Director	CAO

COUNCIL AGENDA

Date: May 31, 2021 Item: 8.

DISTRICT OF WEST VANCOUVER

750 17TH STREET, WEST VANCOUVER BC V7V 3T3

COUNCIL REPORT

Date:	May 10, 2021
From:	Emily Willobee, Policy & Programs Planner
Subject:	EV Charging Study for District Fleet
File:	0332-01

RECOMMENDATION

THAT

1. staff prepare the following detailed requests for 2022 and 2023 budget submissions:
    a. dedicated investment of approximately $300,000-$400,000 annually for two years to electrify light-duty fleet vehicles and
    b. $40,000 over two years for EV charging infrastructure to support them;
2. staff continue to optimize electrification in the fleet;
3. staff report back to Council with an update in Q1 of 2023; and
4. Staff revisit the EV Charging Study for District Fleet every 5 years to respond to anticipated technological innovation.

1.0 Purpose

In October 2019, Council directed staff to proceed with an approach to reduce greenhouse gas (GHG) emissions in corporate operations in order to make progress on the United Nations International Panel on Climate Changes (IPCC) targets of 45% below 2010 levels by 2030.

At Council's direction, the District engaged a consultant to conduct a study to inform a long-range plan for electric vehicle (EV) charging infrastructure that would support further electrification the District's fleet.

This report provides a summary of findings from the consultant study for Council's consideration. It also provides Council with a high-level update on current projects related to the outputs of that study.

2.0 Executive Summary

District fleet vehicles generate GHG emissions while providing various municipal services, including the provision of potable water and wastewater disposal; maintenance of parks, roadways, and facilities; delivery of recreational programming, as well as police/fire/bylaw services.

Fleet Emissions Profile

Emissions associated with fleet operations have remained relatively stable at around 1,000 tonnes of carbon dioxide emitted (tCO2e) annually when emissions associated with contracted services are excluded. Police vehicles are estimated to contribute an average of 275 tCO2e annually. Per provincial guidelines for the Climate Action Revenue Incentive Program (CARIP), the District's annual GHG reporting historically excludes emissions associated with police vehicles. However, emissions reductions are available in police fleet operations and these opportunities were considered in the EV Charging Study for District Fleet.

Between 2015 and the end of 2021, the District's fleet will have increased by 14 vehicles or approximately 10%. Fleet size has expanded in response to increased demand for municipal services. In addition, the District has also increased its use of leased fleet vehicles over the last five years to meet seasonal operational demands (e.g. summer park maintenance).

Due in part to staff's historical efforts to decrease fleet GHGs, the addition of fleet vehicles has not resulted in a corresponding net increase to fleet emissions. However, fleet emissions are not decreasing on track with the District's Corporate Energy and Emissions Plan (Corporate EEP) or IPCC (Intergovernmental Panel on Climate Change) reduction targets.

Table 1: Emissions reductions targets

District Corporate EEP	IPCC
33% below 2010 baseline by 2020	45% below 2010 baseline by 2030

The most expedient way to reduce fleet emissions continues to be replacing internal combustion engine (ICE) vehicles with electric vehicles (EV). At the end of 2019, only four of 154 fleet vehicles were hybrid or electric. Medium and heavy-duty construction vehicles make up just a third of the District fleet, but account for more than half of fleet emissions. Electric vehicle technology is less readily available for medium and heavy-duty vehicle classes at this time.

The District has recently operationalized a set of green fleet purchasing procedures to further support fleet electrification and emissions reduction efforts. Investment in fleet EV charging infrastructure will also be critical.

EV Charging Study for District Fleet and Long-range Emissions Planning

At Council's direction, staff initiated work on an EV Charging Study for District Fleet (**Appendix A**) with the following objectives:

- provide EV charging platform and hardware recommendations for fleet;
- provide conceptual design for fleet charging stations at key District facilities; and

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- Develop planning tools to predict future greenhouse gas emissions reductions associated transitioning the fleet to rely more heavily on EVs over a 20-year horizon.

The study's primary focus is the District's municipal fleet. To a lesser degree, the study considers future demand for charging at District facilities from non-fleet user groups such as staff, visitors and the general public.

In late 2020, the District awarded the contract for this project to a consulting firm called Picea Hoa Cleantech ("the consultant"). As part of the EV Charging Study for District Fleet, the consultant analyzed the District's fleet utilization based on 2019 data. The study concluded that the District will require at least 30 Level 2 (6.2 kW and 13 kW) chargers and two Level 3 fast chargers (25kW) be installed over the next 5 years. The study report includes a series of recommendations to inform District procurement and administrative processes to bring this network of EV charging online.

The consultant also created a long-range planning tool for the District, and used this to model two GHG scenarios for the District fleet on a 20-year horizon. Scenario 1 is based on the District's current approach for fleet management, which is to introduce EVs wherever possible and provide charging when and where necessary. This scenario can be realistically operationalized, but does not achieve Corporate EEP targets or the more aggressive IPCC emissions reductions.

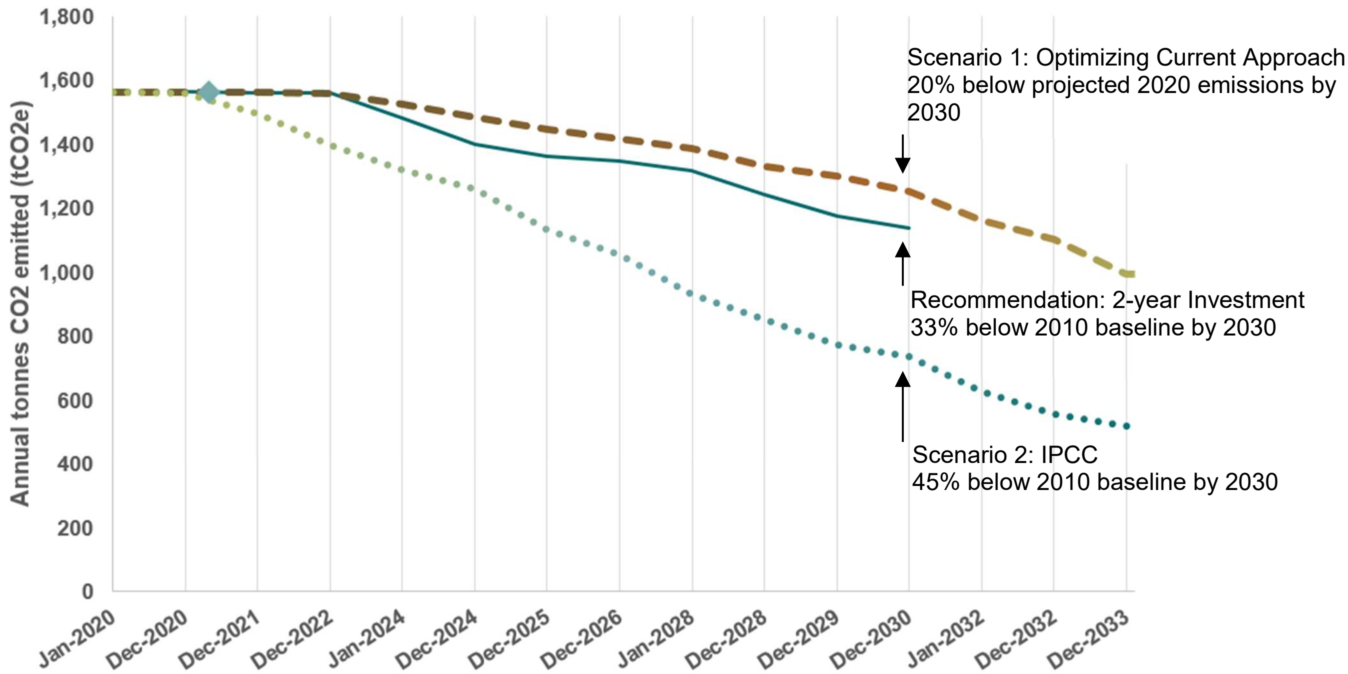
Scenario 2 models an approach by which the District could theoretically achieve IPCC targets by making a series of investments and operational adjustments. However, projected emissions reductions can only be realized if a number of external factors fall into place – in particular, vehicle and clean fuel technology developments for heavier vehicle classes.

Between the two scenarios is an approach that could be reasonably implemented with a high degree of certainty for achieving measurable results.

Both Scenario 1 and Scenario 2 project that the District's first significant investment in light-duty EVs will take place in 2023-24 (with 13 light-duty vehicle replacements scheduled over two years), with associated emissions reductions realized beginning in late 2025.

Given current market availability of light-duty EVs, the District could move forward this electrification with targeted investment beginning in 2022 to realize emissions reductions sooner, and increase projected reductions over the long term.

Figure 1: Fleet emissions projections over a 10-year horizon (includes police emissions)



With a dedicated additional investment of approximately $300,000-$400,000/year for two years the District could replace 10-12 cars, SUVs, vans and light-duty trucks. Charging infrastructure to support these 10-12 vehicles would require an additional investment of approximately $40,000 over two years.

