



# A Primer on the Transition to Electric Vehicles in Metro Vancouver

*Prepared for TransLink  
in collaboration with  
Metro Vancouver*

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## **About This Document**

### **Purpose**

**This document provides regional and municipal decision makers with a primer to support transition to a higher level of deployment of plug-in electric vehicles (PEVs) in the light duty vehicle fleet across Metro Vancouver.**

Specifically, this document will support:

- An improved understanding of the role that PEVs can play in achieving a sustainable transportation system
- Implementation of TransLink's *Transport 2040* strategy, particularly as it relates to Goal 1 (below), and the update of this strategy (2013)
- Implementation of Metro Vancouver's *Integrated Air Quality and GHG Management Plan*
- Actions of individual municipalities across Metro Vancouver in their efforts to prepare for electric vehicles

### **Goal 1: Greenhouse gas emissions from transportation are aggressively reduced, in support of federal, provincial and regional targets**

*(Transport 2040)*

This document's primary audience is local and regional decision makers with a mandate for transportation and land use planning.

The topics covered in this document include:

- Introduction to PEVs
- Benefits of PEVs
- PEV adoption curves for Metro Vancouver
- PEVs and local government fleets
- Policy, bylaws, and permitting for PEVs
- Regionally coordinated charging infrastructure
- Coordinated communications for PEVs

TransLink engaged the Community Energy Association (CEA) to complete this primer. CEA completed the following activities to develop this document:

- Two presentations with questions and answers to Metro Vancouver's Regional Engineers Advisory Committee Climate Protection Subgroup (REAC-CPS)
  - Extensive collaboration with TransLink and Metro Vancouver (the two advisory partners for the project)
  - Meetings with key stakeholders including Province of BC, BC Hydro, City of Vancouver, Electric Mobility Canada, University of BC, Pembina Institute, and Fraser Basin Council
  - Literature review of recent studies on electric vehicle adoption curves, leading practices in other jurisdictions, charging infrastructure technical information and approaches to planning, and PEV charging scenarios, and the role of local governments and agencies in PEV adoption.
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## Abbreviations

The following abbreviations are used.

- BEV Battery Electric Vehicle
- CAC Criteria Air Contaminant
- CEA Community Energy Association
- EVCE Electric Vehicle Charging Equipment, which includes EVSE
- EVSE Electric Vehicle Service Equipment
- GHG Greenhouse Gas
- HEV Hybrid Electric Vehicle
- ICE Internal Combustion Engine
- IRR Internal Rate of Return
- LDV Light Duty Vehicle (also known as Passenger Vehicle)
- LEV Light Electric Vehicle
- LSV Limited Speed Vehicle (Canadian term for NEV, which is commonly used in the US)
- NEV Neighbourhood Electric Vehicle (less than 35 mph vehicle street legal)
- NPV Net Present Value
- PEV Plug-in Electric Vehicle
- PHEV Plug-in Hybrid Electric Vehicle
- PM2.5 Particulate Matter (<2.5 µm)
- TDM Transportation Demand Management
- VKT Vehicle Kilometres Travelled



## TABLE OF CONTENTS

<b>EXECUTIVE SUMMARY</b> .....	<b>1</b>
<b>INTRODUCTION</b> .....	<b>3</b>
TYPES OF ELECTRIC VEHICLES .....	3
OPPORTUNITIES FOR PEV ADOPTION IN METRO VANCOUVER.....	4
<b>2 CONTEXT</b> .....	<b>5</b>
THE ROLE OF PLUG-IN ELECTRIC VEHICLES (PEVs) IN A SUSTAINABLE TRANSPORTATION SYSTEM.....	5
IMPACTS OF TRANSITIONING TO ELECTRIC VEHICLES .....	11
INITIATIVES AND COLLABORATION IN THE METRO VANCOUVER REGION .....	13
<b>3 PLUG-IN ELECTRIC VEHICLE MARKET PENETRATION &amp; LIFECYCLE COST</b> .....	<b>16</b>
LESSONS FROM HYBRID MARKET PENETRATION .....	16
RESEARCH .....	17
LIFECYCLE COST COMPARISON .....	20
<b>4 LEVERS TO ACCELERATE PLUG-IN ELECTRIC VEHICLE DEPLOYMENT</b> .....	<b>23</b>
LEARNING FROM OTHER JURISDICTIONS .....	23
METRO VANCOUVER’S STATUS .....	25
LEVERS FOR ACCELERATING PEV USE IN METRO VANCOUVER .....	25
<b>5 PLUGGING IN: LOCAL AND REGIONAL TOOLS</b> .....	<b>27</b>
UNDERSTANDING ELECTRIC VEHICLE SUPPORT EQUIPMENT (EVSE) .....	27
AT HOME – NEW CONSTRUCTION .....	30
AT HOME – RETROFITS.....	30
AT WORK.....	31
‘ON THE GO’ .....	31
<b>6 MINIMUM REGIONAL ‘ON THE GO’ CHARGING NETWORK</b> .....	<b>34</b>
ROLE AND CHARACTERISTICS OF ‘ON THE GO’ INFRASTRUCTURE.....	34
<b>7 OPPORTUNITIES FOR EARLY LOCAL GOVERNMENT FLEET ADOPTION</b> .....	<b>41</b>
<b>8 CONCLUSIONS</b> .....	<b>42</b>
<b>SOURCES OF ADDITIONAL INFORMATION</b> .....	<b>44</b>
<b>APPENDIX A – TRANSLINK’S GOVERNANCE MODEL</b> .....	<b>45</b>
<b>APPENDIX B – RESEARCH SUPPORTING MARKET PENETRATION SCENARIOS</b> .....	<b>46</b>
<b>APPENDIX C – METRO VANCOUVER PEV MODEL</b> .....	<b>49</b>
<b>APPENDIX D – HOW TO ADD AN EV TO A LOCAL GOVERNMENT FLEET</b> .....	<b>51</b>
<b>APPENDIX E – CHARGING INFRASTRUCTURE MANUFACTURERS</b> .....	<b>57</b>
<b>APPENDIX F – EVSE REQUIREMENTS/INCENTIVES FOR HOMES</b> .....	<b>59</b>



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## Executive Summary

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**This report** provides regional and municipal decision makers with a primer to support transition to a higher level of deployment of **plug-in electric vehicles (PEVs)** in the light duty vehicle fleet across Metro Vancouver.

**Metro Vancouver** has many characteristics that favour PEVs. Environmental benefits will be higher here than in many other jurisdictions because electricity provided by BC Hydro has a small carbon footprint now and is intended to be carbon neutral by 2016<sup>1</sup>. (Net Zero requirements outlined in the 2007 BC Energy Plan mean that all GHG emissions from existing thermal generation in B.C. will be required to be offset to zero, starting in 2016, while direction from the *Clean Energy Act* will see BC Hydro minimize its use of the Burrard Generating Station, which is fuelled by natural gas.) Fuel savings are also compelling because Metro Vancouver's electricity rates are some of the lowest in North America while gasoline and diesel prices are among the highest, creating one of the largest price differentials between electricity and gasoline. Metro Vancouver's driving patterns also favour electric vehicles, with 76% of commutes outside downtown Vancouver being less than 10 km and only 3-6% of trips within Vancouver exceeding 30 km. These distances are well within the typical battery electric vehicle (BEV) range.

There is a precedent of rapid growth in the hybrid- electric vehicles (HEV) segment. Since being introduced in Metro Vancouver 2000, hybrids grew in market share to 0.5% of passenger vehicles in 2007 and 1% in 2010<sup>2</sup>, representing a 10 year compound annual growth rate (CAGR) of 31%. Twenty-five percent of HEVs in Canada are located here.<sup>3</sup> Based on this growth, and other BC market attributes, BC is expected to have one of the highest electric vehicle adoption rates in Canada.<sup>4</sup>

Broad PEV adoption can help Metro Vancouver, its member municipalities and Translink:

- Achieve GHG reduction targets
- Improve air quality via reduced emissions of fine particulate matter and other emissions
- Improve quality of life from environmental and health benefits, including noise reduction
- Support regional land use and transportation planning management plan goals and objectives
- Build a more sustainable transportation system

**Provincial Support** announced in November 2011 includes a \$17 million initiative providing up to \$5,000 towards the cost of battery electric and plug-in hybrid vehicles and \$6.5 million to develop a provincial charging network. The initiative also includes a \$500 rebate for household chargers.

**PEV adoption rates** are expected to result in at least 5,000-10,000 PEVs in the region by 2020 without incentives. With incentives, this estimate doubles, resulting in a 0.5% decrease in light duty vehicle emissions by 2020 and a more rapid deployment of EVs over the 2020-2030 timeframe. Mass production of EVs as the market matures will reduce the price of EVs.

**Financial savings** are projected to be on the order of \$875,000 for carbon (at \$25/tonne) on an annual basis by 2020. Particulate matter (PM2.5) at \$813/tonne achieves annual reduced regional health costs between \$1,600 and \$5,600 by 2020.<sup>5</sup> Savings on fossil fuel spending could reach \$14 million in the year 2020. Consequently, PEVs in Metro Vancouver in 2020 could save almost \$15 million annually due to fuel cost savings and emissions reductions.

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<sup>1</sup> According to BC Hydro ([http://www.bchydro.com/about/our\\_commitment/sustainability/greenhouse\\_gases.html](http://www.bchydro.com/about/our_commitment/sustainability/greenhouse_gases.html))

<sup>2</sup> ICBC data for 2010 indicates 12,107 total hybrid vehicles in Metro Vancouver. Total LDVs estimated at 1.154 Million vehicles in 2010, yielding 1%.

<sup>3</sup> John Stonier, Signature Renewables, provided via comments on this document (the Primer).

<sup>4</sup> From *Shaping Electric Transportation in BC Preparing a Utility for the Transformation to Electric Mobility*, Mark Dubois-Phillips, BC Hydro, Chief Technology Officer, at the EV Trade Show, Sept 2010, Vancouver, Canada

<sup>5</sup> The CAC calculation is based on 1,154,880 passenger vehicles in Metro Vancouver and the inventory of PM2.5 from passenger vehicles of 127 tonnes which results in 0.00011 tonnes per vehicle, monetized at \$813 per tonne.

**Challenges** include:

- Slight cost premium for purchase of PEV's
- PEV's are not a silver bullet; although they reduce emissions from fossil fuel, they do not reduce trip distance or encourage mode shifting
- A long timeframe for large-scale penetration combined with a need to invest in infrastructure early
- Supply of rare earth metals for motors

**Next steps** could include:

- 1 Clarify roles for Translink, Metro Vancouver and its member municipalities.
- 2 Identify policy levers and specific actions for regional collaboration.
- 3 Initiate a structured regional collaboration partnership to further develop and implement levers and actions identified.



## Introduction

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The Primer has been written, in partnership with TransLink and Metro Vancouver, to help evaluate the potential of electric vehicles (EVs) to contribute to sustainable transportation policies being considered in the update of *Transport 2040*. The primer provides useful information about electric vehicles in terms of purchase and lifecycle costs, support structures, business case, and benefits in terms of fuel and emissions savings.

The primer provides a brief description of EV types and provides policy context for determining how electric vehicles contribute towards the region's goals related to vehicle kilometres travelled, GHG emissions reductions and impact on air quality. The Primer seeks to provide both hands-on useful information to local governments implementing EV infrastructure throughout Metro Vancouver as well as policy and strategic analysis for regional planners.

The scope of the Primer is limited geographically to Metro Vancouver. Only the light duty vehicle market space is considered, which limits the scope of electric vehicles considered to Plug-in Electric Vehicles (PEVs), a category that includes both Battery Electric Vehicles (BEVs) and Plug-in Hybrid Electric Vehicles (PHEVs). From a temporal perspective the Primer analyzes implementation of electric vehicles to 2020 and, in select cases, refers to 2030 and 2050.

In developing the Primer, several sources of information were investigated. These included interviews with individuals involved with light duty vehicle electrification in Metro Vancouver as well as discussions with Provincial government representatives leading the Electric Vehicle Working Group, the City of Vancouver and BC Hydro. In addition, non-governmental organizations such as the Fraser Basin Council and the Pembina Institute have contributed significantly to this paper in terms of education and program information. The City of Vancouver and its Project Get Ready team have contributed significantly to the understanding of the authors via their progress towards EV implementation. Finally, academic and industry literature has been referenced widely for to provide perspectives on other jurisdiction's marketing, technology, policy and financial measures related to EVs.

### Types of Electric Vehicles

The scope of the Primer is restricted to electric vehicles that can replace the light duty internal combustion engine vehicle market in Metro Vancouver. Several types of vehicles are commonly referred to in one way or another as electric vehicles, but only one type, Plug-in Electric Vehicles (PEVs), relates to the direct replacement of the existing Internal Combustion Engine (ICE) light duty vehicle market.

Light Electric Vehicles (LEVs), Hybrid Electric Vehicles (HEVs) and Limited Speed Vehicles (referred to as Neighbourhood Electric Vehicles in the US) described in Table 1 are NOT included in this analysis. LEVs and NEVs are generally not considered substitutes for the existing light duty vehicle market and HEVs use fossil fuels instead of electricity as a source of energy. Heavy duty vehicles, such as TransLink's revenue fleet of vehicles, are also outside the scope

Plug-in Electric Vehicles (PEVs), including Plug-in Hybrids and Battery Electric Vehicles, address the light duty vehicle market and are fully or partially powered by electricity. Light duty vehicles account for approximately 29% of GHG emissions in Metro Vancouver. Of note, the scope of this document is consistent with the first element of Perl & Gilbert's thesis regarding light duty vehicle electrification<sup>6</sup> but excludes topics of electricity as a grid supplied fuel and the future of marine and air transport.

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<sup>6</sup> R. Gilbert and A. Perl, *Transport Revolutions: Moving People and Freight without Oil*, New Society Publishers, 2009

**Table 1: Types of electric vehicles**

Type	Description	Example
<b>Plug-in Electric Vehicles (PEVs) Within Study Scope (Possible Substitutes for Internal Combustion Engine Light Duty Vehicles)</b>		
<b>Plug-in Hybrid Electric Vehicle (PHEV)</b>	PHEVs have the ability to travel for some distance in charge depleting (CD) mode using electrical energy from the grid. These vehicles also have an on-board fossil fuel engine which acts a generator for the electric motors in Charge Sustaining (CS) mode. The engine is also sometimes called a 'range extender'. This class of vehicle automatically engages the engine when the battery charge becomes low.	Chevrolet Volt
<b>Battery Electric Vehicle (BEV)</b>	BEVs are fully electric with no fossil fuel engine. Energy is received from the electrical grid and stored in a battery. Range on these vehicles can be limited due to battery capacity and weight.	Mitsubishi MiEV
<b>Plug-in Electric Vehicles (PEVs) Not Within Study Scope (Not Possible Substitutes for Internal Combustion Engine Light Duty Vehicles)</b>		
<b>Light Electric Vehicles (LEV)</b>	A Light Electric Vehicle LEV is a land vehicle propelled by an electric motor that uses an energy storage device such as a battery or fuel cell, has two or three wheels and typically weighs less than 100kg.	Scooters, electric bicycles & Segways
<b>Hybrid Electric Vehicles (HEV)</b>	HEVs were first introduced to Metro Vancouver streets in 2000 and now number over 12,000. These vehicles do not receive energy from the electrical grid. Energy from an on-board gasoline engine is stored in a battery. Both an electrical motor and gasoline engine are used to move the vehicle.	Toyota Prius Honda Insight
<b>Limited Speed Vehicle (LSV)</b>	A LSV is a fully electric vehicle typically manufactured in low volumes and not crash-tested and is therefore limited to low speed roads (usually less than 50 km/hour).	Might-E truck Dynasty Corporation vehicles (defunct)
<b>Fuel Cell Vehicles</b>	A Fuel cell vehicle or Fuel Cell Electric Vehicle (FCEV) is a type of hydrogen vehicle which uses a fuel cell to produce electricity, powering its on-board electric motor. Fuel cells in vehicles create electricity to power an electric motor using hydrogen and oxygen from the air.	BC Transit's fuel cell buses.

## Opportunities for PEV Adoption in Metro Vancouver

Metro Vancouver has many characteristics that favour the rapid adoption of PEVs. Environmental benefits are higher here than in many other jurisdictions because electricity from BC Hydro's power grid has a small carbon footprint now and will become carbon neutral by 2016. Fuel savings are also attractive because Metro Vancouver's electricity rates are some of the lowest in North America, while gasoline prices are among the highest, creating a large price differential between electricity and gasoline. Additionally, there is a precedent of rapid growth in the HEV segment. Since being introduced in 2000, hybrids represented 0.5% of passenger vehicles in 2007 and rose to 1% in 2010.

### Box 1: Plug-in Electric Vehicles (2011)

- Battery Electric Vehicles (BEVs)
  - Nissan Leaf
  - Mitsubishi iMiEV
  - Ford Transit Connect (EV)
  - SMART Fortwo Electric Drive (EV)
- Plug-In Hybrid Electric Vehicles (PHEVs)
  - Chevrolet Volt

Metro Vancouver's driving patterns favour electric vehicles, with 76% of commutes outside downtown Vancouver being less than 10 km and only 3-6% of trips driven in Vancouver exceeding 30 km<sup>7</sup>; distances are well within the typical BEV range. Finally, Metro Vancouver's climate is temperate, avoiding significant vehicle occupant heating loads and cold operating conditions.

<sup>7</sup> For map, see *Shaping Electric Transportation in British Columbia* (presentation by Alec Tsang, BC Hydro)

[http://www.bchydro.com/etc/medialib/internet/documents/power\\_smart/commercial/shaping\\_electric\\_transpo\\_em\\_ed\\_series\\_dec2009.Par.0001.File.shaping\\_electric\\_transpo\\_em\\_ed\\_series\\_dec2009.pdf](http://www.bchydro.com/etc/medialib/internet/documents/power_smart/commercial/shaping_electric_transpo_em_ed_series_dec2009.Par.0001.File.shaping_electric_transpo_em_ed_series_dec2009.pdf)

## 2 Context

This section will cover provincial, municipal, TransLink, and Metro Vancouver policy context related to support for electric vehicles (and low emission vehicles). Electric vehicles (EVs) are positioned to provide significant energy and emission benefits to Metro Vancouver, but they will require policy support from local, regional and provincial governments to realize their potential. Initial growth in emissions reductions is expected to be moderate and it will take over ten years until EVs have a significant emissions savings impact within the region. Electric vehicles are not a 'silver bullet' solution to the region's energy, emissions or transportation challenges and their role has been positioned in this Primer as a Sustainable Transportation System component of an overall Transportation Demand Management strategy.

### The Role of Plug-in Electric Vehicles (PEVs) in a Sustainable Transportation System

#### Sustainable Transportation

In *Transport 2040*, and its adopted Sustainability Policy, TransLink uses a definition of a sustainable transportation system developed by the Centre for Sustainable Transportation and adopted by the Ministers of Transport of the European Union (see Box 2).

#### **Box 2: What is a Sustainable Transportation System?**

A sustainable transport system is one that allows the basic access and development needs of individuals, companies, and societies to be met safely and in a manner consistent with human ecosystem health, and promotes equality within and between successive generations.

It is affordable, operates efficiently, offers choices of transportation, and supports a competitive economy as well as balanced regional development.

It limits emissions and waste within the planet's ability to absorb them, uses renewable resources at or below their rates of generation, and uses non-renewable resources at or below the rates of development of renewable substitutes while minimizing the impact of the use of land and the generation of noise.

Source: *Transport 2040: A Transportation Strategy for Metro Vancouver, Now and in the Future*, (via Ministers of Transport of the European Union, 2001).

Metro Vancouver's Regional Growth Strategy (*Metro Vancouver 2040 – Shaping our Future*, adopted in July, 2011) also supports sustainable transportation via Goal 5, which states that:

*Metro Vancouver's compact, transit-oriented urban form supports a range of sustainable transportation choices. This pattern of development expands the opportunities for transit, multiple-occupancy vehicles, cycling and walking, encourages active lifestyles and reduces energy use, greenhouse gas emissions, household expenditure on transportation, and improves air quality....*

Similarly, Metro Vancouver's draft *Integrated Air Quality and Greenhouse Gas Management Plan* establishes three goals, which are addressed by 12 strategies and 63 actions, for Metro Vancouver and its partners. The implementation of these actions requires collaboration and integration to ensure an informed and coordinated process. Each of these three goals can be achieved in part by broad PEV adoption.

- Goal 1: Protect public health and the environment.
- Goal 2: Improve visual air quality
- Goal 3: Minimize the region's contribution to global climate change

An increased use of PEVs in BC will help achieve a sustainable transportation system via reductions in common air contaminant and greenhouse gas emissions, helping to meet the goals of regional transportation, growth management and air quality strategies, as well as goals of member municipalities.

The City of Vancouver has recently begun requiring all new single-family homes to have electric-car plug-ins and new and existing multifamily residential buildings to provide 20% of all parking stalls with plug-ins. These, and other related initiatives, will help Vancouver meet Goal 2 of its *Greenest City Action Plan*: eliminate dependence on fossil fuels. (Strategy 5 specifically requires accelerating the shift to low- and zero emissions vehicles.) Vancouver City Council has also approved a bylaw to permit the use of electric vehicles that cannot go faster than 40 km/hour on all streets where the speed limit is 50 km/hour or lower. Meaning that, for all practical purposes, they can be driven on most streets in within the City.

### **Box 3: DNV Green Lights Electric Car Charging Station**

District of North Vancouver's council approved a local business's application to install a public-use electric vehicle charge station within a city-owned right of way. The station — which will be the first of its kind in Canada run by a private enterprise — will act as a pilot project.

Source: *North Shore Outlook*, January 28, 2011

## Security of Energy Supply and Renewable Energy Source

PEVs reduce our reliance on fossil fuels because about 85% of electricity in BC is generated from renewable sources<sup>8</sup> and BC Hydro is required by legislation to be carbon neutral by 2016. A higher share of vehicles that can use non-fossil fuel energy sources will also help increase the resiliency of the transportation system to potential increases in fossil fuel prices.

