Electric Vehicle Strategy – Technical Report

Prepared for:

CITY OF VICTORIA

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Introduction

Context

In 2016, the City of Victoria Council committed to reducing community greenhouse gas emissions by 80 percent from 2007 levels by 2050 and in March 2019, declared a climate emergency. The pathway to achieving these reductions was outlined in the 2018 Climate Leadership Plan (the Plan). This ambitious goal requires a transformation in the way the City uses and manages energy in five major City sectors: buildings, mobility, waste management, municipal operations, and adaptation.

Transportation is currently responsible for 40 percent of community emissions, requiring multi-pronged approach to reduce emissions. Along with active and public transportation and land use goals, the Plan identifies that the remaining personal transportation vehicles should be electrified. Specifically, the City set the following target:

By 2030, renewable energy powers 30 percent of passenger vehicles registered in Victoria, and 100 percent of passenger vehicles are renewably powered by 2050.

The City of Victoria engaged Dunsky Energy Consulting, with partner AES Engineering, to develop an Electric Vehicle Strategy as a roadmap to realizing this ambitious goal. To develop a realistic and made-for-Victoria plan, a thorough analysis of the current conditions and the strategic infrastructure, investment, and policies required to reach the 2030 passenger vehicle target through electrification. This report summarizes the results of these analyses, including the current state of the local EV market, infrastructure best practices and levers for action for accelerating adoption, and the modeling of different adoption scenarios based on infrastructure and incentive interventions. Key findings and recommendations are summarised in the EV Strategy, which has been developed in parallel and in combination with this report.

Background

Electric vehicles (EVs) are currently the most readily available, energy efficient and cost effective zero emission passenger vehicle and, therefore, have been identified by the City as the core focus for the Strategy. Other zero emissions vehicle technologies, such as hydrogen fuel cell, are at an earlier stage of market-readiness. This analysis covers both plug-in hybrid EVs (PHEVs) and battery EVs (BEVs).

The primary focus of this analysis is on the role of charging infrastructure in enabling EV adoption, a critical area where local governments can have significant influence. The most convenient place to charge an EV is at home, and any steps the City can take to increase home charging access can help to ensure that Victoria residents see EVs as an attractive alternative to gas-powered vehicles. Additional charging infrastructure at workplaces and public locations can support those without access at home while affording all EV drivers greater flexibility to travel longer distances. Through investment and policy, the City can play an important role in improving access to charging infrastructure for residents. Other policies and incentives to build a supportive EV ecosystem and market are also addressed.

Charging infrastructure for PHEVs and BEVs falls into three common types of charging infrastructure: Level 1 and Level 2 (both using AC) and Direct Current Fast Charging (or DCFC). Government support is typically targeted towards the installation of Level 2 and direct current fast charger (DCFC) infrastructure, due to their faster charging and higher cost. These two charging types are the focus of this analysis. An overview of the three types is presented in Table 1.

Table 1 Common EV charging infrastructure types and characteristics

	Level 1 (AC)	Level 2 (AC)	DCFC
Typical Output	1.5 kW (120 Volts)	7.2 kW (240 Volts)	50 kW – 350 kW (400 to 800 Volts)
Range Added per Hour (approximate)	8 km	40 km	300+ km
Equipment and installation costs	$150 - $1,500[1]	$2,000 - $15,000	$75,000 - $250,000
Typical use locations	Some homes, workplaces, public spaces	Homes, workplaces, public spaces	Major corridors, public spaces
Used by	BEV and PHEV	BEV and PHEV	Primarily BEVs

EV charging can be grouped by charging type, and further grouped by purpose (e.g., residential, workplace, "on the go" or opportunity charging) and location (e.g. private and public parking lots and on-street). For each charging type, Figure 1 shows the most appropriate purpose and locations.

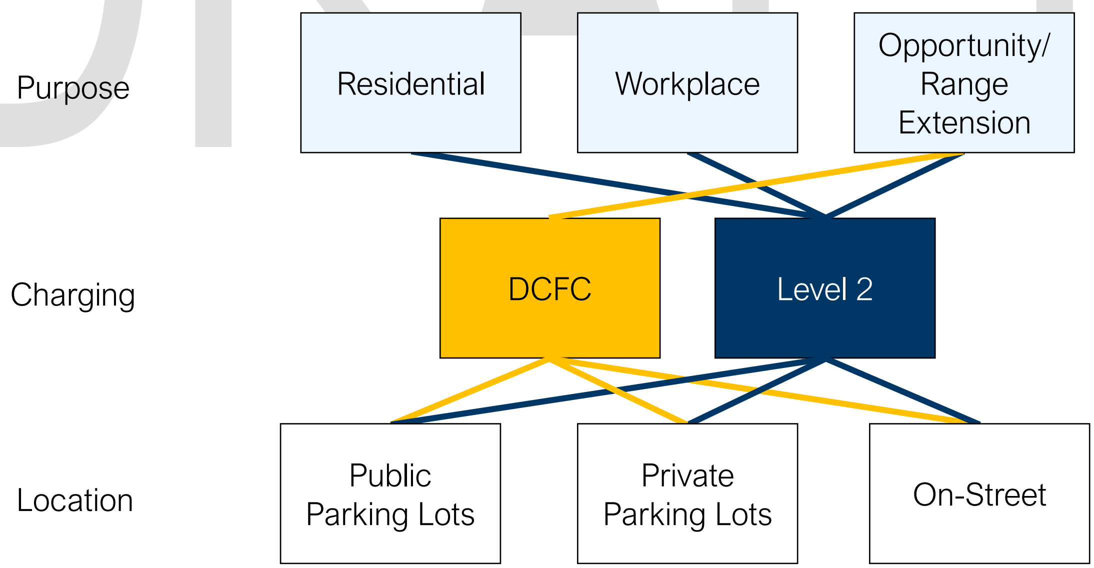

Figure 1: Location, types, and purposes of EV charging.

[1] While a standard 120 V AC outlet can be used, an EV driver will need to provide their own portable charging infrastructure to make the connection possible. Alternatively, Level 1 charging can refer to a permanently affixed 120 Volt charging station that can be used by EVs without requiring additional equipment.

The type of charging and location should be chosen with careful consideration of the purpose of that charging, and this is reflected in the leading practices reviewed in this report. For example, DCFC is an appropriate type of charging for opportunity charging and range extension because it is fast and can be used by people on-the-go. For residential and workplace applications, DCFC is both inconvenient (the driver needs to return to their car to move it shortly after parking) and expensive to build; therefore, it is more appropriate to focus on Level 2 charging in these contexts.

In addition, the demand for each of workplace, residential, and opportunity charging will depend on the availability of charging for each of the other purposes (e.g. with more residential charging, the demand for workplace charging will decrease; conversely, a lack of residential charging access can be partially mitigated by access to workplace and opportunity charging). These themes are further explored in the Scenario Assessment and EV Strategy.

Objective & Structure of this Report

The objective of this report is to provide the technical details and context for the EV Strategy. The Strategy outlines the optimized plan for investment and supports required to achieve the City's 2030 target. This technical report is the technical companion to the public-facing document.

This report is structured into the following three sections:

1. Condition Assessment: an overview of the current EV adoption context in Victoria.
2. Leading Practices Review: summary of approaches to accelerate adoption in top EV jurisdictions.
3. Scenario Analysis: EV Adoption (EVA) modeling results of adoption scenarios, including the baseline and optimized scenarios.

Together, this analysis was integrated and iterated to produce the optimal scenario and recommendations within the EV Strategy.

This section reviews the current state of electric vehicle (EV) adoption in Victoria, as well as access to EV charging infrastructure both at home and in public locations, including charging stations operated by the City of Victoria.

Key Insights

- Victoria's EV adoption rates are above the provincial average.
- Despite strong adoption, current trends will not reach the City's 2030 target.
- The majority of current EV owners live in single-family dwelling, whereas the majority of Victorians live in multi-residential buildings.

1. EV Adoption

The Victoria region has the highest percentage of EV sales in Canada. Early data from Statistics Canada from the first half of 2020 shows that 13.4% of new vehicle registrations were EVs in the Victoria region [1]. Within the City of Victoria, there were 825 EVs on the road in 2020[2], representing approximately 12% of new vehicles and nearly 2% of all vehicles registered in Victoria[2].[3]

Despite Victoria's relative speed adopting EVs, much more rapid progress will be required to reach the City of Victoria's goal of 30% of all registered vehicles being EVs by 2030, as shown in Figure 2. Figure 3 shows how the City of Victoria compares to neighbouring municipalities, Vancouver Island, and all of British Columbia (BC) in terms of percent of EVs of all registered vehicles.

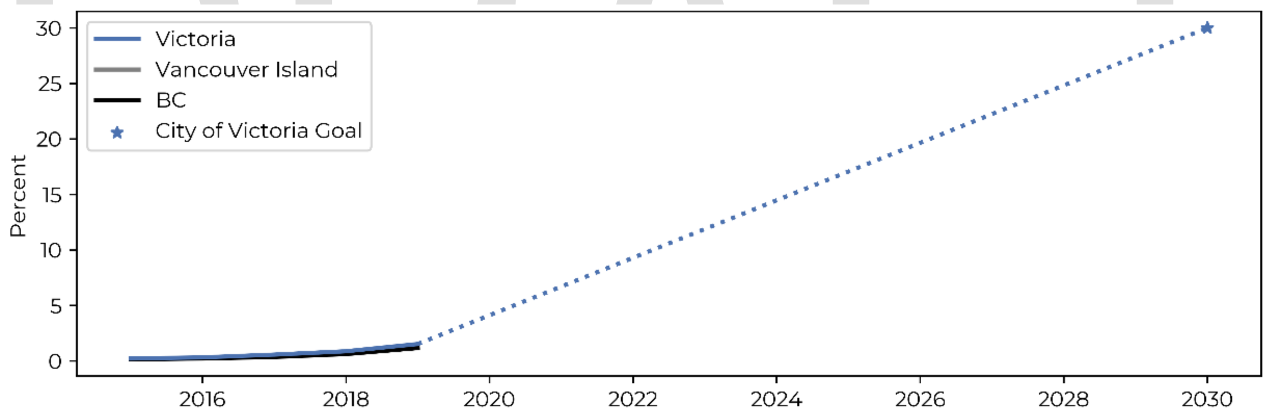

Figure 2: Current EV ownership as percent of all vehicles in Victoria and the City of Victoria goal of 30% EVs by 2030. (Data Source: [2])[4]

[2] BC Ministry of Energy, Mines, and Low Carbon Innovation. (2020). EV vehicle registration data. *Personal communication, October 13, 2020.*
[3] Due to the absence of vehicles sales data by municipality, vehicle model year from ICBC registration data is used as a proxy for new vehicle sales. This is not a perfect proxy for new vehicle sales as it does not take into account vehicles purchased in one jurisdiction and registered in another. However, by model year, EVs did make up 9% of vehicles in 2019 province wide, which matches with reported sales for that year.
[4] Data obtained from the public ICBC Tableau site includes inconsistencies when classifying PHEVs. Data was cleaned by AES Engineering to properly classify most PHEVs, though errors may still exist. Cleaned data differs slightly from data provided by the Ministry of Environment and Climate Change Strategy, however differences are less than differences with the original ICBC data.

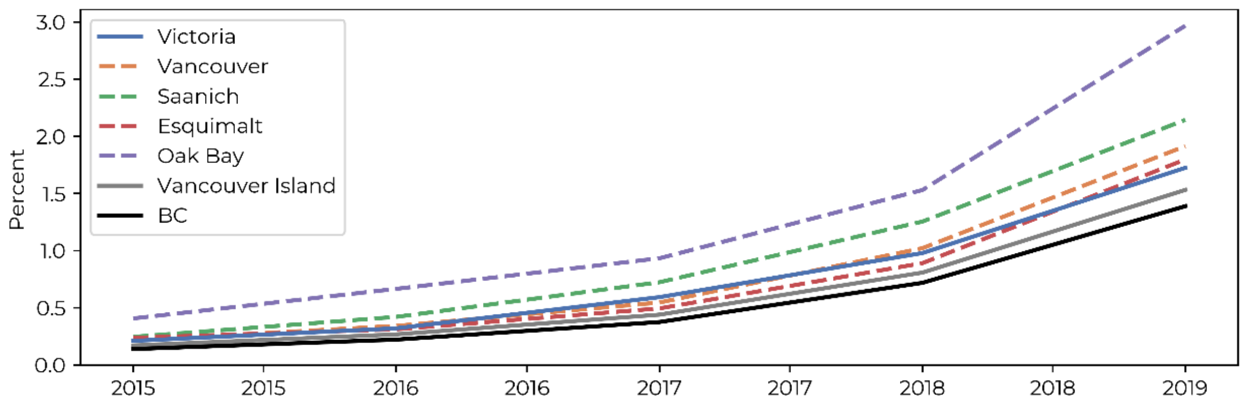

Figure 3: BEV and PHEV ownership as a percent of all vehicles in Victoria and other municipalities, Vancouver Island, and BC. (Data Source: [2])[4]

The distribution of EV ownership in 2018 and 2020 in Victoria by postal code is shown in Figure 4, with EV ownership aggregated by census tract in Figure 5. The corresponding housing types of EV owners in Victoria is shown in Figure 6, based on housing types and EV counts aggregated by postal code. This shows the majority (55%) of EV owners live in single family dwellings (SFDs) [3] [4].