Strategic, front-loaded investment over a 2-year term would achieve a projected emissions reduction of 410 tCO2e annually by 2030. This would position the District to achieve its Corporate EEP 2020 target of 33% reduction from the 2010 baseline by 2030.

Alongside these efforts, the District should continue to monitor the emissions reductions associated with transition to EV, and revisit the EV Charging Study for District Fleet and GHG model for long-range projections every 5 years in anticipation of technological innovation.

3.0 Legislation/Bylaw/Policy

The Province requires local government signatories of the BC Climate Action Charter to have targets, policies, and actions for the reduction of GHG emissions. The District signed the Climate Action Charter in 2008. Council adopted the District's Corporate Energy and Emissions Plan (Corporate EEP) in October 2016, which includes a series of actions to guide GHG reduction in municipal fleet operations. Council last received an update on the implementation status of corporate emissions reduction in October 2019, following the District's declaration of a "climate emergency".

The Province also has its own climate action plan, entitled “Clean BC”, which was adopted by the legislature in 2018. With its adoption, the Province set new targets compared to 2007 levels for GHG emissions as follows:

- 40% by 2030,
- 60% by 2040, and
- 80% by 2050.

Federally, Canada’s First Ministers adopted the Pan-Canadian Framework on Clean Growth and Climate Change in December 2016. In April 2021, the federal government reaffirmed its commitment, announcing that Canada set its emissions reduction target to 40-45% below 2005 levels by 2030. The Pan-Canadian Framework includes more than 50 concrete policy actions spanning the country and all sectors of the economy.

Regionally, Metro Vancouver is currently in the process of developing a climate action plan entitled “Climate 2050”.

4.0 Council Strategic Objective(s)/Official Community Plan

The 2018 OCP embedded emissions reduction actions into planning and land use management, including a community GHG reduction target in accordance with Section 473 of the *Local Government Act*.

The District’s OCP emissions targets for the community reflect IPCC targets of 45% below 2010 levels by 2040 and 100% by 2050.

Section 2.5 of the OCP includes the following corporate action to show leadership in sustainable operations:

> 2.5.19 Implement corporate energy and emissions reduction initiatives (e.g., energy and GHGs derived from municipal operations) to advance towards the District’s corporate GHG reduction target of 33% below 2007 levels by 2020 and 80% by 2050, and seek to achieve goals earlier if possible.

Additionally, Council’s Strategic Goal 3.0 is to *Protect our natural environment, reduce our impact on it, and adapt to climate change.* Included in Strategic Objective 3.1 is direction that the District reduce emissions in District operations such as fleet.

5.0 Financial Implications

This report recommends that Council direct staff to prepare capital budget requests for a two-year investment in fleet vehicles and EV charging infrastructure to support corporate fleet emissions reductions.

Capital investment is estimated at approximately $300,000-$400,000 annually for two years to electrify 10-12 light-duty fleet vehicles, and a capital budget of $40,000 over two years to provide EV charging infrastructure for these vehicles.

Strategic, front-loaded investment over a 2-year term would achieve a projected emissions reduction of 410 tCO_2e annually by 2030. The District could realize its Corporate EEP 2020 target of 33% reduction from the 2010 baseline by 2030.

Budget requests will be separate from and on top of the annual fleet renewal requirements, and clearly identified as investments in fleet emissions reduction. Although proposed to begin with the 2022 budget cycle, funding requests could be included for Council consideration as soon as July 2021 due to the District's recent implementation of a new "just-in-time" capital budget process.

6.0 Background

6.1 Previous Decisions

Council, at its October 28, 2019 meeting, received for information a report entitled "Climate Emergency – Corporate Approach to Meeting IPCC Climate Change Targets" and approved the following recommendation:

THAT

1. *the report dated October 11, 2019 regarding the Corporate Climate Action and Greenhouse Gas Reduction Strategy be received for information;*
2. *staff be directed to conduct an Electric Vehicle Charging Capacity Study, which will establish a long range plan for supportive charging infrastructure;*
3. *staff be directed to develop a green fleet purchasing procedures document to accompany a revised Purchasing Policy, in accordance with the Corporate Energy and Emissions Plan;*
4. *staff be directed to develop a Green Buildings Policy for Council consideration and approval requiring all District buildings be constructed to high levels of efficiency; and*
5. *staff report back with further information on the establishment of a Climate Action Reserve Fund.*

This Council Report provides an update to items 2 and 3 of the October 28, 2019 recommendation.

Council, at its July 8, 2019 Meeting, passed the following resolution:

THEREFORE BE IT RESOLVED THAT:

(1) Council recognizes that climate change constitutes an emergency for the District of West Vancouver; and

(2) Staff be directed to report back at the July 22, 2019, regular Council meeting regarding:

i. actions the District is presently taking to reduce GHG emissions (corporate and community) and performance metrics regarding emission targets;
ii. actions the District is presently taking to adapt to climate change; and

(3) Staff be directed to report back within 90 days regarding:
i. actions that other municipalities are taking to reduce their GHG emissions; and
ii. an approach to a comprehensive climate adaptation strategy that meets the present IPCC climate change target of 45% below 2010 levels by 2030 and 100% below 2010 levels by 2050.

Staff reported to Council on October 28, 2019 with respect to Clause (3) from a corporate perspective.

6.2 History

A summary of the District's recent history on climate action includes:

2016 – Adopting both the Corporate Energy and Emissions Plan (Corporate EEP) and Community Energy and Emissions Plan (CEE Plan);

2018 – Embedding the CEE Plan actions into OCP;

2019 – Recognizing that climate change constitutes an emergency;

2020 – Embedding IPCC targets for community emissions into the OCP and approving updates to other local bylaws (e.g. Building Bylaw) to support of emissions reduction; and

2020 – Initiating a long-range EV Charging Study for District Fleet as well as civil and electrical works to "EV-ready" select District facilities in preparation of supporting future electrification of fleet.

7.0 Analysis

7.1 Discussion

This report is comprised of the following sections:

- *Fleet Operations and Emissions Profile*, to provide Council with baseline information regarding the composition of the District fleet and emissions trends in fleet operations;
- *EV Charging Study for District Fleet,* which provides a summary of the District's long-range plans for EV Charging infrastructure to support electrification of the District's fleet as well as outputs from a GHG modeling exercise completed by study consultants, including options for implementing study findings to achieve emissions reductions in the District's fleet operations;

Fleet Operations and Emissions Profile

The District operates a fleet of 154 vehicles with a broad range of functionality. Nearly 60% of the District's fleet is considered light-duty, with the remainder being predominately medium, heavy-duty, and off-road construction vehicles.

District fleet vehicles generate emissions while providing various municipal services, including the provision of potable water and wastewater disposal; maintenance of parks, roadways and facilities; delivery of recreational programming, as well as police/fire/bylaw services.

In 2019, the District reported 3,213 tonnes of corporate CO2 emissions to the Province in its annual Climate Action Revenue Incentive Program (CARIP) report. Of these emissions, 950 tCO2e were associated with municipal fleet operations (excluding police)[1]. Mobile fuel use by contractors (e.g. garbage collection) accounted for an additional 594 tCO2e in 2019.

On average, municipal fleet operations account for approximately 30% of the District's annual corporate emissions, and contracted services fleet emissions account for an additional 8-15%.

Table 2: Corporate mobile fuel emissions for 2010 baseline and 2019 reporting year (excl police)

	Municipal Fleet mobile fuel emissions	Contracted Services mobile fuel emissions	Total
2010 Baseline (estimated)	1046 tCO2e	400 tCO2e	1446 tCO2e
2019 CARIP Reporting	950 tCO2e	594 tCO2e	1544 tCO2e

Council's adoption of the Corporate EEP in 2016 established corporate emissions reductions targets of 33% by 2020, and 80% by 2050, using 2010 as a baseline year. In declaring a climate emergency in 2019, Council expressed interest in more aggressive IPCC targets of 45% by 2030 and 100% by 2040, using 2010 as a baseline year.

Since the adoption of the Corporate EEP, the District has taken a number of steps to reduce emissions in the District fleet including:

- increasing the use of renewable diesel blends featuring higher biofuel content than the 5% required provincially (B5);
- retrofitting Utilities vehicles with anti-idling modules and auxiliary heaters to reduce fuel use due to idling;

[1] GHG emissions associated with local policing are not included in provincial CARIP reporting requirements because not all municipalities operate police departments. For the same reason, emissions associated with Blue Bus transit are not attributable to the District, but to TransLink. The District is, however, accountable for vehicle emissions associated with contractor-delivered services (e.g., garbage collection) and staff use of personal vehicles for work purposes.

