Residential Electric Vehicle Charging:

A Guide for Local Governments

BC Hydro Power smart

Richmond

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ABOUT THIS GUIDE

This guide provides local governments and other interested parties with guidance on improving access to “at home” electric vehicle charging in new and existing residential buildings. Though not its primary intent, this guide may also inform efforts to support “at work” and “on the go” charging.

Note: although electric vehicles (EVs) technically include hybrid vehicles that do not plug in, for the purposes of this guide, EVs refers to plug-in electric vehicles only.

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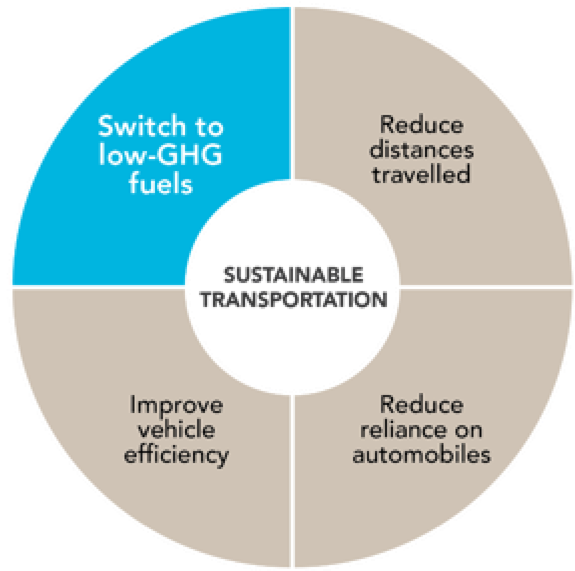
1.0 BACKGROUND

1.1 Electric Vehicles: Part of a Comprehensive Approach to Low-carbon Transportation

Electric vehicles (EVs) are one critical component of a broader, comprehensive sustainable transportation strategy over which local governments have some control. A sustainable transportation system begins with a shift away from single-occupancy vehicles, achieved through compact land use and complete communities connected by high-quality active and public transportation infrastructure. This may be supplemented by car sharing, ride sharing, and ride hailing opportunities to reduce use of privately owned vehicles. Greenhouse gas (GHG) emissions from these shared trips, in addition to remaining single-occupancy trips, can be effectively reduced by the switch to electric vehicles, which supports a low-carbon transportation system.



Reducing trips and distances travelled is critical because even though electric vehicles significantly reduce community GHG emissions, they do not solve other transportation and quality of life challenges such as traffic congestion. Kilometres driven may increase because electric vehicles are more efficient and less costly to fuel: like other energy efficient technologies, they come with a potential "rebound effect."[1] Electric vehicles are best considered, therefore, in the context of a larger sustainable transportation strategy.

Electric vehicles have substantial emissions reduction potential, particularly in British Columbia, where 98% of electricity generation is clean power. *Figure 1* outlines some key benefits of electric vehicles. The electrification of transportation will be an important component to achieve emission reduction targets set by local, provincial, and federal governments alike. As such, many local governments are now including EV policies and actions in their Official Community Plans (OCPs), Community Energy and Emission Plans (CEEPs), and Transportation Plans.

[1] Research from the U.S. EPA notes that the exact amount of rebound at this point is not known and depends on multiple variables (e.g., oil prices, income levels, congestion, urbanization). Rebound effects in recent years have been lower than earlier historical trends. The U.S. EPA concludes that the rebound effect from more fuel efficient vehicles is likely to be moderate and decline with increased income (United States Environmental Protection Agency. 2015. The rebound effect from fuel efficiency standards: measurement and projection to 2035. Office of Transportation and Air Quality, Assessment and Standards Division. EPA-420-R-15-012. https://nepis.epa.gov/Exe/ZyPDF.cgi/P100N11T.PDF?Dockey=P100N11T.PDF)

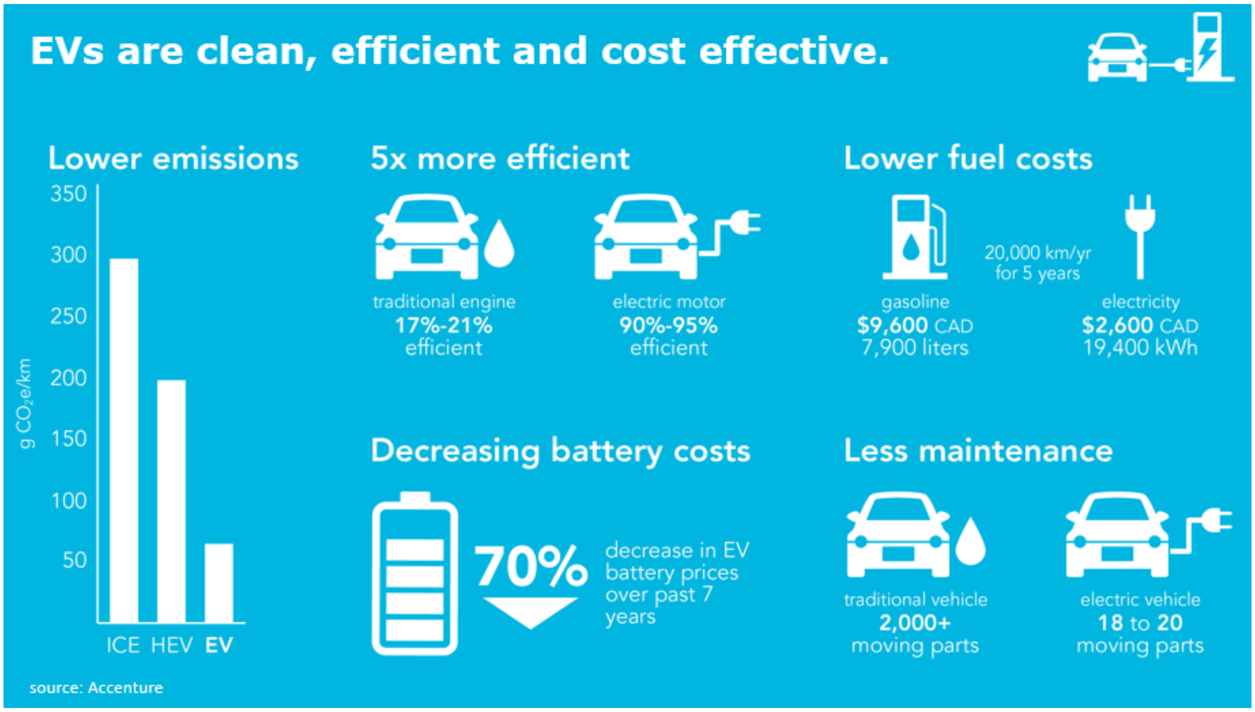


Figure 1: Benefits of electric vehicles.[2]

1.2 Types of Electric Vehicles

Battery electric vehicle (fully electric) (BEV): A BEV relies completely on the electric battery and motor to propel the car. These vehicles store electricity onboard with battery packs, and are powered by electricity from an external source by plugging into an outlet or charging station (or, in some cases, wirelessly).

Extended range electric vehicle (EREV): These are a form of plug-in hybrid electric vehicle (PHEV), but the gas engine functions as a generator (alternator) to charge the battery rather than propelling the vehicle. Generally, EREVs will drive exclusively in electric mode until the battery is depleted; at that point, the gas generator will kick in to keep the battery charged until the car plugs in.

Electric vehicle (EV): An electric vehicle is an automobile that uses an electric motor as a source of propulsion. While EV is often used to refer to vehicles that plug in (PEV), technically, EVs include traditional hybrid cars and fuel cell vehicles. In this guide, EV refers to plug-in vehicles only.

Fuel cell vehicle (FCV): An FCV is an electric vehicle that uses a fuel cell instead of a battery to power its on-board electric motor. These vehicles are fueled with hydrogen. In this guide, FCVs are not included among EVs.

Hybrid electric vehicle (HEV): An HEV is a “traditional” or “conventional” hybrid, and has a two-part drive system: a conventional fuel engine and an electric drive. These vehicles do not plug in; electrical energy is generated via an alternator or regenerative braking. In this guide, HEVs are not included as an EV.

Internal combustion engine (ICE): These vehicles derive their energy from the combustion of a fuel (typically gasoline or diesel, sometimes natural gas) in a combustion chamber.

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[2] Graphic courtesy of BC Hydro and C2MP. The fuel costs are based on an assumed internal combustion engine fuel efficiency of 7.9 L/100 km, gasoline costs of $1.22/L, and electricity costs of $0.134/kWh. Emissions data are from Axsen et al. 2015. EV insights. Pg. 17, Figure E-11. The emissions data are for British Columbia and measure “well to wheels emissions.” Emissions can be reduced by 79–98% depending on vehicle and charge access (for further information, see Axsen, J., Goldberg S., and Bailey J.. 2015. Electrifying vehicles: insights from the Canadian plug-in electric vehicle survey. Simon Fraser University, Burnaby, BC, pp. 147–154. http://rem-main.rem.sfu.ca/papers/jaxsen/Electrifying_Vehicle_(Early_Release)-The_2015_Canadian_Plug-in_Electric_Vehicle_Study.pdf

Plug-in electric vehicle (PEV): PEV refers to electric vehicles that have the ability to plug in to charge, and includes BEVs, EREVs, and plug-in hybrid electric vehicles.

Plug-in hybrid electric vehicle (PHEV): Similar to HEVs, PHEVs have a two-part drive system, and are equipped with an electrical drive and battery storage capacity, in addition to an internal combustion engine (generally with larger battery storage and a smaller engine than HEVs). The batteries can be recharged by plugging into an electrical outlet, as well as via a gas-powered alternator and/or by regenerative braking.

Zero emission vehicle (ZEV): This refers to electric vehicles with no tailpipe emissions. This category comprises BEVs and FCVs. However, ZEV is also often used as a catch-all; for example, government ZEV mandates generally categorize PHEVs and EREVs among ZEV vehicles, though these have combustion engines.

1.3 Uptake Projections

British Columbia welcomed its 10,000th plug-in electric vehicle in 2018, and sales trends show the popularity of electric vehicles has grown rapidly in the province (*Figure 2*) and across the country since the Canadian debuts of the Nissan Leaf and Chevy Volt in 2011.

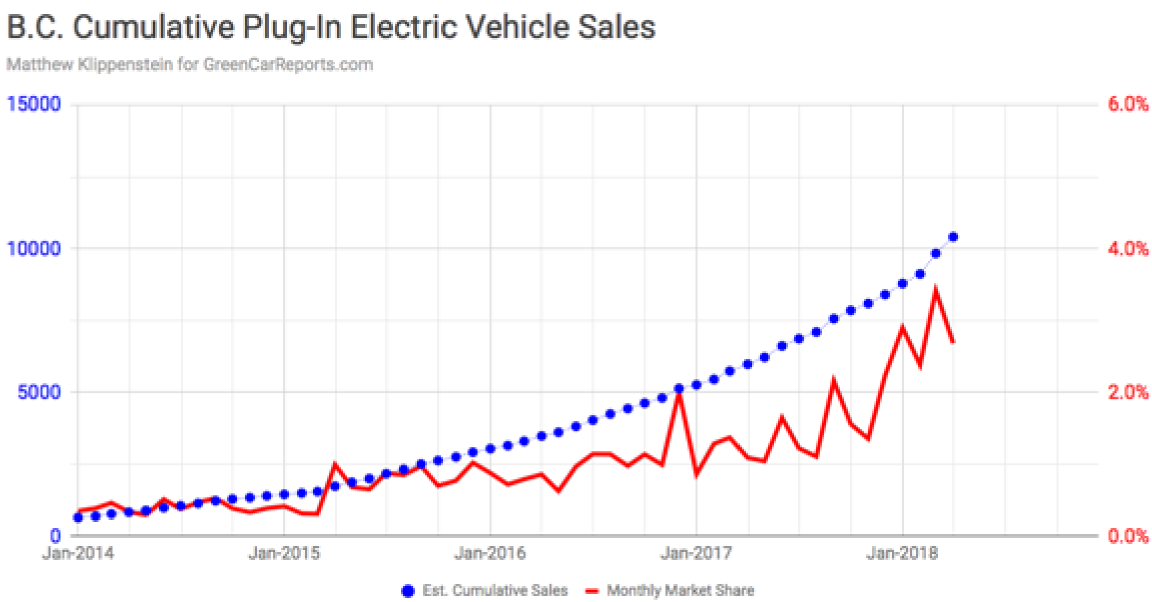

Figure 2: Estimated market share and cumulative plug-in electric vehicle sales in British Columbia. (Source: GreenCarReports.com[3])

[3] Data and chart at tinyurl.com/CanadaEVSales

Through the first four months of 2018, British Columbia led all provinces in plug-in electric vehicle market share; British Columbia and Quebec compete strongly for national leadership (*Figure 3*). Ontario, the other province with electric car purchase rebates, is in third place. Electric vehicle adoption is far slower in the rest of Canada.

