategies (e.g., time-of-use rates and other utility charges). As opposed to EVEMS interventions that are focused on reducing adverse impacts at the panel and circuit level, VGI solutions are generally employed to mitigate upstream impacts at the utility distribution system level.

Arguably the most common form of VGI today is time-of-use (TOU) electricity rates. TOU rates vary predictably depending on what time of day that electricity is consumed; periods of high electricity system demand, or "on-peak" periods, generally command higher per-kWh rates while "off-peak" periods of modest demand allow utility customers to consume electricity at a lower per-kWh rate. Because L2 charging stations have the potential to double the instantaneous electrical load of a single-family home, well-designed TOU rates can play an important role in managing EV load to avoid unnecessary distribution system upgrades[xvi], mitigate power sector emissions by encouraging charging during periods of greater renewable generation[xvii], and optimize fuel cost savings from switching from gasoline-powered vehicles to EVs [59]. **Figure 7** from the recently released *Charge the North* report illustrates that while average EV charging loads are relatively low at the city or provincial level, unmanaged transformer-level EV loads can be highly coincident and potentially exacerbate residential evening peaks [60].

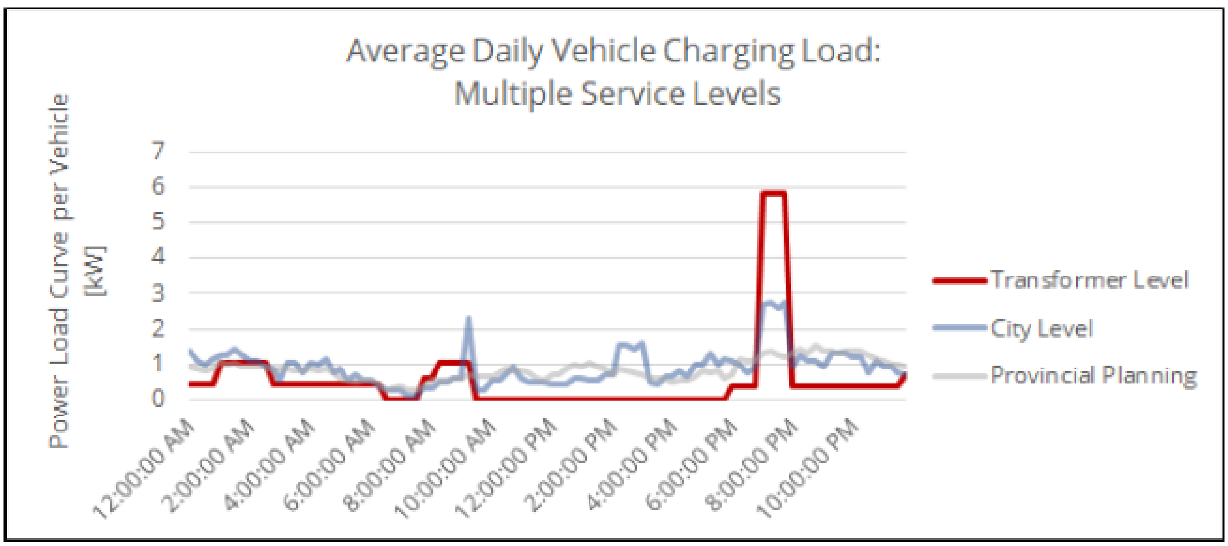

Figure 7: Ontario EV Charging Loads by Service Level (Source: Charge the North report)

[xvi] NOTE: during the engagement sessions ENMAX's feedback that the concern amongst Alberta utilities is that TOU is difficult to implement in an unregulated market, and that TOU may cause a second peak when 'off peak' rates begin and just move the problem rather than resolve it.
[xvii] A study from Simon Fraser University finds that the marginal emissions factor of Alberta's electricity grid is lowest during the afternoon peak when natural gas and imported hydro generation are used to meet demand. This finding suggests that incremental emissions from EV charging will be lower during the afternoon period, but the emissions factor will change as Alberta's energy mix evolves. http://rem-main.rem.sfu.ca/papers/jaxsen/Electrifying_Vehicles_(FINAL)_V2.8_(July10).pdf?_ga=2.218622864.888857198.1566855183-1479706354.1566855183

To date, there has been limited research on actual system costs attributable to incremental EV load. However, the CPUC collects this data at the residential level on an annual basis through its *Joint Investor-Owned Utilities Electric Vehicle Load Research Report*. In the 2018 report, the CPUC found that with over 415,000 EVs located within three major utility service areas across the state, only 618 vehicles – or 0.15% — generated a service line or distribution system upgrade as a result of new EV load [61]. In total, the three utilities spent approximately $7 million in 2018 on EV-related infrastructure upgrades. Considering the utilities spend a combined $5 billion annually to maintain their systems, these EV upgrade cost figures are negligible (0.14%).

Demand response refers to the modification of customer electricity consumption at certain times in response to various economic signals and grid conditions. In many cases, demand response encourages customers to reduce electricity usage or shift demand to different times of the day. EVs that are plugged into the grid have significant potential to be leveraged as demand response resources that contribute to the reliability and flexibility of the electricity system. A paper from the Lawrence Berkeley National Laboratory in the U.S. finds that with the 1.5 million EVs that California expects to have on the road by 2025, the State has the potential to leverage 1.0 gigawatts of energy storage capability for valuable grid services such as valley-filling (increasing electric load during periods of low demand on the electricity system) and ramp-up mitigation (reducing the amount of additional generation capacity needed to satisfy electricity system demand in the transition from off-peak to on-peak periods) with smart, demand-responsive technology that is readily available today [62]. Similar to TOU rates, effective demand response for EV charging can reduce wholesale energy supply, transmission, and distribution costs during grid peaks, align charging behaviour with the availability of low-carbon electricity generation, and lower EV charging costs. According to the Smart Electric Power Alliance, 22 out of 28 EV charging service providers surveyed offer managed charging capabilities [63].

Vehicle-to-grid (V2G) refers to the bidirectional flow of power between EVs and the grid. Similar to energy storage, this concept involves the conversion of energy in the vehicle battery into an AC current that is discharged back onto the electricity grid. V2G can magnify the benefits associated with demand response, creating opportunities to support grid reliability by supplying power on the system when it is needed most and potentially providing valuable grid services such as frequency regulation. However, V2G is an emerging load management solution and faces several additional barriers to full deployment. First and foremost, many automakers void the warranty on their vehicles' batteries if they are used for V2G due to battery degradation concerns; Nissan is the only known automaker that provides a warranty for its vehicles that participate in V2G activities [64]. Additionally, V2G capability typically requires additional hardware costs for AC/DC conversion and additional permitting and engineering costs required by utilities and local grid operators [65]. Finally, without access to ancillary service markets and time-varying rates that allow for arbitrage opportunities, there is a little economic incentive for EV drivers to dispense power back onto the grid.

3.5.4 Policies and Programs in Alberta

3.5.4.1 Electric Vehicle Energy Management Systems

The Cities of Calgary and Edmonton do not have specific policy or guidance on EVEMS as of February 2020. The AUC had not considered the topic of EVEMS as of August 2019.

3.5.4.2 Vehicle-Grid Integration

Alberta's electricity market is restructured, meaning that energy (generation) prices are not regulated by the Alberta Utilities Commission (AUC) and instead determined by supply and demand in wholesale electricity markets overseen by the Alberta Electric System Operator. Utility customers have the option to procure energy from competitive suppliers or receive default service from retailers that are regulated by the AUC. The AUC also regulates transmission and distribution rates, which are often recovered from utility customers on a cents per kWh basis. A large share of utility customers' electricity bills is comprised of energy, transmission, and distribution charges. The AUC estimates that between 37 to 75 percent of a typical residential customer bill is driven by transmission and distribution charges alone [66].

To date, the AUC has generally not advanced TOU options in the rates that it regulates – although there are some exceptions.[xviii] Regulated default suppliers charge for energy on a flat, volumetric basis with a minor month-to-month variation. In many cases, transmission and distribution rates for transmission and distribution companies are similarly charged to customers on a per kWh basis and do not vary by time of day. Without visible price signals, utility customers may not be encouraged to shift electricity load to times that lower peak demand and enhance the reliability of the distribution system.

No utilities in the province appear to be publicly testing the VGI capabilities of EVs, nor has the AUC appeared to have approved any related VGI pilots for regulated utilities. However, in December 2018, the Alberta Utility Commission (AUC) initiated the Electric Distribution System inquiry – a proceeding to explore the implication of new, grid-edge technologies and business models on Alberta's regulated utilities and the Alberta Electric System Operator [67]. While not solely focused on EVs, the AUC identified EVs as an emerging technology and seeks stakeholder feedback on how EVs may affect electric distribution service. The proceeding will also consider how electricity rate structures may be modified in response to the deployment of these technologies to ensure that grid assets are utilized in an efficient and cost-effective manner [68].

> **NOTE: While there exists no direct rules or regulations for the use of an EV as a means of energy storage, grid-interactive/bi-directional EV Charging equipment would be subject to Alberta Regulation 27/2008 Micro-Generation Regulation (small micro-generation less than 150 kW, large micro-generation at least 150 kW and less than 5 MW) which outlines the requirements for the supply of the grid with electrical power. Level 2 chargers are by definition less than 150 kW, and should the technology be made available to EV owners for bi-directional power flow (vehicle to grid) such systems would be subject to the rules and**

[xviii] Examples of the exceptions including ENMAX and Epcor which do have transmission and distribution TOU tariffs for its large commercial customer class.
https://www.enmax.com/ForYourHomeSite/Documents/2019-04-01-DT-Tariff-Rate-Schedule.pdf
https://www.epcor.com/products-services/power/rates-tariffs-fees/Documents2/DistributionAccessServiceTariffApril-2018.pdf

regulations of small micro-generation; greater than 150 kW would require DCFC chargers, which are currently not supported by residential power supplies. While this Act does not speak directly to battery storage, the application of this Act to interactive systems is a grey area, and local inspectors or utilities may limit or prevent interactive installations. For EV charger pricing regulations, the AUC does not have any regulations or rules for the pricing mechanism for power usage, but if the charger is to bill users based on energy use (i.e., kWh), the charger is subject to Measurement Canada requirements. According to Measurement Canada:

> **"Electric vehicle charging stations allow consumers to charge their electric car by buying electricity. The practice of charging a fee for the use of these stations is relatively new. Various levels of government and private industry organizations have started to install these stations to invest in clean technologies.**
>
> **Many of these charging stations use measurement systems that incorporate new technologies. These new technologies must comply with different federal measurement laws depending on how the electricity is sold.**
>
> **When electricity is sold at these stations, the consumer is usually charged a flat rate, a time-based rate or a blended rate (e.g. the consumer is billed for parking and for the vehicle charge together). Blended rates may also be time-based.**
>
> **If the fees for the use of these stations are based on time, these stations are currently exempt from inspection or any intervention by Measurement Canada. However, if the fees are based on an energy or power measurement, then an approved and inspected meter must be used. Measurement Canada is closely" following how this technology is being used, both in Canada and internationally" [69].**

3.5.5 Other Jurisdictions

3.5.5.1 Electric Vehicle Energy Management Systems

As noted by the CSA Group, EVEMS is an emerging technology for which there is currently no product standard – precluding standards organizations from performing product testing and certification [70]. However, EVEMS have been recently recognized in Section 8 of the 2018 edition of the Canadian Electrical Code [71]. Moreover, some local jurisdictions have taken steps to clarify the role of EVEMS in their bylaws. For example, the City of Richmond (BC) amended its zoning bylaw to specify performance standards for EVEMS used in new multifamily developments with shared parking areas [72]. While the bylaw does not require the use of EVEMS at these facilities, the performance standard requires that:

- *The system must be capable of supplying a minimum performance level of 12 kWh per parking space over an eight (8) hour overnight period, assuming that all parking spaces are in use by a charging EV*; and
- *Projects implementing EV energy management systems must provide for communications technology necessary for the function of an EV energy management system (e.g., cellular, wireless, or cabled infrastructure) [73].*

The purpose of the standard is to ensure that EVs receive an adequate level of charging during overnight periods. The City of Vancouver has also advanced a similar amendment to their parking bylaw that allows the City's Chief Building Official to set a minimum performance standard for EVEMS to ensure that EV charging still occurs at a sufficient rate [74]. These charging rates are intended to satisfy the estimated average daily driving patterns of residents, which vary by city.[xix] Both the Cities of Richmond and Vancouver have introduced these policies as a part of broader EV-readiness requirement modifications, suggesting that EVEMS can be viewed as a potential compliance strategy for EV ready building codes.

3.5.5.2 Vehicle-Grid Integration

TOU rates are common among many electric distribution utilities across Canada and the US, and they can be designed in myriad ways to accommodate local grid conditions. For example, the Ontario Energy Board notes that the "vast majority" of residential and small commercial customers are billed on TOU rates set by the Board [75]. Under this paradigm, Toronto Hydro offers a three-period residential TOU rate that includes higher per-kWh pricing during the middle of the day (on weekdays) and significantly lower rates during evenings and early morning periods. **Figure 8** shows the Toronto Hydro's summer pricing period [76]. TOU rates generally require the deployment of smart meters that are able to record and send energy usage data at frequent, regular intervals.

Summer pricing period, effective May 1, 2019 to October 31, 2019

TOU period	Hours	Price
On-Peak	Weekdays from 11 a.m. to 5 p.m.	13.4¢ per kWh
Mid-Peak	Weekdays from 7 a.m. to 11 a.m. and 5 p.m. to 7 p.m.	9.4¢ per kWh
Off-Peak	Weekdays from 7 p.m. to 7 a.m. and all day weekends and holidays	6.5¢ per kWh

The rates quoted above cover the cost of electricity purchased on your behalf. Toronto Hydro passes this cost through to you, without mark-up, and pays it directly to our suppliers.

Figure 8: Toronto Hydro Residential TOU Rate Schedule (Source: Toronto Hydro)

Similar to other smart, connected devices that are beginning to proliferate on the grid, networked (or "smart") EVSE are able to perform VGI-enabled grid services that enhance the reliability and flexibility of the electricity system. One of the largest active EV charging demand response pilots in Southern California Edison's (SCE) Charge Ready Demand Response Pilot [77]. As a condition for participation in SCE's Charge Ready EVSE incentive program, SCE required that vendors' charging equipment be capable of receiving demand response signals from the utility to modify EV charging loads. With over 1,000 charging ports enrolled across a variety of market segments, the pilot sought to test customer responsiveness to two different kinds of test events; 1) load shift events allowed customers to receive incentives for shifting their charging from morning peak periods to midday periods during periods of high renewable generation and 2) traditional demand response events allowed customers to receive incentives

[xix] Calgary and Edmonton residents may drive longer distances than their British Columbian counterparts on a daily basis, suggesting that Calgary and Edmonton may consider higher minimum performance standards to satisfy those driving patterns.

for reducing their charging during steep ramping of electrical demand on the grid [78]. In the test events that have been called in 2019, SCE estimates that 19-35% of morning EV load was reduced, and 1-8% of the load was shifted to the midday incentive period [79].

Green Mountain Power (GMP), a utility in Vermont, runs the *e-Charger* Pilot. In exchange for a free L2 residential charging station and unlimited off-peak charging at a low fixed price, utility customers give GMP permission to control and reduce EV demand during peak times [80]. In the event that customers opt-out of a demand response event, they are charged a higher per kWh energy price. The pilot has 300 customers enrolled and, according to GMP, provides valuable data on the demand response potential of residential EV charging [81].

At least a dozen other utilities in North America have completed or are implementing similar VGI pilots; additionally, some utilities that have received regulatory approval to support the deployment of EVSE require charging equipment to be capable of receiving demand response signals for participation in future load management programs [82].

V2G pilots have been limited in scale but continue to grow. One of the earliest pilots was administered by the University of Delaware, in which 15 V2G-capable EVs responded to signals from the regional grid operator to charge and discharge in response to grid conditions. It was estimated that the vehicles' participation in the grid operators' frequency regulation market generated about $5 a day in revenue per vehicle, or approximately $1,800 year [83]. A more sophisticated pilot was administered by the California Energy Commission and the U.S. Department of Defense at the Los Angeles Air Force Base that tested the V2G capabilities of 13 Nissan LEAFs and several medium-duty and heavy-duty vehicles between 2016-2017 [84]. The pilot found that the LEAFs had the potential to generate approximately $1,200 per year from the California Independent System Operators (CAISO) frequency regulation market. However, when considering CAISO market regulations and transaction fees, costs often exceeded revenues collected. These findings suggest that the economic viability of V2G's participation in ancillary service markets is heavily dependent on grid operator market rules, fees, and the magnitude of the V2G resource available. Nonetheless, a small but growing number of utilities are beginning to test electric school buses' potential as a V2G resource – particularly during summer months when the vehicles are not frequently used [85].

Policies that stipulate specific EV load management programs and requirements are not common. However, in legislation that clarified regulated electric utilities' role in supporting the deployment of charging infrastructure (Senate Bill 350, 2015), the California Legislature declared that:

> *Deploying electric vehicles should assist in grid management, integrating generation from eligible renewable energy resources, and reducing fuel costs for vehicle drivers who charge in a manner consistent with electrical grid conditions [86].*

Legislative recognition of the load management capabilities of EVs can potentially encourage greater investment in VGI and related pilots, thereby enhancing EV adoption and the corresponding EVSE deployment.

3.6 EV and EVSE Programs and Incentives

3.6.1 Overview

There are three key areas that EV and EVSE programs could be designed to overcome, these include financial barriers, lack of experience with the relevant codes and installation requirements for charging infrastructure, and lastly providing current and prospective EV owners with sufficient EV charging infrastructure such that they can readily find it and charge their vehicle.

Pricing for EVs has been and continues to be a large barrier to increased adoption, as EVs currently cost significantly more on an upfront basis than a comparable model of vehicle with equivalent features. The cost for EVs may also come with capital expenditures to upgrade to Level 2 home chargers, with a notably higher cost of installation in MURBs. While this price differential is a reality today, it may not be the case in the future, as analysts at Bloomberg New Energy Finance adjusting their estimate for EV price parity with ICE vehicles from 2026 to 2024 in the 2018 EV forecast report; i.e., the price parity point is expected to arrive two years sooner [87].

While the increased competitiveness of EVs is promising for advocates, the existing price barrier will require some form of financing or discounts in order to appeal to the general consumer and to ensure strategic or accelerated growth in EVs is achieved. Within Canada, the impact of incentives can be inferred from the regionality of EV sales. For example, in 2018, over 97% of EV sales in Canada were in Provinces with incentive programs targeted at EV purchases (BC, Ontario, and Quebec) [88]. Additionally, incentives can and do have demonstrable impacts on sales of EVs in mature markets, as was the case in Ontario after they phased out their incentive program in 2018. Looking at Canadian EV sales in Q1 of 2019 (see **Table 2**), it can be seen that Ontario was the only region in Canada where sales volumes dropped compared to Q1 2018, [89] as sales appear to have slowed without financial support.

Table 2: EV Sales Q1 2018 versus Q1 2019

Province/Territory	Q1 2018	Q1 2019	Q1 '18-'19 Change	Approx. EV Total
Alberta	116	191	64.7%	2,269
BC	1,361	2,718	99.7%	19,893
Manitoba	17	21	23.5%	402
NB	10	11	10.0%	186
Newfoundland	1	9	800.0%	48
NWT	0	1	-	9
Nova Scotia	10	17	70.0%	240
Nunavut	0	0	-	1
Ontario	2,633	1,219	-53.7%	35,271
PEI	4	5	25.0%	34
Quebec	2,446	3,814	55.9%	42,551
Saskatchewan	9	18	100.0%	208

Yukon	0	1	-	4
Canada	6,607	8,025	21.5%	101,116

3.6.2 Policies and Programs in Canada

For Canadian policies, three key regions were examined, British Columbia, Ontario, and Quebec. These regions have been leaders in the sector and have introduced programming for years with the aim of accelerating and fostering EV's integration into existing transportation networks. In addition to the summary of EV Programs in these regions, a quick overview is also provided of programs, projects, and policy that exists within Alberta, and the actions that have been undertaken by the Government of Canada.

3.6.2.1 Canada

In 2009, Natural Resources Canada released the "Electric Vehicle Technology Roadmap for Canada," which set a goal of 500,000 plug-in electric vehicles by 2018 [90]. Since the roadmap was released, Canada obtained sales of only 93 thousand EVs, well short of the initial target [91]. While the roadmap had outlined how the Government, where feasible, by 2010 should provide action on initiatives for EV technology, update/harmonize Codes, standards, and regulations; commission and complete EV studies and assessments; and work to develop education, training, and outreach for EV technology. Since 2010, the Government of Canada was inactive in the development of incentives to meet the requirements of the roadmap until December 2016, where they launched the Electric Vehicle and Alternative Fuel Infrastructure Deployment Initiative, which funded the construction of 131 EV chargers, and they have committed to funding the construction of 395 more. Additional programming came under the incentive for the Zero Emission Vehicle (iZEV) program, which set targets 10%, 30%, and 100% of new light-duty vehicle sales to be zero-emission vehicles by 2025, 2030, and 2040 respectively. In order to help meet the new targets, the Government of Canada introduced incentives for battery electric vehicles (BEV), plug-in hybrid electric vehicles (PHEV)[xx], and hydrogen fuel cell electric vehicles (HFCEV) effective for vehicles purchased on or after May 1, 2019 [92].

As part of the iZEV program, the Government of Canada introduced incentives of $2,500 for short-range PHEV and $5,000 for BEV, long-range PHEV, and Hydrogen Fuel Cell Electric Vehicle (HFCEV) pending the with a manufacturer's suggested retail price (MSRP) of less than $45,000 for the base model or less than $55,000 for upgrade/higher price versions of the former base model[xxi]. For businesses, the program does allow for a 100% tax write-off up to purchase price up to $55,000 plus federal and provincial sales tax on the purchase of light-duty, medium-duty, or heavy-duty vehicles that are BEV, long-range PHEV, or HFCEV. Eligible vehicles are to

[xx] PHEV are considered by the Government of Canada as short range if the battery pack capacity is less than 15 kWh, which would yield an estimated electric travel range of 50 km. Vehicles with battery capacity of 15 kWh or more are considered long range.
[xxi]This is for vehicles with less than 6 seats (typical for existing EVs as most are cars or small SUVs). For vehicles with 7 or more seats, the base model MSRP must be less $55,000 and the higher priced version must be less than $60,000.

be purchased on or after March 19, 2019, and before January 1, 2024. The Federal incentive is designed to stack with any Provincial or local incentives on EVs or ZEVs.

The Government of Canada also supports fueling and charging infrastructure under the existing Electric Vehicle and Alternative Fuel Infrastructure Deployment Initiative [93], where EV fast chargers—i.e., DCFC—can receive up to $50,000 per charger, with a cap of $5 million per project. The program has closed to submissions for Phase 2, and there does not appear to be any commitments for Phase 3 at this time.

Another program from the Government of Canada is the Zero-Emissions Vehicle Infrastructure Program [94], which was launched in June 2019. The program accepted applications until September 18, 2019, for the Public Places and On-Street Parking EV charger installations. The rebates for the program cover up to 50% of the project costs up to $5M, with rebates as follows: $5,000 per Level 2 connector[xxii], $15,000 per DCFC station ranging from 20 kW to 50 kW, and $50,000 per DCFC station greater than 50 kW. The program requires the installation to support charging for a minimum of 20 vehicles—i.e., 20 charging ports or stations—and is limited to electrical or gas utilities, companies, industry associations, research associations, standards organizations, indigenous and community groups, academic institutions, and provincial, territorial, regional, or municipal governments/departments/agencies. The future of the program is planned to target workplaces, fleets, MURBs, and mass transit.

