Vancouver's *EV Ecosystem Strategy*

City of Vancouver
November 2016

Vancouver's *EV Ecosystem Strategy*

Summary

The *EV Ecosystem Strategy* builds on the City's experience with electric vehicles, or "EVs", since 2007; and, formalizes the City's role in the expansion of charging options until the year 2021.

As part of the *Renewable City Strategy*, the City committed to developing an electric vehicle infrastructure strategy to support the transition to renewably-powered transportation, this is the first five-year strategy to make that a reality.

What is an EV Ecosystem?

Electric vehicles integrate into the urban environment and daily life in a way that fossil-fueled vehicles cannot. EVs can charge on any accessible electrical outlet, but at the same time require charging times that are much longer than is required to fill up with a liquid fuel. EVs can be fueled at night in a person's garage, at their workplace parking stall, while buying groceries or stopping for a morning cup of coffee. At the same time, a typical day of driving in Vancouver requires about 4 hours charge time on a wall outlet, one hour on a "Level 2" station or about 3 to 5 minutes at a Fast Charging Station.

In expanding access to EV charging in Vancouver, the City considers all of these interactions and the required time to charge a car. The integration of EV infrastructure into the community requires an understanding of the types of homes and businesses in each neighbourhood, the existing EV charging network, and the amount of time residents spend at different services in that area.

EV infrastructure, as an increasingly important community amenity, can also be integrated with car-sharing services, and be located such that it ensures a continued shift to increased walking, cycling and public transit. For example, by placing EV charging stations at a Skytrain station that is also equipped with bike share bicycles, users can charge their vehicle in one place, comfortably shift to cycling or transit for other parts of their journey, and then return to a vehicle that has been charged at a cost far less than for the equivalent amount of gasoline.

By increasing access to EV infrastructure through a holistic view into how it fits into city life, the *EV Ecosystem Strategy* will enable the majority of Vancouver residents to "go electric" and continue Vancouver's transition to renewable transportation.

Primary Goals of the *EV Ecosystem Strategy*

1. **Accessibility:** Improved access charging infrastructure
2. **Affordability:** Reduced cost barriers to EV uptake
3. **Economic Opportunity:** Develop a market large enough to support private sector operation of EV charging infrastructure

Why the City Needs To Lead With This Strategy

The business case for private sector management of publicly accessible EV infrastructure has three key barriers that require the City to counter as an early market supporter. The success of this strategy will result in a future where the private sector plays a significant role in providing access to EV charging.

1. A private sector business that operates one or more EV chargers is deemed to be a "public utility" under the *BC Utilities Commission Act* and cannot currently sell electricity for a fee without having to first obtain approval, or an exemption, from the BC Utilities Commission ("BCUC")[1]. Since this limits the mechanisms for cost recovery or a positive return on investment for EV infrastructure, this poses a barrier to private sector operation of EV chargers and expanded access for users.

2. The City, as a municipality, is not deemed a "public utility" under the BC Utilities Commission Act but remains subject to certain technical restrictions under the Act and BC Hydro's rate tariff. The City, however, can take the lead in working with the Province, BC Hydro, and the BC Utilities Commission to clarify or streamline these regulations.[2]

    - The *EV Ecosystem Strategy* **advocates for provincial, BCUC and BC Hydro support for more clarity, blanket exemptions or more streamlined and appropriate regulations under the *BC Utilities Commission Act* as they apply to private sector businesses and municipalities**

3. The number of electric vehicles currently on the road is too small to create adequate demand for public stations; conversely, a lack of charging options means fewer people can switch to an EV.

    - The *EV Ecosystem Strategy* **enables increased access to EV charging through land use policy, building code and other City by-laws and deploys public infrastructure that can substitute for home and workplace charging.**

4. Costs to retrofit buildings with EV charging are prohibitive for property owners and residents

    - The *EV Ecosystem Strategy* proposes to develop programs to encourage the **retrofitting of existing multi-family and workplaces with EV charging infrastructure and advocates for the Province to do the same.**

    The *EV Ecosystem Strategy* will support the early EV market by ensuring charging infrastructure is present, available and reliable. The strategy reserves the option for the City to transition away from providing and operating infrastructure once a market size large enough to support private sector investment is achieved, which is estimated to be about 5-7 years away.

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[1] The *BC Utilities Commission Act* is mainly designed to regulate large, institutional sellers of electricity and other utility services and not EV charging specifically. This activity nevertheless falls within the Act due its broad scope. This can be very onerous in terms of time and cost relative to the low margins and small-scale nature of potential EV operators at this early stage in the industry.

[2] Until such clarification or streamlined regulation takes place, the City will move forward carefully in respect of City operated EV chargers with the support of the Province and BC Hydro. In light of the Province's and BC Hydro's strong support and encouragement of municipalities to operate and expand access to EV chargers, the City is optimistic that they will be supportive of clarifying or streamlining regulation for EV charging.

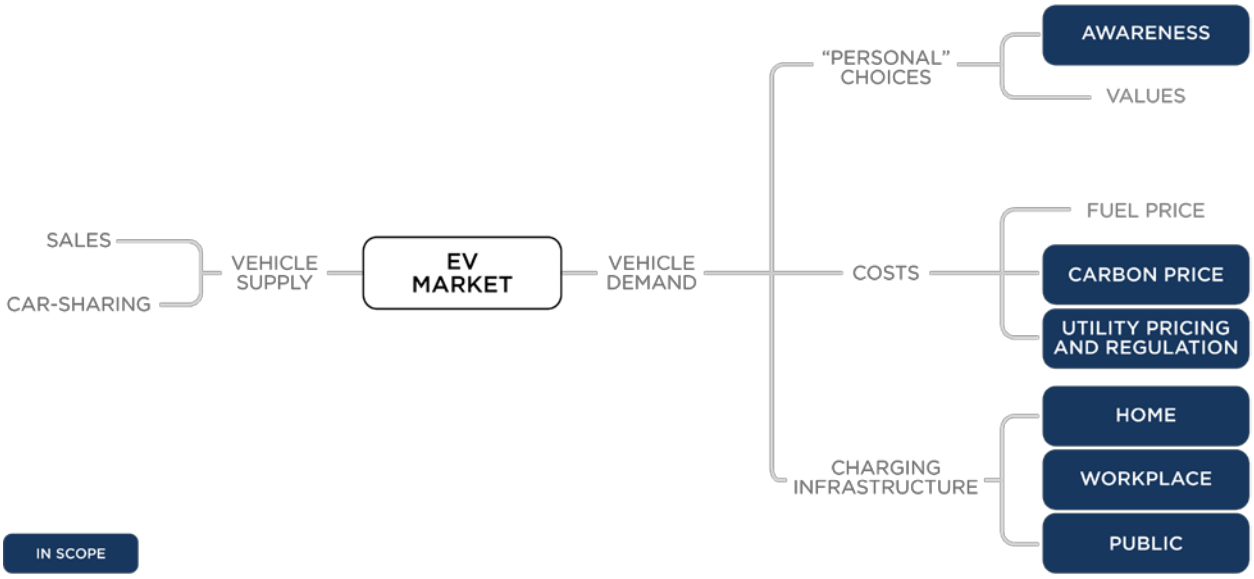
Scope of the *EV Ecosystem Strategy*

- Deployment of EV charging infrastructure in residential, public and workplace contexts.
- Communications and public awareness opportunities promoting EV infrastructure and leveraging that infrastructure to create awareness of electric vehicles

Not Discussed in This Strategy

The following are an important part of the successful transition to Renewable Transportation; however, many are outside of the City's jurisdiction or are addressed through other City policies, and are not included as part of this strategy.

- Electrification of public transit or heavy-duty vehicles
- The use or integration of electric vehicles in the City fleet
- Fuel standards
- Fossil fuel pricing
- Electrification of, or infrastructure for, non-road vehicles
- Hydrogen-fueled vehicles



The EV Market and the Scope of the *EV Ecosystem Strategy*

Barriers to Widespread EV Adoption

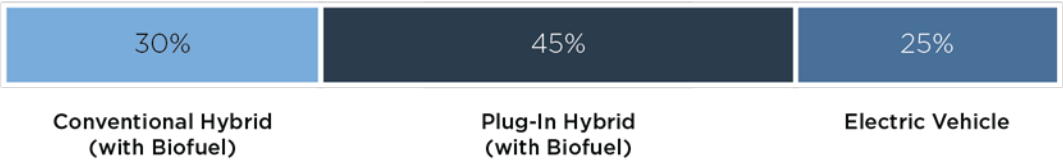
1. Most Vancouverites do not have access to charging at a home or workplace parking stalls.
2. The current public charging network does not meet user needs due to:
   a. Long charging times in public locations are often out of step with drivers' needs

b. Many stations are in use most of the time and are not perceived as an available amenity to new EV drivers

c. Stations are managed on an *ad hoc* basis, leading to reduced reliability of the network, which in turn can be more negative than the absence of stations

d. Failure to increase public awareness of EVs and charging infrastructure

3. When only charged overnight, EVs with ranges less than 200km are not practical for most Canadians as a primary vehicle.
4. The business case for deployment of EV infrastructure has high risks for the private sector from a lack of certainty on cost recovery, due to low vehicle numbers and regulatory burden of selling electricity.
5. Current EV uptake is strong, but the current charging network and building code requirements will not meet the vehicle electrification goals of the *Renewable City Strategy*.



***Renewable City Strategy*: Passenger Vehicle Count by Vehicle Type in 2050**

Approximately 70 per cent of light-duty vehicles will plug into an external power source, according to modelling done for the *Renewable City Strategy*. Current *Vancouver Building By-law* requirements are for 20 per cent of parking stalls in new multi-unit residential buildings have EV charging circuits. With most Vancouver residents already living in such buildings (and increasing as the city densifies), a much higher proportion of parking stalls will need EV charging capabilities to support the transition to electric mobility.

Aims of the *EV Ecosystem Strategy*

1. Maximize access to EV charging
2. Improve community experience and knowledge in vehicle charging
3. Displace fossil fuel kilometres travelled with electric kilometres
4. Create the conditions for EV infrastructure to eventually be a viable private enterprise option
5. Establish an electric vehicle ecosystem to support the transition to 100% renewable transportation before 2050.

Strategic Approach and Actions

The strategy seeks to build an EV "ecosystem" that incorporates different charging technologies to meet different user needs in different contexts. This will be done through three primary approaches:

Expanded access to home and workplace charging; an improved public charging network; and, integrating electric vehicle infrastructure planning and management into City processes.

1. *Expanded access to home and workplace charging through:* [Supports Aims 1, 2, 3 & 5]

Flexibility: Create more flexible EV charging requirements in buildings that reflect building use and that can adapt to changing technologies and occupant needs.

- ***Flexible Requirements Quick Start:*** Move development-specific elements of EV charging requirements (e.g., – number of stalls equipped) to the *Vancouver Parking By-law*.
- ***Curbside Pilot Quick Start:*** Explore the potential for and implement, if feasible, a curbside charging pilot program for commercial business and single-family home owners who do not have access to off-street parking.

Simplicity: Simplify and expand construction requirements and ensure that any building not built with 100% of parking stalls EV-enabled is equipped for simple upgrades.

- ***MURB Quick Start:*** Evaluate cost-effective means to require some degree of EV charging access to 50% of stalls in new MURBs.
- ***Standards of Maintenance Quick Start:*** Update Vancouver's *Standards of Maintenance By-law* to require existing EV charging equipment (including outlets for e-bikes and e-scooters) are reasonably accessible.
- ***Panel Exemption Quick Start:*** Remove 200A panel exemption for new construction of one- and two-family homes under the *Vancouver Building By-law*.

Visibility: Require builders to provide specific and highly visible labelling of dedicated charging electrical supply in new homes; include promotion of other EV incentives.

- ***Visibility Quick Start:*** Update construction requirements for the labeling of EV charging circuits and create sample media and guidelines for builders.

Retrofit Support: Develop programs to encourage the retrofit of MURBs and workplace parking with EV charging. For any programs directed at MURBs, timelines of at least two years must be considered to obtain adequate participation.

Advocacy: The City will advocate for provincial regulations that guarantee residents' access to EV charging if available. Continue to promote evcondo.ca.

2. *Improve The Public EV Charging Network* [Supports Aims 1, 2, 3, 4 & 5]

Integrated Planning: Incorporate charging hubs – with an emphasis on Fast Charging, so-called "EHubs" - into community development options and into the redevelopment of existing parking facilities. Location planning will also incorporate models developed by the UBC Transportation, Infrastructure and Public Space Lab to determine ideal areas within the City for Fast Charger deployment.

Expanded Access: Increase availability of Level 2 charging infrastructure in public parking for City buildings and expand to all community centres.

- ***Network Review Quick Start:*** Review all existing public Level 2 stations on City property to identify those with limited availability and/or monitoring capabilities.

Fair Access: Establish controls for City-owned public EV charging infrastructure and support businesses in EV charging infrastructure adoption.

- ***Fair Access Quick Start:*** Create and implement a fee structure for existing public Level 2 charging stations that will encourage use of home charging where available, but still provide a significant cost incentive compared with fossil fuels.
- ***Utilities Commission Quick Start 1:*** Create a template model to support local businesses in applying to BCUC for EV charging regulatory exemptions. Pilot an initial run through BCUC with a large supplier of EV charging in the City.
- ***Utilities Commission Quick Start 2:*** Work with large EV station hosts (e.g., EasyPark) to advocate the Province, BCUC and BC Hydro for blanket exemptions or more streamlined and appropriate regulation under the *BC Utilities Commission Act*.

Improved User Experience: Create a consistent look and feel for all public stations managed by the City, including the method by which users can access stations and pay fees.

- ***User Experience Quick Start:*** Investigate and, where appropriate, implement options for network interoperability between the existing five EV charging data networks managed by the City. Includes potential connections with PayByPhone, VanConnect, Compass, Treo and other mobile payment technologies.

Financed Partnerships: Many ideal locations for Fast Charging EHubs are not on City land. The City will partner with other organizations that can provide siting for EHubs, with the City providing financial support for their development.

3. Integrate Electric Vehicle Infrastructure Deployment into Core City Processes

[Supports Aims 1, 2 & 5]

Integrate Public Charging with Community Planning: Subject to Council, Engineering and other necessary approvals, include EV infrastructure as an Engineering Community Amenity Contributions, create planning guidelines for EV Infrastructure Deployment and integrate EV charging deployment with new developments and large re-developments.

- ***Operating Sites Quick Start:*** Operate and administer (via Engineering Services) existing City-owned charge station network and work with external network operators to maintain high station uptimes and availability.

Coordinate EV Infrastructure Management through an internal EV Task Force

- ***Training Quick Start:*** Train Building and Development Services staff on EV charging requirements, technologies, and potential configurations in building construction. Training on these requirements will subsequently be disseminated to contractors.
- ***Metering Quick Start:*** Install BC Hydro meters for existing EV charging at all City-owned buildings for energy management tracking.

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How to Read This Strategy

The *EV Ecosystem Strategy* provides a direction on the deployment of electric vehicle infrastructure in the City of Vancouver until 2021, embedded within the longer term view of achieving 100% renewable transportation before 2050. It does not provide specific regulatory language, but in some cases by-law changes are recommended with specific intentions. The strategy is structured to provide an overview of what an EV Ecosystem is and how the strategic approach was achieved. In each of the three major sections detailing the strategic approach (*Home and Workplace Charging*, *The Public Charging Network*, and *Integration: Electric Vehicle Infrastructure Planning and Management*), the following structure is followed:

- a contextual overview of the section
- a brief summary of actions
- a detailed discussion of the relevant challenges facing the community;
- actions that the City will take to achieve the strategic aims; and,
- a summary of the residual risks to the City and how the City can mitigate to them.

Throughout the document, reference is made to the City of Vancouver or "the City," which refers to the municipal corporation, while references to the "city" (with a lower-case "c") make reference to the community as a whole. In addition, references are made interchangeably between "electric vehicle" and "EV", both of which refer to plug-in electric vehicles, but not conventional hybrid vehicles or hydrogen fuel cell electric vehicles.

Finally, the strategy refers to "public" charging. In this context, "public" refers to any charging station that is available to the general public, either on City-owned or private property; and, may in some cases refer to contexts where charging may only be available to patrons of the entity that owns the site in question. This is in contrast to "residential" and "workplace" charging, where only specific individuals are given access to charging infrastructure.

1. Objective

The objective of the *Electric Vehicle Ecosystem Strategy* is to formalize the City of Vancouver's role as a provider of and a market enabler for electric vehicle charging access as a community amenity over the next five years.

2. Introduction

Vancouver Is Well-Suited to Electric Vehicles

Vancouver has what is needed to successfully support the widespread adoption of electric vehicles ("EVs") among residents, businesses and visitors alike. Serviced by a clean and reliable electrical system, which also powers much of the city's transit service, Vancouver is in a strong position to support the electrification of personal transportation choices.

- Vancouver is already a world leader in the development of complete, compact, and liveable communities with approximately 95 per cent of trips taken under 30 km, and approximately 70 per cent of trips taken under 10 km, making people's travel patterns well-suited to operating EVs.
- The City of Vancouver has its own building code that has supported EV charging infrastructure in new construction since 2009.
- The public in British Columbia tends to be "early adopters" of green technology, with a 2.1 times higher adoption rate of hybrids than the Canadian average, and the highest per-capita EV uptake in Canada.

EVs present a key opportunity for Vancouver to continue to reduce transportation Greenhouse Gas (GHG) emissions, improve local air quality, increase electrical grid resilience, and integrate renewable energy into the system.

The *EV Ecosystem Strategy* continues the City of Vancouver's climate leadership by cementing its role in the provision and market incubation of EV charging infrastructure until 2021, and catalyzing the transition from fossil-fueled vehicles to EVs over the coming years.