Plug-in Electric Vehicles in Canada

EV market share (among new car sales) by province

	B.C.	Quebec	Ontario	Rest of Canada
2013	0.32%	0.31%	0.16%	0.02%
2014	0.4%	0.6%	0.2%	0.03%
2015	0.72%	0.68%	0.25%	0.04%
2016	1.0%	1.1%	0.4%	0.10%
2017	1.4%	1.6%	0.9%	0.15%
Jan - Jun 2018	3.5%	3.2%	2.2%	0.20%

Matthew Klippenstein (@ElectronComm) for GreenCarReports.com

Data sources: automaker and vehicle registration (IHS Markit) data, AVEQ.ca (Quebec), author estimates.

Figure 3: Estimated market share and cumulative plug-in electric vehicle sales in British Columbia. (Source: GreenCarReports.com)

With more electric models arriving every year, EV sales look poised to increase in the long term.[4] In the short term, EV sales in British Columbia may plateau in 2018–2019. While pent-up demand for the long-awaited Tesla Model 3 will offer a one-time boost to electric vehicle sales, the Clean Energy Vehicles for British Columbia (CEVforBC) Program, which offers purchase rebates of up to $5000 for qualifying EVs, is likely to run out of funds by the end of 2018. If the Province does not provide further funding, overall EV adoption could slow.

Modelling for Metro Vancouver, based on assumptions from a larger Simon Fraser University study, has projected how many EVs could be on the region's roads by 2030 (*Figure 4*). Aside from the low scenario, which assumes little to no supportive EV policy, EVs could account for 12–23% of the region's light-duty vehicles.[5]

[4] Projections for overall EV uptake in coming decades vary widely. Organizations that are generally supportive of renewable energy tend to forecast high uptake of electric vehicles, particularly in developed countries, and often incorporate assumptions of policy support for zero emission vehicles and/or policy restrictions on combustion vehicles (as is currently the case in Norway and China). Organizations that are generally associated with the fossil fuel sector have been less positive, often assuming that policy support will end and/or that consumers will continue to prefer combustion vehicles.

[5] See *Figure 7* for information on the underlying assumptions and data sources.

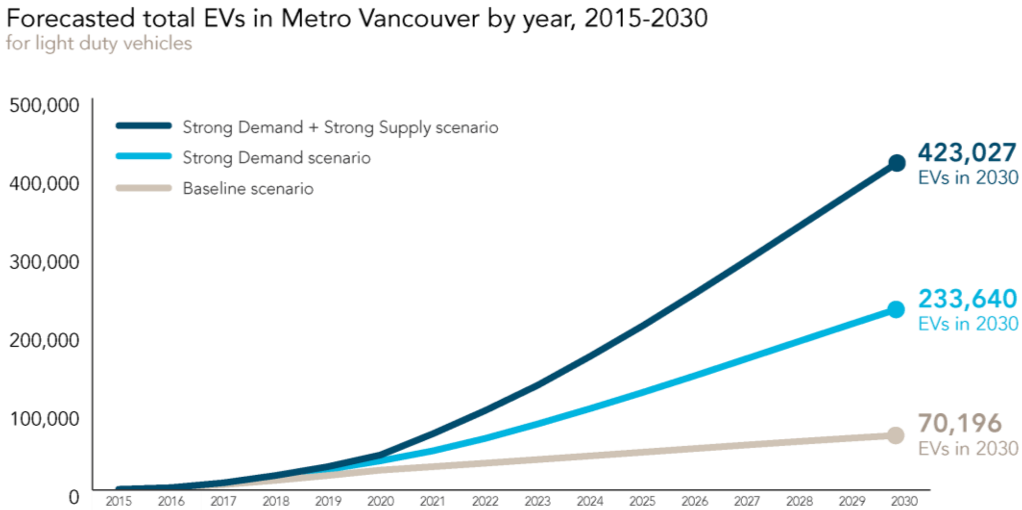

Figure 4: Projected numbers of light-duty electric vehicles in Metro Vancouver, to 2030.

These trends are consistent with EV market growth globally: electric vehicle uptake increased by 54% from 2016 to 2017. Growth has been driven largely by government policy, in addition to improvements in battery technology and costs. The International Energy Agency's 2018 Global EV Outlook projects the number of electric cars worldwide will reach 125 million units by 2030 under current and planned policies, and as many as 220 million units if policy efforts become more ambitious.[6]

1.4 About Charging Equipment or Electric Vehicle Supply Equipment[7]

Currently, there are three commonly used types of charging infrastructure, or electric vehicle supply equipment (EVSE).

Electric vehicles have on-board equipment that converts alternating current (AC) to direct current (DC) for the batteries, which enables the use of Level 1 and Level 2 EVSE.

Level 1 (AC) charging uses a standard house plug (120V) and provides the slowest charging. It can be used for overnight charging or all-day charging at work. When charging cars overnight (8–10 hours), Level 1 EVSE can fully recharge most PHEVs and "top up" a BEV from a typical work commute.

Level 2 (AC) charging uses a dedicated 208V or 240V circuit like those used for clothes dryers. In addition to home and workplace installations, Level 2 chargers are generally the preferred option for home charging. Level 2 is also appropriate in public locations where cars generally park for one or more hours, which allows EV owners to top up their charge while shopping, recreating, or working.

Direct current fast charging (DCFC), sometimes formerly referred to as Level 3 charging, can provide about an 80% charge in half an hour.[8] Direct current fast charging is generally not considered suitable for residential installations due to the high cost of equipment, installation, and power requirements.[9] Not all electric vehicles can plug into a DCFC charger.

[6] International Energy Agency. 2018. Global EV Outlook 2018. https://webstore.iea.org/global-ev-outlook-2018
[7] The following is drawn from Plug In BC. 2017. The Beginner's Guide to Electric Vehicles (EV); City of Vancouver and City of Richmond information; Weston, L. 2016. Fleetcarma. A simple guide to electric vehicle charging, Powertech Labs.
[8] While DC fast chargers "fill" batteries rapidly at the beginning of a charging session, the rate of charge then tapers off. An 80% charge is therefore a normal charge to achieve at a DCFC station.
[9] Direct current fast charging stations can cost $60,000 or more to purchase and install; they require three-phase power, which is not available everywhere, and they may trigger "demand charges" (higher electricity prices due to the large amount of power being sent through the local transmission system).

A Note on Charging Standards

SAE J1772 AC (also known as J plug) is a standard connector used for Level 1 and 2 charging, which almost all electric vehicles on the market use (except Tesla).

CHAdeMO DCFC: this fast charge connector standard is used by Nissan and Mitsubishi, among others. Vehicles that use CHAdeMO connectors are not compatible with a combined charging system (CCS).

CCS DCFC: the combined charging system is the fast charge option for SAE J1772, and is also known as combo coupler (because it uses the same L1/L2 connector, with a DC option). Manufacturers that are using this standard are Volkswagen, General Motors, and BMW, among other North American and European manufacturers.

Most new DCFC equipment will offer both CHAdeMO and CCS standards in a dual port configuration (generally only one vehicle can be charged at a time). However, it is not uncommon to come across older stations with the CHAdeMO standard only, as this standard was established a few years before CCS.

Tesla uses its own standard connector for both AC and DC “superchargers.” Only Teslas can connect to these stations. There are adaptors to allow Teslas to use the J1772 connector or CHAdeMO. Non-Teslas cannot connect to Tesla stations.

About Electric Vehicle Energy Management Systems

Electric vehicle energy management systems (EVEMS), also referred to as “load sharing,” “power sharing,” or “smart charging,” refer to a variety of technologies, including service provision, that allow multiple vehicles to charge on the same circuit. In contrast to a “dedicated EVSE” where one circuit services one stall, one circuit is able to service multiple stalls simultaneously by controlling the rate and timing of charging (*Figure 5*). This reduces the necessary electrical infrastructure and total electrical supply needed to power multiple EVSE.

Electric vehicle energy management systems drastically reduce the capital costs required to install multiple EVSE. Operational costs or network fees may be required to operate the EVEMS.

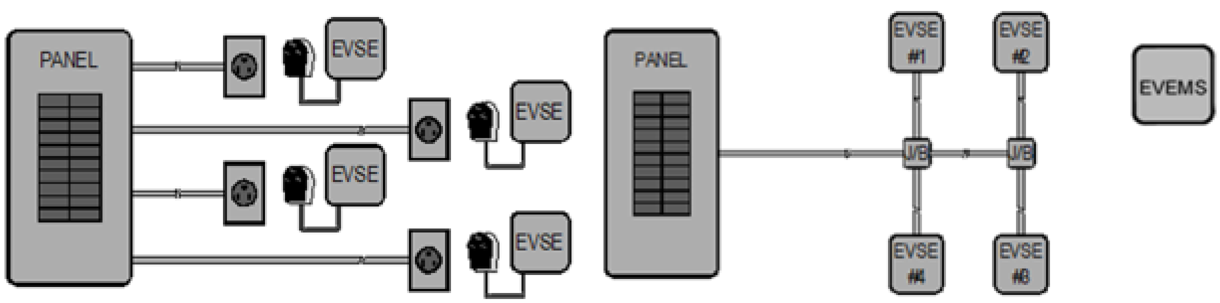

Figure 5: Dedicated circuits (left) compared to an electric vehicle energy management system (EVEMS) (right), showing the reduction in electrical infrastructure required for the EVEMS. (EVSE: electric vehicle supply equipment)

Electric vehicle energy management systems track usage and can enable or allocate billing to individual users. They can be used in any situation with shared parking, from multi-unit residential buildings to single-family homes with multiple parking stalls.

Electric vehicle energy management systems are recognized in the 2018 edition of the Canadian Electrical Code, which is likely to be adopted in early 2019. Technical Safety BC is developing a variance process to permit installation of EVEMS prior to adoption of the new code. The City of Vancouver currently permits installation through its regular variance process. Other municipalities not administered under Technical Safety BC are at various stages in terms of developing processes to permit installation of

EVEMS, with most expected to follow the precedents established by Technical Safety BC and the City of Vancouver. More information on the configurations of EVEMS is available in a companion technical report prepared for the City of Richmond.[10] In short, three **circuit sharing** configurations are available: rotational, static, and dynamic. Rotational is not suitable for residential parking. Static circuit sharing is more suited to small-scale installation where load sharing is used in two parking stalls for the same dwelling unit. Dynamic EVEMS is suitable for multi-family residential with shared parking areas and requires communications capabilities.

Three **load management** systems are available: dwelling, panel, and building. Dwelling demand load management is suitable for configurations where the utility meter is located near the parking stalls; i.e., single-family, duplex, some townhouse, and low-rise apartment buildings. Panel load management and building demand management are suitable for larger multi-unit residential buildings (MURBs).

Additional Charging Equipment Considerations

Use of block heater plugs for EV charging: At best, block heater receptacles provide the equivalent of Level 1 charging. They are generally insufficient for EV charging, and are not designed for this purpose.