3.6.2.2 Alberta

In Alberta, there are no current Provincial programs for EVs in effect.

While there are no Government programs, the Municipal Climate Change Action Centre (MCCAC)—a joint venture of the Government of Alberta, the Alberta Urban Municipalities Association (AUMA), and the Rural Municipalities of Alberta (RMA)—does offer EV incentives as part of their Electric Vehicles for Municipalities (EVM) Program. The EVM Program offers funding for EV Studies and rebates on new vehicle purchases. The program is limited to municipalities and thus would not apply to general consumers and does cover non-road EVs as well. BEV and long-range PHEV, which are eligible for rebates of $8,000, and short-range PHEV are eligible for rebates of $4,000 [95].

ENMAX does have an EV pilot program called Charge Up, (now fully subscribed) that provided 60 Level 2 EV chargers to residential customers and Level 2 or Level 3 chargers for public installations [96].

Another program in Alberta has been the Peaks to Prairies project, which was a collaborative project which included The City of Calgary, SouthGrow Regional Initiative, Alberta SouthWest Regional Alliance, City of Lethbridge, City of Medicine Hat, and Medicine Hat College [97]. The project is in the process of installing 20 DCFC and Level 2 chargers across Southern Alberta, with completion scheduled for the first half of 2020.

[xxii] **Level 2 chargers must support a dedicated parking spot for each connector; i.e., support charging and a parking space at the same time.**

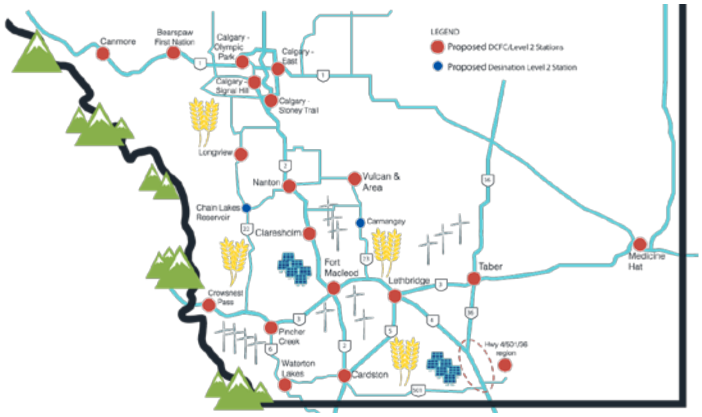

Figure 9: Peaks to Prairie Charger deployment map (Source: City of Calgary)

In an effort to increase EV charging accessibility in its urban core, the City of Calgary unveiled the installation of 42 new L2 charging stations in May 2019 [98] The charging stations are located at three Calgary Parking Authority parkades and are accessible to all commercially available light-duty EVs. Charging is free, but standard parking rates apply.

3.6.2.3 British Columbia

Numerous programs and guidelines have been implemented in British Columbia. Existing programs include the Specialty-Use Vehicle Incentive (SUVI) Program, the Clean Energy Vehicle (CEV) for BC Program, the BC SCRAP-IT, and Zap BC.

The Government of British Columbia has implemented the Clean Energy Vehicle for British Columbia (CEVforBC) program, which provides Zap BC. This program was introduced on November 5, 2011.

After several program renewals since then, on June 22, 2019, the Government of BC funding incentives were adjusted to address the high level of applications. The program will now remain open until March 31, 2020. CEVforBC provides $3,000 for BEV, long-range PHEV, and HFCEV, and $1,500 for short-range PHEV [99]. Effective on September 26, 2019, the Government of BC launched the CleanBC program, which lists the CEVforBC rebates with the Federal iZEV rebates (see **Part 3.6.2.1**) [100].

CleanBC has re-introduced a charger rebate Program (BC's EV Charger Rebate Program) available from FortisBC and BCHydro. This program replaces the Charging Solutions and Incentives Program, which was closed on July 6, 2018, due to being fully subscribed. The former program provided rebates for EV charging stations at homes and workplaces as follows [101]:

- For homes: 75% of the charger costs up to $750.
- For residential buildings/MURBS: 75% of the project cost up to $4,000 per Level 2 station, max of 2 stations.
- For Workplaces: 50% of the project cost up to $2,000 per Level 1, and $4,000 per Level 2 charging station.

Effective September 26, 2019, the new CleanBC BC EV Charger Rebate Program offers the following rebates [102, 103, 104]:

- For homes: 50% of the charger costs up to $350 on a Level 2 charger.
- For MURBS: Subject to Pre-Approval there are two rebates levels available, depending on whether the building was constructed prior to or after changes to the municipal bylaws requiring EV ready parking stalls:
  - Prior to the change, the rebate was 50% of the project cost up to $2,000 per Level 2 station, up to a max rebate of $14,000 per application.
  - After the change, the rebate was 50% of the project cost up to $350 per Level 2 station, up to a max rebate of $5,000 per application.
- For Workplaces: 50% of the project cost up to $2,000 per Level 2 charger up to a maximum rebate of $14,000 per application.

The BC SCRAP-IT provided funding for the purchase of EVs and EV chargers. The program is not a provincial program and relies on private funding, grants and contributions from individuals and program partners. Currently, the program is fully subscribed. BC SCRAP-IT offered $6,000 for new EV purchases, $3,000 for used EV purchases [105]. For the vehicle rebates, the program applicants need to meet two requirements. Applicants need to be the registered owner of the scrapped vehicle (must be scrapped within 30 days), and the vehicle had to be insured for driving for at least 6 months prior to the date of application for the rebate; a vehicle in storage is not eligible. The charger rebate program, which is now called ZAPBC, distributed 1000 Level 2 EV chargers for free to qualified applicants.

Not only has BC seen a strong level of financial support for EVs, many regional governments, the utility, special interests/non-profit groups, have worked to facilitate EV adoption and EVSE deployments, this included the following guidelines and studies that are freely available online.

- The Condominium Home Owners Association of BC developed and released guidelines for installing EV charger infrastructure in MURBs; see the 2014 "Installation of Electrical Vehicle Charging Stations on Strata Properties in British Columbia."
- The City of Richmond and BC Hydro Power Smart have developed and released the following guidelines:
  - *Residential Electric Vehicle Charging: A Guide for Local Governments;* [106]
  - *Electric Vehicle Charging Infrastructure In Shared Parking Areas: Resources to Support Implementation & Charging Infrastructure Requirements* [107].
- In 2013, the UBC TIPS Lab prepared for BC Hydro and the BC Government the *Design Guidelines and Standards: BC Public Electric Vehicle Charging Stations* [108].
- In 2014, in partnership with BC Hydro, CEATI International released the *Canadian Electric Vehicle Infrastructure Deployment Guidelines 2014* [109].
- The City of Vancouver completed a pilot project which closed on June 30, 2019, called the *Curbside Electric Vehicle Pilot Program* and released an engineering services design guideline [*110*].
- BC Hydro has also rolled out a charging app and RFID card that can be used to access charging stations, which greatly improves the user ease of use for accessing public charging stations.

3.6.2.4 Ontario

Ontario introduced the Electric Vehicle Incentive Program (EVIP) in 2010, which was updated in January 2017 to include zero-emissions vehicles creating the Electric Hydrogen Vehicle

Incentive Program (EHVIP). Ontario also created the Electric and Hydrogen Vehicle Advancement Partnership (EHVAP), which partnered the automotive sector, environmental advocacy organizations, and government agencies to work on reducing Ontario's GHG emissions and reach a target of 5% of new vehicle sales to be ZEVs. The programs are no longer active and were cancelled by the Government of Ontario effective on July 11, 2018. The program did undergo changes throughout its operation, with the incentive varying based on the vehicle and purchase price. The program had two incentive ranges, which were for vehicles under $75,000 and vehicles under $150,000. Incentives were increased in 2016 from a rebate range of $5,000 to $8,500 to a rebate range of $6,000 to $10,000. Additional rebates of $3,000 were available for large battery capacities, and an additional $1,000 was made available for vehicles with five or more seats. A list of the rebates per vehicle is available on the Ontario Ministry of Transportation webpage.[xxiii]

Incentives also existed for EV chargers for homes and workplaces. The home rebate covered 50% of the cost of the charger and installation up to $1,000 for Level 2 chargers (up to $500 for the charger plus up to $500 for the installation). The Workplace Electric Vehicle Charging Incentive Program covered 80% of the cost for installing chargers up to $7,500 per charger—note the $5 million dollars available for the program was fully subscribed quite quickly.

Currently, Plug'n Drive, a non-profit organization, which is "committed to accelerating the adoption of electric vehicles in order to maximize their environmental and economic benefits" in partnership with the Clean Air Partnership—a charitable environmental organization in Toronto, Ontario—are offering a $1,000 incentive on the purchase of a BEV or PHEV with a purchase price less than $50,000 [111].

Work has also been undertaken by non-governmental organizations such as the Condominium Authority of Ontario, who released a step-by-step guide for the installation of EV charging systems [112]. Another guideline is from, and NGO called Plug 'n Drive—with support from Ontario Power Generation, Power Workers' Union and TD—released the *Make your Condo EV Ready: 2018 Guide for Condo Owners, Boards, and Managers* [113].

3.6.2.5 Quebec

Quebec has a long history with the promotion of EV adoption in the Province, starting with the Roulez Vert Program, which was launched on January 1, 2012, and current applications are being accepted until March 31, 2021. Quebec has built its EV programs around its 2013-2020 Action Plan on Climate change and its 2015-2020 Transportation Electrification Action plan, which set a goal of 100,000 EVs by 2020, and currently, Quebec has 42,500 BEV. As of July 31, 2019, they have already issued 13,000 rebates on BEVs and PHEVs in 2019 [114].

These programs are supported by the Provincial Act A-33.02 "Act to increase the number of Zero-Emission motor vehicles in Quebec in order to reduce greenhouse gas and other pollutant emissions (ZEV Act). This Act aims to parallel the current requirements set by California, which will require auto manufacturers to hit minimum sales targets for EVs (BEV and PHEV) starting with their 2018 model lineup [115]. They will use a credit system, similar to a carbon cap and trade market, and manufacturers can buy and sell excess requirements as required. Quebec currently offers incentives for EV Charger installations as part of the Roulez Vert Program. The

[xxiii] (http://www.mto.gov.on.ca/english/vehicles/electric/electric-vehicle-rebate.shtml).

Province has over 1500 public chargers installed and is planning for at least 1600 DCFC to be installed in the next 10 years by Electric Circuit [116].

Through the Roulez Vert program, rebates are available for BEV and PHEV, as well as low-speed EVs and electric motorcycles and scooters. The program provides rebates for BEVs of $8,000 and $3,000 for vehicles with an MSRP below $75,000 and between $75,000 to $125,000, respectively—note that effective on April 1, 2020, the MSRP will need to be below $60,000. For PHEVs, the rebates are $500, $4,000, and $8,000 depending on the battery capacity of the vehicle with an MSRP of less than $75,000— note that effective on April 1, 2020, the MSRP will need to be below $60,000 [117]. The program also offers rebates up to $4,000 for used EVs, effective as of April 1, 2019.

For homeowners, the purchase and installation of Level 2 charger are eligible for up to $600 in rebates--$350 for the charger and $250 for installation. For MURBs, the program provides up to $5,000 per charging station and a maximum of $25,000 per building [118].

The primary utility Hydro Quebec has taken an active role in supporting EV adoption, releasing the “Electric Vehicle Charging Stations: Technical Installation Guide” in August 2015. The guide provides a detailed overview of charging technology at the time, site selection, installation requirements and procedures, and maintenance.

3.6.2.6 Manitoba

Manitoba does not currently have any EV incentive programs offered by the provincial government or any regional entity. The electrical utility, Manitoba Hydro, does offer financing for EV chargers under their Home Energy Efficiency Loan Program [119]. The program provides homeowners with up to $3,000/charger/EV for Level 2 chargers. The program finances a loan at an annual rate of 4.8% per year, with a maximum term of 5 years. The loan repayments are added to the existing utility bill and are non-transferable in the event the property is sold.

3.6.2.7 Other U.S. Jurisdictions

The California Green Building Code (CALGreen) establishes requirements for EV readiness in new residential, commercial, and other buildings to support Level 2 charging stations. These requirements represent minimum obligations that local jurisdictions can exceed through their own building codes. Starting January 1, 2020, CALGreen will require new single-family residences, duplexes, and townhomes to have dedicated circuits installed to support the installation of L2 EVSE [120]. For new multi-family buildings, at least 10 percent of parking spaces must be EV capable, meaning that adequate conduit and panel capacity are installed to accommodate future installation of dedicated branch circuits and charging stations. For new non-residential buildings, 4 to 10 percent of parking spaces must be EV Capable, depending on the size of the building. CALGreen also has “reach codes” that local jurisdictions can adopt that represent higher levels of commitment to creating EV ready parking spaces. Some cities, such as Oakland and San Francisco, require a portion of parking spaces to be *EV Ready* while other cities like Menlo Park and Palo Alto require some spaces to be fully equipped with EVSE. Other cities have extended EV ready building codes to existing facilities: for example, San Francisco requires EV infrastructure deployment when buildings undergo major retrofits.

Outside of California, the City of Atlanta passed ordinance 17-0-1654 (the “EV Ready” Ordinance) in 2017, which requires 20 percent of all spaces in new commercial and multi-family residential parking structures to be equipped with the conduit, wiring, and electrical capacity to support EV charging stations. The ordinance also requires all new single-family residential homes to be equipped with similar infrastructure to support a 40-amp, 240 V branch circuit for the future installation of an EV charging station. The City of Denver also updated its building code in 2016 to accommodate greater access to residential charging. The code requires new one- or two-family dwellings to be able to support a minimum continuous load of 4800VA, which should enable residents to install L2 charging stations without the need to upgrade electrical service. The code also requires the property's electrical panel to have at least two spare spaces for the installation of a two-pole breaker and any conduit needed for the garage.

3.6.2.8 EV and EVSE Funding Incentive Summary

A summary of the EV and EVSE financial incentives under different programs across Canada, along with the organization implementing the respective program, is provided in **Table 3** below.

Table 3: Summary of EV and EVSE Incentives in Canada

		Vehicle				EV Charger			
Funding Org and Program	Region	BEV	PHEV	HFCEV	Electric Motorcycle	Home	Workplace	MURB	Fast Charger
Government of Canada/NRCan Incentive for Zero Emission Vehicle (iZEV) Program	Canada	$5,000	$2,500 to $5,000	$5,000	N/A	N/A	N/A	N/A	N/A
Municipal Climate Change Action Centre (MCCAC) Electric Vehilces for Municipalities	Alberta	$8,000	$4,000 to $8,000	N/A	N/A	N/A	$2,000/charger up to $40,000/municipality		
Government of Quebec Roulez Verte	Quebec	$3,000 or $8,000	$500, $4,000, or $8,000	$3,000 or $8,000	$2,000	$600	$5,000	$5,000	N/A
Government of BC CEVforBC	BC	$3,000	$1,500 to $3,000	N/A	N/A	N/A	N/A	N/A	N/A
Government of BC CleanBC	BC	N/A	N/A	N/A	N/A	$350	$2,000	$350 or $2,000	N/A
Plug'n Drive	Ontario	$1,000	$1,000	N/A	N/A	N/A	N/A	N/A	N/A
Government of Canada/NRCan Electric Vehicle and Alternative Fuel Infrastructure Deployment Initiative	Canada	N/A	N/A	N/A	N/A	N/A	N/A	N/A	50% up to $50,000
Government of Canada/NRCan Zero-Emissions Vehicle Infrastructure Program	Canada	N/A	N/A	N/A	N/A	N/A	L2: $5,000	N/A	DCFC (<50 kW): $15,000 DCFC (>50 kW): $50,000
Manitoba Hydro Home Energy Efficiency Loan Program	Manitoba	N/A	N/A	N/A	N/A	$3,000	N/A	N/A	N/A

3.7 Clean Fuel Standards

3.7.1 Overview

In this report, clean fuel standards (CFS) refer to market-based approaches to reduce the GHG content, or "carbon intensity" (CI), of transportation fuels. CI refers to the measurement of GHG emissions associated with the production, distribution, and consumption of transportation fuels and is typically measured in grams of carbon dioxide equivalent per megajoule of fuel (gCO2e/MJ). CFS policies can support EV charging by allowing EVSE owners to generate monetary credits from EV charging that can be sold to offset a portion of the costs associated with purchasing and operating the EVSE.

A CFS set an annual CI target that declines until a CI reduction target is achieved. Once an annual CI target is set, regulated fuel suppliers (typically refiners producing gasoline and diesel) are required to achieve compliance by reducing the CI of their fuels. Fuel suppliers typically have two primary pathways to achieve compliance: they can reduce the CI of their fuels by switching to lower carbon fuels, or they can purchase credits in a credit market. Fuels that have a CI above the target will generate deficits proportional to the amount of fuel sold, while fuels that have a carbon intensity below the target will generate credits expressed in tonnes of CO2e avoided relative to the CI target.

As credit values rise, regulated fuel suppliers may be encouraged to shift to lower-carbon fuels to reduce the price risk associated with purchasing credits in the marketplace. Moreover, as the target becomes more stringent, low carbon fuels will generate fewer credits and more carbon-intensive fuels will generate greater deficits. Figure 10 illustrates how fuels accumulate credits and deficits as the CI target declines. At a basic level, CFS encourages economic GHG reductions by encouraging regulated fuel suppliers to evaluate whether CI reductions can be achieved more cost-effectively by modifying internal fuel production practices or by purchasing credits on the CFS market to offset their deficits.

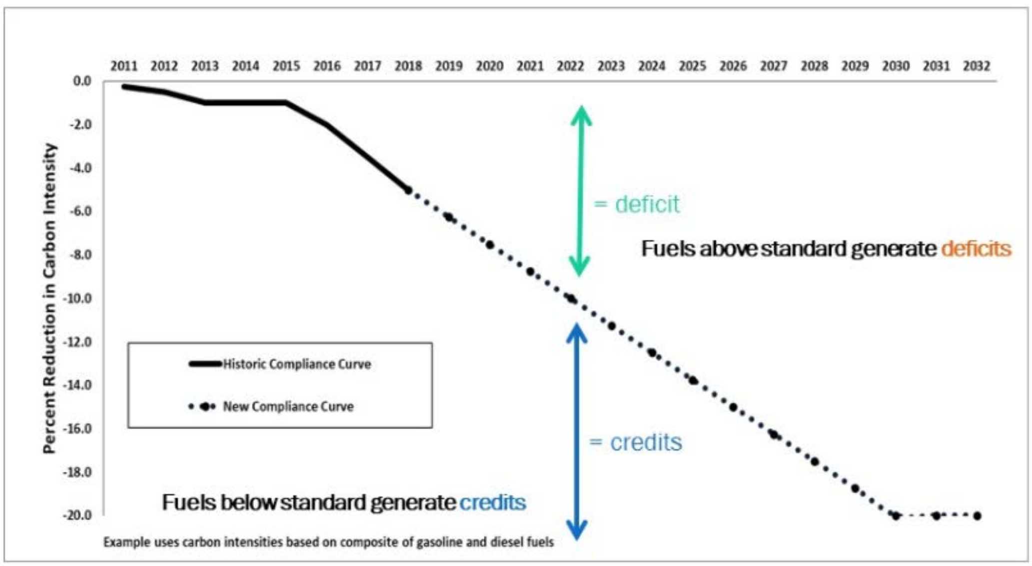

Figure 10: Illustration of CFS Credit and Deficit Generation (Source: CARB)

CI targets are generally set such that low carbon transportation fuels – including electricity – generate credits that can be sold into the market. This credit generation opportunity can potentially offset costs for entities that purchase, install, or operate EV charging infrastructure. Moreover, as the CI of electricity continues to decline with the increased deployment of renewable generation resources, the greater number of credits electricity generators can potentially generate as EVs replace ICE vehicles.

3.7.2 Policies and Programs in Alberta

Calgary and Edmonton do not have CFS policies in place. Local governments do not typically establish CFS programs, as these programs often require significant administrative resources and large regulatory footprints to achieve the intended goal of reducing GHG emissions from transportation fuels. These standards are often set at the provincial or federal levels. Alberta does not have a CFS policy in place.

3.7.3 Other Jurisdictions

3.7.3.1 **British Columbia**

Under authority provided by the *Greenhouse Gas Reduction (Renewable & Low Carbon Fuel Requirements) Act* [121] and the *Renewable & Low Carbon Fuel Requirements Regulation [122].* from 2008, the British Columbia provincial government established the British Columbia Low Carbon Fuel Standard (BC-LCFS). The standard, which began implementation in 2010, currently requires regulated fuel suppliers to reduce the carbon intensity of their fuels by 10 percent by 2020 and 20 percent by 2030 relative to 2010 levels [123]. In 2017, the most recent year for which data is publicly available, the BC-LCFS resulted in the mitigation of an estimated 1.36 million tonnes of GHG emissions; since the outset, it has avoided a cumulative 7.73 million tonnes of GHG emissions [124].

Electricity has played a relatively small but important role in the BC-LCFS. A combined 194.9 million kWh of electric fuel was reported for compliance in 2017; the vast majority of this electricity displaced diesel fuel, suggesting that medium, heavy, and off-road vehicle electrification generated significantly more credits than electricity that was used to offset gasoline consumption [125]. The British Columbia Ministry of Energy, Mines, and Petroleum Resources estimates that electricity mitigated 165,981 tonnes of CO2e in 2017, or approximately 12.2 percent of total 2017 BC-LCFS GHG reductions [126]. With credits trading at an average of $187.25 per ton on the BC-LCFS market in the second quarter of 2019, the program has the potential to provide an important revenue stream for owners and operators of EVSE and offset EV charging costs [127].

3.7.3.2 California

California also has a Low Carbon Fuel Standard (LCFS) that operates similarly to the BC-LCFS and is administered by the California Air Resources Board (CARB).[xxiv] The LCFS is the most significant GHG emissions reduction program addressing transportation sector emissions in the state and is a critical strategy for achieving the state's broader climate goals: since program implementation began through 2018, the LCFS has mitigated over 38 million tons of CO2e emissions, increased alternative fuels use by 74 percent, and reduced petroleum use by 51.86 billion litres [128]. After the LCFS was amended and extended in 2018, the standard now

[xxiv] Oregon is the only other U.S. state that has a CFS, referred to as the Oregon Clean Fuels Program (CFP). Given the similarities of the CFP to the California LCFS, we focus on the LCFS in this report.

requires a 7.5 percent CI reduction by 2020 and a 20 percent reduction by 2030 from 2010 levels.[xxv]

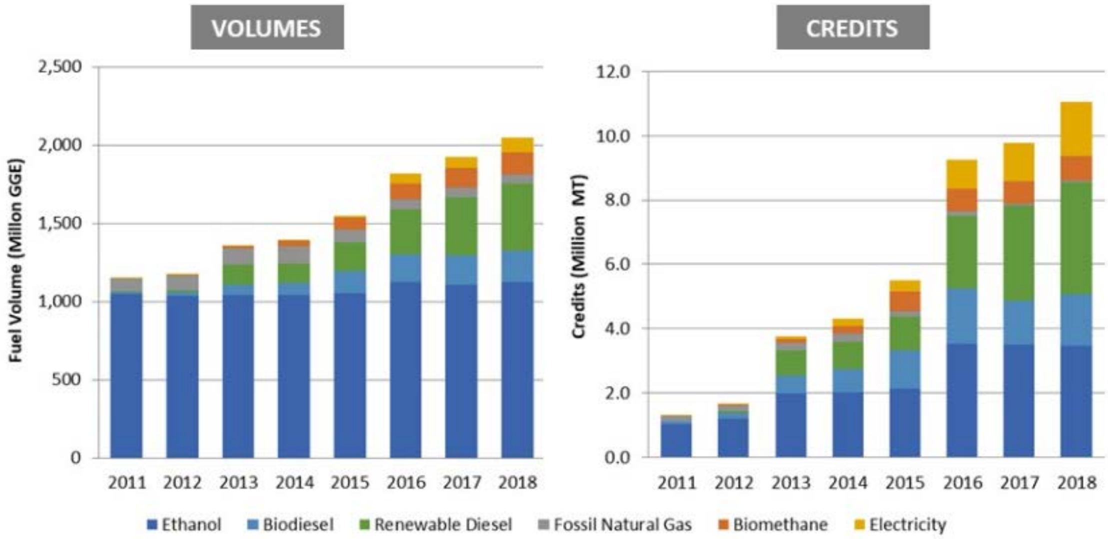

Figure 11: LCFS Fuel and Credit Volumes (Source: CARB)

Electricity has played a relatively minor role in LCFS compliance compared to other alternative fuels such as ethanol and renewable diesel. However, electricity's contributions are continuing to grow as transportation electrification advances in California. Figure 11 shows alternative fuel volumes and credit generation from 2011 to 2018.