- purchasing several plug-in electric or hybrid vehicles and electric equipment where possible, and deploying across multiple departments;
- right-sizing vehicles with smaller, more efficient engines and the lightest-weight vehicle bodies that meet operational requirements;
- replacing backhoes and other heavy equipment with engines certified to Tier IV standards to reduce particulate emissions;
- being an early adopter of new technology as it becomes available (e.g. the District is one of the first municipalities in Canada to deploy hybrid electric police cruisers for frontline operations);
- introduced emissions reporting requirements into the procurement process for contracted services; and
- adopting and operationalizing an interim set of corporate Green Fleet Purchasing Procedures in 2020-2021.

During the same period, the District fleet has expanded in response to demand for an increase in municipal services such as critical utilities work required to respond to aging infrastructure. Between 2015 and 2018, the fleet increased by 12 vehicles. By the end of 2021, the District will have added two more vehicles (one heavy-duty diesel truck, and its first light-duty hybrid electric truck). These additions amount to a 10% increase in overall size of the fleet.

Table 3: Expansion of District fleet by vehicle class and fuel type

	2015	2016	2017	2018
Additional Light-Duty Vehicle *Car, SUV, Van, Light-duty Truck*				
Electric or Hybrid	1			
Gas		4	1	1
Diesel		1		
Additional Heavy-Duty Vehicle				
Gas	1			
Diesel	1			
Off-Road Diesel	1			1

Over the last five years, the District has also increased its use of leased fleet vehicles to meet seasonal demands (e.g. summer park maintenance). Due in part to staff's historical efforts to reduce fleet GHGs, fleet expansion has not resulted in a corresponding net increase to fleet emissions.

Fleet emissions have remained relatively stable year-over-year at around 1,000 tCO_2e annually (with police and contracted emissions excluded).

Emissions are not decreasing on track with the District's Corporate EEP or IPCC emissions reductions targets.

Police vehicle emissions are excluded from the District's 2010 fleet emissions baseline calculations and the District's annual CARIP reporting, but are estimated to contribute an average of 275 tCO_2e annually. Although not historically included, there are emissions reductions available in police fleet operations. Opportunities for police fleet electrification are considered as part of the long-range planning exercises in the EV Charging Study for District Fleet.

The most expedient way to reduce fleet emissions without decreasing municipal service levels continues to be replacing internal combustion engine (ICE) vehicles with electric (EV) where possible, or plug-in electric (PHEV) and hybrid electric vehicles at minimum.

EV charging infrastructure is critical to support this transition.

2020 EV Charging Study for District Fleet

Following Council's direction in fall 2019, staff initiated work on an EV Charging Study for District Fleet (**Appendix A**) funded as part of the 2020 Budget. The objectives of the study were to:

- provide EV charging platform and hardware recommendations for fleet;
- provide charging station conceptual designs for key District facilities; and
- develop planning tools to predict future greenhouse gas emissions reductions associated transitioning the fleet to rely more heavily on EVs.

The study's primary focus is the District's municipal fleet. To a lesser degree, the study considers future demand for charging at District facilities from non-fleet user groups such as staff, visitors and the general public.

In late 2020, the District awarded the contract for this project to a consulting firm called Picea Hoa Cleantech ("the consultant") following a public procurement process. To produce the study report (Appendix A), the consultant analyzed utilization of the District's 154 fleet vehicles based on 2019 data provided by the District.

In 2019, medium and heavy-duty construction vehicles made up just a third of the District fleet, but accounted for more than half of fleet emissions. Four of 154 fleet vehicles (~2%) were hybrid or electric. The District has since replaced two frontline police vehicles with hybrid technology and increasing the proportion of fleet lower-emissions vehicles to 4%.

Table 4: Municipal fleet profile as of December 2019 (includes police)

Vehicle Class	Vehicle Count & Type	Proportion of Overall Fleet Assets	Estimated Proportion of Fleet Emissions
Car/SUV	33 Internal Combustion (ICE) 1 Hybrid (ICE) 2 Plug-in Electric Hybrid (PHEV) 1 Electric (EV)	24%	17%
Van	12 ICE	8%	2%
Shuttle Bus	3 ICE	2%	3%
Light-duty Truck	49 ICE	32%	24%
Medium Duty Truck	18 ICE	11.5%	15%
Heavy-duty Truck	17 ICE	11%	30%
Off-road Construction	18 ICE	11.5%	9%

Average vehicle usage sets a baseline for minimum EV charging requirements. The consultant identified that average daily vehicle usage is approximately 48km or 1.8 hours, and varies greatly across vehicle types. Peak vehicle utilization also drives fleet charging requirements. During simulations, it became clear that a number of frontline police, fire, and roads/utilities vehicles used for emergency or weather response would have very little downtime for re-charging during peak usage periods under the current operating approach. Because the anticipated peak usage requirements for these vehicles would skew the District's overall charging demand (and charging infrastructure cost projections) substantially, peak charging demand for these vehicles were excluded from conceptual charging designs provided in the final study report. These will require additional consideration in the future.

Based on projected fleet utilization, 1,100MWh of energy will be required to operate the majority of the District's fleet by 2040. To provide this energy as electricity rather than fossil fuels, the District will require a mixture of Level 2 (6.2 kW and 13 kW) chargers and Level 3 fast chargers (25kW), with at least 30 of these installed over the next 5 years. The District can expect to require a variety of hardware over the 20-year horizon, and should remain adaptable as the charging infrastructure and vehicles continue to evolve.

To manage a network of EV charging hardware, the District should pursue a horizontally-integrated network that relies on open communication protocols. This network architecture will offer the District the greatest flexibility in the selection of hardware vendors, minimize risks associated with relying on a single hardware provider, and provide functionality the District would require to avoid unnecessary power surcharges and to develop new revenue streams from its charging infrastructure.

The report provides a plan for deploying charging infrastructure that aligns with anticipated electrification rate of vehicles over the next 10-20 years. Some of the District's facility sites are likely to require electrical service upgrades to support new EV charging infrastructure in the future (e.g. Operations Centre).

Staff are currently preparing a Request for Proposals (RFP) for EV fleet charging equipment provider based on study recommendations.

Limitations of study and long-range emissions projections

Most importantly, the District's progress toward emissions reductions is in many cases dependent on vehicle emissions policies set by Provincial and Federal governments to drive technology changes and push industry standards. For example, Provincial Clean BC plan includes commitments such as:

- every new light-duty vehicle sold in BC will be a Zero Emissions Vehicle by 2040; and that
- BC will increase the low-carbon fuel standard, requiring that fuel suppliers reduce the carbon intensity of diesel and gasoline by 20% by 2030.

The implementation of Provincial and Federal plan elements, as well as industry's ability to deliver vehicles, batteries, and low-carbon fuels to market affect the District's progress toward emissions reduction targets in its fleet. This impact cannot be understated.

Study projections are based on information and technology currently available. However, vehicle and charging infrastructure are emerging fields and technology is evolving rapidly. Technology advancement, supply chains and vehicle availability are difficult to predict beyond a 3-5 year horizon, as are cost projections.

The operational realities of a municipal fleet also create near-term barriers to full electrification. Although some vehicle technology is available now (cars, SUVs) or in the near future (light-duty trucks, vans, shuttle buses), timelines for medium, heavy-duty and off-road electric vehicles are harder to predict. These heavier vehicle types account for approximately a third of the District's fleet and more than half of the fleet's emissions.

Additionally, municipal fleet vehicles are critical part of response for emergencies (e.g. snow, ice and extreme weather, fire and police emergency response). Further peak demand analysis, including risk

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assessments, are required to better understand and quantify emissions reduction opportunities for frontline vehicles.

Long-range planning scenarios based on GHG model

The consultant developed a modeling tool to inform municipal fleet planning and establish milestones influenced by IPCC emissions reductions targets. Embedded in the modeling tool are a number of parameters, including the following financial assumptions:

- 1% inflation rate
- Operational cost savings will be limited to fuel costs.[2]
- There will be no significant variation in fuels costs for diesel or gasoline.
- That charging infrastructure installation is scheduled to go hand-in-hand with the acquisition of vehicles requiring this infrastructure.
- Provincial and Federal EV rebates and grant programs for fleet charging infrastructure are currently available, but these were not included in long-term cost projections because program requirements and funding levels may change unexpectedly over time.

Financial assumptions are conservative and more detailed costing work will need to be done during budget planning, including rebate and cost-saving opportunities. However, the tool serves as a crucial starting point for long range planning toward emissions reduction targets.

Scenario 1: Optimizing Current Practices. (Existing Fleet Policy, replacement schedule, charging infrastructure installed when needed)

This scenario modeled GHG emissions reductions based on the District's current trajectory for municipal fleet asset renewal, technology projections, and recommendations for supportive EV charging infrastructure. The report provides a detailed roadmap for vehicle replacements and charging requirements over a 5-10 year horizon, and estimates over the 10-20 year timeframe.