Networked EVSEs connect to a charging station network via cellular, hardwired connection or wireless signal, thereby making usage tracking, remote monitoring, user reports, mobile app integration, payment collection, online reservation systems, and use of an EVEMS possible. Networking often requires a subscription to an electric vehicle service provider, and can be more costly to operate than non-networked EVSE.[11] In underground parking garages, networked EVSE may require cellular repeaters, wireless access points, or cabled infrastructure.

Open Charge Point Protocol is a means of automatic communications between charging equipment and a central management system or network. This protocol allows any vendor to use the same network. Some vendors, but not all, have adopted this protocol.[12]

How do charge times compare?

When plugged into Level 2 charging stations, plug-in electric vehicles generally charge at 3.3 kW (PHEVs and some older BEVs) or at 6.6 kW (most BEVs). The station's amperage and the vehicle's energy efficiency also factor into how much range can be recovered per hour.

With DCFCs, charging speed depends on the power capacity of the station itself, and the size and state-of-charge of the battery. Most early generation DCFCs deployed today provide 50 kW of power, but can range from 24 kW to 200 kW, or even higher.

Drivers generally use only a fraction of a BEV's range on a given day, so charge times are often expressed in terms of range recovery—the speed at which the EV recovers its electric range. Charge times for several popular plug-in electric vehicles are provided in Table 1.

[10] AES Engineering, 2018, Electric Vehicle Charging Infrastructure in Shared Parking Areas: Resources to Support Implementation & Charging Infrastructure Requirements. Prepared for City of Richmond, Richmond, BC.
[11] http://pluginbc.ca/charging-stations/
[12] At the time of writing, this protocol was common in many markets but was less widely used in North America.

Table 1: Examples of Range Recovery for Level 2 and DC Fast Charging (DCFC)

Vehicle	Dedicated Level 2 (km in 60 min)	DCFC – 50 kW CCS/CHAdeMO (km in 30 min)	DCFC – 120 kW Tesla Supercharger (km in 40 min)
BMW i3	42	103 (144 option)	–
Chevy Bolt	41	273	–
Chevy Volt	18	–	–
Mitsubishi Outlander PHEV	12	28	–
Nissan Leaf (2nd generation)	17 (option for 34)	194	–
Tesla Model S (base model)	45	–	321
Tesla Model X (base model)	43	–	306
Tesla Model 3 Long Range	60	–	399
Toyota Prius Prime	21	–	–
Volkswagen e-Golf	21 (option for 41)	161	–

1.5 Charging Needs: Home, Work, and On the Go

Currently, most charging occurs at home, and the ability to charge at home is the primary driver and indicator of electric vehicle adoption.[13] However, EV charging infrastructure needs to be considered as part of a comprehensive system that includes access at work, in public parking spaces, at destination sites, and along highway corridors for longer distance trips (*Figure 6*). These additional charging options not only serve EV owners with home charging while they are "on the go," but also provide essential charging to EV owners without home access, such as those in rental buildings and existing strata corporations.

This guide deals mainly with installing and accessing charging in multi-unit residential buildings, also known as multi-family buildings or multi-unit dwellings. Such installations can be complex, with barriers going well beyond financial obstacles.[14]

[13] Wolinetz, M. and J. Axsen. 2016. How policy can build the plug-in electric vehicle market: insights from the REspondent-based Preference And Constraints (REPAC) model. Technological Forecasting and Social Change 117:238–250. http://dx.doi.org/10.1016/j.techfore.2016.11.022
[14] Plug In BC. 2015. BC Level 2 gap analysis report 2015. https://pluginbc.ca/resource/bc-level-2-gap-analysis-report-2015

Figure 6: The charging pyramid[15] by Argonne National Laboratory demonstrates the hierarchy of electric vehicle charging location type frequencies. Electric vehicles are most frequently charged at home, where the vehicles are most often parked. Public charging, which has a comparatively lower demand, still plays an important role in the electric vehicle charging ecosystem.

"At home" Charging is Key to the Electric Vehicle Transition

Home charging is reliable and convenient, similar to plugging in your phone overnight.

More than 30% of Canadian households have an interest in purchasing a PEV as their next vehicle,[16] but PEVs have only recently surpassed 3% of the new car market share in British Columbia. A Simon Fraser University study found that barriers to EV purchases include, in order of impact, lack of at home charging, limited availability of desired vehicle class (e.g., SUV, truck), limited availability of desired make and model, and lack of familiarity with electric vehicles.[17]

While early adopters of electric vehicles were willing to accept challenges (and take steps such as rewiring to install charging equipment), mainstream adopters require lower barrier entry, such as easily installed charging equipment and available electrical outlets. One of the best ways to reduce barriers to EV purchases, therefore, is to ensure access to charging at home.

Local Governments Can Influence Access to "At home" Charging

Modelling of high-level policy options has shown that increased charging access is critical to rapid uptake of electric vehicles (*Figure 7*).

Local governments have an important role to play in the uptake of electric vehicles because they can improve their residents' access to EV charging. Policy options include requiring EV charging capabilities in new residential and commercial construction, supporting deployment in existing multi-family dwellings, deploying charging infrastructure at public facilities, and providing on-street charging opportunities.

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[15] Santini, D.J., Y. Zhou, V.V. Elango, Y. Xu, and R. Guensler. 2014. Daytime charging — what is the hierarchy of opportunities and customer needs? — a case study based on Atlanta commute data. Submission to 93rd Transportation Research Board Annual Meeting.
[16] Wolinetz, M. and J. Axsen. 2016. How policy can build the plug-in electric vehicle market: insights from the REspondent-based Preference And Constraints (REPAC) model. Technological Forecasting and Social Change 117:238–250. http://dx.doi.org/10.1016/j.techfore.2016.11.022
[17] Axsen, J., S. Goldberg, and J. Bailey. 2015. Electrifying vehicles: insights from the Canadian plug-in survey. Simon Fraser University, Burnaby, BC http://rem-main.rem.sfu.ca/papers/jaxsen/Electrifying_Vehicle_(Early_Release)-The_2015_Canadian_Plug-in_Electric_Vehicle_Study.pdf

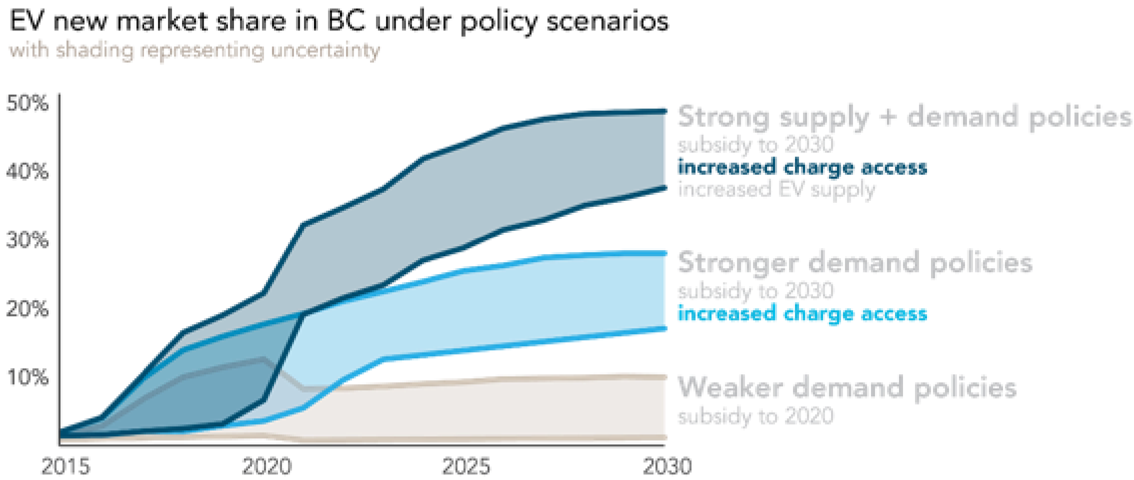

Figure 7: This figure shows Electric vehicle new market share in British Columbia under different policy scenarios. Policies that increase charging access are critical to reach higher uptake rates of electric vehicles. Supply-side policies include mandates that require zero-emission vehicles to represent a rising percentage of automakers' sales. Demand-side policies include electric vehicle purchase incentives and electric vehicle infrastructure requirements and investments.[18]

[18] Wolinetz, M. and J. Axsen. 2016. How policy can build the plug-in electric vehicle market: insights from the REspondent-based Preference And Constraints (REPAC) model. Figure 4. Technological Forecasting and Social Change 117:238–250. http://dx.doi.org/10.1016/j.techfore.2016.11.022

2.0 SUPPORTING ACCESS TO ELECTRIC VEHICLE CHARGING IN NEW DEVELOPMENT

2.1 British Columbia *Building Act*

The Province has clarified that local government EVSE requirements are “out of scope” of the *Building Act*. The Act therefore does not appear to impede local governments’ ability to implement requirements for electric vehicle charging infrastructure, as noted in the Building Act Guide:[19]

> If the requirements do not concern a matter addressed in the Building Code, they are ‘out of scope’ of the Building Act and local governments can regulate these matters if they have authority to do so in other statutes… examples of matters that are ‘out of scope’ of the section 5 limitations [include:]
>
> Electric vehicle charging stations/plug-ins: Electric vehicle charging stations concern the number, location, and type of charging stations (and related matters such as signage) required in a building or facility to charge electric vehicles that use the building for parking. This includes wiring or pre-ducting for electric vehicle plug-ins.

2.2 Local Government Policy Mechanisms in Use or Being Considered

High-level Framing Policy

Communities that have brought in EV requirements to date have had supporting language in an Official Community Plan, Environmental Sustainability Plan, or other high-level framing document. A Community Energy and Emission Plan with an EV action may provide adequate support to advance specific policy requirements or negotiate EV charging infrastructure during rezoning.

Negotiating for Electric Vehicle Charging Infrastructure at the Time of Rezoning and/or Development Approvals

One approach to obtaining EV charging infrastructure is to have a formal or informal policy that includes negotiated provision of some level of electric vehicle supply equipment in new residential construction as part of rezoning.

The advantage is that it can help both sides (local government and developers/builders) become comfortable with EV charging infrastructure prior to a requirement, and some percentage of new parking will be EVSE serviced.

The challenges are that each development must be negotiated separately, which increases the administrative burden; exact EV charging infrastructure requirements are unknown, which leads to project costing uncertainty; levels of EVSE may be inadequate to meet future demand; and projects that are not subject to rezoning will not include EVSE.

Critically, in strata corporations, any policy that negotiates or requires only a percentage of residential parking stalls to be EV-ready or wired for EV could lead to future conflicts within the strata. As EV ownership rates increase beyond the available EV parking stalls, a mismatch could occur between EVSE-serviced parking stall ownership and EV owners who need to charge.

Zoning Bylaw

Requirements for EV charging infrastructure could be included in each specific residential land use designation (as well as commercial and institutional designations) in a zoning bylaw.

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[19] Province of British Columbia. 2017. *Changes for Local Governments Under Section 5 of the Building Act, Appendix to Section B1 of the Building Act Guide*. Office of Housing and Construction Standards, Victoria, BC

A possible advantage of this approach is that it allows the EV charging infrastructure requirements to be tailored to the various residential land use designations. For example, a local government could make a requirement that applies only to single family homes, duplexes, or townhomes, if it so desired.

Requiring EVSE through the zoning bylaw ensures that all new construction in those zones (not just negotiated rezonings) would have EVSE infrastructure.

However, given the number and complexity of residential designations, such an approach could prove cumbersome and overly complex for the need at hand. An alternative, more streamlined solution is to include the requirements as part of the overall parking requirements (as a stand-alone bylaw or schedule in the zoning bylaw).