Affordability

Electric vehicles are often viewed as expensive choices and not appropriate for the mainstream. However, with more affordable options coming to market and a growing number of used EVs now available, they are becoming accessible to a wider part of society. One key barrier to their uptake, as described subsequently in this document, is the up-front capital cost of installing infrastructure. Retrofitting existing buildings with electrical supply that supports EV charging is approximately 2.5 times as expensive as installing the same equipment in a new building. To overcome this key barrier, an obvious choice is to ensure that as much supply is guaranteed to residents when a home or workplace is constructed.

Further, the ability for lower income individuals and families to access electric vehicles can actually save money over time. While the up-front capital cost of EVs is higher than equivalent internal combustion powered vehicles, the total cost of owning a vehicle – from purchase through to resale – is often lower. Within the decade, the purchase price is expected to be less than that of internal combustion powered

vehicles, without government intervention. In the meantime, progressive financial institutions are finding ways to reduce cost barriers, with loans specifically targeting low-carbon vehicles.

Current BC Hydro residential electricity rates ($0.13/kWh) mean that the cost to charge an EV at home is equivalent to purchasing gasoline that costs about $0.20 to $0.30 per litre. And since BC Hydro rates are highly regulated and do not have large fluctuations over time, cost-conscious drivers have greater certainty on their transportation costs.

On top of low fuel costs, EVs have few maintenance costs, requiring no oil or transmission fluid and have far fewer moving parts than an internal combustion engine. This again reduces the costs (often unexpected) of maintaining a vehicle.

Equity and Environmental Justice

In some contexts – such as social housing – car-sharing is less commonly implemented than in other residential contexts. While some of this is a result of lower awareness by residents, some is a result of means: smartphone-driven technologies like car-share may not be an option for those without access to the technology. The same may be said of some EV charging technologies. People with lower incomes may also have less flexibility with employment, with jobs that have schedules or locations that are not well supported by walking, cycling, transit, or car-sharing. Policies that are perceived as affecting transportation habits may therefore be perceived as a threat to employment status.

Many leading US cities – including Portland, OR and Los Angeles, CA – are creating specific programs that provide access to EVs to low-income residents. The City will continue to collaborate with these cities and to amplify their successes.

The City of Vancouver, in applying the *EV Ecosystem Strategy*, will ensure that EV charging that is required in lower income housing presents options for reasonable and accessible technologies to the residents. Residential charging solutions for any multi-family scenario must also ensure individuals pay for their own transportation, and that this cost is not passed on to other residents. As the EV market matures, incentives (financial or otherwise) that target low-income residents and would enable access to low-cost EVs should be considered by the City.

The impacts of fossil fuels – from diminished air quality and contaminated sites to climate change – impact the lowest income members of society disproportionately. Environmental justice considerations must be acknowledged: the most vulnerable members of society will have the biggest health benefits from improved air quality and a more stable climate. Ensuring that all residents are given opportunities to switch to electric vehicles, and encouraging those that have the ability to make this switch, is an important goal that will impact the health and well-being of all our residents.

An Ecosystem Perspective

The City of Vancouver considers electric vehicles in terms of how they fit into a broader, inter-related and inter-dependent urban system. This system is comprised of a transportation network that prioritizes, in terms of both policy and actual mode share, walking, cycling and public transit over

automobiles[3]. This system is also dependent on the housing types and densities of different neighbourhoods throughout the city, and different amenities and public services available in those neighbourhoods, including the existing EV charging that is available.

In addition to the built form of Vancouver, this interconnected system is also comprised of builders, vehicle manufacturers and dealers, technology providers, public utilities and other levels of government, and the end receivers of transportation services: the people who live, work and play in Vancouver. The characteristics of each can create or remove barriers to EV uptake.

The strategy looks at the interplay between public space, workplaces, homes, transportation networks and public amenities that connect us. These factors affect why and how we make transportation choices and the effectiveness of policies aimed at transitioning to EVs. The strategy considers current and potential policies from different levels of government and utilities that can affect the transition to electrified transportation.

The *EV Ecosystem Strategy* considers the private sector's current and future role in providing vehicle and charging options to the public. Commercially available electric vehicles have been on the British Columbia market since 2011, approximately doubling in numbers year-over-year. Electric vehicles must, by definition, have access to an electrical source to charge. From 2011 to 2014, the City of Vancouver deployed public EV infrastructure in lockstep with vehicle uptake, as part of the Federation of Canadian Municipalities (FCM)-funded field trial conducted by the City.

The strategy is part of a broader suite of City policies that enable a rapid transition to EVs. In November 2015, Vancouver City Council adopted the *Renewable City Strategy*, which commits to deriving 100 per cent of Vancouver's energy, from renewable sources before 2050. This is necessary in Vancouver and worldwide to reduce GHGs to minimize the catastrophic social and economic impacts of climate change.

Gasoline and diesel account for approximately 23 per cent of the total energy use in Vancouver, and approximately one-third of all fossil energy use in Vancouver. By transitioning to electricity as a transportation fuel, electric vehicles will play a key role in Vancouver's transition to renewables, as electricity in British Columbia is derived largely from hydropower and is legislated to be 93 per cent renewable.

[3] The City's goal of generating more than half of all trips in Vancouver from walking, cycling or public transit by 2020 was reached in 2015, five years ahead of the target.

3. Scope

Vancouver's *EV Ecosystem Strategy* outlines the City's role and direction related to the planning, installation, operation and decommissioning of electric vehicle charging infrastructure within the following boundaries:

Geographic: within the Vancouver city limits.

Locations: residential, workplace and public charging.

Technologies: all current or expected technologies, including Level 1, Level 2 and Fast Charging technologies, both wired ("plug-in") and wireless charging.

Vehicles: primarily focused on light-duty passenger vehicles, including personal and shared vehicles, with a secondary focus on electric scooters, electric bikes, and commercial fleets.

Outside the Scope of Vancouver's *EV Ecosystem Strategy*

The *EV Ecosystem Strategy* is part of a broader policy context, described in Section 5. This strategy will not address issues related to:

- Electrification of public transit or heavy-duty vehicles
- The use or integration of electric vehicles in the City fleet
- Fuel standards
- Fossil fuel pricing
- Electrification of, or infrastructure for, non-road vehicles
- Hydrogen-fueled vehicles

The above excluded items are important parts of the successful transition to renewable transportation; however, many are outside of the City's jurisdiction or are addressed through other City of Vancouver policies, and are not included as part of this strategy. Figure 1, below, describes the scope of the *EV Ecosystem Strategy* from the perspective of an EV supply and demand ecosystem.

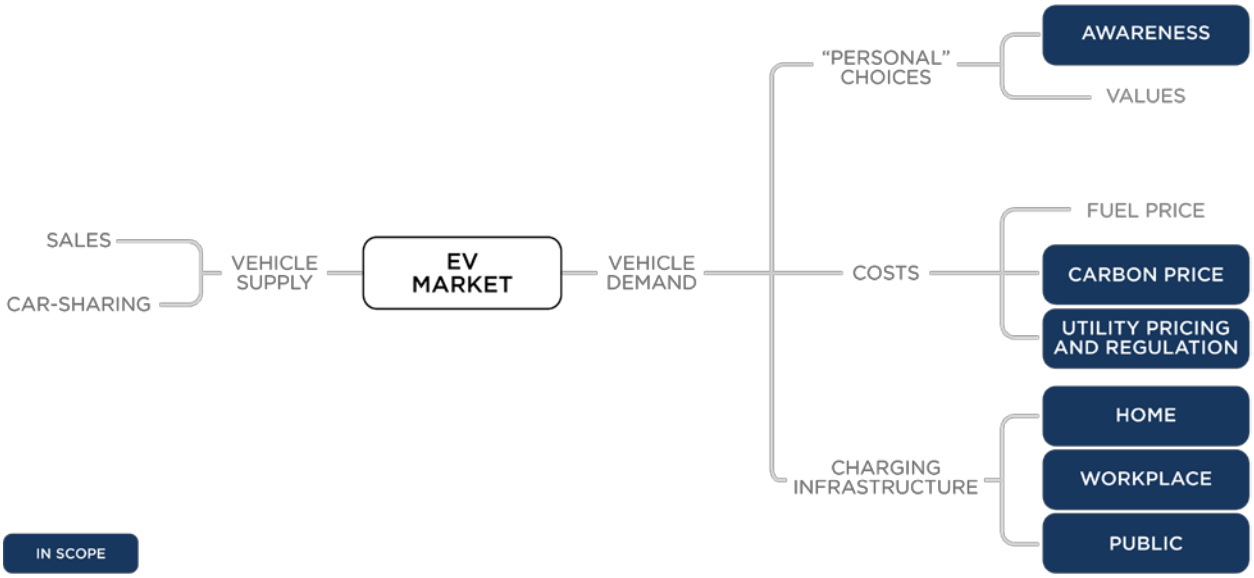

Figure 1 - The EV Market and the Scope of the *EV Ecosystem Strategy*

4. Where We Are Now

The City has supported the transition to electric vehicles since 2007, and since that time has:

- amended the *Vancouver Building By-law* to require electrical supply for electric vehicles in new developments, and recently to ensure minimum power outputs and the ability to use electrical load management technologies,
- installed 114 public, residential and fleet EV charging stations through its *Charge and Go* EV infrastructure field trial—the only multi-vendor infrastructure trial in the world. The public stations complement approximately 170 EV charging stations installed by private owners, for an estimated total of 250 publicly accessible stations in the City of Vancouver in 2016,
- replaced 33 light-duty fossil fueled City of Vancouver fleet vehicles with EVs, and committed to a total of 115 fleet EVs in service by 2020,
- partnered with Telus to integrate EV charging with cellular monopoles at four locations,
- worked with Modo to enable EV car-sharing locations,
- partnered with BC Hydro to install a direct current "fast charge" station at Empire Fields, and
- partnered with the Province of BC, BC Hydro, Metro Vancouver and others to develop and deliver the *Emotive* electric vehicle public outreach program in the Lower Mainland.

Barriers to Widespread EV Adoption

Despite the suitability of Vancouver for electric vehicles, and a general interest from Vancouver's residents– and Canadians in general – to consider electric vehicles, some critical barriers remain to the widespread adoption of EVs. Five main barriers are as follows and are addressed in the *EV Ecosystem Strategy*:

1. The majority of residents today do not have access to charging at a home or workplace parking stall.
2. The current public charging network does not fully meet EV drivers needs due to:
    a. Existing network does not adequately enhance the limited public awareness of EVs and charging infrastructure availability
    b. Charging times in public locations often require more time at a location than drivers can reasonably spend
    c. Many stations are in use most of the time and are not perceived as an available amenity to new and prospective EV drivers
    d. Charging stations are managed by Sustainability Staff on an *ad hoc* basis, leading to reduced reliability of the network and lengthier downtimes, which in turn can be more negative than the absence of stations altogether

3. When only charged overnight, EVs with ranges less than 200km are not practical for most Canadians as a primary vehicle[4].
4. The business case for EV infrastructure is weak for the private sector, namely, because there is a lack of certainty on cost recovery due to current low vehicle numbers and regulatory restrictions on selling electricity.
5. The current charging network and *Vancouver Building By-law* requirements do not support enough charging infrastructure to meet the needs of current or projected growth in EVs as outlined in Vancouver's *Renewable City Strategy*.

Other key barriers identified in independent studies[5] and through public consultation include the cost of purchasing an electric vehicle and the limited number of suitable electric vehicle models. While these are outside of the City's authority to change, efforts to increase the affordability of the infrastructure do reduce the cost to purchase an EV.

EV Ecosystem Strategy in Context

The *EV Ecosystem Strategy* is part of a broader context comprised of municipal, regional, provincial and federal policies. Figure 2, below, outlines the broader policy context surrounding the *EV Ecosystem Strategy*.

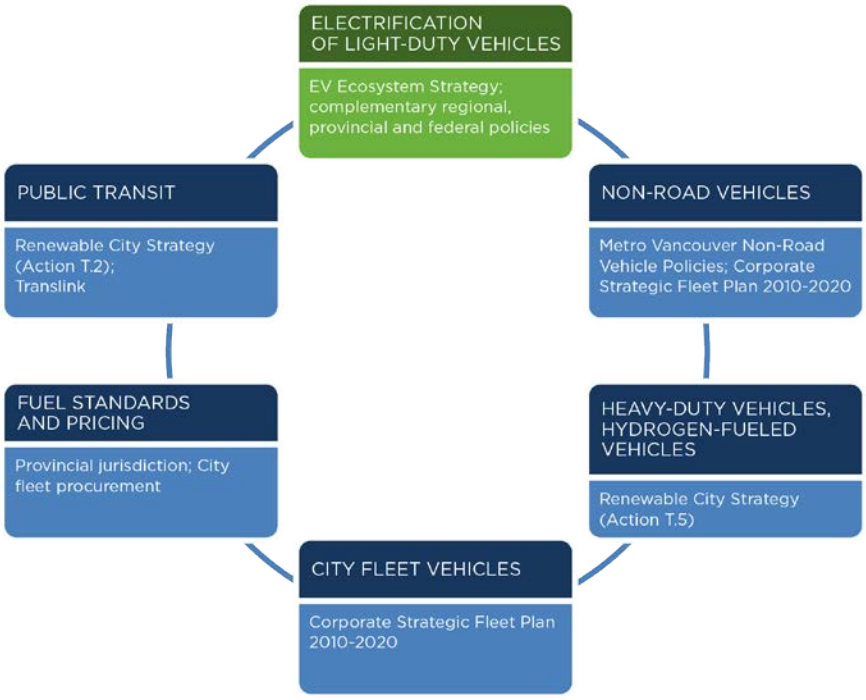

Figure 2 – Summary of Complementary Renewable Transportation Policies

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[4] Ribberink, H. , Natural Resources Canada, CanmetENERGY, *EV Suitability and Effectiveness of Public Charging Stations in Canada* (Ottawa: CanmetENERGY, 2014),27.

[5] For example, Axsen, J., S. Goldberg, J. Bailey, G. Kamiya, B. Langman, J. Cairns, M. Wolinetz, and A. Miele (2015). *Electrifying Vehicles: Insights from the Canadian Plug-in Electric Vehicle Study.* Simon Fraser University, Vancouver, Canada.

Municipal Policies

In March 2015, Vancouver City Council approved the *Renewable City Strategy*, committing to derive 100 per cent of Vancouver's energy from renewable sources before 2050, and reaffirming its goal to reduce greenhouse gas (GHG) emissions 80 per cent compared with 2007 levels by 2050.

Achieving the goal of having completely renewably-powered transportation before 2050 will require the transition of personal transportation to plug-in electric vehicles. Access to charging infrastructure will be necessary to achieve that goal.

Figure 3 shows the passenger vehicle counts expected in 2050, as modelled during the development of the *Renewable City Strategy*. In achieving 100% renewable transportation, 70 per cent of vehicles will be plug-in vehicles utilizing an external electrical source. Of these, 25% will be purely battery electric vehicles, and 45% will be plug-in hybrid electric vehicles.

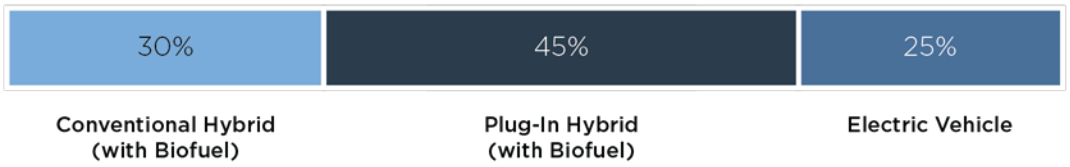

Figure 3 - *Renewable City Strategy*: Passenger Vehicle Count by Vehicle Type 2050

The *EV Ecosystem Strategy* is the outcome of one Quick Start under the *Renewable Transportation* goal within the *Renewable City Strategy*: *"To develop and implement an electric vehicle infrastructure strategy to accelerate electric vehicle uptake".*

The *EV Ecosystem Strategy* aligns with the direction of other City strategies, including: *Transportation 2040* (M5.1), the Greenest City Action Plan (Goals 2 and 9), and air quality goals of the Healthy City Strategy. The City regulates construction requirements for EV infrastructure through the *Vancouver Building By-law*.

The *EV Ecosystem Strategy* is designed to maximize electric kilometres travelled in place of fossil-fueled transportation for the passenger vehicle sector. The strategy conforms to the transportation hierarchy from *Transportation 2040*: walking, bicycling and public transit takes priority over the use of personal vehicles, while the conditions are created for shared journeys – preferred over personal vehicles – to be increasingly powered by electricity.

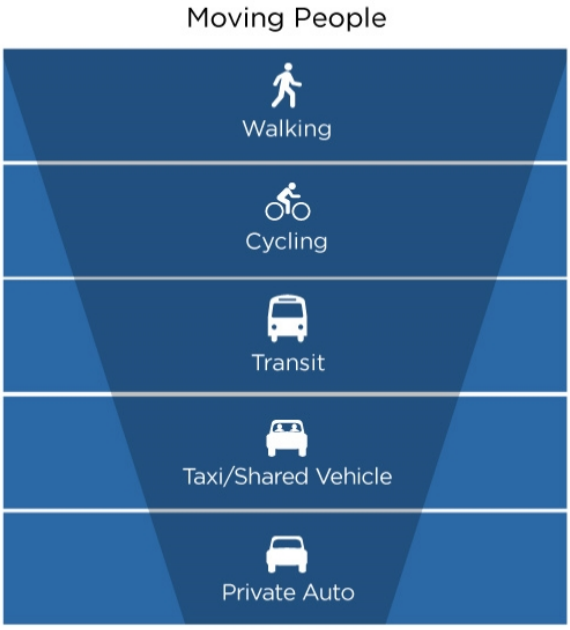

Figure 4 - Transportation Hierarchy from *Transportation 2040*

Implementation of regional mobility pricing will also be critical to ensuring the shift towards walking, cycling and public transit continues from over other modes of transportation. Mobility pricing is supported by *Transportation 2040*.

EVs alone will not get us to our renewable transportation goals, especially given that Vancouver's road network is largely built out. The City will continue to prioritize compact, complete communities where a majority of trips can be made on foot and by bike, and mass transit can efficiently move large volumes of people over longer distances.