## Reducing Vehicle Emissions

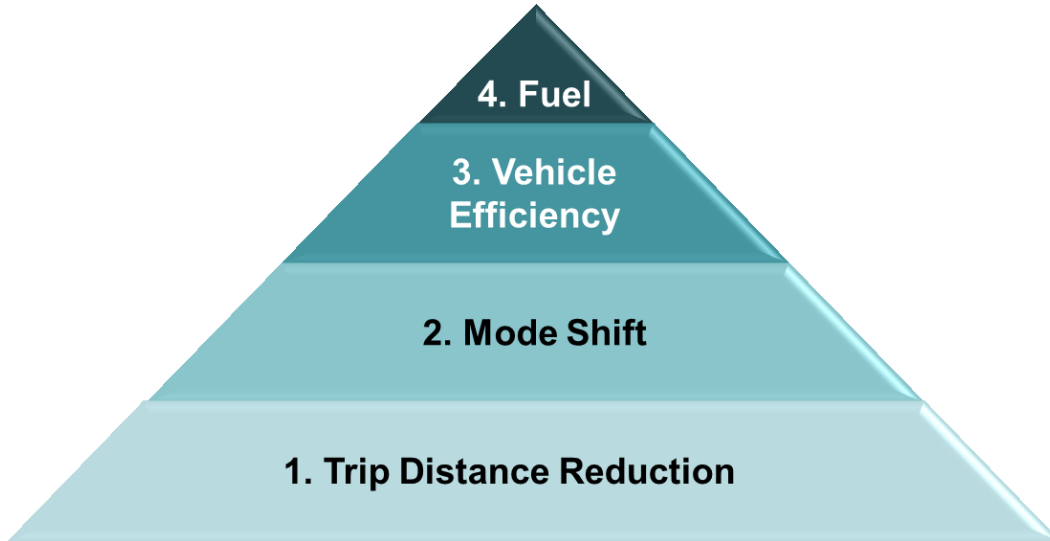
PEVs are one part of an integrated strategy to reduce passenger vehicle emissions (Figure 1). In *Transport 2040*, three ways are articulated for reducing GHGs (as well as common air contaminants) from transportation:

- Lowering the amount of total vehicle kilometres travelled by reducing car trips through demand side management and encouraging walking, cycling or transit use
- New and emerging energy efficient and clean transportation technologies
- Using lower carbon sources to power transportation

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<sup>8</sup> BC Ministry of Energy and Mines, <http://www.em.gov.bc.ca/EPD/Electricity/supply/thermal/Pages/default.aspx>

**Figure 1 Passenger Transportation Pyramid**

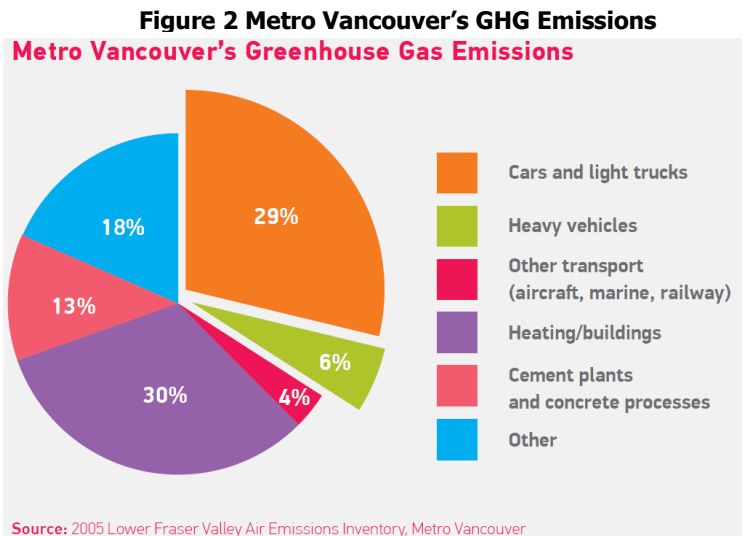


- 1. Trip Distance Reduction:** Reduce the need to travel by vehicle through urban form and transportation demand management
- 2. Mode Shift:** Shift remaining kilometers travelled to cycling, walking, public transit, ride-sharing and out of the single-occupant vehicle
- 3. Vehicle Efficiency:** reduce the size of vehicles and improve engine efficiency, rightsize vehicles to the need, minimize the tonnes of steel being moved to move a person
- 4. Fuel:** Electrify what is left of the passenger fleet and / or consider biofuels, consider biofuels and natural gas for the heavy-duty fleet

The use of PEVs addresses the fourth tier by moving away from a fossil fuelled passenger fleet. Doing so results in energy and emissions reductions per vehicle kilometre travelled (VKT). The first two tiers of the pyramid are most effectively influenced by local governments, suggesting that local government policies supporting mode shift will be an important part of the solution.

PEVs are only one part of an integrated strategy to reduce passenger vehicle emissions. Other actions can and must be pursued at the same time to achieve aggressive emissions reductions. Transportation Demand Management (TDM) strategies prioritize reducing the need for passenger vehicle transportation as much as possible, and then aim to make remaining passenger vehicles highly efficient and powered by low or no carbon fuel. The sequence of first reducing VKT then making VKT more energy efficient avoids over use of clean energy by reducing the overall demand first. This framework also addresses other transportation issues, such as congestion, which EVs do not address.

Urban form and land use are the strongest levers local governments have to influence passenger vehicle



emissions over time. Compared to conventional low-density, single-use development, smart growth reduces the amount people drive by 20 to 40 %<sup>9</sup>, translating into an 18-36% reduction in GHGs emissions compared to a business-as-usual scenario. A smart growth approach to land use policy is not one-size-fits-all, and different communities will have different opportunities to encourage smart development and reduce GHG emissions.

Metro Vancouver and its member municipalities are actively engaged in trip reduction and modal shift through land use, transportation and urban design policies. TransLink also interacts with Metro Vancouver and its member municipalities on urban form and other topics related to trip reduction and mode shift via formal mechanisms for consultation on the development of the regional growth strategy and other regional plans. Both Metro Vancouver's regional growth strategy and TransLink's *Transport 2040* are informed by strategic thinking about transportation and land use in the region. A diagram representing TransLink's governance model is attached in Appendix A.

In *Transport 2040*, TransLink set a goal that most trips would be by transit, walking and cycling. TransLink also has specific strategies to achieve mode shift including a regional cycling strategy with a goal that by 2040, 15% of all trips less than 8 km are made by bicycle.

The federal government has adopted US Environmental Protection Agency on-road vehicle emissions standards which will require both a vehicle fleet fuel efficiency increase and GHG and Common Air Contaminant (CAC) emissions reductions, likely to be achieved through a combination of vehicle efficiency and fuel shifting. These standards require a 25% improvement in average fuel efficiency of automobiles and light trucks sold in Canada by 2016, compared to 2008 levels, based on the US Corporate Average Fuel Economy (CAFE) standard of 35.5 mpg by 2016. The Province of BC has also legislated a low-carbon fuel standard which requires an average 5% renewable fuel content in gasoline and diesel by 2010.

PEVs can be an important part of an integrated strategy to reduce passenger vehicle emissions. The impact of PEVs on emissions is likely to become significant in 10-15 years and continue increasing beyond then. Early steps are important to set the conditions to achieve long-term targets for PEV adoption and decarbonisation of passenger transportation.

## GHG Benefits

A primary benefit of PEVs is the reduction in Greenhouse Gas (GHG) emissions from switching from gasoline or diesel to low-carbon electricity (electricity in BC will be carbon neutral by 2016). The Province of British Columbia has established GHG reduction targets of 33% below 2007 levels by 2020 and 80% below 2007 by 2050. Metro Vancouver has adopted the same targets regionally. Passenger transportation comprises 29% of Metro Vancouver's GHG inventory. Metro's member municipalities have also adopted targets to reduce greenhouse gas emissions locally. TransLink has a mandate to support regional strategies.

A battery electric vehicle (BEV) will reduce emissions by 97.5% compared to a conventional gasoline powered internal combustion engine (ICE) light duty vehicle operating over the same distance travelled<sup>10</sup>. After 2016, a BEV will reduce emissions by 100% because BC electricity will be carbon neutral. Even a PHEV (plug-in electric hybrid) can reduce emissions by approximately two thirds. As PEVs gradually become a significant proportion of total passenger vehicles, their impact on GHG emissions will become increasingly important to achieving municipal, regional and provincial GHG reduction targets.

## Air Quality Benefits

PEV vehicles use reduces emissions of primary air pollutants in addition to greenhouse gas. Typical ICE light duty vehicles emit pollutants that include carbon monoxide, nitrogen oxides (NOx), sulphur oxides (SOx), lead, particulate matter (PM) and hydrocarbons (HC). Further, light duty vehicle emissions contribute to secondary pollutants in the lower level of the atmosphere, most commonly referred to as smog. Through complex chemical reactions involving several chemicals and sunlight, ozone is produced, which can damage human health and building materials. BEV

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<sup>9</sup> John Holtzclaw, David Goldstein, Center for Neighbourhood Technology, USA.

<sup>10</sup> Baseline calculated from data in this report as 2007 average GHG / LDV of 3.9 tonnes/LDV per year.

vehicles are zero emission vehicles and therefore fully mitigate ICE light duty vehicle emission pollutants. PHEV vehicles, depending on usage patterns could fully eliminate air pollutants while operating on electric battery, but will emit combustion gases when their ICE is used to recharge the on-board batteries.

A value of \$813/tonne, used by Metro Vancouver, of PM2.5 has been used to calculate the regional benefit of reducing PM2.5 from PEV vehicles.<sup>11</sup>

### Noise Benefits

Vehicle noise is generated from engine noise but also from road surface and tire interaction, braking and aerodynamic effects. Internal combustion engine vehicles on roadway operate at approximately 76 dB. EVs have an opportunity to significantly reduce vehicle road noise, particularly at slower speeds, below 35 km/hr, when an EV may be as much as 17 decibels quieter. At higher speeds, the vehicles were effectively equivalent in noise level. In the US, the National Federation for the Blind (NFB) lobbied for sound generating devices on EVs operating at low speeds, because, it argues, blind persons are able to better identify the vehicles if they make noise.<sup>12</sup> From an occupant and driver perspective, it is reported that when EVs are operating in electric mode, the occupants experience similar lower noise levels, particularly at low speed.

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<sup>11</sup> From *Reducing Emissions from Municipal Fleets: Sustainable Procurement & Life Cycle Costing*, presented by J. Perkins, Superintendent of Fleet Services, Metro Vancouver, at Federation of Canadian Municipalities Sustainable Communities Conference, 2011.

<sup>12</sup> [http://www.asse.org/professionalsafety/docs/Fender\\_0111.pdf](http://www.asse.org/professionalsafety/docs/Fender_0111.pdf)



## PEV Stakeholder Benefits

Multiple stakeholders benefit from accelerated adoption of PEVs.

**Table 2: Multi-stakeholder benefits from accelerated adoption of PEVs**

Stakeholders	Value of PEV adoption in the passenger vehicle fleet	Value of Regional PEV Collaboration
Municipalities	<ul style="list-style-type: none"> <li>PEVs can help municipalities achieve GHG reduction targets in their Official Community Plans and Community Energy and Emissions Plans</li> </ul>	<ul style="list-style-type: none"> <li>Enhanced peer to peer learning</li> <li>Improved infrastructure investment efficiency</li> <li>Help maintain a level playing field for developers</li> <li>Increase the likelihood of residents of individual municipalities investing in PEVs due to a regional network of charging infrastructure and support</li> </ul>
Metro Vancouver	<ul style="list-style-type: none"> <li>Alignment and support for Metro Vancouver's <i>Integrated Air Quality and GHG Management Plan</i></li> <li>Alignment and support for municipal GHG reduction plans</li> <li>Assists in branding of the region as a green leader</li> </ul>	
TransLink	<ul style="list-style-type: none"> <li>Supports TransLink's <i>Transport 2040</i> Goal 1 – 'Greenhouse gas emissions from transportation are aggressively reduced'</li> <li>Supports Metro Vancouver regional plans</li> </ul>	
BC Hydro and City of New Westminster <sup>13</sup>	<ul style="list-style-type: none"> <li>Supports electrification mandate and potentially provides saleable credits through providing a low-carbon fuel for mobility<sup>14</sup></li> <li>Supports provincial legislated commitment to GHG reductions</li> </ul>	<ul style="list-style-type: none"> <li>Informs distribution infrastructure planning</li> <li>Coordinates charging deployment with BC Hydro's DC Fast Charging infrastructure</li> </ul>
Province of BC	<ul style="list-style-type: none"> <li>Supports provincial legislated commitment to GHG reductions</li> </ul>	<ul style="list-style-type: none"> <li>TBD. If the province provides charging incentives in the future, a regional approach will help ensure the incentives are deployed efficiently. If the province establishes an 'EV-Ready' regulation (similar to the 'Solar-Ready' regulation), a regional approach can accelerate adoption of the bylaw.</li> </ul>
NGO's	<ul style="list-style-type: none"> <li>Supports environmental protection objectives</li> </ul>	<ul style="list-style-type: none"> <li>Efficiency in engagement by connecting with a regional group rather than each entity</li> </ul>
Automakers	<ul style="list-style-type: none"> <li>Assists in meeting federally legislated fleet average tailpipe emissions goals</li> </ul>	<ul style="list-style-type: none"> <li>Demonstrates that the region is committed to building the PEV market and that allocating portion of the limited production of PEVs is likely to be a good investment.</li> </ul>
Health Care Providers	<ul style="list-style-type: none"> <li>Reduced costs for air quality related illness and death.</li> </ul>	<ul style="list-style-type: none"> <li>Promotes higher level of EV uptake and consequently, greater benefits.</li> </ul>
Public Residents	<ul style="list-style-type: none"> <li>Benefit in human health from improved air quality, benefit in reduced smog damage, and mitigation of climate change impacts by contributing to reducing GHG emissions</li> </ul>	<ul style="list-style-type: none"> <li>Regional approach improves cost effectiveness of infrastructure, reducing tax and/or costs to citizens.</li> <li>Regional strategy improves brand recognition.</li> <li>Regional approach to infrastructure rationalizes needs for commuters who live and/or work in different municipalities.</li> </ul>

<sup>13</sup> The City of New Westminster Electrical Department runs the oldest continuously - operating electrical utility in BC. The Electrical Department distributes electricity to 25,000 commercial and residential customers and maintains the electrical systems in City - owned recreation centres, arenas, pools, streetlights, traffic signals, and City Hall. Source: [http://www.newwestcity.ca/residents/residents\\_services/utilities/electrical.php](http://www.newwestcity.ca/residents/residents_services/utilities/electrical.php)

<sup>14</sup> Potential ownership of credits is an unresolved issue.



## Impacts of Transitioning to Electric Vehicles

Transitioning the light duty vehicle fleet away from fossil fuel and towards electrification has implications related to vehicle production, use and end of life. Table 3 compares the impacts of electric vehicles to internal combustion engine vehicles on a lifecycle basis.

**Table 3: Comparison of electric vehicle (EV) and internal combustion engine (ICE) lifecycles**

Use Phase	EV	ICE
Production	<ul style="list-style-type: none"> <li>Rare &amp; other metals mining and refining – ecological impact</li> <li>Petroleum extraction, refining, transport and combustion for supply chain and manpower – ecological impact</li> <li>Manufacturing processes in main assembly and supply chain</li> </ul>	<ul style="list-style-type: none"> <li>Rare &amp; other metals mining and refining – ecological impact</li> <li>Petroleum extraction, refining, transport and combustion for supply chain and manpower – ecological impact</li> <li>Manufacturing processes in main assembly and supply chain</li> </ul>
Vehicle use	<ul style="list-style-type: none"> <li>Electricity generation and distribution – electrical grid in Metro Vancouver is 93% clean and GHG neutral in 2016</li> </ul>	<ul style="list-style-type: none"> <li>Petroleum fuel distribution and combustion in ICE. GHG and air pollutants</li> </ul>
End of Life	<ul style="list-style-type: none"> <li>Metals and plastic recycling for vehicle body part</li> <li>Battery recycling is a significant component of ecological impact and technology; legal and environmental implications are still evolving</li> </ul>	<ul style="list-style-type: none"> <li>Metals and plastic recycling for vehicle body parts and engine block</li> <li>Lead-acid battery recycling</li> </ul>

### Electric Battery Disposal

If electric vehicles are to mitigate their ecological lifecycle impact in the long term, recycling and reuse of battery packs must ensure that energy sources are in a closed loop and complete a full lifecycle. According to a Frost and Sullivan report<sup>15</sup>, while there is currently little economic sense in recycling lithium-ion (Li-Ion) batteries, the EV Li-Ion battery recycling market is expected to be worth more than \$2 billion by 2022, with more than half a million end-of-life EVs' battery packs becoming available for recycling through the waste stream.

The report also notes:

- Existing batteries contain only a small fraction of lithium carbonate as a percentage of weight and, while they are inexpensive compared to cobalt or nickel based batteries, a lack of valuable materials in batteries often limits the potential for recycling. Apart from the cobalt or nickel found in existing battery packs, only a few valuable metals with battery potential are under research and development. Low-value elements like iron and phosphorous, currently under research, will pose a challenge to creating a profitable recycling program without additional incentives or the addition of more valuable lithium.
- Although lithium currently costs less than other raw materials needed for manufacturing a battery, there is some risk due to its availability depending on a small geographic area (almost 70% of deposits are in South America), even though reserve levels are high.
- With second life applications, such as stationary grid storage, Li-Ion batteries are poised to contribute to a further net reduction in emissions beyond that achieved by powering an EV. But Li-Ion batteries will have to compete with dedicated batteries used for these applications. Li-Ion batteries will also have to compete in terms of cost, power and energy storage because most of their characteristics with regard to reuse degradation are unknown at this point.
- Although lithium is 100% recyclable, battery-grade lithium from the recycling process is costlier than lithium from direct sources. Broadly, a lack of price incentives and legislation restricts lithium recycling, and there are

<sup>15</sup> *Global Electric Vehicles Lithium-ion Battery Second Life and Recycling Market Analysis*, 2010  
<http://www.frost.com/prod/servlet/report-toc.pag?repid=M5B6-01-00-00-00>

only limited incentives for utilities using energy storage, hindering reuse activities.<sup>16</sup> However, lithium is recycled in BC (via Cominco, located in Trail), providing a relatively local source of recycling services.

## Other Considerations for Transitioning to Electric Vehicles

### 1. A supply chain risk could evolve for rare earth metals used in high-tech batteries and equipment

Vehicles with electric motors can use more rare earth metals than traditional ICE vehicles. Traditional vehicles use rare earth metals (REMs) in their catalytic converters. Some EVs use about 100% more rare earth metals than ICE vehicles by virtue of REM use in permanent magnetic windings and battery production, in addition to catalytic converter use for PHEV and HEV vehicles, while other EVs use motors that do not depend on rare earth metals. Many other industries make use of REMs (called “lanthanides” in the Periodic Table), including the petroleum industry, which uses them in the refining process as catalysts. These reactive metals are relatively rare commercially compared to industrial metals.

While current production levels are approximately 100,000 tonnes/year, production levels are expected to grow relatively quickly over the next decade as society uses more electronic equipment. Supply/demand may become imbalanced as early as 2013<sup>17</sup>. And while the US dominated production as recently as 10 years ago, China now produces 95% of global supply, raising US concerns about pricing and strategic trade imbalances. Of note, lithium, often referred to for its role in potential future battery production, is not a lanthanide, it is an alkali metal and does not share the same supply chain issues. Industry response to these issues has been to design lanthanide-free motors and batteries (Toyota). For a detailed explanation of rare earth metals, see <http://seekingalpha.com/article/103972-rare-earth-metals-not-so-rare-but-valuable>

### 2. PEVs do not address underlying issues with autos from a sustainable transportation perspective

Electric vehicle use will be predominantly adopted by those who want to mitigate the harmful environmental air emission impacts caused by internal combustion engines. But the use of on-road personal vehicles does not directly mitigate other issues such as reliance on the automobile and the kind of urban development that supports it. It is possible that people will actually drive more if they perceive that EVs are clean and without many impacts. However, the modelling supporting this Primer assumes an average vehicle kilometres travelled (VKT) reduction projection of 3% over the period 2007 to 2041, based on the Province of BC’s Community Energy and Emissions Inventory (CEEI).

### 3. Charging infrastructure needs to be provided in advance of, or at least at the same time as, PEV uptake

Studies by Rocky Mountain Institute’s Project Get Ready, Electric Mobility Canada, BC Hydro, the Province, among many others, have indicated that charging infrastructure is a critical issue for advancing the success of electric vehicles. Investments in infrastructure need to be made up front or simultaneously with EV uptake to address ‘range anxiety.’

### 4. Demand for electricity

BC Hydro expects EVs to create more demand for electricity in four key areas:

- Residential charging: Level 2 (3.3 kW<sup>18</sup>) charging increases the peak, as early as 2015 according to BC Hydro Load Forecast.<sup>19</sup>
- Distribution transformers: 70% are over 20 years old; high concentrations of EVs have the potential to stress aging distribution system assets including transformers.
- BC Hydro needs to investigate opportunities to incorporate intelligent grid technology enabled by smart meters to mitigate demand peaks and lessen impact of EVs. Achieving higher system efficiencies through better utilization of resources will delay the need for capacity upgrades.
- Substations: Stations feeding areas with EV penetration will see accelerated capacity increase requirements.

<sup>16</sup> This is expected to change as demand for EV vehicles and their components increases.

<sup>17</sup> Robert Bryce, author of the book *Power Hungry: The Myths of ‘Green’ Energy and the Real Fuels of the Future*.

<sup>18</sup> Level 2 demand in current and near future vehicles is 3.3 kW; in 3-5 years Level 2 demand will be 6.6 kW, according to BC Hydro, via comments on this document.

<sup>19</sup> BC Hydro, 2010. *Electric Load Forecast 2010/11 to 2030/31*

[http://www.bchydro.com/planning\\_regulatory/meeting\\_demand\\_growth/forecasting\\_growth.html](http://www.bchydro.com/planning_regulatory/meeting_demand_growth/forecasting_growth.html)

- Generation: Additional peak load requirements as early as 2015 as per BC Hydro Load Forecast, more substantial peaks in the 2030 may require additional peak load capacity.

**5. Tradeoffs between BEVs and PHEVs**

Battery Electric Vehicles (BEVs) and Plug-in Hybrid Electric Vehicles (PHEVs) both leverage electric batteries and electric motors but PHEVs leverage an on-board internal combustion engine in addition to the electric motor. Table 4 illustrates a simple comparison of the two types of vehicles.