Parking Bylaw or Schedule

A requirement that parking stalls in newly built residential buildings include EV infrastructure can be added to a parking schedule or parking bylaw. As of June 2018, Burnaby, Richmond, and Vancouver had chosen this policy tool to require Level 2 charging access to all non-visitor parking stalls in new residential buildings.[20] Port Coquitlam has required Level 2 charging access for one parking stall per unit in new residential construction.[21] Several other Metro Vancouver municipalities, some of which currently have more modest thresholds in place, are evaluating similar requirements. The parking schedule changes have generally been advanced through amendments to the parking sections of the local government's zoning bylaw.[22, 23]

The advantage of using the parking schedule is simplicity, flexibility, and clarity: a percentage or number of EVSE-ready stalls per unit can be applied to all new residential parking stalls. Performance standards and other technical matters can be set out in a Technical Bulletin.

This policy lever can then be used in conjunction with other tools, such as higher level policy language that supports EVs in OCPs, CEEPs, or other sustainability policies.

Stand-alone Policy

A local government could adopt a stand-alone policy on electric vehicle charging. Such a policy may not have the same enforceability as a parking or zoning bylaw; however, the policy could act as a guide to planners and building staff as they move a project through the development application and permitting process.

2.3 Electric Vehicle Charging Infrastructure Options for Local Government Policy

This report deals with Level 2 charging, defined by the SAE J1772 standard. Level 1 charging can provide charging overnight, but it may not provide an adequate level of charging (particularly for newer electric vehicles with larger batteries and longer range). DC fast charging, which can provide an 80% charge in approximately 30 minutes, is costly and could lead to congestion challenges in multi-unit residential buildings. It is more suitable for publicly accessible charging.

Readiness Options

Electric vehicle infrastructure in residential development and construction may be installed with a variety of readiness options (*Figure 8*).

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[20] All three leading communities had previously required or negotiated EVSE in residential construction as a percentage of parking stalls in multi-unit residential buildings.
[21] City of Port Coquitlam. Port Coquitlam Zoning Bylaw, 2008, No. 3630. See also https://www.portcoquitlam.ca/wp-content/uploads/2017/12/11-28-Council-EV-Charging-Report-with-Appendices.pdf
[22] City of Richmond. Richmond Zoning Bylaw 8500, Amendment 9576. https://www.richmond.ca/__shared/assets/_6_-_EVCharging48818.pdf
[23] Amendment to Vancouver Parking Bylaw 6059 is noted in Appendix B: http://council.vancouver.ca/20180314/documents/cfsc3.pdf

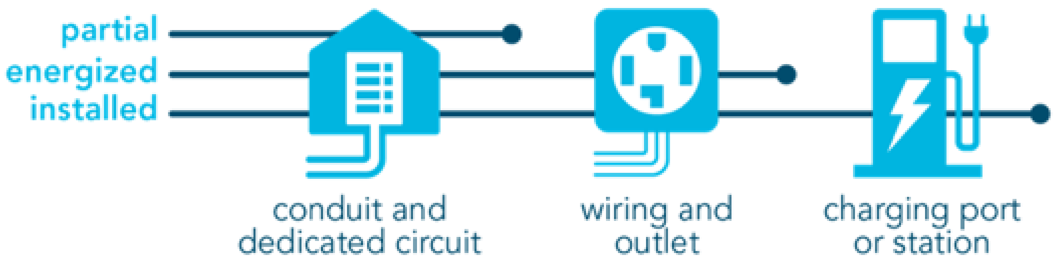

Figure 8: Various readiness options for electric vehicle supply equipment requirements, showing the electrical equipment visible to electric vehicle users (additional infrastructure, such as transformers and switchboards, is not shown).

Partial electric vehicle supply equipment ("pre-serviced low" or "pre-serviced high"): Specific definitions of partial EVSE are variable. The intent is to partially install the required electrical infrastructure, such that either only the wire is required to be pulled, or the conduit/raceway, outlet, and wire are required to be installed prior to the charging station installation and use.

The following is one technical definition of partial EVSE for multi-family residential buildings:

> All infrastructure required for charging of an electric vehicle (EV), including all electrical equipment (including metering), cabling and associated raceways, and connections, up to the provisional branch panelboard locations, minus the feeder cabling to the panelboards. Raceways for the feeder cabling to the provisional panelboard locations would be included; the branch panelboards and associated feeder cabling, branch cabling and associated raceways, and connections to EVSE's would be installed at a later date.[24]

For Part 9 residential (small buildings), partial EVSE may refer to a raceway or conduit from the dwelling unit panel board to an electrical outlet in the parking area that may or may not have a dedicated circuit.

Partial EVSE is the least costly option at the time of development; however, it is more costly overall because additional electrical infrastructure must be added at a later date. In addition, the partial infrastructure cannot be verified to function at the time of electrical inspection because it is not energized.

Partial EVSE may be used for smaller parking areas, such as smaller townhouse developments, if adding the remaining infrastructure would not incur large future costs. However, partial EVSE is not considered an optimal option, and all electrical room equipment should be included in the initial installation. An electrical engineering report for the City of Richmond strongly recommended against partial EVSE for new developments.[25]

Energized ("EVSE-ready"): All the infrastructure required for charging an EV, with the exception of the Level 2 EVSE equipment, is included; i.e., all electrical equipment (including metering, transformers, sub-panels as needed), cabling and associated raceways, and connections (energized outlets).

The EV owner would purchase their own EVSE and have it installed. The development costs are variable, depending on the system configuration (see more on costing scenarios in section 2.5 costs below). Load sharing using an EVEMS can significantly reduce the costs of providing EV-ready or fully energized outlets. Currently, in most cases, all residents who use an EVEMS would have to have the same manufacturer of charging station for load sharing to work. Technology is continually evolving, and new systems that could allow different manufacturer models to work together may emerge.

[24] AES Engineering Ltd. 2017. Report for electric vehicle charging infrastructure in new multifamily developments – requirement options and costing analysis. Prepared for City of Richmond, Richmond, BC.
[25] Ibid.

Electric vehicle supply equipment – installed: All the infrastructure required for charging an EV is at the parking stall, including all electrical equipment (including metering, transformers, sub-panels as needed), cabling and associated raceways, and connections. In addition, Level 2 EVSE equipment is permanently installed. This is the easiest option for EV owners, and the most costly to install during development.

Coverage Options

A second policy choice involves the percentage of parking that should have access to EV infrastructure, or how many stalls should be equipped with EV infrastructure per residential unit. Examples are shown in Table 2.

Several local governments that began with percentage-based requirements (e.g., 20%) have updated or are in the process of updating their requirements such that either all residential stalls have an energized outlet or one EV infrastructure parking stall per residential unit has an energized outlet (Table 2). The choice between all stalls versus one stall for each residential unit depends in part on a community's parking requirements: if the parking requirements per unit are significantly greater than one, then one EV-ready stall per unit may be preferable to every stall being EV-ready. Exclusions such as visitor parking could be considered.

Table 2: Examples of Current and Prior Electric Vehicle Requirements in New Residential Development, Local Governments in British Columbia

Community	Current Policy	Previous Policy, if applicable
City of Burnaby	Every dwelling unit: every required parking space, excluding visitor and secondary suite, provided with energized outlet, Level 2.	Multi-unit residential buildings: negotiated ~10% of parking stalls EV-ready or EVSE installed.
City of Coquitlam	Apartment, townhouse, and street-oriented village home: one energized outlet per dwelling unit, Level 2.	
City of North Vancouver	Single-family: capacity for Level 2 in 100% of parking spaces. Multi-family: 20% of parking spaces supplied by 40A 240V branch circuit. Capacity in electrical room for 100% of parking spaces.	
City of Port Coquitlam	Every dwelling unit: one stall per residential unit roughed-in (all electrical infrastructure other than wire), Level 2.	
City of Richmond	Every residential parking space, excluding visitor parking, provided with energized outlet, Level 2.	Multi-family parking spaces: 20% provided with 120V receptacle; 25% pre-ducted.
City of Vancouver	Single-family: one energized outlet per parking area (garage, carport). Multi-family: every parking space, excluding visitor, energized outlet, Level 2.	Level 2 (40A, 240V) for 20% of parking stalls in multi-unit residential; all garages/carports of 1–2 family homes.
District of North Vancouver	Multi-family: 20% of parking spaces EV-ready, wired for Level 1; conduit for 100%. Secure bicycle storage to include one outlet for electric bicycle charging.	
District of Squamish	Multi-family: 30% of off-street parking stalls in shared parking areas have shared access to EV charging receptacles, Level 2.	

Evaluating Options for New Development

The following are suggested evaluation criteria for determining which Level 2 EVSE option (coverage and readiness) to negotiate or require:

- allow developers to design for EVEMS to minimize upfront costs. Load management significantly reduces upfront infrastructure costs;
- enable and minimize **costs to retrofit**. Depending on the parking stall location and available electrical supply/infrastructure, retrofit costs can be prohibitive;
- make it simple for **stratas to administer**. Under the *Strata Act*, parking stall allocation and ownership is complex.[26] If stratas have less than one energized stall per unit, how best to allocate?;
- make it simple for **local government to administer**, inspect/approve. Which readiness and coverage option best streamlines the development process from the local government's perspective? This includes plan checking, permitting, and inspections;
- ensure fair and **equitable access** for residents (initial and long-term). Questions to consider include the following: how much cost should all the strata owners bear to include EV charging? If stratas have fewer than one energized stall per unit, what are the costs to non-EV-ready parking stall owners to retrofit for their EV?[27];
- maximize **future choices**. Electric vehicle infrastructure and the EV market continue to evolve. What is the right level of infrastructure now that will support future needs? Is the EVSE equipment needed, or only the energized outlet?

Table 3 provides example combinations of coverage and readiness options.

[26] AES Engineering Ltd., 2018, Electric Vehicle Charging Infrastructure in Shared Parking Areas: Resources to Support Implementation & Charging Infrastructure Requirements. Prepared for City of Richmond, Richmond, BC.

[27] Consider that while the cost of the initial retrofits may be feasible, installation costs increase as the demand on the electrical system increases (potentially triggering major electrical equipment upgrades) and the parking stalls are farther from the electrical room. Thus, the first EV owner or the owner adjacent to the electrical room is likely to have much lower costs to install EVSE than the last EV owner or the owner that is farthest from the electrical room, whose retrofit costs could be prohibitive.

Table 3: Evaluating Electric Vehicle Requirement Options[28]

Example option evaluation	Minimize upfront costs*	Minimize retrofit costs	Simple for strata	Simple for City	Equitable for residents	Future-proof
Percentage-based (e.g. 20%)	Green	Red	Red	Orange	Red	Red
Partial (pre-serviced low, all stalls)	Green	Red	Red	Red	Red	Orange
Partial (pre-serviced high, all stalls)	Orange	Orange	Orange	Orange	Orange	Green
Energized (EVSE-ready, all stalls)	Orange	Green	Green	Green	Green	Green
EVSE Installed (all stalls)	Red	Orange	Green	Green	Green	Orange

* Green best meets the criterion; orange somewhat meets the criterion; red does not meet the criterion.

2.4 Requirements for Single Family Homes, Duplexes, and Townhouses with Private Parking Stalls

Electric vehicle charging in low-density residential development is essential because residents generally have fewer sustainable transportation choices (such as high-quality public transit).

Level 2 charging (i.e., 40A, 208–240V) is recommended to ensure sufficient charging for the average driver, based on average daily driving distances and available charging time. Charging stations rated at 40A provide a reasonable charge time and make load sharing possible, such that multiple parking spaces for the same unit, for a main unit and secondary suite, or for multiple units could use EVSE with load sharing.

In cases where no additional circuits are available for EVSE and dedicating a 40A circuit to the charging infrastructure would lead to a panel upgrade and additional development costs, a "load miser" or "watt miser" could be used. This load-sharing option allows a Level 2 charger to share a circuit with a dryer or a stove, and is allowed under the Canadian Electrical Code. The EV would charge only when the appliance on the circuit is not in use.