The roadmap described under Scenario 1 is based on the following additional operational assumptions & limitations:

- That the District will continue to support an average capital fleet budget of $2 million annually.
- That the District will procure EV options where possible for a vehicle's scheduled replacement, given operational requirements and availability of technology.
- That fleet assets are replaced and upgraded according to a planned lifecycle of 7-12 years (excluding some police and fire vehicles, which are renewed more frequently).
- That fleet asset replacement cycles could be adjusted slightly to accommodate emerging technology. This may mean deferring the

[2] Other jurisdictions have observed additional operational and maintenance cost savings due to transitioning fleet vehicles to EV. In some case studies, maintenance savings are 50% or more.

replacement of a medium duty vehicle if an EV alternative is scheduled to become available in the near future. It also assumes the District will consider short-term leases as a stop gap and, in some years, make greater capital investments in order to replace multiple vehicles in the same class at the same time to achieve volume price savings, when new technology becomes available in that category.

- That there will be no expansion of the District's fleet assets, and no significant changes to fleet operational requirements.

Scenario 1 Findings:
At this current level of funding, 55 existing fleet vehicles will be replaced with EVs by 2030 resulting in an annual GHG reduction of 310 tonnes. The majority of vehicles proposed for electrification over the next 10 years are in the lighter duty vehicle classes. By 2040, the number of fleet EVs increases to 99 resulting in an annual GHG reduction of 580 tonnes.

Based on high peak usage requirements, the Scenario 1 roadmap recommends emergency response vehicles be replaced with either more efficient ICE (internal combustion engine) vehicles or, if available, PHEVs. However, in the long term, excluding these vehicles from electrification will limit emissions reductions that the District can achieve in its fleet.

Under Scenario 1, projected emissions reductions for 2030 and 2050 fall short of Corporate EEP emissions reduction targets and the more aggressive targets set by IPCC.

Scenario 2: IPCC Objective (What would it take to attain IPCC targets in the District Fleet)

A second scenario provided a theoretical roadmap by which the District could achieve IPCC targets of 45% reduction below the 2010 baseline year in fleet emissions by 2030 and 100% reduction by 2050.

Like Scenario 1, the report provides a detailed roadmap for vehicle replacements and charging requirements over a 5-10 year horizon, and estimates over the 10-20 year timeframe.

This roadmap builds on the baseline actions proposed in Scenario 1, and includes additional commitments to achieve further fleet emissions reduction. The roadmap described under Scenario 2 is based on the following additional assumptions:

- That the District is willing to increase the annual capital fleet budget to achieve IPCC targets.
- That the District would consider expansion of District fleet assets with EVs in order to meet peak usage requirements.
- That the District will invest in 100% renewably-sourced diesel fuel beginning in 2022 to reduce emissions associated with heavier vehicles where no suitable EV option is available. 100% renewable

diesel is more expensive, and has a lower emissions factor than B5 diesel.

Scenario 2 Findings:
It may be exceptionally difficult for the District to meet GHG reductions targets set by the IPCC in its fleet operations.

Scenario 2 roadmap indicates that in order to meet the IPCC targets, it will be critical that the District is able to substantially reduce emissions associated with heavy-duty vehicles (e.g. tandem dump trucks) as well as vehicles used for frontline policing, snow and/or debris clearing, and emergency vehicles (e.g. fire trucks).

To get on track to achieve IPCC targets, it is critical that the District makes near term investment in lower-carbon fuels such as 100% renewable diesel for medium, heavy-duty, and off-road vehicle classes.[3]

This roadmap to achieve IPCC targets depends heavily on the District having access to technological advancements from the private sector, particularly in the medium, heavy-duty vehicle, and off-road categories. This technology is likely to come over time, driven by provincial and federal policies, but the District has little direct control over market forces.

The report assumes these technologies will become commercially available, and suggests a number of additional steps the District could take to make progress on the IPCC target to reduce emissions by 100% by 2050. Recommendations include:

- expanding the District light-duty fleet with EVs that meet operational requirements for emergency and weather response. Additional vehicles would serve as a relief valve during peak usage periods, increasing frontline vehicle downtime to enable sufficient time to charge[4];
- installing additional and costly ultra-fast charging stations over the 20-year horizon;
- as an alternative to diesel, the District could consider compressed natural gas (CNG) or hydrogen fuel cell electric technology for heavy-duty fleet vehicles where plug-in electric technology is not available.

Findings in the study suggest that implementing the recommended changes results in an estimated minimum increase of $1M - $1.5M to the

[3] The District's fuel supplier has indicated that renewable diesel is only commercially available as a blend at this time. The District would need to pursue special arrangements with suppliers to access 100% renewable diesel fuel.
[4] During non-peak periods, these vehicles might also be considered for use as staff pool vehicles. Including electric pool vehicles in the fleet provides an opportunity for the District to reduce emissions associated with business use of a personal vehicle, and may support a future transportation demand management program for staff.

fleet capital budget over 10 years ($100-$200k per year, or a 5-10% annual increase between 2021 and 2030). Additional capital costs associated with electrifying police frontline operations, including vehicle and high-speed charging infrastructure, are projected for 2031 and beyond.

The proposed capital expenditures account for only a fraction of projected emissions reductions. Also embedded in Scenario 2 emissions projections is that the District will invest in lower-carbon diesel fuel beginning in 2022. Nearly half of projected emissions reductions in this scenario are gained from converting to 100% renewably-sourced diesel for all diesel-fueled vehicles. If the District is able to procure a steady supply of unblended renewable diesel, this could increase the District's diesel costs by at least $100,000 annually (approximate increase of 150% to the District's diesel budget). Additional fuel costs would be reflected in the fleet operating budget in the near term, prior to the District realizing operating cost savings that might be gained by converting vehicles to EV.

Two other key considerations are not included in costing for Scenario 2. The first is potential cost implications of operating changes to ensure vehicle downtime for charging. The second is the potential cost associated with upgrading back-up electrical power systems at the Operations Centre to provide energy to vehicles in case of a major event or electrical outage. Both are obstacles that could be addressed over the 20-year horizon if prioritized and funded.

Further study is required to verify and confirm whether other lower-emission fuel types, such as CNG or hydrogen fuel cells, could be viable alternatives to 100% renewable diesel for heavy-duty and off-road vehicles where EV options do not meet fleet operational requirements.

Discussion of Options

Scenario 1 is realistic and can be operationalized, but does not achieve Corporate EEP or the more aggressive IPCC emissions targets. Scenario 2 theoretically achieves IPCC targets by making a series of investments and operational adjustments, but only realizes projected emissions reductions if number of external factors fall into place.

The scenario modeling exercises from the EV Charging Study reveals a few key criteria by which to inform the District's decision-making with regard to achieving fleet emissions reductions. A few of the most important considerations include costs, availability of technology, and measurable emissions reduction potential.

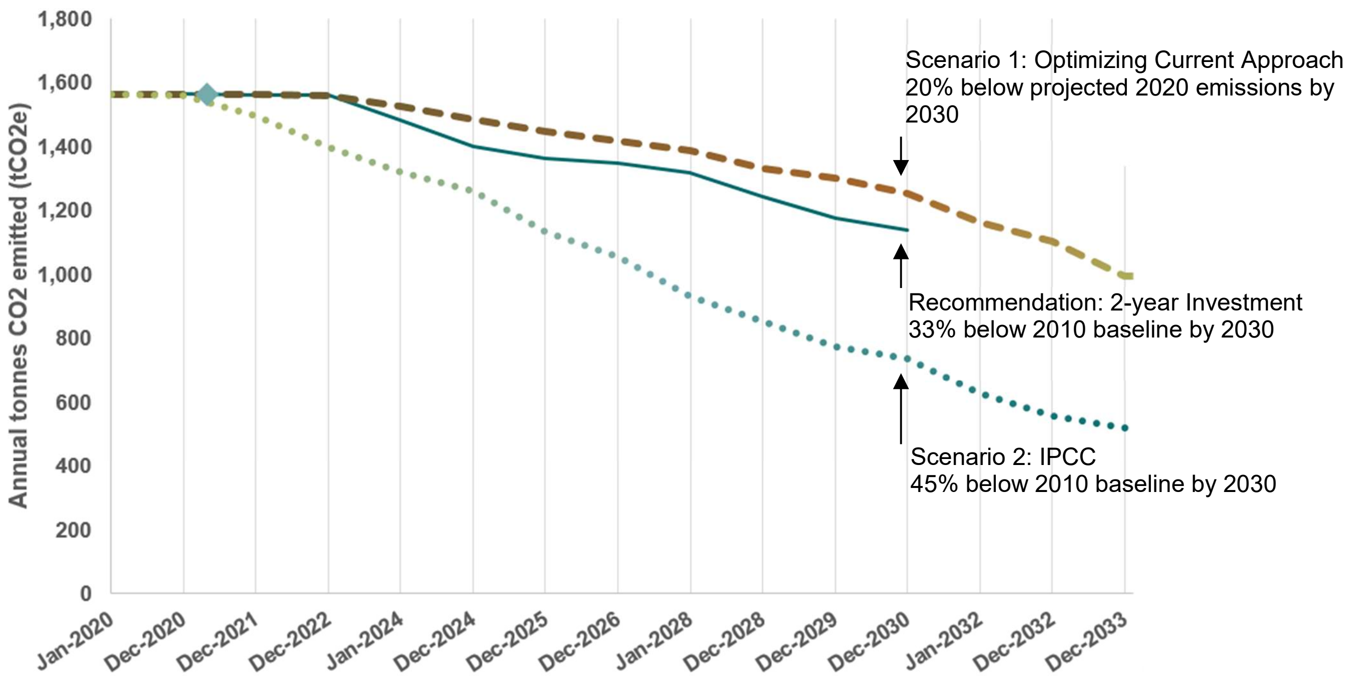
Additionally, the District must balance the opportunity costs of investment in fleet against possible investments in other areas that could reduce corporate emissions (e.g. facilities upgrades and retrofits) or community emissions. Municipal facilities, particularly recreation facilities, account for a similar proportion of the District's annual corporate emissions as its fleet operations (~30%).