**Table 4: Battery operated vehicles vs. plug in hybrid electric vehicles – tradeoffs (as of 2011)<sup>20</sup>**

Parameter	Battery Operated Vehicle	Plug-in Hybrid Electric Vehicles
Fuel supply	Electricity only, must receive plug-in or grid supplied energy.	Electricity from grid or from on-board fossil fuel.
Emissions from vehicle use	No GHG emissions.	GHG emissions when internal combustion engine is supplementing electric battery and motor range.
Battery size	Nissan Leaf - 24 kWh. Mitsubishi i-MiEV - 16 kWh.	Toyota Prius PHEV - 9 kWh. Chevy Volt - 16 kWh.
Motor type	Electric motor only.	Electric motor and Internal Combustion Engine.
Range	~160 km.	400 to 500 km.
Average cost	~\$40,000.	~\$42,000.

**6. Risks and uncertainties around PEV technology and fuel costs**

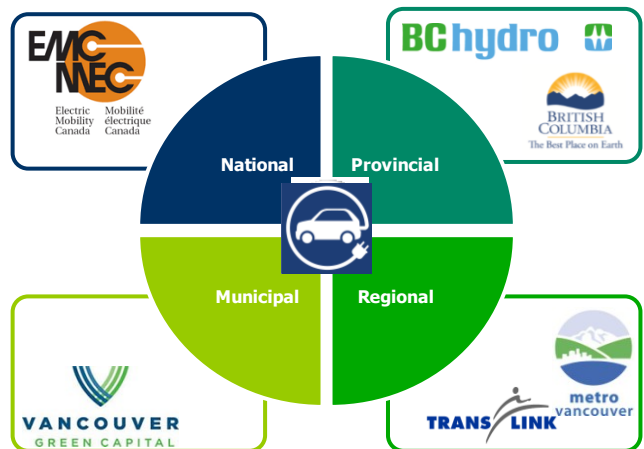
Several known risks exist related to the future impact of electric vehicles. These include economic forces that support the status quo and regulatory and political issues affecting energy pricing for both fossil fuels and electricity. Future political support for financial incentives for PEVs is uncertain. Risks can develop from technology developments in the standard combustion engine light duty vehicle sector that may affect either PEVs or their competitor technological development. While the impact of future technology development is hard to predict, it may also have a positive effect on EV uptake.

**Initiatives and Collaboration in the Metro Vancouver Region**

TransLink coordination of national, provincial, regional and municipal stakeholders to prepare for PEVs is one of the cornerstones required for rapid, large-scale deployment of electric vehicles across Metro Vancouver. One objective of this paper is to provide a map of current initiatives and discuss potential future roles for TransLink and other agencies.

TransLink already has one of the largest electric vehicle fleets in North America with its fleet of trolleys, the SkyTrain

**Figure 3 PEV Collaboration**



<sup>20</sup> Note: Actual vehicle range and cost are dynamic parameters; technical advancements and market conditions are constantly evolving and vehicle range is expected to increase while costs decrease.

network and over 180 hybrid diesel-electric buses. While TransLink has one of the greener fleets in North America, initiatives supporting EVs at the community level are still under consideration.

TransLink has a goal to reduce greenhouse gasses from transportation in the region. Most of this reduction will need to come from community-wide vehicles because corporate fleets only represent a small proportion of regional GHG emissions. TransLink is just beginning to consider regional efforts to understand the role of EVs in a sustainable transportation system, their impact on targets and goals, and TransLink’s potential role in supporting wider EV deployment.

A national program has been underway for several years with Electric Mobility Canada (Figure 3) working on a national electric vehicle roadmap, national branding / way-finding for charging stations, development of a PEV ready guide for utilities and municipalities, and other important activities. The superintendent of fleet services at Metro Vancouver and a representative from BC Hydro are members of Electric Mobility Canada.

The Plug-in BC EV Working Group has been working at the provincial level for a number of years. This group has concluded memorandums of understanding with automakers to allocate electric vehicles to British Columbia in the 2011-2012 year and is coordinating placement of these vehicles in primarily government fleets. This group is also coordinating a variety of provincial initiatives including planning a provincial network of fast-charging stations. City of Vancouver, Metro Vancouver, Province of BC, and BC Hydro are all members of the working group.

City of Vancouver has been a leader in EVs in BC. The City has prepared for electric vehicles by establishing a bylaw for charging infrastructure readiness in new multi-family and single-family homes. The bylaw requires conduit runs in single family homes and space for charging equipment. Completed circuits are required in 20% of multi-unit building parking spaces. Neither single family homes nor multi-unit buildings require the equipment that comes with the car. Vancouver is also piloting a variety of charging infrastructure technologies.

Vancouver, Surrey and Metro Vancouver are also showing leadership by demonstrating EVs in their corporate fleets. BC Hydro demonstrated a Mitsubishi MiEV and Toyota Prius PEV as part of an early-stage pilot.

**Figure 4 PEV Roles**



Electric vehicle supply equipment (EVSE) implementation strategies are being investigated by Surrey, which will require new gas stations to provide alternative fuelling such as EV charging and the City of Vancouver which is conducting EVSE trials in its city owned Easy Park lots, via a memorandum of understanding with BC Hydro (the Conservation Collaboration) that defines five areas of collaboration, one of which is EV infrastructure deployment.

Non-governmental organizations such as Pembina Institute, Community Energy Association and Fraser Basin Council are collaboratively contributing to advancing EV market penetration in Metro Vancouver. Pembina Institute is working with several local governments to speed adoption of specific actions. Pembina Institute has published a local government checklist to help municipal governments with establishing an EV strategy. Fraser Basin Council is coordinating the Plug-in BC EV Working Group’s Buyer’s Group through its *Green Fleets BC* program, to facilitate early local government and commercial EV adoption. The group is targeting between 100 and 160 electric vehicles to be allocated to BC fleets. The Fleet Buyers Group consists of over 100 fleets, forming a network of informed early adopters across the province. Based on the success of the program, auto manufacturers will have feedback on buyer interest and deployment issues in BC. Local Government electric vehicle fleet adoption is an example of ‘walking the talk’. The objective of the Plug In BC Fleet Buyers Group is to promote and actively support the introduction of plug-in and full battery electric vehicles for use in both private and public vehicle fleets. By working collaboratively with other fleets, Plug In BC and the vehicle

manufacturers' objective is to create the logistical and economic conditions that will attract the most electric vehicle investment and to facilitate acquisition of electric vehicles by fleets across BC.

Community Energy Association has completed this Primer to assist regional planners with their own EV strategies and regional policies. Many Metro Vancouver municipalities have adopted aggressive GHG reduction targets. PEVs can help them achieve community-wide reduction targets for the transportation sector, using resources described in this Primer to assist in developing and executing EV strategies.

### 3 Plug-in Electric Vehicle Market Penetration & Lifecycle Cost

To evaluate the many issues, benefits and challenges associated with the electrification of the light duty vehicle market it is critical to understand the projected market penetration of electric vehicles and their segmentation amongst EV types and regional distribution.

To develop a representative model of projected EV penetration, the Primer reviewed 13 published EV market projection studies and related them to the Metro Vancouver market. In addition to the literature review, actual Hybrid Electrical Vehicle (HEV) market penetration was evaluated, from their market entry in 2000, over a ten year period, to 2010.

Other North American jurisdictions have recognized parallels in market entry dynamics between HEVs and PEVs. In using the HEV market penetration data to model PEV uptake, we assume that PEV market penetration, and therefore the consumers of these vehicles, will behave in a very similar manner to HEV vehicle consumers. This data has an additional advantage of being specific to Metro Vancouver, with our own road and weather conditions, transit options, similar vehicle incentives, fuel pricing, demographics and geographic layout.

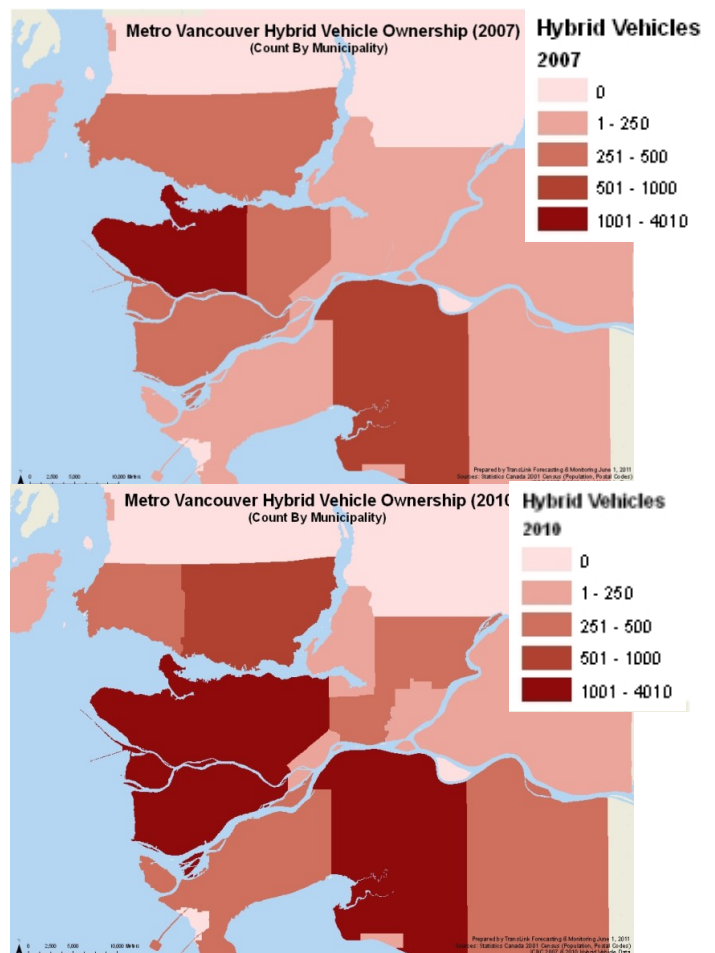
#### Lessons from Hybrid Market Penetration

Projecting the market penetration of Plug-in Electric Vehicles (PEVs) is complicated by the fact that they are a new product without a documented penetration curve elsewhere that could be applied to the Metro Vancouver context. Hybrid Electric Vehicles (HEVs) are the most similar product. HEVs were introduced in Metro Vancouver approximately 11 years ago. According to Insurance Corporation of BC data, there were 5,049 hybrids registered as passenger vehicles in 2007. By 2010, this number had grown to almost 11,000 vehicles.<sup>21</sup>

Figures 5 and 6 show the geographic distribution in 2007 and 2010 of absolute numbers of hybrids by municipality. Vancouver, Surrey and Richmond have the most hybrids overall. When we look at per-capita hybrid ownership in 2007 and 2010 (Figure 6), residents of the north shore, Belcarra and Anmore are the most likely to own a hybrid followed by Vancouver, Richmond, Port Moody and White Rock. Most of the areas with higher VKT per capita in the region (outer areas), which could have quicker payback periods (with the exception of Anmore, Belcarra and Lions Bay, which have high adoption rates). This could be the result of several factors, including, but not limited, to household size and income.

For the period between 7 and 11 years after introduction, sales of hybrids grew at approximately 31% per year. This local experience with hybrids can inform projections of

**Figure 5 Metro Vancouver hybrid vehicle ownership counts by municipality 2007 and 2010**



<sup>21</sup> These figures do not include vehicles within commercial fleets, which were 279 in 2007 and 823 in 2010.



growth rates, early adopter locations and longer term growth areas for plug-in-electric vehicles. Consequently, one market penetration scenario developed was based on the

local hybrid experience (the HEV scenario). This is one of several scenarios analyzed in this chapter.

Importantly, historical HEV data for Metro Vancouver indicates there is proven consumer acceptance of alternative fuel vehicles, with a 2.1 times higher adoption of hybrids occurring compared to the Canadian average. Rapid HEV adoption in Metro Vancouver suggests there may be a bias toward faster PEV uptake here than in other areas of Canada. However, this report takes a conservative approach, balancing projection results against known risks to PEV uptake.

## Research

Projecting PEV market penetration involves uncertainty, particularly when projecting over a 20+ year period. Multiple perspectives on potential uptake exist and assumptions must be made. However, projections are fundamental to making policy, regulatory, and infrastructure investment decisions. The approach taken in this section is to apply existing credible studies to the Metro Vancouver situation through scaling and other techniques. This allows us to compare and contrast expert opinions, view multiple perspectives and develop a likely range for PEV market penetration.

## Studies Reviewed

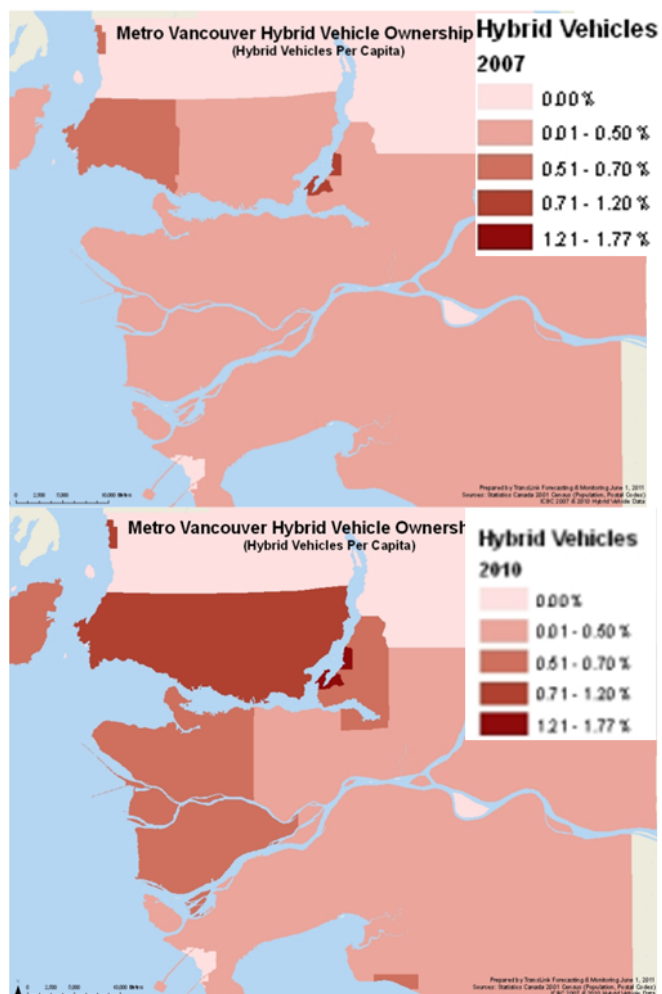
In completing this Primer, the research team reviewed 13 different projections on PEV adoption rates in North America, Canada and BC and created one projection (HEV) based on the adoption curve observed for HEVs in Metro Vancouver. All studies reviewed were published between 2008 and 2011 by reputable organizations and have at least one relevant data point between 2011 and 2031. For studies providing multiple scenarios, a mid-range scenario was chosen. A list of studies reviewed is in Appendix B.

Although not all scenarios provide exactly the same data, four comparable data sets were compiled and plotted, including:

- percentage of new passenger vehicle sales,
- total PEV passenger vehicle sales,
- percentage of total on-road passenger fleet, and
- total number of PEV passenger vehicles on the road.

Off-road and commercial uses were not included in this study based on the agreed-upon scope. All studies except the Natural Research Council study and the Boston Consulting Group study provided fleet numbers or percentages; these latter studies provided only % of new sales in select years.

**Figure 6 Metro Vancouver hybrid vehicle ownership – vehicles per capita 2007 and 2010**



## Assumptions

All studies were scaled to Metro Vancouver for population size. All used the same assumptions about Metro Vancouver population and fleet growth rates as well as emissions intensities for fuels and PHEV-BEV market split. BEVs are assumed to make up approximately 26% of the PEV fleet with PHEV's being more popular due to flexibility and increased range. All assumptions are documented in the model along with links to sources. More information about the model can be found in Appendix C to this report.

## Results

Study results were plotted over time and clustering was immediately apparent (Figure 7). Four studies (Deutsche Bank, McKinsey, Electric Mobility Canada, and the 'high' scenario of the BC Hydro Load Forecast) projected PEV volumes that were, in some cases, ten times higher than more conservative studies. These studies have been labelled as 'optimistic' studies.

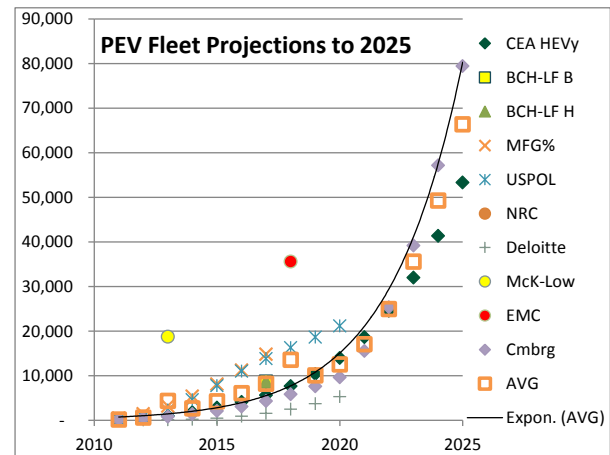
A second group of 'probable' studies includes Cambridge Systematics, Sentech (US Policy scenario or USPOL and Manufacturer % of North American PEV allocation), Deloitte, and Community Energy Association's HEV scenario based on market penetration by Hybrid Electric Vehicles (HEVs) in Metro Vancouver.

The scenario selected as most probable is discussed in more detail below. The optimistic scenario includes ambitious targets that may be more aspirational than realistic. More information on the optimistic scenario can be found in Appendix B.<sup>22</sup>

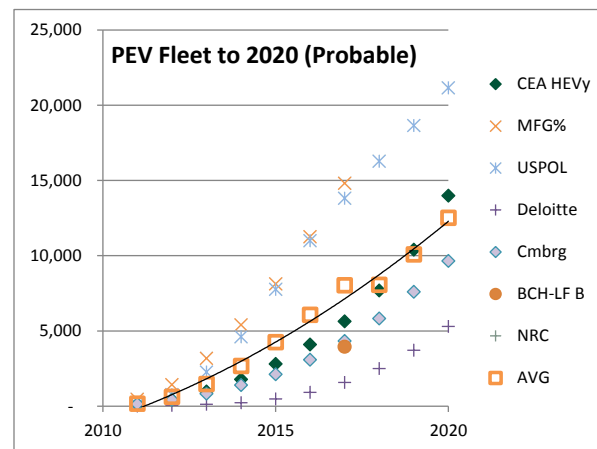
## Probable Scenarios

The PEV fleet probable scenario chart (Figure 8) zooms into the 2011-2020 timeframe. The most conservative projection (Deloitte) shows 5,000 PEVs in Metro Vancouver by 2020. Based on work completed by Sentech, the Manufacturer % of North American allocation (MFG%) and the US Policy projection (USPOL) are on the higher end of the projections. The MFG% scenario is based on Metro Vancouver achieving 1% of the expected North American allocation of PEVs from automakers. Based on population, historical sales of all light duty vehicles, and projections for Washington State, 1% is a reasonable estimate of Metro's share of North American sales. To achieve this, purchasing incentives and charging infrastructure support competitive with other jurisdictions would likely need to be in place. The US Policy (USPOL) scenario, which projects the PEV fleet assuming the current US federal policies remain in place, mirrors this conclusion. Under these scenarios, Metro Vancouver could see up to 20,000 PEVs by 2020.

**Figure 7 PEV fleet projections to 2025 – combined probable and optimistic scenarios**



**Figure 8 PEV fleet projections to 2025 – probable scenario**



<sup>22</sup> While some stakeholders believe that stronger growth in the EV market can be expected, the authors of this report have taken a conservative approach to modelling growth.



The centre-oriented scenarios – CEA HEV<sub>y</sub>, Cambridge and BC Hydro’s load forecast – achieve similar volumes of PEVs using different approaches. Of note is the fact that HEVs benefitted from a provincial sales tax exemption until recently and this may have induced a slightly higher adoption rate than would be seen without incentives.

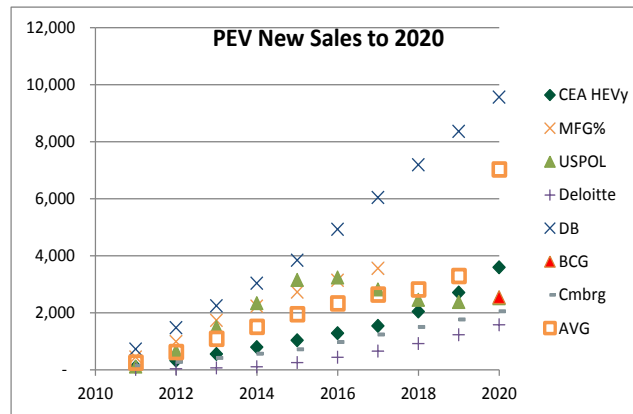
After 2020, PEV market penetration rates accelerate to a degree typical of new product introductions – an initial slow build is followed by rapid acceleration and, finally, by a mature levelling off, forming an ‘S’ curve. The time period to 2020 in Figure 8 represents the ‘bottom’ or slow build portion of the S curve for EV market penetration.

**BOTTOM LINE: If no supporting incentives or significant infrastructure are in place, expect 5,000-10,000 PEVs by 2020. With incentives, this estimate doubles to 10,000-20,000. It is difficult to see a plausible path to achieving the optimistic projections without substantial actions and incentives by senior governments that go beyond actions seen to date in other jurisdictions.**

### PEV New Sales

Providing another perspective on these scenarios is the volume of new PEV sales to 2020, as shown in Figure 9 (absolute new sales). Only some studies reviewed provided projections of new sales. Of these, the Deutsche Bank projection is aggressive while the Boston Consulting Group projection is high but falls within the range of the probable cluster of scenarios.