Costs for EVSE in single-family and duplex homes are variable, depending on the building and site configuration, calculated load, and panel size. The following general costs are provided as a guide only; they are general estimates and do not reflect actual costs for installation in a particular location:

- new construction: **$200–$500** materials and labour for an energized outlet on a dedicated 40A 240V circuit (Level 2);
- retrofit costs: **$500–$1200** plus permit cost[29];
- cost of EVSE/charger (owner purchases): **$600–$1400** plus labour to hardwire if necessary.

[28] Table adapted from City of Burnaby.
[29] Concern that an existing connection with BC Hydro may need to be upgraded could be mitigated through use of a "load miser" to share the circuit.

Installing energized outlets for EV charging at the time of construction, rather than as a later retrofit, reduces infrastructure costs. Importantly, having the infrastructure installed at the time of construction reduces the complexity of installing home charging for a new EV owner, making EV ownership easier.

2.5 Requirements for Multi-Unit Residential Buildings

Electric vehicle infrastructure retrofits can be expensive and complex in the shared parking areas of multi-unit residential development. In one provincial incentive program, the average installation cost, including electrical infrastructure, EVSE, and labour, averaged $6800 per retrofit EV stall.[30]

In contrast, EV charging infrastructure installed at the time of construction is a cost-effective way to make at home charging available in MURBs, particularly when load sharing is employed. Providing such infrastructure reduces cost and institutional barriers to EV ownership.

Costing Information for New Development

The following cost analysis is based on a study of EV systems across four residential building types: townhouse, mid-rise in city centre, mid-rise outside city centre, and high-rise.[31] Costs for two dedicated and six different load-sharing systems were estimated for each building type, excluding the EVSE cost.

A summary of EVSE-ready costs is provided in Table 4; additional data follow the table. Note that **these costs are an indicative guide only**. The cost estimates were prepared for the City of Richmond, and are specific to the particular characteristics of the building types, driving distances, and terrain in that region. While broad trends across infrastructure configurations and building types are generally applicable to all municipalities, municipality-specific assessment is recommended where more accurate costing is required.

Table 4: Summary of Electric Vehicle Supply Equipment (EVSE) – Ready Costs

Installation Costs per New Stall, assuming 100% of Stalls are EVSE-Ready (Energized Outlets)	
Dedicated Level 1	Townhouse: $126 (least cost option for townhouse) Mid-rise: $847–$881 High-rise: $1443 Note: no additional life cycle costs for L1
Dedicated Level 2	Townhouse: $2655 per stall Mid-rise: $2314–$2448 per stall High-rise: $3023 per stall
Lowest cost, Level 2*	Townhouse: $307 Mid-rise: $566–$572 High-rise: $760
Additional life cycle costs are estimated at $8000 over 20 years, assuming $2000/L2 charger and $6000 in service costs.	

* Depending on the building type: 4-way load shared and load managed or 18-way load shared, 80A.

[30] Based on data from a Plug In BC multi-unit residential building retrofit incentive program; aggregated average should be used as a guide only.
[31] AES Engineering Ltd. 2017. Report for electric vehicle charging infrastructure in new multifamily developments – requirement options and costing analysis. Prepared for City of Richmond, Richmond, BC Note that costs are based on driving characteristics and conditions, as well as construction costs specific to the City of Richmond, and should not be considered applicable to other municipalities without verification specific to the municipality.

High-rise Costs[32]

Load sharing reduces costs by 45–75% compared to dedicated Level 2 and can be less costly than dedicated Level 1 (*Figure 9*, *Figure 10*).

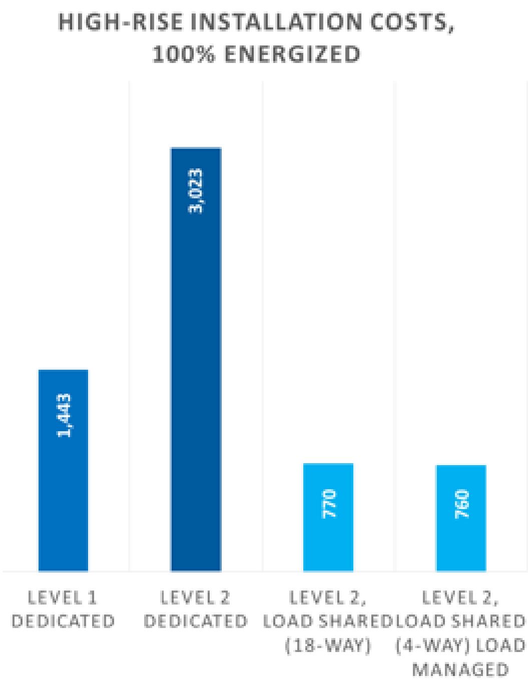

Figure 9: High-rise: dedicated circuits compared to lowest cost load-sharing options, all stalls electric vehicle supply equipment-ready (provided with energized outlets).

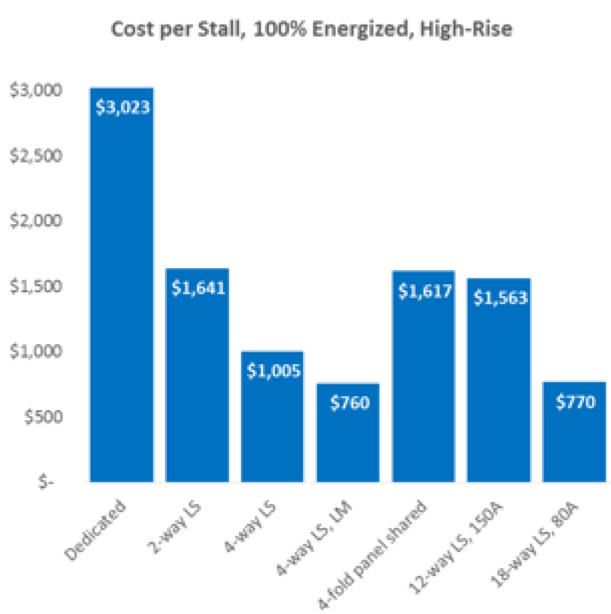

Figure 10: High-rise: dedicated Level 2 cost per stall compared to six load-shared (LS)/managed (LM) options, all stalls electric vehicle supply equipment-ready (provided with energized outlets).

[32] The high-rise building archetype assumes 100 units, 14 floors above grade, 108 parking stalls, and construction costs of $250/ft^2 for $25 million total.

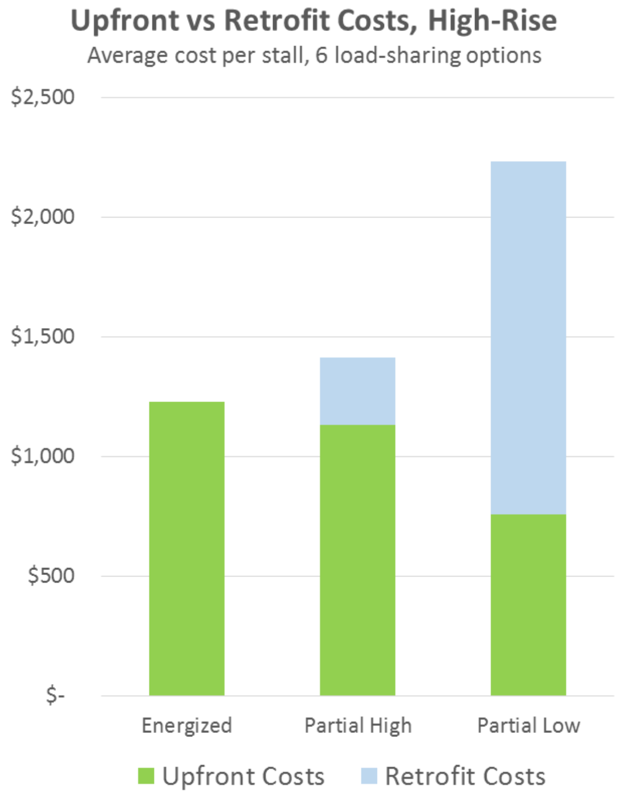

Figure 11: High-rise: electric vehicle supply equipment-ready (energized) infrastructure costs compared to two partial infrastructure options, split by upfront and future retrofit costs.

Figure 11 shows the average cost per stall[33] when implementing EVSE-ready (energized) infrastructure compared to two partial EV infrastructure configurations. The figure shows the split between the upfront costs (borne by the developer) and the retrofit costs (borne by EV owner/strata).

A partial EVSE installation with a high level of infrastructure (not including wire and outlets) averages ~$1400 per stall after all retrofits have been completed.[34] A partial EVSE installation with a lower level of infrastructure (i.e., not including conduit, wire, and outlets) averages ~$2230 per stall after all retrofits have been completed,[35] representing a cost premium of more than 80%.

Partial EVSE defers some costs to the future owner, thereby reducing initial installation costs but increasing the total cost of providing EV infrastructure. Additional challenges include convincing the strata to permit completion of the infrastructure, determining access and associated bylaws, and addressing metering/billing arrangements.

[33] The costs shown are averaged across six load-sharing options and are for configuration comparison only. Individual EVEMS costs would vary.
[34] Pre-serviced high assumes that 20% of stalls are energized and most remaining infrastructure has been installed up front (e.g., transformers, panelboards, circuit breakers, conduit). The final wire and outlets must be installed later for 80% of the stalls.
[35] Pre-serviced low assumes that 20% of stalls are energized and most infrastructure has been installed up front (e.g., transformers, panelboards, circuit breakers). The conduit, wire, and outlets must be installed later for 80% of the stalls.

Townhouse Costs[36]

Load sharing reduces costs when compared to dedicated Level 2, although it is not necessarily less costly than Level 1 (*Figure 12, Figure 13*). Note that townhouse parking configurations can vary greatly, from private parking stalls attached to individual units to shared underground parking areas, and costs will vary as well.

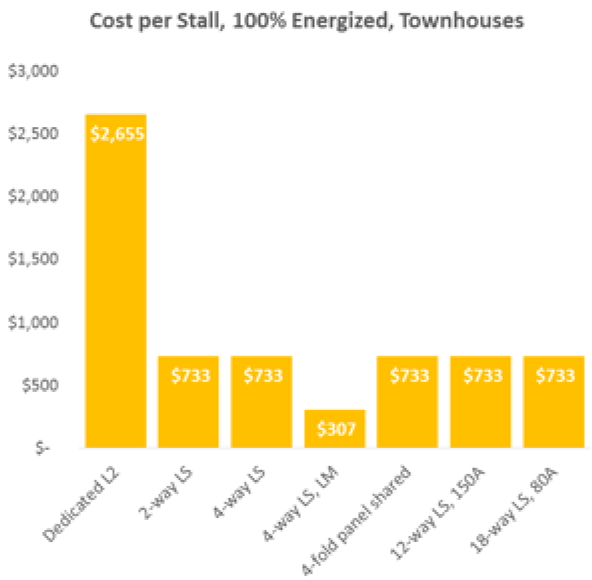

Figure 12: Townhouse: dedicated Level 2 cost per stall compared to six load-shared (LS)/managed (LM) options, all stalls electric vehicle supply equipment-ready (provided with energized outlets).

Figure 13: Townhouse: electric vehicle supply equipment-ready (energized) infrastructure costs compared to two partial infrastructure options, split by upfront and future retrofit costs.

2.6 Model Requirement Language for New Development

Definitions for Use in a Bylaw

Electric vehicle means a vehicle that uses electricity for propulsion, and that can use an external source of electricity to charge the vehicle's batteries.

Note: the definition of electric vehicle from the Canadian Electrical Code, Canadian Standards Association (CSA) C22.1 is complex and not considered necessary for use in a bylaw:

Electric vehicle—an automotive-type vehicle for use on public roads that:

a) includes automobiles, buses, trucks, vans, low-speed vehicles, motorcycles, and similar vehicles powered by one or more electric motors that draw current from a fuel cell, photovoltaic array, rechargeable energy storage system (such as a battery or capacitor), or other source of electric current;

b) includes plug-in hybrid electric vehicles (PHEVs);

c) excludes off-road electric vehicles, such as industrial trucks, hoists, lifts, transports, golf carts, airline ground support equipment, tractors, and mobility scooters for persons with disabilities.