Between the two scenarios may be an approach that could be reasonably implemented with a high degree of certainty for achieving measurable results.

Both Scenario 1 and Scenario 2 project that the District's first significant investment in light-duty EVs will take place in 2023-24 (with 13 light-duty vehicle replacements scheduled over two years), and associated emissions reductions begin to be realized in late 2025.

Given current market availability of light-duty EVs, the District could move forward this investment to 2022 or sooner. Moving forward investments in fleet electrification and charging infrastructure serves to reset the starting point for the Scenario 1 trend line and achieve greater emissions reductions in the longer term.

Figure 2: Fleet emissions projections over a 10-year horizon (includes police)



With a dedicated investment of approximately $300,000-$400,000/year for two years, the District could replace 10-12 cars, SUVs, vans, and light-duty trucks. The District would target two sets of fleet vehicles with this funding. The first group are vehicles that have surpassed their scheduled renewal dates, but replacement has been deferred either because EV option will be available in the near future or due to the impact of budget constraints on the annual fleet capital program. Addressing this group would help to address a backlog of deferred reinvestments in fleet, reduce operating costs associated with increased maintenance for aging vehicles, and clear the runway for electrifying additional fleet vehicles through the annual fleet capital program as technology becomes available. The second group are vehicles scheduled for replacement in the next 2-3 years that could be electrified sooner than anticipated in the existing fleet replacement programming. Charging infrastructure to support these 10-12 vehicles would cost an additional $40,000 over two years.

Budget requests would be separate from and on top of the annual fleet renewal requirements so as not to interrupt scheduled replacements of critical heavy vehicles, and clearly identified as an investment in fleet electrification and emissions reduction.

After a two-year capital injection, fleet capital budgets could return to its average annual of $2M. The District would continue to apply Scenario 1 practices to optimize emissions reductions in fleet.

A dedicated investment in electrification indicates a commitment to early adoption of EV technology (e.g. vans, light-duty trucks) and also allows the District to leverage cost saving opportunities such as better pricing and rebate programs.

A short-term initial investment in 2022 and 2023 would produce measurable nearer-term emissions reduction. It also avoids opportunity costs of drawing out the capital investments over 8 or 10 years, while staff:

- establish a fleet charging network and administration approach;
- monitor operational savings associated with transitioning to EV, such as fuel and maintenance, that off-set capital investments;
- continue to be an early adopter of emerging vehicle technology;
- work with suppliers to pilot more expensive but cleaner burning renewable diesel fuels for vehicles that are not yet viable for electrification; and
- continue to monitor emissions associated with fleet operations.

Table 5: Summary of emissions projections for options (includes police)

	Fleet mobile emissions projection (tCO2e)	Fleet mobile emissions projection (%)	Likelihood of achieving projected reductions on a 5-year horizon	Cost impacts above annual average fleet capital program ($2M)
Scenario 1	Reduction of 310tCO2e annually by 2030	~20% below 2010 baseline Falls short of Corporate EEP and IPCC targets	High	**Charger costs**: approx. $49k over 3 years
2-year investment (recommended)	Reduction of 430 tCO2e	33% reduction from 2010 baseline Achieves Corporate EEP 2020 target by 2030.	High	**Vehicle capital**: $300-$400k/year for 2 years, totalling $0.6M -0.8M **Charging capital**: approx. $40,000 over 2 years
Scenario 2	Reduction of 814tCO2e	45% reduction from 2010 baseline. On track to achieve IPCC targets	Medium/Low	**Vehicle capital**: $1.5M over 10 years ($100-$200k per year, or a 5-10% annual increase) **Fuel operating:** $100k or more added to annual diesel budget (150% increase) **Charging capital**: approx. $1M over 10 years

7.2 Sustainability

Reduction of GHG emissions is critical to support environmental sustainability. It also provides a range of social benefits including supporting complete, inclusive communities and minimizing the disruption from adaptation measure or associated risks of climate change.

Corporate emissions total less than 2% of West Vancouver's community emissions. Still, the climate emergency can only be addressed if every party does their part. The District has an opportunity to show leadership and reinforce its commitment as a Climate Action Charter member by taking corporate actions to meet the latest IPCC targets.

7.3 Public Engagement and Outreach

In 2016, a community Working Group contributed to the development of the District's Corporate Energy and Emissions Plan. Related to the

Declaration of a Climate Emergency in 2019, Council received substantial community feedback.

For this specific corporate emissions reduction initiative, no public engagement occurred. However, Council decisions regarding the District's annual budget – including capital and operating funds for the municipal fleet – are subject to public engagement processes, which take place in accordance with the District's *Community Engagement Policy*.

7.4 Other Communication, Consultation, and Research

Internal stakeholders representing various District departments and staff groups who rely on District fleet vehicles to conduct municipal business participated in two workshops regarding preliminary findings of the EV Charging Infrastructure Study and long range plans for District Fleet.

Additionally, staff reached out to colleagues and fleet managers from other municipal fleets and provincial fleet programs such as Plug-in BC to collect information about best practices for fleet emissions reduction.

8.0 Options

8.1 Recommended Option

THAT

1. staff prepare the following detailed requests for 2022 and 2023 budget submissions:
    a. dedicated investment of approximately $300,000-$400,000 annually for two years to electrify light-duty fleet vehicles and
    b. $40,000 over two years for EV charging infrastructure to support them;
2. staff continue to optimize electrification in the fleet;
3. staff report back to Council with an update in Q1 of 2023; and
4. staff revisit the EV Charging Study for District Fleet every 5 years to respond to anticipated technological innovation.

8.2 Considered Options

1. THAT staff do not prepare the budget submissions for 2022 as described above. This option was not recommended because it does not accelerate fleet emissions reductions in support of Council's Declaration of a Climate Emergency.
2. THAT Council provide alternative direction (to be specified).

9.0 Conclusion

In October 2019, Council directed staff to proceed with an approach to reduce greenhouse gas (GHG) emissions in corporate operations in order to make progress on the United Nations International Panel on Climate Changes (IPCC) targets of 45% below 2010 levels by 2030. To achieve emissions reductions in corporate will have financial implications for the District.

Strategic, front-loaded investment over a 2-year term would achieve a projected emissions reduction of 410 tCO2e annually by 2030. The District could realize its Corporate EEP 2020 target of 33% reduction from the 2010 baseline by 2030.

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Appendices:

Appendix A – EV Charging Study for District Fleet prepared by Picea Hoa Cleantech

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Hoa Cleantech

District of West Vancouver

Electric Vehicle Charging Infrastructure Study for District Fleet

Report

Date: 19 April 2021

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Report No.: 121000 (Rev C)

Executive Summary

The District of West Vancouver ("District") is planning for electric vehicle (EV) charging infrastructure to support the adoption of more electric vehicles into the corporate fleet in order to achieve reductions in its corporate greenhouse gas (GHG) emissions. To that end, the District requested proposals in 2020 for a study to:

- Provide conceptual designs for charging stations, platform recommendations, and recommend administrative approaches to the EV charging system that meets the needs of the predicted expansion of our EV fleet.
- Develop a model to predict future Greenhouse gas emissions, and emission reductions associated with the transition of its fleet to rely more heavily on EVs.

This study focuses on EV charging requirements of the District's corporate fleet. To a lesser degree, the study includes considerations related to building in some capacity for staff, public or visitor charging at District facilities.

The District awarded Picea Hoa Technologies Ltd. ("Hoa Cleantech") the contract for this charging infrastructure study, and this report provides the results, including strategic roadmaps to support the electrification of District fleet vehicles over a 20-year horizon.

Vehicle Charging & Systems Recommendations

Hoa Cleantech performed analyses on the existing utilization of the 154 fleet vehicles ranging from light to heavy-duty and off-road vehicles. Based on the 2019 data provided by the District, Hoa Cleantech identified that District fleet vehicles travel an average of approximately 48km per day or operate for approximately 1.8 hours per day, and are estimated to have emitted 1,590 tonnes of CO_2e in 2020.