**Figure 9 PEV new sales to 2020**

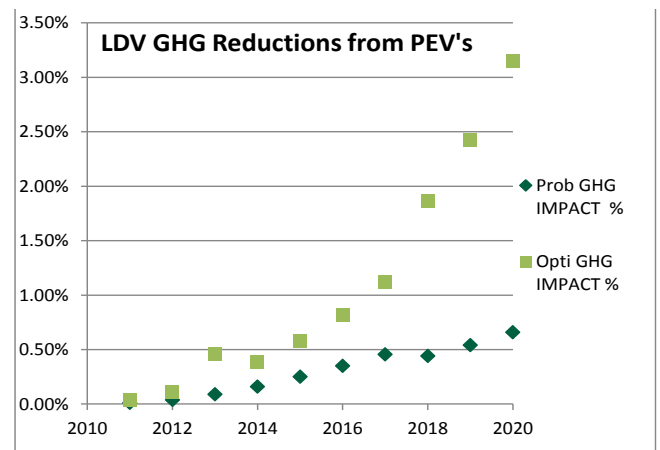


**BOTTOM LINE: New sales are expected to start slowly then accelerate, with several thousand EVs per year entering Metro Vancouver roads by 2020. As a percentage of new sales, PEVs are expected to be 2-3% in 2020. The provincial purchase incentive announced in November 2011 will likely provide a boost to EV sales.**

### GHG Emission Reductions

PEVs (assuming a 75%-25% split between plug-in hybrids and battery operated vehicles) are expected to produce about 76% fewer GHG emissions than the average vehicle. Based upon this assumption, Figure 10 plots GHG impacts using yearly average GHG emission reductions from both the optimistic and probable scenarios. Averaging scenario values is done cautiously, however, given the number of different assumptions in each case. Under optimistic scenarios, GHG emissions from the passenger vehicle fleet could be reduced by 3.2% (167,000 tonnes) by 2020. Under probable scenarios, GHG emissions could be reduced by around 0.66% (35,000 tonnes).

**Figure 10 LDV GHG reductions from PEVs 2010 - 2020**



As noted earlier, PEV adoption is expected to accelerate rapidly post 2020 and, with it, GHG savings will also accelerate. Given accelerating EV adoption post 2020, a very conservative estimate, using a linear interpolation from 2018 to 2020 out to 2030, yields an annual PEV GHG emission reduction of 111,000 tonnes in 2030.

In April 2009, the Canadian federal government announced that new vehicles would be subject to CO<sup>2</sup> regulations requiring emissions equivalent to the economy set by the US Corporate Average Fleet Economy (CAFÉ) standard. The US CAFÉ standard will increase to 54.5 mpg in 2025 from the target level of 35.5 mpg by 2016. Increased fleet average fuel economy will likely incent auto manufacturers to explore new technologies and materials and contribute to electric vehicle offerings and marketing.

**BOTTOM LINE: PEVs alone will not achieve a 33% emissions reduction by 2020 but can be an important part of an integrated strategy to aggressively reduce passenger vehicle emissions. PEVs could contribute 0.66% to 3.2% to GHG emission reductions by 2020 and will play a larger role in post 2020 emissions reductions.**

### Financial Impacts

Assuming a \$25/tonne cost of carbon, projected GHG emission reductions to 2020 represent vehicle owner’s savings of between \$875,000 on an annual basis for the probable scenario and \$4,100,000 for the optimistic scenario. Monetizing PM2.5 at a cost of \$813/tonne<sup>23</sup> provides a value of between \$1,600 and \$5,600 total regional health care savings in 2020.<sup>24</sup>

**Table 5: Costs avoided by PEV adoption**

Avoided Costs	Probable Scenario	Optimistic Scenario	Who Benefits?
Avoided Carbon Tax on Fossil Fuels	\$875,000	\$4,100,000	Combustion engine vehicle owners
Health Care Cost Reductions (via PM2.5 Mitigation)	\$1,600	\$5,600	Provincial Health Care
Reduced Vehicle Owner Fossil Fuel Costs*	\$14,000,000	\$70,000,000	Combustion engine vehicle owners
Total Reduced Costs	\$14,876,600	\$74,105,600	

\* A portion of these savings will be offset by electricity purchases from electric utilities.

These benefits will not come without cost. A business case and net present value for investments in electric vehicles is presented in the next section and in Appendix D. Average optimistic and probable case PEV scenarios are 43,200 and 12,500 respectively in 2020, a 4 times range.

**BOTTOM LINE: By 2020, PEVs in Metro Vancouver could save between \$15 and \$74 million annually due to fuel cost savings and emission reductions.**

### Lifecycle Cost Comparison

Lifecycle value is a good approach to evaluating the business case for PEVs. A lifecycle analysis includes first cost (the initial capital cost or purchase price), the differences in costs and benefits over the life of the asset including fuel costs and maintenance and any recovery or costs at end of the life. The time-value of money is also considered.

<sup>23</sup> From *Reducing Emissions from Municipal Fleets: Sustainable Procurement & Life Cycle Costing*, presented by J. Perkins, Superintendent of Fleet Services, Metro Vancouver, at Federation of Canadian Municipalities Sustainable Communities Conference, 2011.

<sup>24</sup> The CAC calculation is based on 1,154,880 passenger vehicles in Metro Vancouver and the inventory of PM2.5 from passenger vehicles of 127 tonnes which results in 0.00011 tonnes per vehicle, monetized at \$813 per tonne.

Quantification, where possible, of non-monetary benefits or weighing of monetary and non-monetary impacts in a multi-criteria analysis is also encouraged.

### First Cost vs. Lifecycle Value

Electric vehicles first cost is approximately \$15,000 to \$25,000 more than their comparable internal combustion engine (ICE) alternatives. Any point-of-purchase grants should be deducted from the MSRP. Any differential taxation between ICE’s and EVs should be factored into the accounting.

In addition to the cost of the vehicle, the cost of charging equipment must be considered. If a standard outlet (Level 1) is available and a 12-20 hour charging time is acceptable, limited or no cost for charging infrastructure is required. Most PEV fleet sites are expected to install Level 2 (240V/40Amp) charging that allows a 4-6 hour full charge. Installed cost of Level 2 charging equipment may be as high as \$10,000 per station.

Lifecycle values to consider when comparing the cost of EVs to ICE vehicles include:

- Fuel costs - energy per kilometre, estimated kilometres travelled per year and cost of energy (gasoline, diesel, or electricity)
- Value of emissions – greenhouse gasses (GHGs) and common air contaminants (CACs), particularly PM2.5
- Vehicle maintenance, including parts and inventory requirements
- Extended useful life (for example, an EV may have a 20% longer useful life than an ICE vehicle because of reduced vibration and wear)
- Residual value
- Possibility of special road tax for EVs to offset displaced gasoline taxes

In addition, non-monetary factors such as supporting organizational mandates and goals are recommended to be included in a full analysis.

Fuel costs are significantly different between a PEV and an ICE vehicle. Fuel efficiencies of existing ICE and hybrid electric vehicles are available at the Ministry of Natural Resources of Canada’s Transportation Fuel Consumption guide website: (link: <http://oee.nrcan.gc.ca/transportation/tools/fuel-consumption-guide/fuel-consumption-guide.cfm>). In Appendix D, Table 16 provides a sample comparison of fuel costs for a battery electric vehicle (BEV) and a traditional ICE.

The value of reduced GHG and CAC emissions is often a consideration in the lifecycle comparison of BEVs and ICEs. GHG reductions can be determined using the *Province of BC Climate Action Toolkit Project Profile for Low Emission Vehicles*. (See: [http://smartplanningbc.ca/cgi/content.cgi/Project\\_Profile\\_LEV\\_2011-05-24.docx?id=1962&name=Project\\_Profile\\_LEV\\_2011-05-24.docx](http://smartplanningbc.ca/cgi/content.cgi/Project_Profile_LEV_2011-05-24.docx?id=1962&name=Project_Profile_LEV_2011-05-24.docx)). Tables 16 and 17, in Appendix D, show calculated values for GHG reductions in Metro Vancouver. The value of emissions is taken from the values currently employed by Pacific Carbon Trust (GHG) and Metro Vancouver (CAC).

Accounting for the time value of money over the life of the vehicle to develop a net present value (NPV) is the final step in lifecycle analysis. Other benefits, such as market positioning, maintenance and inventory savings if quantifiable will enhance the business case.

**Table 6: Lifecycle Cost Comparison PEVs vs. ICEs**

Summary Table	
<b>First Cost for EV vs ICE</b>	
BEV	\$ 42,595
ICE	\$ 23,442
<b>Differential</b>	<b>\$ 19,153</b>
<b>Fuel Cost over Life Cycle</b>	
BEV	\$ 3,200
ICE	\$ 16,544
<b>Differential</b>	<b>\$ 13,344</b>
<b>Emissions Cost Savings (borne by taxpayer)</b>	
GHG	\$ 780
CAC	\$ 1
<b>Net Present Value of ICE vs EV Choice</b>	<b>\$ (7,373)</b>

An estimate of the approximate cost differential (including fuel savings, CACs, GHG emissions) expressed in net present value terms over an assumed eight year service life, discounted at 6%, represents a differential of \$7,400 in favour of ICE vehicles, from the perspective of a prospective owner.<sup>25</sup>

In November 2011, the Province announced a \$17 million initiative providing up to \$5,000 off the cost of battery electric and plug-in hybrid vehicles and \$6.5 million to develop a provincial network of charging stations. The initiative also includes a \$500 rebate for household chargers.

**BOTTOM LINE: A cumulative value of incentives in the region of \$7,500 would make the economic choice between ICE and EV equivalent. When the cost of EVSE is added, estimated at \$10,000 at the time of vehicle purchase, it makes the differential \$16,900 in favour of ICE's. The up-to-\$5,000 purchase price incentive from the province helps reduce this gap.**

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<sup>25</sup> This differential is reduced to around \$5,000 if average EV purchase costs are calculated for passenger vehicles only. EV stakeholders have noted that maintenance costs for EVs are estimated to be lower than for ICE vehicles; estimates generally vary between 1/3 to 1/2 of ICE vehicle costs.

## 4 Levers to Accelerate Plug-in Electric Vehicle Deployment

The Plug-in Electric Vehicle (PEV) market penetration will require coordinated action by national, provincial and local governments to successfully achieve the targets set by the electric vehicle industry and government organizations. Coordination will have to occur at appropriate levels of government in order to take action on:

- creating leadership opportunities for all public institutions to invest in adopting electric vehicles into their fleets of vehicles which will contribute towards creating a critical mass of electric vehicles and infrastructure,
- demonstration projects highlighting electric vehicle use and possible applications,
- the development of a minimum charging infrastructure, and,
- supportive public policy regarding the use and charging of electric vehicles, including financial incentives for procuring electric vehicles and their support equipment.

The following sections will provide guidance on how other jurisdictions have approached purchasing incentives for electric vehicles and electric vehicle supply equipment (EVSE).

### Learning from Other Jurisdictions

Many jurisdictions in North America and globally have developed financial incentives to encourage the adoption of electric vehicles. A summary of these incentives is presented in Table 7.

**Table 7: Financial Incentives for EVs throughout North America**

Jurisdiction	Actions
US Federal	\$2,500-\$7,500 for the first 200,000 vehicles. The largest PEV preparation project in North America is the "EV Project" which is the largest deployment of electric vehicles and charge infrastructure in history. With partner matches, the total value of the Project is approximately \$230 million. The EV Project includes approximately 14,000 Level 2 (240V) chargers, 300 - 400 DC Fast Charger (480V) ports, 5,700 Nissan LEAF cars, 2,600 Chevrolet Volt cars, 60+ project partners, 1,200 new jobs by 2012, 5,500 new jobs by 2017, 18 major cities and metropolitan areas. Source: <a href="http://www.theevproject.com">http://www.theevproject.com</a>
Ontario	Electric Vehicle Incentive Program - \$5,000 to \$8,500 scaled on battery size, for the first 10,000 plus green licence plates which will allow PEV owners to travel in the province's carpool lanes. Target: 1 in 20 vehicles electric by 2020.
Quebec	Up to \$8,000 per vehicle scaled based on battery size, for the first 10,000 vehicles and 50% subsidy on residential charging stations (\$50 million until 2016)
United Kingdom	The Plug-in Car Grant reduces prices by providing 25 percent grant towards the cost of new plug-in electric cars that qualify as ultra-low carbon vehicles, but the benefit is capped at GB£5,000 (US\$7,800).
California	Clean Vehicle Rebate Program - Up to \$5,000 per vehicle.
Seattle	Funding for Seattle's EV charging infrastructure is coming from federal stimulus funds. For public property, the Puget Sound Clean Cities Coalition was awarded funds for the City of Seattle to install up to 50 EV charging stations for the City's fleet and for public access on public property.
Manitoba	Manitoba EV Road Map: A comprehensive plan to convert the transport system of Manitoba to an electrically powered one. Hybrid Electric Vehicle Rebate: \$2,000 rebate on lease or purchase of a HEV.
Toronto	FleetWise's EV300 initiative aims to get at least 300 electric vehicles on the road in the Greater Toronto Area by 2012, helping to prepare the region for full-scale electric mobility. Cash incentives not provided.
British Columbia (NEW!)	In November 2011, the Province announced a \$17 million initiative supporting clean energy vehicles. Funding will support up to \$5,000 off the cost of battery electric and plug-in hybrid vehicles and \$6.5 million to develop a provincial network of charging options. The initiative also includes a \$500 rebate for household chargers.

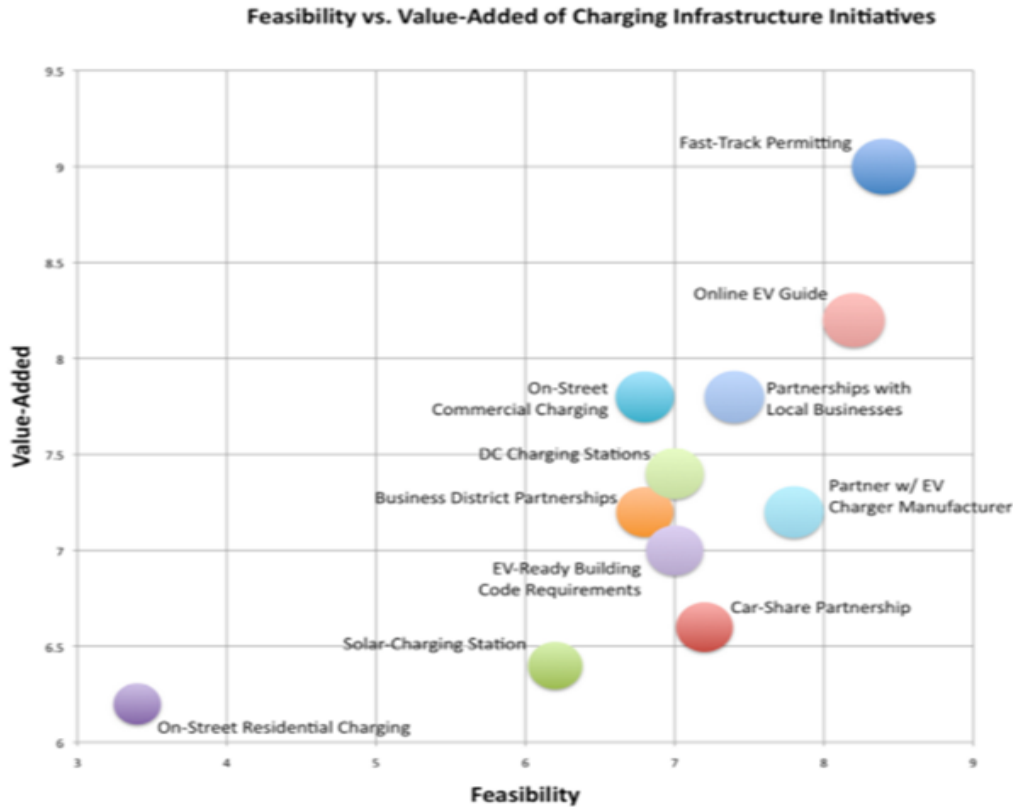
### City of Berkeley's Options Analysis

Figure 11, taken from *Electric Vehicle Charging Infrastructure in the City of Berkeley* (City of Berkeley, 2010, p.23) illustrates the feasibility and amount of value added for 11 policy and regulatory approaches evaluated for the unique circumstances of the City of Berkeley. The following policy and/or regulatory approaches were considered:

- On-street residential charging
- Solar charging stations
- On-street commercial charging
- Business District partnerships
- DC charging stations
- EV-ready building code requirements
- Car share partnership
- Partnership with local businesses
- Partnership with EV charger manufacturer
- On-line EV guide
- Fast track permitting

Not all of these measures are equally applicable in Metro Vancouver's unique circumstances, nor are they equally applicable to all aspects of EVSE acceleration. However, these measures may provide a useful starting point for developing policy and regulatory approaches in Metro Vancouver. Figure 11 positions each of these measures according to its feasibility and its potential for adding value.

**Figure 11 Berkeley's assessment of policy and regulatory approaches supporting PEV adoption**



The study can be found at: <http://www.slideshare.net/JustinCBean/electric-vehicle-charging-infrastructure-in-the-city-of-berkeley-6138151>

## Metro Vancouver’s Status

Prior to the November 2011 announcement of the provincial EV financial support program, there were no financial incentives for PEV purchases or EVSE installations. Support for fleet buyers is provided via coordination of a buyer’s group through the Plug-in BC Fleet Buyers Group led by *Green Fleets BC*. Innovative action is also being taken by individual municipalities such as Vancouver and Surrey, such as exploring novel electric vehicle supply equipment (EVSE) configurations and using EVs in their corporate fleets. Ongoing dedicated regional coordination has not yet emerged across Metro Vancouver, suggesting that may be a role for Metro Vancouver and/or TransLink.

## Levers for Accelerating PEV Use in Metro Vancouver

There are many specific actions cited as useful to accelerating the deployment of PEVs. These actions tend to fall into the three strategies outlined in Table 8.

**Table 8: Strategies for Accelerating PEV Deployment**

<b>1. Buying</b>	<ul style="list-style-type: none"> <li>• PEV purchase price incentives</li> <li>• EVSE installation cost incentives</li> <li>• Local government leadership in fleet purchasing</li> </ul>		
<b>2. Using</b>	<ul style="list-style-type: none"> <li>• Carbon taxes or fuel taxes to maintain or improve the electricity - fuel price difference</li> <li>• Preferred parking and HOV lane access to save time and improve convenience</li> <li>• Reduced licensing fees</li> </ul>		
<b>3. Plugging in</b>	Existing Home & Work <ul style="list-style-type: none"> <li>• How to guide</li> <li>• Streamlined permitting</li> <li>• Info at permit time</li> <li>• Exempt EV supply equipment improvements from valuations</li> </ul>	New Residential & Commercial Construction <ul style="list-style-type: none"> <li>• Developer incentives for EVSE</li> <li>• Developer incentives for public EV supply equipment (amenity)</li> <li>• Building code EV supply equipment requirements</li> </ul>	Public <ul style="list-style-type: none"> <li>• Minimum Regional EVSE network plan</li> <li>• Public EV supply equipment Signage Regulation</li> <li>• Simple, standard process for private sector public EV supply equipment investment</li> <li>• Invest in public EV supply equipment</li> </ul>

### Buying

Automobile manufacturers typically provide one manufacturer’s suggested retail price (MSRP) per country. This causes PEVs to be up to \$8,000 more expensive in jurisdictions without incentives compared to the jurisdictions with incentives. PEV sales in jurisdictions without incentives will likely lag sales in jurisdictions with incentives.

Senior governments in other jurisdictions are experimenting with rebates based on PEV purchases and EV supply equipment (EVSE) installations, sales tax exemptions for PEVs and EVSE installations and income tax credits. Local and regional authorities can support senior government efforts to implement these incentives.

An additional financial incentive for charging infrastructure could include a property tax exemption for improvements related to charging infrastructure.

### Using

Local and regional authorities have some opportunities to increase operating savings for PEV owners through collaboration regionally and with other regulatory bodies. TransLink’s gas tax and the Province’s carbon tax increase the price differential between gasoline and electricity. This will increase the fuel savings associated with switching from gasoline to electricity in a PEV.

Providing preferred parking and high occupancy vehicle (HOV) lane access to PEVs is another way to reduce operating costs by allowing PEV owners to save time. Parking and HOV lane access may require special vehicle identification. Other jurisdictions have special designations such as green licence plates or licence plate stickers. These options would require collaboration with the Insurance Corporation of British Columbia.

### Plugging In

Ensuring the ability to charge is an area where local and regional authorities can play a significant role. As such, this is the subject of the following two chapters which cover the policy and regulatory tools available to local and regional authorities, followed by an exploration of regionally coordinated public charging network.



## 5 Plugging In: Local and Regional Tools

### Understanding Electric Vehicle Support Equipment (EVSE)

Plug-in-Electric Vehicles need something to plug into. The plug and associated equipment is referred to as electric vehicle support equipment (EVSE) or charging infrastructure (CI). This chapter outlines the local and regional role in ensuring that there are places to plug in.

#### Charging Levels

Experts expect that 80% of the charging of PEVs will occur 'At Home.'<sup>26</sup> The workplace, where people leave vehicles for eight or more hours a day, will be a secondary charging location. Some charging will also occur 'On the Go', particularly for Battery EVs (BEVs) which do not have the on-board range extender that Plug-in EVs (PHEVs) do.

**Table 9: PEV Charging Levels/Locations**

Level	% of EVSE	Circuit	Charging	Cost Range	Time to fully charge	Use
Level 1	54%	120v 20amp	1.4kW- 1.9kW	\$1,000 or less	12-20 hours	@Home EV owners are expected to be predominant, but may also be commercial and public locations. Function of EV ownership
Level 2	43%	240v 40amp	7.7kW <sup>27</sup>	\$2,000 - \$10,000 <sup>28</sup>	4-6 hours	Significantly lower distribution required. Some at @Home, initially in 'On the Go' network. 'On the Go' user, long commute.
DC Fast Charging	3%	450V DC 200Amp	62.5kW DC	\$60,000 - \$100,000	Under 30 minutes, 50% in 10-15 minutes	Commuters, Long trip travellers

Table 9 provides an overview of the three charging levels that are currently being planned in North America. Level 1 is a standard electrical outlet. This level is the least expensive to install new and is the most readily available. The low installation cost is balanced with the inconvenience of a long charge time. Level 2 is a compromise between charge time and cost. DC Fast Charging is primarily designed to extend the range of BEVs for inter-community travel. The market research firm Frost & Sullivan has estimated the proportion that each level will make up of the total EVSE infrastructure.

Level 1 needs little more than a standard household outlet. Level 2 may require the installation of some equipment to make charging easier and safer. There are a variety of manufacturers of EVSE. PIKE research has identified ten manufacturers and charted them according to their role as leaders, contenders, challengers and followers; this chart is included in Appendix E. This is a fast-moving early market and interested purchasers should consult the latest research and contact others who have installed and tested EVSE.