The transportation system will change dramatically over the coming years. Reduced vehicle ownership and an increase in shared journeys, a shift toward autonomous vehicles, more affordable electric vehicles, and use of electric bikes and scooters in place of automobiles is already underway. In the future, fueling a vehicle at a gas station will be replaced by charging vehicles overnight at home, and while doing other tasks such as shopping or buying a morning coffee.

To achieve this shift in approach to transportation, the City must ensure the presence of charging opportunities within the broader context of building complete communities. Through the *EV Ecosystem Strategy*, the City is actively supporting EV charging where it has control – land use, local roadways and the built form.

The City of Vancouver also provides other, non-Infrastructure EV incentives:

- Preferential parking rules for (under development) that would provide discounted parking rates to electric vehicles and other zero emission vehicles, such as hydrogen fuel cell vehicles.
- Access to City of Vancouver HOV lanes regardless of number of passengers in an EV

The electrification of transportation will also rely on other levels of government to provide funding and policy support to ensure the supply and demand of electric vehicles, and a marketplace that prioritizes the move to zero emission vehicles.

Through advocacy and partnership with agencies in areas where the City has little or no control, the City of Vancouver will continue to support complementary policies that would increase the accessibility of EV charging and the transition to EVs.

Regional (Metro Vancouver) Policies

Metro Vancouver has jurisdiction over air emissions – including both local air pollutants and greenhouse gas emissions – in the region. These are regulated through the *Integrated Air Quality and Greenhouse Gas Management Plan*.

Metro Vancouver, in coordination with the Province of BC, the Fraser Basin Council, and other municipal and private sector partners (including the City of Vancouver) funds and supports the Emotive EV outreach program. Emotive creates awareness of electric vehicles by demonstrating the EV driving experience through campaigns that include ride-and-drive events and social media. The City of Vancouver is an active member of Emotive's steering committee.

Development of a regional mobility pricing plan – a policy that City staff continue to advocate for - could support the goals of this strategy, by continuing to support a shift to EVs that does not result in a mode shift away from walking, cycling and public transit.

Provincial Policies

The Province of British Columbia joined the International ZEV Alliance in 2015 with a stated goal that all new vehicles in B.C. will be zero emissions by 2050. The provincial government currently offers financial incentives towards the purchase of electric vehicles. In spring 2016, the provincial government introduced an incentive program for retrofitting EV charging stations in strata complexes. The program was over-subscribed in less than one month, suggesting significant latent demand for EV charging in existing multi-family buildings.

The Province of BC has jurisdiction over policies related to electrical utility regulation (the *BC Utilities Commission Act*), provincial roadways, carbon pricing that is regulated through the *Carbon Tax Act*, mobility pricing, fuel standards, vehicle emissions standards, and vehicle supply. All of these factors have implications for the success of the *EV Ecosystem Strategy*.

The provincial government allows for EVs to access HOV lanes, regardless of the number of passengers in the vehicle. This is regulated through voluntary registration by EV owners and provides registered EV drivers with an identifying window decal for their vehicle. These decals can also be used for City-implemented, non-charging incentive programs.

The province also has jurisdiction over the BC Building Code, stratified properties through the *Strata Property Act*, and rental properties through the *Rental Tenancy Act*. The BC Building Code provides the basis for the *Vancouver Building By-law*.

The provincial government, through the Fraser Basin Council, also provides significant funding and oversight to the Emotive EV outreach program, as described in the *Regional (Metro Vancouver) Policies* section, above.

The recently released B.C. Climate Leadership Plan suggests further support for electric vehicles; however, policy details have yet to be announced.

Federal Policies

The Federal Government through Natural Resources Canada provides funding for fast charging infrastructure. Environment and Climate Change Canada has signaled a renewed interest in climate change mitigation, including development of a national carbon pricing plan. The federal government has jurisdiction over vehicle fuel economy standards, federal highways, transportation safety regulations, and international trade. All of these can impact the availability and uptake of electric vehicles.

Co-Benefits of the *EV Ecosystem Strategy*

Through the reduced combustion of fossil fuels, the transition to electric vehicles improves air quality and reduces noise from traffic. EV uptake enables the transportation network to use renewable sources from BC Hydro's grid; and, a potential re-imagining of transportation development in Canada, since electric vehicles can receive energy anywhere an electrical connection is available.

5. Where We Are Going

Access to EV Charging Is Where It's Needed

The City has used the intervening time and lessons learned since the completion of *Charge and Go* (described in Section 5) in 2014 to determine the role that the City can play in accelerating the transition to EVs. That role is to ensure equitable access to EV charging where it's needed across the city. Private sector businesses have continued to deploy infrastructure independently of the City, although only in certain areas.

It Is Time to Act

The first production EVs came to Canada in 2009. Widespread adoption of EVs and the resulting shift away from fossil fueled vehicles is fast approaching. Electric vehicle registrations have been increasing 70-80 per cent year-over year, with the overall rate of sales continuing to rise. The arrival of affordable EVs with ranges above 300 km will have the potential to capture a much broader segment of the market. The City must be ready for this change in transportation that is already underway.

The pioneers and early adopters of electric vehicles are enthusiasts who have been able to make significant lifestyle changes to own, operate and drive an EV. They have now been joined by the larger "early majority market" of users that may have more limited time, resources and flexibility to adapt their lifestyles to EV ownership. Going forward, most potential EV drivers will need an EV network and ecosystem that integrates into their daily life.

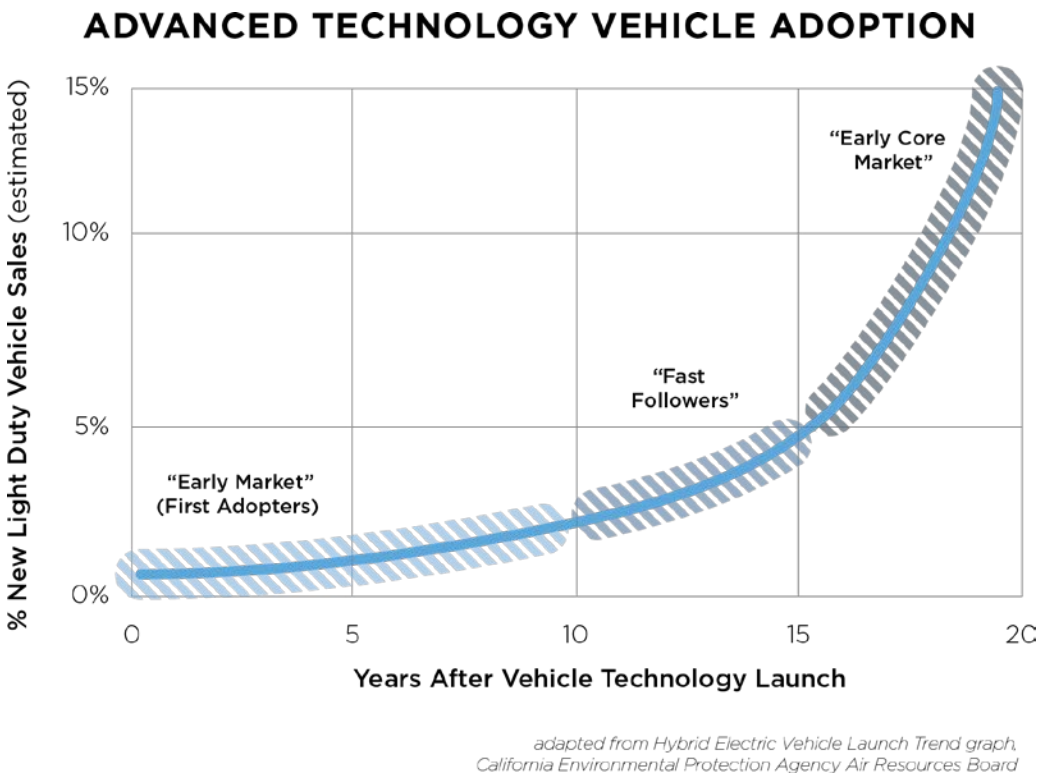

Figure 5 - Technology Adoption Curve

The public network of EV charging stations expanded rapidly between 2011 and 2014, due to both private sector deployments of charging stations and the City's *Charge and Go* field trial. Expansion of EV

charging stations has now slowed and is not keeping up with increased EV ownership, leading to congestion at stations.

Most personal vehicles operate for about 15 to 17 years. To achieve the necessary transition to renewable transportation by 2050, only approximately two vehicle lifetimes remain. Rapid uptake of EVs must therefore begin now.

By actively expanding the EV ecosystem in all areas where the City exercises some control, and through advocacy and partnership with agencies in the areas where the City has little or no control, the City of Vancouver will create an EV ecosystem that keeps up with public demand, and fosters widespread adoption and continued innovation and investment by associated industry.

The Benefits of an EV Ecosystem

The *EV Ecosystem Strategy* is a key component in the transition of light-duty vehicles to renewable energy. This strategy is intended to create the conditions that will enable a mass-market transition to electric vehicles.

Those conditions are:

1. Access to electric vehicle charging infrastructure
2. Range confidence
3. Integration with broader transportation networks beyond municipal borders
4. Mass market of EV drivers

The presence of user friendly electric vehicle charging infrastructure that supports local and regional transportation planning goals will be essential to maximizing uptake of electric vehicles in the shortest time possible.

1. Access to Electric Vehicle Charging Infrastructure

EV charging ideally occurs at home: overnight charging of vehicles allows EV drivers to start each day with a fully charged vehicle and eliminates the need to make additional trips to public charging stations on most days. It allows drivers to recharge their vehicles at times when they are likely to be parked for the longest times, allowing for lower-powered options to be installed (see “EV Charging Technologies” for a description of power outputs). Home charging infrastructure also means reduced pressure on public space for vehicle charging.

Many homes in Vancouver do not have even the most basic EV charging capacity[6] in their garages or parking stalls. Neighbourhood charging – access to public charging at or near services used by residents as part of a complete community - can enable drivers to transition to electric vehicles without significant lifestyle changes. As vehicle ranges increase, the need to charge vehicles on a near-daily basis will disappear, creating opportunities to incorporate vehicle charging into other lifestyle activities.

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[6] Commonly referred to as "Level 1" charging, which is described in Section 5 (*EV Charging Technologies*)

Beyond Municipal Borders

BC Hydro, with support from the Province of BC, began deploying DC Fast Charging stations in 2011. Since then, BC Hydro has supported the deployment of 27 Fast Charging Stations, complementing a provincial network of nearly 1,000 public Level 2 stations.

Other municipalities throughout Metro Vancouver are expanding their public charging networks, and are exploring ways to increase their residents' access to home charging.

Seattle, WA currently has 8 fast charging stations, and is connected to Vancouver with between 15 and 20 more (depending on the route). Seattle, like Vancouver, is looking to vastly expand urban fast charging. Seattle plans to deploy 20 fast charging stations in 2017!

North Vancouver, Squamish and Whistler also host networks of Level 2 and fast chargers.

The City of Vancouver's fast charger, located at Empire Fields, adjacent to Highway 1, enables longer-distance travel between all of these centres, virtually emissions free!

The *EV Ecosystem Strategy* addresses access to charging in homes and neighbourhoods.

2. Range Confidence

The "range" of an electric vehicle refers to the total distance that it can travel on a single charge. As with fossil-fueled vehicles, EV driving range depends on terrain, weather conditions and individual driving habits. Electric vehicles available in 2016 have less range than fossil-fueled vehicles have on a full fuel tank. While at least four EV models costing around $35,000 with ranges of over 300 km are coming to market in 2017 (and increasing thereafter), this is still a significantly shorter driving range than a fossil-fueled vehicle.

However, almost all trips (95%) taken by drivers in British Columbia's urban areas are less than 30 km[7]. While this is less than even the shortest-range EVs, electric vehicle suitability is not determined by the average daily driving distance, but by the distance typically driven on longer day trips[8]. Vehicles with over 200 km of range are likely to be suitable for nearly all Canadians, and even more so in a compact urban environment such as Vancouver.

Access to facilities throughout the city provides a measure of confidence to drivers, who may be concerned when their journeys are longer than expected. Providing infrastructure can make the transition to EVs more appealing to the general public, who at present may feel the range of most EVs is not compatible with their lifestyle. In addition, drivers who use plug-in hybrid electric vehicles ("PHEVs"), which supplement a shorter battery range with a gasoline-powered "range extender" (generator) will be able to increase the electric kilometres travelled within the city through occasionally accessing public charging.

3. Integrating With Broader Transportation Networks Beyond Municipal Borders

Reducing greenhouse gas emissions from the transportation sector and building an EV ecosystem requires more than just

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7 http://pluginbc.ca/wp/wp-content/uploads/2015/10/BC-DCFC-Gap-Analysis-Report-FBC_Aug-2015.pdf

8 Ribberink, H. , Natural Resources Canada, CanmetENERGY, *EV Suitability and Effectiveness of Public Charging Stations in Canada* (Ottawa: CanmetENERGY, 2014),27.

action within Vancouver itself. For EVs to achieve widespread adoption, it is important to have a wider network of infrastructure beyond the city to enable their use for longer trips, and to eliminate range limitations.

Electric vehicle infrastructure is being deployed across BC, as well as in the US Pacific Northwest. A dense public charging network with widespread coverage allows for longer distance trips. This enables EV users to more easily commute between municipalities. Such a network will also create broader tourism and business opportunities by allowing non-residents to travel to the region in their EVs, and for commercial fleets operating throughout the region to more easily transition to EVs.

The success of this strategy will in part depend on continued expansion of longer-distance corridor options for EVs and more charging options for drivers throughout the region. These initiatives are already being undertaken by the provincial government and nearby municipalities. Vancouver is an important destination in the region and must have complementary amenities to provide viable travel options for EV drivers; and, to allow EV drivers to extend their journeys by hopping from one charger to the next along a corridor.

The presence of a robust electric vehicle charging network will also support long-distance, light duty commercial vehicle travel, enabling conversion of light-duty commercial fleets to electric power over time. These businesses can capitalize on the reduced fuel and maintenance costs of electric vehicles.

4. Mass Market of EV Drivers

The market uptake of electric vehicles is currently about one per cent of light-duty vehicles. This number is too low to provide a strong business case for private sector investors to install and operate the required amount of public charging stations.

The City is presently one of the only entities allowed to charge fees for electricity for EV charging, other than BC Hydro. While the City will advocate for changes to provincial legislation that would enable electricity resale, without reasonable cost recovery options, private sector involvement in the deployment of charging infrastructure is unlikely in the short term.

The City has capacity for patient (long-term) capital, and can act as an early supporter of the EV charging market to increase the number of customers at public charging stations – and particularly fast charging stations – that will reduce the future business risk in public charging investments.

Over time (likely by 2021–2024), it is estimated that EVs will have enough market share to support private sector ownership and operation of public charging[9].

[9] Ducharme, P., Marcon, *Feasibility of a Pan-Canadian Network of DC Fast Charging Stations for EVs,* presentation at EVS29 in Montreal, QC, June 19-22, 2016.

Aims of the *EV Ecosystem Strategy*

The *EV Ecosystem Strategy* has the following five high-level aims:

1. Maximize access to EV charging
2. Improve community experience with and knowledge of vehicle charging
3. Displace fossil fuel kilometres travelled with electric kilometres travelled
4. Create the conditions that will support green, private sector jobs in EV infrastructure deployment and operation
5. Establish an electric vehicle ecosystem to support the transition to 100% renewable transportation before 2050.

The Need for an *EV Ecosystem Strategy*

The City of Vancouver is taking an ambitious step forward in ensuring residents, businesses and the city are ready for widespread adoption of EV's by developing an *EV Ecosystem Strategy*. The strategy outlines the role we can and will play in EV charging infrastructure so that we can overcome current barriers and realize future EV opportunities.

The time to plan is now:

- EV numbers have almost doubled every year since 2011
- Existing public infrastructure is at capacity, with the most used public stations in all of B.C.
- Many prospective EV drivers cite lack of charging options as a barrier to switching to an EV
- More affordable vehicle models with battery ranges over 300 km are coming to the Canadian market in 2016-17
- Fleet and commercial operators require access to charging
- Viable business options for EV infrastructure deployment – and particularly Fast Charging –are expected in 2021 assuming that market uptake of EVs grows at currently anticipated rates.
  - Conversely, EV uptake is hindered by a lack of available charging access.
- Modeling predicts that, in order to achieve 100% renewable transportation, EVs are expected to comprise the majority of light-duty vehicles in 2050.
  - *Most* vehicles will need places to charge
  - With most vehicles lasting 12-13 years, the transportation system needs to begin the transition now

6. An Ecosystem Approach to EV Infrastructure

To meet the above aims, the *EV Ecosystem Strategy* takes an ecosystem approach to vehicle charging. An ecosystem, by definition, functions through the interrelationships between its various niches. This strategy considers all of the options available to maximize charging access and to expand the options for displacing fossil-fueled kilometres with electric kilometres travelled.

With this ecosystem approach, home charging is prioritized as the least expensive and most convenient way for residents to charge personal vehicles. Where home charging is not adequate or available, public charging, either through fast charging hubs ("EHubs") or slower "destination" charge points (including workplace charging) is encouraged. In addition, options to enable the conversion of light-duty commercial fleets, electric vehicle car-sharing, and the eventual conversion of taxi fleets are addressed. These options are based on the relevant local neighbourhood context. This is discussed further in in the following sections.

The City's current role in EV infrastructure is considered to be short term but critical to enabling the long-term viability of the renewable transportation transition. By enabling residents to confidently switch to electric vehicles, the market for EVs and charging infrastructure will grow, creating greater certainty and reduced business risk for prospective private charging station operators, thereby accelerating the EV transition and diminishing the need for government support.