In 2018 and 2019 employees were reimbursed for work use of personal vehicles a combined total of 115,880km and 125,705km respectively, resulting in an estimated 32 tonnes of CO_2e in 2019. In addition, 51 employees were provided a monthly vehicle allowance for work use of a personal vehicle totalling 324,300km per year.

Based on current fleet utilization rates, 1,100MWh of energy is required to operate the District fleet for a year if vehicles are electrified. Staff vehicles for work trips if transitioned to pool electric vehicles equate to an additional 25MWh of energy per year. To provide this energy as electricity rather than fossil fuels, Hoa Cleantech recommends that a mixture of Level 2 (6.2 kW and 13 kW) chargers and Level 3 fast chargers (25kW) will be required at the different facility sites to support fleet electrification over the next 20 years. The deployment of the charging infrastructure should be synchronized with the electrification of the vehicles, and electrical infrastructure upgrades will be required in the coming years to support EV charging infrastructure at some sites.

The charging infrastructure technology continuously evolves with new types of equipment and services to charge electric vehicles. The District is going to require a variety of hardware and technology as the charging infrastructure grows. Hoa Cleantech has recommended the District adopt a horizontally integrated approach using open communication protocols. This architecture will offer the District the greatest flexibility in the selection of vendors, minimize the risk of relying on a single provider, and maintain a good level of technological opportunity to leverage cost savings and potentially new revenue streams from fleet charging infrastructure.

20- Year Strategic Emissions Forecasts for Fleet EV Adoption

The District proposed four different scenarios to inform a 20-year strategic plan to reduce GHG emissions through fleet electrification. Scenarios included:

1. **Scenario #1**: Existing fleet policy, replacement schedule, charging infrastructure available when needed
2. **Scenario #2**: IPCC - What would it take to attain IPCC (Intergovernmental Panel on Climate Change) targets in the District fleet (45% GHG reduction by 2030, 100% by 2050)
3. **Scenario #3**: Expansion of zero-emission light duty pool vehicles
4. **Scenario #4**: Constrained funding

Hoa Cleantech developed a GHG Model by which to analyze these scenarios and generated roadmaps that would inform the District strategic decision-making for fleet emissions reductions. The main findings from modelling the four scenarios are highlighted below.

Scenario #1: *Existing fleet policy, replacement schedule, charging infrastructure available when needed*

The District's annual average CAPEX budget for fleet renewal is around $2M. At this current level of funding, 55 existing fleet vehicles will be replaced with EVs by 2030 resulting in an annual GHG reduction of 310 tonnes. By 2040 the number of fleet EVs increases to 99 resulting in an annual GHG reduction of 580 tonnes. These decreases are, respectively, 25% and 35% compared to anticipated 2020 emissions and fall well short of IPCC emissions reduction targets.

The Scenario 1 roadmap recommended frontline emergency response vehicles be replaced with either ICE (internal combustion engine) vehicles or PHEVs if available, based on their high peak usage. However, excluding these frontline vehicles from electrification in the long term will results in the District falling short of meeting the GHG reduction targets set by the IPCC.

Scenario #2: *IPCC - What would it Take to attain IPCC targets in the District fleet (45% GHG reduction by 2030, 100% by 2050)*

The Scenario 2 roadmap included some potential options to lower the emissions of the frontline police, snow and/or debris clearing, and emergency vehicles, which will be critical in order to meet the IPCC targets.

To achieve IPCC targets in District fleet operations, the District would need to consider a combination of purchasing renewable diesel, operational changes, back-up EVs and ultra-fast charging stations over the 20 year horizon. Implementing these changes between 2021 and 2030 results in an estimated increase to the 10-year CAPEX of $1M - $1.5M (5-10% increase), and an estimated annual increase in fuel cost of at least $30k (based on the assumption renewable diesel can be purchased at 50% more than the cost of existing diesel).

However, further work is required to verify and confirm whether these additional measures are the best approach given the operational requirements of District fleets. For example, more detailed analysis of the peak usage requirements for frontline, clearing and emergency vehicles would help to refine these projections. Analysis should include in-depth discussions with the relevant departments to better understand actual peak usage requirements, complete risk assessments, and consider alternative technologies like hydrogen fuel cell electric vehicles.

Other key considerations for vehicles utilized during emergency response include resilience of electrical power, back-up power, and fuel supply systems at the Operations Centre to provide energy to vehicles in case of a major event - all obstacles that could be addressed over the 20-year horizon if prioritized and funded.

Scenario 3: *Expansion of zero emission light duty pool vehicles to reduce emissions from personal vehicles for work trips*

The addition of approximately 13 electric pool vehicles over the next several years should significantly reduce staff personal vehicle use for work purposes. This expansion of the District's fleet would increase fleet CAPEX of $150,000 annually from 2022 to 2026. This investment could result in an annual GHG reduction of 30 tonnes from these staff vehicles (assuming they are gasoline powered) and save the District approximately $55k per year from mileage reimbursements.

Scenario 4: *Constrained funding*

If the annual CAPEX budget for District fleet vehicle renewal were constrained to approximately $1.5M, only around 27 existing fleet vehicles can be replaced by EVs by 2030, resulting in an annual reduction in GHG emissions of 110 tonnes. Fleet budget constraints could prevent the District from making progress on GHG reductions for medium and heavier duty vehicles, as well as frontline and emergency response vehicles.

Separately from these scenarios, there is also a potential to significantly reduce the peak power from charging EVs through the implementation of a smart charging management system. Charging infrastructure recommended in this report would enable the District to implement such a system, which would result in savings on the electrical demand charges. Finally, the District could apply to become a Part 3 Fuel supplier under the BC Low Carbon Fuel Standard. As a Part 3 Fuel Supplier, the District could generate approximately $50k per year of new revenue by 2030 through the generation of carbon credits.

Next Steps

To lower the District's GHG emissions over the next 3-5 years, it is recommended:

- Electrical infrastructure is designed and installed at the Municipal Hall and Operations Centre to accommodate future EV charging stations as per the conceptual designs.
- Vehicles at the end of their service life are replaced with equivalent electric vehicle versions, where practical and available (excluding frontline emergency response vehicles). This will start with cars and SUVs, and by 2025 should include vans, light-duty trucks, heavy-duty trucks and some off-road vehicles.
- A mixture of Level 2 (6.2 kW and 13 kW) chargers and Level 3 fast chargers (25kW) are installed across facility sites as vehicles are electrified. This will start with Level 2 (6.2 kW) chargers to support the electric cars and SUVs, and include Level 2 (13kW) chargers and Level 3 fast chargers (25 kW) as larger electric vehicles are purchased.

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Glossary

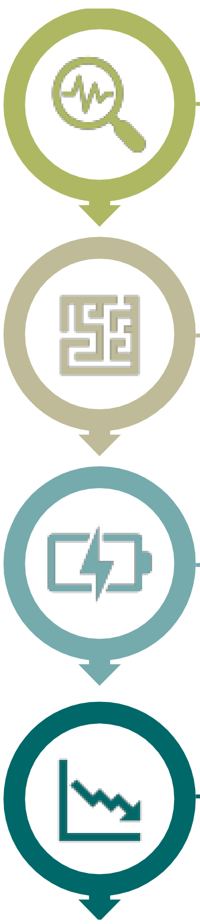
AC charging	Charging a vehicle using Alternating Current. This type of charging goes from 1.2 to 19 kW and can charge an EV in several hours
Annual Capex Requirement	Capital expenditure required by the District of West Vancouver under the defined scenario.
Authentication	Identification of a driver or a vehicle
Average energy/power	Mean value calculated based on yearly data provided
BC LCFS	BC Low Carbon Fuel Standard. A standard imposing gasoline and diesel fuel to reduce their carbon intensity until 2030. A carbon market was developed to incentivise carbon reduction projects.
BCUC	British Columbia Utility Commission. Organization regulating electricity rates in British Columbia.
Biodiesel	Biodiesel is a form of renewable diesel produced through a process called transesterification and must be blended with petroleum diesel to be used in existing diesel engines (i.e. B10 biodiesel contains 10% biodiesel and 90% petroleum diesel).
CAPEX	Capital Expenditure
Carbon Intensity (CI)	Carbon intensity (CI) measures the amount of carbon dioxide equivalents that will be emitted per MJ of energy consumed by that fuel.
CCS Combo	Combined Charging System. DC Charging standard used in North America, Europe and Oceania
CHAdeMO	DC Charging standard developed by Japanese automakers.
Charge Point	Term used in OCPP standard to define a charger/charging station.
Clearing vehicles	Snow and/or debris clearing vehicles
Clearing House	System connecting multiple CPO and eMSP together and managing the transactions.
CO_2e	Carbon dioxide equivalent is a measure used to compare the emissions from multiple greenhouse gases based upon their global warming potential.
Connected charger / networked charger	Charger with an internet communication able to send and receive command from a cloud-based system.
CPO	Charge Point Operator. Centralized system capable of communicating with the Charge Points.
CRA	Canadian Revenue Agency
Daily energy requirement	kWh of battery capacity used by driving the vehicle in a single day
Daily power requirement	kW required by the charging station to recharge the vehicle in the time it is parked
DC charging	Charging a vehicle using Direct Current. This type of charging goes from 20 kW up to 350 kW and can charge an EV in less than an hour.
DC Fast Charger	Charger capable of delivering 20 kW or more of DC charging
DSO	Distribution System Operator operates the utility distribution power system (from hundreds of Volts to several kiloVolts)
EER	The energy efficiency ratio reflects the relative efficiency of a powertrain compared to an internal combustion engine using gasoline or diesel.
ELD	Electronic Logging Device. Device plugged in a vehicle that logs the driving information and may report it remotely to a cloud platform.

Emergency vehicle	Fire and off-road emergency response vehicles
e-Mobility	Electromobility
eMSP	Electromobility Service Provider. Driver interface handling payment and customer interactions with the CPO.
EV	Electric Vehicle
Extreme Charging	Terms used for charging power over 150 kW
Fleet Telematics	Onboard data collection of vehicle information
Frontline vehicles	Police frontline vehicles
GHG	Greenhouse Gas
ICE	Internal Combustion Engine is a motor using gasoline/diesel to power a vehicle. ICE also refers to vehicle powered by gasoline/diesel.
ICCT	International Council on Clean Transportation
IEC	International Electrotechnical Commission. Organization defining international electrical standards.
IEEE2030.5	Communication protocol for smart energy
IPCC	Intergovernmental Panel on Climate Change
ISO15118	International standard supporting Plug and Charge feature.
J1772	AC Charging standard used in North America
Level 2 charger	Charger capable of delivering 19 kW or less
Level 3 charger	Charger capable of delivering 20 kW or more
Load control	Control of the electrical load from a third party
Non-Frontline vehicles	Police vehicles that are not frontline
OBDII	Port in vehicle that allows electronic logging access to the onboard computer
OCPP	Open Charge Point Protocol. Most popular open protocol.
OEM	Original Equipment Manufacturer
Open protocol	Protocol developed by a community and open to any suppliers to use.
OpenADR	Communication protocol for the utility to control the charging through demand response
Peak energy/power	Maximum value estimated from assumption and data provided
PHEV	Plug-In Hybrid Electric Vehicle
Plug and Charge	Feature combining the payment transaction with the connection of the charging plug to the vehicle
Proprietary protocol	Protocol developed and owned by a specific vendor.
Renewable Diesel	Renewable diesel or hydrogenation-derived renewable diesel can be used in existing diesel engines without needing to be blended with petroleum diesel.
Roaming	Agreement between different eMSP to share information
SAE	Society of Automotive Engineers. Organization defining charging standards.
Smart Charging	Intelligent distribution of charging power across several chargers to optimise cost, GHG, etc.
Stranded electric vehicle	A stranded electric vehicle refers to an EV that does not have enough energy in the battery to drive the distance required.
Vehicle to X	Capability of EV to supply the energy of their battery, creating a bidirectional energy flow.

1. Introduction

Human activities are estimated to be causing global warming. If the current rate of greenhouse gas (GHG) emissions continues, global temperatures are likely to climb 1.5°C above pre-industrial levels between 2030 and 2052. This will compromise food security, water supply and health of most humans on the planet[1]. To limit global warming to 1.5⁰C with no or limited overshoot, the IPCC (Intergovernmental Panel on Climate Change) estimated that global net CO_2 emissions must decline by about 45% from 2010 levels by 2030, reaching net zero around 2050.

In July 2019, the District of West Vancouver ("District") declared a climate emergency and has made commitments to lower their greenhouse gas (GHG) emissions. This includes the District's corporate fleet, which comprises approximately 50% of the total corporate emissions. This study details a plan for electric vehicle (EV) charging infrastructure to support the adoption of more electric vehicles into the corporate fleet in order to achieve reductions in its corporate greenhouse gas (GHG) emissions over a 20-year horizon. The approach and methodology used in this study is outlined in Figure 1.



WBS 1: Condition Assessment
- Daily utilization of each vehicle and corresponding energy requirements for equivalent EVs.
- Constraints and opportunities at each Facility of Interest for EV charging infrastructure and associated platforms.

WBS 2: EV Technology Trend Review
- Technology trajectories of different electric vehicles and charging infrastructure.

WBS 3: Vehicle Charging Systems Recommendations
- Recommendations on an EV charging management platform.
- Recommendations on fleet management systems / processes for tracking EV costs.
- Recommendations on billing processes for EV charging.
- High-level pricing for implementation of recommended technology systems.

WBS 4: 20 Year Strategic Plan with Emission Forecasts
- Roadmaps showing the fleet electrification and supporting EV charging infrastructure designed for the four scenarios.
- Conceptual designs of the EV charging infrastructure.
- Financial forecasts documenting capital and operating costs.
- A model that forecasts future Greenhouse gas (GHG) emissions and emission reductions by year and by vehicle for each of the roadmaps.

Figure 1 - Study methodology

[1] The Intergovernmental Panel on Climate Change (IPCC)

The key to successful deployment of electric vehicle (EV) charging infrastructure is an understanding of how current and future technologies can be implemented to cost effectively meet the requirements of the end-user. The approach used in this study has been tailored to develop an effective 20-year strategic plan for the District's charging infrastructure to facilitate the electrification of the corporate fleet and account for charging staff owned and public / visitor vehicles at District facilities

Study Limitations

Municipal fleet vehicles play a critical role during emergencies (e.g. snow, ice and extreme weather; fire and police emergency response). During simulations of the fleet electrification, the District and Hoa Cleantech identified 55 frontline police, fire and utilities vehicles used for snow/ice clearing and emergency response that would be challenging to electrify with currently available technology. During their peak usage periods, these vehicles would require large batteries[2] and have very little downtime that would allow for re-charging.

Because their usage during emergency response would skew the District's average fleet EV charging requirements, these frontline vehicles are excluded from conceptual designs for EV charging at this time. Further data collection and analyses would help to better quantify frontline vehicle peak usage and future electrification opportunities for these vehicles. It is noted the scenario planning does include opportunities for electrifying these vehicles and installation of the associated charging infrastructure.

Another limitation of this study is that the availability and future costs of electric vehicles are difficult to predict beyond a 3-5 year horizon, as technology in this space is evolving rapidly (discussed further in Section 3).

[2] The estimated battery sizes required during peak periods are larger than forecasted battery sizes for equivalent electric vehicles.

2. Condition Assessment

The first step in determining what EV charging infrastructure is required, is to analyze the varying daily energy and power requirements[3] of each vehicle. Throughout a year, each vehicle will have different daily driving patterns and utilization requirements. The charging infrastructure, therefore, has to be designed to make sure each vehicle is always recharged sufficiently in the time it is parked to meet the utilization requirements of the next trip.

An analysis of the average and peak energy and power requirements will enable the charging infrastructure to be optimally sized in the most economical way while reducing the risk of having stranded electric vehicles[4].

This section analyzes the utilisation of vehicles to determine the requirements of equivalent battery electric vehicles (BEVs) and associated charging infrastructure needed at District facilities. By calculating the average daily energy demand for each vehicle from the fuel consumption, the energy requirements for equivalent BEVs could be determined using an energy efficiency ratio (EER). The EER accounts for:

- Internal Combustion Engines (ICEs) being much less efficient than electric motors in converting input energy to output motion.
- ICEs using energy when vehicles are idling, coasting or braking. Electric motors not only don't use energy during these operations, they can act as a generator when coasting or braking, generating energy in a process known as regenerative braking

The Canada "Clean Fuel Standard: Proposed Regulatory Approach" (2019) defined different energy efficiency ratios by application. For the purposes of this study, the two EERs that will be used are:

- Electric vehicles for light and medium-duty application (replacing gasoline) = 4.1
- Electric vehicles for on-road heavy-duty applications and off-road vehicles (replacing diesel) = 5

These ratios are consistent with findings from the California Air Resources Board in a 2018 report comparing the efficiencies for battery electric trucks and buses to their diesel counterparts. They also resulted in BEV efficiencies in line with available data from testing and manufacturers.

Once the average daily energy requirements for each equivalent BEV are known, the average power requirements from charging stations can be calculated using an assumed time each vehicle is parked at a facility site overnight. The next step is to determine the peak daily distance / operating time and associated time each vehicle is parked at a facility site overnight during this peak period.

[3] The energy requirements refers to the kWh of battery capacity used by driving the vehicle. The power requirements refer to kW required by the charging station to recharge the vehicle in the time the vehicle is parked.
[4] A stranded electric vehicle refers to an EV that does not have enough energy in the battery to drive the distance required.