<sup>26</sup> "A survey carried out on behalf of the South and West London Transport Conference (Sweltrac) asked 108 electric vehicle owners where they charged their car. 68% of respondents charged their car at home, with 45% of those questioned carrying this out overnight. Only 8% used public recharging points, however at the time the survey was carried there were fewer public recharging points in London," from *Understanding Existing Electric Vehicle Charging Infrastructure, Vehicles Available on the Market and User Behaviour and Profiles*, City of Westminster, UK, April 2009, p. 19 and *Electric Vehicles: Characterizing Consumer's Interest and Infrastructure Expectations, Focus Group Findings*, May 2009, Electric Power Research Institute (EPRI), pp 3-25

<sup>27</sup> Most EVs today have only a 3.3 kW charging capacity, so even when connected to a higher capacity outlet, they will only charge at the slower rate. This is expected to change as new models are developed.

<sup>28</sup> Average cost for residential installation of a Level 2 charger is around \$2,500 according to BIG Green Island Transportation ([www.BIGGreenIsland.com](http://www.BIGGreenIsland.com)). A \$10,000 installation would require trenching and heavy duty equipment, a rare scenario.

## Charging Locations

Project Get Ready is a non-profit initiative led by Rocky Mountain Institute in conjunction with a wide array of partners and technical advisers. Project Get Ready will:

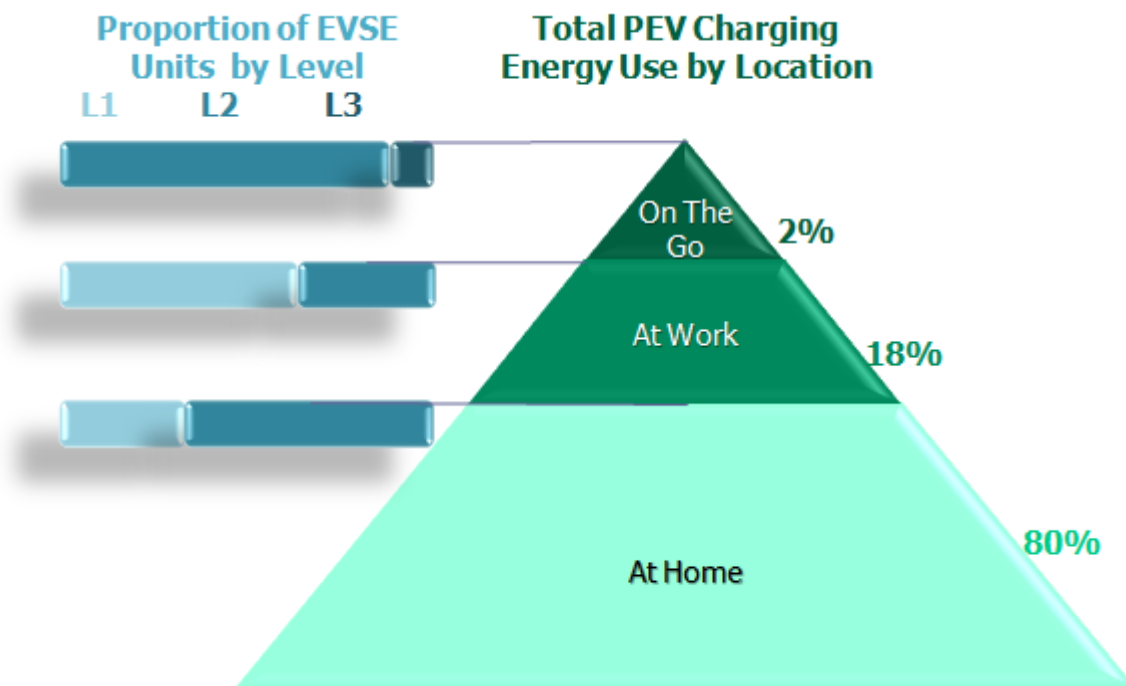
- Create a dynamic menu of strategic plug-in readiness actions including the business case for each action.
- Provide a web database of American and international plug-in readiness activities.
- Convene at least 20 cities as well as technical players regularly to discuss their lessons learned and best practices, and report these conversations on our website and materials.

The Project Get Ready market segmentation approach to EV support equipment (EVSE) divides the EV market into three EV user modes<sup>29</sup>:

- **At Home:** residential location and time spent while the EV user is at their home.
- **At Work:** work location for the EV user. Considered public domain, i.e. not 'At Home'.
- **On the Go:** EV user is commuting to work or recreation or travelling to shopping or services either intra or intercommunity.

Each use mode will have its own unique mix of charging infrastructure. Most research indicates that at least 80% of total PEV charging is expected to be done 'At Home'. The workplace is expected to pick up the majority of remaining charging. 'On the Go' charging will be the least utilized but has an important role to play in the overall network and PEV adoption.<sup>30</sup>

**Figure 12**



<sup>29</sup> <http://projectgetready.com/resources/ready-set-charge-a-guide-to-ev-ready-cities>

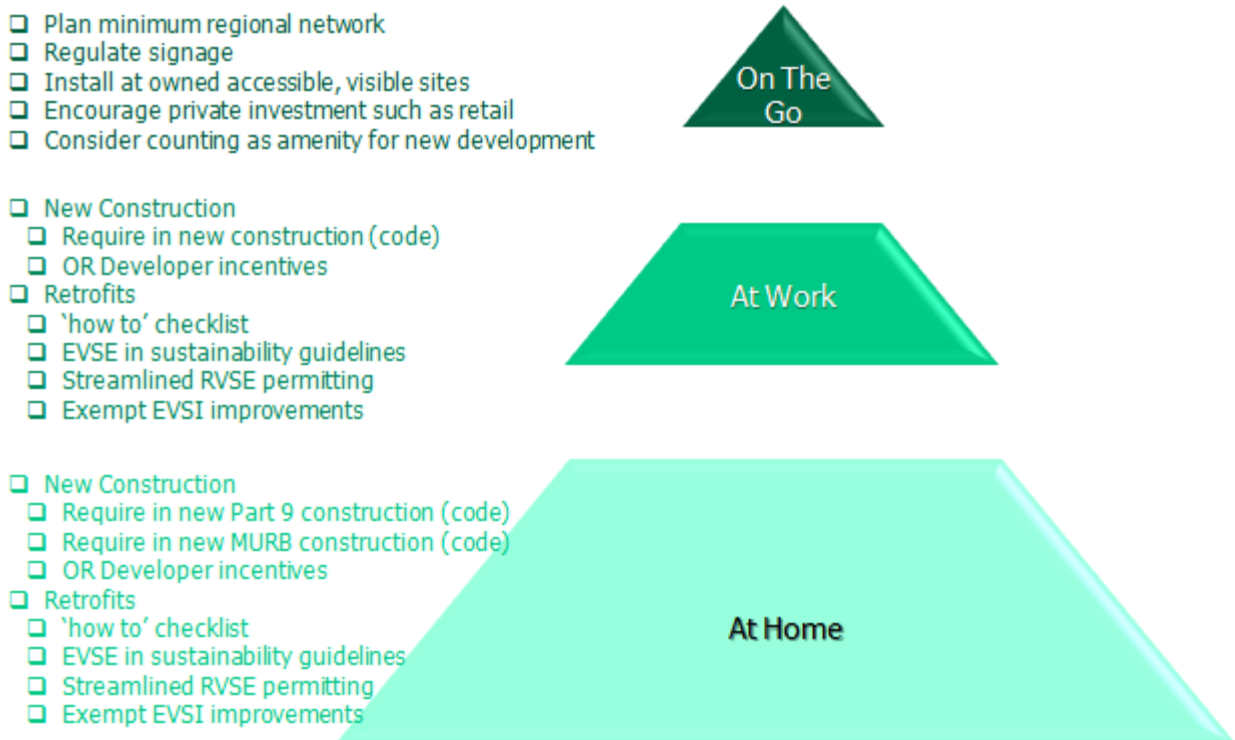
<sup>30</sup> Some stakeholders believe that "On the Go" charging will be greater than 2% and 'At Work' charging will be less than 18%.

## Local and Regional Tools

For each use mode and EVSE level, there are policy, regulatory, financial, and process tools available to local and regional authorities to ensure that EVSE is sufficiently available to support the initial deployment of PEVs as well as scaling as PEVs become commonplace. Many of these tools will require collaboration among local governments, TransLink, BC Hydro and the Province of BC. The following sections in this chapter explore the toolset associated with each of the user modes, starting at the bottom of the pyramid with 'At Home,' followed by 'At Work,' and finishing with 'On the Go'.

**Figure 13**

### Plugging In: Local and Regional Tools



## At Home – New Construction

Most BC Building Code Part-9 construction (low-rise residential construction, including single family, duplex, townhomes and row homes and some walk-up apartments) will have a Level 1 circuit but not Level 2. At present most multi-unit residential buildings (MURBs) would not have any charging available. Given the charging time differential between Level 1 and Level 2 and the small incremental cost in new construction (about \$500 to \$4,000), Level 2 is recommended in new construction.

There are two approaches to getting EV Service Equipment (EVSE) into new construction – requiring it (through code) or incenting it (through approaches similar to those in Community Energy Association’s *Policy and Governance Guide*). More detail on these two approaches is provided in Appendix F.

The electrical code requires a dedicated 20A circuit minimum for EV charging. Multi-family buildings should avoid the use of shared receptacles, which would only allow one vehicle to charge at a time. Incentives need to cover pre-wiring costs only because EVSEs come with the EV.

## At Home – Retrofits

Installing EV support equipment (EVSE) in existing homes will also be a significant component of EVSE deployment. Key local and regional actions to accelerate this involve making it easy for homeowners to install EVSE installation and encouraging homeowners to install EVSE.

Local or regional governments can make it easier for homeowners by creating a “how-to” checklist which would include the steps involved, key questions and considerations, and contact information for relevant organizations such as BC Hydro. Ideally, this would be developed collaboratively and would be consistent across Metro Vancouver.

Streamlining permitting for EVSE at the municipal level is another part of making EVSE installations easier. Providing a quick turnaround on electrical permits related to EVSE installations reduces the potential for delays and frustrations on the part of the homeowner. This may require some training of staff who review permits along with templates, checklists, and processes. This may vary somewhat by each municipality.

Exempting EVSE improvements from property tax valuations may also reduce a barrier or frustration related to EVSE installation. Homeowners may be frustrated that installing an EVSE increases their property value and therefore the municipal taxes that they have to pay. Similar arrangements have been discussed for renewable energy technologies such as solar hot water.

Including EVSE in sustainability guidelines and training for permit counter staff can be an effective way of encouraging homeowners to consider energy issues when renovating, particularly when combined

### Box 4: City of Vancouver Bylaws Single Family Dwellings

#### 12.2.2.10. Cable Raceway

- 1) Each dwelling unit shall have a cable raceway leading from the electricity circuit panel to an enclosed outlet box in the garage or carport.
- 2) A raceway not smaller than size 21 shall be provided to accommodate future conductors of a separate branch circuit intended to supply a future receptacle for use with the electric vehicle charging system. (Note: this is expected to be updated to a completed circuit/receptacle with a raceway size of 41 mm.)
- 3) An outlet box for the receptacle referred to in Sentence (2) and approved for the purpose shall be provided in a parking space or a parking stall of a storage garage or carport intended for use with the electric vehicle charging system.
- 4) The raceway described in Sentence (2) shall be installed between the dwelling unit panel board and the outlet box referred to in Sentence (3)

#### Multi-unit Residential Buildings (MURBs)

Part 13, which comes into force on April 20, 2011, of the Vancouver Building Bylaw has been updated accordingly (see paragraphs below). These bylaw changes are intended to be responsive and dynamic and will be reviewed annually.

#### 13.2.1.1. Parking Stalls

- 1) Each one of 20% of the parking stalls that are for use by owners or occupiers of dwelling units in a multi-family building that includes three or more dwelling units, or in the multi-family component of a mixed use building that includes three or more dwelling units, must include a receptacle to accommodate use by electric vehicle charging equipment.

#### 13.2.1.2. Electrical Room

- 1) The electrical room in a multi-family building, or in the multi-family component of a mixed use building, that in either case includes three or more dwelling units, must include sufficient space for the future installation of electrical equipment necessary to provide a receptacle to accommodate use by electric charging equipment for 100% of the parking stalls that are for use by owners or occupiers of the building or of the residential component of the building.

with a 'how to' checklist and the assurance of streamlined permitting.

## At Work

'At Work' is expected to represent a small proportion (<20%) of overall charging compared with 'At Home' (80%). 'At Work' will fill an important niche in PEV charging with PEVs regularly being parked for eight hours or more. The issues and approaches to 'At Work' are similar to those with multi-unit residential buildings (MURBs) including:

- Typically no charging options available in both surface and underground parking lots
- Potential for ownership or leasing or chargeback to multiple tenants or owners
- Initial EVSE-ready infrastructure and longer term capacity to scale up infrastructure

The goal for 'At Work' is to accelerate the deployment of both Level-1 and Level-2 charging points. The approach to doing this is basically the same as for 'At Home' MURBs. Ideally building code would require some percentage of parking stalls to be ready for charging while also requiring that the electrical service be sized to scale up the charging points in the future. If a regulatory approach is not possible, then incentives as described in Community Energy Association's *Policy and Governance - Renewable Energy Guide for Local Governments in BC* can be implemented.

### Unique Considerations for 'At Work'

Providing preferred parking locations reserved for PEVs for new workplace parking can be a positive incentive for staff at those locations to consider a PEV.

Signage in workplace parking lots related to charging points is also a key consideration. Signage is discussed in more detail in the 'On the Go' section. Employers will need to decide how charging costs for privately owned vehicles will be handled; this may have an impact on the kind of charging infrastructure selected.

## 'On the Go'

### Characteristics

'On the Go' charging is needed for Battery EVs (BEVs), about 24% of the PEV market, since they do not have the on-board range extender (i.e. gasoline engine) that Plug-in Hybrid EVs do. While the 'On the Go' network is expected to comprise well under 10% of total PEV charging, it is critical to accelerating the use of PEVs. An 'On the Go' network reduces range anxiety in BEV uses, promotes the PEV concept through highly visible and preferred locations and contributes to the functionality of PEVs.

The network will be primarily Level-2 with some Level-3, particularly at key points along highways to enable BEVs to travel long distances. Level-2 charging is expected to take 4-6 hours to fully charge a BEV. The network is expected to be used primarily for topping up a charge. Top-ups are faster than a full charge and may take as little as 30-60 minutes.

**BOTTOM LINE: The targeted range for two of the first BEVs to hit Metro Vancouver streets, the Mitsubishi MiEV and Nissan leaf is 135 km 160 km respectively.<sup>31</sup> A 25% top-up provides over 30 km (Vancouver to Surrey).**

### Planned US Public Networks

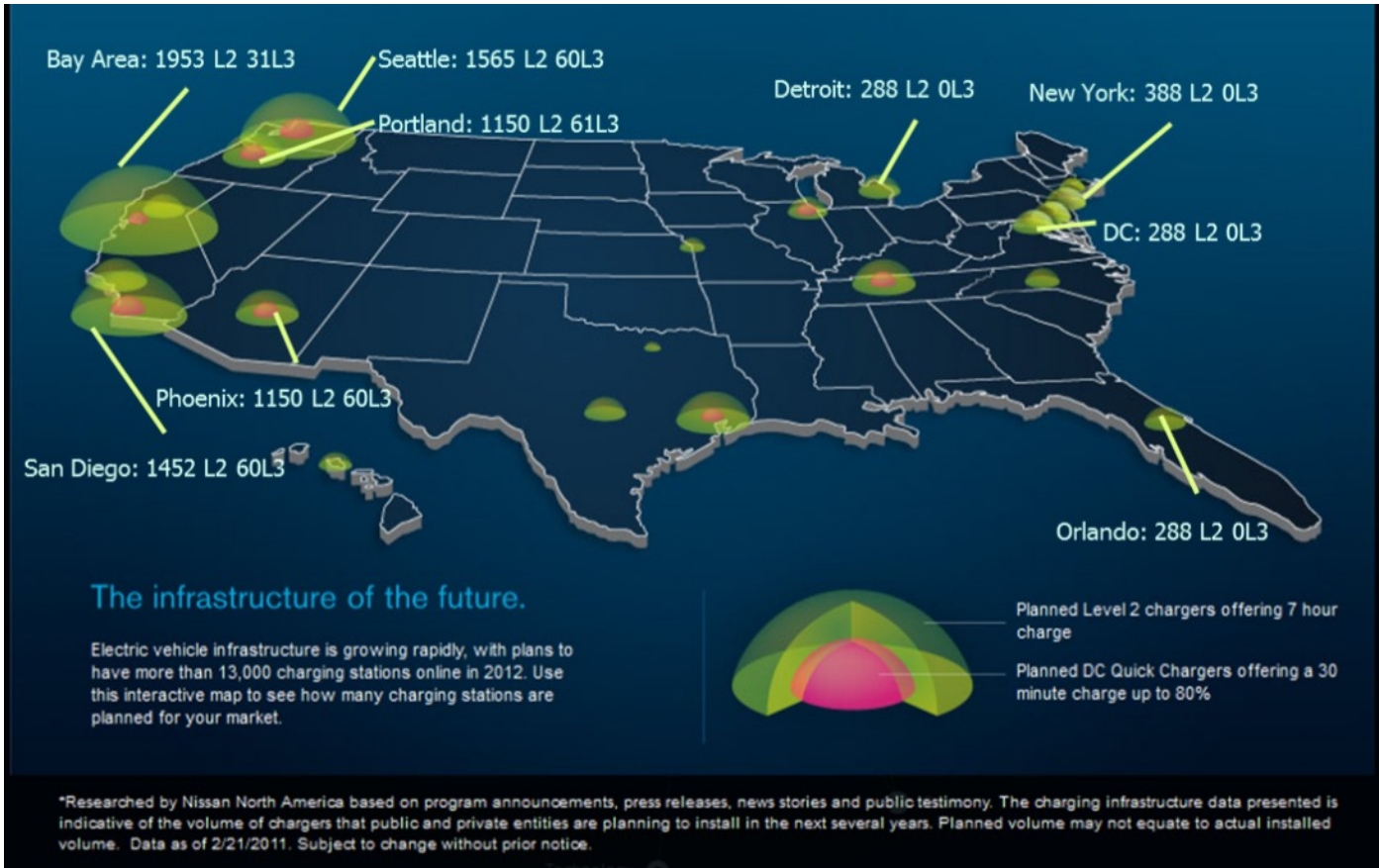
Figure 14, obtained from Nissan's website (<http://www.nissanusa.com/leaf-electric-car/index#/leaf-electric-car/chargingMap/index>) outlines planned Level-2 and Level-3 public charging networks in the United States. Most of the stations will be privately owned. Much of this infrastructure deployment is due to a United States federal stimulus package that includes funding for charging stations. The map indicates that the west coast is deploying significantly more publicly accessible EV support infrastructure than the east coast. This has positive implications for personal travel

<sup>31</sup> Note: These are range targets; Consumer Reports notes that the Nissan Leaf gets an average of 104 kms per charge.



north and south along the west coast for Metro Vancouver EV owners; a greater availability of charging stations will help reduce “Range Anxiety” and encourage EV uptake.

**Figure 14 Electric vehicle charging stations planned for 2012 (United States)**



## Perspectives on Usage

The following quote from *Charge Spotting: Determining the Right Mix for Public EV Access* by John Gartner (December 13, 2010) on the PIKE Research blog sums up the public network usage issues well and also touches on same issues relevant to TransLink.

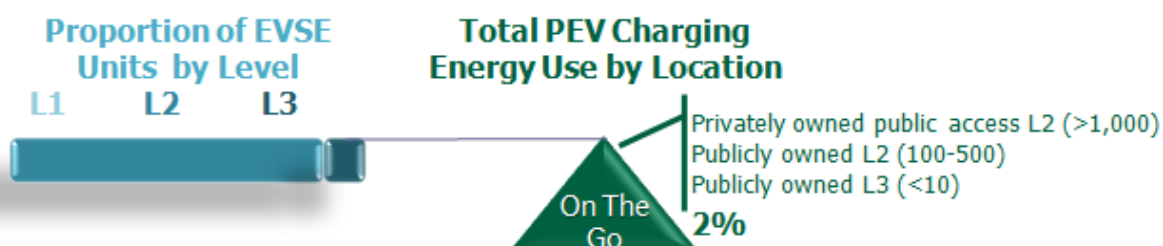
*Charging at places of employ and at park and rides, where suburbanites can park and then take mass transit for the rest of their journeys, are expected to have high utilization rates. Charging facilities at gas stations and suburban retail locations are more likely to be underutilized because they are not central to where people will need to spend a long time to charge, or close to where drivers will be when their vehicle batteries will be sufficiently depleted to warrant a charge. ...*

*While having a highly visible public charging infrastructure is an important psychological factor in reducing “range anxiety,” expect some of the chargers we’re hearing about to be largely inactive during the next few years.*

## Ownership

'On the Go' is expected to be comprised of primarily privately and publicly owned Level-2 with some Level-3 in the region. BC Hydro will likely lead the installation and siting of early deployments but will seek owner/operator partners. Current regulation prevents BC Hydro from owning charging stations or equipment.<sup>32</sup> A low level of utilization expected over the first years of PEV introduction. This is described in the Figure 15.

**Figure 15 On the Go expected EVSE ownership**



Privately owned publicly accessible Level-2 EV support equipment (EVSE) is likely to include retailers such as malls and big-box stores. Surrey is considering requiring all new gas stations to provide alternative fuelling infrastructure such as EVSE, natural gas, or hydrogen. Reviews of this proposal have suggested that shopping malls or restaurants might be better locations. Some restaurants or destination centres may also deploy Level-2 in a bid to attract 'green' customers. There may be conditions for use of this EVSE such as purchasing something from the vendor that provides the EVSE. This infrastructure is generally available to anyone to pull up to and charge. Private parking lot operators and hotels will likely deploy EVSE with limited access.

## Local and Regional Steps to Deploying an 'On the Go' Network

Regionally, the following steps are recommended to design and deploy a regionally coordinated 'On the Go' network.