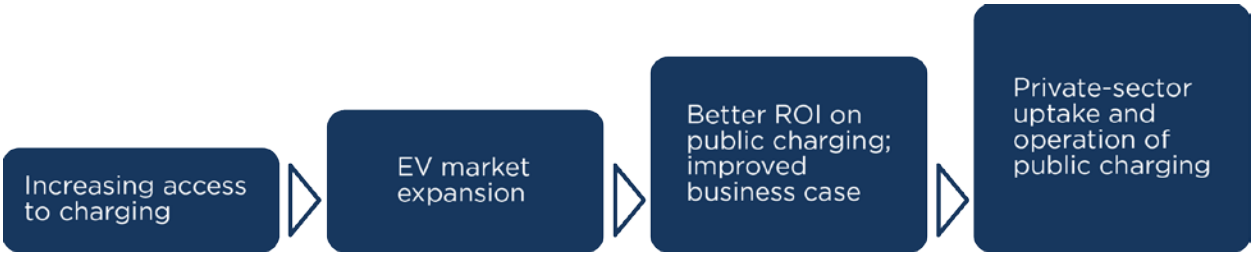

Figure 6 - Steps to Private Sector Infrastructure Deployment and Management

As shown above, as the City removes barriers to charging by increasing access to charging infrastructure, more people will be comfortable switching to EVs. As the market expands, more public charging sessions will occur, increasing the potential revenue at public stations. This in turn will create a stronger business case for the deployment, operation and management of EV charging stations by the private sector[10]. Eventually, the need for the City to provide public charging can decrease.

The potential levels of City involvement span from completely managing a large network of EV charging stations (with some private sector involvement separately - the City does not track), to complete delivery of the EV network by the private sector.

[10] The business case for the private sector requires private operators to be able to charge fees for electricity use (i.e., the resale of electricity) under the *BC Utilities Commission Act*.

Summary: The City of Vancouver's Role in EV Infrastructure

The City of Vancouver's role with respect to EV infrastructure is to:

1. Support the early EV market by ensuring charging infrastructure is present, available and reliable
2. Use land-use and building policies and planning to direct the deployment of charging in public, residential and workplace locations

The electric vehicle market relies on a broad set of policies and stakeholders to grow, as shown in Figure 2. The City has limited jurisdiction over many of these aspects, but it does have responsibility over land use and the building code. The City can therefore incorporate EV charging requirements into land use policies and the *Vancouver Building By-law* to ensure the expansion of charging infrastructure in residential, workplace and public locations.

Building the EV Ecosystem

Section 2 (An Ecosystem Perspective) describes the City's approach to planning and deploying EV infrastructure as part of a broader, connected system. In such an ecosystem, infrastructure is planned based on existing charging infrastructure, the make-up of residences and businesses in a neighbourhood, and the ways in which EV drivers can most easily charge their vehicles.

The strategy considers technical and practical issues related to infrastructure deployment, regulatory barriers, and business implications. Electric vehicle charging technologies are discussed below.

EV Charging Technologies

Level 1 Charging

Level 1 charging is the simplest form of EV charging. It is accomplished through a 120V outlet operating at 15A (similar to a standard wall outlet, but with its own dedicated circuit breaker). Level 1 charging is the least expensive technology to install. It provides approximately 9km of range per hour of charging[11]. Few, if any, Level 1 charging stations operate on a data network.

Level 1 should be used on a dedicated circuit, though that is often not the case for standard home use and existing household wiring. The charger is included with the purchase of an electric vehicle, and is often referred to as the "convenience charger." It is typically carried on-board and can be used in the case of emergencies.

Based on the results of *Charge and Go*, which saw virtually no use of public Level 1 chargers, Level 1 is not considered a valuable technology for public charging of multi-passenger vehicles. However, the growth in use of electric scooters and electric bicycles may benefit from available 120V outlets in parking areas. Level 1 charging is also adequate for most home users of multi-passenger EVs, despite requiring significant time to fully recharge vehicle's battery. Longer-term parking, such as at marinas, is also compatible with Level 1 charging.

[11] Vehicle charging rates are limited in part by a particular vehicle model's capabilities. For the purposes of this strategy, charging rates are stated based on what a station of a given type can deliver. Actual rates may be slower for certain, and particularly older models of vehicles.

Time for Tea

CHAdeMO is an abbreviation of "CHArge de MOve", equivalent to "move using charge" or "move by charge". The name is also a pun drawn from "*O cha demo ikaga desuka*" in Japanese, translating to English as "How about some tea?", referring to the time it would take to charge a car.

Level 1 charging is currently required under the *Parking By-law* to support access for e-scooters and e-bicycles.

Level 2 Charging

The City of Vancouver manages a network of 78 public Level 2 charging stations across the city. The total number of public charging stations is estimated at around 250, but no precise tracking mechanisms exist. Public charging is not uniformly distributed in Vancouver.

Level 2 charging is through a 240V circuit (or 208V, in parking areas that use three-phase electrical systems), usually operating with a 20A or 40A service, but can be as high as 80A. The *Vancouver Building By-law* requires Level 2 charging as the standard residential and commercial installation. The vast majority of residential, fleet and public Level 2 charging stations operate at 40A. This provides approximately 30km of range per hour of charging.

Fast Charging

Fast Charging, also referred to as "Quick Charging", "DC Fast Charging" or "DCFC", uses a high-powered charging station to provide an 80 per cent charge in as little as 20 minutes, or a typical days' worth of driving in Vancouver in 3-5 minutes.

Three fast charging connector types exist in North America. These are CHAdeMO, SAE Combo or "CCS", and Tesla Supercharger.

The City of Vancouver currently operates one 50 kW Fast Charging Station at Empire Fields through a provincially-funded program. That station supports CHAdeMO and CCS plug types. No Tesla Superchargers currently operate in Vancouver.

Until recently, most DCFC stations provided a maximum 50kW output, with the exception of Tesla Superchargers that provide approximately 125kW. As longer range vehicles come to market, stations providing 150kW or more are now being manufactured. These will provide significantly faster charging times. For example, a 50kW DCFC can provide about 100km of range in 20 minutes; whereas a 150kW DCFC can provide up to 300km of range in the same amount of time, provided the connected vehicle is capable of receiving so much power.

DCFC stations provide two primary uses: corridor travel, by providing interconnectivity between municipalities; and, in urban clusters, providing support for travel within urban areas. The DCFC located at Empire Fields (adjacent to Highway 1) primarily serves corridor travel, as it is in an area of low population density with few adjacent amenities but high vehicle traffic travelling through Vancouver.

Wireless Charging

Wireless charging is a young technology that can be deployed in either moving traffic lanes or static (parked) charging applications. Wireless induction is currently the most common form of charging,

although few EVs come equipped to use wireless charging. A number of vehicle manufacturers suggest that induction charging will be available in future models.

The Society for Automotive Engineers (SAE) is developing a standard for wireless induction charging, which once completed (expected in late 2016), will allow for a more widespread adoption of wireless charging by vehicle manufacturers.

Wireless charging systems include a receiver that is permanently attached to the underside of the vehicle. Wireless charging stations use the same electric power outputs as Level 1 or Level 2 stations, so can be deployed in any setting that a "wired" station would be used.

Wireless systems are more expensive than standard Level 2 home charging systems. However, they have potential novel applications that may increase EV adoption. For example it would benefit:

- handicapped users in adopting EVs, especially for home charging,
- small commercial fleets with frequent returns to base,
- car sharing, where misuse of charging stations leaves subsequent drivers without adequate charge, and
- situations where large pedestals will not fit (such as some curbside settings) or where theft is common.

Wireless charging will be transformative when autonomous vehicle or automated parking become more prevalent and vehicles are able to charge in the absence of a driver.

Data Networks

Many EV charging stations operate on a data network connected via cellular or Wi-Fi signals. Networks provide the ability to track usage, monitor or manage energy consumption, restrict or enable access, monitor stations for problems, and collect payments. Historically, data networks were primarily used for public EV charging stations. However, the evolution of "smart charging" systems has created a niche for networked EV charging stations in residential and workplace settings as well.

Smart Charging

Technologies allowing for the management of EV charging stations' electrical loads have recently appeared on the Canadian market. These systems allow an electrical designer to "oversubscribe" an electrical circuit or panel without overloading the system. In the absence of smart charging capabilities, the Canadian Electrical Code, Part 1 requires that EV charging be installed as though all stations are operating at full power, 100 per cent of the time. This results in significantly over-sized electrical supplies to buildings.

While still in its infancy, smart charging can significantly reduce the cost of installing multiple Level 2 charging stations in a building, by reducing the total electrical supply needed for EV charging. Smart charging systems operate as a network, where stations' individual power outputs are managed based on the total amount of vehicle charging occurring at any given moment.

Solar Power

On-site solar power technologies are not yet capable of supporting EV charging in most cases. While some trials are being conducted elsewhere, it is not considered a viable technology in Vancouver for the time being. In addition, the low cost and high renewable energy content of electricity in BC does not make a strong case for solar power deployment for the purpose of carbon reduction in Vancouver. This strategy will not pursue solar charging technologies for public charging for the time being; however, the City will continue to monitor their advancement.

However, the advent of home energy storage systems may advance the ability of homeowners to pair rooftop solar panels with batteries for EV charging. Having a standalone power source in a home parking setting will increase the resilience of the overall system, ensuring that EV drivers have access to power in the event of power outages in the BC Hydro grid.

A Note on Autonomous Vehicles

Autonomous vehicles are an emerging technology with the potential to transform transportation. Significant research and media attention has been directed at autonomous vehicles, both in terms of their potential benefits (such as increased safety and efficiency, improved convenience and productivity, and reduced land needs for parking) and risks (including ethical considerations of individual responsibility and potential negative mode shifts away from walking, cycling and public transit).

It is likely, although not guaranteed, that autonomous vehicles will be electric and therefore would require charging infrastructure. While some novel plug-in designs have already been publicized, it appears likely that fully autonomous electric vehicles will use inductive wireless technologies to charge. This strategy does not consider how best to support autonomous vehicles. However, increased electrical supply in buildings, which does play a role in this strategy, will also allow for lower-cost deployment of wireless charging intended for autonomous vehicles.

The Interface between Vehicles and Urban Setting

Different vehicle applications, such as personal vehicles, car-share vehicles and light-duty fleet vehicles, have different barriers to electrification. Similarly, different charging locations in an urban environment have different barriers in terms of deploying charging infrastructure. The table below provides an example of different charging locations and vehicle applications, and what sort of charging infrastructure solutions can be deployed.

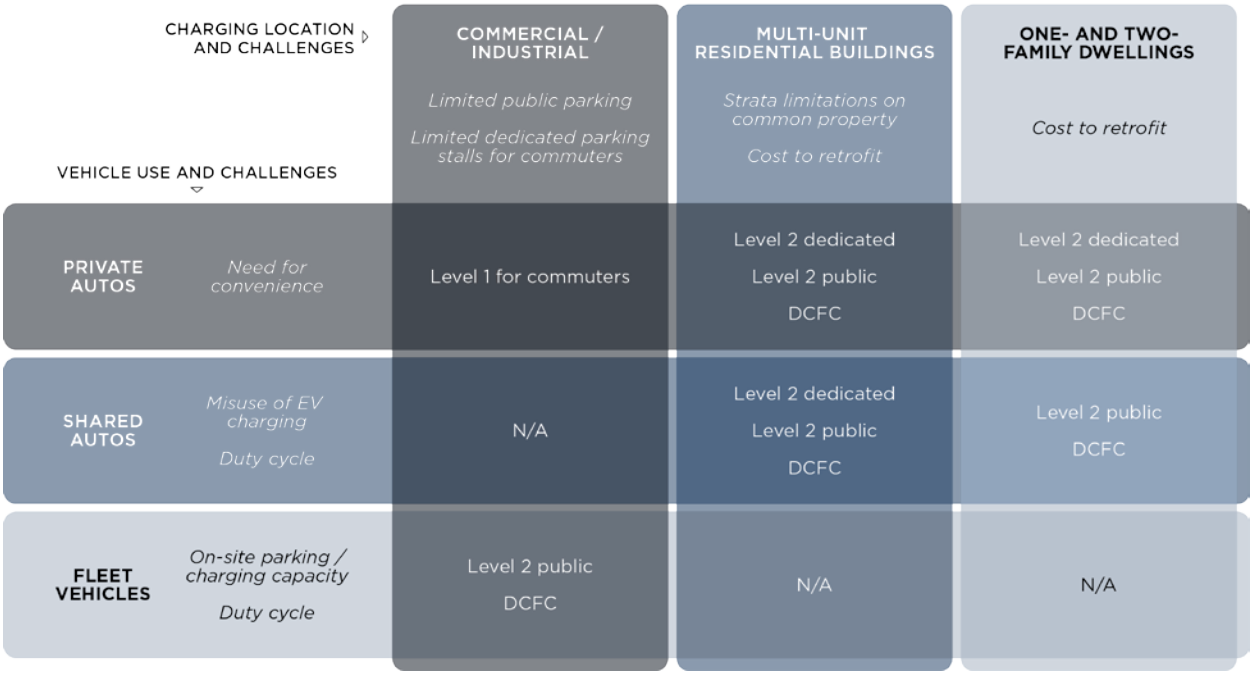

Figure 7 – Example EV infrastructure solutions for various vehicle applications and charging locations

In the above examples, each charging location (commercial / industrial, multi-unit residential building or one- and two-family dwelling) have specific challenges for the deployment of EV charging infrastructure. Similarly, different vehicle uses (private, shared and fleet) present challenges to drivers with respect to EVs. The table also lists potential technology applications that can support these scenarios. In other words, the above is a generalized ecosystem model for the deployment of EV infrastructure.

The City will build the EV Ecosystem through the following three H-I-P areas:

(H) Home and Workplace Charging

(P) The Public Charging Network

(I) Integration of EV Infrastructure planning and operation as a core city service

The following sections will detail the challenges that the community would face in the absence of the *EV Ecosystem Strategy*, the approach and actions that the City will take, and the residual risks that the City must be aware of. In preparing for a renewable transportation system in Vancouver, the City will investigate the relationship between autonomous vehicles, the sharing economy and electric vehicle infrastructure.

7. (H) Home and Workplace Charging

Context

Residential charging will provide the "anchor" for EV charging in the long term. Research shows that approximately 70 per cent of EV charging ideally occurs at a driver's residence.

The *Vancouver Building By-law* has required that homes built in Vancouver since 2011 have circuits supporting Level 1 and homes built after 2013 have circuits supporting Level 2 EV charging. However, the present requirements coupled with existing pre-2011 buildings will not be adequate to meet the future demand of at least 70% of vehicles being plug-in hybrid or full battery electric in 2050.

Many existing homes do not have enough electrical capacity to support charging an EV. For existing homes without EV charging capacity, retrofit costs can be very high depending on the age and existing conditions of the building's electrical system. In general, retrofitting EV charging into an existing home can cost over twice as much as the same system in a new building. Enterprising developers and stratas are already using EV charging as a marketing tool for their buildings.

In homes without EV charging, or for EV commuters, workplace charging can supplement or fully replace home charging. Vehicles are often parked at the workplace for at least 8 hours during the day. This creates the opportunity to fully recharge an EV. While a less frequently used option compared with home charging, workplace charging can remove barriers to switching to an EV (such as limited range or lack of home charging) and can often be simpler than installing EV charging in a strata or rental property. Many employers or commercial building managers are already using EV charging access as a "perk" to attract employees or tenants.

Many commercial fleets will switch to EVs under the right circumstances. As incentives such as HOV lane access and discounted parking expand, fleet managers will see EVs as a viable option. The reduced maintenance costs (including mechanics' time), coupled with reduced fuel costs, will offset the higher capital cost of EVs. Many other cities globally are seeing shifts to EVs in car-sharing, taxis, couriers and other light-duty fleets. However, barriers such as cost or capacity to install charging infrastructure, vehicle duty cycles and required range, and employee knowledge must all be addressed.

Electrical retrofits to support EV charging require an electrical permit. At present, the timeline to obtain a permit is not considered a barrier to charge station deployment.

Home and Workplace Charging Actions in Brief

Quick Starts

Flexible Requirements Quick Start: Move development-specific elements of EV charging requirements (e.g., – number of stalls equipped) to the *Vancouver Parking By-law*.

Curbside Pilot Quick Start: Explore the potential for and implement, if feasible, a curbside charging pilot program for commercial business and single-family home owners who do not have access to off-street parking.

MURB Quick Start: Evaluate a cost-effective means to requiring some degree of EV charging access to 50% of stalls in new MURBs.

Standards of Maintenance Quick Start: Update Vancouver's *Standards of Maintenance By-law* to require that existing EV charging equipment (including outlets for e-bikes and e-scooters) are reasonably accessible.

Panel Exemption Quick Start: Remove 200A panel exemption for new construction of one- and two-family homes under the *Vancouver Building By-law*.

Visibility Quick Start: Update construction requirements for labeling of EV charging circuits and create sample media for use as a guideline by builders.

Actions

H1. Expand building requirements for EV charging readiness in MURBs such that each resident has access to EV charging in their own parking stall.

H2. Require cellular repeaters in all underground parking levels to enable networked stations and to prepare for access by autonomous vehicles.

H3. In coordination with other levels of government, provide education to stratas, landlords and property managers to further acceptance of MURB EV charging retrofits.

H4. Develop in-building "Innovation Zones" that link incentives for car-share parking with creation of EV charging at car-share parking stalls.

H5. Develop a Workplace Charging Challenge.

H6. Develop a MURB and workplace program to encourage Retrofits of EV chargers

H7. Review of taxation and labour implications.

H8. Work with BC Hydro to determine how best to mitigate impacts to distribution system.

Multi-Unit Residential Buildings

Over 60 per cent of Vancouver residents live in multi-unit residential buildings ("MURBs"), and this proportion will increase as the city densifies. MURBs constructed since 2011 have dedicated electrical capacity supporting at least Level 1 for EV charging in 20 per cent of their parking stalls.

The *Vancouver Building By-law*[12] requires that all new residential buildings with three or more suites provide Level 2 EV charging capacity in 20 per cent of parking stalls.