The LCFS includes several provisions that support the use of electricity as a transportation fuel. First, a wide variety of entities are eligible to opt-in to the LCFS and generate credits under the program, including EV service providers (for public charging), EV fleet operators, battery switch station owners, site hosts of private access EV charging stations at workplaces, transit agencies that operate fixed guideway systems or electric buses, electric forklift fleet operators, and electric distribution utilities (for residential charging and all of the above categories if no other entities claim their credits) [129]. In the case of home charging, the CPUC required regulated utilities to pass through the value of their LCFS credits to their customers in the form of rebates toward the purchase or lease of EVs [130]. The LCFS also has the flexibility to adjust CI when EVs are charging during periods of high renewable generation on the grid. Finally, the 2018 amendments to the program also allow for additional credit generation from the deployment of DCFC stations based on their rated capacity (kW); previously, stations could only earn credit based on the amount of electricity dispensed (kWh) [131]. The intent of these capacity-based credits is to provide a stronger financial incentive to install the needed DCFC infrastructure in the near-term while station utilization rates are still relatively low.

There is notable value in potential LCFS revenues from EV charging. CARB estimated that with a credit price of $150 per ton, light-duty EV charging would generate 12.04 cents of revenue per kWh in 2016 [132]. For transactions that occurred during the first week of August 2019, the volume-weighted average credit price was $193.55 per ton [133]. These credit prices could

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[xxv] The standard previously required a 10 percent CI reduction by 2020 from 2010 levels. https://ww3.arb.ca.gov/regact/2018/lcfs18/fro.pdf

have a significant impact on the economics of operating EV charging infrastructure and offset some of the operating and capital costs associated with their deployment.

3.7.3.3 Canada

The Government of Canada, led by Environment and Climate Change Canada (ECCC), is currently considering the development of a national CFS program; the ECCC published a proposed regulatory approach to the CFS in June 2019 [134]. The government estimates the CFS would achieve 30 million tonnes of GHG emissions reductions by 2030 and would assist in the achievement of Canada's target to reduce emissions by 30% by 2030 from 2005 levels [135]. The proposed CFS is expected to undergo further consultation through 2021, with liquid fuel class regulations beginning implementation in 2022. Gaseous and solid fuel regulations would follow in 2023.

The proposed regulation stipulates that EV charging would be eligible to generate credits provided that the CI of the electricity is less than the annual CI fuel target. EV charging service providers will be able to claim credits from public EV charging stations, while site hosts will generate credits for private and commercial EV charging [136]. Residential EV charging that occurs via networked ("smart") charging stations would generate credits for the charging network operator, while residential EV charging credits from non-networked charging stations would default to automakers. The CFS will also likely require a portion of credit revenues from EV charging to be reinvested into programs that incentivize the adoption of EVs and other zero-emission vehicles, including EV infrastructure incentives, EV purchase, and lease incentives, or EV education and outreach incentives.

3.8 Market Overview of Policy and Implementation for EV Infrastructure Closing Comments

Transportation electrification is still in a nascent stage in Alberta and Canada as a whole. However, sales are beginning to increase as vehicle costs decline, customers gain more familiarity with EV technology, and charging infrastructure is deployed to support the needs of EV drivers. The availability and ease of installing of EVSE is influenced by a suite of interconnected policy areas: codes and standards, permitting, incentives, load management, parking, utility regulation, and clean fuel standards play an important role in making EV charging investments simpler, more cost-effective, and more accessible. The Cities of Calgary and Edmonton have taken initial steps to facilitate greater EV adoption, and there are ample opportunities to learn from other policies that cities, provinces, and federal governments have implemented to grow the EVSE market.

4 Stakeholder Engagement Plan

The Stakeholder Engagement Plan was meant to serve as the central organizing material for all engagement elements of the Electric Vehicle Home and Workplace Charging Study. This section lists the members of advisory committee, stakeholder group, and their roles and responsibilities for this study. It explains the engagement plan that was followed during the study and the consultation timelines.

4.1 Advisory Committee Composition

The advisory committee was designed to be reflective of the broader stakeholder group and comprised the organizations most directly impacted by policies related to EV charging infrastructure. The list of advisory committee members and a brief introduction to them is provided below:

Advisory Committee Members

- **Utilities:** ENMAX, EPCOR
  - As the stewards of the electric grid and provider of fuel for EVs, the investor-owned utilities serving Calgary and Edmonton have a direct interest in engagement regarding EV charging stations.
- **Real Estate Associations:** Building Owners and Managers Association (BOMA Calgary and Edmonton), BILD Calgary, Urban Development Institute (UDI)-Edmonton
  - BOMA represents the commercial building owners' community and would be impacted by city policies regarding workplace EV charging.
  - BILD Calgary – formerly Canadian Home Builders Association and UDI-Calgary – represents the building industry in Calgary and advocates for policy in the interest of its members at the city level.
  - UDI-Edmonton represents the land development industry in Edmonton and also advocates for policy in the interest of its members at the city level.
- **Electrical Workers Association:** Electrical Contractors Association of Alberta (ECAA)
  - ECAA represents union and non-union electricians in the province (eight chapters) and would be impacted by changes to the relevant building and electrical codes for EV charging.
- **EV Drivers Association:** Electric Vehicle Association of Alberta (EVAA)
  - EVAA brings the EV driver perspective to the discussion, which can provide greater real-world context for the state of home and workplace charging in Alberta.
- **Provincial Agency:** Alberta Energy
  - Alberta Energy broadly regulates and ensures the safe development of energy resources in the province. Alberta Energy also oversees the Alberta Utilities Commission.

4.2 Advisory Committee Responsibilities

Advisory Committee members brought a depth and breadth of experience on EV charging that influenced the ultimate trajectory of the project. Beyond the responsibilities expected of organizations participating in the Stakeholder Engagement Process, the members of the Advisory Committee were expected and provided insight on:

- The overall vision and goals for the stakeholder engagement plan;
- Relevant information and data that informed the engagement process;
- In-depth feedback regarding barriers and opportunities for home and workplace charging;
- Recommendations to improve the stakeholder engagement process.

Advisory Committee members were available for communication via phone or email on a more regular basis than the broader stakeholder group over the course of the project.

4.3 Stakeholder Group – Outreach List

The table below lists the organizations that were invited for stakeholder consultations during the course of the project, this includes webinars, in-person engagement sessions, phone interviews, and email/survey feedback. These include the advisory committee members too. Stakeholders were provided an option to join the consultation session either in Calgary or in Edmonton. In case of those who were not able to participate in either of the sessions, feedback was solicited via email and conference calls.

1. City of Calgary	2. City of Edmonton
3. ENMAX	4. EPCOR
5. ATCO	6. City of Vancouver
7. Alberta Motor Association (AMA)	8. Electrician Contractors Assn. of Alberta (ECAA)
9. Alberta Energy	10. Electric Vehicle Association of Alberta (EVAA)
11. Flo	12. Alberta Transportation
13. ChargePoint	14. Alberta Utilities Commission (AUC)
15. Canada Green Building Council (AB)	16. Tesla
17. Building Owners and Managers Association (BOMA)	18. Siemens
19. Calgary Housing Company	20. Urban Development Institute – Edmonton (UDI-Edmonton)
21. Alberta Urban Municipalities Association (AUMA)	22. Association of Condominium Managers of Alberta (ACMA)
23. Edmonton Federation of Community Leagues (EFCL)	24. homeEd
25. Unico Power Corp.	26. Federation of Calgary Communities
27. Calgary Motor Dealers Association (CMDA)	28. Greenlots
29. Canadian Home Builders Assn. - Edmonton	30. Edmonton Motor Dealers Assn. (EMDA)
31. The Municipal Climate Change Action Centre (MCCAC)	32. Motor Dealers' Association of Alberta
33. Infill Development Edmonton Association	34. EVBox
35. Impark	36. Alberta Residential Landlord Association

4.4 Engagement Plan

ICF executed the Stakeholder Engagement Plan over the course of mid-August to mid-December 2019, providing ample opportunity for stakeholders to:

1. learn about the dynamics of home and workplace EV charging,
2. share information with one another, and
3. provide candid, constructive input to guide city and provincial EV policy development.

The Advisory Committee played a crucial role in this process: members were encouraged to provide substantive policy and technical feedback as well as recommendations on the overall stakeholder engagement process.

During the process, it was possible to answer several key questions related to EV charging infrastructure planning and deployment, those were:

- What barriers do the stakeholders perceive (or have experienced) in providing home or workplace charging infrastructure?
- What are the primary concerns of each stakeholder group around providing home or workplace charging infrastructure?
- Do the stakeholders have any recommendations that would enable and encourage them

to incorporate home and workplace charging infrastructure in their projects?
- Are there policies, incentives or requirements from other jurisdictions that they think would be effective in Alberta?
- What do the stakeholders need from the government, if anything, to encourage the installation of home and workplace charging infrastructure?

In order to answer these questions, ICF employed a series of tactics to elicit candid responses from stakeholders and create a collaborative environment that allows for future coordination among participating organizations, including:

- **Webinars:** ICF held an introductory webinar in August 2019 to introduce the project, objectives, timeline, and stakeholder engagement process. This webinar allowed the project team to "break the ice" and level set stakeholders' expectations on the project. This was a cost-effective and resource-light approach to introducing the project to the list of stakeholders.
- **In-person stakeholder engagement sessions:** ICF facilitated four main in-person stakeholder engagement sessions – two in Calgary and two in Edmonton. These included two types of sessions, one for all stakeholders and one session targeted to developers and the building industry.
    - The first session focused on the program objectives and feedback for what the Cities should do in the future to best address how to accelerate EV adoption and support EV charging infrastructure. The second session brought developers and building contractors together to review draft recommendations, highlight concerns with the impact on their business, and identify any solutions to minimize or eliminate those barriers.
    - As opposed to the webinar, the objective of these sessions was to pose questions to stakeholders, create a forum for constructive discussion and collaboration, and collect stakeholder feedback. ICF covered the breadth of topics related to EV charging infrastructure deployment and ensured that questions and exercises were tailored to the feedback that the Cities were seeking to inform policy development. While resource-intensive, this approach was beneficial for collecting large amounts of stakeholder feedback in short periods of time and allowed for real-time vetting of ideas and hypotheses with multiple stakeholders.
    - These sessions were complemented with five additional engagements held over phone calls, in person meetings and webinars.
- **Surveys:** ICF sent out multiple online surveys in which stakeholders were able to provide additional feedback beyond what was provided in the discussion held during the in-person stakeholder engagement sessions. This allowed for stakeholders who 1) were not able to attend the sessions, 2) were not able to share their feedback due to time constraints, or 3) were not comfortable sharing their feedback during the sessions to provide input. The survey participation provided a resource-light avenue for the project management team to collect additional insights.
- **Phone calls:** ICF engaged in one-on-one phone calls with certain stakeholders – including members of the Advisory Committee. Similar to surveys, these calls provided additional opportunities to gather candid feedback from key organizations. However, unlike surveys, the phone calls and in-person meetings were much more dynamic and allowed stakeholders to provide more complex or sophisticated input.

4.5 Stakeholder Engagement Timeline

Over the course of the project, the following engagement sessions were completed in Calgary and Edmonton.

1. Advisory Committee Webinars
    a. August 28, 2019
    b. September 19, 2019
    c. November 14, 2019
    d. December 13, 2019
2. City of Calgary Stakeholder Engagement Session
    a. October 2, 2019
3. City of Edmonton Stakeholder Engagement Session
    a. October 3, 2019
4. Utility Engagement (ENMAX)
    a. November 7, 2019
5. EVSE Installer Engagement
    a. Unico, November 8, 2019
    b. AES, November 14, 2019
6. Meeting with the City of Vancouver staff
    a. September 10, 2019
    b. February 4, 2020
7. EVSE Supplier and Manufacturer (included Tesla, ChargePoint, Flo, Siemens)
    a. October 25, 2019
8. City of Calgary Building Developers and Construction Company Engagement Session (BILD Calgary)
    a. November 1, 2019
    b. December 13, 2019
9. City of Edmonton Building Developers and Construction Company Engagement Session (UDI, Built Green Canada, CHBA)
    a. December 12, 2019

5 Stakeholder Engagement Sessions – What We Heard

5.1 Engagement Overview

As part of the Stakeholder Engagement, two general sessions were conducted—one each in Edmonton and Calgary—that brought together NGOs, utilities, building developers, homeowner associations, car dealer associations, and EV charger manufacturers. Additional meetings (for targeted stakeholder engagement) were scheduled with EV charger installers, EV charger manufacturers, utilities, and building developers to review early recommendations and further discuss points of concern with EV charging and potential paths the Cities of Calgary and Edmonton might take for supporting charging infrastructure development in the cities. For a list of stakeholder organizations that participated in the program and list of engagement sessions, refer to **Part 4.3** and **Part 4.5,** respectively.

Both the Calgary and Edmonton sessions followed the same engagement process, where individuals were organized into smaller group(s) of 5-7 individuals to discuss each topic at hand. Ideas were deliberated by each group, and after the allotted group discussion time, a representative from each group presented the key points of the group discussion to all stakeholders present in the session. After the group summaries, the discussion was opened to all stakeholders present in the session. This process was repeated for each topic, and general discussion was held at the end of the engagement session to highlight any new ideas that the stakeholders may have thought that they did not cover in the earlier sessions.

5.1.1 What We Asked

Each engagement session was divided into two periods, with the first half of the session focusing on challenges and the second half focusing on potential solutions or suggestions for the deployment of EV charging infrastructure in single-family residential buildings, multi-unit residential buildings (MURB), workplace/commercial buildings, and charging hubs. Attendees were encouraged to consider the implications for existing buildings and new construction buildings and to identify what, if any, difference that would make to installing an EV charger.

Challenges for each building type focused on having stakeholders discuss barriers to deployment (e.g., hardware costs, installation costs, applicable codes and standards, permitting, bylaws, etc.) and existing City policies that are reinforcing these concerns. For the opportunities and solutions, attendees shared potential solutions that could overcome these barriers (e.g., parking bylaws, building codes, incentives) and the initiatives from municipal governments or the province that would enable and foster the identified solutions.

5.1.2 What we heard Overview

A range of potential challenges, as well as innovative ideas with regard to EV charging infrastructure development, were received during the stakeholder engagement sessions. Key among those were:

- For single-family residential homes, the two primary concerns were that (a) Level 2 chargers are too easy to install and thus could have rapid proliferation and (b) EV charging leading to adverse impacts the electrical grid.
- Additional concerns were raised about how utilities might face distribution system capacity challenges if charging infrastructure in residential communities becomes widespread. It was accepted that further discussions were needed to understand better which parties would bear the costs of upgrade utility infrastructure (ratepayers, City, or EV owners).
- For multi-unit residential buildings, there exist several challenges and delays in order to receive the condo board's approval for installations of an EV charger. This stemmed from the lack of information and established procedures for condo boards concisely understand the technical and logistical impacts of an EV charger installation in the building. Currently, there is a lack of guidance on how to hold a discussion for the installation of a charger, and a clear framework to allocate the cost for charging equipment installations and electricity.
- Installing charging infrastructure at workplace buildings had several stakeholders raise concerns over the need for and economic viability of EV chargers; there are not clearly defined metrics or studies at this time that indicate a financial return on the EV charger.
- Lastly, the benefits, needs and opportunities for community charging hubs were discussed, with the general consensus being that the use case was uncertain, and developments at this time should be focused in high use areas with existing infrastructure; e.g., park-and-ride stations, recreation centres, and shopping centres.

5.2 Single-family Homes

5.2.1 What are the barriers to deployment?

- The engagement sessions identified a general lack of familiarity with EVs and EV charging technology among the stakeholders.
  - Many of the group discussions focused on better understanding the content provided in the stakeholder engagement material, which included examples of EV charging challenges, what the current state of the technology is, and why EV owners would need an EV charger at their home or workplace.
  - Few individuals at the session had any experience with installing or using EV chargers.
  - There was uncertainty on how to select an appropriate charger and what steps would be required to have one installed at home or at the workplace.
- There may not be many barriers to installing a charger in a residential home, which can result in a great deal of uncertainty for utilities in managing their service equipment most effectively, particularly those in suburban neighbourhoods. As homeowners can easily install an EV charger without having to pull a permit or notify the utility, this, in turn, can place excess stress on the electrical system, and utility companies would not be able to identify the locations of EV chargers readily.

    - Currently, in Calgary and Edmonton, installing an EV charger in a single-family home does not always require a permit, and there is limited knowledge of where and when EV chargers get installed.

- ENMAX and EPCOR outlined that as few as three 40 A EV chargers on a single residential transformer (typically one 37.5 kVA transformer per 12 homes) could result in local system faults and blackouts.
    - While the utilities highlighted this issue, they were concerned about introducing new rules or standards. It is the belief of the utility staff that the issue can and will be handled by the utility, but it will require sufficient information to address the issue in a proactive manner.
- Stakeholders raised concerns of safety from increased risks should an EV catch or be exposed to a fire, as the lithium-ion batteries require different considerations and effort to address compared to a normal home or vehicle fire.[xxvi]
- Cost barriers for EV chargers were raised, including:
    - Who is covering the costs for the impacts on the utility infrastructure?
    - Developers do not believe there is adequate market demand for EV chargers or EV ready infrastructure in new builds and passing the costs to consumers could impact the competitiveness of new developments or hurt already thin margins.
    - Costs for labour and installation were raised, and is the increased retrofit costs significantly high to justify requiring chargers in all-new single-family homes?
- Requirements for smart chargers could lead to increased design and cost challenges.
    - A limited selection of smart/networked chargers and they have significantly higher price points.
    - Will the utility need or be utilizing smart chargers? Are there not more cost-effective strategies that could be used as timers or charge time settings?
    - Can the EV's internal software be used instead?
- Single-family homes with secondary suites may want to install two EV chargers; this can lead to increased issues with power demand for the building.
    - Concerns that this could further compound impact on utility for neighbourhoods with a higher density of secondary suites.
- Concerns over future demand for EV chargers were raised, and whether people will either be purchasing EVs or personal vehicles in general in the future. The rise of autonomous vehicles could negate the need for chargers in single-family homes.
- Concerns of charger location for single-family homes that do not have garages, driveways, or assigned parking. Where would chargers be located for garage orphans?
- If there are requirements for EV chargers, how can there be any certainty that the technology will not be irrelevant in the near future? Will the charger technology change (e.g., plug connector type, power levels, etc.)?

[xxvi] The challenges and best practices for EV fires is covered in **Part 3.1.4** which covers the National Fire Code.

5.2.2 Are there any City or Provincial policies related to these concerns?

- Current policy and rules do not limit the size of EV chargers, and larger chargers can put extra strain on the electrical system; i.e., higher-capacity lines and services would be required to deliver the increased ampacity draw for higher power Level 2 chargers.
  - Concerns were raised about the impact on the reliability of the electrical grid.
  - What size chargers does the average EV owner need?
  - Who will be required to pay for the infrastructure upgrades to support higher ampacity chargers?
  - Is it possible that the end user that causes the extra power demand would pay? Or would the existing framework in Alberta push the costs to ratepayers as a whole?

5.2.3 What are the potential solutions and policy interventions that should be considered?

- EV education or awareness sessions could help to build the needed confidence among stakeholders to support the deployment of EV charging infrastructure

- Grid impacts of EV charging (resulting primarily from potential concurrent charging by EV owners) could be limited by the introduction of policies or regulations encouraging users to install networked/smart EV chargers with an ampacity limit (for example, less than 32 A). As was outlined by stakeholders that own EVs, charging overnight allows for more than enough time to fully charge an EV for daily commutes, and the faster charging time for chargers greater than 32 or 40 A is of minimal impact to the regular use of an EV but does introduce challenges to the utility and other electricity users.

- Some stakeholders asked if enhancing the single-family home’s power service to 200 A can help prevent the grid impacts of EV charging? The stakeholders were informed that enhancement to 200 A service would be a reasonable solution to prevent issues at the home level (although it will still be required to manage the range of load properly to prevent overloading of that enhanced capacity). However, the 37.5kVA transformer is a limiting factor for the distribution grid, and upgrades to it will help manage the grid impacts.

- Another solution discussed was the use of energy management systems (EMS) or smart/networked chargers that could minimize impacts on single-family home electrical infrastructure. For example, a house EMS can monitor the household power usage and regulate EV charging to ensure that it does not overload the distribution panel and can shift the EV charging to periods of lower electrical power usage in the home, i.e., off-peak hours. The use of smart/networked chargers can not only achieve similar results but also bring the ability to schedule charging during specific off-peak hours.

- The use of EMS may also make it possible to use a charger with ampacity higher than 40% of a single-family home power service capacity, given that the needed changes are made in the building code.

- Further, other broader applications of smart chargers could be used to communicate with the utility to adjust charging power levels and operation based on utility signals (e.g., variable pricing, power throttling, etc.). The introduction of time of use rates, smart meters and incentive programs could all help to manage impacts of EV charging on the distribution system. Such initiatives, however, will fall under the purview of the Alberta Utility Commission, and the City can play an advocacy role in it.

- Financing support such as incentives/rebates, long-term financing, building requirement offsets, etc., could be employed to support the deployment of charging stations in both retrofit and new construction projects.
- Rather than supporting EV chargers in all homes, a community charging hub could be utilized to provide a central point of access for all EVs in the community and would not require individual home power system upgrades or EMS. The hub could be managed by the utility or external party that would seek to minimize the operational impact and costs to the distribution system.

5.2.4 What is needed from the local/provincial government to enable these solutions?

- Organizing EV awareness events and campaigns and publishing educational material to help stakeholders make informed decisions about investing, owning and maintaining EV charging stations will help in accelerating the charger deployment and also in the uptake of more EVs
- Purchase or mail-in incentive programs could be useful to help deployment.
- Increased support at all levels of government can help ensure the longevity and effectiveness of the programs. This would require cities to partner with provincial or federal governments to secure adequate levels of funding for incentives.
- The City needs to work with other governments to provide increased inter-Provincial alignment on EV infrastructure requirements. This could include establishing uniformity in areas such as building codes, zoning, or standards, and policies.