1. Plan minimum regional network for next ten years to support early adoption of PHEVs and coordinate with provincial DC fast charging network. This will inform approaches to targeted encouragement of private sector investment and identify specific areas where the local or regional authority will have to invest. This is the subject of the next chapter.
2. Establish signage regulations and collaborate with highway authorities regarding highway and major road signs. Local and regional authorities are encouraged to consult with Electric Mobility Canada regarding current signage regulation best practices.
3. Identify private sector role in publicly accessible EVSE
4. Public investment for private sector 'holes'. This can include local and regional authorities installing publicly accessible EVSE at sites that they own or on rights of way at highly visible locations.
5. Encourage or require further private investment. Possible approaches include
  - Surrey's new gas station bylaw
  - Requiring all new parking lots to have EVSE-only designated preferred parking stalls
  - Considering public EVSE as an amenity for major new developments



The following chapter examines options for minimum regional charging network.

<sup>32</sup> Regulatory issues can present barriers to EV adoption. California has deregulated the sale of electricity for transportation. Ownership and business models will evolve over time. (Via comments from BC Hydro on this document, known as the Primer.)

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## 6 Minimum Regional 'On the Go' Charging Network

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### Role and Characteristics of 'On the Go' infrastructure

Chapter 2 examined 'At Home' and 'At Work' charging infrastructure and reviewed the key policy and regulatory elements associated with 'On the Go' charging. This chapter further explores what a minimum regional 'On the Go' charging network could look like.

The objective of the coordinated regional EV support equipment (EVSE) is to provide order of magnitude target values for charging infrastructure across the Metro Vancouver region, based on milestone years of two, five and ten years into the future to inform local governments at the sub-regional level about their possible opportunity and challenges with respect to electric vehicle charging infrastructure.

Rationale for public charging infrastructure

- Usage case / convenience
- Range anxiety
- Marketing for 'green' businesses
- Marketing for EVs

As with any projection into the future, many risks or factors, will affect the actual outcome and it is useful to identify what those factors, which are listed below:

- Electric vehicle (BEV, PHEV) market penetration rate is a significant determinant of the ultimate charging infrastructure required in the Metro Region.
- 'Range Anxiety' reduction is arguably the most important benefit of the public charging infrastructure. If this psychological effect of EV consumers is overcome through other means, such as education, information technology or improvements to battery technology then the charging infrastructure requirements may be mitigated. Battery technology, and range, is advancing rapidly and will likely reduce the need for public charging stations substantially toward the end of this analysis.
- Charging infrastructure business and technology models will evolve overtime and may change significantly from the current public charging station model, envisioned by the authors at this time. Battery packs, utility pricing, aggregation of charging stations by private entities, etc may reshape the EV and charging infrastructure market place.

### Project Get Ready Approach

City of Vancouver's Project Get Ready is taking a six-step approach to developing a minimum 'On the Go' network map. This provides a useful model that can be adapted to a region-wide approach.

1. Research approaches
2. EV (PEV & BEV) regional market penetration model
3. Level-2 EVSE ratio applied to EV vehicle projections
4. Prioritize available public locations for the targeted number of charging locations
5. Mapping and visual screening
6. Review and corrective action

### Approaches

There are multiple objectives for an 'On the Go' network including reducing range anxiety, promoting the PEV concept, and providing convenient functional charging. There are four broad approaches to determining the minimum size of the network that would be required to achieve these complementary goals.



These approaches can provide an estimate of the total minimum size of the public charging network. From a local and regional perspective, private sector investment in publicly accessible charging is beneficial but not critical. Approaches to estimating the minimum size of the network are outlined in Table 10.

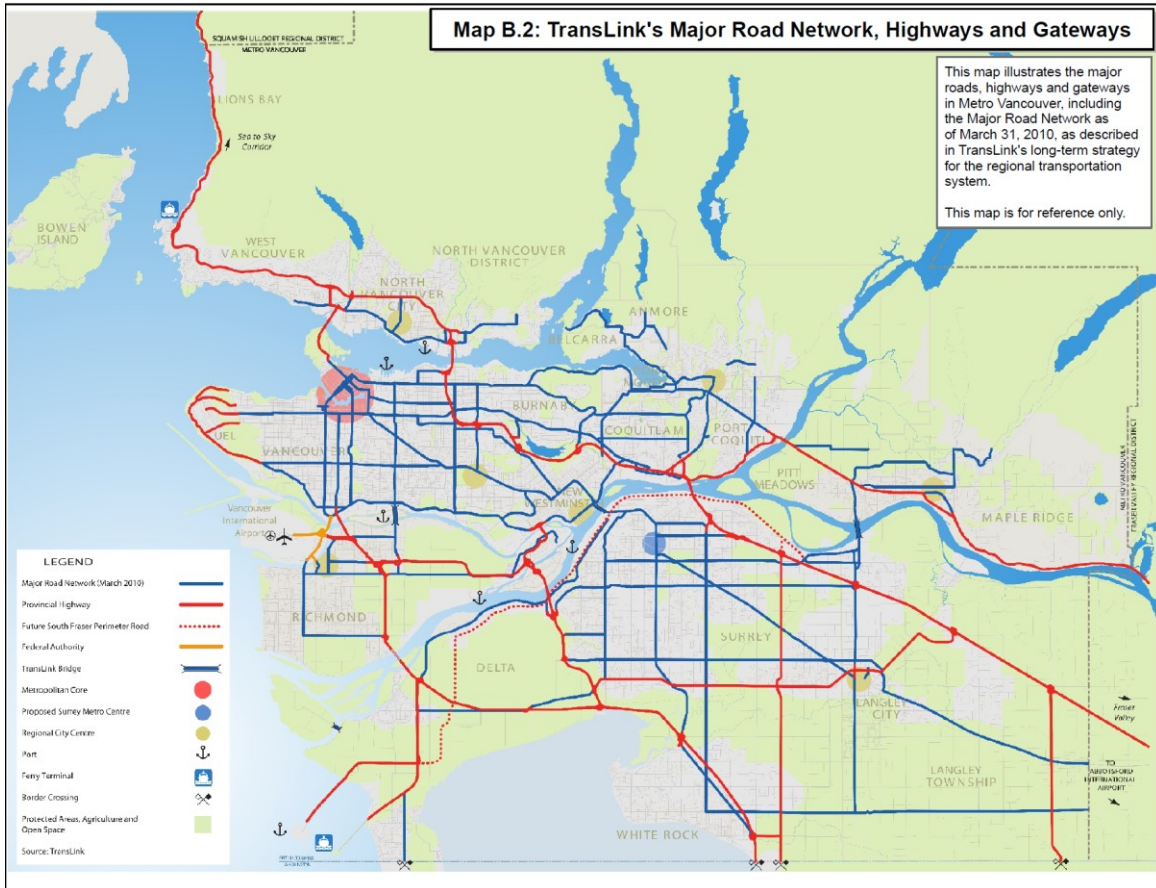
**Table 10: Estimating minimum size for charging networks**

Approach	Rationale	Input Numbers	2020 Results for # of Level X Recharging Stations
Per BEV	BEVs have the highest need for the network. More BEVs should require a larger network. This approach is being explored by City of Vancouver's Project Get Ready in collaboration with this TransLink research project. PIKE Research has estimated that there will be about 1.15 charging stations ('At Work' and 'On the Go') sold per PEV sold in the US by 2020. We expect a greater demand for 'At Work' charging than 'On the Go' charging. <b>If we assume a 1:1 ratio for PEVs and 'At Work' charging, that leaves 0.15 EVSE per 1 PEV for 'On the Go'.</b>	15,000 PEVs by 2020 26% are BEVs: 3,900 1.5 for 10 PEVs* 1.5 for 10 BEVs*	2,250 (1.5 per 10 PEVs*)  563 (1.5 per 10 BEVs*)
Per capita	This can be used to scale between jurisdictions for comparison purposes. The research has not led to a defensible approach to recommending a specific number of EV support equipment (EVSE) per capita.	2,374,628 population	n/a
Per square km	An 'On the Go' network that you are never more than 10 km (6%-7% of total BEV range) is one approach to reducing range anxiety. This requires BEV drivers to be able to easily and confidently locate the charge points.  A 5 km network would provide a higher level of confidence.	Metro Vancouver is 2,877 square km in size.  Always within 10 km at any point in the road network  Always within 5 km of any point on the road network	30   120
Per km of major roads	Reducing range anxiety and providing convenient charging opportunities can also be achieved by targeting a minimum number of charge points per kilometre of major road and highway in the region. These arteries have the highest traffic volume (and highest visibility) in the region. Drivers are also more likely to be familiar with these routes than side streets. Placing charge points at approximately every 5 km (3%-4% of BEV charge) on or visible from major roads and highways can result in effective marketing and charging.	1074 km of major roads and highways. 1 for every 5km	215

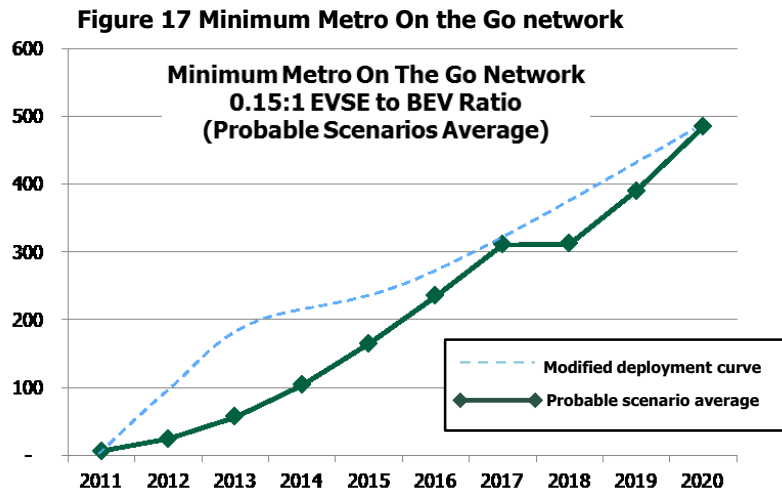
\* Based upon a ratio of 0.15 EVSE per PEV.

TransLink’s service map (Figure 16) depicts TransLink’s major road network (in blue) and the provincial highways / roads (in red). This high-traffic network of roads has good geographic distribution as well as concentration around population centers. In addition to this minimum charging network, local / regional authorities will likely choose to install public charging points at many of the publicly accessible parking lots that they own to demonstrate their commitment to PEVs. This includes parking at recreation sites (such as local and regional parks and BC Hydro recreation areas), inter-modal transfer points such as park-and-rides and SkyTrain stations. The inter-modal points are likely to be some of the most utilized public charging points.

**Figure 16 Metro Vancouver major road network, highways and gateways**



Project Get Ready is currently basing network design on a per-BEV basis. Using the PEV penetration model (Appendix C) and PEV projections for Metro Vancouver from 2011 to 2020, the EVSE to BEV ratio is charted from 2011 to 2020 in the graph below. (Figure 17)



This particular PEV penetration model approach does not take into account the need to build the network in advance of BEV purchases. The blue dotted line represents a modified deployment curve that results in front-loading of the public network deployment. This early investment will assist in promoting PEVs and overcoming BEV range anxiety.

**BOTTOM LINE: Assuming Level-2 at \$10,000 per station, this represents an investment of \$5 million dollars over 10 years.**

In November 2011, the Province announced a \$17 million initiative supporting clean energy vehicles which includes \$6.5 million to develop a provincial network of charging options. The initiative also includes a \$500 rebate for household chargers.

### Prioritizing Locations

There are a variety of approaches to siting. BC Hydro has sponsored a fast charger siting framework study for Metro Vancouver. The goal of the study is to generate a generic siting framework applicable to any region of Canada. This study will be completed in early 2012.

Project Get Ready has used a multi-criteria analysis to define a geographic distribution and approach to specific location selection. Table 11 describes a subset of the criteria along with weights for each use mode and objective of charging infrastructure.

**Table 11: Multi-criteria analysis for selecting charging infrastructure location**

Scale	Criteria for selecting Charging Station Locations	Examples	Charging Infrastructure Target Market Weighting Factors (0 - 1)				
			Range Fear	At Work Commuter	On the Go Convenient	At Home Park On Street	Inter Urban Level 3
Region	<b>Employment Density:</b> Some public EVSE will need to be installed near or at workplaces until private EVSE come online.	All Easy Park Lots	0.4	1	0.5	0	0
Region	<b>Security:</b> For this pilot project it is imperative that customers feel safe using the City's EVSE. If vandalism or in-car theft is known to happen in potential sites then the City must assure the safety of EVs while being charged to avoid any negative setbacks in the project.	DTSE, Woodwards	0.2	0.2	0.3	0.5	0.5
Region	<b>Retail:</b> Business Improvement Areas that have retail, services, and dining outlets co-located.	Woodwards, Cambie North	0.3	0.2	1	0.2	1
Region	<b>Traffic Corridors:</b> Most gas stations are at intersections of major traffic corridors. This is also good for EV Charge stations. They have high visibility, easy to find and access..	Oak and King Edward	0.4	0.5	0.7	0	1
Region	<b>Destinations:</b> Recreation, education, health, sports, community centers, libraries, parks and other non-work locations that people go and park for long enough (1 hr adds 15-30 Km) to get a convenience charge to extend their trip.	Stanley Park, Jericho, Nat Bailey Stadium, City Hall	0.4	0.2	1	0	0.2
Region	<b>Even Distribution:</b> Level 2 EVSE must be placed approximately equidistantly from each other to maximize the area covered by charging stations and to ensure access within a short drive. Regardless of any other factors, EVSE must be accessible to any EV driver at any time at any location. It is too early in the deployment of EVs to perform more advanced simulations of where EV drivers would likely cluster more often, thus for this study the first premise when siting EVSE is to spread them evenly across the city. Ideally an EV driver would always be within one or two kilometers of a charge location in an urban setting.	26 Community Centers are evenly spaced, 43 cities in BC are 100 Km apart	1	0.3	0.2	0.5	1
Region	Visibility: High visibility helps publicity.	MEC and outdoor outlets on Broadway	0.9	0.8	1	0.3	1
Region	Residential Population Density: medium or high density residential areas since most likely they will not have individual garages or the necessary infrastructure to install private home chargers.	Kitsilano	0.2	0.3	0	1	0
Region	Future Growth Areas: Areas that will become more frequented in future and need enough EVSE now to make them attractive destinations.	Athlete's Village	0.1	0	0.5	0.6	0
Region	<b>Projected EV buyer areas:</b> Choose neighbourhoods with high density of Prius and HEV buyers as per historical data	Point Grey, Shaunessy	0.3	0	0.5	0.5	0
Street	<b>City Owned:</b> It is easier for the city to install EV Charging on land that it owns rather than coercing a number of private businesses to share their land and costs. This particularly in the near term, until it becomes a popular business competitive advantage.	community centers, parks, easy park lots	1	0.7	0.6	0.8	0.5
Street	<b>Availability:</b> The importance of this point seems to be omitted in the current literature. All charging stations should have at least two parallel EVSE so more than one EV can charge at the same time. If the main purpose of the EVSE grid is to provide convenience and reassurance to early adopters of EVs, then drivers must be confident that when they reach their closed charging station there will be a plug waiting for them. If all EVSE in one site are being used at the same time the City will need to enforce fair use policies so everyone can get a chance to charge their vehicles without waiting too long and thus creating inconveniences for the drivers. This topic is ready for further research.	Install sufficient rough in for upgrade or initially.	0.3	0.6	0.5	0.5	0.6
Street	<b>Priority Parking:</b> Pros are a benefit for EVs Cons are lack of parking revenue if unused, frustration for others, unavailable due to illegal parking in prime spots.	"Please allow EVs to park here"	0.4	0.5	0.5	0.8	0

**Table 21: Multi-criteria analysis for selecting charging infrastructure location (cont'd)**

Charging Infrastructure Target Market Weighting Factors (0 - 1)							
Scale	Criteria for selecting Charging Station Locations	Examples	Range Fear	At Work Commuter	On the Go Convenient	At Home Park On Street	Inter Urban Level 3
Site	<b>eCycles co-location:</b> co-locate charger for cars beside	Motorcycle triangles	0.7	0.8	0.6	0.4	0
Site	<b>Low Cost / Existing Receptacle:</b> Utilize existing outlets where possible for cost savings. Often a simple adaptation from 120V to 240V is possible	Easy Park Lots have many existing plugs	1	0.7	1	0.5	0
Site	<b>Cost / Nearby:</b> Choose locations where power is available nearby to reduce cost.	Jericho Olympic RV power	0.6	0.5	0.6	1	0.5
Site	<b>Cost / Concrete:</b> Concrete is expensive to install power through or under. Choose locations where there is minimal concrete between the electrical supply and the charging station or overhead access is feasible..	Spaces beside building outdoors, also use street lights	0.7	0.6	0.6	1	0.5
Site	<b>Cost / Transformer:</b> Transformers are expensive. Choose locations where extra power is available and transformer upgrades are not needed.	Yaletown, Kitsilano need upgrades, consult BC Hydro study	0.8	0.7	0.7	0.7	0.5
Site	<b>Cost / Panelboard:</b> Panelboards require space in front of them to access. Choose locations where existing panelboards have capacity or there is space to install new ones.	Review with qualified electrician	0.5	0.4	0.4	0.2	0.1
Site	<b>Cost / Spare Capacity:</b> Electrical capacity is normally sized to a minimum with limited expansion capability. Seek locations that have adequate electrical capacity in the building and the supporting sub-station. This can be the most significant cost.	Whistler Works office and bio-fueling station beside substation	1	1	1	0.6	1
Site	<b>Hills:</b> EVs don't have parking gears or transmissions and rely solely on hand brakes. Choose locations not on hills.	Flat parking stall vs hills	0.1	0.1	0.4	0.7	0.2
Site	<b>Open 24 Hrs:</b> Some parking areas are gated or closed at night, limiting charging access. Make exceptions for EV emergency charging. Choose unrestricted areas.	Non-gated, overnight parking allowed	0.3	0	0.5	1	0.8
Site	<b>Above Ground:</b> Locate at ground level or above, not below or where water will pool.	avoid basements of garages	0.2	0.2	0.2	0.2	0.5
Site	<b>Access:</b> Ease of access and manoeuvrability for vehicles. For sites with more than one EVSE it is necessary that cars can park and exit without disrupting the charging process of nearby vehicles. Different layouts of parking spaces and EVSE can fulfil this need, so this requirement should be considered on a per-site basis.	Charge station installed beside handicapped parking or exit vs. at far end of lot where few others park..	0	0.5	0.6	0.3	0.8
Site	<b>Shelter and Lighting:</b> Whenever possible charging sites should be well lit and sheltered, given Vancouver's climate. Good lighting makes it easier for the drivers to use the equipment at night and it acts as a vandalism deterrent. Shelter provides a dry area to operate the EVSE when it's raining.	electrical out of rain	0.2	0.2	0.2	0.5	0.8
Site	<b>Ventilation:</b> Indoor stations need adequate ventilation if charging older lead acid batteries used in LSVs and conversions.	normal ventilation for ICE fumes is adequate	0.5	0	0	0	0
Site	<b>Distance from EVSE to car plug:</b> Site design must be flexible to service multiple EVs simultaneously in a safe manner. Tripping hazards and cords frozen to the ground during winter time must be avoided by carefully designing each site for EVSE	back in or front in	0.3	0.3	0.4	0.8	0.7
Site	<b>Barriers:</b> Since the design of EVSE sites have not been standardized yet, each site must uniquely provide barriers to protect EVSE from car collisions while minimizing tripping hazards. Also from snow plows.	Concrete Bollards	0.2	0.4	0.5	0.1	0.5

**BOTTOM LINE: Siting frameworks are critical to selecting locations for charging infrastructure. Similar criteria can be applied regionally to site selection for locating early-stage deployment of charging points. Regional collaboration in setting selecting a framework (and making value-decisions regarding multiple objectives) would be beneficial. A region-wide charging infrastructure working group is recommended to ensure active participation of key staff from across the region.**

## Deployment

Once a minimum coordinated regional charging infrastructure map is agreed upon, local and regional authorities can encourage private sector investment in specific target areas. Local and regional authorities can then confidently invest directly in charging infrastructure themselves.

The plan for the 'On the Go' network should be reviewed and revised after the initial deployment.

## 7 Opportunities for Early Local Government Fleet Adoption

Local governments in Metro Vancouver, BC have significant experience with electric vehicles. TransLink owns and operates one of the largest fleets of ‘on-rail’ and ‘on-road’ EVs in North America. Operating the fleet of rail cars and buses has meant construction of a regional electrification infrastructure of both AC and DC voltages. While electrified public transit has been around for a long time, technology has advanced over the last two decades to a point where it is viable to extend electrified fleets to light duty vehicles (LDVs).

Leading sources, such as *Developing a Charging Infrastructure Strategy for Canadian Municipalities* (M.Beck), Pembina Institute’s *Top Municipal Actions for Municipal Operations*, and Electric Mobility Canada (EMC) *Electric Vehicle Technology Roadmap for Canada* (Electric Mobility Canada, 2008), recommend inclusion of PEVs in municipal and regional fleets.

By integrating electric vehicles into highly visible roles and establishing charging infrastructure to support it, local government provides value to their communities by providing incentives for broader community participation and simultaneously reducing their own corporate emissions and contributing to achieving their carbon neutrality commitments under the Climate Action Charter.

### Why Consider an EV as a Fleet Car?

By adding EVs to their fleets local government will:

- Demonstrate leadership to the community
- Gain knowledge and experience to expand further roles for EVs
- Reduced operating costs by saving fuel and emissions costs
- Contribute to corporate carbon neutral and community GHG reduction goals

#### Box 5: Typical Planned Uses for PEVs

- By-law enforcement officers
- Community Demonstration vehicle
- Local Government Corporate travel
- Supervisor travel
- Staff Pool vehicle
- Test/Pilot vehicle

### Plug In BC Fleet Buyers Group

The Fleet Buyer’s Group provides local government with early information related to vehicle availability, auto manufacturer’s pilot trials and connection to a network of other fleet buyers.

In collaboration with the provincially chaired Plug-In Electric Vehicle (PEV) Working Group, Fraser Basin Council is coordinating with the electric vehicle auto manufacturers, BC Hydro, the City of Vancouver and Metro Vancouver, to establish an inventory of available electric vehicles and facilitating their introduction to public sector fleets.

Participation in the Plug In BC Fleet Buyers Group is completely voluntary and does not require a commitment to purchase an electric vehicle. There are no caps in terms of the number of vehicles a particular fleet may acquire. There are currently approximately 100 vehicle fleets in BC participating in the program. Indications of interest are made during polling for ‘Hand raisers’ as new electric vehicle entrants become available from the auto manufacturers. Commercial terms and conditions are made between the purchaser and the auto manufacturer.