Infrastructure Challenges for the Community

Practical and technical challenges for deploying charging stations in MURBs include the following:

1. **Retrofit cost:** Retrofitting parking areas with EV charging is often prohibitively expensive, owing to necessary upgrades to the building's electrical supply. EV charging circuits are not present in MURBs built before 2011, although some have standard power outlets that may support EV charging. Most standard wall outlets in MURB parking areas are common property and would be off-limits for EV charging.

2. **Lack of Awareness:** Owners, stratas, property managers and developers have limited understanding of EV charging technologies and options. To reduce construction and retrofit costs, and opposition to creating EV charging access, greater awareness of implementing technologies and managing electrical loads throughout the sector is required.

3. **Metering:** How charge stations are owned and managed within MURBs presents challenges for deployment. While ownership and liability concerns related to station installation are ostensibly under the mandate of the provincial *Strata Property Act*, these are not specifically addressed within that act and have not historically been considered in strata by-laws, leaving stratas without clear direction.

4. **Regulatory:** The provincial *Strata Property Act* and the *Rental Tenancy Act* regulate the use of common property areas (e.g., parking in strata corporations and rental buildings). Under these laws there is no legal mechanism for a strata lot owner or renter to compel the installation or activation of EV charging equipment if their strata or landlord objects.

EVCondo.ca

Metro Vancouver hosts EVCondo.ca, a website that walks EV owners, strata councils and property managers through typical steps in setting up EV charging in stratified buildings. The site also provides an "EV-Friendly Strata Registry" that provides a map-based list of buildings that have EV charging installed.

The allocation of parking in stratas is determined through strata plans and may be assigned through at least 18 different configurations, as outlined in a recent report by the BC Condominium Homeowners Association[13]. Many configurations do not allow the flexibility to ensure that EV drivers (or prospective EV drivers) are assigned parking stalls that have a charging station or could have one installed.

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[12] *Vancouver Building By-law*, Part 10, Section 10.2.3.1

[13] Condominium Home Owners Association of BC, *Installation of Electric Vehicle Charging Stations on Strata Properties in British Columbia*, 2014, p.8.

One- and Two-Family Homes

Approximately 40 per cent of Vancouver residents live in one- or two-family homes. In most cases the challenges for renters will be somewhat different for owners. Both are summarized below.

New one- and two-family homes, including any parking stalls for secondary suites and laneway homes, are presently required to have Level 2 charging in all parking stalls per the *Vancouver Building By-law*[14].

Infrastructure Challenges for the Community

1. **Electric Panel Sizing Exemption (affects renters and owners)**: The current *Vancouver Building By-law* provides an exemption to providing EV infrastructure if the additional supply causes the house panel to exceed 200A. For larger (e.g. ~ 15 m wide) lots, this exemption would be triggered in most cases, and would not specifically be a result of the addition of EV charging loads. These homes would be left unequipped with EV charging supply.

2. **Electrical Distribution System Impacts (affects renters and owners):** Impacts on neighbourhood-level electrical distribution systems are not well documented at present, but in some cases upgrades to the BC Hydro system in the neighbourhood may be necessary, increasing costs.

3. **Regulatory Barriers for Renters:** For renters in either one- or two-family homes, there is no legal mechanism to ensure EV charging is present in parking spaces under the BC *Rental Tenancy Act*.

4. **Regulatory Barriers for Owners:** Two-family homes that are stratified are regulated under the provincial *Strata Property Act*, and can therefore face similar opposition as MURBs, described in the previous section. For homeowners in single-family homes, upgrades to their electrical systems to accommodate EV charging are not likely to be limited by regulatory barriers.

5. **Garage Orphans:** In Vancouver, many homes do not have off-street parking stalls. Approximately 2,000 one- or two-family homes do not have off-street parking. Residents of some multi-unit residential buildings also do not have their own parking stalls. Referred to as "garage orphans", residents of these homes typically rely on on-street parking.

One of the primary advantages cited by EV drivers is the ability to charge overnight at home and start each day with a fully charged battery. Residents who must rely on public Level 2 locations to charge do not realize this advantage, removing a significant incentive of EVs over fossil-fueled vehicles. No legal mechanisms currently exist to allow the provision of privately-owned, on-street charging connected to a home's electrical panel, nor does it allow for the assignment of parking stalls on-street for individual residents.

[14] *Vancouver Building By-law* Part 10, Section 10.2.3.1

Home Charging: *Imagine a neighborhood where homes are powered by affordable renewable energy that provides accessible and reliable charging for electric vehicles when families need to drive. Citizens will have a broad range of renewable transportation options with all new homes equipped with an EV charging circuit and an expanded public network of EV charging at City facilities like your local community centre. By charging at home, people can start their day with a full charge. Walking, biking and public transit will remain as the highest priority sustainable transportation choices; but for those times when personal or shared vehicles are needed, residents can still make zero emission journeys.*

Workplace Charging

The availability of workplace charging can incentivize EV uptake for longer-distance commuters who do not use public transit. In Vancouver, many larger commercial buildings do not have specific employer-managed parking areas. Workplace parking in these instances is often managed through building managers or landlords, and often through a parking management company.

The ability to charge at work may enable employees with longer commutes to still drive using only electricity. Free workplace charging can lead to shifting the primary charging location from home to the workplace, leading to congestion at chargers.

Many employers and building landlords will see the provision of EV charging as having the potential to attract employees and tenants, respectively. Since commuters are typically parked for at least 8 hours during the workday, they can adequately recharge a vehicle using lower-powered charging station. Installation of Level 1 stations, or load-managed Level 2 stations, can significantly reduce retrofit costs for many workplace parkades. Since use of workplace charging can be tied to other parking fees in many situations, employers, landlords and building managers may be able to install non-networked stations to reduce operating costs related to network fees.

Under the *Vancouver Building By-law*, all new commercial buildings since 2013 have been required to include a Level 2 circuit in 10 per cent of parking stalls. Whether a commercial building operator chooses to utilize these for customers, employees, or both (or not at all) is at the operator's discretion.

The Workplace Charging Challenge

The US Department of Energy's Workplace Charging Challenge aims to have 500 U.S. employers join the initiative as partners by 2018. Partners set a minimum goal of providing charging for a portion of plug-in electric vehicle (PEV) driving employees and a best practice goal of meeting all employee demand. As of January 2016, more than 250 employers joined as Challenge partners, allowing the installation of workplace charging as a sustainable business practice to grow across the US.

For the purposes of this document, light-duty commercial fleets are considered as a subset of workplace charging, and include car-sharing fleets and taxi fleets.

Commercial Fleets

Light-duty commercial fleets are transitioning to EVs in other cities around the world. All of the reasons that make Vancouver great for EVs as personal vehicles apply to commercial fleets as well.

Unlike with drivers of personal vehicles, fleet managers are more likely to take an analytical approach to purchasing vehicles and will make their choice of vehicle based on lifecycle costs and utility. Incentives such as HOV lane access to reduce the time vehicles are sitting in traffic, coupled with discounted parking or other incentives, may help the business case for switching to an EV. However, infrastructure barriers, as outlined in Table 1 must also be overcome for incentives to be of value.

For fleets with a return-to-base model, access to on-site charging in parking areas is important. For free-floating vehicles or higher-mileage vehicles that may require recharging over the course of a day, access to public charging – and in particular fast charging –

may also be required.

Community Infrastructure Challenges for Workplace Charging

1. **Level 1 / Level 2 deployed capacity:** New construction requirements do not require building owners to install EV charging *stations* that are supported by the electrical supply required under the *Vancouver Building By-law*. Additionally, to support a growing number of commuters using EV, once more than 10 per cent of vehicles parking in a given building require charging, additional electrical supply would need to be added.
2. **Access**: The presence of electrical supply or charging stations also does not guarantee reasonable access to them by commuters. For example, if a building owner chooses not to not to set stalls with EV charging capabilities aside for EV charging, commuters may be left without workplace charging options. Landlords choosing to simply disable power to those locations are currently not prohibited from doing so.
3. **Retrofit Costs**: Retrofit costs for electrical upgrades can be a barrier, despite lower cost of Level 1 or load-managed Level 2 stations. Additionally, networked stations in many parkades require cellular access, requiring cellular repeaters to be installed. However, workplace charging stations can be less expensive than commercial units, as they do not necessarily require the same payment and networking features[15].
    - **Retrofit costs for fleets**: The business case for adding EVs to a fleet will be affected by the cost of purchasing and installing EV charging. As with residential and workplace charging for commuters, this cost can be high in buildings not pre-supplied with adequate electrical capacity.
4. **Regulations:** Should EV charging be provided as an employee benefit, rules on taxable benefits, and potential union conflicts may arise.
    - For non-government or non-utility employers, charging fees for electricity will be subject to onerous approvals under the *BC Utilities Commission Act*;
    - The City will seek clarification from BCUC and BC Hydro as to whether landlords are exempted from these approvals[16]; and, whether the charging of a premium on parking fees in the form of a convenience fee for access to equipment may be exempt.
5. **User knowledge (affects commercial fleets):** employees using company vehicles, or users of EV car-sharing, may not understand how to use EV charging. This can include range anxiety and a tendency to avoid using the fleet EVs and failure to plug vehicles in when returning them. For companies seeking to maximize the utilization of their vehicles (such as the case with car-

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[15] Garas, D., Collantes, G., Nicholas, M., University of California at Davis Policy Institute for Energy, Environment and the Economy, *City of Vancouver EV Infrastructure Strategy Report*, 2016, p. 23.

[16] *BC Utilities Commission Act*

sharing), reduced use through range anxiety, or users encountering improperly charged vehicles can have significant business implications.

6. **Business Models:** Level 1 charging can be installed when retrofitting workplaces desiring charging options for employees. This lower power option will still recharge commuting vehicles for the majority of commuting distances over the course of a workday.

There are benefits of free workplace charging for both the employer and employees. For the employers, this includes simplified charge station installation and operations/administration costs (no service provider needed, since no revenue is collected), avoiding the impression of pettiness in charging for electricity used, and "green image" for something that provides a tangible benefit to employees.

The biggest detriment may be that in switching home charging to workplace charging for those who don't need it, free workplace charging may lead to congestion at the chargers, and for EV drivers who may rely on access to workplace charging, a subsequent decrease in availability.

The City's Approach: Expanded Access to Home and Workplace Charging

The City will expand access to home and workplace charging, supporting Aims 1, 2, 3 and 5.

1. Maximize access to EV charging
2. Improve community experience and knowledge in vehicle charging
3. Displace fossil fuel kilometres travelled with electric kilometres
4. Establish an electric vehicle ecosystem to support the transition to 100% renewable transportation before 2050.

The underlying approach will mitigate retrofit costs; maximize access; and improve the overall level of knowledge of the existence, benefits and minimal risks of EV charging at home or workplace.

Studies have indicated that many buildings, once constructed, have significant spare electrical capacity. This has the potential to be used for EV charging with minimal electrical upgrades. However, the cost of construction for additional electrical supply must also be a consideration in developing charging requirements.

The City's approach to home and workplace charging will expand access through:

Flexibility: Create more flexible EV charging requirements in buildings that reflect building use and that can adapt to changing technologies and occupant needs.

- ***Flexible Requirements Quick Start:*** Move development-specific elements of EV charging requirements (e.g., – number of stalls equipped) to the *Vancouver Parking By-law*.
- ***Curbside Pilot Quick Start:*** Explore the potential for and implement, if feasible, a curbside charging pilot program for commercial business and single-family home owners who do not have access to off-street parking.

Simplicity: Simplify and expand construction requirements and ensure that any buildings not built with 100% of parking stalls EV-enabled are equipped for simple upgrades.

- ***MURB Quick Start:*** Evaluate cost-effective means to requiring some degree of EV charging access to 50% of stalls in new MURBs.
- ***Standards of Maintenance Quick Start:*** Update Vancouver's *Standards of Maintenance By-law* to require that existing EV charging equipment (including outlets for e-bikes and e-scooters) are reasonably accessible.
- ***Panel Exemption Quick Start:*** Remove 200A panel exemption for new construction of one- and two-family homes under the Vancouver Building By-law

Visibility: Require builders to provide specific and highly visible labelling of dedicated charging electrical supply in new homes; include promotion of other EV incentives.

- ***Visibility Quick Start:*** Update construction requirements for labeling of EV charging circuits and create sample media for use as a guideline by builders.

RetrofitSupport: Develop programs that encourage the retrofit of MURBs and workplace parking with EV charging. For any programs directed at MURBs, timelines of at least two years must be considered to obtain adequate participation.

Advocacy: The City will advocate for provincial regulations that guarantee residents' and commuters' access to EV charging if available. Continue to promote evcondo.ca

Actions

H1. Expand building requirements for EV charging readiness in MURBs such that each resident has access to EV charging in their own parking stall.

The City will update its building requirements so that a larger proportion of stalls are equipped with EV charging circuits. The advent of load management technologies means that costs to completely equip a parking area with charging are far lower than before. Investigate how incentives can be used for builders to add charging capacity beyond minimum requirements.

H2. Require cellular repeaters in all underground parking levels to enable networked stations and to prepare for access by autonomous vehicles.

The City will update Vancouver Building By-law requirements to include cellular repeaters in construction of underground parking areas. This will ensure that networked stations can operate correctly, supporting electric vehicles that receive software updates over the cellular network, and to prepare for autonomous vehicles requiring cellular connectivity to function,

H3. In coordination with other levels of government, provide education to stratas, landlords and property managers to further acceptance of MURB EV charging retrofits

The City will engage with appropriate organizations to clarify the means by which buildings can be retrofitted with EV charging infrastructure, and to clarify any misunderstandings related to electric vehicles and charging infrastructure.

H4. Develop in-building "Innovation Zones" that link incentives for car-share parking with creation of EV charging at car-share parking stalls

The City will develop means by which various innovative and sustainable technologies that occur in parking areas can be co-located to increase awareness.

H5. Develop a Workplace Charging Challenge

Create an awareness and information campaign focused on greatly expanding EV charging access in commercial buildings, targeting employers and building managers of commercial properties.

H6. Develop a MURB and workplace Retrofit Program.

The City will develop a program that will encourage multi-family buildings and workplaces to carry out EV charging retrofits. Where possible, this program will leverage other building energy retrofit programs already underway or under development.

H7. Review of taxation and labour implications

The City will conduct a review of the taxation and labour implications of employers providing EV charging as an employee benefit.

H8. Work with BC Hydro to determine how best to mitigate impacts to distribution system

The City will continue to work closely with BC Hydro to ensure that widespread EV charging deployment does not have significant negative impacts on the electrical distribution system, homeowners, developers, or ratepayers. Where possible, solutions that can mitigate the cost impacts to newer, denser developments will be sought.

Risks to the City

The above actions will significantly improve access to home and workplace EV charging. However, some risks to the City's goals will still exist, and must be addressed as the strategy is implemented.

1. **Reverse Mode Shift:** Workplace charging can replace home charging for residents without it. This can potentially incent a shift to driving from more sustainable modes, such as cycling or public transit if the only option for an EV driver to charge is at their workplace.
    - **Response**: Convenient public charging can provide alternatives to workplace charging, offering EV drivers more flexibility.
2. **Technology Change:** EV charging technologies are evolving quickly, with many newer options allowing for significant cost savings and innovative financing.
    - **Response**: City policies should limit specifying charging technologies and focus on ensuring adequate electrical supply to buildings.
3. **Technology Lock-in:** As with other services such as cable TV, high-speed internet or natural gas, once buildings are constructed, residents of MURBs often have limited options to change providers. Many networked EV charging technologies have similar potential "lock-ins": once a developer has installed a network provider, stratas have limited options to change providers.

- **Response**: Work with the provincial government to create rules enabling stratas to switch EV charging networks if desired, within the first six months following transfer from the developer.

4. **Overbuild**: Potential exists for the addition of excess electrical capacity as a result of Canadian Electrical Code rules.

    - **Response**: Provide information to the development community on load managing technologies that can minimize overbuild and costs.

5. **Misalignment with Broader Housing Priorities:** A drive toward technology solutions that require smartphone access, have high ongoing maintenance costs, or rely on future retrofits, may prevent lower-income residents from accessing the growing opportunity to switch to electric vehicles.

    - **Response**: Consult with housing advocates on how best to meet the needs of their stakeholders.

6. **Re-Purposing Of Public Streetscape:** Any future policies that the City might develop to re-purpose public street space currently used to park private vehicles may have implications for installed EV charging.

    - **Response**: Consider deployment of EV charging at curbside within public space and broader transportation planning priorities for a neighbourhood. In residential parking contexts where on-street parking is removed in favour of off-street parking, such policies could actually remove a barrier to switching from fossil-fueled vehicles to electric vehicles, since all residents captured by such policies would now park off-street.

***Workplace Charging**: Imagine a city that supports a diverse, strong and sustainable economy, where businesses both big and small accelerate the shift to electric vehicles, with electric commercial fleets moving goods and services, and commuters driving personal and shared electric vehicles to and from work accessing EV charging at a workplace parking stall. Commercial fleets without on-site charging can access fast charging at EHubs during a delivery or over a coffee break, while EV taxis can charge up routinely throughout a shift.*

8. (P) The Public Charging Network

Context

EV drivers in Vancouver use an average of 8 kWh/day of electricity. That equates to between 1.25 and 1.5 hours of charging on a Level 2 charger for newer vehicles. This can easily be managed through brief charging sessions throughout the day or in typical residential and workplace context(s). Further, this average usage is far less than the range of the vehicles; however, the perception of most people is that range offered by EVs will not be practical for their needs.

Public charging infrastructure provides both range confidence and the ability to charge vehicles that have travelled longer distances over the course of the day (or for EVs having reduced range during colder weather). The presence of public charging stations in neighbourhoods – be they Level 2 or DC Fast Charge stations – can also replace home or workplace charging for residents without such access.

However, research indicates that while the presence of DC Fast Charging can actually increase EV uptake, the same is not true for public Level 2 charging. The longer dwelling times required at Level 2 stations simply do not provide the convenience required by most drivers[17]. Therefore, where public charging is intended to stand in for a lack of home and workplace charging, an increased emphasis on DC Fast Charging is essential.