[36] The townhouse archetype assumes 18 units, 2–3 floors above grade, with 36 parking stalls, and construction costs of $125/ft^2 for $2.5 million total.

Electric vehicle energy management system means a system 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). (2018 version of the Canadian Electrical Code [CSA C22.1-18])

Electric vehicle supply equipment means a complete assembly consisting of conductors, connectors, devices, apparatus, and fittings installed specifically for the purpose of power transfer and information exchange between a branch electric circuit and an electric vehicle. (2018 version of the Canadian Electrical Code [CSA C22.1-18])

Energized outlet means a connected point in an electrical wiring installation at which current is taken and a source of voltage is connected to supply utilization equipment. **Note:** "energized outlet" is not specifically defined in the Canadian Electrical Code. Defining energized outlet in the bylaw provides clarity on the requirement, which may be met by either a receptacle ("plug") or a junction box for permanent connection. These can be specified in a Technical Bulletin.

Level 2 charging means a Level 2 electric vehicle charging level as defined by SAE International's J1772 standard.

Example Clauses for Use in a Bylaw

(1) *For new dwelling units, all required parking spaces (or, all parking spaces provided for residential use) shall each feature an energized outlet capable of providing Level 2 charging to the parking space for charging an electric vehicle.*

Alternative language to require one outlet per residential unit rather than all residential parking spaces: *One parking space per dwelling unit shall be provided with…*

Exemptions such as visitor parking may also be added here.

(2) *Energized outlets, provided pursuant to section xx.x(1) above, shall be labelled for the use of electric vehicle charging.*

Labelling the outlet for EV charging is important to deter other non-EV uses and increase visibility of EV charging. It also ensures that the appropriate outlet is installed according to the Canadian Electrical Code.

(3) *The Director of (Planning and Building) may specify requirements for a performance standard for electric vehicle energy management systems to ensure a sufficient rate of electric vehicle charging, metering, and other technical matters related to electric vehicle charging infrastructure.*

(4) *The Director of (Planning and Building) may issue a variance for an exceptional circumstance where the requirements of section xx.x are demonstrated to be not feasible.*

This clause is not technically necessary because a variance can be issued without being stated in the bylaw. However, such a clause may alleviate concerns about the transition to EV charging requirements.

Supporting Documents: Technical Bulletin

Additional information for the developers and builders about EV infrastructure requirements can be included in a Technical Bulletin or guidelines.[37] The following technical matters could be considered:

1. **Compliance with Code:** All installations are to be compliant with the Canadian Electrical Code.

2. **Energized outlet**: An energized outlet may be either a junction box for permanent connection or a receptacle.

3. **Circuit amperage for electric vehicle supply equipment**: Although a 20A 208–240V circuit will allow Level 2 charging, few EVSE on the market are designed for 20A circuits. Doubling to 40A allows more equipment choice and provides an increased charge. If an additional 40A circuit is a concern with regard to increased panel load (and consequently the need to upsize a panel), parking stalls serviced by an individual unit such as a single-family residence could use load switching.

4. **Load switching** for residences with private parking spaces: In residences such as single detached homes, duplex homes, and townhouses that feature parking spaces exclusive to a dwelling unit (in garages, carports, or non-enclosed parking areas), the Canadian Electrical Code allows EVSE to be supplied from a branch circuit that supplies another load(s) (such as a dryer or stove). Control equipment such as a load miser (also known as a watt miser) is used to prevent simultaneous operation of the EVSE with other circuit loads so the calculated demand of the circuit is not exceeded (see CSA 22.1-15 Rule 86-300).

5. **Electric vehicle energy management systems** for shared parking areas:

    a) EVEMS refer to a variety of systems that manage the load from electric vehicle charging across multiple electric vehicle supply equipment. When multiple EVSE are supplied from a single branch circuit or panel, demand is controlled to ensure circuit rating is not exceeded. Specific electric vehicle supply equipment must be specified for a particular EVEMS, and amperage must match the particular energy management system employed.

    b) Minimum performance standard: The intention of the performance standard is to ensure that sufficient electricity is available to EVSE users to ensure a reasonable rate of overnight charging.

    The recommended minimum performance standard for EVEMS in communities with average daily driving distances less than 45 km, minimal topographic/elevation variability, and a mild, maritime climate is a minimum performance level of 12 kWh per EVSE, over an 8-hr overnight period, assuming all stalls are in use by a charging EV. A 40A 208V connection to each parking stall, with circuit sharing of up to four stalls per branch circuit, or equivalent range (additional EVSE on a circuit of greater ampacity) is sufficient to provide the minimum charging requirement, assuming provision of load management.

    The above statements should not be interpreted to preclude the use of alternative configurations to achieve the minimum performance level.

    Note: For communities in the Lower Mainland that have relatively low average daily driving distances (< 45 km/day), a minimum performance standard of 12 kWh is likely sufficient. Communities with longer driving distances, more extreme climates, and/or more mountainous terrain will require a higher performance standard to ensure that the standard provides a charge that exceeds the average daily driving distance.

[37] For example, the City of Richmond has issued a first Technical Bulletin on the EV requirements. The City of Port Coquitlam included guidelines in its Report to Council.

c) Variance required[38]: Due to a current lack of CSA standard for EVEMS (to be rectified in 2019) and to recognition of load management technologies in the Canadian Electrical Code (to be rectified by adoption of CSA C22.1-18 in 2019), approval for installation must be obtained through a variance process.39 The variance must be completed by an appropriate qualified professional, and include load calculations, detailed drawings and specifications, notification of BC Hydro (or other relevant utility) regarding the increased load, and commissioning details for the equipment. For examples, see the Appendix of the *Electric Vehicle Charging Infrastructure in Shared Parking Areas: Resources to Support Implementation & Charging Infrastructure Requirements* prepared for City of Richmond, Richmond, BC by AES Engineering Ltd., 2018.

d) Communications technology: Projects that implement EVEMS must provide for communications technology that is necessary for the function of the chosen EVEMS (e.g., cellular repeaters, wireless access points, or cabled infrastructure).

6. **Separate metering:** In strata properties that have common areas, EV electrical infrastructure should be separately metered by BC Hydro to enable the strata to easily distinguish between common area electrical use and EV charging electrical use.

   The following is one example of a metering guideline: *In a strata building with a shared parking area, a separate utility electrical meter(s) and disconnect(s) (if applicable) shall be provided in line with the electrical panel(s) intended to provide for charging of electric vehicles.*[40]

7. **User fees:** To enable user fees to be charged to individual EV owners in configurations where more than one dwelling unit is serviced by the electrical infrastructure for EV charging, the specified EVSE and/or EVEMS should be capable of tracking usage by user unless a fixed rate user fee system is used. For more on apportioning costs, see Section 4.2: Billing Rules and Electricity Cost Reconciliation Mechanisms.

8. **Building permit application requirements:** Provide information here based on your local government processes.

9. **Managing EV charging in stratas:**. See Section 4.1: Responsibility and Procedures for Electric Vehicle Supply Equipment Installation in New and Retrofit Multi-Unit Residential Buildings, and the report *Electric Vehicle Charging Infrastructure in Shared Parking Areas: Resources to Support Implementation & Charging Infrastructure Requirements* prepared for City of Richmond, BC by AES Engineering Ltd., 2018 for more information on EV management in stratas, including suggested covenants and bylaws.

[38] Note that the variance requirement will not apply once the Canadian Standards Association develops a standard for electric vehicle energy management systems, anticipated in 2019.
[39] Pursuant to Rule 2-030 (deviation or postponement) of the Canadian Electrical Code.
[40] Adapted from City of Port Coquitlam. Electric Vehicle Charging Bylaw Amendments. Report to Council. November 20, 2017, pg. 7.

3.0 RETROFITTING

As previously noted, retrofits are more costly than EVSE installation at the time of construction for all building types. Multi-unit residential buildings can be the most challenging retrofit due to costs and other barriers that come with the complexities of strata corporations, including social, institutional, and legal factors. This section outlines retrofitting barriers and provides some options for local governments to support MURB retrofits.

3.1 Cost Barriers and Solutions for Multi-Family Building Retrofits

The upfront cost of adding a charging station in an existing MURB generally includes the electrical permit, labour (including scanning and coring), materials, and EVSE. The cost range is typically $4000–$8000 per unit[41] (*Figure 14*). This immediate upfront cost can be a barrier for a resident or strata that is considering installing one or several charging units. Building owners and strata corporations must prioritize their spending, and some may assign a low priority to the installation of EV chargers when the infrastructure might benefit primarily the one or two residents who currently own plug-in electric vehicles.

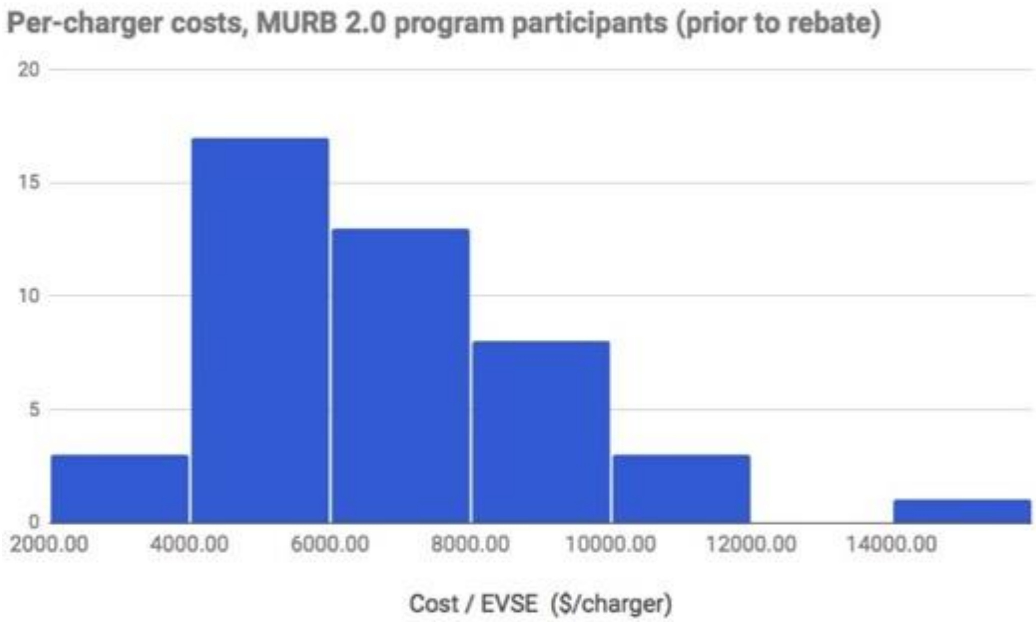

Figure 14: Costs of infrastructure retrofits. (Source: Plug In BC)

Purchase incentives can help in these situations by reducing the upfront cost. For example, the Province of British Columbia is offering an incentive through March 2020 (or until funding lasts) of 75% of costs, up to $4000, for the installation of a Level 2 EVSE in multi-family buildings. This incentive will reduce the average cost to $2800 for each installed EVSE, although some projects may incur much higher costs.

As part of the incentive program, the Province also requires an oversized conduit to be installed in the parking garage. This will make it less expensive to add future EV infrastructure because additional cables can be run through the same conduit.

If enough EV infrastructure is added to a MURB, the building will eventually reach the capacity of its electrical service. (For MURBs that are near their electrical capacity, the first EV charging station could even do so.) Multi-family buildings, therefore, face a long-term cost barrier, namely the cost of increasing electrical service to accommodate additional EV infrastructure. As a rule of thumb, this is commonly estimated at $5000 for an additional 200A of service, which is sufficient for five 40A charging stations

[41] From Plug In BC—MURB charging program; average per unit cost was $6800.

operating in parallel, or additional stations if load-sharing technology is deployed (see Section 1.4: about electric vehicle management systems). Costs could be significantly higher, however, if a distribution transformer upgrade is required. Unless all residents—or, at a minimum, all the EV owners—share in the costs of such upgrades, a situation could arise where early adopters pay much less to obtain EV charging access than later EV buyers. The perceived unfairness could cause friction within the MURB community.