Currently, electric vehicles are available to be acquired either on a purchased or leased basis. The purchase or lease is made based on the ‘whole’ vehicle, there are no separate financing or ownership options for batteries vs the rest of vehicle. There are differences in warranty between the vehicle and battery life. Financial terms must be considered in the purchaser’s use and financial context. More detail on how to add an EV to a local government fleet is provided in Appendix D.

**BOTTOM LINE: The BC Fleet Buyers Group is where local / regional authorities will go to add PEVs to their fleet for 2011-2012 and likely beyond.**



## 8 Conclusions

This report is intended to provide regional and municipal decision makers with a primer for the transition to a greater number of electric vehicles (EVs) in the light duty vehicle fleet across Metro Vancouver. Only two types of plug-in electric vehicles (PEVs) can directly replace existing internal combustion engine (ICE) light duty vehicles – Plug-in Hybrid Electric Vehicles (PHEVs) and Battery Electric Vehicles (BEVs). Consequently, the scope of this report is restricted to a discussion and analysis of the existing and future potential of these vehicles within Metro Vancouver.

An increased use of PEVs in BC will help achieve the sustainable transportation system goals of Metro Vancouver and Translink via reductions in common air contaminant and greenhouse gas emissions, helping to meet the goals of regional transportation, growth management and air quality strategies, as well as those of member municipalities.

Metro Vancouver’s characteristics favour the rapid adoption of PEVs. An initial policy framework that supports low carbon vehicles and a collaborative approach among the key stakeholders already exists. There is also a precedent of rapid growth in the hybrid- electric vehicles (HEV) segment. Since being introduced in Metro Vancouver 2000, hybrids have grown in market penetration to represent 0.5% of passenger vehicles in 2007 and rose to 1% in 2010, which represents a 10 year compound annual growth rate (CAGR) of 31%. Based on this growth, and other BC market attributes, BC is expected to have one of the highest electric vehicle adoption rates in Canada.

Fuel savings are compelling because Metro Vancouver’s electricity rates are some of the lowest in North America while gasoline and diesel prices are among the highest, creating one of the largest price differentials between electricity and gasoline. A lifecycle cost analysis comparing the value of ICE and EV vehicles shows that a cumulative value of incentives in the region of \$7,500 would make the economic choice between ICE and EV equivalent.

Metro Vancouver’s driving patterns also favour electric vehicles, with 76% of commutes outside downtown Vancouver being less than 10 km and only 3-6% of trips within Vancouver exceeding 30 km. These distances are well within the typical battery electric vehicle (BEV) range.

The research team assessed 14 projections on PEV adoption rates in North America, Canada, and BC. These projections suggest that if no supporting incentives or significant infrastructure are in place, Metro Vancouver can expect to have 5,000-10,000 PEVs by 2020. With incentives, this estimate doubles, translating into a 0.5% decrease in light duty vehicle emissions by 2020 and more rapid increases over the 2020-2030 timeframe. In November 2011, the Province announced a \$17 million initiative providing up to \$5,000 off the cost of battery electric and plug-in hybrid vehicles and \$6.5 million to develop a provincial network of charging options. The initiative also includes a \$500 rebate for household chargers.

With respect to environmental benefits, if carbon is priced at \$25/tonne, carbon costs are reduced by \$875,000 on an annual basis by 2020. Monetizing fine particulate matter (PM2.5) at a cost of \$813/tonne achieves annual reduced health costs between \$1,600 and \$5,600 by 2020.<sup>33</sup> The probable scenario shows savings on fossil fuel spending of around \$14 million in the year 2020 (some of these savings will be mitigated by electricity purchases from electric utilities). Consequently, PEVs in Metro Vancouver in 2020 could save almost \$15 million annually due to fuel cost savings and emissions reductions.

**Table 12: Lifecycle Cost of EVs vs. ICE vehicles**

<b>Summary Table</b>	
<b>First Cost for EV vs ICE</b>	
BEV	\$ 42,595
ICE	\$ 23,442
<b>Differential</b>	<b>\$ 19,153</b>
<b>Fuel Cost over Life Cycle</b>	
BEV	\$ 3,200
ICE	\$ 16,544
<b>Differential</b>	<b>\$ 13,344</b>
<b>Emissions Cost Savings (borne by taxpayer)</b>	
GHG	\$ 780
CAC	\$ 1
<b>Net Present Value of ICE vs EV Choice</b>	<b>\$ (7,373)</b>

<sup>33</sup> The CAC calculation is based on 1,154,880 passenger vehicles in Metro Vancouver and the inventory of PM2.5 from passenger vehicles of 127 tonnes which results in 0.00011 tonnes per vehicle, monetized at \$813 per tonne.



Metro Vancouver, its member municipalities and Translink can all benefit from a higher level of PEV adoption in the region.

**Table 13: Value to stakeholders**

Stakeholders	Value of PEV adoption in the passenger vehicle fleet
Municipalities	<ul style="list-style-type: none"> <li>• PEVs can help municipalities achieve the GHG reduction targets in their Official Community Plans and Community Energy and Emissions Plans</li> </ul>
Metro Vancouver	<ul style="list-style-type: none"> <li>• Alignment and support for the Integrated Air Quality and GHG Management Plan</li> <li>• Alignment and support for municipal GHG reduction plans</li> <li>• Assists in branding of the region as a green leader</li> </ul>
TransLink	<ul style="list-style-type: none"> <li>• Supports Transportation 2040 Goal 1 – ‘Greenhouse gas emissions from transportation are aggressively reduced’</li> <li>• Supports achievement of a sustainable transportation system where transportation fuels are provided from renewable sources</li> <li>• Supports regional and municipal plans</li> </ul>

There are many specific actions that are useful to accelerate the deployment of PEVs. These actions tend to fall into the three strategies outlined below.

**Table 14: Strategies for accelerating PEV deployment**

<b>1. Buying</b>	<ul style="list-style-type: none"> <li>• PEV purchase price incentives</li> <li>• EVSE installation cost incentives</li> <li>• Local government leadership in fleet purchasing</li> </ul>						
<b>2. Using</b>	<ul style="list-style-type: none"> <li>• Carbon taxes or fuel taxes to maintain or improve the electricity - fuel price difference</li> <li>• Preferred parking and HOV lane access to save time and improve convenience</li> <li>• Reduced licensing fees</li> </ul>						
<b>3. Plugging in</b>	<table border="0"> <tr> <td>Existing Home &amp; Work</td> <td>New Residential &amp; Commercial Construction</td> <td>Public</td> </tr> <tr> <td> <ul style="list-style-type: none"> <li>• How to guide</li> <li>• Streamlined permitting</li> <li>• Info at permit time</li> <li>• Exempt EVSE improvements from valuations</li> </ul> </td> <td> <ul style="list-style-type: none"> <li>• Developer incentives for EVSE</li> <li>• Developer incentives for public EVSE (amenity)</li> <li>• Building code EVSE requirements</li> </ul> </td> <td> <ul style="list-style-type: none"> <li>• Minimum Regional EVSE network plan</li> <li>• Public EVSE Signage Regulation</li> <li>• Simple, standard process for private sector public EVSE investment</li> <li>• Invest in public EVSE</li> </ul> </td> </tr> </table>	Existing Home & Work	New Residential & Commercial Construction	Public	<ul style="list-style-type: none"> <li>• How to guide</li> <li>• Streamlined permitting</li> <li>• Info at permit time</li> <li>• Exempt EVSE improvements from valuations</li> </ul>	<ul style="list-style-type: none"> <li>• Developer incentives for EVSE</li> <li>• Developer incentives for public EVSE (amenity)</li> <li>• Building code EVSE requirements</li> </ul>	<ul style="list-style-type: none"> <li>• Minimum Regional EVSE network plan</li> <li>• Public EVSE Signage Regulation</li> <li>• Simple, standard process for private sector public EVSE investment</li> <li>• Invest in public EVSE</li> </ul>
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**Suggested Next Steps:**

- Clarify roles for Translink, Metro Vancouver and its member municipalities.
- Identify policy levers and specific actions for regional collaboration.
- Initiate a structured regional collaboration partnership to further develop and implement levers and actions identified.

## Sources of Additional Information

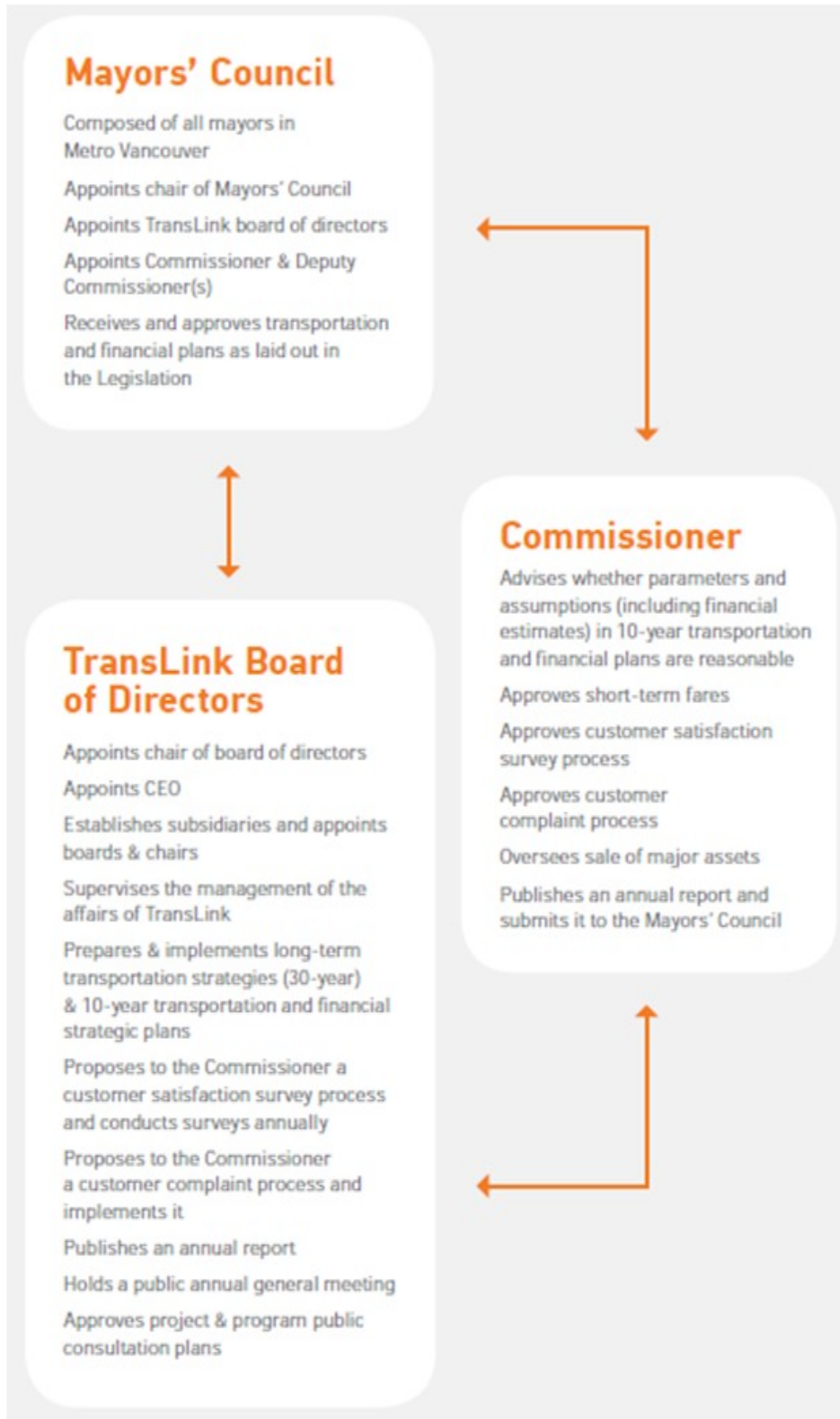
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The following are sources of additional information:

1. Green Fleets Plug-In Electric Vehicle Buyers Group: [http://www.e3fleet.com/plugin\\_bc.html](http://www.e3fleet.com/plugin_bc.html)
2. Pembina Institute – Electric Vehicles – Powering the Future: <http://pubs.pembina.org/reports/powermyride-bg-final.pdf>
3. Rocky Mountain Institute: <http://projectgetready.com/js/tco.html>
4. Vancouver Electric Vehicle Association: <http://www.veva.ca>

## Appendix A – TransLink’s Governance Model

Figure 18 TransLink’s Governance Model



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## Appendix B – Research Supporting Market Penetration Scenarios

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### Studies Reviewed

AutoGuide.com, *Mitsubishi Sets Goal of 2,000 EV Sales By April 2012*. <http://www.autoguide.com/auto-news/2011/07/mitsubishi-sets-goal-of-2000-ev-sales-by-april-2012.html>

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National Research Council, *Transitions to Alternative Transportation Technologies – Plug-in Hybrid Electric Vehicles*, National Academies Press, 2010

The Boston Consulting Group, *The Comeback of the Electric Car? How Real, How Soon, and What Must Happen Next*, 2009. <http://www.bcg.com/documents/file15404.pdf>

**Optimistic Scenarios**

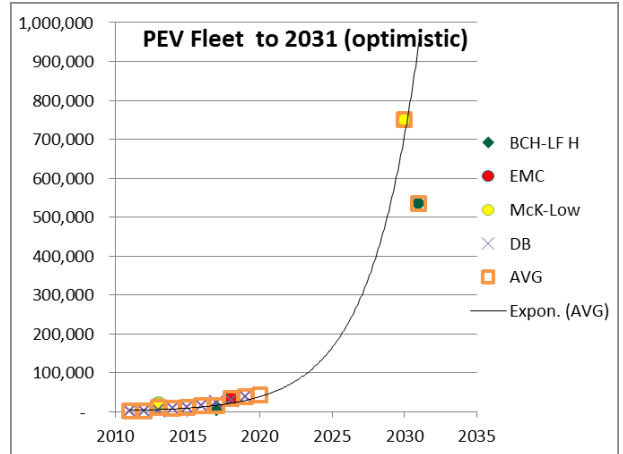
In contrast to the ‘probable’ scenarios, EMC and McKinsey (low) scenarios / goals would see over 40,000 PEVs on Metro Vancouver roads by 2020. This rises to between 500,000 and 750,000 (BC Hydro Load Forecast, 2010 – High, and McKinsey – Low scenarios) by 2030. This represents between 1/3 and 1/2 of all passenger vehicles on Metro Vancouver roads in 2030. McKinsey high scenario is 30% higher.

Optimistic scenarios were plotted to 2031 to encompass the years that specific studies identified projections for.

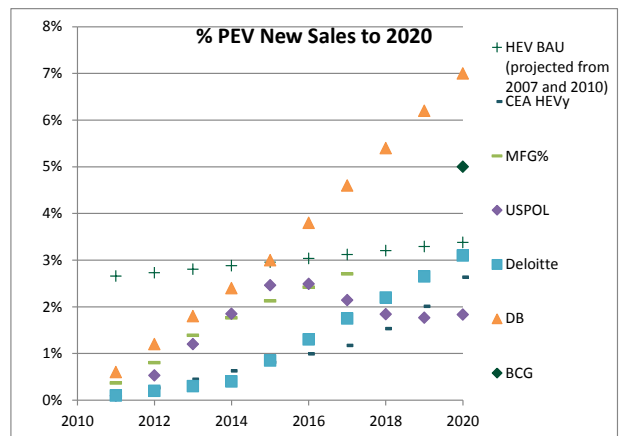
**PEV New Sales**

Providing another perspective on these scenarios is the volume of PEV new sales to 2020 as shown in Figure 20 (absolute new sales). Not all studies provide projections of new sales. The Deutsche Bank Projection is aggressive. Boston Consulting Group is high, but falls in the range of the probable cluster of scenarios.

**Figure 19 PEV projections – optimistic scenario**



**Figure 20 Percent PEV New Sales to 2020**





## Appendix C – Metro Vancouver PEV Model

In completing the Primer, the research team reviewed 13 different projections on PEV adoption rates in North America, Canada, and BC. The team also created one projection, referred to as CEA Hybrid Electric Vehicle – scenario ‘y’ or (HEVy). The scenario is based on the actual historical adoption curve observed for HEVs in Metro Vancouver from market entry in 2000 out ten years to 2010. In total, 14 projections were assessed. All studies considered had at least one relevant data point between 2011 and 2031 and were published between 2008 and 2011 by reputable organizations. For studies that provided multiple scenarios, the mid-range projection was chosen.

1. **Pacific Northwest National Laboratory (PNNL) – (U.S. Department of Energy (DOE)) “Plug-in Hybrid Electric Vehicle Market Penetration Scenarios”, PNNL-17441 (R&D scenario)**: PHEV forecast built off existing market forecasts of hybrid technology according to Greene et al. (2004) with PHEV shares of the hybrid market estimated in EPRI and NRDC (2007). PHEV technology development accelerated as a result of advancements made in hybrid technology.
2. **Pacific Northwest National Laboratory (PNNL) – (U.S. Department of Energy (DOE)) – “Plug-in Hybrid Electric Vehicle Market Penetration Scenarios”, PNNL-17441 (Technology based scenario)**: Delphi approach asking domain experts for their best judgment, given the following conditions:
  - \$4,000 marginal cost of PHEV technology over existing hybrid technology
  - 40 mile all electric range
  - 100 miles per gallon equivalent
  - PHEV batteries meet industry standards regarding economic life and safety
  - Tax incentives, regulations and technical standards favour PHEVs.
3. **BC Hydro Load Forecast, 2010 - Base Scenario**: The reference case includes the following main assumptions:
  - A constant energy efficiency, 25 miles per gallon for gasoline vehicles and 0.20 KWh per km for EVs.
  - No specific new policy initiatives for encouraging EVs.
  - The supply of EVs is constrained in the first 10 years of the forecast. Auto manufacturers will need several years to significantly increase mass production once demand for EVs increases. In addition the market place will need time to evolve in areas of battery production, retrofitting current factories or creating new facilities dedicated to EV manufacturing.
4. **BC Hydro Load Forecast, 2010 -High Scenario**: a series of potential actions are taken to facilitate the introduction of EVs.
  - Capital cost for EVs is reduced by a \$5,000 government subsidy on the purchase of EVs.
  - There is an additional credit of \$2,000 towards home charging equipment costs
  - The range of EVs is allowed to increase over time based on the assumption of a significant number of EV charging stations in BC Hydro’s service territory.
  - These measures and initiatives significantly increase the adoption rate of EVs over the Base Scenario.
5. **McKinsey & Company – “BC Hydro’s Electric Transportation Strategy: Discussion Document. Prepared for BC Hydro. June 26, 2009** - low case: Suggests of PEVs 2013, 25,000 and number of PEVs 2030 is 1,000,000 in BC.
6. **Deloitte – “Gaining Traction: A customer view of electric vehicle mass adoption in the U.S. automotive market”, 2010**: Based a consumer preference analysis with the following ‘probable’ scenario values:
  - Awareness (familiarity with brand): 83%
  - Opinion (charging infrastructure): 44%
  - Consideration (range, price and ownership cost): 24%
  - Projected EV (PHEV & BEV) sales US market: 2015: 0.4%, 2020: 3.1%
  - Purchase price: \$35K, Range: 200 miles, Gase price: \$3.50/USGal
7. **Deutsche Bank – “Electric Cars: Plugged In 2”, November 2009**: By 2020, we believe PHEVs/BEVs will approach 11% of the global market, with HEVs at just below 9%. Importantly, PHEVs and EVs utilize batteries that are up to 10x the size of those used in HEVs. We’ve incorporated the following assumptions:
  - Assume that all PHEVs and EVs are powered by lithium-ion batteries. For HEVs, we’ve assumed that Nickel Metal Hydride batteries power 85% of HEVs in 2013, 65% in 2015, 50% in 2018, and 30% in 2020.



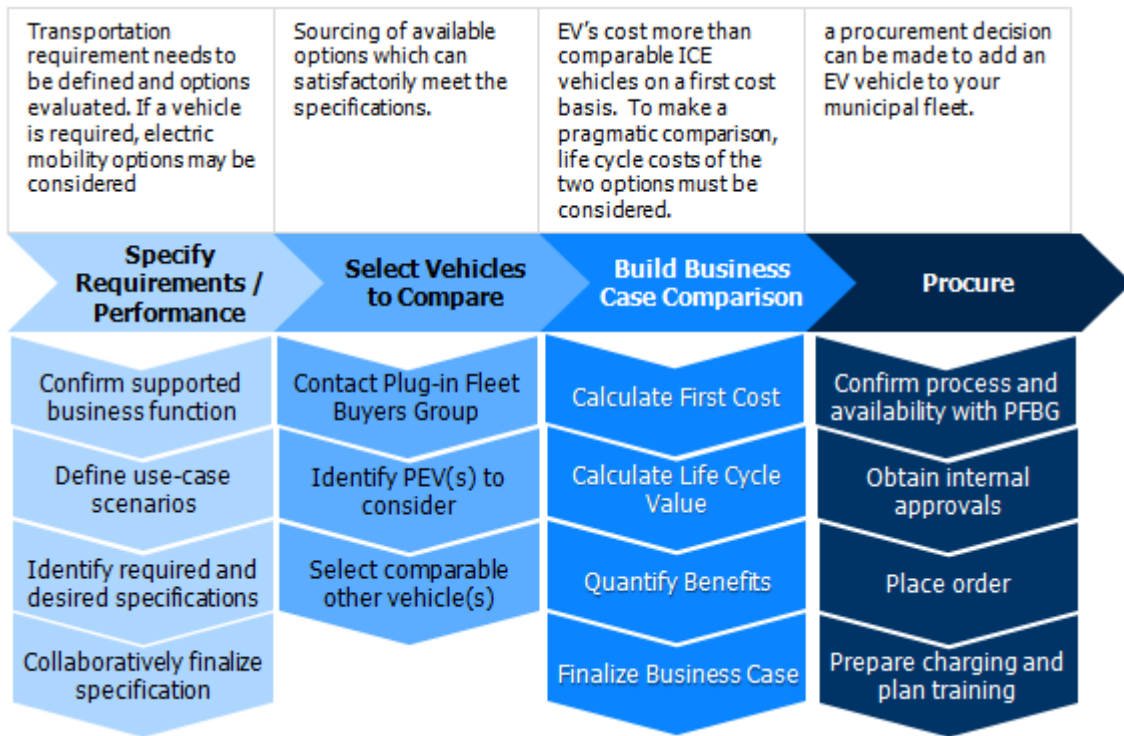
- Assumed that EVs use 25 kWh batteries, PHEVs use 12.5 kWh batteries, full hybrids use 2 kWh batteries, and mild hybrids use 1 kWh batteries.
  - Assumption incorporates flat battery pricing through 2012. And then, starting in 2013 assume that pricing declines by 7% per year through 2020.
8. **Electric Vehicle Technology Roadmap for Canada, 2008, Electric Mobility Canada (EMC) – Targets**: at least 500,000 Electric Vehicles on the road in Canada in 2018. This represents 15% of vehicles produced in 2018 would be EVs. Doesn't differentiate between PHEV and BEV. The 500,000 vehicles target has been scaled to the BC market place based on population. It is assumed PHEV technology development accelerated as a result of advancements made in hybrid technology in conjunction with supportive policy.
  9. **Mitsubishi Goal, 2010**: PEVs as a percentage of new sales in 2020 will be 20%.
  10. **National Research Council (NRC), 2010 – “Transitions to Alternative Transportation Technologies”**: PHEV market penetration 2030 4.30%.
  11. **Cambridge Systematics, BC Ministry of the Environment, March 2010**: (Scenario 2 – Mid Range) Assumes 50% of the EV penetration rate assumed in Scenario 1. Projected ZEV sales as % of new vehicles 2015 0.56% and 2020 1.5%. Assumes
  12. **Sentech, Inc. / ORNL – “Plug-in Hybrid Electric Vehicle Market Introduction Study”**: (US Policy high tech Case) Assumes 2015 PEV % of total new vehicle sales 2.46%, 2020 PEV % of total new vehicle sales 1.84%.
  13. **The Boston Consulting Group (BCG) – “The Comeback of the Electric Car”**: (steady pace scenario) New sales % PEV (PHEV 3% + BEV 2%) 2020 5%.
  14. **Community Energy Association (CEA) Hybrid Electric Vehicle**: Scenario 'y' is based on actual historical market penetration of HEVs into the Metro Vancouver light duty vehicle market place. Includes all vehicles, commercial and residential and is based on ICBC data. 2000 0%, 2007 0.6%, 2010 1%.