Finally, public charging stations provide an opportunity to create awareness of electric vehicles and the available charging options. Public stations can be made visible to non-EV drivers, and are often positioned next to sidewalks.

Consultation with external experts has determined that public EV infrastructure is essentially "invisible" to non-EV drivers and therefore presents a missed opportunity to create awareness and understanding with the general public.

Business Models

The business model(s) under which private sector businesses can expect a reasonable return on investment are not clear. Numerous models have been attempted with limited success[18].

At least three private sector business models may have potential for positive returns-on-investment once mass market of EV adoption has occurred. Some potential examples are:

1. **Charge station network operators:** generate revenue by selling hardware and network fees paid by site hosts to manage the billing and access to the charging equipment. They earn revenue based on host sites paying them to manage the access and billing of customers
2. **Charge station infrastructure owner and operator:** A company supplies and owns the infrastructure and the back-end networking and billing capabilities, and determines the fees for

[17] Public Level 2 charging has been shown to increase the total electric kilometres driven, by extending the battery range of PHEVs or increasing the use of EVs that are secondary vehicles.

[18] UC Davis report

use. Return on investment (ROI) is strongly dependent on higher user throughput (i.e., infrastructure utilization). The primary source of income is the monthly subscription fees that users pay to the infrastructure company, regardless of whether they use electricity in a given month.

3. **Financial Lease Construction:** Corporate investment on charging infrastructure and access to such infrastructure is provided for a monthly fee, similar to the case of mobile telecommunication. However, cell towers and charging stations differ in the user throughput they can accommodate. While one cell tower is sufficient to provide connectivity for its area of coverage into the broader network, one single charging station cannot guarantee coverage to all prospective users in a given area. Corporations pursuing a monthly-fee model would need to plan on significant investments to ensure adequate service to end users.

In all of these examples, a significant market of potential EV customers must arise before a reasonable return on investment can occur. It is unlikely that private sector investments can expect a reasonable return until significant market adoption has occurred, which will require intervention by various levels of government over the next five to seven years.

The following table shows a likely Canadian scenario where urban fast charging can expect a reasonable return on investment in 2021.

Table 1 - Financial forecast for one Fast Charging Station to 2021[19]

	2017	2018	2019	2020	2021
Revenues from Charging (Annual)	$5,000	$15,000	$9,500	$75,000	$150,000
Capex Depreciation[20]	$4,500	$4,500	$4,500	$4,500	$4,500
Cost of Capital[21]	$4,500	$3,600	$2,700	$1,800	$900
Management Fees	$1,600	$3,100	$2,300	$13,000	$25,000
Electricity	$1,300	$6,300	$5,000	$35,000	$70,000
Unforeseen / Miscellaneous Costs	$500	$500	$500	$500	$500
Net Profit (Loss)	($7,400)	($3,000)	($5,500)	$20,200	$49,100

[19] Adapted from Ducharme, P., Marcon, *Feasibility of a Pan-Canadian Network of DC Fast Charging Stations for EVs,* presentation at EVS29 in Montreal, QC, June 19-22, 2016.

[20] Assumes a 10-year linear depreciation of the asset, but table only shows time for this 5-year strategy

[21] Based on a five-year loan at a 10% interest rate to reflect higher risk of investment

Public Network Actions in Brief

Quick Starts

Network Review Quick Start: Review all existing public Level 2 stations on City property to identify those with limited availability and/or monitoring capabilities.

Fair Access Quick Start: Create and implement a fee structure for existing Level 2 charging stations that will encourage use of home charging where available, but still provide a significant cost incentive compared with fossil fuels.

Utilities Commission Quick Start 1: Create a template model to support local businesses in applying to BCUC for EV charging exemptions. Pilot an initial run through BCUC with a large supplier of EV charging in the City.

Utilities Commission Quick Start 2: Work with large EV station hosts (e.g., EasyPark) the Province, BCUC and BC Hydro to allow businesses to charge fees without the need for onerous approvals under the *BC Utilities Commission Act*.

User Experience Quick Start: Investigate and, where appropriate, implement options for network interoperability between the existing five EV charging data networks managed by the City. Includes potential connections with PayByPhone, VanConnect, Compass, Treo and other mobile payment technologies.

Actions

P1. Develop charging EHubs that support residents, commercial fleets, EV taxis and EV car-sharing

P2. Improve public Level 2 charging access and visibility

P3. Investigate potential carbon credit mechanisms that can encourage investment in public charging

P4. Develop public charging points to be sources of information for non-EV drivers

***P5. Advocate with the provincial government, BCUC and BC Hydro to exempt or streamline regulation to enable private sector station hosts to charge fees for use of their EV chargers under the* BC Utilities Commission Act**

Infrastructure Challenges for the Community

1. **Parking arrangements:** Electric scooter and electric bicycle users may not always park in designated car parking stalls. Many park in secured bicycle parking or in dedicated scooter parking. City-owned public EV charging stations have only been located in standard parking stalls to-date.
2. **Data Management and Access Control for Scooters and E-bikes:** 120V outlets may be co-opted for other uses, and cannot be monitored through a data network as with Level 2. Therefore, it is best used in managed, secure locations.

3. **Network Distribution:** Private sector deployment of charging stations has resulted in increased charging infrastructure density. The infrastructure is not uniformly distributed throughout the city which leaves many neighbourhoods underserved by public charging. At present, the majority of public stations are along major commercial corridors in the downtown core. East Vancouver and much of southwest Vancouver do not have substantial public charging.
4. **Capital Cost:** DC Fast Charge stations cost up to $100,000 to install, including station cost and electrical equipment.
5. **Required electrical capacity:** Fast Charging stations such as at the Empire Fields location require up to 50kW of supply, which translates into significant supporting infrastructure that is rarely if ever present in existing developments.
6. **Multiple connector types:** While many DCFC manufacturers now offer stations with both CHAdeMo and CCS plugs, only Tesla vehicles use the Supercharger connector type (see Section 7 "EV Charging Technologies" for details). Tesla does sell adaptors for the CHAdeMo connector (but not the CCS); conversely, only Tesla vehicles can connect to Superchargers. Predicting the appropriate station type for a location may be problematic for many station hosts. Installing multiple stations covering all connector types mitigates this, but increases the capital cost and would require management of multiple data networks and hardware providers at a location[22].
7. **Utilities and Regulations:**
    a) **Demand Charges:** In an effort to limit demand peaks and strain on the electrical distribution system, BC Hydro costs can include "Demand Charges" that increase fees based on peak usage at a site. The high power output of Fast Chargers can trigger these demand charges, greatly increasing the cost to operate Fast Chargers.
    b) **Cost Recovery:** Under the *BC Utilities Commission Act*, private businesses are prohibited from charging fees for EV charging unless they obtain approvals or exemptions, which can be onerous in terms of time and cost, thereby limiting their ability to recover capital, operating, maintenance and administration costs. Individual exemptions to this rule have been granted; however, the time and resource requirements to go through the BC Utilities Commission hearing process are a significant barrier to most businesses.
8. **Business Models**

    Research indicates that reasonable returns can only be achieved once significant numbers of charging events occur on a regular basis. This will require significantly more vehicles on the road, which in turn requires consumer confidence in accessible vehicle charging.

[22] Tesla often acts as a turnkey provider for their stations, reducing resource requirements for station hosts of Tesla Superchargers.

The City's Approach: Improve the Public Charging Network

Expansion of public charging is necessary to increase visibility of EV charging; to provide charging access to residents or visitors without other ways to charge their EV; and, in the case of fast charging, to support vehicles or fleets with long duty cycles or short dwell times.

The City can play a role in expanding access to public EV charging infrastructure by owning or operating EV chargers – at least during the early years of the industry before a more viable private sector market develops. The City, as a municipality, is not deemed a "public utility" under the *BC Utilities Commission Act* and is therefore exempt from certain approvals under the BC Utilities Commission Act that are applicable to private sector businesses. The City, however, as well as businesses, may still be subject to certain technical restrictions under the Act and BC Hydro's rate tariff if we were to charge a fee for the use of City operated EV chargers.

In light of the Province's and BC Hydro's strong support and encouragement of municipalities to operate and expand access to EV charging, the City is optimistic that they will be supportive of clarifying or more streamlined regulation for EV charging. Accordingly, the City will advocate the Province, BCUC and BC Hydro to clarify or streamline existing regulations – or to provide a blanket exemption. Until such clarification, more streamlined regulation or exemption takes place, the City will move forward carefully in respect of City owned or operated EV chargers with the support of the Province and BC Hydro.

Until the City makes a decision relating to operating and charging a fee for use of a City EV charger, this section describes a number of other initiatives that the City may commence.

The City will develop EHubs comprised of multiple chargers throughout the City at locations that are close to other amenities that are aligned with a 20-30 minute stop. Fast chargers should support multiple protocols, at a minimum both CHAdeMO and CCS plugs. Hubs may ideally include Tesla Superchargers, and should also be paired with one or more Level 2 charging station.

One purpose of an increased emphasis on Fast Charging is to supplement for a lack of access to home, workplace and fleet charging[23]. An urban cluster model—one that co-locates Fast Charging with amenities having dwell times of 20 to 30 minutes—will achieve this purpose more effectively than installing Fast Charge stations along arterial corridors.

Public EV charging infrastructure has the potential to create greater awareness of electric vehicles. The visibility of charging stations in the community can therefore be leveraged to expand awareness.

By providing a faster charge, DCFC can also be used for commercial applications where Level 2 charging is not a practical option. For example:

- Car-sharing: providers seek to maximize the utilization of their vehicles. Vehicles needing to reside at a Level 2 station for an hour or more will significantly decrease the value for a car-share provider to purchase an EV.

[23] In this context, "fleets" include taxis, car-share vehicles and other commercial fleets.

- Light-duty commercial fleets: companies often do not have the option to add a dedicated Level 2 charger for each vehicle on their own properties. Having the option to charge vehicles off-site during a coffee break or a delivery would make integration of EVs into a fleet far simpler.

The City will improve the public charging network through the following:

Integrated planning: Incorporate charging hubs – with an emphasis on Fast Charging - into community development options and into redevelopment of existing parking facilities. Location planning will also incorporate models developed by the UBC Transportation, Infrastructure and Public Space Lab to determine ideal areas within the city for EHub deployment.

Visibility: Use EV charging infrastructure to provide awareness of electric vehicles to the community.

Expanded Access: Increase availability of Level 2 charging infrastructure in public parking for City buildings and expand to all community centres. Where feasible, additional cellular monopole integration projects will be considered.

- ***Network Review Quick Start:*** Review all existing public Level 2 stations on City property to identify those with limited availability and/or monitoring capabilities.

Fair Access: Establish controls for City-owned public EV charging infrastructure and support businesses in EV charging adoption.

- ***Fair Access Quick Start:*** Create and implement a fee structure for existing Level 2 charging stations that will encourage use of home charging where available, but still provide a significant cost incentive compared with fossil fuels. Pricing across the Metro Vancouver region will be coordinated through a Pricing Task Force, to be convened by the City of Vancouver.
- ***Utilities Commission Quick Start 1:*** Create a template model to support local businesses in applying to BCUC for EV charging regulatory exemptions. Pilot an initial run through BCUC with a large supplier of EV charging in the City.
- ***Utilities Commission Quick Start 2:*** Work with large EV station hosts (e.g., EasyPark) and BC Hydro to advocate the Province, BCUC and BC Hydro for blanket exemptions or more streamlined regulation to enable the charging of fees for use of EV Chargers under the *BC Utilities Commission Act*.

Improved User Experience: Create a consistent look and feel for all public stations managed by the City. This includes the method by which users access stations and pay fees.

- ***User Experience Quick Start:*** Investigate and, where appropriate, implement options for network interoperability between the existing five EV charging data networks managed by the City. Includes potential connections with PayByPhone, VanConnect, Compass, Treo and other mobile payment technologies.

Financed Partnerships: Many ideal locations for EHubs are not on City land. The City will partner with other organizations that can provide siting for Fast Charge Hubs, with the City providing financial support for the development of EHubs.

Fees for Infrastructure Use

Three potential models for fees are possible:

1. Time-based ($ / hour)
2. Energy-based ($/ kWh)
3. Hybrid rate ($/kWh until battery full, then $/hour)

Charging fees based on the length of time a station is in use will ensure that charging stations are used by those who need them and not simply as parking spaces, and optimize access through improved availability. Hourly fees are simple to understand, and would mirror existing rate structures for parking meters.

An alternate argument suggests that a fee based on energy (per kWh) would be more equitable between different models of vehicles with different on-board charging speeds. This, however, may hamper the ability for users who may be queuing to use station to determine wait times, and the ability for enforcement staff to manage these systems becomes increasingly complex.

The third, hybrid option, would ensure equity in terms of pricing of energy delivered, while at the same time ensuring that users continue to pay a rate for staying at a charging station. Some jurisdictions have examined using relatively high hourly rates once a battery is fully charged to more strongly disincentivize “squatting”. However, a hybrid rate is also more difficult for users to understand, and may possibly lead to a less positive user experience.

Pricing will be designed so that residential charging will cost less than public charging, and Level 2 to cost less than Fast Charging. The primary goal of this graded pricing model is to encourage drivers with home or workplace charging options to use them when possible.

Because of the large price differential between electricity and liquid fuels in the region, it will be possible to implement charge station pricing that is effective in minimizing abuse while at the same time being far less expensive than gasoline or diesel.

The pricing structure will be developed as an “add-on” to optimize station utilization. In other words, the Level 2 and DCFC rates that are developed under the above criteria will be in addition to a given parking lot price or fee zone prices.

Actions

P1. Develop charging hubs that support residents, commercial fleets, EV taxis and EV car-sharing

The City will manage the deployment of EHubs at approximately 8-10 locations throughout Vancouver over five years.

P2. Improve public Level 2 charging access and visibility

The City will deploy Level 2 charging stations at all public-facing, City-owned buildings. Installations will be prioritized for areas of the City not presently supported by public charging and whose neighbourhoods are less likely to have residential charging early on.

P3. Investigate potential carbon credit mechanisms that can encourage investment in public charging

The City will partner with Carbon Neutral City Alliance cities to create a methodology for monetizing EV charging infrastructure in tradable carbon markets, creating a stronger business case for private sector involvement in EV charging infrastructure.

P4. Develop public charging points to be sources of information for non-EV drivers

In support of broader awareness of electric vehicles and charging options, the City will leverage charging infrastructure that is visible in the public realm as a potential "canvas" for both information and public art. Infrastructure will also be used to highlight other incentives, such as access to HOV lanes regardless of number of passengers, financial incentives and preferential parking rules as they are developed. The City will also work with partners to promote any workplace incentive programs on a site-specific basis. Promotion through tourism will also be explored.

P5. Advocate with the provincial government, BCUC and BC Hydro for blanket exemptions or more streamlined regulation to enable the charging of fees for use of EV Chargers under the BC Utilities Commission Act

The City will advocate for the introduction of exemptions or more streamlined regulation for EV charging under the *BC Utilities Commission Act,* as has recently been introduced in Ontario and some US states.

Risks to the City

1. **Battery impact of DCFC**: Using fast charging exclusively can lead to imbalanced battery cells, temporarily reducing vehicle range by about 10-15%.
    - **Response**: Include Level 2 stations at fast charging hubs and ensure continued deployment of Level 2 stations throughout the network. Provide education materials to the public.
2. **Streetscape Impact:** Though DC Fast Charging stations are shrinking in size, even the smallest units are comparable in size to an electrical kiosk. This can have implications for where stations can be accommodated (challenging on narrow boulevards) as well as on aesthetics.
    - **Response:** Incorporate urban design considerations into site selection and where possible, minimize the amount of equipment placed at curbside.
3. **Reputational Risk:** The *EV Ecosystem Strategy* creates new core services for the City. Arguments as to the cost of infrastructure, the appropriate role of government, and even the value of electrification of light-duty vehicles will be made.
    - **Response**: The City committed to 100% Renewable Transportation by 2050 under the *Renewable City Strategy*, and to supporting EV Infrastructure under *Transportation 2040*. Both of these are widely accepted strategies by the public. The *EV Ecosystem Strategy* provides an Exit Strategy for the City once mass market adoption of EVs creates a business case for private sector involvement in public EV infrastructure.
4. **Stranded Assets:** In the event that other key drivers of mass EV adoption do not arise, the City may end up with EV charging stations that are not utilized.
    - **Response**: Unmet public demand has already been demonstrated through large-scale vehicle pre-orders, the over-subscription of provincial incentive programs, and year-over-year increases in EV sales. The life of typical EV charging stations is longer than the anticipated need for the City's involvement as a market incubator, thereby leaving some additional time for assets to develop reasonable returns on investment.

Public Charging: *Imagine a city with vibrant compact, connected neighborhoods, where driving electric vehicles is part of an integrated transportation system that is safe, affordable and comfortable, where homes, offices, and streets support personal, shared and commercial electric vehicle use through private and public charging, and citizens have the opportunity to be healthy and mobile. People can access charging while they get their morning cup of coffee, pick up groceries, or take rapid transit. EV charging is a seamless integration into daily life, without the need to make separate trips to recharge or worry about battery range.*

9. (I) Integration: Electric Vehicle Infrastructure Planning And Management

The Sustainability Group manages the existing public EV network. The only existing policy for EV charging is contained within the *Vancouver Building By-law*, and is updated by the Sustainability Group in coordination with the Chief Building Officer.

The City's own fleet has already been fully integrated within Equipment Services through their Fleet Strategy.

Actions in Brief

Quick Starts

Operating Sites Quick Start: Operate and administer (via Engineering Services) existing City-owned charge station network and work with external network operators to maintain high station uptimes and availability.

Training Quick Start: Train Building and Development Services staff to on EV charging requirements, technologies, and potential configurations in building construction, which will then be disseminated to contractors.

Metering Quick Start: Install BC Hydro meters for existing EV charging at all City-owned buildings for energy management tracking.