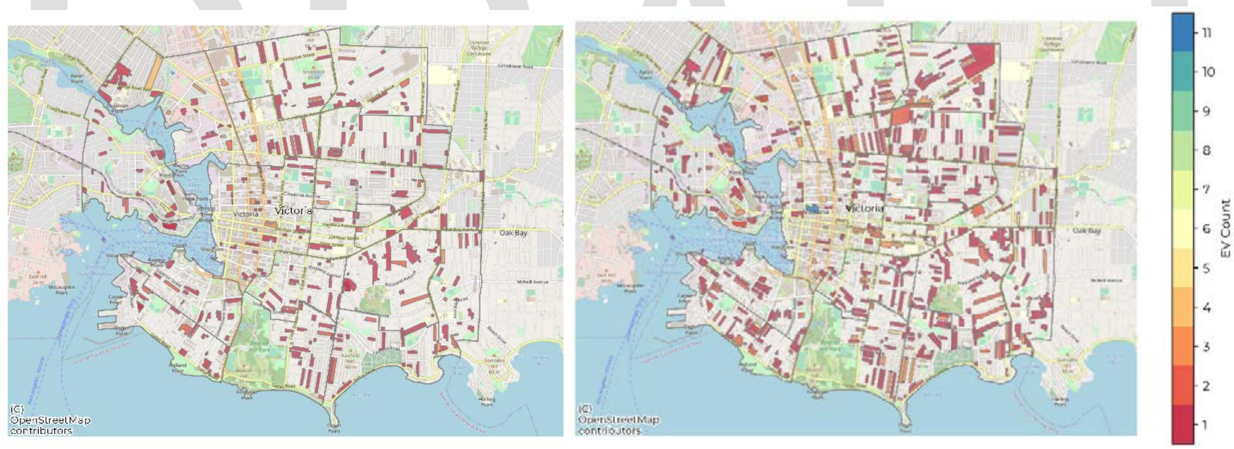

Figure 4: EV ownership by postal code in Victoria for 2018 (left) and 2020 (right). (Data Source: [3])

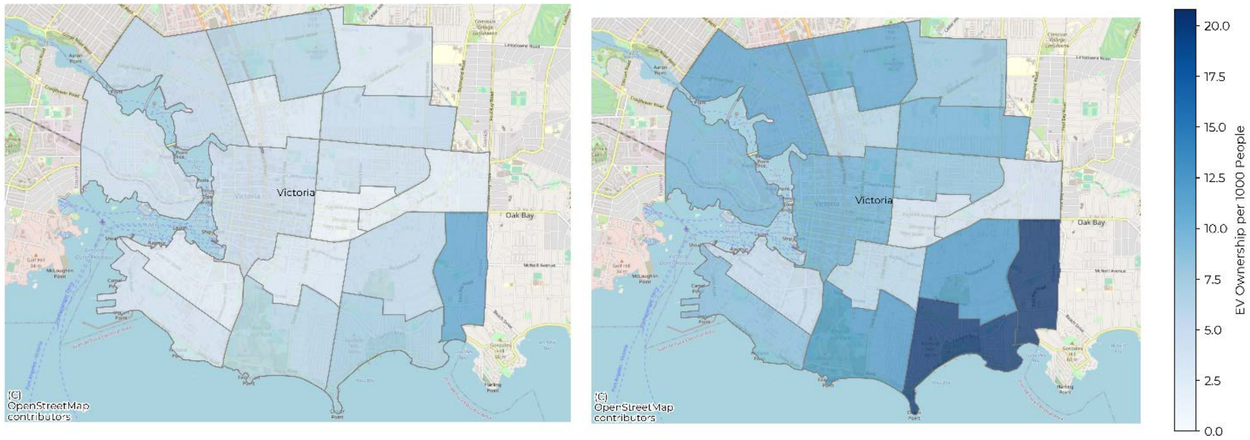

Figure 5: EV ownership per 1000 people by census tract in Victoria for 2018 (left) and 2020 (right). (Data Source: [3])

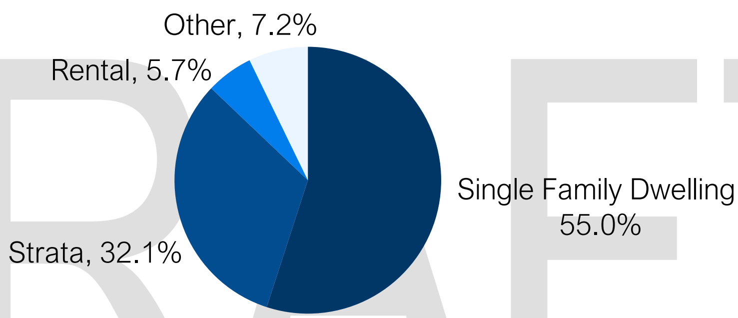

Figure 6: EV ownership by housing type (title) in Victoria. (Data Source: [3] [4])

2. Charging Infrastructure

Charging infrastructure, whether in homes, workplaces, or public locations, is critical for EV adoption. This section looks at current access to home and public charging in Victoria. An in-depth review of potential charging infrastructure expansion options for the City is covered in the Leading Practice Review section.

Key Insights

- At home charging is currently challenging because the majority of Victorians live in multi-residential buildings. Only 22% of residents currently have the potential to charge at home.
- Public charging consists of 74 Level 2 stations, but there is no DCFC access inside City limits.
- City-owned stations are typically engaged by people charging while at work and secondarily while enjoying evening shopping or entertainment.

Access to Home Charging

The most convenient location for EV drivers to charge their car is generally at home, where vehicles are frequently parked for long periods of time. Therefore, increasing access to home charging is a key opportunity for increasing EV adoption.

Access to home charging can be estimated by considering the potential to install charging in different housing types. For example, home charging can often be installed in SFDs if there is a driveway in which to park a vehicle. Experience at Dunsky Energy Consulting and input from the City of Victoria indicate approximately 75% of SFDs in Victoria could install a charging station on their own property with relatively simple and inexpensive changes to existing electrical infrastructure. In contrast, multifamily housing types like apartments generally require more substantial and challenging upgrades to provide access to home charging. A summary of estimated charging potential for different housing types is provided in Table 2.

In Victoria, the majority of residents live in multifamily dwellings; only 14.3% live in single-detached houses. A full breakdown of the percent of Victoria residents in different housing types is shown in Table 2. The large number of residents in apartment buildings makes home charging particularly challenging in Victoria.

Using the housing types and the charging potentials in Table 2, home charging potential across Victoria is estimated at 22%, approximately half of the estimated 45% access across the Capital Region. Figure 7 shows a map of home charging potential by census tract in Victoria, overlayed with median household income.

Table 2: Estimated charging potential housing type and percent of Victoria residents living in each housing type (Data source: [5]).

Housing Type	Assumed Charging Potential	Percent of Victoria Residents
Single-detached house	75%	14.3%
Other single-attached house	75%	0.2%
Semi-detached house	70%	2.5%
Apartment or flat in a duplex	50%	9.8%
Row house	40%	4.9%
Apartment less than 5 storeys	5%	50.3%
Apartment greater than 5 storeys	5%	17.9%

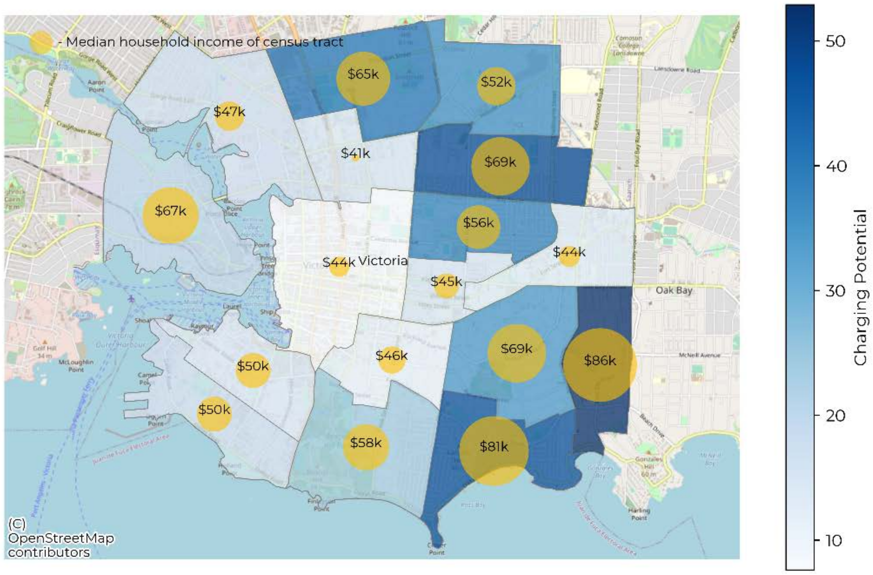

Figure 7 Home charging potential in Victoria by census tract, overlayed with median household income. (Data source: [5])

Home charging access will need to increase significantly in order to meet the City's targets for 2030 and beyond, especially when considering other barriers to adoption. Strategies for addressing this gap will be explored further in the Scenario Analysis section.

Public Charging Infrastructure

Public charging stations in Victoria are shown on the map in Figure 8. There are 74 Level 2 public charging stations within Victoria, and two DCFCs located on Store St close to the Johnson St Bridge. These maps show the total number of stations in each census tract, as well as marking individual station locations with the type of facility they are located at. Facility types are based on Natural Resources Canada classifications, with similar facility types grouped together for readability.

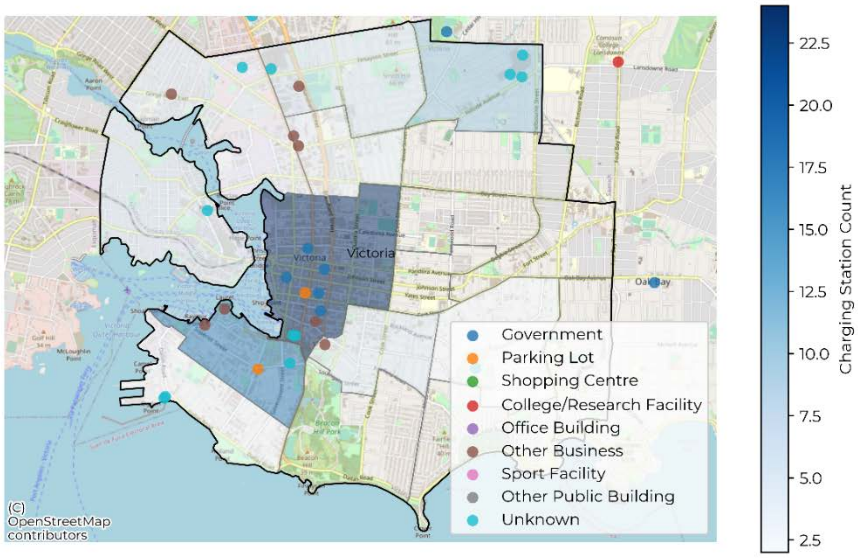

Figure 8: Map of public Level 2 charging stations in Victoria, with total number of charging stations shown with shading. (Data source: [6], [5])

Some of these stations are owned and operated by the City of Victoria. Those stations are shown in Figure 9, with the bubble size for each station representing usage since 2018, as indicated by the total amount of energy delivered by each station. Usage patterns of these station can be seen by considering the heat maps in Figure 10, which show, on the left, the starting hour of each session for each day of the week, and on the right, the amount of power delivered by the station during each hour for each day of the week.

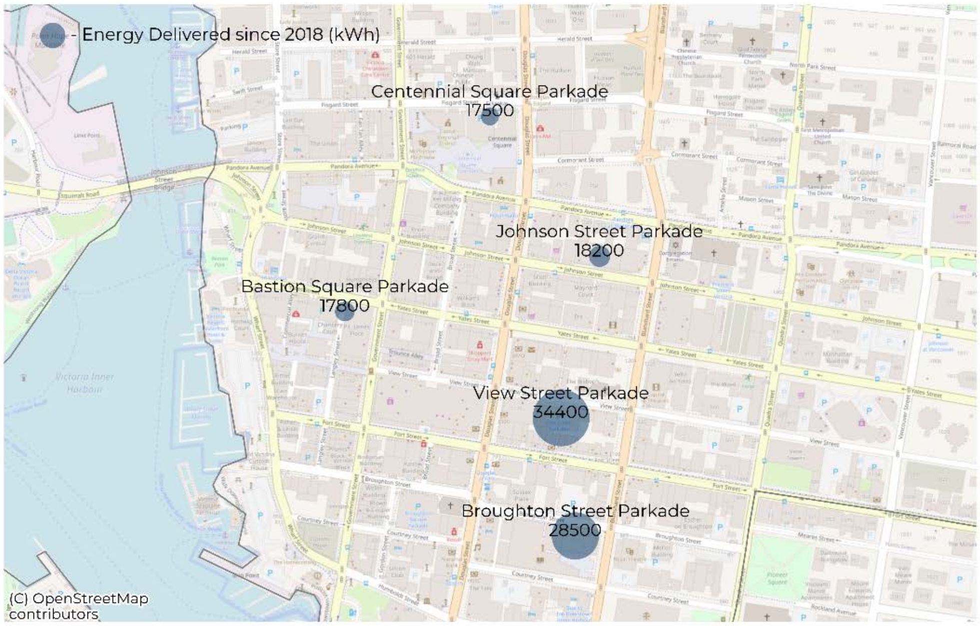

Figure 9: Location of City of Victoria Level 2 charging stations, with total energy delivered since 2018 shown in bubble size and text. (Data source: [7]) In addition, a DCFC station has been installed at Store Street.

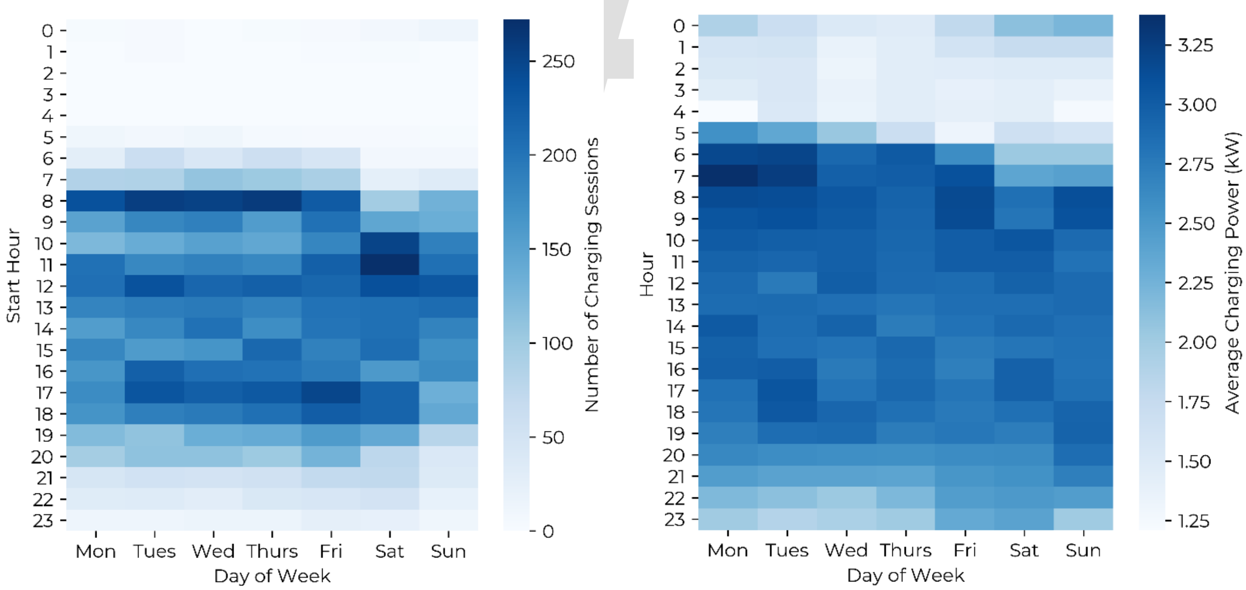

Figure 10: City of Victoria Level 2 charging station usage by hour of day and day of week. Left: Number of charging sessions starting at each time. Right: Average power delivered at each time. (Data source: [7])

On weekdays, the greatest number of charging sessions start in the morning (around 8am), which is consistent with charging patterns expected from commuters into Victoria. There are also a significant number of charging sessions which start around 5pm, which likely represents people charging after work who come into Victoria for shopping or entertainment in the evening.

On weekends, charging often starts mid-morning (10 or 11am), with more usage on Saturday than Sunday. Throughout the week, although almost no vehicles arrive at the stations between 11pm and 6am, some vehicles plug-in before 11pm and charge through the night. This likely represents a very limited number of residents who use the stations in lieu of home charging.

This section details leading practices from around the world to accelerate the adoption of EVs, and the technical, cost, and policy consideration for implementation of each. The first five options focus on the deployment of EV charging infrastructure, with a section at the end on other supporting policies and strategies.

Charging at Home	1. Comprehensive EV ready retrofits 2. On-street residential charging
Charging at Work & On-the-Go	3. Enhanced EV ready new construction requirements 4. DC fast charging hubs 5. On-street and public parking lots in commercial centres
EV Ecosystem Policies	6. Financial Incentives 7. Advocating for supportive policies 8. Educational initiatives

1. Comprehesive EV Ready Retrofits

How it Works

Retrofits to make large percentages (e.g. 100%) of residential parking in existing buildings "EV Ready" represent a promising opportunity to cost-effectively provide convenient access to charging for residents that would not otherwise have home charging.

Type: Level 2

Location: Private Parking Lots

Purpose: Residential, Workplace, Opportunity

EV Ready means that residential and commercial developments are retrofitted so that they have energized electrical outlets installed that can charge an EV when a charging station is installed in the future. These retrofits typically include designs for load sharing using EV energy management systems that can allow for significantly greater amounts of EV charging within an existing building's limited electrical supply.

Example(s)

The City of Los Angeles Department of Water and Power offers residential and commercial EV charging station rebate programs. Different rebates are available for Level 2 charging stations, DCFC, and AC and DC charging stations for medium and heavy-duty EVs [8].

Considerations for implementation

Technical

Rather than retrofitting a few individuals stalls at a time, a comprehensive EV Ready retrofit parking has some technical advantages including:

- A future-proof design to accommodate high levels of future EV charging by designing for EV energy management systems from the outset. Otherwise, incremental additions of a few pieces of electric vehicle supply equipment (EVSE) can result in stranded assets once electrical systems need to be upgraded to accommodate additional charging;

- Improved convenience, as drivers are not expected to move vehicles from EVSE parking spots at inopportune times. In 100% EV Ready buildings, drivers park in their normal assigned parking space and charge overnight.

Cost

In multi-residential and non-residential buildings, retrofits to make a large percentage of parking EV Ready can often be achieved at much lower cost per parking space than incremental additions to EV charging. The cost of incrementally installing charging infrastructure through the BC Charging Solutions Incentive Program has been approximately $7,000 per Level 2 EVSE (including both EVSE and other electrical infrastructure costs). In contrast, AES Engineering has typically been able to achieve costs of less than $1,200 per stall of EV Ready parking for 100% EV Ready retrofits, though costs per project will vary substantially and thus far there have been few 100% EV Ready retrofits constructed, making future average cost values uncertain.

Policy

The provincial government may implement a program to provide incentives for 100% EV Ready residential retrofits. The program would also include incentives for EV Ready retrofits to workplaces and fleet parking areas. There may be opportunities for local governments to provide “top-up” funding for this program.

In addition, the City could explore requirements for EV charging infrastructure in existing buildings and facilities. BC municipalities have adopted requirements for residential and commercial parking in new developments to be EV Ready; it may be the case that local governments have authority to establish requirements for EV charging infrastructure in existing buildings.

The City could explore whether it could use its authority to regulate parking design to require that parking in existing buildings be made EV Ready by a future date (e.g. 2025 or 2030). Combined with incentives, this could help ensure access to EV Ready parking in multi-residential buildings and/or workplaces. Likewise, the City could explore applying EV Ready requirements if developments undergo renovations.

EV retrofits could be supported via financing programs involving municipalities. For example, Californian cities have supported EV charging infrastructure as part of Property Assessed Clean Energy (PACE) financing initiatives [9]. While PACE financing authority requires investigation and is unlikely to be appropriate for stratas, it could be valuable for rental building owners. Other sorts of financing tools (e.g. credit enhancements to support more favorable terms for loans to stratas) could also be explored.

2. On-Street Residential Charging

How it Works

Type: Level 2

Location: On-street

Purpose: Residential

On-street level 2 charging can also be deployed to support residential charging for drivers without charging at home. Although it may be feasible to install charging stations from dedicated power sources, most programs for on-street charging for residential applications have either been powered from existing streetlight infrastructure (see *On-Street Level 2 Charging with Streetlight Hardware* inset), or from private residences. The specific requirements of residential charging relative to opportunity charging (see Practice 5) are important to consider when designing charging systems and the policies that support them [10].

Example(s)

The City of Berkeley, California has run the *Residential Curbside Electrical Vehicle (EV) Charging Pilot Program* since 2014 with the goal of allowing residents without off-street parking to access EV charging. Residents can apply to install two types of EV charging: on-site and curbside. On-site charging can be installed at residences with no driveway but room on the property for charging (e.g. in the yard), where "vehicle-related paving" can be installed for EV charging, which does not require the same zoning and permitting as a parking space. Curbside charging can be installed if there is no room on-site with electricity fed from the adjacent residence. The applicant can decide to use the installed station for personal use only or make it available to other members of the public, however, the parking space cannot be reserved in any way. Personal-use stations must be made inaccessible to the public by locking the cord or disconnecting power. Public-use stations must be accessible and free of charge. All costs are covered by the applicant. All additional details can be found in the pilot manual at [11]. Staff at the City of Berkeley have expressed that both cost, concern about access to curbside chargers (due to lack of restrictions for parking), and placement limitations (e.g. street trees) have limited the number of stations that have been installed, with "far fewer" of the 35 qualified applications for curbside charging actually being installed [12].

New Orleans has also implemented a program which allows residents to install curbside charging stations if they do not have off-street parking. Installed EVSE can only be used for private, non-commercial uses and fees cannot be charged. Like the City of Berkeley, the resident cannot reserve the parking space beside the EVSE in any way. [13]

A similar program was also piloted in the City of Vancouver from 2017 to 2019 [14]. In this case, use of the charging station was explicitly restricted only to the resident, although existing parking regulations were maintained for access to the parking space [15]. This pilot has since ended, and Vancouver's 2020 Climate Emergency Action Plan shifts focus towards installing charging on streetlights and third-party lots near homes, while also providing guidance on use of cord covers to enable safe use of extension cords to cross sidewalks to support Level 1 charging on residential streets.

Considerations for implementation

Cost

Bringing power from residences to curbside can be expensive, as highlighted by experience in the City of Berkeley which saw costs of $5000 to $20,000 [12]. If parking spaces are to be publicly accessible, allowing residents to recoup electricity and infrastructure costs through EVSE user fees should be considered.

Policy

Allowing residents to install curbside charging stations associated with private dwellings will likely create an expectation that they will have 24/7 access to charging if they pay for the charging station and power. This will generally conflict with parking regulations, unless they can be adapted to allow residents exclusive access to a parking location.

Alternatively, this kind of approach could be targeted in areas with low demand for street parking. Areas with high demand for street parking (typically the case in Victoria) may be better suited to public on-street charging using streetlight or other power sources which is managed by the City.

On-Street Level 2 Charging with Streetlight or Utility Pole Hardware

On-street Level 2 charging can be implemented making use of existing streetlight hardware. Additional considerations for these systems are discussed here, along with examples of implementations in other regions.

Examples

In partnership with BCIT, in 2017 the City of New Westminster piloted implementation of five streetlight chargers on streetlights to provide curb-side charging.

The City of Toronto and Toronto Hydro recently launched a new on-street EV charging pilot, including in neighbourhood parking permit locations. Overnight, when permit parking regulations are in effect, only permit holders with an EV that is plugged in can park in these spots. Charging equipment is installed directly onto Toronto Hydro utility poles.

London Councils' Go Ultra Low City Scheme (GULCS) programme has provided guidance and funding to boroughs on the installation of EVSE using streetlight supply, resulting in 320 lamppost charge points [26]. Extra capacity on lamp poles that could be used for EV charging was made available by changing light-fixtures from HPS to LED [31]. Lamp post charging in London requires the driver to use their own "smart cable", supplied by Ubitricity. This cable includes metering and communication to bill the driver for electricity use [27]. In 2018, Ubitricity also won the NYCx Climate Action Challenge to pilot the use of its smart charging cable on streetlight poles in New York City [32] although it is unclear whether detachable cables are permitted for Level 2 charging in North America.

The City of Los Angeles' has also installed 431 EV charging stations on streetlights around the city. These are predominantly FLO and ChargePoint charging stations with an attached cable. They make use of extra electrical capacity resulting from the switch from sodium-vapour to LED bulbs [28].

Technical Considerations

Streetlight systems must be evaluated to determine if they have sufficient electrical capacity for EV charging. Spare capacity may exist or could be made available from retrofits to LED streetlight bulbs. LED upgrades can reduce electrical load by 50% compared to High-Pressure Sodium or Metal Halide light fixtures [12]. Victoria has completed retrofits of lighting in the City which may have created spare capacity.

Streetlight charging systems can either have a charging station mounted on the pole which includes a charging cable (similar to standard Level 2 charging stations in North America), or they can require that the user supplies their own "smart cable" which plugs directly into an electrical outlet on the pole. Requiring EV drivers to carry their own charging cable would be a paradigm shift for North American drivers; however a pilot project in New York does provide a North American precedent for requiring drivers to supply their own cable. The smart cable offered by Ubitricity does not yet appear to be certified in Canada, so these solutions may be delayed until solutions certified for use in Canada are available [31].

Cost Considerations

Costs for London's streetlight charging stations are reportedly about $2300 CAD per charging point, with the "smart cable" costing the user an additional $340 CAD [31]. The cost of installed charging stations with cables in the City of Los Angeles are estimated between $6,800 and $9,500 CAD [31].

Policy Considerations

BC Hydro owns many of the light poles in Victoria and indicated initially to the City that they will not allow other parties to use them for EV charging. This topic could be revisited given the recent precedent in other cities including Los Angeles and Toronto.

3. Enhanced EV Ready Requirements for New Buildings

How it Works

Type: Level 2

Location: Private Parking Lots

Purpose: Residential, workplace

EV charging requirements for new buildings include:

1. Requirements for all residential parking in new developments to be EV Ready.
2. Requirements for some non-residential parking to be EV Ready (e.g. 20-50% for workplace parking, 10-20% for visitor parking).

An EV Energy Management System (EVEMS) can support load sharing between vehicles, reducing electrical system sizes and associated costs. BC municipalities typically specify minimum performance requirements for projects using EVEMS, to ensure sufficient energy delivery per vehicle for overnight charging in residential parking.

Example(s)

17 BC local governments have adopted 100% EV Ready residential requirements, and some also require EV Ready commercial parking. City of Victoria is a leader on Vancouver Island, having recently adopted 100% EV Ready requirements for residential parking, as well as interim non-residential EV Ready requirements. In addition, the City is participating as part of a cohort of BC municipalities is currently considering options for non-residential EV Ready parking requirements (led by AES Engineering).

Considerations for implementation

Technical & Cost

Requirements for EV charging infrastructure in non-residential buildings should consider different use cases (workplace parking, visitor parking, car-share, and ride-hailing) and the charging systems that will best supports these. For example, charging provided at workplaces can make use of load-sharing via EVEMS in order to reduce infrastructure costs while still providing sufficient power to workers who will leave their vehicle for the entire day to charge, similar to EV Ready requirements for residential buildings. Conversely, visitor, car-share, and ride-hailing users will need higher power charging.

For example, for non-residential building archetypes with a large amount of workplace parking, such as office buildings, estimates of the incremental cost of 20% EV Ready parking in new developments with dedicated circuits (no load sharing) often range from $2300 to $4600 per parking stall for surface parking and $1600 to $2900 for underground parking. With 4-way loading sharing for workplace parking, and 25% EV Ready workplace parking and 10% EV Ready visitor parking, this range is reduced to approximately $1300 to $2200 for surface parking and $900 to $1300 for underground parking. These estimates are based on costing studies performed by AES Engineering for cities in the Lower Mainland.

Policy

Ongoing work to develop non-residential EV charging requirements for BC municipalities suggests that these requirements would achieve the best outcomes by differentiating between workplace and visitor designated parking, with higher power and lesser percentages of EV Ready parking required for visitor parking. An example distribution of workplace parking is presented in Table 3. Means of differentiating between workplace and visitor (opportunity, car-share, ride-hailing) parking as part of EV Ready requirements in the City's Zoning Bylaw are recommended to be explored.

Table 3: Example distribution of workplace and visitor parking based on building use.

Non-Residential Use	Percent Workplace Parking (Remainder is Visitor Parking)
Store, Restaurant	30%
Office space	90%
Industrial & commercial	90%
Storage warehouse	90%

4. DC Fast Charging Hubs

How it Works

DC fast charging (DCFC) can provide fast charging in high-traffic locations. DCFC is seen as critical to allowing long-distance travel. It can also provide convenient, fast charging to users without readily accessible charging at home. Locating multiple chargers in a single hub can support a larger volume of EV drivers as adoption increases.

Type: DCFC

Location: Private Parking Lots, Public Parking Lots, On-street

Purpose: Opportunity/ Range Extension

Example(s)

London's Electric Vehicles Infrastructure Delivery Plan includes the development of rapid charging hubs, primarily serving high-mileage/business users, with the goal of delivering five flagship hubs. [16] The first of these hubs, located in Stratford International Station, opened in December 2019. [17]

The City of Vancouver currently manages nine DCFC stations at five locations. The City of Vancouver has stated the goal of having a DC Fast Charging hub within a 10 minutes drive anywhere in Vancouver by 2021. [18]

The City of Portland, Portland State University, and Portland General Electric (PGE) have partnered to setup a DC fast charging hub in downtown Portland with three 50kW DCFC stations supplied by Greenlots. PGE has additional charging hubs, called "Electric Avenues" in six other locations which have both DCFC and Level 2 stations [19] [20].

Considerations for implementation

Technical

DCFC stations generally require a three phase 480 V supply. The cost of a new electrical service for the high power necessary for DCFC hubs can vary substantially from site to site. The cost of different locations should be considered early-on, and utilities engaged early, when selecting suitable sites for DCFC hubs.

Publicly accessible DCFC may become increasingly viable and convenient as a primary means of charging vehicles as vehicles' range and charging speeds increases.

Cost

The cost for DCFC charging stations is approximately $800-1000/kW but varies depending on the supplier. The electrical infrastructure and installation costs vary more widely depending on the site but can easily cost as much or more than the charging station itself. Some sample costs are provided in Table 4.

Table 4: Example costs for DCFC charging station and installation based on experience at AES Engineering and recent Dunsky analysis conducted for the federal government. Costs may vary widely depending on charger selection, number of charging stations, and site selection.

DCFC Power	Charging Station Cost	Approx. Installation Cost	Total Cost
25kW	$15k	$10k - $50k+	$25k - $65k+
50kW	$55k	$20k - $100k+	$75k - $150k+
100kW	$90k	$40k - $100k+	$130k - $190k+
350kW	$140k	$60k – $115k+	$200k - $255k+

5. On-street and Public Parking Lots in Commercial Centres

How it Works

On-street Level 2 and DCFC can support opportunity charging. Access to such charging may be particularly important for ride-hailing, taxis, and other high-mileage vehicles [21]. In addition to implementing with standard freestanding EVSE, on-street opportunity charging can make use of existing streetlight hardware (see *On-Street Level 2 Charging with Streetlight Hardware* inset).

Type: Level 2, DCFC

Location: On-street, public parking lots

Purpose: Workplace, Opportunity/ Range Extension

Level 2 charging infrastructure can also support workplace and opportunity charging when it is made available in public parking lots, whether these lots are owned by the City or by other entities. The City could invest in Level 2 charging at its City-owned off-street parking lots.

Example(s)

The City of Vancouver currently manages 79 public level 2 charging stations, 38 of which are on City properties. [18]

The City of Seattle's Department of Transportation (SDOT), in partnership with its Office of Sustainability & Environment and the City-owned electric utility Seattle City Light, launched a pilot program in 2017 to facilitate the permitting of Level 2 or DCFC charging on-street or in other public rights-of-way (ROW), the Electric Vehicle Charging in the Right-of-Way Permit Pilot (EVCROW). This program was open to both City-owned EVSE, as well as private sector EV charging network operators. The program received 68 applications for EVSE installations; however, due to challenges with the pilot, only 1 EVSE installation has occurred, and this EVSE is owned and operated by the City. A program evaluation published by the SDOT identified the following opportunities to improve outcomes [22] [10]:

- Identify appropriate parking spaces for EVSE implementation, rather than relying on the private sector to propose sites. The most important challenge facing program participants was finding suitable sites where charging infrastructure could be installed at a reasonable cost. Sites should be screened against transportation and utility plans to avoid potential conflicting ROW demands (e.g. future bike lanes; transit lanes; utility upgrades; etc.)

- Consider relaxing EVSE siting criteria. It proved very difficult to find sites that met all requirements, includes maintaining accessibility of public rights-of-way to comply with the Americans with Disabilities Act (ADA) (e.g. large sidewalk and parking space widths); not being in high demand areas; protecting street trees; and avoiding interference with pedestrian and bike infrastructure.

- Reduce risk for private investment related to on-street operating permit. The SDOT program included an annual permit renewal, creating uncertainty for private investment. Private sector investment in on-street parking requires a 3-5 year timeline at very minimum, to allow for a reasonable business case for installing infrastructure.

The cities of Montreal, New York, and LA have also installed on-street EV charging using AddEnergie stations. [23]

Considerations for implementation

Technical

The City can streamline the site selection process by pre-selecting suitable sites for EV charging [10]. If DCFC stations are to be installed, the ability to bring 480 V with sufficient capacity to the charging stations and the associated costs is an important consideration when selecting suitable sites.

When using Level 2 charging at for workplace charging in public lots, parking dwell times of approximately 8 hours can generally be expected and returning to a vehicle during the day may be infeasible. Therefore, providing slower charging rates for EVs that require workplace charging is ideal to properly support these users

Cost

Costs for on-street charging depend heavily on proximity to existing power, number of charging stations, and whether charging stations are freestanding or streetlight mounted (see *On-Street Level 2 Charging with Streetlight Hardware* inset). Based on experience at AES Engineering, for large installations of freestanding charging stations, costs may average about $10k per station, while for smaller installations (i.e. less than 5), costs could be up to $20k per station.

For parking lots, converting a large percentage of parking to EV Ready at one time is generally much lower cost per parking space than incrementally adding EV charging (as discussed in the Comprehensive EV Ready Retrofits section). The ongoing operating costs should also be considered.

Policy

The City can conduct comprehensive upgrades to its City-owned parkades to support a growing amount of EV charging into the future.

Any policy to promote on-street EV charging should consider the needs of different charging technologies (Level 2, DCFC) and use-cases (ride-hailing, freight and goods delivery, private vehicle owners) separately [10].

Competition for on-street space from transit, active transportation, and vehicle congestion can lead to challenges is providing on-street opportunity charging in urban centres or commercial areas, as was experienced in the City of Seattle [10].

If the City wishes to enable private investment in on-street EV charging infrastructure, the experience from Seattle suggests it is important to consider how to support an attractive investment climate [10]. Pre-identification of sites, engagement with BC Hydro to determine likely costs, and long-term permitting to provide certainty for private EV charging network developers.

The City could provide funding and other supports for the private sector to implement publicly accessible EV charging on private property. Alternately, the City could partner with private sector partners to implement City owned and/or managed EV charging infrastructure on private property. The City should consider the pros and cons of managing charging infrastructure on private property; staff from some leading cities have expressed hesitancy about implementing City-owned EV charging services on private property. Key considerations include:

- Access to EV charging sites.
- Liability issues.
- Whether the City can provide funding businesses, and if this constitutes an assistance to business.

EV Ecosystem Policies

Accelerating adoption requires a supportive market and EV ecosystem. Charging infrastructure is a critical tool in this effort, made even more powerful due to the City's level of control. However, the City's ambitious 2030 target requires an all-encompassing approach. This section reviews a series of policies that can be introduced to support the incentive required to achieve the 2030 adoption. There are many aspects of the legislative and market ecosystem that are outside the City's power, but not its influence. Advocacy and education with these key players are vital to ensure the City is ready to go electric.

Financial Incentives

How it works

The business case for owning an EV must be advantageous compared ICE vehicles to accelerate adoption. These costs include both upfront and lifetime costs, including operations and maintenance. In Victoria, where average kilometers travelled is quite low compared to other regions, the cost-effectiveness of EVs is lower due to lower savings on fuel and maintenance costs. Currently, the federal and provincial governments offer financial incentives for EVs and charging. If needed, the City could also deploy incentives through several approaches, which could be partially or fully self-financing through a fee-bate system introducing fees to ICE vehicles with a reduced or removed fee as a 'rebate' for EVs.

Examples

Zero Emissions Zones (ZEZs) are increasingly recognized as perhaps the most potent tool local governments can use to support adoption of EVs [24]. ZEZs are areas that cities designate that by some point in the future (e.g. 2025, 2030, etc.), only EVs and other zero emissions vehicles may access the area; polluting vehicles will need to pay a fee, and may ultimately be banned entirely.

ZEZs may start by impacting only certain modes of transportation (e.g. taxis, delivery trucks) and then ultimately encompass private automobiles as well [24]. ZEZs have been established by prominent European cities, such as London, Madrid and Amsterdam. Moreover, city signatories to the Fossil Fuel Free Streets Declaration, including the City of Vancouver, have committed to making some major portion of the City zero emissions by 2030.

On-street parking regulations offer a tool to prioritize the allocation of this on-street resource to low-carbon vehicles. Notably, the City of Vancouver recently approved a carbon pollution surcharge on residential parking permits, and will charge significantly higher fees for *newly-purchased* vehicles above a certain price threshold (e.g. $40k - $50k); these requirements would not impact existing vehicles, nor lower cost new vehicles, thereby addressing equity concerns.

Considerations for Implementation

Zero Emissions Zones:

The legal authority for BC local governments to establish ZEZs still requires exploration and establishing a ZEZ may require legislative changes. It may be possible for the City to integrate a ZEZ into any future mobility pricing scheme, for example by reducing fees for EVs. Alternatively, local governments may be able to approximate a ZEZ by charging higher fees for polluting vehicles to stop or park at the curb, under existing authorities with regards to parking.

As these types of charges are not currently imposed by the City, the development of a statement of intent would be sufficient until such a time that these types of charges are implemented. Indeed, a significant source of the power of a ZEZ is signalling cities' intent regarding future vehicle regulations, and thereby encouraging vehicle owners to choose zero emissions vehicles.

The City could create a cross-divisional working group to explore the feasibility of ZEV pilot project. In parallel, the City could explore developing a statement of intent to reduce or exempt EVs from future toll or congestion charges.

On-street Parking Regulations:

The City's parking regulations currently do not discriminate between electric and ICE vehicles. The City could consider revising the residential parking permit zone requirements to move to a user-fee based system. Under this structure, ICE vehicles could higher fees imposed than EVs. Implementation of this type of update should include an assessment and profile of users of on- and off-street parking and ensure fees do not create inequitable financial barriers.

Advocate for Supportive Policies

Requirements and incentives provided by the Provincial and Federal governments can play a large role in advancing the EV market in the City.

The City can advocate for Provincial and Federal policies to encourage the transition to EVs. Opportunities exist at both levels of government for rebates for new and used vehicles, for incentives for EV charging, or to expand existing benefits for EV drivers (e.g. HOV lane access on provincial highways). The City could support provincial Right-to-Charge legislation and advocate for the regulation to provide appropriate timelines considering individual or comprehensive retrofits. Strengthening the provincial zero emission vehicle act and/or introducing a national mandate could play a major role in increasing the supply of EVs.

Similarly, the City can advocate and work with the province's electricity and natural gas utilities to encourage adoption. The City could encourage beneficial policies (e.g. demand charge reform) and continued or enhanced incentives. The City could encourage the development of electrical resource education and availability of local electrical resource information.

Educational Initiatives

Many consumers and businesses are unaware, misinformed and/or uncomfortable with EVs, charging infrastructure, incentive programs, and other important information supporting consumer adoption of EVs.

The City can play a role in electric mobility transportation by acting as a centralized information hub to support residents and business preparing for or deploying EV infrastructure. The City can leverage the strong existing network of engaged residents and association resources. The City can also utilize *Go Electric BC* and *Plug-in BC* as a guide for residents and business, while assessing and filling any local information gaps.

Scenario Analysis

This section provides an assessment of EV adoption in the City of Victoria over the 2021-2030 period. First, a baseline forecast was developed to estimate adoption in the absence of further charging infrastructure investments and supporting policies. Charging infrastructure and incentives were added to the baseline and scenarios were modeled such that the adoption forecasts met the City's target for 2030. In addition to providing EV forecasts, this section also quantifies the infrastructure and incentives required to achieve the 2030 goal and a proposed investment plan for the City.

Key Insights

- Under a business-as-usual baseline scenario, EV adoption will reach between 8% and 13% by 2030, well below the City's target.
- To reach the adoption target, the City would need to invest $15M between 2021-2030 across EV Ready retrofits for existing buildings, Level 2 and DCFC charging infrastructure.
- With this infrastructure investment and with current purchase incentives maintained, the City's EV adoption will reach between 17% and 31% by 2030.

Dunsky's Electric Vehicle Adoption (EVA) Model

Dunsky's Electric Vehicle Adoption (EVA) Model was developed in-house to address a growing need to understand the adoption of electric vehicles in specific jurisdictions. Based on a rigorous review of research from academia and industry, EVA assesses the likely penetration of electric vehicle technology based on several key factors, grouped according to the following four categories:

1) Technical potential: The theoretical potential for EV adoption based on the size and composition of the overall vehicle market, as well as availability of different powertrain types (e.g. plug-in hybrid, battery electric) in different vehicle classes (e.g. cars, SUVs, trucks)

2) Customer economics: The unconstrained economic potential based on incremental total cost of ownership of electric vehicles over conventional vehicles, taking into account forecasted energy costs, annual vehicle kilometers travelled, and forecasted battery and vehicle costs

3) Market constraints: Accounting for EV-specific barriers including range limitations and access to both public and home charging infrastructure

4) Market dynamics: Incorporating technology diffusion theory and other market factors to determine rate of adoption and competition between vehicle types

By quantifying the impact of these various factors, EVA allows the development of jurisdiction-specific forecasts for EV adoption and the assessment of the relative effectiveness of a range of policy and program options for accelerating EV adoption, such as home retrofits and public charging infrastructure deployment.

Baseline Scenario

In the absence of additional infrastructure deployments in the City of Victoria (by the City or private market actors), adoption of EVs will continue to grow – largely thanks to decreasing vehicle costs and vehicle model availability – although this growth will be constrained due to limited home and public charging infrastructure. Although some residents will still adopt an EV, those without access to charging at home or work are expected to perceive significant barriers to EV ownership and many are not expected to transition from internal combustion vehicles.

By first populating EVA with Victoria-specific housing and vehicle market data and then calibrating the model to historic EV uptake in Victoria, the Dunsky team forecasted EV adoption under baseline conditions. Although the baseline conditions do not consider further charging infrastructure installations in the City, the EV-ready new construction code is accounted for, representing a modest increase in home charging potential from 2020 to 2030[5]. The baseline scenario also assumes that financial incentives currently offered by the provincial and federal governments phase out gradually over the next 5 years. Under the baseline, EVs are expected to represent 8-13%[6] of the total vehicle fleet by 2030 (Figure 11). This falls well below the City's Climate Leadership Plan target for 2030[7], indicating the need for market intervention to achieve uptake in-line with the City's goals.

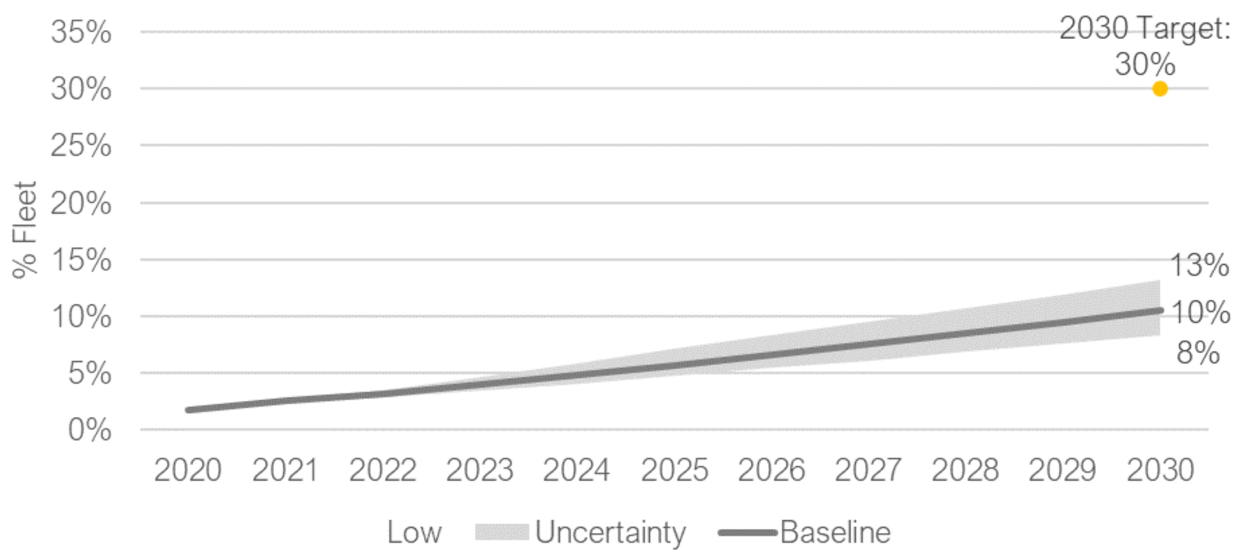

Figure 11. Electric vehicles as a percentage of total fleet under the baseline scenario

Although City targets focus on electric vehicles as a percentage of total fleet, electric vehicles as a percent of annual sales is another common metric used to develop electric vehicle targets. Under the Zero-Emission Vehicle Act, the Province of British Columbia has established targets of zero-emission vehicle sales as 10% of new light duty vehicle sales by 2025 and 30% by 2030. These targets are provided along with the percent annual sales value under baseline in Table 5.

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[5] New construction assumptions are included in the appendix.

[6]Adoption is influenced by broader market conditions outside of the City's control, including vehicle prices, vehicle model availability, electricity rates, and gasoline prices. High and low bounds were developed for each of these factors and were applied to all scenarios to generate high, mid, and low forecasts.

[7] The City of Victoria's Climate Leadership Plan includes a target of 30% of all passenger vehicle trips being renewably powered by 2030, and 100% by 2050.

Table 5. Electric vehicles as a percentage of annual sales under the baseline scenario

		2025	2030
% Annual Sales	Baseline – Upper bound	24%	26%
	Baseline – Midpoint	17%	21%
	Baseline – Lower bound	13%	16%
	Provincial target	10%	30%

Under baseline conditions, EV adoption in Victoria will exceed provincial electric vehicle annual sales targets by 2025, even under pessimistic market conditions. By 2030, however, adoption in Victoria drops below provincial targets. This indicates that, while Victoria is currently one of the strongest EV markets in BC today, it will fall well behind other areas of the province that have fewer inherent barriers to EV adoption (primarily access to charging at home) without significant investments in charging infrastructure.

The following sections provide an assessment of the interventions and investment required to achieve City targets.

Infrastructure Investment Scenario

The infrastructure interventions considered in this study include funding for EV Ready building retrofits, public level 2 infrastructure (including on-street, workplace and public lots), and public DCFC charging infrastructure, each of which address different market barriers currently preventing the adoption of electric vehicles. A description of each intervention is provided below along with the total investment requirements. In all cases, the total cost of the deployment is provided along with the estimated City share of that investment. Depending on available funding from other levels of government and potential partnerships with 3rd party organizations, the City would likely not be required to cover the entire cost of these deployments.

EV Ready Building Retrofits

A large portion of Victoria's population lives in multi-family residential buildings and has limited access to home charging infrastructure. While public charging infrastructure can serve as a substitute for home charging access for many early adopters, EV adoption among a broader segment of mainstream consumers is impacted by the reduced convenience and potentially higher costs compared to charging at home overnight. To address this barrier, the city of Victoria has implemented a new construction EV readiness requirement that has been in place since July 2020 and requires all new buildings to have energized electrical outlets installed at the time of construction. The province of BC also offers an EV Charger Rebate program which offers $2000 for the installation of a level 2 charging station designed for multiple users in existing multi-unit residential or commercial buildings with workplace parking.

Looking towards the City's 2030 target for EV adoption, enabling access to charging at home for a significant portion of residents will require retrofits of a large portion of the existing building stock. Recent analysis by AES Engineering has determined that the most cost-effective approach for existing buildings is to perform a comprehensive EV-ready retrofit, whereby energized circuits are provided to every parking stall during a single renovation, enabling easy installation of an EV charging station at a later date when required. Through this approach, average per-stall costs are estimated to be approximately $1200. Based on anticipated funding programs from other levels of government and expected demand from building owners, we estimate that a City-funded top-up of up to 20% of retrofit costs would be sufficient to general strong uptake of this approach.

Preliminary modeling suggests that while this approach is scalable to enable EV adoption among the majority of multi-residential building residents with access to parking, significant levels of investment would be required. The costs outlined below represent the costs associated with retrofitting all eligible stalls[8] across the residential building stock.

- Total investment: $48.75 million
- Estimated City investment: up to $9.75 million
- Number of retrofit stalls: 40,623

Workplace and Public Level 2 Charging Infrastructure

Level 2 (L2) public and workplace charging infrastructure can enable EV adoption for those with limited or no home charging, provided that access to this infrastructure is reliable. A subset of those currently unable to install Level 2 charging infrastructure without EV-ready retrofits are estimated to consider public or workplace charging an acceptable substitute for home charging and may decide to purchase an EV in the absence of charging access at home. That said, while this approach can be attractive to early adopters who are motivated to adopt an EV, the reduced convenience of relying on L2 charging away from home limits the overall scalability of this solution for increasing EV adoption among a broader portion of the market who would be more likely to choose a gas-powered vehicle.

To estimate the investment required for Level 2 charging to support these EV drivers, preliminary modeling explored and identified a point of diminishing returns from further investment. The non-linear relationship between increased L2 infrastructure and adoption can be explained by the limited number of potential EV drivers who are willing to substitute charging at home with public or workplace L2 charging.

Ongoing Monitoring of Infrastructure Utilization

Monitoring usage of the City's public chargers can ensure planned infrastructure continues to be appropriate to residential patterns and needs. Annual or bi-annual usage reports for City chargers should be prepared and reviewed, with the results used to validate or update installation plans. To support this monitoring effort, all City chargers should be networked.

For Victoria residents, L2 infrastructure deployment is modeled as a mix of 125 charging ports in parkades at $5,000 per port, and 125 charging

[8] Eligible stalls include stalls in multi-family buildings requiring a retrofit prior to the installation of level 2 charging equipment, excluding buildings built from 2020 onwards (assumed to be EV ready as a result of the new construction EV ready building code). The portion of stalls assumed to require retrofits by housing type is included in the appendix.

ports in curbside installations at $15,000 per port, for an average of $10,000 per port. While the modeling results are focused on impacts on EV adoption among Victoria residents to align with the City's targets, an additional 400 ports in parkades are recommended to provide workplace charging for commuters driving into Victoria. Comprehensive retrofits of the City's public parking facilities would enable cost savings on a per-port basis to achieve $5,000 per port for these parkade installations. The following is a summary of the total recommended investment in Level 2 infrastructure:

- Total investment: $4.50 million
- Estimated City investment: up to $2.25 million
- Number of incremental ports: 650 ports

Supporting Commuters into Victoria

As a hub that serves a number of surrounding communities, infrastructure in Victoria will support commuters from jurisdictions beyond the City core who adopt electric vehicles. An overview of the proportion of commuters from neighbouring communities is presented in Table 6.

Table 6: Commuters to Victoria (from census subdivisions representing more than 1% of commuters

Home Census Subdivision of Commuters	Percent of Commuters from this Census Subdivision to Victoria
Victoria	36%
Saanich	32%
Langford	7%
Esquimalt	5%
Oak Bay	5%
Colwood	3%
Central Saanich	3%
View Royal	3%

To estimate the level 2 workplace and public infrastructure expected to be required to meet the needs of those commuting into Victoria for work from Saanich, Langford, Esquimalt, Oak Bay, Colwood, Central Saanich, and View Royal, the following analysis was completed:

1) Quantified the number of light-duty personal vehicles in each municipality in 2019 [2]
2) Estimated the population in each municipality over the 2019-2030 time period [36]
3) Forecasted the light-duty vehicle population over the 2021-2030 period, maintaining the same vehicle per person ratio in each year as 2019
4) Estimated that approximately 10% of the vehicle population in the surrounding areas will be electric vehicles by 2030, in-line with the baseline scenario for Victoria.
5) Given that home charging access levels in these areas exceeds likely EV penetration, estimated that approximately 5% of commuter electric vehicles from the surrounding areas will depend on charging infrastructure in Victoria due to limited home charging access, and that 50% of these EV drivers park in City-owned parkades.

Using the methodology and assumptions outlined above, Victoria is estimated to need approximately 400 additional level 2 ports to support commuters in the surrounding area.

DCFC Public Charging

DCFC public charging infrastructure provides rapid on-the-go charging for both long-distance commuters and visitors, while also potentially providing a substitute for home charging for those without access. As with L2 charging infrastructure, preliminary modeling of investments in DCFC charging infrastructure identified a point of diminishing returns from further investment, although DCFC investments have a much more significant impact on adoption among those without access to charging at home. With charging times of 30 minutes or less, fast charging approaches the convenience of owning a gas-powered car, especially if fast chargers are sited at convenient locations (e.g. grocery stores) such that charging can be incorporated into a weekly routine. That said, the portion of the market that would see DCFC as a substitute for home charging is limited due to the increased total cost of ownership for an EV relying exclusively on public fast chargers that include higher electricity costs. Beyond a certain level of investment incremental spending would be better spent on other initiatives – notably improving home charging access.

Investments in DCFC infrastructure should consider both geographic coverage (ensuring convenient access to nearby charging sites for all residents) and charging capacity (ensuring each site provides sufficient power to minimize charge times and has a sufficient number of ports to handle the anticipated number of EVs without lineups). The modeled scenario assumes an average charging power of 150kW (enabling up to 300km of range in under 30 minutes) and assumes chargers are distributed at sites with between 2-4 ports per site, achieving a per-port cost of $175,000.

- Total investment: $5.95 million
- Estimated City investment: up to $2.98 million
- Number of incremental ports: 34 ports

Influence of Individual Interventions

To understand the relative impact of EV ready retrofits, level 2 charging, and DCFC charging, each intervention was assessed in isolation. Figure 12 outlines the change in cumulative vehicles adopted by 2030 as compared to the mid-point baseline scenario if investments were only made for a single intervention at a time.

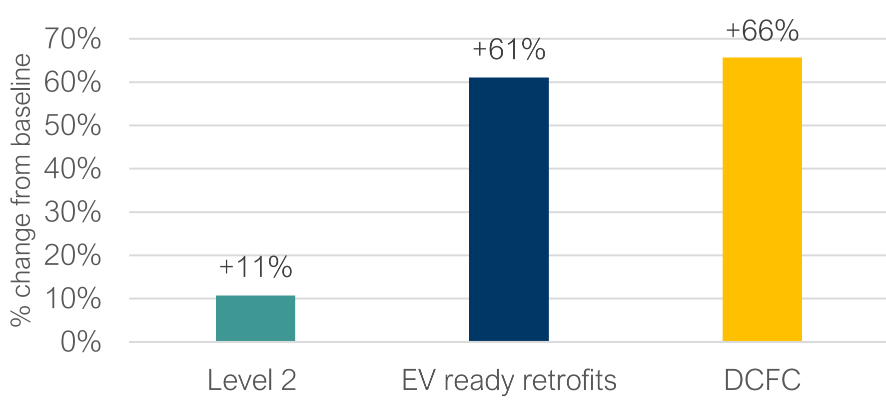

Figure 12. Increase in cumulative vehicles over baseline midpoint by 2030 by intervention

Investments in DCFC charging infrastructure show the greatest influence over adoption. Similar to owning a gas car, EV owners without charging access at home could charge up at a DCFC station once a week or so to meet their driving needs, resulting in limited behavioural changes required from new EV drivers.

City investment of $2.98 million in DCFC charging infrastructure is estimated to increase the cumulative number of electric vehicles on the road by 66% over baseline (although still fall short of City targets).

EV ready retrofits are noted as the second most impactful interventions when considered in isolation. After a building has been retrofit, the cost and effort of installing level 2 charging infrastructure is greatly reduced. Once level 2 home charging infrastructure has been installed, EV drivers are able to start each day with a “full tank”, minimizing reliance on shared public charging infrastructure. City investment of $10.6 million by 2030 is forecasted to increase cumulative EVs by 61%. While impacts of adoption beyond the study period were not modeled in this analysis, investments in improving home charging access would also have significant long term impacts by ensuring that the vast majority of Victoria residents could benefit from the convenience of charging at home.

Finally, **public level 2 infrastructure** investments increase adoption over the baseline forecast by filling an important role in the market through offering additional public and workplace charging, but shows a limited ability to increase adoption in absence of other complementary interventions. City investment of $1.25 million by 2030 is forecasted to increase cumulative EVs by 11%. However, while the modeling results presented here focus on impacts on adoption among Victoria residents to align with the City’s 2030 target, investments in workplace charging would lead to further incremental adoption among residents of the broader CRD region that are not reflected in these results. Further analysis at a regional level could help to build a better understanding of the impact of investments in workplace charging in Victoria.

Infrastructure Investment

To fully address market barriers to adoption, all infrastructure interventions outlined above must be deployed - no intervention will reach the 2030 target in isolation, and in fact even investments in all are not expected to achieve the City’s ambitious 2030 goals. Figure 13 outlines the adoption expected from the combined investments in EV ready retrofits and level 2 and DCFC charging infrastructure outlined in the previous section, resulting in EVs representing 14-24% of fleet by 2030 depending on market conditions.

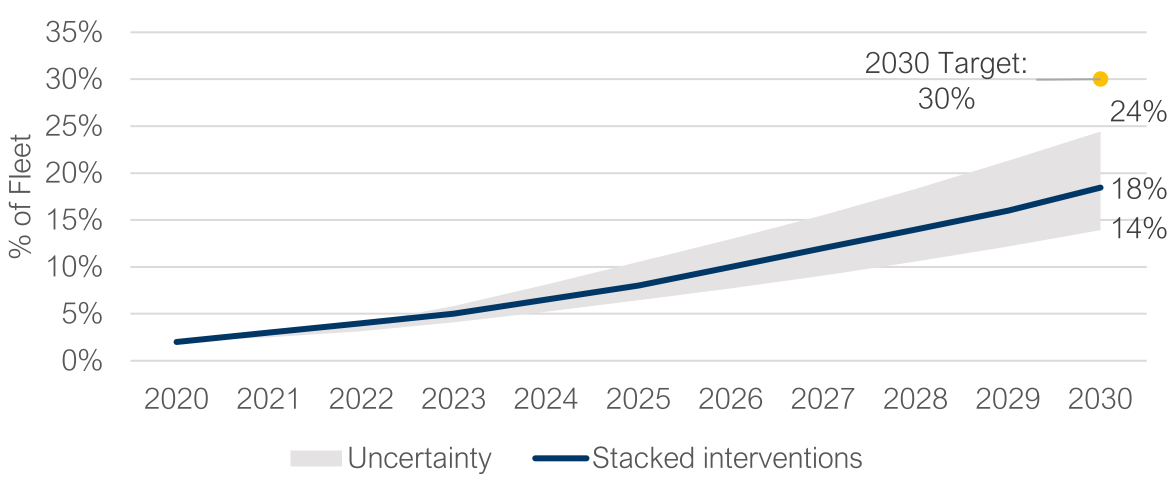

Figure 13. Electric vehicles as a percentage of total fleet following infrastructure investments

Although adoption under this scenario remains below the targeted percent of fleet, EVs as a percent of annual sales greatly outpace Provincial sales targets, as outlined in Table 7, underlining the ambition of Victoria's goals.

Table 7. Electric vehicles as a percentage of annual sales following infrastructure investments

		2025	2030
% Annual Sales	Baseline - Midpoint	17%	21%
	Stacked interventions – Upper bound	45%	62%
	Stacked interventions – Midpoint	31%	48%
	Stacked interventions – Lower bound	23%	35%
	Provincial target	10%	30%

Infrastructure Investment+

Even with the significant city investments in infrastructure seen in the previous scenario, adoption in Victoria is expected to remain below the City's target due to challenging economics for EV drivers. Although electric vehicles currently cost more upfront than internal combustion engine vehicles, electric vehicles often have lower total cost of vehicle ownership compared to internal combustion engines as a result of lower operations and maintenance costs. Victoria vehicle owners drive very few kilometers per year[9], however, and consequently will not experience the same degree of total cost of ownership benefits from the adoption of electric vehicle as drivers who travel further each year.

Given the economic limitations of the Victoria market, an infrastructure investment + incentives (infrastructure investment+) scenario was modeled in which financial benefits in-line with current vehicle purchase incentives were maintained through 2030[10]. Adoption under this scenario was found to reach 17-31% depending on market conditions, presented in Figure 14.

[9] An origin destination household travel survey was completed for the Capital Regional District in 2017, and subsequent analysis found that drivers in Victoria's Core Region travel approximately 6,000 kilometers per year.
[10] This scenario assumes incentives of $4,000 for plug-in hybrid electric vehicles and $8,000 for battery-only electric vehicles are available from 2021-2030.

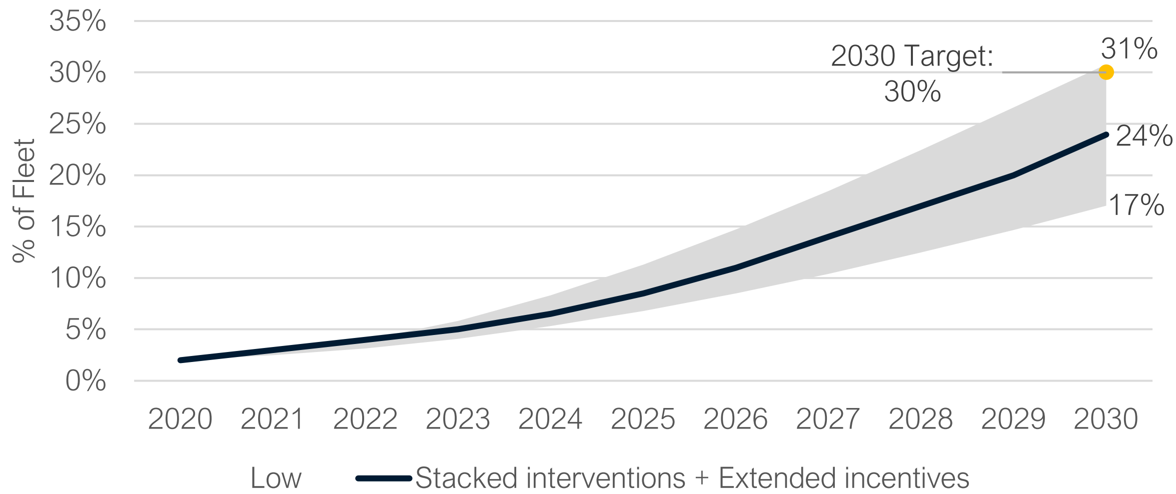

Figure 14. Electric vehicles as a percentage of total fleet following infrastructure investments and extended incentives

Maintaining the current financial incentives offered by the federal and provincial governments is one of a number of approaches that could deliver the same overall results in terms of improving the economics of EV ownership in Victoria. A transition towards a feebate system (where gradually declining purchase incentives for EVs are compensated by gradually increasing fees for the purchase of a gas-powered vehicle) could provide a similar economic signal to encourage EV adoption while being completely self-financing. Alternatively, recurring fees and/or rebates could be designed to have the same overall impact as the current up-front financial incentives. These could take the form of annual parking fees or broader mobility pricing that include discounts for EVs. In all cases, the City will need to work with other actors, either at the regional level to enact a coordinated approach for mobility pricing, or through advocacy with the provincial and federal governments to maintain and/or adapt their current incentive programs.

Again, adoption can be considered from the perspective of EVs as a percent of sales to provide a point of comparison against Provincial targets. When incentives are added to the market in addition to the infrastructure investments included in the previous scenario, adoption reaches well beyond provincial goals, with an upper bound that surpasses 80% annual sales in 2030 as shown in Table 8.

Table 8. Electric vehicles as a percentage of annual sales following infrastructure investments and extended incentives

		2025	2030
% Annual Sales	Baseline - Midpoint	17%	21%
	Stacked interventions+ – Upper bound	56%	83%
	Stacked interventions+ – Midpoint	38%	71%
	Stacked interventions+ – Lower bound	28%	47%
	Provincial target	10%	30%

The following sections outline recommendations for the timing of investments.

Investment Plan

The following investment scenarios presented see City budgets for infrastructure deployment scaling up over the first four years then remaining relatively constant until 2030[11]. As shown in Figure 15, initial deployments focus on public charging infrastructure in an effort to serve the portion of the market with limited home charging access, with the majority of level 2 and DCFC charger installations occurring in the first half of the study period. EV ready retrofits are limited in the early years of the study as programs ramp up, representing the time needed to attract participants and potentially build the capacity of the local workforce. The number of stalls retrofit per year is recommended to grow significantly each year, however, becoming the primary focus of investments over the 2026-2030 period.

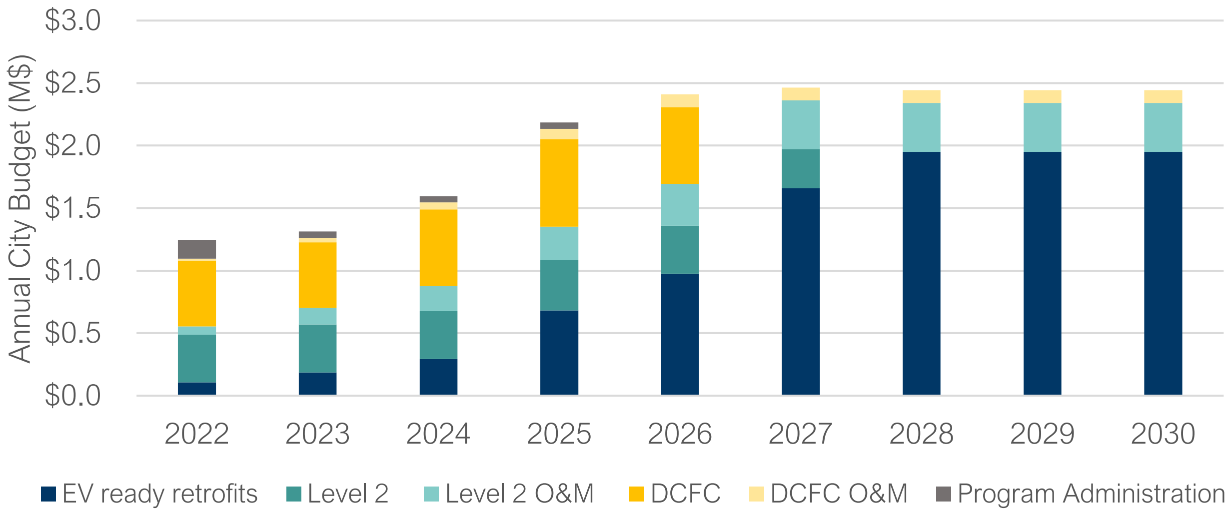

Figure 15. Annual city budget by intervention, 2021-2030

Below, Table 9 provides a breakdown of the annual budget required for each intervention for three points in time during the study – 2022, 2025, and 2030 - and the resulting number of incremental stalls or ports. Budgets for program administration and charger operations and maintenance are also included. Program administration is assumed to be $150,000 for the first year, including costs required to build, deploy, and implement campaigns, and $50,000 for the next four years representing ongoing implementation costs. Administration costs are not included for years 2026-2030 – this budget should be developed after analyzing actual spend over the initial program years. Level 2 operations and maintenance (O&M) is assumed to be $600/port/year and DCFC is assumed to be $3,000/port/year.

[11] It is assumed that the city will cover 50% of level 2 and DCFC charging infrastructure installation costs with the remaining costs covered by other market actors (e.g. government, utility, private sector). It is assumed that the city will cover 20% of EV ready retrofit costs.

Table 9. Annual city budget and overall required investment 2022, 2025, and 2030 (Rounded to Nearest $1,000)

		2022	2025	2030
EV Ready Retrofits	Annual City budget	$107,000	$683,000	$1,950,000
	Stalls retrofit per year	445	2,844	8,125
Level 2 Infrastructure	Budget	$381,000	$402,000	$0
	Ports installed per year	110	116	0
DCFC Infrastructure	Annual City budget	$525,000	$700,000	$0
	Ports installed per year	6	8	0
Program Administration	Annual City budget	$150,000	$50,000	TBD
Level 2 O&M	Annual City budget	$66,000	$268,800	$390,000
DCFC O&M	Annual City budget	$18,000	$81,000	$102,000
City total	Annual City budget	$1,247,000	$2,185,000	$1,950,000
Total Investment Required	Annual total budget	$2,346,000	$5,616,000	$9,750,000

*Values may not sum due to rounding

Infrastructure Investment Scenario: 2021-2025

In this section, we present our recommendations for the City of Victoria's investment plan over the coming five years. For each intervention type, the total investment requirement is provided alongside the expected portion of the investment expected from the City as compared to other market actors (private industry, provincial and federal governments, utilities, etc.).

EV Ready Building Retrofit Investment

The EV ready building retrofit investment assumptions include the costs required to electrify existing multi-residential buildings so that they are 'EV-Ready' using a comprehensive approach, after which private actors – including building or apartment unit owners – can install level 2 chargers without further upgrades to the electrical system.

Total Investment: $6.34 million

Estimated City Investment: $1.27 million

Number of Retrofitted EV Ready Stalls: 5,280

Under the near-term infrastructure investment scenario, approximately $1.27 million of City investment in 'EV Ready' retrofits (not including the cost of level 2 chargers) is expected be required by 2025, equivalent to 5,281 EV Ready stalls.

Level 2 Public and Workplace Charging Investment

Level 2 public and workplace charging infrastructure can enable EV adoption for those with limited or no home charging, a portion of which are estimated to consider public or workplace charging an acceptable substitute for home charging. City investments in level 2 infrastructure are estimated at $1.55 million, equivalent to approximately 448 ports.

Total Investment: $3.10 million

Estimated City Investment: $1.55

Number of Ports: 448

DCFC Public Charging Investment

Under this scenario, $2.38 million of City investment is required – equivalent to 27 ports – to meet rapid on-the-go charging needs of EV drivers.

Total Investment: $4.73 million

Estimated City Investment: $2.36 million

Number of Ports: 27

Infrastructure Investment Scenario: 2026-2030

For the period from 2026 to 2030, the focus of the City's investments should shift towards tackling the existing building stock and improving home charging access. That said, the investment recommendations for this period should be seen as preliminary, and they should be adapted based on lessons learned from the first period.

EV Ready Building Retrofit Investment

Under the 2026-2030 infrastructure investment scenario, EV Ready retrofits are greatly scaled up as programs expand to reach a greater number of buildings. Approximately $8.48 million of City investment for EV Ready retrofits expected be required, equivalent to an additional 35,342 stalls

Total Investment: $42.41 million

Estimated City Investment: $8.48 million

Number of Retrofitted EV Ready Stalls: 35,343

Level 2 Public and Workplace Charging Investment

The initial focus on public charging infrastructure in the first half of the study reduces the spend required for level 2 installations over the 2026-2030 period. Approximately $675,000 of City investment is required, equivalent to 195 ports.

Total Investment: $1.40

Estimated City Investment: $699,000

Number of Ports: 202

DCFC Public Charging Investment

As with level 2 infrastructure, investments in DCFC chargers are greatly reduced during the 2026-2030 period thanks to early progress made during the first period. Approximately $565,000 of City investment is required, equivalent to 6 ports.

Total Investment: $1.23 million

Estimated City Investment: $613,000

Number of Ports: 7

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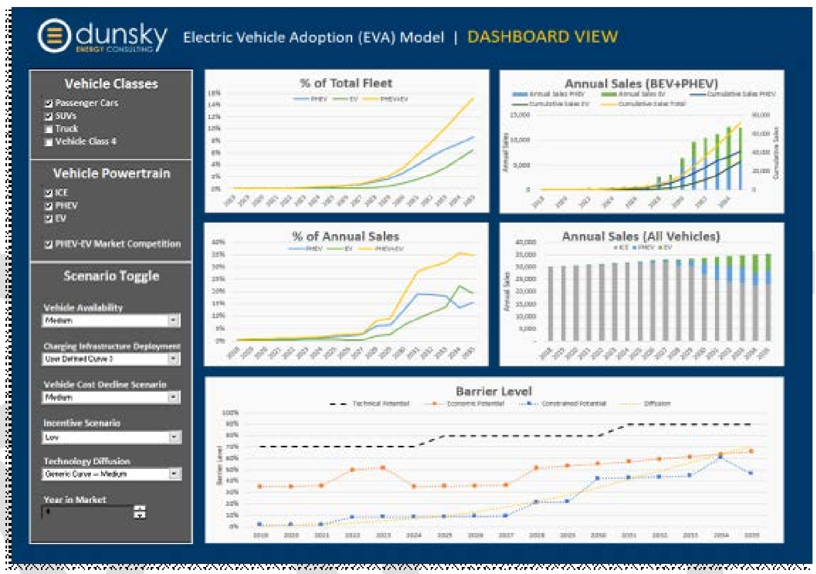
Appendix

EVA Methodology

With such a complicated electric mobility landscape, it can be hard to determine the best strategies for accelerating adoption. Dunsky's EVA Model was developed in-house to address a growing need by our clients to understand the potential size of the electric vehicle market in their respective jurisdictions and corresponding impacts. Based on rigorous review of research from academia and industry, EVA leverages the modeling framework behind Dunsky's Solar Adoption Model (SAM) and builds on the knowledge base and expertise from our EV practice. EVA projects market adoption of EVs based on several key factors:



Sample EVA Dashboard View

- Technical potential: The theoretical potential for deployment based on the size and composition of the overall vehicle market, as well as availability of different powertrain types (e.g. plug-in hybrid, battery electric) in different vehicle classes (e.g. cars, SUVs, trucks, buses, etc.).
- Customer economics: The unconstrained economic potential based on incremental Total Cost of Ownership (TCO) of electric vehicles over conventional vehicles, taking into account forecasted energy costs, annual vehicle-miles travelled, and forecasted battery and vehicle costs.
- Market constraints: Accounting for EV-specific barriers including range limitations and access to charging infrastructure, and how various approaches to infrastructure deployment can address these barriers.
- Market dynamics: Incorporating technology diffusion theory and other market factors to determine rate of adoption and competition between vehicle types.

By quantifying the impact of these various factors, EVA allows us to not only provide our clients with jurisdiction-specific forecasts for EV adoption, but also to assess the effectiveness of a range of policy and program options for accelerating EV adoption, such as financial incentives and charging infrastructure deployment. EVA also allows us to assess the impact of the electrical load growth associated with an increasingly electrified transportation sector, helping those working in the energy industry to plan ahead for this transition and put solutions into place that can help to manage this load growth in the most effective way.

Market Assumptions

Vehicle Assumptions

Vehicle Market Total Fleet and New Sales Assumptions[12]

		2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Cars	Total fleet	26,663	26,114	25,576	25,049	24,533	24,028	23,533	23,048	22,574	22,109
	New sales	1,386	1,358	1,330	1,303	1,276	1,249	1,224	1,199	1,174	1,150
SUVs	Total fleet	13,061	13,736	14,446	15,193	15,979	16,805	17,674	18,587	19,549	20,559
	New sales	793	834	877	923	971	1,021	1,073	1,129	1,187	1,249
Trucks	Total fleet	1,513	1,635	1,767	1,910	2,064	2,231	2,411	2,606	2,817	3,045
	New sales	79	85	92	99	107	116	125	136	146	158

Building Stock Assumptions

Forecasted Number of Dwelling Units by Housing Type[13]

	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Single detached	6,433	6,399	6,364	6,330	6,296	6,262	6,229	6,195	6,162	6,129
Semi-detached	1,248	1,250	1,253	1,255	1,258	1,261	1,263	1,266	1,268	1,271
Row	2,336	2,359	2,383	2,406	2,430	2,454	2,479	2,503	2,528	2,553
Apartment and other	38,380	38,918	39,464	40,018	40,579	41,148	41,726	42,311	42,905	43,506

Forecasted Annual New Construction Units by Housing Type[14]

	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Single detached	29	29	29	28	28	28	28	28	28	27
Semi-detached	13	13	13	13	13	13	13	13	13	13
Row	11	11	11	11	11	11	11	12	12	12
Apartment and other	548	556	564	571	579	588	596	604	613	621

Forecasted Parking Stalls by Housing Type

	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Single detached	6,433	6,399	6,364	6,330	6,296	6,262	6,229	6,195	6,162	6,129
Semi-detached	1,248	1,250	1,253	1,255	1,258	1,261	1,263	1,266	1,268	1,271

[12] To forecast the total light-duty vehicle population, historic population and ICBC vehicle registration data were used to develop a historic car/population ratio. This ratio was then combined with forecasted population to estimate total light duty vehicles over the study period. To capture the split of cars, SUVs, and trucks within the light-duty vehicle population over time, historic trends were developed using the split found in the 2015-2019 ICBC registration data. These trends were then extrapolated out over the study period. Annual sales were forecasted using province-wide sales as a percent of fleet data from the Canadian comprehensive energy use database in combination with fleet forecasts.

[13] The average annual growth in units was calculated using 2011 and 2016 StatsCan census data for each building type. These rates were used to estimate the total units for each year.

[14] Using historic data from the Canadian Mortgage and Housing Corporation on the annual number of new home completions in Victoria, the rate of new construction as a percent of existing building stock was estimated for each building type. These rates were used to forecast the annual number of new construction units.

Row	2,871	2,894	2,918	2,943	2,967	2,992	3,017	3,042	3,068	3,094
Apartment and other	48,322	48,786	49,257	49,734	50,218	50,708	51,206	51,710	52,222	52,740

Assumed Portion of Existing Stalls Requiring EV Ready Retrofit by Housing Type

Single detached	25%
Semi-detached	30%
Row	60%
Apartment and other	91%

Infrastruction Assumptions

Cumulative and Annual Stalls Retrofit to be EV Ready

		2022	2023	2024	2025	2026	2027	2028	2029	2030
Infrastructure Investment Scenario	Annual	445	772	1,219	2,844	4,062	6,906	8,125	8,125	8,125
	Cumulative	445	1,217	2,436	5,280	9,342	16,248	24,373	32,498	40,623

Assumed % of Stalls with Access[15]

		2022	2023	2024	2025	2026	2027	2028	2029	2030
Baseline Scenario	Single detached	76%	76%	77%	77%	78%	78%	79%	79%	80%
	Semi-detached	72%	73%	74%	75%	76%	77%	78%	79%	80%
	Row	41%	41%	42%	42%	43%	43%	44%	44%	44%
	Apartment and other	12%	14%	15%	16%	18%	19%	20%	22%	23%
Infrastructure Investment Scenario	Single detached	80%	82%	85%	87%	90%	92%	95%	97%	100%
	Semi-detached	77%	80%	83%	85%	88%	91%	94%	97%	100%
	Row	53%	59%	65%	71%	77%	83%	89%	94%	100%
	Apartment and other	15%	18%	24%	31%	40%	55%	70%	85%	100%

[15] 'Access' is defined as those who have charging at home, or those who have the ability to install a level 2 charger without major retrofits. The budget included in the body of the report accounts for the costs associated with retrofitting multifamily units to be EV ready but does not account for the costs for single-family dwellings (including single detached, semi-detached, and row housing) that require retrofits. This assumes that most residents of single-family dwellings are willing to cover the required investment. Under the baseline scenario, it is assumed that single family access grows moderately over time (0.5% per year). Under the infrastructure investment scenario, it is assumed that single family access grows more aggressively over time (2.5% per year), keeping access levels in-line with multi-residential units, reflecting the likely competition in the rental market.

Assumed % of Dwelling Units with Access[16]

		2022	2023	2024	2025	2026	2027	2028	2029	2030
Baseline Scenario	Single detached	76%	76%	77%	77%	78%	78%	79%	79%	80%
	Semi-detached	72%	73%	74%	75%	76%	77%	78%	79%	80%
	Row	41%	41%	42%	42%	43%	43%	44%	44%	44%
	Apartment and other	11%	12%	13%	15%	16%	17%	18%	19%	21%
Infrastructure Investment Scenario	Single detached	80%	82%	85%	87%	90%	92%	95%	97%	100%
	Semi-detached	77%	80%	83%	85%	88%	91%	94%	97%	100%
	Row	53%	59%	65%	71%	77%	83%	89%	94%	100%
	Apartment and other	13%	16%	21%	28%	36%	49%	62%	76%	89%

Level 2 Charging Infrastructure Assumptions (Cumulative Number of Ports)

	2022	2023	2024	2025	2026	2027	2028	2029	2030
Baseline	76	76	76	76	76	76	76	76	76
Infrastructure Investment	186	297	408	524	635	726	726	726	726

DCFC Charging Infrastructure Assumptions (Cumulative Number of Ports)

	2022	2023	2024	2025	2026	2027	2028	2029	2030
Baseline	0	0	0	0	0	0	0	0	0
Infrastructure Investment	6	12	19	27	34	34	34	34	34

Infrastructure Cost Assumptions

EV Ready Retrofit ($ per stall)	$1,200
Level 2 curbside ($ per port)	$15,000
Level 2 in parkade ($ per port)	$5,000
DCFC ($ per port)	$175,000

[16] Note that the number of stalls with access is greater than the number of units with access for the 'Apartment and other' housing type due to the assumption that approximately 11% of units do not have a parking stall.

Detailed Adoption Results

Baseline Adoption Forecast

			2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
High	Cumulative Vehicles	PHEV	291	473	732	1,037	1,357	1,673	1,992	2,342	2,723	3,134
		BEV	814	968	1,181	1,423	1,671	1,903	2,125	2,359	2,608	2,872
		Total	1,105	1,441	1,913	2,460	3,027	3,576	4,117	4,701	5,331	6,006
	% of Annual Sales	PHEV	5%	8%	11%	13%	14%	13%	13%	14%	15%	16%
		BEV	5%	7%	9%	10%	11%	10%	9%	9%	10%	10%
		Total	10%	15%	21%	24%	24%	23%	22%	24%	25%	26%
	% of Fleet	PHEV	1%	1%	2%	2%	3%	4%	5%	5%	6%	7%
		BEV	2%	2%	3%	3%	4%	4%	5%	5%	6%	6%
		Total	3%	3%	5%	6%	7%	8%	9%	11%	12%	13%
Mid	Cumulative Vehicles	PHEV	267	407	591	801	1,033	1,276	1,536	1,818	2,126	2,458
		BEV	786	900	1,047	1,207	1,381	1,555	1,732	1,917	2,115	2,327
		Total	1,053	1,306	1,638	2,009	2,414	2,831	3,269	3,736	4,241	4,785
	% of Annual Sales	PHEV	4%	6%	8%	9%	10%	10%	11%	11%	12%	13%
		BEV	4%	5%	6%	7%	7%	7%	7%	8%	8%	8%
		Total	8%	11%	14%	16%	17%	17%	18%	19%	20%	21%
	% of Fleet	PHEV	1%	1%	1%	2%	2%	3%	4%	4%	5%	5%
		BEV	2%	2%	3%	3%	3%	4%	4%	4%	5%	5%
		Total	3%	3%	4%	5%	6%	7%	7%	8%	9%	10%
Low	Cumulative Vehicles	PHEV	238	345	485	646	823	1,013	1,216	1,434	1,668	1,923
		BEV	757	840	945	1,061	1,184	1,312	1,444	1,584	1,729	1,885
		Total	994	1,185	1,431	1,706	2,007	2,325	2,660	3,018	3,397	3,808
	% of Annual Sales	PHEV	4%	5%	6%	7%	8%	8%	8%	9%	9%	10%
		BEV	3%	4%	5%	5%	5%	5%	5%	6%	6%	6%
		Total	6%	8%	11%	12%	13%	13%	14%	15%	15%	16%
	% of Fleet	PHEV	1%	1%	1%	2%	2%	2%	3%	3%	4%	4%
		BEV	2%	2%	2%	3%	3%	3%	3%	4%	4%	4%
		Total	2%	3%	3%	4%	5%	5%	6%	7%	8%	8%

Infrastructure Investment Forecast

			2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
High	Cumulative Vehicles	PHEV	321	503	737	979	1,243	1,515	1,809	2,141	2,507	2,903
		BEV	837	1,149	1,695	2,444	3,243	4,070	4,960	5,964	7,067	8,262
		Total	1,158	1,652	2,432	3,423	4,486	5,585	6,769	8,105	9,574	11,165
	% of Annual Sales	PHEV	6%	8%	10%	10%	11%	11%	12%	13%	15%	15%
		BEV	5%	14%	24%	32%	34%	35%	37%	41%	44%	47%
		Total	12%	22%	34%	43%	45%	46%	49%	54%	59%	62%
	% of Fleet	PHEV	1%	1%	2%	2%	3%	4%	4%	5%	6%	6%
		BEV	2%	3%	4%	6%	8%	9%	11%	13%	16%	18%
		Total	3%	4%	6%	8%	11%	13%	16%	18%	21%	24%
Mid	Cumulative Vehicles	PHEV	292	434	600	772	988	1,251	1,553	1,872	2,195	2,524
		BEV	805	1,030	1,408	1,906	2,418	2,943	3,525	4,216	5,013	5,912
		Total	1,097	1,464	2,008	2,678	3,407	4,194	5,078	6,088	7,208	8,436
		PHEV	5%	6%	7%	7%	9%	11%	12%	13%	13%	13%

	% of Annual Sales	BEV	4%	10%	16%	21%	22%	22%	24%	28%	32%	35%
		Total	10%	16%	24%	29%	31%	33%	36%	41%	45%	48%
	% of Fleet	PHEV	1%	1%	1%	2%	2%	3%	4%	4%	5%	6%
		BEV	2%	2%	3%	5%	6%	7%	8%	10%	11%	13%
		Total	3%	4%	5%	6%	8%	10%	12%	14%	16%	18%
Low	Cumulative Vehicles	PHEV	257	384	550	754	1,001	1,290	1,611	1,958	2,328	2,722
		BEV	772	921	1,157	1,453	1,746	2,034	2,345	2,713	3,139	3,632
		Total	1,029	1,304	1,707	2,207	2,747	3,324	3,956	4,671	5,467	6,354
	% of Annual Sales	PHEV	4%	6%	7%	9%	11%	12%	13%	14%	15%	15%
		BEV	3%	7%	10%	13%	12%	12%	13%	15%	17%	19%
		Total	7%	12%	18%	21%	23%	24%	26%	29%	32%	35%
	% of Fleet	PHEV	1%	1%	1%	2%	2%	3%	4%	4%	5%	6%
		BEV	2%	2%	3%	3%	4%	5%	5%	6%	7%	8%
		Total	2%	3%	4%	5%	6%	8%	9%	11%	12%	14%

Infrastructure Investment + Incentives Forecast

			2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
High	Cumulative Vehicles	PHEV	321	503	737	998	1,323	1,701	2,126	2,593	3,094	3,623
		BEV	837	1,149	1,695	2,502	3,487	4,635	5,925	7,336	8,848	10,445
		Total	1,158	1,652	2,432	3,501	4,810	6,336	8,050	9,929	11,942	14,068
	% of Annual Sales	PHEV	6%	8%	10%	11%	14%	16%	18%	19%	20%	21%
		BEV	5%	14%	24%	35%	42%	48%	53%	57%	60%	62%
		Total	12%	22%	34%	46%	56%	64%	71%	76%	80%	83%
	% of Fleet	PHEV	1%	1%	2%	2%	3%	4%	5%	6%	7%	8%
		BEV	2%	3%	4%	6%	8%	11%	14%	17%	20%	23%
		Total	3%	4%	6%	8%	11%	15%	18%	22%	27%	31%
Mid	Cumulative Vehicles	PHEV	292	434	600	778	1,007	1,297	1,641	2,030	2,452	2,909
		BEV	805	1,030	1,408	1,955	2,627	3,433	4,381	5,470	6,692	8,041
		Total	1,097	1,464	2,008	2,733	3,634	4,730	6,023	7,500	9,145	10,950
	% of Annual Sales	PHEV	5%	6%	7%	8%	10%	12%	14%	16%	17%	18%
		BEV	4%	10%	16%	24%	29%	34%	39%	44%	49%	53%
		Total	10%	16%	24%	31%	38%	46%	53%	60%	66%	71%
	% of Fleet	PHEV	1%	1%	1%	2%	2%	3%	4%	5%	5%	6%
		BEV	2%	2%	3%	5%	6%	8%	10%	12%	15%	18%
		Total	3%	4%	5%	6%	9%	11%	14%	17%	20%	24%
Low	Cumulative Vehicles	PHEV	257	384	550	752	993	1,265	1,557	1,865	2,191	2,546
		BEV	772	921	1,157	1,489	1,899	2,398	2,985	3,657	4,406	5,242
		Total	1,029	1,304	1,707	2,242	2,892	3,663	4,543	5,522	6,597	7,787
	% of Annual Sales	PHEV	4%	6%	7%	9%	10%	11%	12%	13%	13%	14%
		BEV	3%	7%	10%	14%	17%	21%	24%	27%	30%	33%
		Total	7%	12%	18%	23%	28%	32%	36%	40%	43%	47%
	% of Fleet	PHEV	1%	1%	1%	2%	2%	3%	4%	4%	5%	6%
		BEV	2%	2%	3%	4%	4%	6%	7%	8%	10%	11%
		Total	2%	3%	4%	5%	7%	9%	10%	12%	15%	17%

Annual Investment

Annual Total and City Budgets, 2022-2025

		2022	2023	2024	2025
Total Annual Budget	EV Ready Retrofits	$486,000	$926,400	$1,462,800	$3,412,800
	Level 2	$623,077	$768,462	$768,462	$803,077
	DCFC	$875,000	$1,050,000	$1,225,000	$1,400,000
	Total	$1,984,077	$2,744,862	$3,456,262	$5,615,877
City Annual Budget	EV Ready Retrofits	$106,800	$185,280	$292,560	$682,560
	Level 2	$380,769	$384,231	$384,231	$401,538
	DCFC	$525,000	$525,000	$612,500	$700,000
	Program Administration	$150,000	$50,000	$50,000	$50,000
	Level 2 O&M	$66,000	$132,600	$199,200	$268,800
	DCFC O&M	$18,000	$36,000	$57,000	$81,000
	Total	$1,246,569	$1,313,111	$1,595,491	$2,183,898

Annual Total and City Budgets, 2026-2030

		2026	2027	2028	2029	2030
Total Annual Budget	EV Ready Retrofits	$4,874,400	$8,287,200	$9,750,000	$9,750,000	$9,750,000
	Level 2	$768,462	$630,000	$-	$-	$-
	DCFC	$1,225,000	$-	$-	$-	$-
	Total	$6,867,862	$8,917,200	$9,750,000	$9,750,000	$9,750,000
City Annual Budget	EV Ready Retrofits	$974,880	$1,657,440	$1,950,000	$1,950,000	$1,950,000
	Level 2	$384,231	$315,000	$0	$0	$0
	DCFC	$612,500	$0	$0	$0	$0
	Program Administration	TBD	TBD	TBD	TBD	TBD
	Level 2 O&M	$335,400	$390,000	$390,000	$390,000	$390,000
	DCFC O&M	$102,000	$102,000	$102,000	$102,000	$102,000
	Total	$2,409,011	$2,464,440	$2,442,000	$2,442,000	$2,442,000