## Appendix D – How to Add an EV to a Local Government Fleet

Figure 21 (adapted from the Plug In BC Fleet Buyers Group) outlines the steps typically involved in adding a PEV to a local government fleet. Note that specific business case formats and approvals vary significantly among local governments.

Further on is guidance on ‘Building a Business Case Comparison’ and ‘Procuring’.

**Figure 21 Adding PEVs to a local government fleet**



### Business Case Comparison

#### Step 1 – First Cost

As Table 15 indicates, as of November 2011, electric vehicles first cost is approximately \$15,000 to \$25,000 more than their comparable internal combustion engine (ICE) alternatives.<sup>34</sup>

<sup>34</sup> Note: Battery costs are expected to decrease, reducing first cost purchase price for EVs. All emerging technologies suffer higher initial costs but often drop substantially with higher sales volumes and market maturity.

**Table 15: Comparable Purchase Price: Electric Vehicles vs. Standard Internal Combustion Engine Vehicles or Hybrid Electric Vehicles**

PEV	Type	2011 MSRP	Comparable ICE/HEV vehicle	Est. 2011 Price	Price Difference
Nissan Leaf	BEV	\$ 38,395	Toyota Yaris	\$ 14,000.0 [i]	\$ 24,395
Mitsubishi iMiEV	BEV	\$ 32,998	Honda Fit	\$ 14,500.0 [ii]	\$ 18,498
Ford Transit Connect (EV)	BEV	\$ 57,400 [v]	Ford Transit Connect (ICE)	\$ 28,621.0 [iii]	\$ 28,779
Chevrolet Volt	PHEV	\$ 41,545	Toyota Hybrid Prius	\$ 30,045	\$ 11,500
Toyota Prius (PHEV)	PHEV	\$ 42,636 [iv]	Toyota Hybrid Prius	\$ 30,045	\$ 12,591
		\$ 42,595		Average Difference:	\$ 19,153
				\$ 23,442.2	

[i] <http://www.toyota.ca/toyota/en/vehicles/yaris-hatchback/overview>

[ii] <http://www.honda.ca/fit>

[iii] [http://www.ford.ca/app/commercial/en/vehicles/transit\\_connect.do#buildandprice](http://www.ford.ca/app/commercial/en/vehicles/transit_connect.do#buildandprice)

[iv] <http://projectgetready.com/js/tco.html>

[v] US market pricing, July 27, 2011, Globe and Mail, Michael Vaughn;

<http://www.theglobeandmail.com/globe-drive/green-driving/news-and-notes/ford-transits-canadian-connection/article2111747/>

In addition to the cost of the vehicle, charging equipment must be considered. If a standard outlet is available and a 12-20 hour (overnight) charging time is acceptable, limited or no cost for charging infrastructure may be required.<sup>35</sup> Most PEV fleet sites are expected to install Level 2 (240V/40Amp) charging that allows a 4-6 hour full charge. This may be as simple as a dedicated 240v 40amp circuit. Installation costs should consider if additional electrical capacity is needed (transformer, new service, distribution panel, meters, breakers, etc.) as well as permitting and trenching if required to a convenient location. In addition to a 240v 40amp circuit, an EVSE may be desirable to increase safety, provide data, and simplify use. Installed cost may be up to \$10,000 per Level 2 charging station. If there are any point-of-purchase grants, the value of the grant should be deducted from the MSRP. Also, if there is any differential taxation between ICE's and EVs, this should also be factored into the accounting.

## Step 2 – Lifecycle Value

Lifecycle value to consider in a PEV purchase includes:

- Fuel costs - energy per kilometre, estimated kilometres, and cost of energy (gasoline, diesel, or electricity)
- Value of emissions – greenhouse gasses (GHGs) and criteria air contaminants (CACs) particularly PM2.5
- Vehicle maintenance including parts and inventory requirements
- Extended useful life - vehicle life may be 20% longer for EVs due to reduced vibration and wear than for ICE engines.
- Residual value
- Possibility of special road tax to offset displaced gasoline tax.

In addition, non-monetary factors such as supporting organizational mandates and goals are recommended to be included in a full analysis.

**Fuel costs** are significantly different between a PEV and an ICE.

Table 16 (a) summarizes the electricity and gasoline price forecast used to evaluate the economic choice between EVs and ICE type vehicles. The electricity price is forecast to increase at a rate of 5%, approximately twice that of historical the Consumer Price Index (CPI) in Canada. The gasoline price is forecast to increase at an annual increase rate of 8%. It is recognized that several market, fiscal, geo-political and policy decisions could have material impact on these assumptions. A linear average of each of the ten year price projections was used in the purchasing decision calculation.

<sup>35</sup> Note: Level 1 charging infrastructure can effectively “top up” an existing charge, which may suffice depending on anticipated length of journey.

**Table 16 (a) Electricity and gasoline price forecast**

	Unit	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Electricity Price Forecast	\$/kWh	\$ 0.08	\$ 0.08	\$ 0.09	\$ 0.09	\$ 0.10	\$ 0.10	\$ 0.11	\$ 0.11	\$ 0.12	\$ 0.12
Gasoline Price Forecast	\$/Litre	\$ 1.30	\$ 1.40	\$ 1.52	\$ 1.64	\$ 1.77	\$ 1.91	\$ 2.06	\$ 2.23	\$ 2.41	\$ 2.60
		Average \$ non-discounted									
	Unit										
Electricity Price Forecast	\$/kWh	\$ 0.10									
Gasoline Price Forecast	\$/Litre	\$ 1.88									

Fuel efficiencies of existing internal combustion engine and hybrid electric vehicles are available at the federal Ministry of Natural Resources of Canada (NRCAN) Transportation Fuel Consumption guide website: ([link: http://oee.nrcan.gc.ca/transportation/tools/fuel-consumption-guide/fuel-consumption-guide.cfm](http://oee.nrcan.gc.ca/transportation/tools/fuel-consumption-guide/fuel-consumption-guide.cfm)). Table 16 (b) provides a sample comparison of a BEV (fully electric) and a traditional ICE.

**Table 16 (b): Comparable Fuel Costs: Electric Vehicles vs. Standard Internal Combustion Engine Vehicles**

Calculation Parameter	BEV Value	ICE Value
Energy storage capacity	typical 24 - 28 kWh	40 litres
Vehicle mileage per unit of energy	5 km/kWh	5.5 L/100km
Energy cost per unit of energy	\$0.10 /kWh	\$1.88 / L
Energy cost per km	$(\$0.10/\text{kWh}) * (0.2 \text{ kWh}/\text{km}) = \$0.02/\text{km}$	$(1.881 * 5.5 / 100) = \$0.1034/\text{km}$
Average annual Vehicle Kilometres Travelled (VKT)	20,000 km/vehicle	20,000 km/vehicle
<b>Expected annual fuel cost</b>	<b>\$400</b>	<b>\$2,068</b>
Vehicle life expectancy for fleet use	8 years	8 years
<b>Fuel cost over useful life of vehicle</b>	<b>\$3,200</b>	<b>\$16,544</b>

The value of reduced GHG and CAC emissions is often a consideration in the lifecycle comparison of BEVs and ICEs. GHG reductions can be determined using the [Province of BC Climate Action Toolkit Project Profile for Low Emission Vehicles](http://smartplanningbc.ca/cgi/content.cgi/Project_Profile_LEV_2011-05-24.docx?id=1962&name=Project_Profile_LEV_2011-05-24.docx). (See: [http://smartplanningbc.ca/cgi/content.cgi/Project\\_Profile\\_LEV\\_2011-05-24.docx?id=1962&name=Project\\_Profile\\_LEV\\_2011-05-24.docx](http://smartplanningbc.ca/cgi/content.cgi/Project_Profile_LEV_2011-05-24.docx?id=1962&name=Project_Profile_LEV_2011-05-24.docx)) This guide was developed to guide investments in out-of-scope vehicles for the purposes of creating community projects to offset or balance local government emissions to meet carbon neutral commitments under the climate action charter. This approach works equally well for assessing in-scope vehicles.

The value of emissions is taken from the values currently employed by Pacific Carbon Trust (GHG) and Metro Vancouver (CAC).

**Table 17: Value of Reduced GHG and Criteria Air Contaminant Emissions**

Calculation Parameter	GHG	CAC
Value per tonne	\$25 (PCT)	\$813 (Metro Vancouver)
Annual average vehicle emissions (community-wide fleet in Metro Vancouver) (units)	3.9	0.00011
BEV Emissions (units)	0.0975 to 2016 then 0 due to carbon neutral grid	0
Emissions Savings (t/vehicle?)	3.9	0.00011
<b>Annual value of emissions savings</b>	<b>\$97.5</b>	<b>\$0.089</b>
Expected useful life of vehicle	8 years	8 years
<b>Total Savings over lifecycle</b>	<b>\$780</b>	<b>\$0.72</b>

The CAC calculation is based on 1,154,880 passenger vehicles in Metro Vancouver and the inventory of PM2.5 from passenger vehicles of 127 tonnes (Metro Vancouver 2005 Emissions backcast and forecast) which results in 0.00011 tonnes per vehicle. The GHG calculation is based on Metro Vancouver CEEI. GHG and CAC values will vary with actual use and size of specific comparison vehicles.

The Rocky Mountain Institute’s Project Get Ready, has developed a calculator which provides a comparison of electric vehicles to internal combustion engine vehicles (ICE) procurement on a lifecycle basis which provides a tool for simplifying the purchasing decision. Individual fleet operators may have savings values for reduced maintenance and inventory costs. (Link: <http://projectgetready.com/js/tco.html>)

### Step 3 – Quantify Benefits

**Table 18: Calculating GHG Savings**

Calculation Parameter	GHG	CAC
Value per tonne	\$25 (PCT)	\$813 (Metro Vancouver)
Annual average vehicle emissions ( community-wide fleet in Metro Vancouver) (units)	3.9	0.00011
BEV Emissions (units)	0.0975 to 2016 then 0*	0
Emissions Savings (t/vehicle)	3.9	0.00011
<b>Annual value of emissions savings</b>	<b>\$97.50</b>	<b>\$0.09</b>
Expected useful life of vehicle	8 years	8 years
<b>Total Savings over lifecycle</b>	<b>\$780</b>	<b>\$0.72</b>
<b>Net Present Value of ICE vs EV Choice</b>	<b>(\$7,373.14)</b>	

\* due to carbon neutral grid

This step involves accounting for the time value of money over the life of the vehicle to develop a NPV. Other benefits, such as market positioning, maintenance and inventory savings if quantifiable will enhance the business case.

An estimate of the approximate cost differential (including fuel savings, CACs, GHG emissions) expressed in net present value terms over an assumed eight year service life, discounted at 6%, represents a differential of \$7,400 in favour of ICE vehicles, from the perspective of a prospective owner. This value suggests that cumulative value of incentives in the region of \$7,500 would make the economic choice between ICE and EV equivalent. When the cost of EVSE is added, estimated at \$10,000 at the time of vehicle purchase, makes the differential \$16,900 in favour of ICE’s.

### Step 4 – Finalize Business Case

In this step, all the preceding elements are packaged together into a succinct whole ready for approval. This would show that the BEVs are still more expensive over the lifecycle unless grants are included. Therefore, there would likely need to be other benefits, such as showing leadership, to warrant purchasing these vehicles.

Tables 14 through 17 provide information about average BEV vs. ICE first procurement costs, fuel costs over an eight year life cycle, and monetized emissions over the same lifecycle. In the British Columbian jurisdiction, there are not currently Provincial, Federal or Regional financial incentives for the procurement of electric vehicles. Based on the results from the preceding section, it suggests that combined incentives of approximately \$7,500 would off-set the vehicle cost differential, removing the financial disincentive to procure an EV. Further, incentives related to the procurement of EVSE would likely further enhance EV market penetration.

### Step 5 – Procure

Auto manufacturers will require that an electric vehicle Certified Dealer be located close to the location of the acquired fleet electric vehicle. Certified Dealers are present in Metro Vancouver. The auto manufacturers do manage their inventory by allocating a national quota and distribute their available vehicles to sub-regions, subject to their discretion; therefore, orders numbers and locations will be negotiated with the purchaser and auto manufacturer.

Check with the Plug In BC Fleet Buyers Group for current information.

### Step 6 – Determine Roles

A functional or departmental distribution of roles required to acquire and manage electric vehicles can be expected in local government organizations. Participants in the Plug In BC Fleet Buyers Group have indicated the following departments provide key functional support:

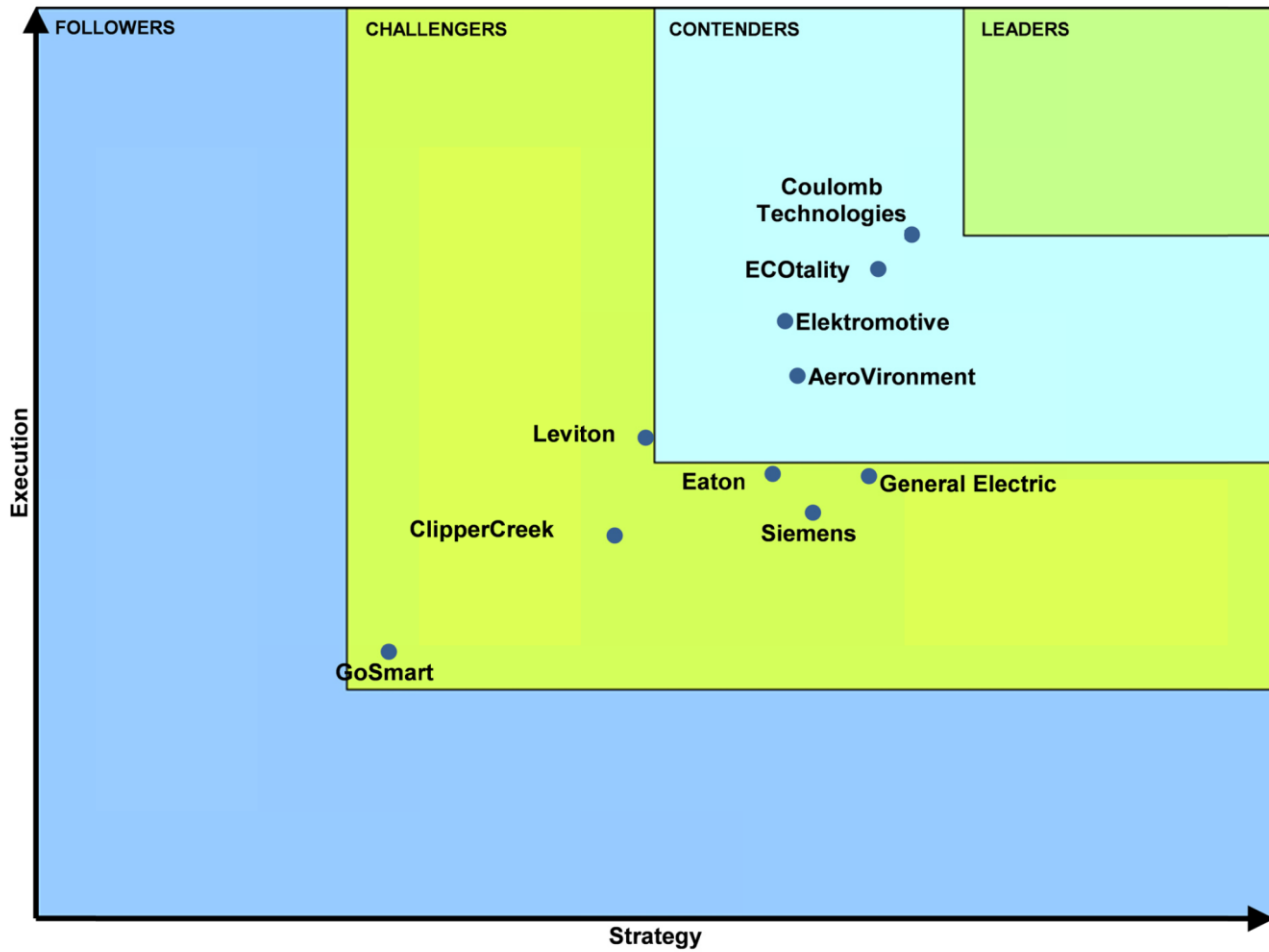
- **Engineering Department - Fleet/Equipment Services Team:** Provides assessment of vehicle applications, develops vehicle requirement specifications for Procurement, provides technical support to procurement and manages vehicles use and maintenance once in inventory, including battery and normal vehicle wear items.
- **Procurement Department:** Receives vehicle requirements specifications, develops Tender documentation, makes electric vehicle procurement decision given policy, commercial and technical constraints, negotiates procurement terms and conditions with auto supplier. Determines optimal commercial terms for local government.
- **Sustainability Group:** Develops and implements local government and community sustainability initiatives related to air quality and climate change. Provides policy and rationale to Engineering Department. Provides charging infrastructure policy and strategy.
- **Chief Financial Officer (CFO):** Sets the financial policies and rules in place for financial decision making in the organization, in consideration of the policy and objectives of the local government.





## Appendix E – Charging Infrastructure Manufacturers

Figure 22 Charging infrastructure manufacturers



(Source: Pike Research)



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## Appendix F – EVSE Requirements/Incentives for Homes

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### Requiring EV Service Equipment (EVSE)

Requiring EVSE in new construction requires collaboration with the Province of BC due to concurrent authority in the building code. There are two options for developing the authority to require EVSE in new construction. The first is based on the experience of the Province of BC's solar-ready regulation which local governments can sign on to and create a bylaw that requires solar hot water "rough-in" for new construction. This would involve the Province of BC developing such a regulation and local governments signing on to it. An alternative approach is for a local government to develop a bylaw and bring it to the minister for approval. A standard form exists for submitting requests for building code changes.<sup>36</sup> Either way, there are technical considerations in crafting and evaluating an EVSE-ready bylaw for new residential construction including but not limited to:

- Technical considerations for part-9 residential construction:
  - A 240V 40Amp dedicated circuit
  - Location of outlet near driveway, carport, or garage for surface parking
  - Adequate space and structure to mount Level-2 EVSE
  - Labelling of circuit
  - Ensuring sufficient capacity for electrical service including electrical panel
  - Completed circuits may further reduce long-term costs. At a minimum, a rough-in including capacity and conduit
- Technical considerations for multi-unit residential buildings (MURBS)
  - All part-9 considerations
  - Number and physical distribution of circuits for underground parking
  - Financial aspects including metering (common area meter or separate meters)
  - Siting possibilities for EVSEs
  - Expansion capacity in panel, incoming electrical service including transformation equipment

### Incenting EVSE

With any new code addition, it is important to ensure that building inspectors and ideally counter-staff are familiar with the requirements.

In the absence of an enforceable bylaw, local governments can incent or encourage EVSE inclusion in new residential construction through the policy and regulatory tools already applied to other energy-related objectives. These are described in CEA's Policy And Governance - Renewable Energy Guide for Local Governments in BC and include tools such as density bonusing, sustainability guidelines, development permit areas, and expedited permitting.

LEED points are available to builders of new construction and owners of existing buildings.

#### **EVSE in New Construction**

In the 2009 LEED Reference Guide for New Construction, EVSE is addressed in Sustainable Sites Credit 4.3 Option 2. You can get 3 points for satisfying the requirement is to provide Alternative Fuelling Stations for 3% of the parking capacity (or 3 spaces for every 100).

#### **EVSE in Existing Buildings**

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<sup>36</sup> A completed form was submitted to the province by Vancouver Electric Vehicle Association in April 2010. It suggests a requirement wording as follows: "A powered outlet shall be provided in at least one of the parking stalls in an attached, built-in or detached garage or carport that serves each residential dwelling for use with an electric vehicle charging system for which specific installation requirements are located in the electrical code." This proposal is being processed by the province now. Consistency with it would be helpful in civic by-laws proposed. This wording is consistent with that in the Electrical Code Part 1 Section 26 (714) approved for the 2012 release.

In the 2009 LEED Reference Guide for Green Building Operations and Maintenance, EVSE is addressed in Sustainable Sites Credit 4.0. You can get 3-15 points for satisfying the requirement to reduce the number of commuting trips by your occupants using conventionally powered vehicles by 10-75%. This requirement requires you to survey your building's occupants to understand how much your actions have reduced commuting trips. Installing EVSE is one of the incentives the guide suggests to reduce the use of conventionally powered vehicles.