Actions

I1. Form an internal task force on autonomous, connected, electrified and shared mobility

I2. Create a consistent user experience using data management and aggregation

I3. Integrate EV charging deployment with new developments and large re-developments

I4. Subject to Council, Engineering and other necessary approvals, add public charging to Engineering's list of Community Amenity Contributions

I5. Create planning guidelines for EV infrastructure deployment

Infrastructure Challenges for the City

1. **Network expansion:** The public electric vehicle charging network is not included in community planning activities, potentially leading to duplication of effort and lost cost-saving opportunities that could occur through combination with other City-led projects.
2. **Network management:** Ongoing management of the existing public EV charging network is not managed in coordination with other City assets or utility functions. This has led to extended interruptions in service and poorer user experience.
3. **Network Access:** The present network of EV charging stations, which uses five different network providers, does not have consistent means for the public to use them. This leads to a diminished user experience.

The City's Approach: Integrate Electric Vehicle Infrastructure Planning and Management into Core City Services

The City will operationalize the deployment and management of EV charging infrastructure. The City will consider access to EV charging as a community amenity, with deployment planning to occur through identification of neighbourhood-specific EV needs and integration into neighbourhood planning processes.

Operating Sites Quick Start: City (via Engineering Services) to operate and administer existing City-owned charge station network and work with external network operators to maintain high station uptimes and availability.

Training Quick Start: Building and Development Services staff to receive training on EV charging requirements, technologies, and potential configurations in building construction, which will then be disseminated to contractors.

Metering Quick Start: Install BC Hydro meters for existing EV charging at all City-owned buildings for energy management tracking, and add these meters to Real Estate and Facilities Management Asset Manager.

Table 2 - Proposed City Departmental Roles for EV Ecosystem Operation and Management

Department	Group(s)	Role
Engineering	Projects	
Engineering	Streets	Electrical design on public property Parking enforcement related to EV charging stations On-street EV infrastructure deployment
Engineering	Parking Management	Coordinate on-street charging rules *Parking By-law* Station procurement; network management
Engineering	Transportation Planning	Public station siting; coordination with *Transportation 2040* goals
Development Services, Building and Licensing	Inquiry Centre	Development permitting that considers EV infrastructure in residential and commercial buildings.
Development Services, Building and Licensing	CBO	VBBL updates Inspections Contractor training (in coordination with Sustainability)
Planning, Urban Design and Sustainability	Sustainability	Technology updates Station siting methodology Staff training

Department	Group(s)	Role
		Policy development
Planning, Urban Design and Sustainability	City-wide and Regional Planning Downtown Midtown South	Incorporate EV infrastructure into community planning
Planning, Urban Design and Sustainability	Urban Design	Incorporate EV infrastructure into public realm Contribute to station use as information source
Park Board	Business Services Parking Operations Parks Planning	Community centre EV charging upgrade coordination Parking areas in select parks
Community Services	Housing Policy	Consult regarding construction requirements
Real Estate and Facilities Management		Community centre upgrade coordination City parking lot charging station management Deployment of charging at marinas

Actions

I1. Form an internal task force on autonomous, connected, electrified and shared mobility

The City will convene an internal task force with key members of staff from Planning, Engineering, Real Estate and Facilities Management, Park Board, Digital Infrastructure & Assets, and other departments as needed. The task force will stay abreast of technology updates, guide and inform city policy, and assess progress on the integration of autonomous, connected, electrified and shared mobility in to city planning.

I2. Create a consistent user experience using data management and aggregation

The City will identify third-parties to develop a user access, data management and aggregation plan that will allow for a consistent and reliable user experience in accessing public charging stations in Vancouver.

I3. Integrate EV charging deployment with new developments and large re-developments

The City will incorporate the addition of public EV charging into project plans, and will include EV charging as a flexible option for neighbourhood planning.

I4. Add public charging to Engineering's list of Community Amenity Contributions

Subject to Council, Engineering and other necessary approval, the City will add public charging stations to the list of potential options under Engineering's Community Amenity Contributions, creating options for private sector contributions to expanding the public charging network.

I5. Create planning guidelines for EV infrastructure deployment

Based on Real Estate and Facilities Management guidelines for building construction, as well as models developed by the UBC Transportation, Infrastructure and Public Space Lab, the City will develop internal guidelines for deploying EV infrastructure in terms of community and city-wide planning, as well as in the specific requirements for installation and management of EV charging stations on City property.

Risks to the City

1. **Speed of technology change:** The EV infrastructure market is in a period of rapid evolution. Policy development and technology deployment that fails to minimize barriers to EV uptake will be less effective in electrifying the light-duty vehicle fleet.

    - **Response**: The City will endeavor to develop policy that is "technology agnostic" wherever possible; also, Sustainability will continue to monitor technology change over the five years of the *EV Ecosystem Strategy* to ensure that the newest possible technology options can be incorporated into community design and constructions standards

2. **Resource limitations:** The *EV Ecosystem Strategy* creates a new service to be provided by the City. This will require staff time to plan, procure, deploy, manage, operate and administer EV infrastructure, and to build strategic partnerships. It will also require staff time for training on new building standards. These activities will likely require some additional support, either through changes in work planning or through new hires.

    - **Response**: The City will, wherever possible, contract end-to-end management of the public EV network to third-parties who can guarantee high uptimes. In addition, inclusion of public EV charging in community planning will reduce resource impacts, as it will no longer be a standalone activity. Finally, the City will include impacts to staff resources as part of regular strategy assessment.

10. Strategy Development

Best Practices

The City of Vancouver engaged with other leading jurisdictions and technical experts from around the world and reviewed their EV strategies and actions to identify best practices and develop consistent, effective approaches. Experts provided insights from cities that included Seattle, WA; Portland, OR; San Francisco, CA; Los Angeles, CA; Montreal, QC; Paris, FR; Oslo, NO; and Amsterdam, NL. While Vancouver's context is different there were some common themes that Vancouver incorporated into the strategy design, such as:

- Engage multiple stakeholders
- Make plans and policies for future technologies rather than existing
- Take an ecosystem approach
- Consider home charging as the “anchor”
- Understand that charging infrastructure is just one piece of the puzzle
- Build in extra capacity: stations should be available to users as much as possible
- User experience is critical
- Other benefits beyond charging access, such as preferential parking rules and HOV lane access, will increase EV uptake

In addition, the City of Vancouver attended the Electric Vehicle Symposium (EVS29) in Montreal, Canada in June 2016 to gain insights that supported the development of this strategy. The EVS series of conferences, held since 1969, are the global electric transportation industry’s largest forum.

External Stakeholders and Advocacy

Electric vehicle infrastructure is connected to a broad range of community interests, from urban development and the built environment, to vehicle dealers and manufacturers, to environmental considerations, community health and social equity, and technological advances.

To ensure this strategy meets the needs of Vancouver residents, City staff met with over 50 organizations in 2016. A complete list of these organizations is included in Section 13.

This strategy could not meet its goals without collaboration with the Province of British Columbia and BC Hydro and Power Authority.

The built environment, as represented by the Urban Development Institute, the Building Owners and Managers Association, and the Condominium Homeowners Association, plays a key role in the expansion of residential charging.

In addition, academic and community organizations including Environmental Non-Governmental Organizations, the University of California at Davis, the University of British Columbia, Simon Fraser

University, Clean Energy Canada and the Vancouver Electric Vehicle Association were all consulted for independent research in shaping the strategic direction.

Overall, the response from expert stakeholders to the strategy was supportive. Participants strongly agreed with the Aims of the strategy, as well as the role that the City proposed for itself. Participants universally accepted the ecosystem model of infrastructure deployment, and particularly the focus on fast charging.

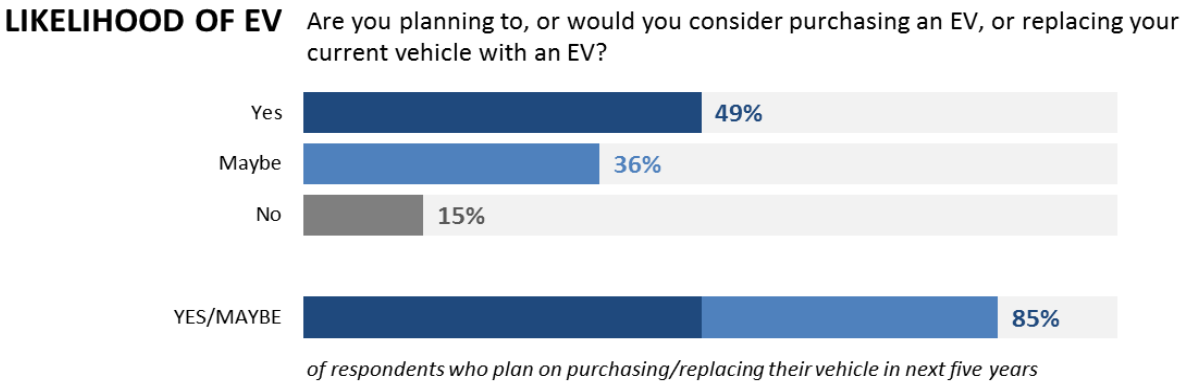
Public Consultations and Response

The City conducted an online public survey from August 2 to 21, 2016. The survey had over 2,143 responses, and asked questions relating to EV ownership, housing types, vehicle buying plans, barriers to purchasing EVs and desired public infrastructure locations, among others.

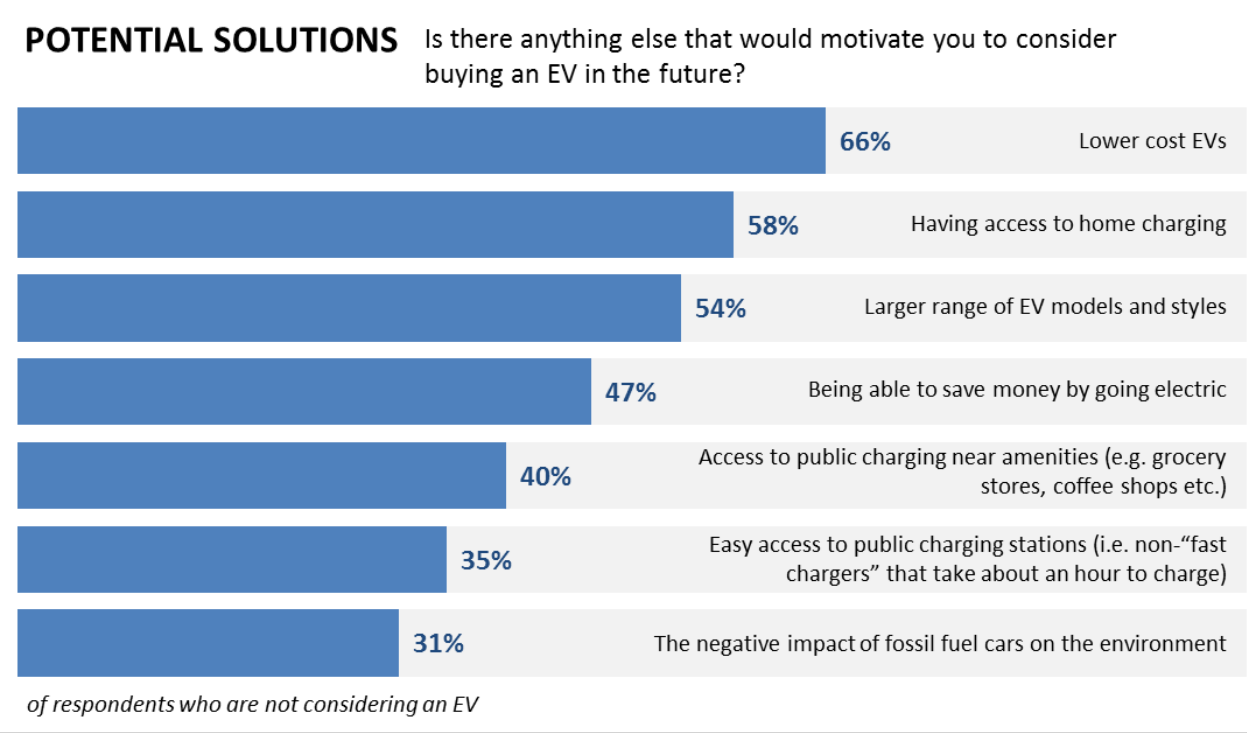
The public survey questions are provided in Appendix A.

The results of the public survey can be summarized as:

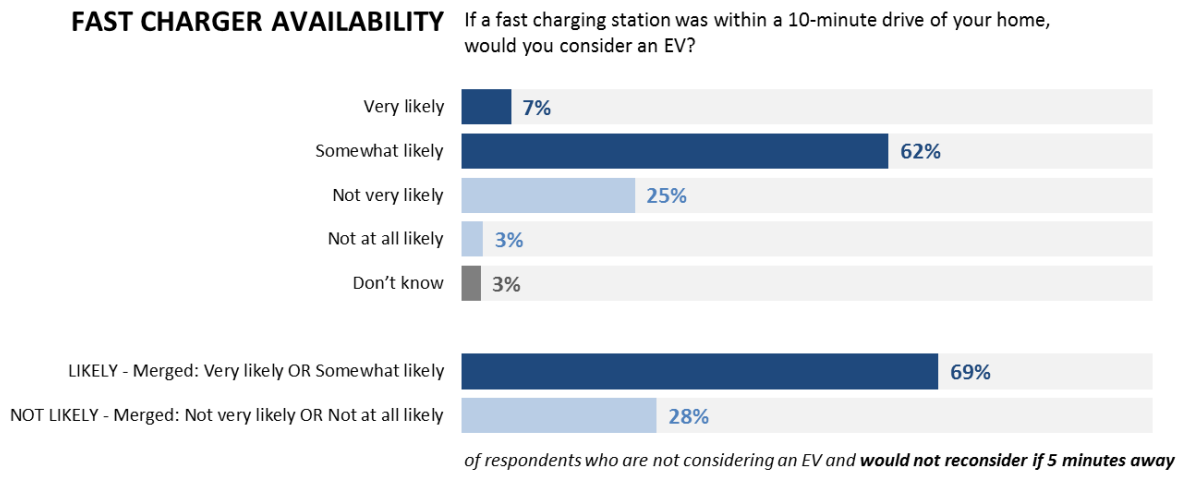
- Approximately 8% of respondents currently own an EV or are on a waiting list for one.
- 49% of respondents said that their next vehicle *will* be an EV, with 36% more saying their next vehicle *may* be an EV



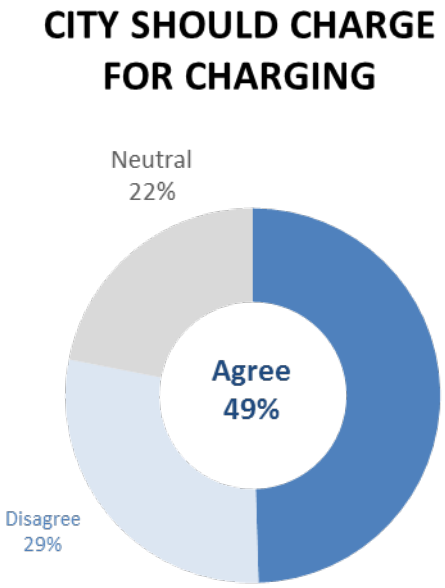
For those not planning on switching to an EV, the leading barrier to purchasing an EV is the vehicle cost (58% of respondents); however, almost all respondents indicated that not having access to charging infrastructure was preventing them from considering an EV.



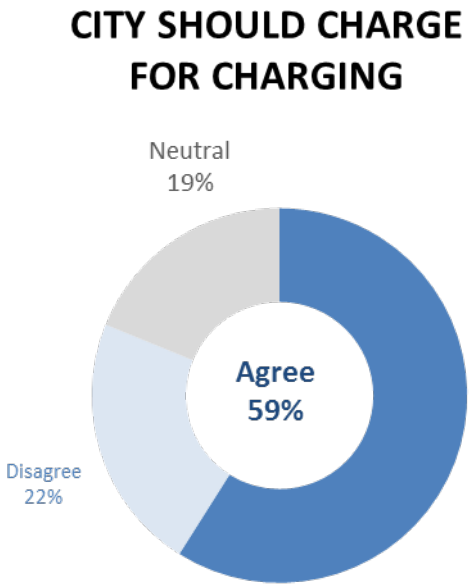
Approximately 70% of respondents said that having access to a fast charging station at a favorite amenity such as a coffee shop or grocery store within a 10-minute drive of their home would make them very or somewhat likely to consider an EV.



Approximately half of all respondents agreed that the City should begin charging fees for access to public charging stations, with approximately 30% of current EV owners (or respondents on waitlists for an EV) disagreeing.



respondents who own an EV



respondents who own a conventional vehicle, or not at all

Strategic Partnerships: Existing and Potential

The City has many existing partnerships with various site hosts throughout Vancouver, a result of the *Charge and Go* field trial. The following table lists examples of potential future partnerships that would support public or workplace charging infrastructure.

Table 3 - Example existing and potential partnerships

Partner	Relationship to EV Infrastructure	Partnership
EasyPark	Parking operator Site host with significant number of Level 2 stations already deployed	Existing station hosting agreement Potential site host for EHubs
Vancouver School Board	Landlord with parking operations	Existing station hosting agreement Potential site host for additional Level 2 charging[24]
Tesla Motors	Vehicle developer Charging infrastructure turnkey provider	Deploy Level 2 infrastructure at strategically important sites Include Supercharger stations at Fast Charging Hubs

[24] The City would likely have to cover the entire cost of deployment, operation, maintenance and administration, as the School Board cannot charge fees for station access under the *BC Utilities Commission Act,* and could not reasonably support the capital or operating costs of EV charging.