5.2.5 What's working?

- Low costs for EVSE has made the procurement and installations of Level 2 chargers relatively prevalent compared to the number of EVs in Edmonton and Calgary.
- Stakeholders in the industry outlined that EVSE installations are relatively prevalent in single-family homes compared to other building types, largely supported by low barriers to installation for early adopters.
- Developers in the sessions outlined that they are already working on demonstration projects with EV chargers pre-installed, aligning with their initiatives for modern sustainable homes—e.g., Blatchford development project in Edmonton and the developer Jayman BUILT new home pilot projects.

5.3 Multi-Unit Residential Buildings (MURBs)

5.3.1 What are the barriers to deployment?

- Similar to that in the case of single-family homes, stakeholders expressed concerns that there's not enough demand for EV chargers in MURBs to justify the investment in them (by the condo owner or the developer), and there is a little to no demand for the charging infrastructure at this time.
- Developers also asserted that EV chargers are like other loads such as air-conditioners (AC), hot tubs etc. which are an electrical device for the home-owners use. However,
  - the real estate development industry was never asked for pre-build for AC or hot tubs
  - what if a particular homeowner takes on the cost of EV charger installation or provisioning but never receives the benefit?
  - will it be less risky for ENMAX or other utilities to provide a rebate for EV chargers if the utilities are comfortable with a projection of EV uptake, allowing them to recover their investment within 20 years?
- Stakeholders asked why shouldn't the utilities such as ENMAX and EPCOR be investing say a $1,000 per EV charging stall if they are a beneficiary of this infrastructure?
- In another similar analogy, it was mentioned that as road infrastructure is paid for by gasoline taxes so EV charging infrastructure could be paid for by the utilities.
- Developers expressed concern that the cost of the charger will escalate beyond the perceived range of $500-1000 by the time these are passed on to the buyer
- Who pays for the cost of the distribution upgrade?
  - Is the cost paid for by the condo association or just those who use EV chargers?
- Working with and receiving approval from condo boards can be and is a major barrier to the installation and operation of EV chargers. Notably, condo boards require a 75% approval rate to move things forward, which could be a major obstacle for making decisions about supporting EV charger deployment. However, EV charger technology itself is not seen as the issue for condos, but the installation and cost allocation of the chargers and electricity are.
- Some stakeholders identified situations in which a Condo Board has requested or required separate metering for EV charging.
  - Issues with the allocation of charging costs if the energy used are not measured separately. Is it fair to all other residents if they have to pay for somebody else to charge their vehicle?
  - However, targeting users with a second meter is also very expensive.
- Is there a risk that the municipality could be stuck having to take ownership of the EV installations in common areas of condo buildings?
- How can it be ensured that a charging spot is accessible to EV owners? Does a condo require dedicated stalls that can be used by EV owners, or should all parking spots be EV ready to ensure those that want an EV charger can easily have one installed?

- Is there a vandalism risk for EVs and charging stations in common areas? How does this impact replacement or insurance for the Condo Board or apartment building?
  - Should the charger be owned by the end-user or the building to address these concerns adequately?
- If a mandatory requirement of making the new MURBs 100% EV ready is brought forth by the City, will it impact financing potential for new buildings?
- Some developers asserted that it will not be fair for the homeowner to pay this cost if they don't use it while also acknowledged that some people who don't own cars still pay for vehicle infrastructure in their building.
- Stakeholders asked if the utilities are going to be more worried about power demand spikes from a MURBs than those from single-family homes? They were informed that this could be a concern in the case where the electrical load for EV charging exceeds the capacity in the building transformer. This condition would require a transformer upgrade if the EV charging load cannot be managed.
- Retrofitting the parking spaces in MURBs to provide for EV chargers is very cost-intensive compared to providing it in new construction. Stakeholders asked why retrofits should not be considered as the prime focus for any new policy aimed at supporting EV charger deployment rather than new construction projects.

5.3.2 Are there any City or Provincial policies related to these concerns?

- In Ontario, a bylaw was put in requiring condo boards to allow the installation of chargers if a reasonable proposal has been brought forward.
- In Richmond, it was mandated that EV chargers in MURBs meet the mandated minimum performance standards:

  > "The system must be capable of supplying a minimum performance level of 12 kWh per parking space over an eight (8) hour overnight period, assuming that all parking spaces are in use by a charging EV. Projects implementing EV energy management systems must provide for communications technology necessary for the function of an EV energy management system (e.g. cellular, wireless, or cabled infrastructure)" [137]

5.3.3 What are the potential solutions and policy interventions that should be considered?

- Stakeholders deliberated if the charger deployment should be mandated with bylaws or through incentive programs? Having EV charging provisions in MURBs as a default reduces the need for other charging developments, such as charging hubs or retrofits, and can, therefore, garner widespread support from current or future EV owners. High densities or concentrations of level 2 or DCFC chargers would be very attractive to individuals that cannot readily install EV charging infrastructure.
- PACE (property assessed clean energy) funding could be a good tool to support EV charger deployment. MURBs present the most challenging category for charger deployment, and thus condo boards and residents would benefit the most from having more information and resources about EV charging technology. This will help them

identify why the issue is of concern to them and how they can most effectively install or address a request to install an EV charger.

- Many developers raised concerns about how the cost of development should be allocated and expressed a desire for the costs to be pushed to EV owners, electrical utilities, or EV manufacturers. The primary concern with policies that support EV charging was any increased development/construction costs that would either increase the price of the house or limit the currently thin margins on new housing developments.
- Curbside charging was identified as being complementary to condo charging that could help the situation but is not necessarily a complete solution.
- The parking spots that can be "assigned" by the condo board to different tenants allow the opportunity to be reassigned and help ensure that EV owners have access to locations that are best suited for the installation of an EVSE. Titled or individually owned parking spaces do not have this flexibility, and alternative policies or measures are required in such cases.
- Following the 2 for 1 EV parking space requirement example from Sacramento (described in **Part 3.2.5**) could help reduce the cost impacts on developers and could help facilitate the development of an increased number of the EVSE ready buildings.
- Contrary to the request from some Condo Boards for a separate meter for EV chargers, it has been identified that doing so prevents the optimal management and use of power and energy.
  - A separate meter does not allow an EMS to optimize the operation of both systems, which would be operating independently of each other. A combined system can focus on shifting charging loads to periods of low use in the building and ensure minimal peak power draw for the overall building.
- Stakeholders suggested that utilities could charge a fee recoup the investment in EV charging infrastructure and provide it as a 'grant' to the developer to cover the costs borne by the developer. Identification of similar programs for Combined Heat and Power (CHP) infrastructure in BC could help plan in a similar way for the EV infrastructure.
- It was mentioned that vehicles parked in a heated space might require less time to charge and hence the overall number of chargers needed in heated parking may be lesser than expected.

5.3.4 What is needed from the local/provincial government to enable these solutions?

- Changes to the Alberta Condominium Property Act could provide a simple and standardized process for the exchange of titled parking spaces. It is suggested that changes should be introduced in order to reduce legal and tax implications that are currently part of the exchange or attempted exchange process of parking locations.

5.3.5 What's working?

- Permitting is required for any significant electrical work in MURBs, such as EV charger installation. Permitting in MURBs does work effectively, which in turn provides adequate visibility on the location and number of charger installations.
- Innovations such as freewire[xxvii] provide an alternative to individual chargers for EV owners or the need for dedicated charging parking stalls. It provides a mobile charging solution that can be brought to the EV and enable the EV owner to charge their vehicle at their designated parking space; no additional infrastructure or construction is required for this solution. Due to the limited number of deployments and early product development of this technology, the pricing information was not identified at this time.

5.4 Workplace and Commercial Buildings

5.4.1 What are the barriers to deployment?

- It can be problematic for tenants and owners to deploy EV chargers in rental properties. For a tenant, there is the risk that the owner will either not permit or support the installation of a charger. Additionally, the tenant may not wish to spend their financial resources to install the charger that cannot be easily removed and reinstalled to a new location at the end of the rental period.
- EV charging service could be considered as a taxable benefit to employees, and this could introduce tax consequences to EV owners and additional time and financial burdens for small business owners (employers) to compute tax implications for employees from the added benefit of EV charging.
- Currently, the return on investment from installing an EV charger in a commercial or workplace establishment is uncertain. It may be difficult to identify the direct impact on sales of the goods and services at the commercial establishment from EV owners, and at workplaces, it may not be easy to attribute employee retention to the EV charger installation.
- The installation could be easier in new buildings since it is difficult to make the business cases for retrofit installations in commercial buildings. The business case may be more challenging for charger installations in commercial buildings (where revenue generation is critical) compared to those in the workplace where the employer may cover the costs.
- Ensuring equitable access of the chargers to all employees in the case of larger companies could be a challenge.
- Stakeholders asked of having access to charging at the workplace will reduce the number of single-family / MURB chargers needed?

[xxvii] For more details on Freewire's website: www.freewire.com

5.4.2 What's working?

- Pushing the social idea of workplace charging as an employee perk and incentivizing workplaces (through rebate programs) to do this, even though it will not generate revenue for the workplace. Workplace chargers will be an important element during the wintertime as EVs age.
- The City of Vancouver was identified as the one that has implemented regulation for costing EV charging use in MURBs by time. This approach could be reviewed for wider adoption.
- Utilities plan to devise a strategy for supporting EV charger installations while preparing to manage the resulting enhanced load and grid impact. In the long-term, the utilities plan to have ongoing discussions with the developers on how best to approach the development of EV charging infrastructure.
- There are potential opportunities on the regulated side of the business for utilities, but this will require further buy-in from the AUC.

5.4.3 Are there City or Provincial policies related to these concerns?

- Nothing mentioned.

5.4.4 What are the potential solutions and policy interventions that should be considered?

- Significant deployment of EV chargers at workplace facilities could reduce the need for home charging for some EV owners without a home charger access to readily accessible means of charging.

5.4.5 What is needed from the local/provincial government to enable these solutions?

- An incentive program or tax credit would help in accelerating charger deployment by helping with cost recovery. Additional materials may be required to identify the impacts on employee taxes or benefit packages.
- Financing opportunities for new or retrofit installations, or in-kind benefits such as company profiles on City website highlighting businesses that have invested in EV charging infrastructure.
- Increased development of EV awareness and educational programs and materials.

5.5 Community Charging Hubs

- The need for community charging hubs was uncertain. Stakeholders could not identify who would/should be responsible for the development and if there should be a fee to use chargers at charging hubs if they were developed and deployed by the City? Further, the need and financial benefit of such deployments are uncertain as few individuals were aware of any charging hub deployments in Canada.

- Park-and-ride (Transit) could be a popular spot for these.
- Fast charging would be most useful in these spots.
- Stakeholders suggested not to build any new infrastructure as “community charging hubs” rather suggested using existing locations such as recreation centres, hockey arenas, parks, etc., for clustered charger deployment.

5.6 What we heard, what we did

In the case of single-family homes, many stakeholders agreed that, in order to not burden the grid, it would be best to mandate what type of EV charger people are permitted to install in their homes. The goal here is to ensure the increase in electricity demand can be managed effectively.

In the case of MURBs, education was identified as a key solution. The implementation, in this case, could be easier than in other locations, so the best way to overcome barriers is by ensuring that condo boards understand the implementation and use of EV chargers adequately. While potential solutions were more difficult to find in the case of workplaces, it was identified that installing chargers will likely help companies meet corporate and sustainability goals, which is a growing priority for many businesses.

6 Research and Analysis: EV Charging Technologies and Markets

6.1 Overview

There exist many technical and logistical considerations that should be evaluated when installing an EV charger. This section provides an overview of these considerations to provide installers, EV owners, or City officials to make informed decisions on EV charging policy. The considerations covered in more detail include:

- Technical considerations EV charger installations
- EV charging station components required for installation
- EV charging cost drivers
- EV charging emerging technologies
- EV home and workplace charging benefits

6.2 EV Charging Components

As described in **Part 2.2**, Level 2 EV charging stations are most prevalent in both public and private EV charging installations and the primary charging type evaluated in this report. While the components are largely similar for Level 1, 2, and 3, the focus of this section will be on Level 2 charging components, which include the following items:

1. EV Charger (**Figure 12**)
2. Wall mounting kit or pedestal mount (**Figure 12**)
3. Charging Cable—J1772 or Tesla L2 connector (**Figure 13)**
4. Circuit breaker (1.25 times the amperage of the charger, e.g., 40 A, 50 A, or 60 A)
5. Cabling
6. Energy Management System or Electric Vehicle Energy Management System (**Optional**)

Figure 12: Level 2 wall charger and mounting bracket [138]

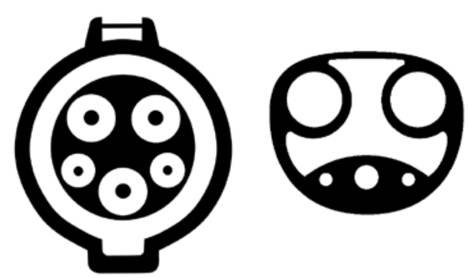

Figure 13: J1772 (left) and Tesla home charger (right)

Figure 12 shows the L2 charger along with the mounting that could be either on the wall or put up using a pedestal. The type of mounting selected for a particular installation depends on cost and space availability considerations. **Figure 13** shows the two most common connector heads in North America, the J1772 and the Tesla home charger. The charging head is used to connect the charging cable to the vehicle. The length of the charging cable typically will come in standard lengths from the manufacturer based on the EV charger model. The length of the cabling (from the distribution panel to the charger) will depend on the distance between the location of the charger; a larger distance will increase the labour and have a modest increase in the material costs. For most homes, an additional circuit breaker will be required and is installed to protect the cable and the charger from overcurrent in the event of a fault. **Figure 14** shows the full schematic of an installed EV charger installation.

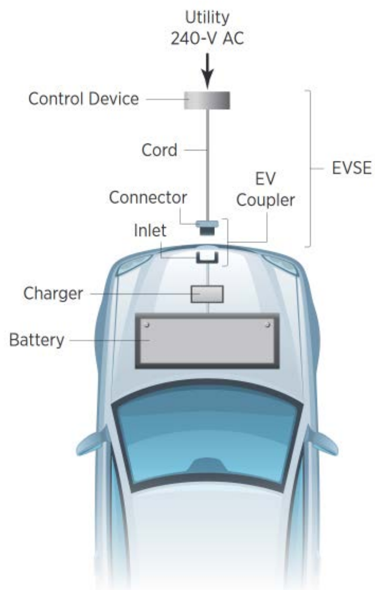

Figure 14: Level 2 EV Charger Schematic [139]

6.3 Residential and Workplace EV Charging Installation Technical Considerations

Understanding that L2 charger is currently most preferred for EV charging installations at homes and workplaces, this section provides the major technical parameters that should be considered when installing an L2 charger. These include:

1. Charger location and access (private or public, indoor or outdoor)
2. Available ampacity

6.3.1 Charging Location

For single-family residential units with indoor parking or garages, the charger can be easily placed on or near a wall. In order to minimize the deployment costs, the chargers can be installed near an existing panel and/or other electrical equipment. For MURBs, the chargers can be deployed at parking spaces reserved for residents as well as spaces reserved for visitor parking. Workplace charging stations are typically located in parking areas reserved exclusively for employee use.

Power can be provided to the charger via a NEMA 6-50R or NEMA 14-50R[xxviii] receptacle if available, or it can be hardwired to a dedicated circuit breaker in the distribution panel (circuit breaker panel). The panel will require an appropriately sized circuit breaker that is at least 1.25 times the ampacity of the charger, for example, a 50 A, 2 pole, 240 V circuit breaker.

6.3.2 Available Ampacity

When selecting an EV charger, it is important to consider the impact on the available ampacity of the main distribution panel. For example, in a residential building with a standard 100 A, 240 V distribution panel, common Level 2 charger sizes of 7.2 kW (30 A) or 9.6 kW (40A) would take up a significant portion of the panel capacity. The use of energy management equipment, load shifting (setting charging periods to night hours), or capping charging power rates can help alleviate these issues.

If sufficient ampacity is not available, there may be the need for costly upgrades to replace the panel and upgrade the main service line from the utility to the home. In the event of a service upgrade (increasing the building ampacity rating), EV charger installation will require coordination and approval from the utility as the main feeder electrical infrastructure (meter, cable, breaker) will need to be upgraded. Increased electrical demand by the building, or a combination of buildings, may also require the utility to upgrade the local transformer to accommodate the increased electrical load.

6.4 EV Charging Installation Costs

Installed costs for charging station will include the cost of the following key components:

1. Charging equipment,
2. Power equipment: cabling, breakers, panels, etc.,
3. Labour,
4. Permitting,
5. If applicable, any applicable distribution system upgrade costs
6. Operations and maintenance costs.

Variation in the cost of these components as per building types is described in the following section.

6.4.1 Single-family Residential

The cost of charging equipment will depend on the model, power rating, and features of the charger selected, see **Part 6.6.1**. A standard home charger is in the $500 to $1,500 range, and for single-family homes, the installation costs are minimal at less than $500 for parts and labour; this would include a breaker (50 A to 70 A $10 to 70$), cabling (less than $15 per metre #6 AWG (American Wire Gauge) 3 conductor copper), permitting ($100), labour ($125 per hour), etc.

[xxviii] Refer to Part 3.3.2 for details on the NEMA plug types.

Table 4: Summary of Single-Family Home EV Charger Components and Costs

Component	Cost Range
Standard Home Charger	$500 - $1500
Installation, parts and labour (SFR)	Less than $500
Breaker (50 A - 70 A)	$10 - $70
Cabling	Less than $15 per metre; #6 AWG 3 conductor copper
Permitting	$100
Labour	$150 per hour
TOTAL (Est.)	**$750 to $2000**

However, there are some aspects that can quickly drive up the overall installed cost to thousands of dollars, making it a financially difficult project to undertake. As also discussed in the "What We Heard" section, upgrades needed to the service ampacity, especially in the neighbourhoods with buried utility cables, will have a major cost impact on the EV charger installations at such locations. Based on the input received during stakeholder engagement sessions, this could be in the order of $1,000 to $10,000 depending on the neighbourhood and proximity of the house to the utility transformer.

The cost of distribution panel upgrades ranges from $75 to $150 for a 200 A panel, compared to $50 to $100 for a 100 A panel. The cost of new cable and trenching to support the increased ampacity will vary based on the building's proximity to the utility transformer; the more ground that must be disturbed, the greater the costs, which can easily be in the thousands of dollars. The increased ampacity would require a larger cable—4/0 AWG versus a #1 AWG cable—with an increased cost of $20 to $50 dollars per metre. As the distance from the utility transformer to the building can be in the range of 100 metres, this can add more than $2000 to the cost of the installation. An effective measure to minimize the costs of an EV charger is to ensure that the EV owner selects the smallest EV charger that can meet their minimum charge requirements, for example, a 16 A charger could easily charge existing EVs overnight to provide more than enough charge for daily commuting.

6.4.2 Multi-Unit Residential Building and Commercial

For MURBs and commercial buildings, the installed EV charging station cost can vary significantly; there are several factors that can include the six categories. The key consideration, in this case, is not just the cost of the charger installation itself but also the equitable distribution of cost among the MURB residents.

Table 5: Summary of MURB or Commercial Components and Costs

Component	Cost Range
Standard L2 Charger	$500 - $1500
Networked or Commercial L2 Charger	$2,500 - $7,200
Installation, parts and labour	Less than $500
Breaker (50 A - 70 A) (100 A to 200 A)	$10 - $70 per stall $70 - $350 per 10 stalls (assuming 10 stalls per circuit with an EVEMS)
Cabling	Less than $15 per metre; #6 AWG 3 conductor copper
Permitting	$100
Labour	$150 per hour
EVEMS	$10 to $100 per stall
TOTAL PER STALL (Est.)	**$1000 to $8800 per stall**

6.4.2.1 Charging and Power Equipment

For MURBs and commercial buildings, there exists a much greater degree in price variations for the charging and power equipment depending on the building layout, whether the installation was completed during the building construction or was a retrofit, the designed use-case, and the equipment selected for the installation.

For MURBs such as condominiums, there are major hurdles in charger installation, depending on the proximity of the parking spot from the electrical room. The further away from the parking spot, the more labour, material, and complexity of the installation. Aside from parking spots directly adjacent to the electrical room, all installations will require the installation to cross over/through parking spots of other tenants or owners. For retrofits, this leads to challenges for the contractor to complete the work if vehicles are obstructing their path while completing the work.

The type of chargers installed will greatly impact the costs; for example, a commercial building may choose to install chargers at a common location rather than having individual chargers at reserved parking spaces. In order to handle increased charging demands, typically a commercial charger would be used in these circumstances, which has much higher equipment costs and can have higher power ratings to allow for faster charging periods for longer periods of time than would be typical for an individual EV charger. These systems have increased functionality for payments, charging, and maintenance.

When there exists a high concentration of EVs in one place, the use of electric vehicle energy management systems (EVEMS) can be introduced to reduce the electrical capacity required for the project greatly. As covered in **Part 3.5,** these systems can group multiple EV chargers on a single circuit and regulate the peak power demand of the chargers reducing the ampacity draw from the grid and can greatly reduce the amount of equipment required—e.g., fewer circuit breakers, lower ampacity breakers and cables, and a smaller transformer.

6.4.2.2 Labour and Permitting

Similar to the equipment costs, there are also implications for the cost of labour for the type of installation, the system design, and the charging equipment. Installing the chargers during the new-build can take advantage of economies of scale that may not apply to all retrofits, and the builder has access to in-house staff that can complete the work for less money than would be paid by EV owner hiring an electrical contractor. Additionally, a one-off EV charger installation would have higher proportional costs for permitting, and setup, as these costs are largely fixed and are marginally different when installing 1 EV charger or 100. Where possible, costs for the installation can be minimized by completing the installation in groups/blocks so that all the fixed costs are more readily distributed and thus reducing the average costs per parking space.

6.4.2.3 Operations and Maintenance Cost

As per the manufacturers of EVSEs, it is strongly recommended that customers develop an annual budget for the operation and maintenance (O&M) of Level 2 chargers. The O&M costs for EV chargers vary based on the number of chargers/charging points, utilization time per day, location of the charger, and treatment of the charger by users (in terms of rough or disciplined use). While there are typically some for replacement parts (e.g., charging connectors), the major costs for operating a charger is the cost of electricity. The higher the use-rate of the charger, the higher the O&M costs would be.

For simple non-networked chargers, the maintenance costs are typically low, and the chargers' modular design and use of standardized parts make it easy to replace worn components rather than the whole unit. The most common wear point is the pins in the connector (as shown in **Part 6.2**), which, when worn, fail to make an adequate electrical connection and must be replaced [140].
While in case of networked chargers, it is important for users to keep the systems up to date to ensure the latest software and operational and security features are available, the highest additional costs are the service fee, which is typically on a monthly contract per charger. This fee typically comes with increased services such as automated billing to charger users, system reporting, and EVEMS functionality for the networked chargers.

6.5 Residential and Workplace EV Charging Installation Technical Considerations

6.5.1 Approvals

Additional challenges will be presented for early adopters, as they may have difficulty receiving approval from the Condo Board to proceed with the installation, which may lead to challenges for how to appropriately allocate associated costs. For example, a single EV charger could be installed in the condo or apartment with little to no impact on the electrical capacity of the building, but as more EV chargers are installed, this will not be the case.

6.5.2 Capital cost distribution

Several EV chargers can lead to the need for an EVEMS, and there does exist some level of debate as to the most equitable manner in which to distribute the costs. For example, would the costs apply to all residents equally, solely to the first EV owner to install an EV charger, to the EV owner that pushes the ampacity demand past the threshold requiring and EVEMS? Viewing these systems over the life of the building can help ensure that such strategies are devised[xxix] and implemented that distribute the costs as equitably as possible, but many early adopters may bear a disproportionate percentage of the costs.

6.5.3 Energy charge distribution

Additionally, there are concerns in retrofits on how to charge for the electricity used by the EV, as it may not be feasible to have the power measured by the same utility meter that serves the unit/suite. Measurement Canada requires an inspected and approved meter in order to bill EV owners based on energy (kWh) or power (kW), which can greatly increase the costs of installation and ongoing operation of the EV Charger. A common solution is to rely on time-based billing or fixed fees that are exempt from this requirement [141]. However, time-based fees and fixed fees may not accurately or equitably reflect the actual energy costs incurred from EV charging.

Similar to that in retrofits, the challenge for new buildings too is how to best monitor and allocate the electrical costs associated with an EV charger. While some developments have relied on separate utility feeds or sub-metering, this can lead to increased operating costs for building as a whole and does not allow building energy management systems to optimize energy and power use in the building as a whole. The installation of additional metering enables the accurate allocation of energy costs to respective EV owners, but the increased upfront and operating expense could be more costly for EV owners than simpler and less accurate strategies such as time-based billing.

6.5.4 Zoning and planning

For new installations, it is important to consider the impacts of not providing adequate infrastructure from the start for EV charger installations. When comparing new installations with retrofits, the costs for electrical infrastructure (panels, wiring/conduit, electrical outlets, and EVEMS) are significantly lower (per parking space) as builders benefit from economies of scale in equipment and labour costs.

Many jurisdictions have introduced zoning requirements that mandate all parking spots in new buildings to be EV ready, thus providing EV owners with buildings in which they or building management can readily install EV chargers without requiring a significant investment of time and resources. These stakeholders should consider the minimum ampacity rating required for each parking space, whether an EVEMS is used or not, and if so, they should consider how

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[xxix] Clear best practices were not observed as of the writing of this report. Further consultation will be required to develop standard procedures for the fair and equitable distribution of costs. A first step as discussed in **Part 11.3.8** is advocacy for changes to how electricity usage and demand costs can be measured and passed along to EV owners.

adequate energy can be delivered per day to satisfy typical driving routines. The minimum charge requirement will vary by region based on regional driving patterns, weather, and vehicle types.

6.5.5 Tenancy in commercial buildings

The cost drivers in case of commercial buildings (businesses or apartments) are likely to be similar to those in MURB retrofits but since the ownership of a commercial building typically lies with a single entity (in place of a condominium board with multiple property owners), there is less complexity in acquiring the approval to proceed with the EV charger installation. However, a tenant in a commercial building could have challenges similar to those of condo owners depending on the building ownership structure (held by a multiple-owners or not) and proposed mechanism for assigning costs between the owner and the tenant. A building owner may not be eager to incur the costs for EV charging equipment and installation if they do not foresee a return on the investment in the form of increased rental revenue. Similarly, a tenant may be reluctant to invest in the cost of EV charging equipment and installation as they would not realize its full benefits if they were to move to another building. Adequate agreements for cost allocations would need to be developed in order to address these issues; for instance, the leasing of chargers is one such market mechanism that can be considered in the case of commercial buildings to address the concerns of both parties.

6.6 EV Charging Technologies

While ICF does not make any assertions as to what the charging technology of the future will be, key technologies to watch are wireless charging, smart or networked chargers, and improvements to battery technology and ultra-fast direct current fast charging. While the manner in which an EV is charged may change in the future, it is expected that the electrical infrastructure to support EVs will remain the same; i.e., an electrical cable will be run to and near a charging station or piece of equipment that will charge an EV. A summary of the underlying technology advancement, as well as the benefits and consequences of these technologies, is provided below.

6.6.1 Wireless Charging

Wireless power transfer can exist in two categories, radiative (e.g., electromagnetic radiation, which includes light, x-rays, and thermal radiation) and non-radiative. For the transfer of electrical power, non-radiative power transfer is used for proximity power transfer via magnetic fields, as is the case in electrical transformers, induction motors, or wireless charging for cellphones.

Wireless or inductive charging is an emerging technology that seeks to improve the user experience by essentially eliminating the need to plug in or handle conductive EV charging equipment. SAE International is active in working on and defining the specifications for Wireless Charging with the work-in-progress standard J2954, which covers wireless power transfer (WPT) levels 1 to 3 (3.7 to 11 kW) [142].

Figure 15: BMW EV Wireless charging mat and visualization of the magnetic field (dashed orange line), primary charging coil (orange) and secondary charging coil (blue) [143]

Currently, there are limited applications of wireless EV charging outside of small pilot studies. Some of the major players in the space include WiTricity (acquired competitor Halo from Qualcomm) and Plugless (part of the EVATRAN Group).

Wireless charging commonly relies on changes in the magnetic fields to transmit energy from one conductive device to another, and for wireless EV charging there are two key technologies:

- **Inductive Coupling (IC)**: "Is the transfer of energy from one circuit to another by virtue of the mutual inductance between the circuits, see **Figure 15**. A common example of IC is a radio-frequency identification (RFID) system that uses inductive coupling, the reader antenna and the tag antenna each have a coil, which together form a magnetic field. The tag draws energy from the field. The microchip uses this energy to change the electrical load on the tag antenna. These changes are picked up by the reader antenna and converted into a unique serial number" [144].
- **Resonant Inductive Coupling (RIC)**: Similar to inductive coupling, but the power is transferred between two resonant circuits, i.e., an electrical circuit with an inductive and capacitive element that is equal in magnitude and 180° out of phase. The resonance between the coils can greatly increase coupling and power transfer, analogously to the way a vibrating tuning fork can induce sympathetic vibration in a distant fork tuned to the same pitch [145,146]. The advantage of resonant inductive coupling is that it provides higher charging efficiencies compared to standard wireless charging technologies.

Advantages of wireless charging

- **Protected connections:** No live connectors and no exposure of electrical conductors to environmental contaminants. This can reduce wireless charger's exposure to salts, oxygen, or other corrosive agents, thus reducing wear and tear.

- **Safety:** Reduced risk of electrical shock as there are no exposed electrical leads. Key areas of concern for traditional plug-in charging are in wet/damp environments in which water may divert or enable the unintended electrical current flow.
- **Ease of use:** The charging process is automated when the vehicle is parked over a wireless charging pad.
- **Aesthetics:** The lack of cables minimizes the visual footprint of the charger and has reduced equipment than can be damaged by regular or improper use.

Disadvantages of wireless charging

- Reduced charging efficiency compared to conductive/plug-in charging. RIC based EV chargers can have 90-93% charging efficiency, which is comparable to 88-95% charging efficiency of standard EV chargers [147]. While wireless charging can achieve charging efficiencies comparable to some existing wired chargers, its theoretical limit is less than conductive charging, and less than the highest measured efficiencies for a conductive charger, which is greater than 98% [148].
- Vehicle system costs are greater as current EVs are not equipped with the technology: a charging pad and adapter plate are required for the installation and use of wireless charging.

6.6.2 EV Charging Rates & Battery Technology

Changes to the battery capacity through the use of advanced battery technology would have a direct impact on EV charging rates. Some of the upcoming technology advancement and resulting potential impacts on EV charging (primarily on battery capacity, charging rates, and cost) are explained below:

- Improved battery density will enable manufacturers to include increased energy capacity into their EVs; this would lead to the increased driving range and a reduced charging time per charge cycle of the EV.
- As new car buyers consider purchasing an EV, the prevalent concern of not being able to charge their EV rapidly can lead to increased demand for higher ampacity chargers[xxx]. The demand for higher ampacity chargers would lead to increased pressures on the electrical system, and cascading cost impacts to all electricity ratepayers. The benefit is that users (ignoring grid or home power limitations) would be able to charge their EV in half the time, which may become increasingly relevant for larger EVs with larger battery packs.
- DCFC charging is undergoing continued development to reduce charging time. The CHAdeMO specification 2.0 is now capable of delivering up 400 kW via a 1000 V, 400 A DC power source. The combined charging systems (CCS) can deliver charging rates

[xxx] While typical Level 2 chargers are less than 40 A, there are Level 2 chargers available with an ampacity up to 80 A—e.g., Sun Country EV80, Tesla 80A Single Phase wall connector, ClipperCreek CS-100, and the WattZilla UNO

from 80 to 350 kW, and Tesla's superchargers V3 can supply up to 250 kW. These systems will enable EV owners to charge their EVs while travelling or as part of their daily commute with a charging time comparable to the refuelling time of existing ICE vehicles; i.e., 5 to 15 minutes to recharge the vehicle. Improvements in the DC chargers may lead to an increase in its demand from consumers to be able to charge faster at home or work regardless of the actual need for fast charging.

- Although several paths are being pursued to improve future lithium-ion battery technology, solid-state batteries, supercapacitors, and ultracapacitors are also being tested for EV charging. While varying battery chemistries have varying capabilities, these are expected to be managed by EV chargers or onboard charging systems. The impact of these technologies is expected to enhance battery capacity and reduce costs primarily. Reduced battery costs could greatly accelerate EV adoption and corresponding enhanced EV charging infrastructure deployment, thereby supporting EV adoption.

6.6.3 EV Smart Chargers

Smart chargers, or networked chargers, are chargers that have enhanced operational capabilities enabled by an interconnection of the charger with a network in which data can be shared. This connectivity allows for the potential to maximize grid efficiency by monitoring, managing, and modifying the use of electricity for EV charging. A smart charger will use real-time information or data in order to manage the operation of the charger.

There are three key vehicle-grid integration models (**Figure 16**) that require the use of smart charger systems.[xxxi]:

- **Unidirectional systems (V1G):** Power flow is in one direction and goes from the electrical supply/grid to the EV. A smart charging system would regulate the power flow rate based on grid signals for pricing, power demand, or environmental (electricity mix) attributes.
- **Vehicle-to-Grid (V2G):** Power flow can be bi-directional; i.e., from the grid to the EV or from the EV to the grid. A smart charger performs the same functions as a V1G system but also can provide power back to the grid to optimize grid operations impacted by system bottlenecks or peak power demands. A smart charger could potentially be used to buy and sell power, providing a financial gain to the charger or EV owner if price signals provided a profit-making opportunity from the differences in electrical power prices.
- **Vehicle to home or Building (V2H or V2B):** A charger with bi-directional power flow, but the power is transferred from the grid or on-site power generation to the EV, or from the EV to the home or building, not back to the grid. V2H/V2B can be used for in-home

[xxxi] Note: All these smart charger technologies are subject to local governing regulations and the charger's ability to complete any of these operational functions does not mean that it would be permitted by the utility or local governing entity.

power backup or load shedding for the home in order to limit the need for increased electrical service from the utility to meet peak power draws in the building.

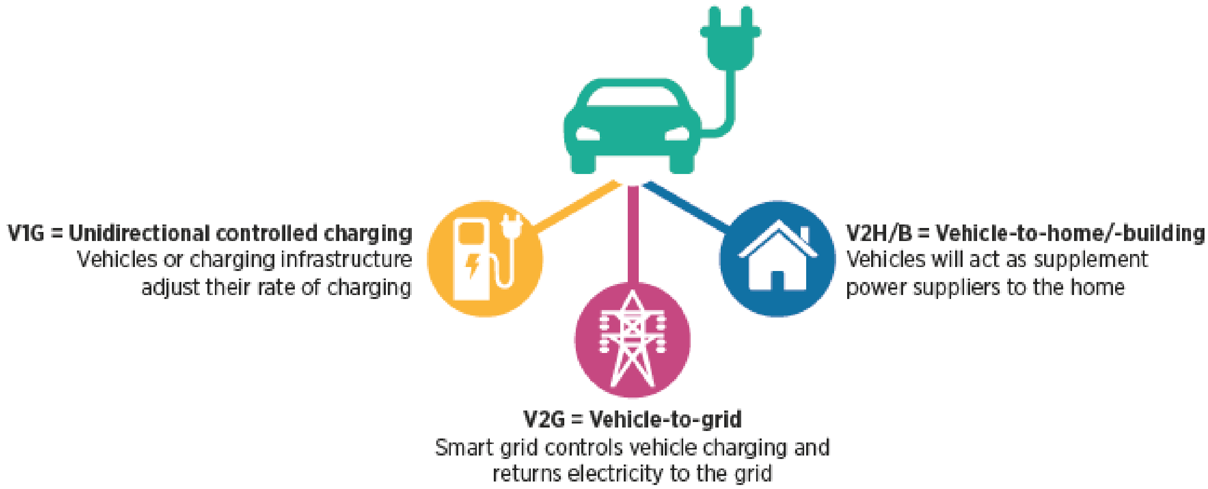

Figure 16: Advanced forms of smart charging [149]

As is evident from the smart charging architecture shown in **Figure 16**, smart chargers have the ability to respond to real-time data and ensure that the operation of the charger is optimized based on the charging system operation. A recent study in California evaluated the EV charging behaviour of residential EV owners in the San Diego area over one year (quarter 1 to 4, Q1-Q4), and it was noted that TOU rates alone resulted in what was referred to as a “twin-peak” load profile. The first peak is the normal system peak (typical home power demand), and the second peak reflects that the EV owners all set their charging cycle to begin at midnight when TOU prices dropped [150]; see **Figure 17**. Some additional insights from the study are that the EV charging behaviour showcases that most EV owners only require short duration charging (average of 2 hours) and that the majority of EV owners chargers are set to start charging at midnight. A more robust TOU structure might alter the start time of the TOU rates for individual users or utilize smart chargers which can respond to operating signals from the utility to manage this behaviour, by enabling real-time load shifting of EV charging.

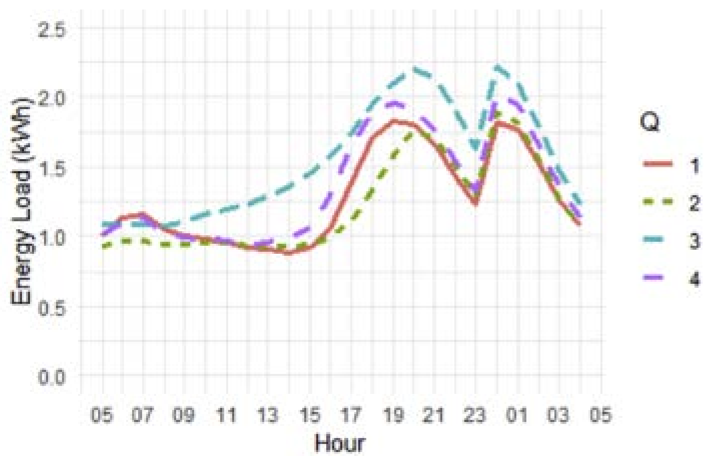

Figure 17: Typical load profile by quarter for a San Diego home with an EV subject to TOU pricing, showing the “twin-peak” behaviour for a limited number of EV penetration. [151]

6.6.4 Key EV Charger Market Players in Canada

With the increasing rates of EV adoption in Canada, most major EV charging companies have invested in setting up charging infrastructure in the country. Some of these key players that also serve the home and workplace EV charging market are:

- **Flo:** Is a leader in EV charging infrastructure and operation of EV charging stations in Canada. Flo has over 60,000 EV drivers using their network and has connected more 5,500 commercial stations, including 225 DCFC stations connected to their network [152].
- **Tesla:** Is a leading EV manufacturer and early developer of EV charging infrastructure. Tesla has deployed Level 2 and DCFC (Superchargers) across Canada, which are readily available to Tesla owners. Tesla utilizes a proprietary charging connector, and thus, their charging stations cannot be used by non-Tesla EVs.
- **ChargePoint:** Operates more than 105,000 charging points and more than 1,700 DCFC charging stations, and their users have access to over 80% of public charging stations in North America [153].
- **EVBox:** Is headquartered in Amsterdam and operates in over 55 countries. EVBox manages 100,000 charging points, including 1500 DCFC stations. [154].
- **Enel X (JuiceBox):** Is a leader in energy solutions for utilities and businesses and recently purchased JuiceBox, a leading manufacturer of EV charging solutions and equipment [155].

6.7 Benefits of EV Charging

EV charging at home and workplace results in a range of benefits for all entities involved in the value chain – the utility, EV user, charging host/provider and other stakeholders. Some of the key benefits are described in the following sections:

6.7.1 Grid and Utility Benefits

With the continued increase in the adoption of EVs, there exist major benefits for utilities and electrical operators. A study on the impact of EVs on the electrical system in California from 2012 to 2017 showed the revenues generated from electricity sales significantly outpaced costs for the utility (PG&E)[xxxii], see **Figure 18**. A key factor enabling the benefit from EV charging was the high rate of charging in off-peak periods, in particular for regions with TOU pricing [156]. Increased rates of power use in off-peak periods improve the operating capacity factor of the transmission and distribution system, which means the same capital investment is being used for a greater period of time, which in turn improves the cost recovery on electrical infrastructure and can lead to reduced power pricing or distribution charges for consumers.

[xxxii] While the benefits of increased electricity sales does vary by jurisdiction, in particular in markets such as Alberta where the utility and the power generator may not be the same entity. The cost benefit can be lower in these markets than the example market in California.

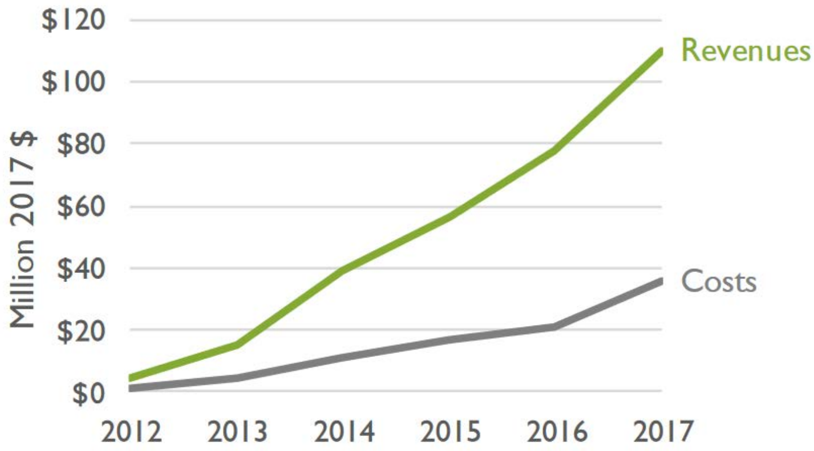

Figure 18: PG&E Revenues and Costs Associated with EVs [157]

As described in **Part 6.6.3**, **Figure 17** smart chargers can be used to optimize the grid operations and can provide significant opportunities to improve overall grid operations when to increase intermittent power sources are installed and connected onto the grid. As outlined in a literature review by the International Renewable Energy Agency (IRENA), see **Figure 19**, both V1G and V2G technologies are expected to have significant benefits for reducing the impact of EV charging on the grid, and with a properly designed system, smart charging technology can improve overall grid operations, assist in peak shaving, and reduced electrical curtailment[xxxiii] for intermittent power generation; e.g. wind and solar power.

[xxxiii] Curtailment occurs when the electrical power that is generated exceeds the electrical demand at a particular moment in time. For renewable energy producers the excess power cannot be sent to the electrical grid and must be reduced turning off or isolating generators from the grid or dumping the electrical load to dump load (e.g., resistors). The electrical energy is lost during curtailment and does not provide any revenue to the power generator.

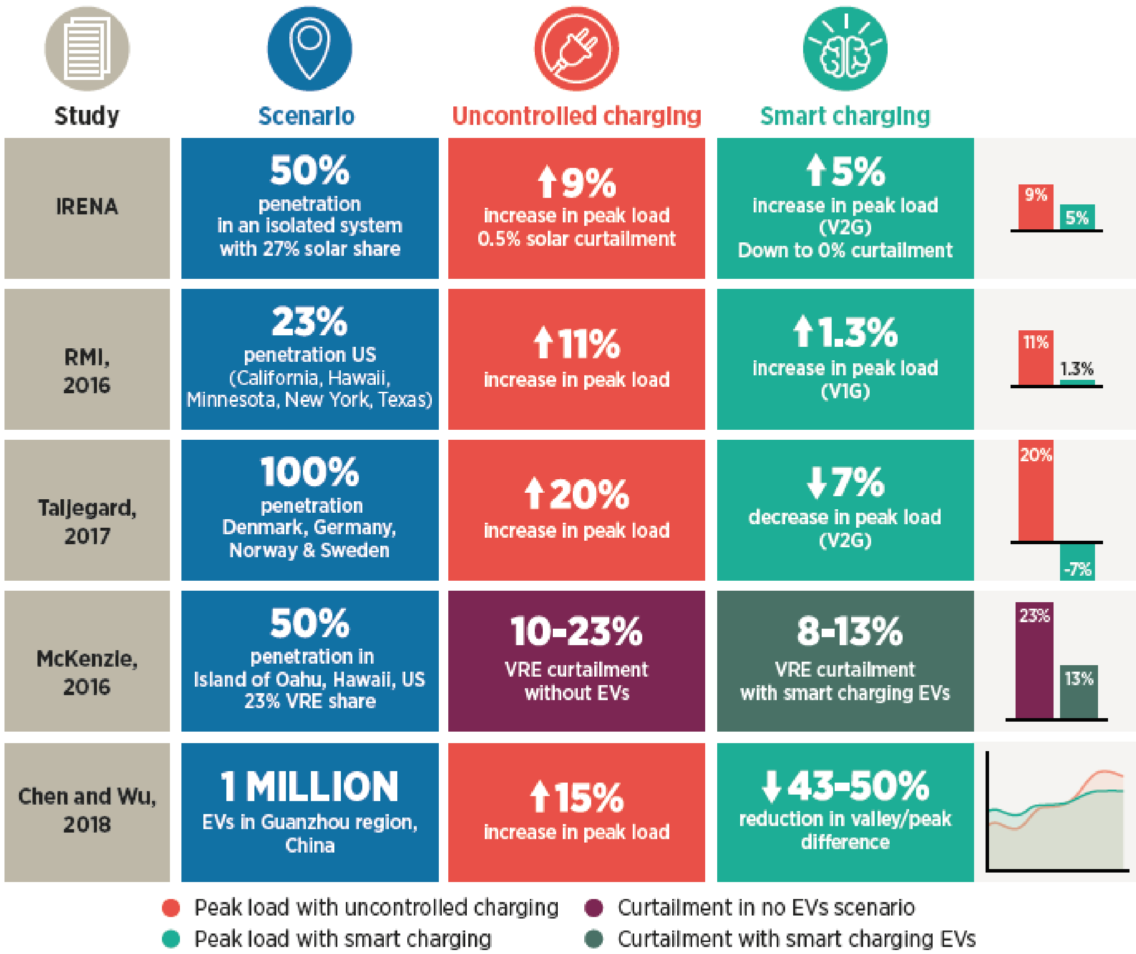

Figure 19: Impact of EV charging on the grid operation for uncontrolled (dumb charging) versus smart charging systems [158]

6.7.2 Benefits of EV Charging at Home

- **Convenient:** Home charging provides the EV owner with an easily accessible source of electricity for their vehicle. For owners that typically have their vehicle at home, it provides them with the opportunity to easily charge their vehicle daily or as required without the need to go to charging stations or contend with queues.
- **Reliable and available power:** The access to the home charger is readily available with utmost certainty and power quality.
- **Low costs:** The home electricity provides one of the most cost-effective means of charging an EV since there is no need to add a margin[xxxiv] to the electricity cost, as is the case with charging stations owned and operated by others.
- **Thermal Preconditioning:** In colder regions, there is a need to ensure that batteries have been sufficiently warmed up before travelling. Doing this can help offset the lost

[xxxiv] Increased margin would be used to cover the capital expense for the charger, the operating costs, maintenance costs, and if applicable the operator profit.

range, which is experienced when batteries become too cold. This can also help extend the battery's operational life. Home charging provides an opportunity for thermal preconditioning and also provides the opportunity for the plugged-in EV to use the grid electricity for pre-heating the cabin.

6.7.3 Benefits of EV Charging at Workplaces and Commercial Buildings

- **Employee Recruitment:** Having EV charging available at the workplace can help signify a company's commitment to environmental stewardship, and to potential employees that own or plan on owning an EV.
- **Increased Customers:** For commercial buildings or offices, having EV chargers installed is an effective way to attract new building tenants. In the case of buildings with retail, having EV chargers can help attract EV owners who choose to shop at locations that enable them also to charge their vehicles.
- **Employee benefits and improved retention:** Providing free EV charging access to employees, similar to providing free parking, can be an addition to employees' compensation or benefit package.
- **Sustainability Goals or Building Certification:** For companies seeking to improve or maintain a positive environmental image, providing EV charging at the workplace is an effective strategy to encourage more sustainable transportation alternatives for their employees. Also, the charging stations can be used towards achieving sustainable or environmental building certification(s)—e.g. LEED.
- **Range security or Range Extension:** Access to workplace charging can effectively reduce the daily commute between charging facilities for EV owners with home charging. The ability to charge at work also provides additional time for an EV to fully charge if it possesses a large battery pack that is not able to fully charge in the evening at home, and enable the EV owner to have a fully charged vehicle as they leave the office to start their evening or weekend.
- **Thermal Preconditioning:** As in the case of EV charging at Home, Workplace charging also provides an opportunity both for thermal preconditioning and for a plugged-in EV to use the grid electricity for pre-heating the cabin.

7 Community Charging Hubs

With the growing number of EVs on Alberta's roadways and the corresponding increase in the need for EV charging, the idea of clustered charging hubs also referred to as 'community charging hubs or 'e-hubs' merits consideration. The cost and logistical barriers of deploying home and workplace charging infrastructure in certain circumstances can bolster the case for charging hub infrastructure that mimics the conventional gas station, fuelling model.

7.1 Examples from other jurisdictions

Some examples of charging hub developments in Canada and the United Kingdom include:

- The University of British Columbia currently manages more than 60 Level 2 chargers to cater to the demand from EV drivers [159].
- Deployment of a fast-charging hub at the Toronto Pearson Airport has was announced in June 2019. The hub will cater to the fleet of electric shuttle buses at the Toronto airport. This project will serve as a model and help identify barriers and strategies for electric bus adoption at airports across Canada [160].
- The city of Vancouver plans to have a DC fast charging hub located within a 10-minute drive from any location in Vancouver, which will require the City to install 12 charging hubs [161]. According to City staff, the initiative to install charging hubs is focused on DCFC chargers. The objective is to ensure some redundancy in the installations, such that a minimum of two DCFC chargers are installed per site, and they have been adding Level 2 chargers at these sites where there is sufficient space. The largest barrier experienced has been limited locations that can accommodate the footprint for charging hubs (parking space, chargers, and transformer). Based on the initial installations, the City has not noted any major economies of scale for installations of 4 or fewer DCFC chargers, with estimated costs of $100,000+ per charging port.
- In London, UK, a 'virtual charging hub' of six 50 kW charging points located within 200 metres of each other at Southwark Street were very well received, and taxi drivers were amongst the most vocal supporters [162]. With the positive feedback on the first project and a growing EV fleet, Transport for London (TfL), in partnership with a UK's leading EV charging networks company, Engenie, opened London's first fast-charging hub at Stratford International Station car park in January 2020. The hub is fully accessible by all drivers who can pay for charging using a contactless card or smartphone without having any prior registration or membership to the hub. The Mayor of London's EV infrastructure delivery plan aims to install five fast-charging hubs in the near future and 300 fast chargers by the end of 2020 [163].

Figure 20 EV Charging Hub at Stratford International Station car park, London UK [164]

- In a similar deployment, a fast-charging hub with 8 chargers supporting all standard EV charging is functional in Milton Keynes about 50 miles northwest of London, UK. The funding for the hub came from the UK's Office for Low Emission Vehicles (OLEV) as part of a package to support the growth of EVs.[165]

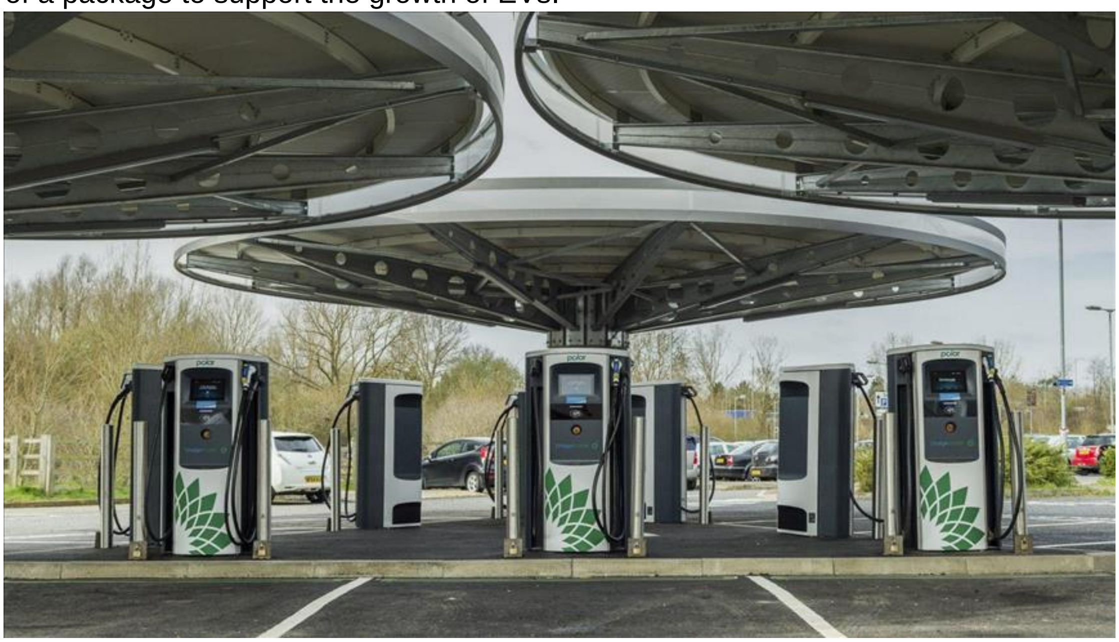

Figure 21 Fast charging hub at Milton Keynes, UK [166]

Although these examples do not clearly cite any thresholds for EV adoption level or fleet size to consider charging hub deployment, these developments clearly indicate a functional model to cater to growing EV charging needs. The UBC example presents a Level 2 charging hub, but most other hub configurations carry fast chargers.

With relatively low numbers of EVs currently on the roads in Alberta and other major Canadian cities, it is difficult to estimate if charging hubs will eventually be required - the examples within

Canada and the US are limited to suggest a strong trend one way or the other. Given that access to a reliable charging network is seen as a key contributor in accelerating EV adoption, the development of charging hubs may not be solely dependent on the EV population.

Further, Tesla currently provides its customers with access to its proprietary Supercharger network. As more EVs from other manufacturers get on the roads without access to the Tesla network, the demand for charging hub infrastructure may surface more clearly.

7.2 Criteria for determining optimal locations

Key categories of EV owners that would benefit from charging hubs would be garage orphans[xxxv] [167] and the higher density residential developments (condos, townhouses, or apartments) or single-family developments without garages or other dedicated, on-property parking. These developments may not have the electrical infrastructure to support in-home or in-building charging and require significant capital investments to upgrade the installed electrical service lines and distribution panels. For EV owners dwelling in such establishments, charging hubs can provide a reliable and convenient EV charging alternative that may be located close to their home, work, or other frequently visited public locations such as grocery stores, shopping centres, and recreational facilities.

During the stakeholder engagement sessions, participants were requested to provide their insight into the potential use cases and locations for charging hubs. Some key locations and corresponding use cases that were highlighted in the sessions are as follows:

- **Highly visited locations:** These locations are commonly driven to and where individuals remain at for a sufficient amount of time, i.e., greater than 30 minutes, such that Level 2 or higher charging could provide sufficient charge to meet daily travel minimum charge requirements. Early investment in such charging infrastructure at these locations may require investment by the City as until sufficient demand is established, there may be a limited financial incentive for businesses to own and operate charging infrastructure.

- **High-density urban areas:** In areas with high concentrations of residential or workplace buildings, rapid growth in EV adoption could outpace the rate at which new buildings with EV charging infrastructure would be constructed. It may make sense to examine deploying EV charging hubs within parkades or large office buildings. These locations would enable employees or nearby residents with the opportunity to access a charger close to home or work. Creative strategies to encourage off-peak parking and appropriate charging pricing may help to increase building utilization and revenue through the deployment of the charging hub.

In addition to these site characteristics, other criteria such as access to grid power, access to highways, proximity to common commuter routes and site accessibility are important to consider in identifying suitable locations for charging hubs.

[xxxv] "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" [**Error! Bookmark not defined.**]

7.3 Charging hub layout and cost

Since most charging hubs include fast chargers, this section includes a diagram of a hypothetical multi-port DCFC complex. It may include onsite storage or power generation, likely from renewable energy sources such as solar. This configuration assumes that the AC-DC conversion, communication between charger and vehicle and power delivery are undertaken within each fast charging unit. The conductors and conduits are sized based on each charger, and the number of chargers in the hub and each DCFC unit is supplied with 480 V with a step-down transformer provided onsite.

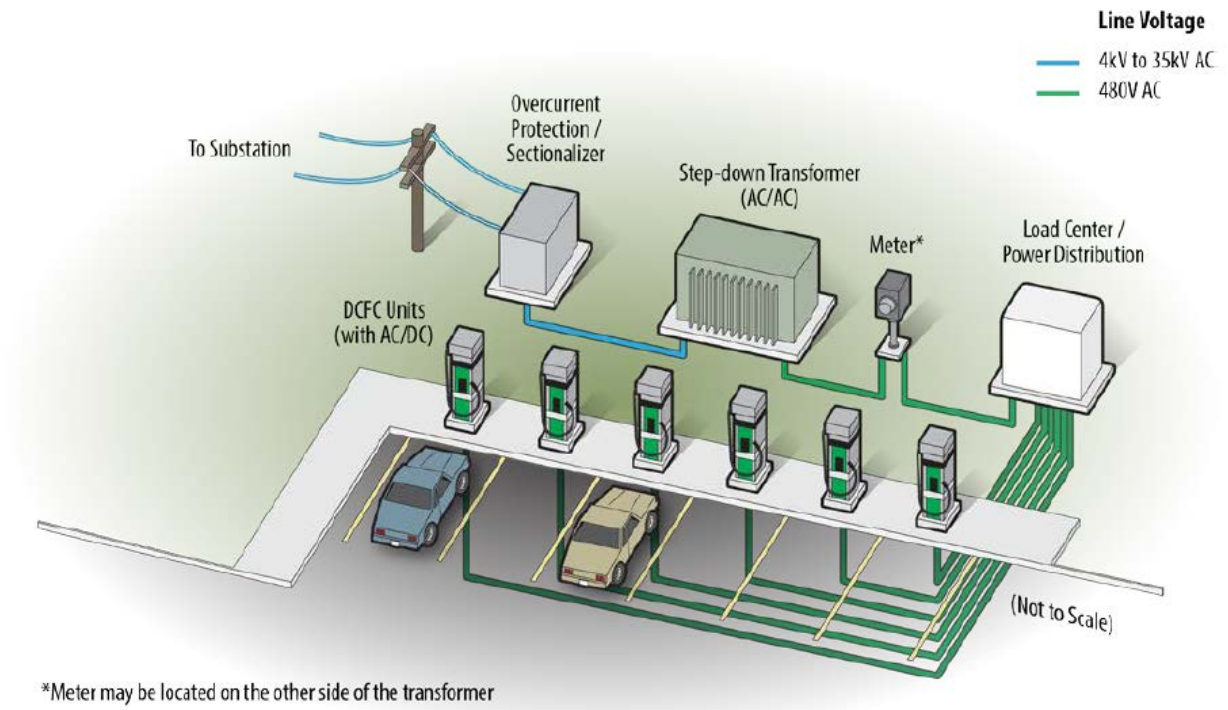

Figure 22: Diagram of a hypothetical multi-port DCFC complex [168]

The publicly available costs of installing DCFC chargers are provided in **Table 6**: Installation costs per DC fast charger by power level and chargers per site (converted to CAD using 1 USD =1.32 CAD) [. These costs were estimated by the International Council on Clean Transportation (ICCT) as part of their publication on “Estimating electric vehicle charging infrastructure costs across major U.S. metropolitan areas.” The study, in turn, utilizes the data from a Rocky Mountain Institute study for estimation of the cost of 50 kW chargers and data from Ribberink et al. to project costs scaling for multiple chargers per site and for higher power stations. The data in ICCT study was in USD and has been converted to CAD (I USD=1.32 CAD) for the purpose of this report to provide an idea of the costs associated with various heads and configurations of an EV fast-charging hub.

Table 6: Installation costs per DC fast charger by power level and chargers per site (converted to CAD using 1 USD =1.32 CAD) [169]

	50 kW			150 kW			350 kW		
Cost	1	3-5	6-50	1	3-5	6-20	1	3-5	6-20
	charger	charger	chargers	charger	chargers	chargers	charger	chargers	chargers
	per site	per site	per site	per site	per site	per site	per site	per site	per site
Labor	$25,344	$14,784	$9,504	$26,611	$15,523	$9,979	$36,749	$21,437	$13,781
Materials	$34,320	$20,592	$13,728	$36,036	$21,622	$14,414	$49,764	$29,858	$19,906
Permit	$264	$132	$66	$277	$139	$70	$383	$191	$96
Taxes	$140	$84	$55	$147	$88	$59	$203	$121	$82
Total	$60,068	$35,592	$23,353	$63,071	$37,372	$24,522	$87,099	$51,608	$33,863

7.4 Curbside Charging

While not technically a charging hub, a growing trend in California and Europe is curbside charging, which functionally achieves the same purpose of providing charging to EV owners at home, work, or near entertainment districts. Los Angeles has recently installed 132 curbside chargers existing streetlight poles powered by the existing lighting circuit—made possible from the reduced power draw of LED lights [170,171]. This technique has been around in Europe for a couple of years, with London, England having installed more 1,000 curbside light post charging systems, with charger power rates from 3 to 7 kW [172].

In Calgary and Edmonton, the residential street lighting is 120/240 V supplies with 30 A per control unit [xxxvi] [173, 174]. This provides an opportunity for developing the curbside charging described above. A concern on this concept was raised during the engagement sessions suggesting that it was likely for the street lighting to be running at the typical residential voltage of 120 V and would only allow Level 1[xxxvii] charging, but based on the City of Calgary and the City of Edmonton street lighting design documents, street lighting has an operating voltage of 240 V—NOTE residential voltage supply for homes is 240 V, but most outlets run off a centre tap (i.e., 120 V).

As such, it would be expected that similar to the aforementioned examples in Europe and California, that Calgary and Edmonton could utilize LED retrofitted lighting poles to provide electrical power for EV charging. While the circuits for lighting are required to be 30 A, LED lighting typically uses 50% or less of the power required by traditional lighting (high-pressure sodium, halogen, etc.) and there is potential for Level 2 charging rates of 3.6 kW (15 A) to be retrofitted in these locations.

The use of retrofitted light poles could also be examined in the downtown core for street-side charging and parking, requiring minimal additional infrastructure other than the EV charger itself. This strategy may also apply to charging hubs for outdoor parking lots with large pole-mounted lighting, including the City Park & Ride lots, parking near parks or recreation facilities.

[xxxvi] Calgary: *Design Guidelines for Street Lighting (2016),*
Edmonton: Road and Walkway Lighting Construction and Material Standards (2018)

[xxxvii] While the preference should be to focus on locations to provide a minimum of Level 2, adding Level 1 chargers to residential neighbourhoods where parking is primarily on the street could provide some users access to some form of electrical charge until alternative solutions can be delivered.

8 EV Charger Installation Guides

This section provides guides that will help with the installation of EV charging infrastructure. The guides also include a table to assist in the sizing of an EV charger, and it is recommended that the table be converted to an online tool that would be accessible on the City's website.

8.1 Single-Family Residential Buildings

The following are some key questions and considerations that should be evaluated prior to installing an EV charger. If the answer to any of the questions below is uncertain, it is recommended that the advice of a qualified professional be solicited.

- **Do you know where you would like to install your EV charger?**
  Consider a location such as your garage or another area to which only the EV owner would have exclusive access to (this limits the chances of another vehicle restricting access to the EV charger when needed).
- **What is the electrical energy consumption of your electrical vehicle—measured in kilowatt-hours per 100 km (kWh/100 km)?**
  This can be found in your vehicle manual or online in the NRCan Fuel Consumption Guide (annual guides released so ensure it matches the year of your vehicle).
- **What size electrical charger do you need?**
  This will vary based on the energy consumption of your electric vehicle and your daily driving distances. For a typical Alberta resident, travelling less than 50 km per day, and parking their vehicle at home for more than 12 hours per night a 16 A, Level 2 EV charger could easily charge the parked EV in less than 3 hours of charge time.
- **Will an EV charger have any impacts on my home electrical system?**
  Review with the electrical contractor in order to identify what size charger you can install in your electrical panel and how energy management systems can be used to minimize or prevent the need for costly upgrades to your home electrical service.
- **What size (power rating or amperage rating) and model of EV charger are you going to install?**
  The charger should be compatible with your current or future model of EV. Technical specifications of the compatible charger should be available in you EV owner's manual.
- **Is there a dedicated 240 V electrical supply available at the identified location, or will the charger need to be wired into the breaker panel?**
  For example, a dedicated 240 V outlet (16 to 40 A) could be used for a compatible EV charger; i.e., the charger just needs to be plugged into the outlet. Consider consulting a qualified electrical contractor if you are not sure whether you have a 240 V outlet or power source near the chose installation point.
- **Are you qualified to complete the electrical work, or will a qualified and licensed professional be required?**
  As mentioned above, for a location where an EV charger compatible electrical outlet is available no electrical work is required, and the installation can be completed by the

homeowner. If a connection to the electrical/breaker panel is required, consult with local policy to ensure if you as the owner are permitted to complete the work or will require a qualified and licensed professional.

- **Is an electrical permit required for installing the EV charger?**
  If the EV charger only needs to be plugged into an electrical outlet, a permit is not required, but a permit is needed for any work that requires changes or additions to the distribution/breaker panel (for more information refer to local permit and home electrical work requirements on the City website).

- **Can the selected EV charger be installed and operated without any upgrades to your utility service or feeder current/amperage rating?**
  Refer to the current release of the Canadian Electrical Code or discuss it further with a qualified professional. The total home electrical load and hours for all typical housing loads will need to be considered.

The installation of an EV charger may require electrical work, which is to be completed by a qualified and licensed professional. EV owners should consult with qualified professionals to confirm specific installation requirements for safe operation and compliance with governing regulations. The steps listed below provide guidance for installing an EV charger at a Single-Family Residential home.

Step 1: Identify the location where an EV charger would be installed. Consider aspects such as ease of access, indoor versus outdoor, and access or proximity to your EV parking location.

Step 2: Determine the size of your EV charger. For determining the required charger size for your current or future EV based on your typical driving distance range, refer to the table below. These tables are a design aid that can help estimate daily charging requirements and the needed charger size to meet the charging requirement.

Step 3: Identify the power source for your EV charger. Two common sources are the building electrical/breaker panel and a dedicated 240 V electrical outlet. If a connection to the breaker panel is required (no electrical outlet available), the work should be completed by a licensed electrician. An electrical permit will be required for installations of this type.

Step 4: Confirm that either the power source has an appropriate amperage/current rating or there is sufficient spare capacity in the breaker panel to accommodate the EV charger. Refer to the current release of the Canadian Electrical Code or discuss further with a qualified professional in order to determine panel capacity.

If yes, proceed to Step 5, if no, consult with a qualified professional (an electrician, qualified electrical contractor, or qualified engineer) to review the EV charger installation. This may require upgrades to your breaker panel, consultation with the utility, and/or installation of new utility equipment.

Step 5: Install the charger as per the manufacturer installation requirements; typically, home EV chargers are wall-mounted.

Step 6: Connect the EV charger to the electrical supply

Step 7: Setup the EV charger as per the manufacturer installation or operation manual.
Note: Consideration should be given to have the EV charger start time after 8:00 pm to minimize impacts on the utility distribution electrical system.

Charging Load Calculation

Item	Typical Value	Actual Value	Calculation
Daily Commute [km/day]	50.0		a
Electric Vehicle Fuel Consumption [kWh/100 km]*	19.9		b
Fuel Consumption Contingency‡	1.20		c
Required Daily Charge [kWh/day]	**11.9**		$d = a * \frac{b}{100} * c$

*To Convert Gasoline Litres Equivalent to kWh, multiply by 8.9; i.e. 1 L_e/100 km = 8.9 kWh/100 km.
‡An additional factor to account for the increased electrical load required for real-world conditions compared to the stated vehicle energy/fuel consumption. For example, winter driving and heating can increase the vehicle energy usage by 20% or more.

Home Electrical System

Breaker Panel Rating (typical 100 amps) [A]	100		N/A
Home Voltage Rating (typically 240 Volts) [V]	240		h

Charger Sizing

Required Daily Charge [kWh/day] (From **Error! Reference source not found.**)	11.9		d
Typical duration car parked at home per day [hr/day]**	8.0		e
Required Charger Size (Power Rating) [kW]	**1.5**		$f = \frac{d}{e}$
Required Charger Current Rating (Amperage) [A]†	**6.2**		$g = f * \frac{1000}{h}$

**Time vehicle parked while the charger is available, for example from 7:00 pm after work until 6:00 am in the morning
†Typical home Level 2 EV Chargers are 240 V and available in the following amperages: 12 A, 16 A, 20 A, 32 A, and 40 A. It recommended that the selected EV charger does not exceed 40% of the breaker panel rating

8.2 Multi-Unit Residential and Commercial Buildings

When looking to install a Level 2 EV charger at a multi-unit residential or commercial building, the following questions and considerations should be evaluated by the building management. If the answer to any of the questions below is uncertain, it is recommended that the advice of a qualified professional be solicited.

General Charger Installation Considerations

- **How many EV chargers are going to be installed?**
  Installing more chargers at once can lower the costs per charger installed. Consider seeking input from other unit owners or tenants that may wish to upgrade their parking space to EV ready.
- **Is the parking area where the charger will be installed located indoor or outdoor?**
  This may change the requirements for how power can be run to the parking spaces, as outdoor parking areas may not have structures on which the power cable or conduit can be attached to. Cables may need to be run below grade, which can greatly increase the labour costs.
- **Will the EV chargers be installed in close proximity to each other?**
  Grouping chargers together can minimize material and labour costs.
- **Where will the EV chargers be relative from the electrical power source (i.e., how far from the electrical room)?**
  The further away, the greater the number of parking spaces that will be impacted by the installation. Preference should be to have the installation occur at as many spaces as possible and focus on the parking spaces closest to the electrical room/power source as possible.
- **Does the building have any pre-existing electrical infrastructure to support EV charging (spare panel capacity, pre-assigned circuits, electrical outlets near vehicle parking spaces, etc.)?**
  This will greatly reduce the challenges and costs of the installation. If the building already has EV ready parking spaces, minimal to no electrical work may be required.
- **What size (power rating or amperage rating) and model of EV charger is going to be installed?**
  This can be found in the vehicle manual or online in the NRCan Fuel Consumption Guide (annual guides released so ensure it matches the year of your vehicle). EV owners should select an EV charger that meets their minimum electrical charge, but it cannot exceed the capacity of the electrical outlet to their parking space. Typically, the outlets can support up to 40 A.
- **Has a licensed electrical contractor been selected for the work?**
  Ensure that the selected contractor is qualified to complete electrical work in Alberta; for example, an electrician should be an Alberta certified journeyperson or hold valid recognized credentials. Additionally, considerations for experience or training with EV infrastructure should be considered.

- **What is the spare electrical capacity for the building?**
  This is the difference between the current peak power draw of the building and the size of the building transformer. Without sufficient capacity to handle the increased load, considerations for upgraded transformer or the use of an EVEMS (see below) will be required.

- **Will the installation require or benefit from the use of an electric vehicle energy management system (EVEMS)?**
  An EVEMS is an effective means to limit the power draw from multiple EV chargers. It is able to limit the total power draw and manages the charging of multiple chargers at a time (for example, 10). This can greatly reduce the strain on the building's electrical infrastructure, avoid costly upgrades, and reduce electricity demand charges.

- **Can the selected EV charger(s) be installed and operated without requiring any upgrades to the utility connection?**
  Depending on the number of EV charging stations to be installed in the building, the power draw may exceed the building power capacity. This is important to review to ensure that all costs, including upgrading the building service size, are considered. If an upgrade is required, further discussion with the local utility (e.g., Epcor or ENMAX).

- **Whose approval is required for the installation of the EV charger(s)?**
  Make sure that all responsible parties are consulted prior to completing the work. This should include, at a minimum, the property owners and the City and may include management, tenants, or building operators.

Additional Considerations for Condominiums

Additional considerations for condominiums include:

- **Are the building's parking spaces assigned or titled?**
  Assigned parking spaces allow the building management or condo board to switch parking spaces such that EV charging infrastructure can be completed on the most cost-effective spaces first. For titled parking spaces, the process is more complicated and would need to be handled by the owners of the respective parking spaces.

- **Are there any procedures in place for EV charger installations at the condominium?**
  If no procedures exist, it is recommended that the condominium board work on developing a process by which EV chargers can be installed. This will significantly reduce time and effort for all parties when there is a clear set of guidelines outlining expectations for all parties.

- **How are installation and operating costs to be assigned? Are the electricity charges included as part of existing condo fees or not?**
  An agreement should be reached for how the costs for the installation and future electricity costs will be allocated. It is common for the installation costs to be covered by the individual requesting the EV charger installation. Depending on the location of the installation, permission from other unit owners may be required to run the power supply from the electrical room to the parking space. While most EV chargers can measure the

power used by the charger, current regulations by Measurement Canada does not allow for charges to be based on electricity usage without a certified meter. It is recommended either an agreed-upon flat rate per month or per minute charge (as measured by the charger) be used. A typical electric vehicle will use roughly $20 to $40 of electricity per month.

- **Was the request for an EV charger by the unit owner or the tenant/renter?**
  If the request is from a tenant/renter, it is important to ensure the unit owner or the authorized representative approves of the installation and has an arrangement for the allocation of costs for the installation and operation of the EV charger.

The installation of an EV charger may require electrical work, which is to be completed by a qualified and licensed professional. EV owners should consult with qualified professionals to confirm specific installation requirements for safe operation and compliance with governing regulations. The steps listed below provide guidance for installing an EV charger at a multi-unit residential or commercial building.

Step 1: Identify the location where the EV charger(s) will be installed. Consider aspects such as ease of access, indoor versus outdoor, and access or proximity to the electrical room.

Step 2: Determine the minimum size of your EV charger(s) and the minimum requirements for electrical power draw for the EV chargers. For assistance in determining the required charger size for your current or future EV based on your typical driving behaviour, refer to the tables below. **Note:** These tables are a design aid that can help estimate daily charging requirements and the needed charger size to meet the charging requirement.

Step 3: Identify the electrical source for the EV charger(s). If the building is EV ready, existing 240 V electrical outlets will be available at or near the parking space where the charger(s) will be installed. In a retrofit situation, power will need to be brought to each charger being installed. It is recommended that a 240 V electrical be installed at the parking space rather than directly wiring the EV charger in the event the charger is to be removed or replaced in the future.

Step 4: Confirm the electrical source has either an appropriate amperage/current rating or that there is sufficient spare capacity in the breaker panel to accommodate the EV charger. If yes, proceed to Step 5, if no, consultation with a qualified professional will be required to review the EV charger installation. This may require upgrades to your breaker panel, consultation with the utility, and installation of new utility equipment.

Step 5: Install the charger(s) as per the manufacturer installation requirements; typically, home EV chargers are wall mounted.

Step 6: Connect the EV charger(s) to the electrical supply

Step 7: Setup the EV charger(s) and/or the EVEMS as per the manufacturer installation or operation manual. **Note:** Consideration should be given to have the EV charger start time after 8:00 pm to minimize impacts on the electrical system.

Charging Load Calculation per Vehicle

Item	Typical Value	Actual Value	Calculation
Daily Commute [km/day]	50.0		a
Electric Vehicle Fuel Consumption [kWh/100 km]*	19.9		b
Fuel Consumption Contingency	1.20		c
Required Daily Charge [kWh/day]	**11.9**		$d = a * \frac{b}{100} * c$

*To Convert Gasoline Litres Equivalent to kWh, multiply by 8.9; i.e. 1 L_e/100 km = 8.9 kWh/100 km.

Charger Sizing

Building Voltage [V]	240		h
Required Daily Charge [kWh/day]	11.9		d
Typical duration car parked at home per day [hr/day]**	8.0		e
Required Charger Size (Power Rating) [kW]	**1.5**		$f = \frac{d}{e}$
Required Charger Current Rating (Amperage) [A]†	**6.2**		$g = f * \frac{1000}{h}$

**Time vehicle parked while the charger is available, for example from 7:00 pm after work until 6:00 am in the morning

†Typical Level 2 EV Chargers are 240 V and available in the following amperages: 12 A, 16 A, 20 A, 32 A, and 40 A

Minimum charge requirements for Installation

Required Daily Charge [kWh/day]	11.9		d
Number of EVs/EV chargers installed	10		i
Required Daily Charge for the building [kWh/day]	**119**		$j = d * i$
Required Charger Current Rating (Amperage) [A]‡	**62**		$k = j * \frac{1000}{h}$

‡An electric vehicle energy management system (EVEMS) can be used to limit the current for the total number of EV chargers connected to it. For example, if 10 EV Chargers rated at 40 A were selected, the total amperage rating required would be up to 400 A, while an EVEMS could be used to limit the charger load to 100 A, which would exceed the required current rating of 62 A.

9 Recommendations

The recommendations outlined in this section are made by ICF to The City of Calgary and the City of Edmonton. These reflect the leading strategies for EV related policies and stakeholder feedback from consultations sessions organized under this study. The recommendations will focus on actionable measures that The City of Calgary and the City of Edmonton can directly undertake in order to encourage and aid in the availability of EV chargers for current or future EV owners.

The recommendations reflect the most appropriate technical approach in order to facilitate and accelerate EV adoption. Further stakeholder consultation, to be determined by the respective Cities, may be required in order to implement and/or refine these recommendations.

There are a variety of strategies that have been implemented in order to proactively prepare building developments for increased EV ownership rates and demands for accessible charging systems. The most beneficial deployments of EV chargers require that:

1. The charger can be readily accessed when they need to charge their vehicle; and
2. That the available power levels and energy volumes can readily charge the EV to meet daily charge requirements.

For many EV owners, the obvious location to charge their vehicle is at home or work, and as such, it is important to have policies, bylaws, guidelines, or strategies in place to help ensure that the process for installing an EV charger is as simple as possible. The easiest and least expensive[xxxviii] process is to install an EV charger is during construction, but with the current low rates of EV adoption in Alberta, the near-term demand for EV charging infrastructure is low.

9.1 EV Charging Requirements Background

Before delving into the recommendations, it may be helpful to look at the potential EV charging requirement for an average EV owner in Alberta. The daily commute of an EV owner combined with available time to charge the vehicle forms the key consideration in determining the charging requirements. This includes evaluating how much energy an EV will utilize on a typical day and how long the vehicle is plugged in. The plugged-in period sets the required power rate needed to charge the vehicle. For example, the typical Alberta driver travels 15,000 km per year, an average of 42 km per day, the vehicle can be charged overnight while parking at home (assumed to be a maximum of 12 hours per night) [175].

In order to provide some perspective on the adequacy of commonly available chargers, the charging time for various vehicle types has been estimated using the currently available EV consumption data from NRCan's *2019 Fuel Consumption Guide.* It is presented in **Table 7** and **Table 8**. The power consumption levels provided are based on vehicle type and use the most efficient (minimum power consumption) and least efficient (maximum power consumption)

[xxxviii] Least expensive would refer to the nominal price (actual amount paid) of the installation. The real price (is the time adjusted price taking into account future inflation rates) may be less depending on a number of factors including the building type, number of installations, the retrofit installation process, the time between construction and the installation, and the discount rate used.

electric vehicle for each vehicle class (car, van, pickup, or SUV). The estimated charging times do not account for efficiency losses due to weather, temperature, or variations in real-world driving behaviour compared to test environments, which would increase vehicle power consumption and thus increase estimated charging times. In addition, since battery-electric pickups and vans are not commercially available at this time, the potential power consumption rates are estimated relative to their ICE model fuel consumption rates. Lastly, the estimated charging times do not account for thermal management systems used for battery charging that may extend the charging times in order to preserve the vehicle battery life.

The estimated charging time for two common Level 2 chargers sizes (30 A, 7.2 kW and 40 A, 9.6 kW) suggest that these chargers are capable of meeting the minimum charge requirements over a 12 hour period for a daily commute of 200 km which is well above the average distance travelled by Albertans. This estimation, in conjunction with the findings presented in the jurisdictional scan and the inputs received in the stakeholder engagement sessions, forms the basis of the recommendations outlined in the following parts of this report.

Table 7: Estimated daily charging times for various daily commutes for a Level 2, 30 A, 7.2 kW charger [176]

Vehicle Type	Power Consumption Min/Max [kWh/100 km]	Min/Max charge time for various travel distances using a Level 2 Charger (7.2 kW, 30 A at 240 V) [hr]						
		25 km	50 km†	75 km	100 km	150 km	200 km	500 km
Car	13.7/22.6	0.5/0.8	**1.0/1.6**	1.4/2.4	1.9/3.1	2.9/4.7	3.8/6.3	9.5/15.7
Van*	17.6/29.0	0.6/1.0	**1.2/2.0**	1.8/3.0	2.4/4.0	3.7/6.0	4.9/8.1	12.2/20.1
Pickup*	26.6/36.7	0.9/1.3	**1.8/2.5**	2.8/3.8	3.7/5.1	5.5/7.6	7.4/10.2	18.5/25.5
SUV	16.2/28.0	0.6/1.0	**1.1/1.9**	1.7/2.9	2.3/3.9	3.4/5.8	4.5/7.8	11.3/19.4

*Estimated consumption values, not models were listed in NRCan's 2019 Fuel Efficiency Summary
†Typical daily commuting distance in Alberta

Table 8: Estimated daily charging times for various daily commutes for a Level 2, 40 A, 9.6 kW charger [176]

Vehicle Type	Consumption Min/Max [kWh/100 km]	Min/Max charge time for various travel distances using a Level 2 Charger (9.6 kW, 40 A at 240 V) [hr]						
		25 km	50 km†	75 km	100 km	150 km	200 km	500 km
Car	13.7/22.6	0.4/0.6	**0.7/1.2**	1.1/1.8	1.4/2.4	2.1/3.5	2.9/4.7	7.1/11.8
Van*	17.6/29.0	0.5/0.8	**0.9/1.5**	1.4/2.3	1.8/3.0	2.7/4.5	3.7/6.0	9.2/15.1
Pickup*	26.6/36.7	0.7/1.0	**1.4/1.9**	2.1/2.9	2.8/3.8	4.2/5.7	5.5/7.6	13.9/19.1
SUV	16.2/28.0	0.4/0.7	**0.8/1.5**	1.3/2.2	1.7/2.9	2.5/4.4	3.4/5.8	8.4/14.6

*Estimated consumption values, not models were listed in NRCan's 2019 Fuel Efficiency Summary
†Typical daily commuting distance in Alberta

9.2 Recommendations for EV Education

The stakeholder engagement sessions provided some excellent insight into the challenges and opportunities for EV adoption and EV charging infrastructure in homes and workplaces, but an overarching theme that the sessions identified is that there is a lack of familiarity with EVs and EV charging. As is the case with any new technology, education and awareness initiatives are needed to overcome the initial barriers in market acceptance of EVs. The educational initiatives will be critical to help stakeholders better understand not only the benefits of EVs but also the importance of clear and well-constructed procedures, guidelines, and regulations that will help in the installation of EV chargers at homes and workplaces. Fraser Basin Council's website for Plug In BC is a strong example of what type of information and resources that can be provided to City residents. Plug In BC includes information on regional incentives, EV educational material, EV charging materials, relevant policy, and information on the location of EV charging stations [177].

In addition, it is also important to educate consumers on the potential impacts of EV charging on the electrical system and how they can work with the utility to improve the reliability of their EV charger as well as to ensure reduced costs for both installation and electrical use. This can be achieved by the development of educational material on a variety of pertinent topics such as benefits of energy management systems, smart or networked chargers, adjusted charging schedules, off-peak charging, and potential opportunities for bi-directional power sales. It is recommended that EV Education and awareness initiatives be undertaken at both provincial and municipal levels to support EV adoption in Alberta.

Additional education package should be prepared for City inspection staff that highlights what the requirements for EV charging installations as well as the requirements for parkades or parking areas that EVs would be located are. This includes educational material highlighting that EVs do not add to the ventilation requirements for existing or new parking facilities. It is recommended a quick fact sheet or webpage summarizing the findings in **Part 3.1.2.4** and **Part 3.1.3.1** be generated by the City. This should highlight relevant codes and standards, and highlight that the existing Alberta Building Code ventilation requirements far exceed the ventilation requirements for existing EV battery technology or the equivalent battery capacity in technologies with higher ventilation requirements such as lead-acid batteries.

9.3 Recommendations for Municipal Policy

The municipal policy recommendations are based on the best practices and strategies identified by ICF through our jurisdictional scan and the feedback received during the stakeholder engagement sessions. The recommendations below have been prioritized based on ease of implementation, cost implication, impact on the EV sector, and timeliness.

1. Permitting
2. EVSE Requirements for Municipal Buildings
3. EV Advocacy
4. EVSE Parking requirements for Multi-Unit Residential Buildings
5. EVSE Ampacity limits
6. EVSE Parking requirements for Workplace and/or Commercial Buildings
7. EVSE Parking requirements for Single-family Residential

9.3.1 Permitting

For the installation of EV Chargers at locations where an electrical outlet is not available, permitting should be a requirement, and it is recommended that this is clearly and explicitly outlined on the City Permitting webpage. EV chargers can have impacts on electrical reliability beyond the home, and as such, a permit is an effective means of ensuring that EV chargers are installed properly and are effectively integrated with the electrical grid.

Voluntary registration or notification of Level 2 or higher EV chargers with the City should be considered, as EV ready locations would not require a permit for the installation. Considerations would be required for incentives[xxxix] to encourage residents to register or notify the City that they installed an EV charger. This is likely to be of increased importance when EV adoption rates escalate, and some/more building developers begin to include EV charging provisions in their buildings.

Additionally, the City of Calgary and the City of Edmonton should set internal targets for the turn-around time for approval and review of EV charging permit applications for single-family residential homes, multi-unit residential, and commercial properties. Example programs are those such as Los Angeles' City's Express Permit, which allows applicants to receive permits automatically online and use their EVSE immediately after the inspection, see **Part 3.3.5.**

9.3.2 EVSE Requirements for Municipal Buildings

It is important for the City of Calgary and the City of Edmonton to lead by example for the deployment of EVSE infrastructure. It is recommended that the Cities consider updating their standards for newly constructed or heavily renovated municipally-owned buildings required at least 10% of the parking spaces be EV Ready and 5% of the parking spaces be equipped with EV chargers[xl]. It is also recommended that the Cities consider retrofits to existing buildings to have at least two EV charging parking spots available for use by employees.

9.3.3 Public EV Charging Station Target

The Cities of Calgary and Edmonton should review current targets for publicly accessible electric vehicle charging stations and update the targets as needed to reflect current growth projections for Alberta. Such a review should also consider the potential demand for community charging hubs and identify optimal locations for such hubs if appropriate.

9.3.4 EVSE Ampacity

While it may not be directly under the municipal purview, but considerations should be given for limiting the ampacity of home and workplace chargers to less than 40 A. As highlighted by the utilities and EVSE manufacturers during the stakeholder consultation sessions and also

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[xxxix] During the research for this report, no examples for voluntary registration of EV chargers were identified.

[xl] The City of Calgary as part of its *Sustainable Building Guidance Document Part B: Minimum Sustainability Performance Requirements* (April 29, 2019) outlines on page 10 Section "Future Resiliency Planning" a requirement for 10% of parking spaces in municipal buildings to be EV Capable.

presented in the beginning of this chapter, a 40 A charger is capable of meeting the typical charging requirements.

For single-family residential homes, it is recommended to provide some flexibility in the proposed charger ampacity limit whereby a requirement based on the size of the panel and local transformer can be considered. For example, the maximum charger ampacity may be limited to the lesser of 40% of the panel ampacity or the calculated limited at per the Canadian Electrical Code (CEC) Code requirements.

For MURB, it is recommended that the size of the charger be limited to 40 A as well, and the use of an EVEMS is to be encouraged in order to limit the power draw of the building, thereby limiting the infrastructure requirements and utility demand charges to the residents.

Stakeholder inputs identified that in British Columbia, a common technique was to install a separate utility meter for the main building energy use and for EV charging. ICF recommends against this practice, as the introduction of the second meter limits the effectiveness of the EVEMS to not only factor EV charging but also the overall power draw of the building. Having both systems on the same meter can help ensure that the power demand for the building experiences minimal or no impact from EV charging, thus eliminating or reducing additional utility charges to EV owners. This can also help ensure that the building is designed with reduced infrastructure, thereby reducing the cost of the unit and utility bills for all residents.

For single-family homes, the use of energy management equipment can be utilized to ensure that the home's power demands are regulated. Low cost and non-technical solutions are also available to control or shift the EV charging load. For example, as part of the permitting process, the City should work with the electrical contractor to adjust the time for which an EV charger is set to start charging and either randomly or strategically assigning charging start times for each charger. For example, charging start times could be in 15-minute intervals from 7:00 pm to 9:00 pm, which would essentially create an artificial load shifting effect for EV charging. While this solution may be easy to implement, while it would not stop the charger owners from changing these settings in the future, but it is expected that the number of users that actually change the settings will be limited.

Partnering with utilities may provide additional opportunities to evaluate the possibilities for smart charger programs or other alternatives that could help facilitate load shifting such that EV charging can support the grid instead of encumbering it.

9.3.5 EVSE Requirements for Single-family Residential Buildings

The cost for retrofit installations in single-family residential buildings is typically lower than for that in MURBs, and as such, it is not recommended that a requirement in single-family residential buildings be pursued at this time. Encouraging EVSE deployment in single-family homes is advisable, and partnering with key developers to have them as early developers constructing demonstration units can help to have a more organic deployment for these building types. While single-family developers should be encouraged to develop homes that are EV ready, it is expected to be cheaper in the near term to delay the initial expense for all single-family home buyers and to pay for the installation of EV charging infrastructure when and as needed.

9.3.6 EVSE Requirements for Multi-Unit Residential Parking

Changes to the building code are typically not under the municipal purview in Canada, but the authority to modify the requirements for residential and commercial parking through the Land Use Bylaw does lie with the municipalities. Simplifying the process for EV charger installation is expected to support EV adoption. It is important to note that not all multi-unit residential buildings are the same in their operation and therefore face different challenges in the installation of EV infrastructure. Apartment buildings are more closely related to commercial buildings and present fewer challenges in order to complete retrofit installations of EV charging infrastructure as compared to condominiums, in particular, those with titled parking spaces, which are amongst the most challenging in this regard.

For new construction and heavy retrofits[xli] condominiums, it is recommended that the Cities should require 100% EV ready residential parking (excluding visitor parking). Several other markets have tried various other strategies for EV parking requirements in the residential sector, but the example set in the City of Richmond is amongst the most encompassing to ensure future-proofing of building developments and minimizing increased costs for future installations of the EVSE. From the feedback we received from the City of Richmond and the City of Vancouver, the lower thresholds (less than 100%) did not result in developers voluntarily installing more EV chargers or EV ready spaces and did not mitigate the need for large retrofits in the near future to accommodate the growing demand for EV chargers.

In regions that have set lower standards, the common practice for developers (has been to install chargers as per the minimum requirements which does not remove the need for future work and retrofits while also subsidizing the costs for the early adopters at the expense of future EV owners. The difference in retrofit costs in a building with 20% EV ready parking versus no EV ready parking is negligible on a per parking space basis.

For apartment buildings, it is recommended that new buildings be required to have 10% of residential parking spaces (excluding visitor parking) to be EV ready and the remaining 90% of parking spaces meet the partial infrastructure – high (EV capable) requirement. This would require 10% of the parking spaces to have energized electrical outlets at the parking spaces capable of supporting Level 2 charging (up to 40 A) with or without the use of an EVEMS. In addition, this requirement would require the electrical equipment such as distribution panels, and circuit breakers, to be in place for 100% of the residential parking spaces but does not require conduit or cabling from the electrical room to parking area or space for the remaining 90%. The building electrical service would be required to have sufficient electrical capacity to support and install a Level 2 charging (up to 40 A) per parking space with or without the use of an EVEMS and all wall, floor and/or ceiling penetrations are to be in place.[xlii] The wall, floor, and/or ceiling penetrations are completed such that future conduit and/or cabling can be installed to make all non-visitor parking spaces EV ready.

A core intention of this requirement is to limit the lifetime cost of ownership for EV owners that reside in MURBs and to limit future conflicts and challenges for retrofit EV charger installations. There are several core assumptions built into this recommendation that are primarily around the

[xli] Major renovation will need to be defined by the City, but the intention here is to include buildings that are undergoing a significant change in the building use and/or design whereby the internal structure is significantly altered or rebuilt.

[xlii] The use of an EVEMS system is highly recommended as it can greatly reduce the magnitude of the electrical service required for EV charging, but the decision can be left to the developer not to incorporate the use of EVEMS into their design.

comparison of a new residential building with 100% EV Ready parking stalls with a retrofitting case for those same buildings later. These assumptions are:

1. EV adoption will continue in Alberta, and there will be an increased demand for EV ready properties within the next 10 years;
2. The costs for EVSE retrofit installations will be staged—i.e., not all the retrofit installations will be installed at once resulting in higher per-unit costs for the charging infrastructure for the retro-fit installation;
3. EV owners would gravitate toward buildings that have already installed EV chargers over those that have not—i.e.; retrofit installations will concentrate in select buildings rather than being evenly distributed;
4. The development of new properties, and by extension, availability of new EV Ready parking spots, will be lower than the expected demand for EV charger spaces in the City of Calgary and the City of Edmonton.

Based on the assumptions outlined above, over the lifetime of the property, a 100% EV Ready requirement in MURBs will:

1. Reduce the cost barriers for the installation of EVSE equipment.
2. Reduce the timeframe in which residents or owners can have EV chargers installed.
3. Reduce efforts of Condo boards and/or property managers.

As will be discussed in **Part 9.4**, this recommendation should be pursued in parallel with programs and strategies to help mitigate upfront costs borne by developers. This may also include work with utilities to develop the building and metering requirements together such that the cost of implementation can be minimized.

9.3.7 EVSE Requirements for Workplace and/or Commercial Buildings

The requirements for workplace and/or commercial charger installations will be heavily dependent on the determined strategic direction for EV charging established by the Cities of Calgary and Edmonton, as well as the utilities operating in each respective city. Increasing the availability of workplace EV chargers can reduce the need for home charging and alleviate the impacts of residential charging on existing electrical infrastructure. Commercial buildings vary greatly in their locations, building use and occupancy, and construction. Hence, considerations should be given to treat various building types differently. The zoning changes proposed in the District of Saanich (see **Part 3.2.3**), are amongst some of the most robust EVSE requirements that were identified as part of the jurisdictional scan, and provide requirements for various building types. The primary focus of the recommendations listed below is for high rise buildings (e.g., office towers with or without residential units) and all commercial buildings such as retail shopping centres, low-rise office buildings, and recreation centres.

ICF recommends that the City of Calgary and the City of Edmonton consider making the workplace charging a key component of their EV infrastructure strategies. While increased EV adoption will likely result in an increased demand for EV charging at workplaces, it is recommended that the individual building owners or operators be provided with the flexibility to deploy the EV charging infrastructure in their buildings when demand grows. As such it is recommended that 100% of parking spaces in new commercial buildings (outside the downtown core) be required to meet at least the low partial infrastructure requirement; i.e., electrical equipment or cabling/conduits do not need to be in place, but all wall, floor and/or ceiling penetrations need to be completed, and the electrical room must have sufficient space for future electrical equipment. The building service must have sufficient capacity to support and install a Level 2 (up to 40 A) charger per parking space with or without the use of an electric vehicle energy management system (EVEMS).[xliii]

For new commercial buildings in the downtown core, in particular, high rises or commercial developments, it is recommended that enhanced requirements be made mandatory to help facilitate EV adoption by making charging capacity more accessible. In alignment with the recommendations for municipal buildings, it is recommended that workplace and/or commercial buildings in the downtown core be required to have a minimum of 10% of all parking stalls that are Level 2 EV ready and the remaining 90% of spaces have considerations in place for future EV charging (partial infrastructure – low).

For new mixed-use buildings (commercial and residential), 100%residential parking spaces should be required to be Level 2 EV ready. These requirements are in line with similar requirements set in the City of Vancouver and less than the 20% requirements set in the City of Richmond, the City of Surrey and the City of Port Moody. As part of this requirement, the City of Calgary and the City of Edmonton are encouraged to purse pilot projects whereby Level 2 EV chargers are installed and available for use by building occupants or visitors.

9.3.8 EV Advocacy

The changes to governing rules and regulations needed to push EV adoption and deployment of charging infrastructure may not be fully under the municipal purview and would require support from Provincial or Federal agencies or Governments.

- Changes to the building code to set minimum requirements for EV infrastructure to match or exceed the recommendations of this report. This will establish common requirements across the Province and can help increase developers' and contractors' experience and understanding of EV infrastructure and best practices for installations.
- Changes to the requirements of Measurement Canada to allow for the sale of electricity by the kWh for EV charging. This would greatly enable MURBs to more easily attributed electricity costs to EV owners without the need for certified metering equipment and the associate operational costs.
- Changes to the Alberta Condominium Property Act to allow for titled parking spaces to be more readily transferred between condominium owners. The primary goals are to reduce the complexity of the transfer and prevent events that may result in taxable transactions on the sale of the parking space from one owner to the other.

It is thus vital that The City of Calgary and the City of Edmonton collaborate with other major municipalities in the Province and in Canada as a whole to advocate for such changes to

[xliii] The use of an EVEMS system is highly recommended as it can greatly reduce the magnitude of the electrical service required for EV charging, but the decision can be left to the developer not to incorporate the use of EVEMS into their design.

governing rules and regulations that will improve and simplify EV ownership and charger deployment, especially at homes and workplaces.

9.4 Recommendations for Financial Support of EVSE

The stakeholder engagement sessions, especially those held with building and land developers, underscored that the real estate market participants are not willing to absorb the increase in new home costs that would be incurred to ensure that those are EV Ready. There will be challenges in ensuring that costs are equitably distributed as any action or inaction by the Cities will result in a redistribution of EVSE deployment cost allocation. For example, not supporting EVSE installations in new construction can lead to high costs for retrofit installations (2 to 4 times the new installation costs), but the cost-benefit is dependent on the future need for EVSE infrastructure.

While the recommendations for financial support are based on the practises adopted in other jurisdictions and stakeholder feedback received during this study, it should be noted that the economic position of the Cities will greatly impact the financial role that can be played in order to facilitate and support EV charging infrastructure. The financial support paths identified below outline ICF’s recommendations on actions that can be taken by the City but where applicable external funding or strategic partnerships may be required.

Suggested priorities for financial support of EVSE or EV Ready installations are:

1. Building development offsets—provide low to no financial burden to the municipality or developer.
2. Utility Partnerships— provide low costs solutions for the municipality and opportunity for the utility to control EVSE deployment and expand service revenue.
3. Property Assessed Loans—require the initial capital to be made available by the municipality, but a well-designed loan program can be self-sustaining or have minimal realized costs for the municipality.
4. Incentive Programs—limit financial burden for developers and encourage deployment of EV charging infrastructure. Upfront capital costs and reliable funding (internal or external) would be required.

9.4.1 Building development offsets

In addition to directly funding or offsetting the financial costs of the EVSE installations, another strategy that is recommended is working with developers to identify offsets to building requirements if they are to construct buildings that support EV charging. This could include reducing the number of visitor parking spaces required in the building; e.g., an EV Ready parking space is considered equivalent to 1.5 parking spaces, and EV parking spaces can reduce the required number of visitor parking spaces by no more than 50%.

Considerations for other portions of the building requirements can and should be evaluated with developers, which could include some more unique solutions such as the number of visitor parking spaces (allow them to sell more spaces to tenants directly). Further consultation between developers and City staff would be required to identify any solutions that would work best for both parties.

9.4.2 Utility Partnerships

Utility partnerships can include developing programs offering charger rebates or leasing options for smart chargers, networked chargers, or load management equipment. For example, Green Mountain Power[xliv] has demonstrated the viability of market opportunities in which a utility can be provided with some level of control over non-essential loads (battery backup systems) through the provision of financial incentives. Similarly, ENMAX is currently implementing a pilot program in which it is offering discounts on EV chargers in exchange for homeowner data pertaining to how the EV charger is used and how it impacts the electricity demand for the residence [178]. While this project is small, it demonstrates an early indication that market demand exists for utility subsidized and controlled electrical equipment, although the actual size of this market has not been proven on a large scale. Depending on the market response to such initiatives, it is possible that enough level of voluntary signups could mitigate the need for significant capital investments to upgrade electrical infrastructure. By gaining control of non-essential loads, utilities can more effectively utilize their distribution assets and avoid the need for upgrades to meet short-duration demand peaks from EV charging.

Strategic partnerships will be required with utilities in order to ensure that measures and considerations are put in place to enable a proactive response to EV charging. Our initial discussions with the AUC identified that EV charging was a lower point of concern as they considered the impacts from EV charger were likely to be a longer-term issue that did not need to be currently addressed. However, with a large number of EV options that are now available, which are increasingly competitive with the equivalent ICE models, it can be reasoned that the EV adoption curve in Alberta could be faster than it has been other jurisdictions. That is to say, while it may have taken a certain number of years to reach significant levels of EV adoption in other jurisdictions (e.g., 10% of new vehicle sales), but the progress in the current EV market could result in similar adoption levels in Alberta in much less time. It is, therefore, important for the Cities to work with utilities to consider different EV adoption scenarios and plan to pre-emptively modify regulations so that the transition to EVs would have minimal impacts on the operation and reliability of the electrical grid.

9.4.3 Property Assessed EVSE Loans

Developing funding programs similar to the Property Assessed Clean Energy (PACE) loan might be an effective strategy for the Cities to cover the upfront cost of EV charging infrastructure at homes and workplaces and have it paid back through property taxes over an extended period of time. This may prove particularly useful for condos or other MURBs where the retrofit costs are prohibitively expensive, and an argument can be made by the Cities to finance the investment to avoid increased re-work and costs in the future.

As of November 2019, Energy Efficiency Alberta (EEA) has two financing programs, the Green Loan Guarantee Program and Clean Energy Improvement (CEI) Program. The Green Loan Guarantee program is a loan enhancement program where EEA will guarantee 50% of the loan principal and interest amount and thus lowers the risk profile associated with the loan. The CEI Program is an Alberta based PACE program with the terms expected to be released in 2020. Similar programs could be undertaken by The City of Calgary or the City of Edmonton, such that

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[xliv] Green Mountain Power is offering a battery leasing or incentives for personal battery backup systems to be utilized by the utility for peak load power demand on the grid. Expectation of events occurring 5-8 times per month for 3-6 hours at a time. https://greenmountainpower.com/bring-your-own-device/battery-systems/

partnerships are made with financial institutions to provide long-term loans to property owners that could distribute the initial capital investment of EV chargers between the financial institution and the property owner. It would be recommended that the loan repayment be linked to the property taxes of the building, providing an easy way for the loan to be collected and transferred in the event of a change in ownership for the property.

Unlike incentive programs, the property assessed loans result in minimal or zero costs (depending on whether the loans are interests free or not) to the municipality as the capital loan is paid back over a period of time by the property owner through their property taxes. In this regard, homeowners buying the EV ready properties would be the primary ones benefitting from the financing programs. The loan also ensures that the upfront costs of EV ready properties are minimal or zero, and the loan is easily transferable along with the title of the property in the event of resale.

9.4.4 Rebate or Incentive Programs

Rebate programs can directly impact EVSE deployment and should be considered as part of the EV strategy (the financial portion of this recommendation is discussed in **Part 9.4**). As established with energy efficiency programs across North America, an incentive program is an effective way to encourage technology adoptions without requiring modifications or changes to existing codes, standards, or regulations. Further, the programs can be more readily changed, scaled up or down, and can be structured to finite operational budgets or timelines.

A consistent concern highlighted developers in the stakeholder consultation sessions was the increases in costs associated with the EV Ready or EV equipped properties, and the introduction of an incentive program would be an effective way to reduce the financial impacts on developers. In addition, an incentive program enables the municipality to influence the decisions as to what chargers are installed; this could include caps on charger ampacity, requirements for smart or networked chargers, time of use settings within the charger or vehicle software, or the use of EVEMS for multi-charger installations.

Appendix A - Sample Documents

NOTE: The term Strata as used below, is synonymous with condominium; in BC, a strata property also includes townhouses.

SAMPLE Electric Vehicle Charging Bylaw for Charging for Common Property stalls [179]

The information contained in this document about strata housing is provided for the user's convenience as a basic starting point; it is not a substitute for getting legal advice. The content of this document is periodically reviewed and updated as per the date noted on each page: July 21, 2016.

For more resources, please visit the following links:

- ***Options for getting legal advice***
- ***Amending Strata Bylaws***
- ***Placing a Resolution at a General Meeting***

STRATA PLAN [Number – Name] ELECTRIC VEHICLES BYLAW

WHEREAS:

A. The Owners, Strata Plan [Number] (the "Strata Corporation") proposes to acquire and install electrical supply, distribution and associated electrical outlets, signage, and pavement markings (the "Charging Equipment") on common property to allow owners, tenants, and occupants to charge electric vehicles on the common property;

B. [X Number] of stalls located on common property (the "EV Charging Stalls") have been identified by the Strata Council [through consultation with an experienced electric vehicle supply equipment (EVSE) installer] as optimal for conversion to electric vehicle charging stalls due to [insert rationale for stall selection here – for example, access by occupants, proximity to electrical panel, visibility and cost considerations].

BE IT RESOLVED by a ¾ Vote that:

Acquisition and Installation

1. The Strata Corporation purchase the Charging Equipment and install it in the EV Charging Stalls.
2. The purchase of the Charging Equipment is approved in accordance with Section 82 of the Strata Property Act.
3. The Strata Corporation applies up to [$__] from its Contingency Reserve Fund for the purpose of paying for the purchase and installation of the Charging Equipment.

4. The Strata Council take all such steps as are required to retain a contractor to install the Charging Equipment, and any two members of the Strata Council are authorized to sign all agreements as are required.
5. To the extent that the installation of the Charging Equipment and use of the EV Charging Stalls in accordance with this Resolution constitutes a significant change to the use or appearance of the common property, such change is approved in accordance with Section 71 of the Strata Property Act.

Amendment to Bylaws

6. The bylaws of the Strata Corporation be amended to add the following as Bylaw [Number]:
    - *a. An owner, occupant, or tenant (the "EV User") who proposes to use a common property parking stall with electric vehicle charging capability (the "EV Stall") will apply to the Strata Council for written consent;*
    - *b. The Strata Council will grant consent to an EV User to use an EV Stall provided that:*
        - *i. The EV User signs a User Agreement on terms agreeable to the Strata Corporation;*
        - *ii. The EV User at all times complies with the bylaws of the Strata Corporation; and*
        - *iii. The EV User pays the Strata Corporation a user fee in accordance with these bylaws;*
    - *c. The Strata Corporation will charge to each EV User a user fee in the amount of [$_];*
    - *d. No owner, occupant or tenant will use or will permit any person to use an EV Stall except with written consent from the Strata Corporation in accordance with these bylaws; and*
    - *e. No EV User will park a vehicle in an EV Stall for any period greater than 4 consecutive hours or 4 hours in any given 12 hour period.*
7. The Strata Council of the Strata Corporation (the "Strata Council") take all such further actions as are required to register the amendments set out in this Resolution (the "Amendments") with the Land Title Office, including but not limited to filing a Form I, Amendment to Bylaws.
8. Any two members of the Strata Council execute such documents as are required to register the Amendments in the Land Title Office on behalf of the Strata Corporation.

SAMPLE Electric Vehicle Charging Bylaw for Charging in Exclusive Stalls [180]

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- ***Placing a Resolution at a General Meeting***

STRATA PLAN [Number –

Name] ELECTRIC VEHICLES

BYLAW

PREAMBLE: The Owners, Strata Plan [Number] (the "Strata Corporation") proposes to amend its bylaws to allow for the use and charging of electric vehicles by owners, occupants, and tenants who own electric vehicles.

BE IT RESOLVED by a ¾ Vote that:

The bylaws of the Strata Corporation be amended to add the following as Bylaw [Number]:

a. An owner (the "EV Owner") who has the exclusive use of a parking stall (the "EV Parking Stall") may request written consent from the Strata Council to install electrical supply, distribution and an associated electrical outlet accessible to the EV Parking Stall for the purpose of charging an electric vehicle in the EV Parking Stall. In making such request, the EV Owner will provide to the Strata Council a written description of the proposed charging equipment (the "Charging Equipment"), the proposed design and installation, and any other documents or plans requested by the Strata Council;

b. The Strata Council will grant consent pursuant to (a) above provided that:

i. The Strata Council is of the opinion that its existing systems will support the Charging Equipment; and

ii. The EV Owner signs an Alteration and Indemnity Agreement on terms to be determined by the Strata Council, including the following:

1. The EV Owner will pay for all costs related to the installation of the Charging Equipment and will pay for the cost of all future repairs, maintenance, and upgrades to the Charging Equipment;

2. The EV Owner will obtain all necessary permits;

3. The EV Owner will comply with all applicable laws;

4. The EV Owner will comply with all bylaws of the Strata Corporation;

5. The EV Owner will retain qualified contractors for the purpose *of installing the Charging Equipment; and*

6. *The EV Owner will indemnify and save harmless the Strata Corporation for any costs, loss or expense of whatever kind which the Strata Corporation may sustain in connection with the installation and use of the Charging Equipment;*

c. *Upon installation of the Charging Equipment:*

   i. *If in the opinion of the Strata Council the Charging Equipment can be removed with minimal damage to the common property, the EV Owner will be the owner of the Charging Equipment, and:*

      1. *may remove the Charging Equipment at any time; and*

      2. *will remove the Charging Equipment upon the sale of the strata lot owned by the EV Owner;*

      provided that the EV Owner will promptly restore any damage to the common property upon such removal of the Charging Equipment, and provided that the Strata Corporation will own the Charging Equipment if the EV Owner does not remove the Charging Equipment in accordance with 2 above;

   ii. *If in the opinion of the Strata Council the Charging Equipment cannot be removed without damaging the common property, the Strata Corporation will be the owner of the Charging Equipment;*

   iii. *Any wiring required for the purpose of the Charging Equipment will be owned and maintained by the Strata Corporation;*

d. *All electricity costs of the Strata Corporation with respect to the Charging Equipment will be dealt with as follows:*

   i. *[determined by direct metering of the power consumed using internal meter available in some charging station models or a dedicated revenue-grade meter]*

   ii. *The Strata Corporation will charge to the EV Owner a user fee in the amount of $[____________________________] on account of the use of electricity with respect to the Charging* Equipment

   iii. *[estimated for each EV owner based on his or her reported annual mileage and using an electricity cost estimate tool provided by the Canadian Automobile Association http://electricvehicles.caa.ca/electric-vehicle-cost-calculator/]*

2. The Strata Council of the Strata Corporation (the "Strata Council") take all such further actions as are required to register the amendments set out in this Resolution (the "Amendments") with the Land Title Office, including but not limited to filing a Form I, Amendment to Bylaws.

3. Any two members of the Strata Council execute such documents as are required to register the Amendments in the Land Title Office on behalf of the Strata Corporation.

4. To the extent that the installation of the Charging Equipment and use of the EV Parking Stall constitutes a significant change to the use or appearance of the common property, such change is approved in accordance with Section 71 of the Strata Property Act.

SAMPLE – User Agreement [181]

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- ***Amending Strata Bylaws***
- ***Placing a Resolution at a General Meeting***

STRATA PLAN [Number] –

[Name] USER AGREEMENT

[DATE]

WHEREAS The Owners, Strata Plan [_________] (the "Strata Corporation") proposes to grant to the undersigned resident(s) of Unit #____(the "User") the right to use the electric vehicle charging equipment (the "Charging Equipment") located in common property parking stalls (the "EV Stalls"), on the terms and conditions set out in this Agreement.

For useful and valuable consideration, the User agrees:

1. To pay the Strata Corporation a user fee of $[________] per month on the 1st day of each and every month, or such other amount as may be approved in a bylaw or in a rule that has been ratified under Section 126 of the Strata Property Act (the "User Fee");
2. To at all times comply with the bylaws of the Strata Corporation;
3. To use the EV Stall in accordance with all applicable laws and regulations;
4. Not to do anything which may cause damage to the EV Stall;
5. To indemnify and save harmless the Strata Corporation for any cost, loss, or damage to the Charging Equipment or the EV Stalls caused by the User;
6. If the User fails to pay the User Fee in accordance with Section 1 above, the Strata Corporation will terminate this Agreement, and the User will immediately cease using the EV Stalls;
7. The User will not permit any person other than the User to use the EV Stalls; and
8. This Agreement is not assignable by the User.

User:____(Resident)

Strata Corporation:____________________________(Agent, on behalf of Strata Plan [Number])

Date: _____________________________

Figure 23 California GO-Biz EVSE Permitting Requirements and Best Practices

	AB 1236 Compliant (EVCS Friendly)	Not AB 1236 Compliant (Challenging to Deploy Charging)
Required by AB 1236	Ordinance creating an expedited, streamlined permitting process for electric vehicle charging stations (EVCS) including level 2 and direct current fast chargers (DCFC) has been adopted	No permit streamlining ordinance; and/or ordinances that create unreasonable barriers to EVCS installation
	Checklist of all requirements needed for expedited review posted on Authority Having Jurisdiction (usually a city or county) website	No checklist for EVCS permitting requirements
	EVCS projects that meet expedited checklist are administratively approved through building or similar non-discretionary permit	Permitting process centered around getting a discretionary use permit first
	EVCS projects reviewed with the focus on health and safety	EVCS projects reviewed for aesthetic considerations in addition to building and electrical review
	AHJ accepts electronic signatures on permit applications*	Wet signatures required on one or more application forms
	EVCS permit approval not subject to approval of an association (as defined in Section 4080 of the Civil Code)	EVCS approval can be conditioned on the approval of a common interest association
	AHJ commits to issuing one complete written correction notice detailing all deficiencies in an incomplete application and any additional information needed to be eligible for expedited permit issuance	New issue areas introduced by AHJ after initial comments are sent to the station developer
Best Practice	Clear EVCS permitting process detailed on AHJ website	Permitting process not explained on AHJ website
	ZEV Infrastructure permitting ombudsperson appointed to help applicants through the entire permitting process	AHJ does not offer access to an expert who can support station developers through the entire permitting process
	Guidance documents for permitting and inspecting charging stations at single family home, multifamily home, workplace, public (L2 and DCFC), and commercial medium and heavy duty posted on AHJ website	Limited or no information online
	Pre-application meetings with knowledgeable AHJ staff are offered	Full permit package needs to be submitted to gain feedback from AHJ staff
	AHJ has published an ordinance or bulletin clarifying that a plug-in electric vehicle charging space counts as one or more parking spaces for zoning purposes	EVCS installation projects trigger a parking count review
	Concurrent reviews are made available for building, electrical (and planning, if deemed necessary)	Sequential permit reviews only
	Planning for ZEVs and supporting infrastructure is incorporated and prioritized within documents such as the general plan, capital improvement plan, climate action plan, and design guidelines	EV charging guidelines are not incorporated into planning documents
	EVCS are classified as an accessory use to a site, not as a traditional fueling station	AHJ considers charging stations as fueling stations, leading to additional zoning review
	AHJ has established/published timelines for EV permit application review that are expedited when compared to standard building permit review timelines in that jurisdiction.	AHJ does not have expedited permitting process for EV applications – resulting in standard project permitting timelines
	AHJ's expedited EV permit review process encourages permit reviewers to conditionally approve permits (aka "approved as noted")	AHJ does not encourage conditional approval of permits

Appendix B - Resolution Text

Whereas the BC Climate Leadership Plan has a stated goal of supporting vehicle charging development for zero-emission vehicles to reduce greenhouse gas emissions, and lack of access to electric vehicle (EV) charging is an impediment to EV uptake;

And whereas a significant and growing proportion of British Columbia residents live in multifamily dwellings, most of which are stratified;

And whereas requirements for approval by a strata corporation under the BC Strata Property Act for the alteration of common property represent a significant barrier to installing and accessing means of charging in stratified buildings:

Therefore be it resolved that the Province of British Columbia amend the BC Strata Property Act, before the end of 2018, such that strata councils and strata corporations must accommodate reasonable requests from residents, for the purpose of electric vehicle charging, to access existing or install new powered outlets and/or electric vehicle charging infrastructure, where the assignment of associated costs are to be determined by the strata council and/or the strata corporation.

Provincial Response

Ministry of Municipal Affairs & Housing

The government is interested in enabling strata residents to access electric vehicle charging in strata properties. At the same time, it is important to recognize the unique nature of each property and the right of strata residents to govern themselves.

A report by the Condominium Home Owners Association of BC highlights both the opportunities and the practical and site-specific challenges of installing electric vehicle charging in existing strata corporations.

http://www.choa.bc.ca/wp-content/uploads/EVCS-Report.pdf

Rather than setting the stage for further conflict over what constitutes a “reasonable request,” ministry staff are working with strata partners and the Ministry of Environment and Climate Change Strategy to identify and remove regulatory barriers to strata corporation approval of installations. Strata property legislation is regularly reviewed and updated to ensure it is meeting the needs of strata corporations and owners.

Appendix C - References

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