An option to help solve this problem is to design for EVEMS, which allows for a greater number of parking spaces to be served within the finite electrical capacity of an existing building. If buildings were to leverage an EVEMS to redesign electrical service in their garages to accommodate EV infrastructure at each parking stall, the per-parking stall cost would be considerably lower than if EV infrastructure was added to select parking stalls in a piecemeal fashion. The benefits of such a systems-level approach are outlined in the *Electric Vehicle Charging Infrastructure in Multifamily Developments – Requirement Options and Costing Analysis* report prepared for the City of Richmond, which details the costs of different options for making 100% of parking stalls EV-ready in new builds.

The disadvantage is that while the per-parking stall cost for such a system would be considerably lower, the upfront cost would be considerably higher than a partial installation of EV infrastructure for the initial one or two stalls requested by the first EV owners. The much higher project cost could make it more difficult to secure building owner or strata approval to proceed.

3.2 Social and Legal Barriers and Solutions for Multi-Family Building Retrofits

In apartment buildings, there is generally one decision-maker. Costs are generally the biggest barrier to retrofitting, and tenants may be confronted with a landlord who denies their request for charging. The tenant may wish to apply for a dispute resolution to undergo a formal complaint; however, a landlord is not required by law to provide charging access for EVs.

In strata corporations, residents may confront many additional social and legal barriers. Any changes to common or limited common property often trigger a legal review. Strata boards tend to be risk-averse and may not feel well-enough informed to agree to EVSE upgrades or may be unwilling to invest in a legal review.

Swapping Parking Stalls

Certain stalls in a MURB may be more suited than others for EVSE. However, whether a resident with an EV can access those stalls depends on how the parking stall is held. The ability to swap or change users of a parking stall may be difficult or impossible depending on whether the parking stall is common property, limited common property, or a strata lot. Making changes to common or limited common property to enable implementation of EV charging infrastructure involves time-consuming decision-making from stratas, and often requires three-quarter or more majority votes.

Common property: In some cases, these parking stalls may be assigned, and the strata corporation has the ability to reassign them. In other cases, the common property stall may be held through a lease, and the provisions of this lease will indicate whether owners may trade stalls.

Limited common property: The ability to swap a limited common property stall depends on how it was designed. Sometimes a resolution must be passed unanimously at an annual or special general meeting. In other cases, an application may be required to amend the strata plan, which is costly and can be complex.

Strata lot: The strata corporation has no authority to swap these spaces because each space is the property of the registered owner.

Resolutions Required for Electric Vehicle Infrastructure Installation

Where MURBs are owned by strata corporations, a 3/4 strata majority is needed to pass a bylaw that allows the installation and use of EV infrastructure.[42] (While the installation of an EVSE in a parking stall may involve only changes to limited common property, running electric cables to the building panel constitutes a change to common property, and requires the strata's consent.) Residents can decline a request for EV infrastructure without reasonable cause by voting against strata resolutions; indeed, this has been the most common barrier for multi-family building EV charging retrofits.[43]

Although many requests for EV charging get passed without issue, failed resolutions do occur and often come down to the perception that EV charging will benefit only a small number of strata members: strata members who do not perceive a benefit to themselves may be unwilling to share the cost of any infrastructure upgrades. These barriers may be overcome through the presentation of clear options for cost recovery and cost sharing.

For example, one option is for the EV owner to pay for the ongoing operational costs, including the cost of electricity, some cost recovery on the infrastructure, and the network fee (if applicable). If the charging station is located in their parking stall, the EV owner could pay for the charging station hardware (EVSE) and installation as well. This reduces the financial burden on the other residents and provides transparency on how costs would be covered. A fair and balanced approach should be the goal.

Supporting Access to Electric Vehicle Charging in Existing Residential Development

Beyond financial incentives to reduce costs, education and outreach can also improve the chances of an EV infrastructure project being approved.

Plug In BC found that explaining how strata corporations can ensure EV owners are paying for their electricity (whether through metered, networked, or fixed-fee solutions) significantly improved receptiveness to the purchase and installation of EV infrastructure.

The provincial charging program has an EV Advisor who spends time with residents, strata councils, and strata memberships (at annual general meetings or special general meetings) to provide information, answer questions, and address concerns. Stratas have responded positively to the availability of a third-party information source that does not have a vested interest in selling EV infrastructure.

Local governments may consider having someone trained on staff, or in a combined Energy Advisor role, to provide this resource to residents and strata corporations.[44] There may also be an opportunity to align outreach with existing programs or regional initiatives to take advantage of cross-promotional opportunities as they arise.

Metro Vancouver's EVcondo.ca online web resource has FAQs for strata members and residents. Plug In BC's navigating stratas page has additional resources.

City bylaws that require Level 2 charging access for all parking stalls (or suites) in new multi-family buildings appear to have an impact on existing buildings as well. In Plug In BC's outreach to MURBs, strata members in communities with new-build EV infrastructure requirements have been more likely to see EV infrastructure not as a cost but as an investment in their unit's eventual resale value.

[42] In Ontario and some U.S. states, laws have been passed that make it harder to say no to charging requests in MURBs ("Right to Charge Laws"). British Columbia does not currently have this type of legislation.
[43] Plug In BC—observations from L2 MURB incentive program administration.
[44] There is likely to be a strong overlap between residents interested in building energy efficiency and those interested in electric vehicles.

4.0 STRATA RULE RECOMMENDATIONS AND COST RECONCILIATION ISSUES

4.1 Responsibility and Procedures for Electric Vehicle Supply Equipment Installation in New and Retrofit Multi-Unit Residential Buildings

Local governments should consider the following as part of rezoning and approvals processes for new MURB development:

1. Encourage developers to enter into a covenant under section 219 of the *Land Title Act*, which requires the owner of the land to keep the EVSE in operation. The covenant would be binding on the strata corporation. This is to avoid a situation where a strata council, by 3/4 vote, amends its bylaws to decommission or prevent use of EVSE.

2. Encourage developers to include the following in the strata corporation bylaws:

    e) the right of an owner, occupant, or tenant to install EVSE in the appropriate parking stall, provided they sign the Alteration and Indemnity Agreement on EVSE installation;

    f) the responsibilities of a strata corporation to manage and maintain the common property electrical infrastructure intended for EV charging, including costs of future repairs, maintenance, and upgrades to applicable electrical infrastructure, excluding EVSE;

    g) the responsibilities of an owner, occupant, or tenant with regard to installation and use of EVSE.

The following items could be considered for inclusion in strata bylaws, whether new or existing. Alternative language for [new/fully energized parking areas] and [areas requiring retrofits] is provided.

Where an owner, occupant, or tenant is requesting [to install] [the right to install] EVSE in a common property stall that is for the exclusive use of that owner:

- require the owner, occupant, or tenant to [notify the] or [obtain consent from] the strata corporation prior to the installation;
- if the strata corporation has adopted an energy management system, require that the installation, use, and removal of EVSE occur in accordance with the energy management system because it may be updated or replaced from time-to-time, and that only EVSE approved for use with the energy management system may be used;
- require the owner, occupant, or tenant to sign an Alteration and Indemnity Agreement on terms to be determined by the strata council, including the following:
    - the owner, occupant, or tenant will obtain all necessary permits;
    - [if 100% energized]: The owner, occupant, or tenant will pay for the EVSE installation costs and the cost of all future repairs, maintenance, and upgrades to the EVSE;
    - [if less than 100% energized, or a retrofit]: The owner, occupant, or tenant will pay for… (cost breakdown to be determined by the strata);
    - the owner, occupant, or tenant will pay all costs required and take all actions necessary to comply with any existing or future energy management system selected for use by the strata council, including replacing or modifying the owner, occupant, or tenant's EVSE, if necessary;
    - the owner, occupant, or tenant will comply with all applicable laws;
    - the owner, occupant, or tenant will retain qualified contractors for the purpose of installing the charging equipment;

  - [the Strata Corporation OR the owner, occupant or tenant] will be responsible for costs necessary to temporarily remove and re-install the EVSE in situations where parking lot maintenance reasonably requires such removal;
  - the owner, occupant, or tenant will be responsible for costs necessary to repair or remove the EVSE if it is no longer in safe working condition;
  - the owner, occupant, or tenant will indemnify and save harmless the strata corporation for any costs, loss, or expense of whatever kind that the strata corporation may sustain in connection with the EVSE;
- require an owner, occupant, or tenant to pay a user fee. The amount of the user fee should be established, and be fair and reasonable.

Where the strata corporation is installing EVSE for use in a common property stall that is used by multiple users:

- set out the amount of the user fee and how it will be charged and collected;
- set out how the parking stall will be used and managed, for example:
  - whether an owner, occupant, or tenant will need to obtain consent and sign a user agreement before using the stall;
  - a maximum amount of time that an owner, occupant, or tenant may use the stall;
  - whether or not visitors may park in the stall.

More information on parking assignments and legal considerations can be found in the companion report: *Electric Vehicle Charging Infrastructure in Shared Parking Areas: Resources to Support Implementation & Charging Infrastructure Requirements*.[45]

4.2 Billing Rules and Electricity Cost Reconciliation Mechanisms

The British Columbia Utilities Commission (BCUC) is currently (as of August 2018) considering whether persons (including strata corporations and private companies) who provide EV charging services for "consideration" (i.e. for compensation, including a fee) should be considered "public utilities" under BC's *Utilities Commission Act*. If they find that persons who provide EV charging services for consideration *are* public utilities, then there may be a number of additional regulatory requirements for strata corporations and others who pass on the costs of electricity and/or infrastructure used in EV charging. While the resolution of this question is expected soon, the law in BC is currently unclear.

Concurrently, Measurement Canada, a federal agency, has indicated that no person (including a strata corporation) is allowed to charge for EV charging services on the basis of individual energy use (kWh) or demand (kW) unless they use charging equipment that has a Measurement Canada-approved meter. Currently, Measurement Canada has not approved any such meters. Combined with the BCUC creates a number of limitations on EV charging services, with the most recent rules (and uncertainty) summarized below:

Municipalities and Landlords with Lease Terms of Under 5 Years

Municipalities and landlords with lease terms of less than 5 years are permitted to provide EV charging services for consideration without BCUC regulation;[46] However they are still subject to the restriction that they may not charge based on individual energy use (kWh) or demand (kW) unless they use a meter (including a sub-meter) approved by Measurement Canada.

[45] AES Engineering Ltd. 2018, Electric Vehicle Charging Infrastructure in Shared Parking Areas: Resources to Support Implementation & Charging Infrastructure Requirements. Prepared for City of Richmond, Richmond, BC.
[46] *Utilities Commission Act* [BC], [RSBC 1996] c.473 s.1 "Public Utility (d); see also "Tenant".

Strata Corporations

Currently, stratas that provide EV charging services for consideration (such as any form of fee), would likely be subject to some form of regulation as a "public utility" by the BCUC unless they are given a special exemption.[47] The BCUC is currently considering an exemption regime that could apply to stratas, although one has not yet been finalized. Stratas are also subject to the Measurement Canada restrictions described above.

Elsewhere, BC has stated that in multi-unit residential buildings, strata corporations may charge variable user fees for common property or common assets, not including to visitors,[48] provided the strata corporation has a bylaw or a rule that has been ratified under section 125(6) of the *Strata Property Act*. The user fee charged by a strata corporation may be a fixed amount or an “amount calculated on a reasonable basis,” including (but not limited to) the user’s rate of consumption, recovery of operating or maintenance costs by the strata corporation, the number of users, or the duration of use. However, it is unlikely that this provision would override the regulatory authority of the BCUC or Measurement Canada.