Partner	Relationship to EV Infrastructure	Partnership
Fraser Basin Council	Manages numerous provincial EV outreach and incentive programs	Existing partnership (*Emotive* program) Potential for additional outreach and incentive programs
Metro Vancouver	Jurisdiction over air quality, significant interest in EV uptake Enables region-wide information sharing and program delivery	
Chargepoint, AddÉnergie, SemaConnect	EV charging infrastructure manufacturers Can provide end-to-end support for EV charging network Significant deployed capacity of existing Level 2 network in Vancouver	Potential joint ventures on public charging infrastructure
Powertech	Significant knowledge base on advancing EV infrastructure EV charging network installer	TBD
BC Hydro	Crown electrical utility with significant interest in further deployment of EV infrastructure and EV uptake Management of electrical distribution network in Vancouver	Cost sharing on Fast Charging infrastructure Existing Memorandum of Understanding
Ivanhoe Cambridge, Cadillac Fairview, Bentall Kennedy	Commercial property managers with interest in deploying workplace/public EV charging Significant Level 2 network already deployed on their properties	Existing station hosting agreements Potential participation in workplace incentive programs or program promotions Additional station hosting
New Car Dealers Association	Interest in supporting further EV infrastructure	TBD

11. Strategy Implementation

Financing the Strategy

The strategy includes costs for deploying public charging infrastructure and incentive programs. A revenue source for public charging through fees to access charging stations will provide some cost recovery that may increase over time.

The *EV Ecosystem Strategy* will require approximately $3M in capital expenditures over five years. Costs will cover the following:

- $2M for fast charging hubs
- $500,000 for Level 2 network expansion
- $500,000 for MURB / Workplace Retrofit program

Public charging deployment

The City will deploy approximately 8-10 EHubs across the City (Action P1). In addition, the City will deploy Level 2 charging at 20 community centres and/or parks across the City (Action P2).

MURB / Workplace Retrofit Program

Action H6 proposes aprogram for EV charging for stratas, landlords and work places. An outlay of $500,000 could support the retrofit of an estimated 150 EV charging upgrades in the City.

Monitoring and Reporting

Initially, the EV infrastructure program will be evaluated annually. After four years, and on an ongoing cycle of every four years subsequently, the need for continued City involvement in public infrastructure deployment will be evaluated.

Through these evaluations, the City will determine when its involvement may be reduced without compromising service levels.

The evaluation of program success should include the following:

1. Number of monthly charging sessions at each charging station
2. Number of monthly charging sessions across all fast charging stations owned by the City
3. A determination of station-by-station availability, utilization, revenue, and uptime

Rates, network services and other site-specific criteria will be considered if individual stations do not meet a to-be-determined baseline criterion for metric #3 above. In addition, these metrics will be incorporated into future site selection models as network expansion continues.

When metrics 1 and 2 meet the baseline standard for divestment, the City will engage with station hosts and the private sector in general to facilitate the sale of assets and the handoff of station administration for stations not located on City properties. See *Exit Strategy* section below for more details.

The strategy's success will be evaluated on a cycle that is aligned with the City's capital budgeting cycle. Performance results will be integrated into ongoing site selection.

The deployment of EV infrastructure will be reported on publicly through the *Renewable City Strategy* implementation update reporting cycle, once that is determined.

Assessing the Strategy

Performance metrics for the *EV Ecosystem Strategy* will be developed as its components are integrated into City departments. Performance metrics will take into account availability and utilization of public EV infrastructure, as well as station uptime.

Returns on investment will be tracked, but will be more effective as a means of determining the state of the market than the actual performance of the network during the 5-year life of this strategy.

Exit Strategy

Over the past five years the number of EVs on the road has grown exponentially. That same growth is expected in the next 5 years[25], assuming prospective drivers' charging and vehicle needs continue to grow. By the early 2020s, it is expected that the number of vehicles – and resulting charging sessions – will provide a reasonable return-on-investment for public infrastructure.

In supporting EV uptake through the development of persistent, reliable charging options throughout Vancouver, this strategy will enable the private sector to take over deploying, operating and managing public charging infrastructure from the City. The City's role in public EV infrastructure will change once a strong customer base is present in the market:

- Once private sector installations and management are self-sustaining, the City will assess the value in divesting existing charging infrastructure on private property.
- On City property, the ongoing operation, maintenance and administration of public charging stations will be delegated to qualified third-parties.
- The City's role with respect to EV infrastructure will continue to include management of land use and building code policies.
- Public infrastructure located on City land – in particular Level 2 stations – will continue to be a service offered by the City.

[25] Ducharme, P., Marcon, *Feasibility of a Pan-Canadian Network of DC Fast Charging Stations for EVs,* presentation at EVS29 in Montreal, QC, June 19-22, 2016.

12. Action Summary

The City will undertake the following actions.

(H) Expanding Access to Home and Workplace Charging

Quick Starts

Flexible Requirements Quick Start: Move development-specific elements of EV charging requirements (e.g., number of stalls equipped) to the *Vancouver Parking By-law*.

Curbside Pilot Quick Start: Explore the potential for and implement, if feasible, a curbside charging pilot program for commercial business and single-family home owners who do not have access to off-street parking.

MURB Quick Start: Evaluate cost-effective means to requiring some degree of EV charging access to 50% of stalls in new MURBs.

Standards of Maintenance Quick Start: Update Vancouver's *Standards of Maintenance By-law* to require that existing EV charging equipment (including outlets for e-bikes and e-scooters) are reasonably accessible.

Panel Exemption Quick Start: Remove 200A panel exemption for new construction of one- and two-family homes under the *Vancouver Building By-law*

Visibility Quick Start: Update construction requirements for labeling of EV charging circuits and create sample media for use as a guideline by builders.

Actions

H1. Expand building requirements for EV charging readiness in MURBs such that each resident has access to EV charging in their own parking stall.

H2. Require cellular repeaters in all underground parking levels to enable networked stations and to prepare for access by autonomous vehicles.

H3. In coordination with other levels of government, provide education to stratas, landlords and property managers to further acceptance of MURB EV charging retrofits

H4. Develop in-building "Innovation Zones" that link incentives for car-share parking with creation of EV charging at car-share parking stalls

H5. Develop a Workplace Charging Challenge

H6. Develop a MURB and workplace Retrofit Program.

H7. Review of taxation and labour implications

H8. Work with BC Hydro to determine how best to mitigate impacts to distribution system

(P) Improving the Public Charging Network

Quick Starts

Network Review Quick Start: Review all existing public Level 2 stations on City property to identify those with limited availability and/or monitoring capabilities.

Fair Access Quick Start: Create and implement a fee structure for existing Level 2 charging stations that will encourage use of home charging where available, but still provide a significant cost incentive compared with fossil fuels.

Utilities Commission Quick Start 1: Create a template model to support local businesses in applying to BCUC for EV charging exemptions. Pilot an initial run through BCUC with a large supplier of EV charging in the City.

Utilities Commission Quick Start 2: Work with large EV station hosts and the Province, BCUC and BC Hydro (e.g., EasyPark) to enable such station hosts to charge fees under the *BC Utilities Commission Act*.

User Experience Quick Start: Investigate and, where appropriate, implement options for network interoperability between the existing five EV charging data networks managed by the City. Includes potential connections with PayByPhone, VanConnect, Compass, Treo and other mobile payment technologies.

Actions

P1. Develop charging hubs that support residents, commercial fleets, EV taxis and EV car-sharing

P2. Improve public Level 2 charging access and visibility

P3. Investigate potential carbon credit mechanisms that can encourage investment in public charging

P4. Develop public charging points to be sources of information for non-EV drivers

***P5. Advocate with the provincial government, BCUC and BC Hydro for exemptions or more streamlined regulations to enable private sector station hosts to charge fees for electricity under the* BC Utilities Commission Act**

(I) Integrating: EV Infrastructure Planning and Management

Quick Starts

Operating Sites Quick Start: City (via Engineering Services) to operate and administer existing City-owned charge station network and work with external network operators to maintain high station uptimes and availability.

Training Quick Start: Building and Development Services staff to receive training on EV charging requirements, technologies, and potential configurations in building construction, which will then be disseminated to contractors.

Metering Quick Start: Install BC Hydro meters for existing EV charging at all City-owned buildings for energy management tracking, and add these meters to Real Estate and Facilities Management Asset Manager.

Actions

I1. Form an internal task force on autonomous, connected, electrified and shared mobility

I2. Create a consistent user experience using data management and aggregation

I3. Integrate EV charging deployment with new developments and large re-developments

I4. Subject to Council, Engineering and other necessary approvals, add public charging to Engineering's list of Community Amenity Contributions

I5. Create planning guidelines for EV infrastructure deployment

13. Acknowledgements

The *EV Ecosystem Strategy* is the result of many hours of research, discussions and insights from many different individuals and organizations. The City of Vancouver thanks all of those who provided their time, expertise and leadership to develop this transformational direction.[26]

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[26] Inclusion in the Acknowledgments does not explicitly or implicitly represent endorsement of the *EV Ecosystem Strategy* by the individuals and organizations listed.

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14. Appendix A – Public Survey

The City of Vancouver is developing an Electric Vehicle Strategy – a strategy for electric vehicle ("EV") charging infrastructure!

This strategy will determine the City's role with respect to providing charging options within the City over the next five years. EVs can play a part of the City's long term goal to transition to 100% renewable energy before 2050, and contribute to the City's Greenest City and *Transportation 2040* Goals.

- BC Hydro's electrical grid is already over 93% renewable
- EVs reduce air and noise pollution.
- Electricity in BC is among the least expensive in North America, so fueling an EV can cost as little as 1/5 per km as using gasoline or diesel.

Tell us what you think about electric vehicles! Your feedback will inform the strategy by helping us understand the motivators and barriers when it comes to electric vehicles, and needs around infrastructure.

Section 1 - Use, Barriers and Motivators

1. **Do you presently own a plug-in electric vehicle, or do you own another type of vehicle? (Select all that apply)**

   - Yes- an electric vehicle
   - Yes – a plug-in hybrid electric vehicle
   - I'm on a waiting list for an EV
   - I own another type of vehicle
   - I don't own a vehicle, but have car share
   - I don't own a vehicle or have a car share

   [IF OWN EV OR HYBRID OR ON WAITING LIST FOR EV ASK Q2]

2. **What motivated you to buy an EV? (select all that apply)**

   - Having access to home charging
   - Batteries have improved and can last longer distances
   - Saving money
     More public charging stations are now available
   - To reduce my impact on the environment
   - They are a smoother, quieter ride than other vehicles
   - I like the look of them
   - All of the above.
   - Other (please specify)

2a. What have been the benefits of owning an electric vehicle for you? [OPEN-END]

2b. What have been the challenges of owning an electric vehicle for you? [OPEN-END]

[IF NO EV - OWN ANOTHER TYPE OF VEHICLE ASK, Q3]

3. **What type of vehicle do you currently own?** (select all that apply)

[ROWS]	[COLUMNS]
Small automobile	Diesel
Mid-size or larger automobile	Gasoline
SUV	Hybrid
Truck	
Motorcycle	

[IF Q1 OWNERSHIP IS = NO EV – OWN ANOTHER TYPE, CAR SHARE, OR DON'T OWN A VEHCILE ASK Q4]

4. **Do you plan on purchasing a vehicle, or replacing your current vehicle (s) in the next five years?**

- Yes
- Maybe
- No

[IF YES, OR MAYBE PLANNING TO PURCHASE OR REPLACE VEHICLE ASK Q5 AND Q6]

5. **Specifically, *when* do you think you might purchase a vehicle or replace your current vehicle(s)? (select all that apply)**

- < 1 year
- 1-2 years
- 3-5 years
- Don't know when

6. **Are you planning to, or would you consider purchasing an EV, or replacing your current vehicle with an EV?**

- Yes
- Maybe
- No

[IF MAYBE OR NO TO PURCHASING OR REPLACING VEHICLE WITH AN EV]

7. **You've said that you're not planning to buy an EV or aren't sure whether you will in the future. What's holding you back?**

- I don't know where I would charge it
- Vehicles are too expensive
- There aren't any models that fit my needs
- I can't put a charging station at my home parking stall

- I don't have my own parking stall so I wouldn't have my own place charge it.
- The vehicles offered in the Vancouver area can't go far enough between charges.
- I haven't thought of it before
- Other (please specify)

8. **Fast charging stations (or "DC Fast Charging Stations", or "Superchargers") have enough power to recharge a longer-range EV in 30 minutes or less.**

   The average Vancouver driver would need to recharge an EV with a 300km range about once every 7-10 days, and with fast charging it would only take about 30 minutes.

   If a fast charging station was located at your favourite coffee shop or grocery store (for example) within a 5-minute drive of your home, how likely is it that you'd consider switching to an electric vehicle?

   - Very likely
   - Somewhat likely
   - Not very likely
   - Not at all likely
   - Don't know

   [IF Q8 = VERY/SOMEWHAT LIKELY ASK Q8a]

   8a. And if the fast charging station was 10 minutes away instead of 5 minutes, how likely is it that you'd consider switching to an electric vehicle?

   - Very likely
   - Somewhat likely
   - Not very likely
   - Not at all likely
   - Don't know

9. **Is there anything else that would motivate you to consider buying an EV in the future? (Select all that apply)**

   - Having access to home charging
   - Easy access to public charging stations (i.e., non-"fast chargers" that take about an hour to charge)
   - Access to public charging near amenities (e.g., grocery stores, coffee shops etc.)
   - Being able to save money by going electric
   - Lower cost EVs
   - Larger range of EV models and styles
   - The negative impact of fossil fuel cars on the environment

- Other (please specify)

[ASK EVERYONE]

Section 2 - Charging at Home

Depending on the type of dwelling you live and when it was built, you might have access to EV charging at your home.

In 2011 the City of Vancouver adopted a by-law that required all new single, detached houses, townhouses, and duplexes support EV charging either through a standard wall outlet or a 240V connection. This allows them to start each day with a full battery.

10. Do you live in a…

- Single, detached house
- Townhouse/duplex
- Multi-unit building (i.e., apartment or condo)
- Secondary suite (e.g., basement suite)
- Laneway house
- Other (please specify)

11. When was the dwelling that you live in built?

- Before 2011
- 2011 or after
- Don't know

[IF LIVE IN DWELLING 2011 OR AFTER ASK Q11]

12. You've said your place was built in 2011 or later. Did you know that it was equipped for EV home charging?

- Yes
- No
- Not sure

[ASK EVERYONE]

Section 3 - Public Charging

13. Level 2 charging is the most common form of EV charging at public locations. Level 2 stations can recharge an average Vancouver driving day (30km or less) in about an hour.

Did you know that there are already over a hundred public charging points throughout Vancouver?

- Yes

- No
- Not sure

14. The City is also looking at expanding the public Level 2 charging network to all City facilities, beginning with those areas that are presently underserved by public charging.

Where else would you like to see EV charging stations?

- At grocery stores
- At coffee shops
- In shopping districts
- At tourist attractions
- At office towers
- In specific neighbourhood or location (please specify)
- Other (please specify)
- Don't know [EXCLUSIVE CHOICE]

The City currently manages public Level 2 stations located at park and community centres and at City Hall, which are about 30% of the total public stations in Vancouver. The rest are managed and operated by private businesses like parking lots (e.g Easy Park etc.)

15. These City managed charging stations (on city property) were paid for under a federal grant program. Currently, many of these stations experience congestion, and the City is considering charging a fee to alleviate this issue, and ensure that the stations are available to those who need them. The fees would be used to pay for the maintenance and operation of the stations.

Do you agree or disagree with the introduction of fees at the City's public EV charging stations?

- Strongly agree
- Somewhat agree
- Neutral
- Disagree
- Strongly Disagree
- Don't know
- No opinion

15a. Why is that? [OPEN END]

16. 14. Do you have any other comments about EVs, or Vancouver's Electric Vehicle Strategy? [OPEN-END]

<u>Section 4. About You</u>

It's important to us that we hear from a diverse group of people and perspectives. The following questions help us determine how the feedback we receive represents the community.

1. **What is your home postal code?**

2. **Do you identify as…?**

   - Male
   - Female
   - Transgender
   - None of the above. I identify as___
   - Prefer not to say

3. **Which one of the following age groups do you fall into?**

   - 19yrs and under
   - 20-29 years
   - 30-39 years
   - 40-49 years
   - 50-59 years
   - 60-69 years
   - 70+ years

4. **Which of the following categories best describes your total household income per year before taxes?**

   - Under $40,000
   - $40,000 to under $60,000
   - $60,000 to under $80,000
   - $80,000 to under $100,000
   - $100,000 to under $150,000
   - $150,000 and above
   - Prefer not to say

5. **What is the highest level of education you have completed? Please select one response only.**

   - Elementary/grade school graduate
   - High school graduate
   - College / technical school graduate
   - University undergraduate degree
   - Post-graduate degree
   - Professional school graduate (e.g., medicine, dentistry, veterinary medicine, optometry)
   - Other (please specify)

6. **How did you hear about the Electric Vehicle Strategy questionnaire? (select all that apply)**

   - Talk Vancouver email invitation
   - Greenest City email newsletter

- City of Vancouver website
- Other website (please specify)
- City of Vancouver Information Bulletin or Media Release
- Friend/family (word of mouth)
- Facebook
- Twitter
- Media coverage (e.g., news article, radio show, TV etc.)
- Other (please specify)
- Don't remember

7. Thinking about your experience with this questionnaire, how much do you agree or disagree with the following? Please select one response for row (Strongly agree, Somewhat Agree, Neutral, Somewhat Disagree, Strongly Disagree , Don't know).

- The content presented was clear and understandable.
- I understood how my input would be used.
- I felt that my input would make a difference.
- I felt that participating was a valuable experience for me.
- I had the opportunity to share my views.
- I felt I learned something new**.**

Stay Connected with Us!

Would you like to stay informed about the Electric Vehicle Strategy? If you do, let us know how you'd like to stay connected, provide your contact information below, and we'll get in touch.

Would you be interested in…? (select all that apply)

- Attending a public consultation event to get more detail and ask questions about the Electric Vehicle Strategy
- Staying informed about Vancouver's Electric Vehicle Strategy
- No thanks

Please provide your contact information below

Name (optional):
Email Address: