From: "Mochrie, Paul" <Paul.Mochrie@vancouver.ca>
To: "Direct to Mayor and Council - DL"
Date: 11/26/2021 5:35:53 PM
Subject: Incentives and Actions to Encourage Zero-Emission Car Sharing
Attachments: Memo - Incentives and Actions to Encourage Zero-Emission Car Sharing.pdf

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Dear Mayor and Council,

Please see the attached memo from Lon LaClaire. A short summary of the memo is as follows:

- This memo summarizes the recommendations of a study completed in fall 2021 that examined the barriers to and potential incentives for zero-emission car-sharing, and provides background related to car-sharing recommendations contained within the 2022 Engineering Fees report.
- The barriers include high acquisition costs for zero-emission vehicles (ZEVs), lack of publicly accessible charging infrastructure, and increased operational costs to relocate vehicles for charging.
- The recommendations include reductions in meter fees, the removal of permit exemption caps for ZEV car-sharing, provision of charging infrastructure, and advocating for improvements to federal and provincial ZEV incentive programs.

If you have any questions, please feel free to contact Lon LaClaire at 604-873-7336 or lon.laclaire@vancouver.ca.

Best,
Paul

Paul Mochrie (he/him)
City Manager
City of Vancouver
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CITY OF VANCOUVER

The City of Vancouver acknowledges that it is situated on the unceded traditional territories of the xʷməθkʷəy̓əm (Musqueam), Sḵwx̱wú7mesh (Squamish), and səlilwətaɬ (Tsleil-Waututh) Nations.

CITY OF VANCOUVER

ENGINEERING SERVICES
Lon LaClaire, M.Eng., P.Eng.
City Engineer/General Manager

MEMORANDUM

November 26, 2021

TO: Mayor and Council

CC: Paul Mochrie, City Manager
Karen Levitt, Deputy City Manager
Katrina Leckovic, City Clerk
Lynda Graves, Administration Services Manager, City Manager's Office
Maria Pontikis, Chief Communications Officer, CEC
Anita Zaenker, Chief of Staff, Mayor's Office
Neil Monckton, Chief of Staff, Mayor's Office
Alvin Singh, Communications Director, Mayor's Office

FROM: Lon LaClaire
General Manager, Engineering Services

SUBJECT: Incentives and Actions to Encourage Zero-Emission Car Sharing

RTS #: 13753

In summer 2021, the City commissioned a study to examine the potential barriers and incentives to zero-emission car-sharing, in response to Council direction received in February 2020 to explore this area.

The study recommends reductions in meter fees, the removal of permit exemption caps for zero-emission car-sharing vehicles, provision of charging infrastructure and advocating for improvements to federal and provincial zero-emission vehicle (ZEV) incentive programs.

This memo summarizes the study and includes background related to car-sharing recommendations that are contained within the 2022 Engineering Fees report.

Background

Although car-sharing in Vancouver has had some significant set backs since the start of 2020 (withdrawal of car2go and ZipCar from the market and a general decline in travel during the COVID-19 pandemic), the industry now appears to have stabilized and remains an important way for Vancouver residents to meet their transportation needs while reducing vehicle

ownership. At the end of 2020, approximately 32 per cent of Vancouver residents still retained car-sharing memberships.

One area where there has been limited headway in Vancouver is zero-emission car-sharing, in particular with one-way car-sharing. Today, there are currently around 16 zero-emission two-way car-sharing vehicles based in Vancouver, but there are no zero-emission one-way car-sharing options. Transitioning car-sharing vehicles into ZEVs is important for the City to achieve Big Move #3 of the Climate Emergency Response, which calls for 50 per cent of vehicle-kilometers driven on Vancouver streets to be by ZEVs. More specifically, the Climate Emergency Action Plan provided direction to develop programs to support the electrification of light-duty passenger fleets, transit and urban freight. Although internal combustion engine (ICE) car-sharing vehicles are generally fuel efficient, they are driven further distances per year than a personally owned vehicle. As such, switching a car-sharing vehicle from ICE to zero-emissions may result in 10-11 tonnes of GHG savings over a four year operational period. If all of Vancouver's 2400 car-sharing vehicles converted to ZEVs, they could reduce GHG's by nearly 26 kilotonnes over four years, not including the GHG savings related to lower usage of personal vehicles.

In 2019, staff introduced incentives to encourage zero-emission car-sharing:

1. Allowing zero-emission one-way car-sharing vehicles to have a 50 per cent discount when ending trips in metered parking spaces
2. Zero cost car-sharing parking permits, which allow parking in all residential permit parking areas in the City (to a maximum of 50 vehicles/organization)
3. Charging a flat rate of $3000/year for a reserved on-street zero-emission car-sharing space in a metered area (for internal combustion engine car-sharing vehicles, the rate charged is $3100–$31,000/year, depending on the metered rate of the space).

In February 2020, coinciding with the departure of car2go, Council introduced a 35 per cent discount to metered parking charges, up to the posted time limit, for all one-way car-sharing vehicles ending their trips at meters. This action was taken to ensure that car-sharing remained viable in Vancouver and continued to support residents who rely upon it. At that time, staff also recommended reporting back to Council at a later date with an updated alternative for incenting zero-emission car-sharing vehicles.

Potential Barriers and Incentives

To help determine barriers and potential incentives for zero-emission car-sharing, the City commissioned a study with movmi, a consultant specializing in the planning, implementation and launch of shared mobility services. For reference, the full report provided by movmi as been attached in Appendix A.

This study examined other jurisdictions that have launched zero-emission car-sharing throughout the world to develop a model to determine the costs associated with ZEVs. This analysis showed that given the vehicle technology and charging infrastructure available today, the most significant barriers impacting car-sharing today are:

- The high acquisition costs of ZEVs and limited federal and provincial rebates;
- Lack of publicly accessible charging infrastructure; and,

- Increased operational costs related to relocating vehicles for charging purposes.

As a result of these barriers, the cost of operating zero-emission car-sharing remains higher than for ICE car-sharing and therefore, a less attractive option for both the private and not-for-profit sectors.

To incent zero-emission car-sharing in Vancouver, three actions have been identified:
- Fee reductions,
- Provision of charging infrastructure, and
- Advocating for improved incentives from senior levels of government.

Fee Reductions

In the immediate-term, the fastest action that the City can take to encourage zero-emission car-sharing would be to significantly reduce the fees. The most significant fees that the City charges one-way car-sharing vehicles are metered parking charges. The movmi report recommends that zero-emission car-sharing receive a discount of 95 per cent during the metered time limit. As most metered parking is located within busy commercial areas, no reductions in fees are recommended beyond the metered time limit to encourage turnover. This fee reduction is equivalent to approximately $400/year/vehicle for zero-emission one-way car-sharing vehicles.

In addition to reducing metered parking fees for zero-emission one-way car-sharing vehicles, the movmi study recommends that the cap on the number of vehicles that can have parking permit fees waived, currently 50, be removed to encourage larger zero-emission fleets. This change would result in a savings of $80.30/year/vehicle for the 51st and subsequent ZEVs in a car-sharing organization's fleet. These two recommendations have be included as part of the 2022 Engineering Fees report.

Even with these fee reductions ICE car-sharing likely still remains less expensive to operate. Additionally, the switch from ICE to zero-emissions makes less economic sense for shared vehicle organizations that currently have ICE vehicles that are not at their end of life. Notwithstanding the foregoing, ZEV technology is rapidly evolving and vehicle ranges are increasing while purchase costs are dropping. More publicly available vehicle charging stations are coming online as well. In time, the business case to provide zero-emission car-sharing over ICE car-sharing will become more favourable and fee reductions may no longer be necessary.

Provision of Charging Infrastructure

The study conducted by movmi also indicated that strategically located charging that provides a mix of on-street and off-street locations as well as Level 2 and Level 3 charging types is an important component of operating a zero-emission car-sharing operation. The capital costs of charging infrastructure are likely difficult for car-sharing operators to feasibly fund at this time; accordingly, publicly provided charging infrastructure, provided either by the City, BC Hydro, or other levels of government will help accelerate the shift to ZEVs.

In addition, car-sharing companies do not tend to be land-owners or tenants, making the installation and operation of charging infrastructure cumbersome for their businesses. Since 2016, the City has acknowledged in policy that a key role of the City is to provide charging infrastructure as a market incubator, in the absence of a clear private sector business case.

While market conditions for public charging infrastructure have evolved since that time and it is now profitable for site hosts to provide charging infrastructure in certain locations, it is still impractical for car-sharing companies to own or operate charging stations; the City still plays an important role in ensuring equitable, city-wide access to charging infrastructure.

Today, the City already has arrangements with modo to provide charging infrastructure for its electric vehicle (EV) fleet. Using the experience gained from these existing operations, as well as the desired locations for EV charging noted by Vancouver car-sharing operators as part of the movmi report, staff will continue to update the City's charging infrastructure strategy.

Advocating for Improved Incentives from Senior Levels of Government

Today, the incentives available to car-sharing organizations are limited; the federal Incentives for Zero-Emission Vehicles (iZEV) Program only allows 10 ZEVs purchased per year to receive a $5,000 rebate and the provincial CleanBC program only allows 50 ZEVs purchased per company (lifetime maximum) to receive a $3,000 rebate. These caps on incentives hamper Vancouver's shared vehicle organizations in transitioning their entire fleets to ZEVs. The movmi study recommends interfacing with the federal and provincial government to advocate for changes to these limits and staff will work with Intergovernmental Relations to determine the best way to do so.

I trust the information provided in this memo has informed Council on this issue; however, should you have any questions, please feel free to reach out to me directly.

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Policy recommendations for the electrification of carshare in the City of Vancouver

Prepared by: Sandra Phillips, Venkatesh Gopal, movmi
Prepared for: Chris Darwent, Branch Manager (Acting), Parking Management, Engineering, City of Vancouver

November 2021

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1 | Executive Summary

Personal transportation accounts for 35% of all GHG emissions in the City of Vancouver[1]. The City has implemented and surpassed mode shift targets in their Greenest City Action Plan. Part of achieving this goal is Vancouver's long standing support of carsharing. Something that has propelled Vancouver to the largest carshare market with 2 local operators providing more than 2,300 vehicles and more than ⅓ of the population having a membership.

The next logical step is to electrify this large carshare fleet. In fact in its 2020 Climate Emergency Plan, the City added a new goal of having 50% of all vehicle kilometres travelled (VKT) in zero emissions vehicles (ZEVs)[2]. While ZEVs still occupy the same amount of space as gas and diesel vehicles, they're responsible for much less carbon, air, and noise pollution. To achieve the target light-duty passenger fleets, such as car shares, will need to fully transition to zero emissions by 2030.

However, there are three challenges that currently hinder the transition to electric vehicles:

1) High vehicle acquisition costs and rebates that cap ZEV fleet purchases on a provincial and federal level.
2) Lack of publicly accessible charging infrastructure in all neighborhoods where carshare operators provide service.
3) Increased operating cost because of increased relocation efforts.

The authors have identified four ways of addressing these challenges:

1) Provide a parking discount on all metered parking of 95% for ZEV carshare vehicles in addition to the already existing carshare discounts . This will reduce the operating costs and provide an incentive to transition to ZEV. The proposed discount policy shall be revisited in 3 years to consider changes in EV adoption levels and advancements in tech impacting the share of ZEVs in carshare fleet.
2) Remove the 50 ZEV limit in the City's parking bylaw to allow more ZEVs vehicles in a carshare fleet to qualify for parking discounts.
3) Create a charging infrastructure strategy that focuses on creating charging depots in all neighbourhoods where carshare operates. Starting point is integrating EasyPark parking lots and turning them into hubs.
4) Support advocacy efforts of the industry by writing a letter to provincial and federal governments asking to remove rebate caps for carshare fleets.

[1] Metro Vancouver. 2019. "Greenhouse Gas Emissions." Metro Vancouver.

[2] For the purpose of simplicity the terms 'ZEV' and 'electric vehicles' used throughout this report represent only 100% battery electric vehicles.

2 | Background

Carsharing has a long history in the City of Vancouver: Modo Car Coop launched its service in 1997 and 10 years later Zipcar launched with 100 vehicles. In 2011, car2go entered the market and expedited growth for all three providers. In 2015 Evo, the free-floating carshare service by BCAA launched. From 2010 to 2015, membership growth has grown from under 10,000 residents to 175,000. Despite the fact that car2go and Zipcar left the market in 2020, the market is still large with more than 2,500 vehicles. Vancouver presents itself as a lucrative market for car sharing and that attracts new businesses. Gruv-e is a new free-floating carshare operator soon to launch in the city with an exclusively all-EV fleet.

Table 1: Current landscape in Vancouver

Carshare operator	**Modo**	**Evo Car Share**	**Gruv-e (to be launched)**
Size of fleet	700	1,650	TBC
% of ZEV in their fleets	16	0	100%
Years in operations	24 years	6 years	0
Interest in electrifying?	Yes	Yes	Yes
City parking policy at meters[3]	Members park for free during a trip (upto 2 hrs)	Members park for free during a trip and can end a trip metered parking spot. During the allowed length of stay, Evo pays 65% of the metered rate upto 2hrs and 100% after..	NA
Current parking policy for ZEVs in carshare[3]	No annual permit and decal fees. Reduced fixed annual parking fees for dedicated metered spaces irrespective of the meter rates and held at those amounts for 5yrs.		
Maximum number of vehicles/parking spots eligible under current discounts for ZEVs (caps)[3]	50 vehicles and 50 spaces		

Carsharing has been studied extensively and has three distinct advantages for cities such as Vancouver.

1) **Reduction in vehicle ownership (also called vehicle shedding).**
   According to a large-scale study conducted by Vancity in 2018, more than 25% of members disposed of at least one vehicle and another 40% avoided the purchase of a new vehicle. [4]

[3] City of Vancouver. n.d. "Street and Traffic By-Law No. 2849." Accessed August, 2021.
[4] Vancity Credit Union. 2018. "Changing Gears: Exploring the car-sharing culture shift in Metro Vancouver." Report.

2) **Reduction in VKT (vehicle kilometers travelled).**
Support for carshare by cities is often driven by the long term goal to reduce the overall Vehicle Kilometers Travelled (VKT) by the road users.

Decades of research show that car sharing has positive effects on reducing VKT. The majority of kilometers travelled by residents in a city are attributed to private cars, while car sharing is successful in shifting behaviour, translating into a 55% reduction of VKTs. 68% of car-share members use the service less than five times per year and 12% take six to eight trips per year, with the top two reasons being longer journey times and carrying bulk items. Additionally, carsharing is linked to increased use of public and active transport, with approximately 60% of users walking three times a week and 30% cycling three times a week.[5]

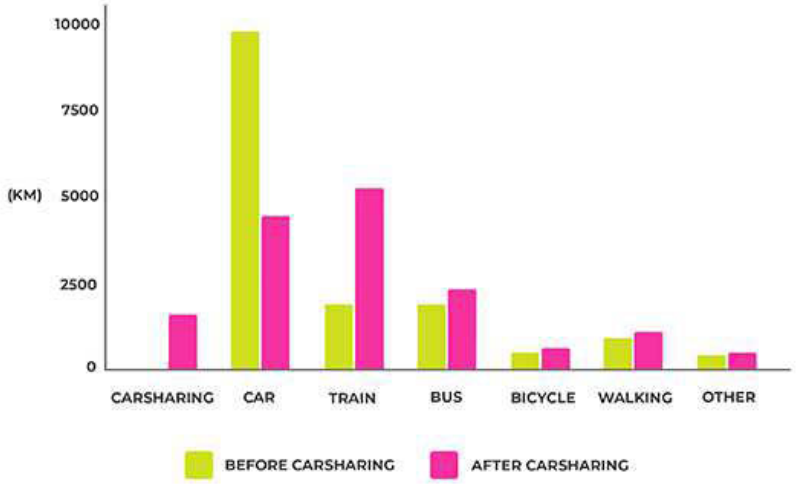


Figure 1: *Before-and-after annual modal distance travelled by an average carshare member in San Francisco. Source: (Amatuni et al. 2020)*

3) **Reduction in GHG emissions.**
Carsharing reduces emissions because carshare fleets are more fuel efficient, have higher utilization per vehicle and users tend to drive less. Electrifying car sharing helps to further reduce emissions, thereby multiplying the impact.

A quick comparison of the GHG emission savings from a ZEV over an ICEV for free floating (FF) & station based (SB) carshare can be explained by considering the following parameters:

Carshare type	TTW Emission factor for light-duty vehicles[6] ($kgCO_2e/L$)	Fuel consumption (L/100km)	Annual distance travelled by a carshare vehicle (km)	**TTW Emission factor for a ZEV[6] ($kgCO_2e/L$)**
Free floating	2.346	5.1[7]	23,000	0.0
Station based	2.346	7.4[6]	14,000	0.0

[5] Dilks, Richard. 2021. "Natural predator of the car? Turns out it's the car." *TransportXtra*, July 13, 2021.
[6] Ministry of Environment and Climate Change Strategy. 2019. "2018 B.C. Methodological Guidance for Quantifying Greenhouse Gas Emissions."
[7] Fuel consumption ratings search tool, Natural Resources Canada.

Total emissions over an average 4 year operational period is found to be as follows:

Light duty hybrid vehicle carshare (FF)	Light duty hybrid vehicle carshare (SB)	ZEV carshare
11.01 tCO_2e per vehicle	**9.72 tCO_2e** per vehicle	**0.0 $kgCO_2e$** per vehicle

Electrifying Vancouver's large carshare would reduce GHG emissions even further. Yet despite all its growth and success, the number of 100% electric vehicles in Vancouver's carshare fleets (SB and FF together) are just 16. The City of Vancouver has already introduced some parking cost reductions in order to incentivize the transition. While these incentives support station-based carshare operators such as Modo, they are simply not strong enough for a large-scale transition.

2.1 Lessons Learnt from other electrified carshare cities

Electrified carshare is not a new concept. It has been tried and tested across 23 cities worldwide by 14 currently active operators and more carshare operators are considering inducting ZEVs in their fleet. The driving factor of such adoption rates are public policies that favor electrifying carshare services.

A few well-known carshare brands tried the first generation ZEVs in their fleet, but the operations were not financially sustainable. In 2011, car2go launched in San Diego with a 100% electric vehicle fleet. These were the electric Smart cars (ED) from Mercedes Benz. Despite favorable policies by the city, car2go incurred huge operational losses because of two major factors. The operations launched based on the agreement with a private charging infrastructure provider to install 1,000 stations which by the end of two years could only be fulfilled upto 400 stations. car2go had operational difficulty keeping more than 80% of the fleet ready for drivers since the vehicles had limited range of ~90km on a single charge. Such instances have highlighted the importance of having reasonably longer range ZEVs coupled with supporting public charging infrastructure in the city for carshare operators to successfully operate a ZEV fleet. This is more critical for a free-floating (FF) carshare model than a station-based (SB) one[8].

movmi together with the City of Vancouver's parking management team conducted a series of interviews with several electric carsharing operators, charging network providers, cities and EV advocacy groups (Figure 2). The objective was to understand what the factors are to successfully transition carshare fleets toward ZEV so they are financially viable in the long-term. Additionally the interviews were focused on the necessary policy frameworks to support such a transition. A summary of findings can be found in Table 2.

[8] Free floating- a type of carsharing that enables users to begin and end their trip anywhere within a designated area in the city
Station based- this type of carsharing allows users to start and end their trip at designated locations (parking spots)

Figure 2: *electric carsharing operators, charging network providers, cities and EV advocacy groups from North America and Europe interviewed by movmi and the City of Vancouver.*

movmi was able to identify three areas that will support the transition of car sharing operators to ZEV.

1) City policies favoring EVs over conventional fossil fuel powered vehicles - for instance free on street parking and/or exclusive access to city center (limited access or congestion pricing zones).
2) Availability and access to charging stations and hubs within the operating area, which helps not only in cutting down operating costs but also increases availability of a larger fleet of EVs for the users.
3) Rebates to reduce initial financial hurdles while providing equitable access to the existing car share users and raising awareness about shared mobility and zero emission vehicles.

Table 2: Summary of Findings From Interviews (EV Carshare Operators, global)

City	Sacramento	Copenhagen	Madrid
Population	0.51 Mio	0.62 Mio	3.2 Mio
EV carshare operators	Gig, 260 cars (FF) Envoy, 90 cars (SB)	Greenmobility, 600 cars (FF) Share Now, 50 cars (FF)	Zity, 800 cars (FF) Share Now, 600 cars (FF) other FF, 800 cars other SB, 600 cars
# of EVs in carshare available for residents	0.7 cars per 1000 residents	1.05 cars per 1000 residents	0.9 cars per 1000 residents
City parking policy	Exclusive discounts for EVs (operator specific)	Free on-street parking for EVs	Free on-street parking for EVs

ULEZ (Ultra Low Emission Zone) policy	NA	Exclusive EV access	Exclusive EV access
Charging network support	City-backed public charging stations - DCFC, L2 (curbside and parking lots)	Public charging infrastructure funded by federal government	NA
EV rebate/ grants for carshare	~USD 15 Million (Green city initiative vehicle grant, Electrify America)	Exclusive discounted registration fees for EVs	Upto 7,000 euros per car (limited to 50 vehicles per operator) Upto 1,500 euros towards EVs per non-EV scrapped (residents may exchange that for carshare credits)

While the interviews could shed some light on the success factors which seem to vary across cities, the challenges faced by carshare operators with inducting EVs into their fleet remained somewhat common.

1) **High vehicle acquisition costs:** Mostly driven by fleet caps imposed by the government, electrifying a fleet of 500 cars while just a portion (about 50) of them qualifying for federal incentives has been pointed out as a major challenge.

2) **High operational costs:** This is an indirect cost resulting from the manpower and related resources costs for relocating vehicles over longer distances (and longer waiting times) only for charging the vehicle batteries. Having vehicles with reasonably longer driving range definitely reduces the frequency, but limited accessible charging stations within the city is a challenge. Although EVs offer far lower maintenance costs (66% less) than their ICE counterparts in fleet operations, an EV fleet does add more labor operational costs owing to frequent and longer charging times compared to ICEVs. This can potentially be reduced by incentivizing users to charge-up their cars in lieu of car share credits (driving minutes), but globally this has seen little traction from the user side.

Car sharing operators and EV advocacy groups shared additional insights on how the transition to electric mobility goes beyond direct financial constraints. These include:

1) **Carshare member concerns:** While in a few markets car share members were excited to have access to EVs and preferred EVs to the other cars, a number of members are still hesitant to do so owing to typical EV-related perceptions of range anxiety. Additionally, there's a major difference between cost of EVs vs cost of non-EVs in car share fleet (including vehicle costs) and members aren't willing to pay a premium for access to EVs.

2) **Government support:** On the federal level, many car sharing operators are eligible and are paid carbon-offset credits towards reducing GHG emissions from their operations. At the municipal level, infrastructure investment from cities helps support individual EV owners, last mile logistics company fleets, city staff fleet and ride hailing drivers in addition to supporting car sharing operators. Certain cities also have a mandate to convert a portion of the car sharing fleet to EVs and are approving policies supporting operators to do so.

3) **Charging infrastructure strategy:** Cities benefit from data sharing and understanding travel patterns not just from car sharing operators but also from charging station usage. Cities, fleet operators and charging station providers must consider reliability and work towards mitigating the adverse impacts of station downtime while expanding access and availability. DCFCs are preferred from an operational perspective for car sharing, but on-street parking drives convenience and vehicle utilization. Each city needs to figure out the right mix of DCFC and L2 network to strike a balance between car share user convenience and cost of installation.

Factors such as changes in driving behaviour impact the rate of adoption. Focusing on GHG emission savings has helped cities go the extra mile and allowed them to consider ROI (return on investments) beyond just financials.

3 | Analysis

From the initial interviews with the local (Vancouver) carshare operators, the team learned that one of the motivations for car sharing operators behind electrifying their fleet is to contribute to the city's climate action plans - reducing GHG emissions from transportation. To support these motivations, there are three main structures that are available to operators:

Incentives/rebates	Federal - iZEV Program[9]: ● $5,000 per vehicle per year for upto 10 vehicles Provincial - CleanBC Car Share Fleet Policy[10]: ● $3,000 per vehicle per company for upto 50 vehicles
Current publicly available charging infrastructure	Visit Transport Canada, PlugShare, ChargeHub
Current parking discounts for EVs	100% discount on annual parking permit and decal fees Discounts on dedicated metered and non-metered parking spaces within the city (however these discounts are limited to the first 50 ZEVs per carshare fleet)

However, they also identified three barriers:

1) **High vehicle acquisition costs and rebates that cap ZEV fleet purchases on a provincial and federal level.**
   Car sharing over the years of operations has been estimated to reduce car ownership. A single carshare vehicle may replace 7-13 individual vehicles[11] which adds to the value delivered by such a service in building sustainable communities. By introducing ZEVs in carsharing, more drivers will therefore be able to access clean energy vehicles. The current federal and provincial rebate schemes restrict all fleet operators (including carshare) to be limited to 50 ZEVs that can qualify for the program. Additionally, the current city parking discounts that apply for ZEVs in carshare are limited to a fleet of 50 vehicles.[12] Existing carshare operators in Vancouver have a combined fleet of over 2,300 vehicles. In such cases, electrifying around 100 vehicles will have a negligible impact on reducing VKTs and will reduce operational feasibility.

   Ultimately, car sharing relies on utilization to achieve financial sustainability. The business of car sharing is highly price sensitive and it deters any pricing increases from the operator side specifically to offset higher operating costs of electric vehicles.

2) **Lack of publicly accessible charging infrastructure in all neighborhoods where carshare operators provide service.**
   Unlike an ICE vehicle that takes 10 minutes to refuel, an EV needs to be parked for anywhere between 1 to 14 hours[13] at a Level 2 charging point before it can be used again. The growing EV population will require charging infrastructure to help meet its charging demand[14]. Currently, a

[9] Transport Canada. 2021. "Incentives for purchasing zero-emission vehicles."
[10] New Car Dealers CleanBC Go Electric. n.d. "Car Share Fleet Policy." Accessed August, 2021.
[11] Martin, Elliot, and Susan A. Shaheen. 2011. "The impact of carsharing on household vehicle ownership." University of California, Berkeley, (January).
[12] City of Vancouver. n.d. "Street and Traffic By-Law No. 2849." Accessed August, 2021.
[13] BC Hydro. n.d. "Choosing an EV charger." Accessed August, 2021..
[14] Slowik, Peter, and Nic Lutsey. 2018. "The Continued Transition to Electric Vehicles in U.S. Cities." The ICCT. White Paper.

majority of EV drivers charge at home, but that doesn't work for carshare fleets: they require non-residential charging, often outside of rental or active driving periods. That is why support for passenger fleets require a concerted effort in building out accessible charging depots conveniently located in different neighbourhoods so repositioning distances of shared vehicles for charging purposes are minimized (less dead-heading). Furthermore, charging stations need to be easy-to-use with accessibility concerns in mind if they are to be used by the public, or if carshare members are incentivized to charge the vehicle.

DC fast charging will play an important role in meeting the needs of EVs on ride-hailing platforms[15]. According to Natural Resources Canada[16]. There are 6,007 electric vehicle charging stations in Canada. The majority are Level 2 (5,255) and in the City of Vancouver there are only 5 DC fast charging depots. Additionally, existing DC fast charging ports may be lacking in redundancy, interoperability, and future-proofing for faster charging capabilities, which means they may not always meet current EV needs or those of future long-range all-electric vehicles. EV charging is being deployed through public-private partnerships, publicly-owned utilities, and unaided private sector investments.

3) **Increased operating cost because of increased relocation efforts.**

Relocation: The process of physcially moving one or more vehicles in the carshare fleet from one location (or area/zone) to another so that they are available closer to members (or user).

Here it also includes movement of the carshare vehicles for refueling/charging, maintenance schedule etc. which requires the cars to be moved between points within the city.

This is one of the most critical operational cost buckets in a free floating carshare business model. Vehicle relocation is a focal point for all operators. When the vehicles are moved, most (if not all) are inspected for defects, checked for missing/forgotten items and refuelled prior to being relocated. Carsharing operators often have a dedicated team for relocating vehicles and thereby manpower resource cost (whether inhouse or outsourced) constitutes the majority of the total relocation expenses.

With ZEV adoption growing at a steady rate especially in British Columbia, the charging infrastructure network is set to grow and these operational costs will be at par with ICEVs in the coming years.

[15] Wood, Eric, Clement Rames, Eleftheria Kontou, Yutaka Motoaki, John Smart, and Zhi Zhou. 2018. "Analysis of Fast Charging Station Network for Electrified Ride-Hailing Services." *SAE International*, (April).
[16] National Resources Canada. 2018. "Electric Charging and Alternative Fuelling Stations Locator." OpenStreetMap.

3. 1 Impact of EVs on costs for carshare

Based on the expert interviews and background research, movmi ran EV assumptions through its carshare financial model to analyse the cost implications of inducting EVs into the fleet. To remain consistent with the current federal and provincial EV rebate schemes, the model has considered a fleet of 50 ZEVs. To successfully support operators in transitioning to a fully ZEV car fleet, movmi firmly believes that it is necessary to remove this 50 vehicle fleet cap specifically for carshare operators.

From an operational perspective, carsharing revenue streams and costs vary between FF and SB models, and that has been factored into the output. The vehicle model considered for modelling purposes is a Chevrolet Bolt EV MY2021 (MSRP ~CAD40,100 to CAD44,000[17]). Other considerations and modeling assumptions are:

- 4 years of vehicle holding period (adjusted for EV depreciation assumptions, see section 3.1.2)
- 15,000 km (mileage) per year
- $1.58~$1.65 per litre fuel (for ICE)
- $0.15 per KWh
- 30kmpl fuel efficiency for ICEVs
- 6kmpkwh energy consumption (charging efficiency of 85%) for EVs

The output is a comparison of major cost buckets between EVs and non-EVs (ICEVs). The shift to EVs causes an expected increase in costs attributed to additional relocation activity, largely due to longer lead times in charging an EV compared to fueling a non-EV. Relocation costs are driven by the number of cars relocated for any reason such as moving between zones in the city, being swapped out as per maintenance schedules, and, for the most part, fueling the car. In the case of EVs, the number of vehicles relocated by the same number of street crew (carshare field staff) will be considerably lower. For instance, if 1 street crew can relocate 10 ICEVs in an 8 hour shift, with the current charging infrastructure availability, this drops to relocating just 6-7 EVs within a single shift.

The second major cost difference is from the vehicle purchase (or lease) price itself. Despite considering federal and provincial rebates for these vehicles, the difference remains significant between the acquisition cost of an EV versus a non-EV. The model also shows that the difference in price of an EV is to a small extent offset by the minimal savings resulting from maintenance, vehicle charging.

3.1.1 Major operating costs

For simplicity and ease of comparison, major operating costs have been grouped under two categories.

1) Cost of goods sold (COGS): In car sharing context, defined as the direct costs involved in generating revenue, this considers the following:
    a) Vehicle cost (lease)
    b) Fuel/ Charging costs
    c) Maintenance & cleaning costs
    d) Parking costs
    e) Insurance, car sharing technology costs
    f) Branding, registration and other vehicle related costs (if any)

2) Relocation costs: Separately categorized for the purpose of reflecting the impact of this head, relocation costs are street crew (carshare field staff) costs/payroll, their transportation and related expenses. The model incorporates the street crew cost for operators based on an estimated average number of vehicles relocated per crew member per shift. Given the current situation in the city, with limited public charging infrastructure available, carshare ZEVs will need to travel

[17] Chevrolet Canada. n.d. “2022 Bolt EV.” Chevrolet. Accessed August, 2021.

further to plug into a station and depending on the level of charging (L2 or DCFC) will take longer to charge up to a 80-100% range. Both of these factors will increase street crew costs as with longer lead times, they will need more crew members or more shifts or both.

Figure 3 shows the calculated output of FF and SB models (all figures indexed to 100)-
The operating costs may differ just by 4-8% in the COGS category, while the Relocation costs increase the costs incurred by a purely EV fleet.

(a) Free floating *(b) Station-based*

Figure 3: *Comparison of EV and non-EV operating costs for (a) free floating and (b) station-based carsharing models.*

3.1.2 COGS

Detailed analysis of the cost of goods sold (COGS) reveals the comparison of key cost buckets for EVs against non EVs in car sharing.

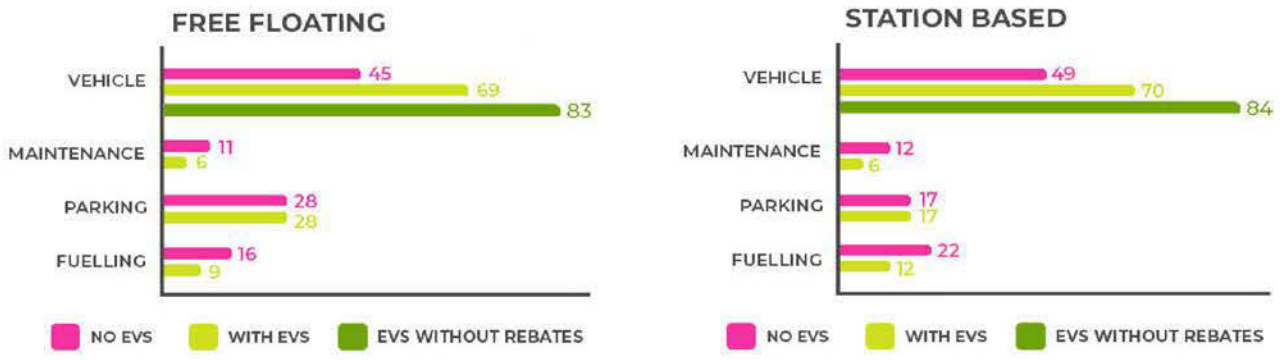
1) Vehicle cost (Acquisition), 43%~53% increase: Records the biggest difference between an EV and non EV fleet. This is after factoring in the EV rebates as available for fleet operators i.e. 10 vehicles eligible for $8,000 (federal and provincial) per vehicle before tax and the remaining 40 vehicles eligible for $3,000 (provincial) per vehicle before tax.

2) Maintenance & cleaning cost, 50%~55% savings: Although accounts for some savings over non EVs, the amount remains negligible. Derived based on research and expert interviews, ZEVs are expected to provide maintenance savings of around 60% over ICE. Cleaning costs remain the same.

3) Charging (instead of refuelling), 54%~56% savings: Based on cost savings from electricity over gasoline, EVs show savings over non EVs. These costs do not factor the cost of charging infrastructure setup and maintenance.

4) Parking, no difference: Although parking costs form a significant contribution to the overall COGS, there's no difference operationally for ZEVs. With an attractive parking discount policy exclusively for ZEVs, the city can support the transition to zero emission in carshare and that's within its scope.

Figure 4 shows the calculated output of FF and SB models (all figures indexed to 100):



(a) Free floating *(b) Station based*

Figure 4: *Detailed comparison of COGS (cost of goods sold) for EV and non-EV in a (a) free floating and (b) station based carsharing model.*

A note on depreciation of electric vehicles:

Depreciation: The portion of the initial value of an asset (such as a vehicle) that has been lost after a given amount of time. Depreciation is the inverse of the residual value.

Depreciation for electric vehicles has been seen to be higher as compared to an ICE vehicle in the same class. Research studies show that the difference between EVs and ICEVs has been reducing significantly for the past 4 years. The reason for this is the advancements in battery technology and the current new versions with about 66-75kWh battery capacity seem to provide an ideal 300-450km driving range over a single charge.

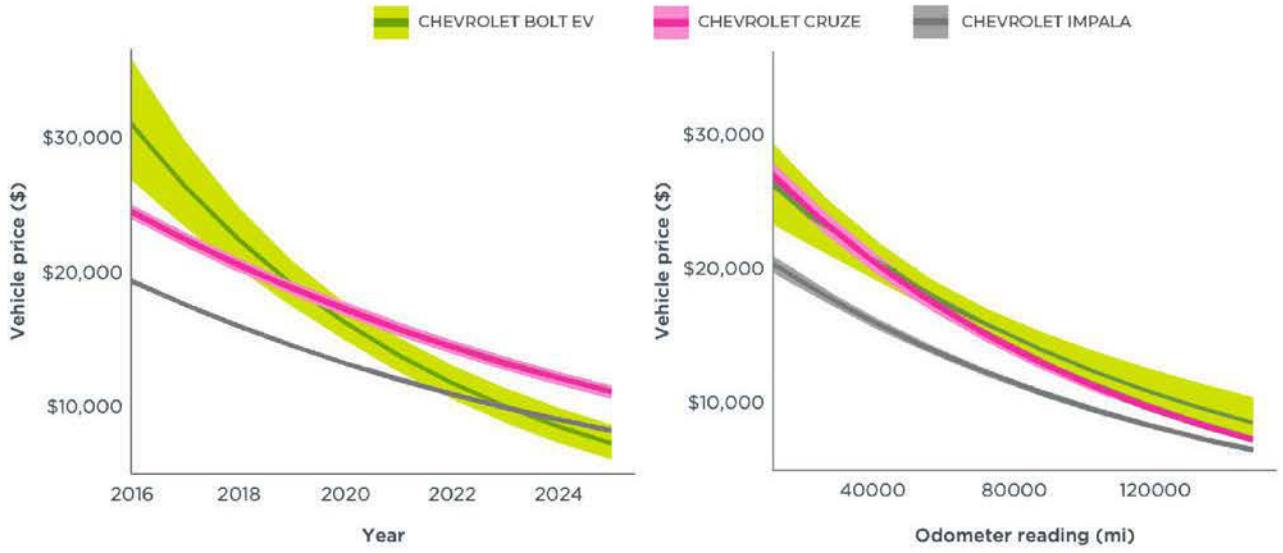


Figure 5: *Comparison between vehicle purchase price for Chevrolet Bolt EV and two comparable Chevrolet gasoline vehicles. Left: Estimated value of a 2016 model driven 15,000 miles per year, by year of sale. Right: Estimated value of a used vehicle driven 15,000 miles per year and sold in 2020, by*

odometer reading. Ribbons show 95%-confidence interval of estimates. Source: (Bauer, Hsu, and Lutsey 2021)

Depreciation also depends highly on the class of vehicle viz. luxury vs compact. The current model considers EVs to hold resale values equal to their ICE counterparts based on the retained range of their batteries (also known as state of health, SoH). As industry practice EV manufacturers provide a battery warranty of 8 years or 160,000 km with the assurance that the batteries will retain around 75-80% of their original SoH. With the EV models considered in calculations in this report, it means vehicles will have between 300-450km of range over 8-10 years of operations. With no major powertrain and other vehicle maintenance costs cropping up as the vehicle holding period goes beyond 4 years, this significantly decreases the depreciation cost that may be considered in carsharing fleet operations.

Additionally, the EV used car market is expected to see major uptick once supply stabilizes, public awareness and acceptance increases and charging infrastructure networks expand in cities.

Table 3: Average Predicted 5-Year Residual Values[18] for EVs Compared with ICE Vehicles.

EV/PHEV Category	Adjusted for Federal Tax Credit	Adjusted for Federal and State Tax Credits	Comparable ICE	ICE Segment Comparison
Luxury EV	0.47	0.48	0.46	Luxury car, luxury SUV, luxury performance
Mainstream 200-plus-mile range	0.44	0.46	0.45	Compact car
Mainstream <100-mile range	0.28	0.29	0.36	Subcompact car

Table adapted from: (Harto 2020)

3. 2 Impact on City Revenue

The primary objective of the project is to recommend a parking discount strategy for ZEVs in the City of Vancouver. Analysis of the financial model showed that parking costs are a significant portion of the overall cost in a carshare operation.

Currently, the city parking policy at meters for SB and FF carsharing are:

- (SB) Modo carshare members park for free during a trip (upto 2 hrs); and
- (FF) Evo carshare members park for free during a trip and can end a trip at a metered parking spot. During the allowed length of stay, Evo pays 65% of the metered rate. If vehicles stay longer, Evo pays 100% of the rate (overage fee).

Additional discounts will have a significant impact in offsetting the difference in EV operating costs for carshare operators. The major challenge will remain that carshare operators cannot access federal and provincial EV rebates for more than 50 vehicles under the current policy and offering additional vehicle purchase rebates does not fall under the city's scope.

[18] Residual value - the remaining portion of the original purchase price of a vehicle after a number of years. Residual value is the inverse of depreciation.

A recommended maximum discount rate of 95% on metered parking spaces for free-floating carshare (no change to the 100% charge on overage fees) will drive significant savings to the COGS. The impact of these reductions on the city revenue are shown in Table 4. The table shows a summary comparison between SB and FF carshares with and without EVs. In all cases, the figures represent revenue impact on a per car per year basis.

The revenue impact, while considerable for the city, will have a significant contribution to the carshare operator costs of inducting EVs. The overall impact on the City's revenues can be mitigated by additional revenue from new entrants to the market. This revised parking policy encourages new players to plan operations exclusively using ZEV, thus converting more VKT to zero emission which ultimately supports the City's Climate Action Targets.

Assumptions towards analysing the impact are as follows:

- Duration - Annual
- (existing) Available discount on parking permit and decal fees for ZEVs in carshare - 100%
- (existing) Available discount on metered parking for free-floating carshare - 35%
- (new) Proposed discount on metered parking for ZEVs in carshare - 95%[19]
- (new) Proposed removal of caps on the maximum number of vehicles that qualify for exclusive ZEV related discounts.
- (no change) 100% charge on overage fees for free-floating carshare at metered parking

The output is as below:

Table 4: Annual impact of discount rate to City revenue

Details	**With ICEV (existing discounts apply)**		**With ZEV (new proposed discounts)**	
	Revenue per car (FF)	**Revenue per car (SB)**	**Revenue per car (FF)**	**Revenue per car (SB)**
Permit & decal fee	80.30	80.30	0.00#	0.00#
Avg metered fee	408.41	0.00	31.42	0.00
Avg metered overage	45.36	0.00	45.36	0.00
Total parking revenue from carshare	**534.07**	80.30	**76.78**	0.00

#No limit on the number of ZEVs in a carshare fleet that qualify for new proposed discounts

[19] The new proposed discount does not cover parking overage fees.

3.3 A charging Infrastructure Strategy that supports carshare

As the interviews with operators have shown, charging infrastructure is one of the key success factors for ZEV carshare. A charging strategy for ZEV carshare needs to consider the following three factors:

1) **Proximity of carshare operational zones to charging station hubs**
   Charging stations need to be strategically located around the city to enable shorter and quicker relocation trips. movmi did an analysis to understand high demand parking areas in the city based on the parking meter rates and the assumption that the parking rates and allowed length of stay were set according to parking demand. The following maps (Figure 6) show (in orange/yellow) the parking areas that are the most expensive and allow vehicles to stay the least amount of time. In our parking index we gave the parking rate twice as much weight as the allowed length of stay.

Weekdays (Mon-Fri) 9am-6pm | **Weekends 6pm-10pm**

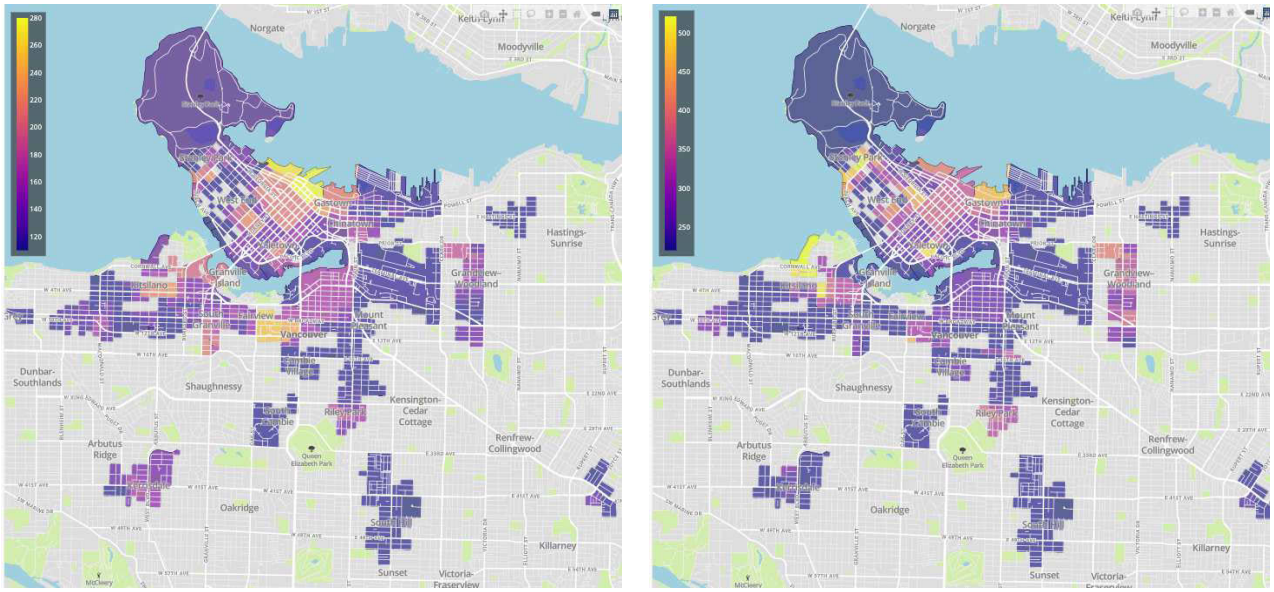


Figure 6: *Heat map of parking costs and length of stay in the City of Vancouver. Areas in purple to yellow show parking areas with the least cost and highest cost-length index.*

movmi also took feedback from local carshare operators to propose possible locations for charging hubs. As a city-centric strategy, we considered the closest EasyPark lot locations to the desired zones and plotted lots equipped with EV charging stations currently (figure 7). Although separated by operating models, availability of charging infrastructure across these identified locations will benefit both FF and SB carshare operators.

Figure 7: *Possible locations for charging hubs in City-owned EasyPark locations according SB/FF carshare models.*

2) **Mix of curbside, parking lots and level 2, DCFC (level 3) charging stations**

The second factor in the charging station network strategy needs to consider the right mix of on-street vs parking lot charging stations. Depending on residential and non-residential zones across the city, there can be an EV charging network strategy implemented. In the car sharing context, operations dictate different charging requirements for FF and SB models. While FF carshare will benefit from a well spread-out network, SB carshare will need charging facilities at their dedicated parking spaces across the city. The latter may incur higher CAPEX as well as lower utilization of such charging stations since the parking space needs to be available for carshare vehicles.

The recommended strategy is to balance utilization of public charging stations between FF and SB carshare operators based on several factors including charging needs, utilization and fleet size. To facilitate station availability, reliability and to ensure carshare members are able to utilize ZEVs optimally, it's best suited if charging stations are allocated exclusively to carshare operators - at least initially.

The advantage of favoring more charging stations at parking lots is that it may prove to be technically and financially more feasible to install an array of charging stations in one location factoring the electricity demand, cabling and installation costs and related complexity. Curbside

chargers will be advantageous in extending proximity of the network to high carshare operational zones that are away from the closest parking lots.

Level 2 and DCFC charging stations allow EVs to charge at different speeds. While faster charging is more convenient even from carshare operational perspective, vehicle manufacturers recommend to limit charging the batteries too often with a DCFC (level 3). While advancements in battery technology will continue to push this limit, with the current vehicles available, a balanced approach is recommended.

3) **Publicly funded charging station network**
In the cities where the interviewee EV carshare operators exist, the operators hugely benefit from the public charging station network available for all EV users. In order to support and incentivize the operators to transition to a ZEV fleet, the locations and mix of charging stations will need to be supported by the city where it pays for the installation (capital costs). The bigger upfront costs of charging infrastructure - installation and maintenance - will be a considerable investment for carshare operators to feasibly fund. The public charging stations installed by the city can service carshare members and individual EV owners while at the same time introducing an additional source of revenue for the city.

The recommended charging infrastructure strategy thus will hugely benefit accelerating EV adoption beyond carshare fleets while making it operationally feasible for carshare operators to gradually increase the mix of ZEVs in their fleet.

4 | Recommendations

Based on the expert and local operator interviews, movmi's existing research and considering the modelling exercises, movmi recommends the following:

1) **Provide a 95% discount for carshare rentals ended at meters**
With vehicle parking contributing to 17-28% of the operational costs, a 95% exclusive discount for ZEVs for free-floating carshare will be a considerable incentive for operators to introduce them in their fleet. The discount will not only support operating costs, but also provide increased convenience for carshare users resulting in increased ridership and carshare usage. The incentive will also attract future carshare operators including exclusive new ZEV carshare operators. As for supporting the SB carshare model, the city has a progressive discounted rate for dedicated parking spaces (metered and non-metered).

2) **Remove the 50 ZEV limit in current City's parking bylaw**
movmi also recommends removing the 50 vehicle limit on any existing ZEV parking policy and consider bringing focus to understanding the need of the EV carshare industry. This is to strike a balance between long term goals and the city's climate change efforts.

3) **Support the build out of ZEV charging infrastructure throughout the city financially and with a carshare lens**
The recommended strategy is to balance utilization of public charging stations between FF and SB carshare operators based on several factors including charging needs, utilization and fleet size. Based on discussion with local operators, we recognize that the ZEV charging infrastructure strategy needs some more data points and further work.

A city-wide charging strategy should at minimum consider:
   a) *Proximity of carshare operational zones to charging station hubs.*

Based on high demand areas for carshare operations. This will allow public charging stations available to operators and individual EV owners alike.

b) *Mix of curbside, parking lots and level 2, DCFC (level 3) charging stations.*
The strategy needs to consider the level of charging stations and between curbside and parking lots to equitably provide access to residential and non-residential areas.

c) *Publicly funded charging station network.*
Installation and maintenance of charging stations forms the major cost of the setup. The city needs to consider the initial investment thereby facilitating reliability and optimizing ZEV availability for carshare members while making it attractive for carshare operators to transition to ZEVs sooner.

4) **Support industry in their advocacy to remove provincial and federal caps on ZEV rebates and incentives for carshare fleets**

To aid carshare operators in transitioning their fleets to zero emissions vehicles, the vehicle cap on federal and provincial ZEV rebates must be removed. Therefore, movmi recommends sending a joint letter to the provincial and federal government advocating for the removal of fleet caps on ZEV qualifying for rebates. This report is to be shared with and the letter co-signed by local stakeholders such as the City of Victoria, City of North Vancouver, City of New Westminster, TransLink, Modo, Evo, Canadian sustainable transportation advocacy institutions including movmi, Vancouver Economic Commission (VEC), Canada Infrastructure Bank (CIB), Vancouver Electric Vehicle Association (VEVA), Victoria EV association, and international climate change advocacy organizations such as The Climate Group and C40.

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Expert Interviewees:

Agustín Muñoa Amas: Chief Operating Officer, Zity
Anders Wall: COO and Deputy CEO, GreenMobility
Casey Brennan: Director of Community Impact & Advocacy, GIG Car Share
Christian Brandt: Regional Fleet Manager, Modo
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movmi: movmi is an award winning, WBE Canada certified (Women Only Business Certification) boutique agency specialised in Shared Mobility Architecture: the planning, implementation and launch of new shared mobility services such as carsharing, micromobility or Mobility-as-Service.

Our services span research, analysis & business case modelling, and the co-creation of new shared mobility services. To date we have been involved in over 60 shared mobility projects worldwide.

Our team has deep expertise in all aspects of shared mobility architecture, in particular how operations, infrastructure and regulation tie together. We have helped public agencies such as TransLink, City of Calgary or the State of Luxembourg as well as shared mobility operators (e.g. BMW's ReachNow, Evo Car Share, eKar, Toyota Hui) develop successful and sustainable service strategies. If you want to learn more, please contact us at info@movmi.net.

6 | Resources

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