Assuming the BCUC provides an exemption regime in the near future, should a strata choose not to use Measurement Canada approved EVSE, alternative user fee solutions may include the following:

- billing a reasonable flat fee to all EVSE users in a building;
- billing a reasonable flat fee adjusted for each EVSE user by EV battery size and typical overnight charging usage for an average driver[49]; or
- billing based on charging time.

Businesses

Businesses providing EV charging services for consideration (i.e. any type of fee) are likely to be treated the same as stratas i.e. subject to BCUC regulation unless an exemption is created and subject to Measurement Canada restrictions regarding billing based on energy or demand.

[47] See BCUC Order No. G-119-18 issued July 4, 2018 Exhibit A-35, in Project No. 1598941 "An Inquiry Into the Regulation of Electric Vehicle Charging Service at p. 5.
[48] Effective March 7, 2018, amendments to Strata Property Regulation 6.9 (OIC 36/208 pdf) clarify that variable user fees are permitted for the use of strata common property.
[49] Note that this option must be carefully reviewed by a qualified lawyer to ensure it does not fall offside of the Measurement Canada requirement not to charge based on "demand (kW)".

5.0 SUPPORTING POLICIES AND PROGRAMS

5.1 Provincial Clean Energy Vehicle Program[50]

British Columbia introduced the CEVforBC Program in 2011 and has since committed more than $71 million to the following program areas:

- vehicle point-of-sale incentives for battery electric and hydrogen fuel cell vehicles;
- investments in charging and hydrogen fueling infrastructure;
- additional support for fleets to adopt clean energy vehicles;
- investments in research, training, outreach, and economic development.

At the time of writing, the CEVforBC Program has delivered:

- more than 6500 new clean energy vehicles on the road[51];
- more than 1300 residential and public charging stations, including 64 DC fast charging stations;
- two new hydrogen fueling stations;
- 10 research and academic curriculum projects;
- funding for electrician training;
- Emotive: The Electric Vehicle Experience outreach and awareness program.

Vehicle Incentives

CEVforBC (Clean Energy Vehicles for BC) is a provincial point-of-sale incentive that offers $2500 for EVs with batteries 2.5–15 kWh, and $5000 for EVs with batteries > 15 kWh (vehicles over $77,000 are not eligible). This program is administered by the New Car Dealers Association of BC. www.cevforbc.ca

Specialty-Use Vehicle Incentive (SUVI) Program is a provincial program that provides rebates on EVs that are not captured through the CEVforBC Program, and includes electric motorcycles, light-duty EVs, trucks, port vehicles, and buses. The program is available to individuals and fleets, but individuals may access incentives only for low-speed vehicles and electric motorcycles. Fleets may access all vehicle categories. The program is administered by Plug In BC (of the Fraser Basin Council). A list of eligible vehicles is provided on the program website: www.pluginbc.ca/suvi

The **BC Scrap-It Program** is a voluntary vehicle retirement program that provides incentives to scrap older vehicles. This program includes EV incentives that offer $6000 toward a new eligible BEV or $3000 toward a used BEV. In addition to the EV incentives, they also offer incentives for electric bikes, mobility scooters, BC Transit passes and car share credits. The program is administered by BC Scrap-It: www.scrapit.ca

[50] From the Province of British Columbia website, with some updates from Plug In BC https://www2.gov.bc.ca/gov/content/industry/electricity-alternative-energy/transportation-energies/clean-transportation-policies-programs/clean-energy-vehicle-program
[51] At the time of writing, there were more than 10,000 plug-in electric vehicles in British Columbia. The discrepancy in figures is due primarily to a 1-year hiatus in the CEVforBC Program, not all purchasers applied for rebates, not all vehicles qualified for CEV rebates, and there was a healthy demand for used electric vehicle imports from the United States.

Infrastructure Programs

Charging Solutions & Incentives is a provincially funded program administered by Plug In BC that provides incentives toward single-family homes (rebates for 75% up to $750 per L2 station), multi-family buildings (incentives for 75% up to $4000 per L2 station), and workplaces (incentives for 75% up to $4000 per L2 station and $2000 per L1 station). The program is intended for retrofits (not new buildings), and as of March 7, 2018, is offered on a first-come, first-serve basis. Additionally, the program offers EV advisory support to assist in pursuing EVSE installations in workplaces and MURBs. www.pluginbc.ca/chargingsolutions

EV Condo is an online resource by Metro Vancouver that offers information for EV owners, strata councils and property managers, on typical steps in the EVSE deployment process. The website also includes an EV friendly strata registry for buildings that offer charging or that have bylaws supporting EV charging. www.evcondo.ca

EV Workplace is an online resource by Metro Vancouver that offers information for employers on how to set up EVSE for their employees. www.evworkplace.ca

High Occupancy Vehicle Access

The high occupancy vehicle (HOV) lane incentives came into effect March 2, 2016. Electric vehicle owners can apply for a free decal to travel in HOV lanes, even if they are the only vehicle occupant.

5.2 Corporate Supply Agreement

This supply arrangement is for Level 2 charging station supply, or supply and install, and applies to British Columbia government ministries and the broader public sector, including local government, grouped into six regions, for purchases up to $10,000. See http://www2.gov.bc.ca/gov/content/governments/services-for-government/bc-bid-resources/goods-and-services-catalogue/ev-charging-stations

5.3 Emotive Outreach Campaign

Emotive: The Electric Vehicle Experience is a British Columbia-wide campaign that aims to raise public awareness of electric vehicles in order to encourage their adoption. This campaign was launched in 2014 through a partnership with the Fraser Basin Council, Province of British Columbia, Metro Vancouver, City of Vancouver, and City of Surrey, and in collaboration with several additional EV stakeholders from industry and end-users. Market research helped inform the communications strategy, which focuses on the tactile experience of EVs by showcasing their performance, convenience, and benefits.

The program includes a campaign toolkit that can be adopted by local governments to deliver Emotive activities and events within their regions. As of June 2018, provincial incentives are also available to support Emotive outreach activities. For more information, go to www.pluginbc.ca/outreach

APPENDIX 1: ADDITIONAL INFORMATION ON ELECTRIC VEHICLES

Life Cycle Emissions Impacts

Life cycle greenhouse gas emissions from EVs are lower than those of equivalent-size combustion engine vehicles. In regions with clean, low-carbon electricity, the emissions can be significantly lower, as has been borne out by numerous studies.

For example, an assessment by the Union of Concerned Scientists concluded that the source of electricity is the most critical factor in the full life cycle impact of electric vehicles:

> The two main stages of a car's life, emissions-wise, are its manufacture and its use—i.e., driving it. We found that driving on electricity produces lower emissions than the average new gasoline vehicle (rated at 29 miles per gallon)—in any region of the country. Moreover, in regions where 66 percent of Americans live, driving on electricity produces lower emissions than those of a 50-miles-per-gallon gasoline vehicle.
>
> …In manufacturing, a battery-electric vehicle (BEV) can have higher emissions, mostly from producing its lithium-ion battery. Assuming the average U.S. electricity grid mix, making an 84-mile-range midsize BEV typically results in 1 ton of global warming emissions—15 percent more than from manufacturing[52] a similar sized gasoline vehicle. However, this manufacturing gap is more than offset by the BEV's emissions advantage when driving.[53]

Estimates from the literature suggest that "disposal accounts for less than 5% of the global warming emissions attributable to the production of the vehicles."[54] Since most EVs are still on the road, large-scale disposal emissions data have not yet been collected. Non-EVs are disassembled and reused/recycled with only a small portion going to landfill; the same will be true of EVs, except for the batteries, which can be reused and recycled. They are unlikely to be landfilled due to the value of the metals they contain.

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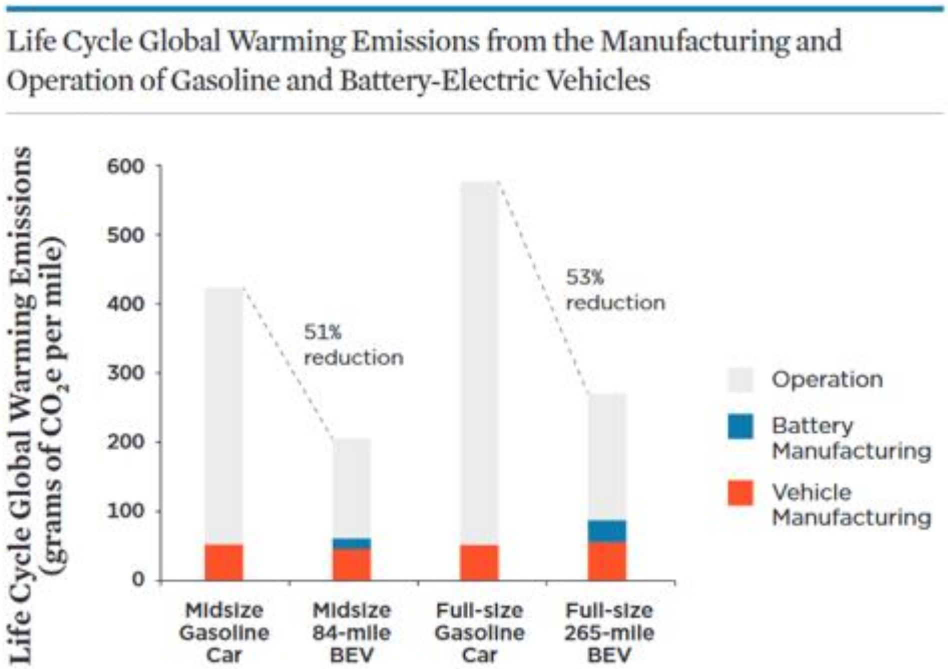
[52] Note: In some studies, the energy intensity of producing batteries for EVs can almost double the total manufacturing emissions. Still, emissions break even at 30,000 km. See: Poovanna P. Davis R. Argue C. EVs are the better choice for Canadians who choose to buy a car — electrifying the vehicles on our roads could be part of the climate change solution, Policy Options 2018. http://policyoptions.irpp.org/magazines/july-2018/electric-vehicles-as-part-of-canadas-climate-change-solution/

[53] http://www.ucsusa.org/sites/default/files/attach/2015/11/Cleaner-Cars-from-Cradle-to-Grave-FAQ.pdf

[54] Union of Concerned Scientists. 2015. Cleaner Cars from Cradle to Grave: How Electric Cars Beat Gasoline Cars on Lifetime Global Warming Emissions. pg. 20. See also https://www.ucsusa.org/clean-vehicles/electric-vehicles/life-cycle-ev-emissions#.Wut-4-Q3kso



Battery Recycling

Currently, most electric vehicle batteries are warranted for 8+ years, and it is too early to model impacts of automotive lithium ion battery recycling based on real-world data. Projected end-of-life uses are manufacturer recovery for secondary use, followed by recycling. Examples of the former include Toyota's use of old Prius batteries as backup power and energy storage for dealerships[55] and Nissan's sale of used Nissan Leaf battery packs to companies such as FreeWire Technologies for use as mobile EV chargers.[56]

While still in their infancy, secondary-market opportunities are being developed, such as electric grid energy storage. These applications allow battery cells, which may still have 70% of their storage capacity after 10 years of use, to be repurposed.

Recycling processes and facilities are also currently under development. China's GEM has established itself as a battery recycling industry leader, and Nissan announced the building of a plant in Japan to recycle lithium-ion EV batteries in a joint venture with Sumitomo Corp (operated by 4R Energy Corporation).[57] In British Columbia, long-established battery recycling company Retriev Technology claims to recover 75% of the weight of incoming cells. Their process focuses primarily on recovering cobalt, nickel, and copper.

[55] https://www.toyota-europe.com/world-of-toyota/feel/environment/better-earth/reuse
[56] https://insideevs.com/freewire-mobi-charger-puts-nissan-leaf-batteries-use-mobile-charging-unit-wvideo/
[57] https://newsroom.nissan-global.com/releases/release-487297034c80023008bd9722aa069598-180326-01-e