The charging stations at the facility sites must be able to recharge each vehicle during peak utilization periods. However, these peak periods do not occur all the time and may not occur at the same time for any given vehicle. If there are multiple vehicles operating at peak utilization at the same time (i.e. snow clearing), these vehicles can be sequenced to return to a facility site for fast-charging at staggered times, limiting the number of fast-chargers required. To account for this, a statistical model was used to calculate the probabilistic distribution of the daily power requirements of each vehicle across the fleet. This model was used to determine the number and type of charging stations needed for each site assuming all fleet vehicles are electrified over the next 20 years. However, the charging infrastructure recommendations are also based on an assessment of practicality, risk and cost.

The analysis is split between fleet vehicles, staff vehicles and visitor vehicles, and between the six different District facilities. The six District facilities included in this study are:

5. Municipal Hall Complex (this includes the Police Station, which is under the same electrical service).
6. Operations Centre.
7. West Vancouver Community Centre.
8. Fire Hall #1.
9. Fire Hall #2.
10. Gleneagles Community Centre.

Fleet Vehicles

The District provided high-level data summarising the annual distance, operating hours and/or fuel consumption for their fleet of existing vehicles. It is estimated these fleet vehicles emitted approximately 1,590 tonnes of CO_2e in 2020 based on the 2019 data and estimated fuel usage of the new 2020 fleet vehicles (i.e. the 2020 Ford Explorer Interceptor hybrid police vehicles).

Table 1 shows the number of different types of vehicles associated with each District facility. There are no fleet vehicles, from the data provided, associated with Gleneagles Community Centre. However, there is one vehicle parked at the District library, which is not accounted for in Table 1 and one van is expected to park at the Gleneagles Community Centre in the near future.

Vehicles that have been identified by the District as needing to be able to operate over long periods of time have their own vehicle sub-class classifications listed below. Separating these out makes it clearer when assessing the practicalities of electrifying certain vehicles and in designing the charging infrastructure.

- Police frontline vehicles: *"Frontline"*
- Fire and off-road emergency response vehicles: *"Emergency"*
- Snow & debris clearing vehicles: *"Clearing"*

A summary of the daily utilization analysis for each vehicle type is provided in Table 2 for energy requirements and Table 3 for power requirements.

To complete the analysis of fleet vehicles, a number of assumptions were made following discussions with the District, which are listed below:

- The vehicles typically operate 5 days a week between the hours of 0700 and 1600, and for 250 days a year.
- The vehicles return back to a District facility site each day.
- Peak utilization assumptions:
    - In an emergency, heavy duty fire trucks are in running operation for 16 hours a day and can return to a Fire Hall site for 2 hours per day. Fire support and command vehicles travel up to 200km a day and can return to a Fire Hall site for 8 hours per day.
    - In an emergency, some off road vehicles are in running operation for 20 hours a day and can return to the Operations Centre for 2 hours per day.
    - For snow and/or debris clearing, some heavy-duty trucks are in running operation for 20 hours a day and can return to the Operations Centre for 2 hours per day. Light and medium-duty trucks used for snow and debris clearing travel up to 250km per day and can return to the Operations Centre for 2 hours per day.
    - Frontline police vehicles travel up to 300km per day and can return to the Police Station for 2 hours per day.
    - Other vehicles are assumed to travel up to 150km per day or be in running operation for 8 hours per day and can return to a facility site for 13 hours per day.

Table 1 - Number and type of vehicles at District facilities

Vehicle Type	Operations Centre	Municipal Hall Complex	West Vancouver Community Centre	Fire Halls #1 & #2
CAR[5] CAR - Frontline	- -	11[6] 1	- -	1 -
SUV SUV - Frontline SUV - Emergency	1 - -	7 12 -	- - -	- - 3
VAN	1	2	-	2
CARGO VAN	2	2	3	-
LIGHT DUTY TRUCK[7] LDT - Frontline LDT - Emergency LDT - Clearing	25 - - 14	5 1 - -	- - - -	- - 4 -
MEDIUM DUTY TRUCK[8] MDT - Clearing	12 6	- -	- -	- -
HEAVY DUTY TRUCK HDT - Emergency HDT - Clearing	3 - 6	- - -	- - -	- 8 -
SHUTTLE BUS	-	-	3	-
OFF ROAD OR - Emergency	11 7	- -	- -	- -
Total	**88**	**41**	**6**	**18**

[5] There is also one CAR associated with the Library, which is not shown here.
[6] Includes 2 police motorbikes
[7] Example vehicles include Ford F-150 to F-350
[8] Example vehicles include Ford F-450 to F-550

Table 2 - Daily utilization analysis of equivalent BEV energy requirements

Vehicle Type	Ave. daily distance per vehicle	Ave. daily energy per equivalent BEV	Peak daily energy per equivalent BEV
CAR CAR - Frontline	10 - 82km 88km	2 - 19kWh 32kWh[9]	15 - 60kWh 140kWh
SUV SUV - Frontline SUV - Emergency	4 - 53km 46 - 208km 13 - 23km	1 - 18kWh 16 - 110kWh 4 - 13kWh	30 - 50kWh 100 - 160kWh 60 - 110kWh
VAN	15 - 21km	3 - 6kWh	40 - 60kWh
CARGO VAN	11 - 133km	5 - 22kWh	70 - 170kWh
LIGHT DUTY TRUCK LDT - Frontline LDT - Emergency LDT - Clearing	4 - 77km 150km 21 - 40km 26 - 116km	2 - 42kWh 80kWh 10-17kWh 17 - 64kWh	40 - 100kWh 160kWh 60 - 100kWh 100 - 200kWh
MEDIUM DUTY TRUCK MDT - Clearing	6 - 85km 37 - 79km	11 - 66kWh 27 - 70kWh	100 - 150kWh 180 - 250kWh
HEAVY DUTY TRUCK HDT - Emergency HDT - Clearing	2.5 - 3.7hrs 0.5 - 3.2hrs 1.9 - 2.9hrs	49 - 86kWh 14 - 95kWh 49 - 76kWh	150 - 230kWh 500 - 900kWh 500 - 700kWh
SHUTTLE BUS	28 - 74km	26 - 71kWh	130 - 140kWh
OFF ROAD OR - Emergency	0.3 - 1.8 hours 1.1 - 3.6hrs	2 - 29kWh 10 - 52kWh	40 - 140kWh 110 - 320kWh
Total	**Ave. = 48km** **Ave. = 1.8hrs**	**4,358kWh** **(Ave. = 28kWh)**	**23,000kWh** **(Ave. = 150kWh)**

[9] This frontline vehicle is a Dodge Charger that uses a relatively high amount of energy per km. Consequently, an equivalent EV may also consume more energy per km than other types of CAR EVs.

Table 3 - Daily utilization analysis of equivalent BEV power requirements for charging

Vehicle Type	Ave. daily power needed per equivalent BEV	Peak daily power needed per equivalent BEV
CAR CAR - Frontline	1kW 3kW	1 - 5kW 70kW
SUV SUV - Frontline SUV - Emergency	1kW 1 - 7kW 1kW	5kW 50 - 80kW 10 - 15kW
VAN	1kW	5kW
CARGO VAN	1 - 2kW	5 - 15kW
LIGHT DUTY TRUCK LDT - Frontline LDT - Emergency LDT - Clearing	1 - 3kW 5kW 1kW 1 - 4kW	5 - 10kW 80kW 10kW 50 - 100kW
MEDIUM DUTY TRUCK MDT - Clearing	1 - 4kW 2 - 5kW	10 - 12kW 90 - 125kW
HEAVY DUTY TRUCK HDT - Emergency HDT - Clearing	3 - 6kW 1 - 6kW 3 - 5kW	10 - 20kW 250 - 450kW 250 - 350kW
SHUTTLE BUS	2 - 5kW	10kW
OFF ROAD OR - Emergency	1 - 2kW 1 - 3kW	5 - 10kW 55 - 160kW
Total	**290kW (Ave. = 2kW)**	

Staff Vehicles

Staff vehicles are broken down into two groups:

- Staff vehicles used for work purposes.
- Staff vehicles used for personal purposes.

The District provided data summarising the work trips taken by employees in their own vehicles. This summary showed that in 2018 and 2019 employee vehicles were reimbursed for travelling a combined total of 115,880km and 125,705km respectively. Business units located at the Operations Centre made up around 70% of these kms, with the road administration unit accounting for 50-60% alone. Staff located at the Municipal Hall and West Vancouver Community Centre accounted for a further 10% and 15% respectively. The remaining kms were spread across the library, Gleneagles Community Centre and off-site vehicles.

If half of these kms were driven by gasoline cars and the other half by gasoline light-duty trucks, then they would have emitted approximately 32 tonnes of CO_2e in 2019[10]. One possible solution to reduce these emissions is to introduce electric pool vehicles for staff to use on work trips. Assuming staff use their vehicles across 240 days per year for work purposes, the number of pool vehicles required to significantly reduce staff vehicle usage at each site is assessed to be:

- 13 vehicles operating over the Municipal Hall, Operations Centre and West Vancouver Community Centre.

These numbers assume each pool vehicle is used on average 40km per day.

The data also shows that an additional 51 employees were provided a vehicle allowance totalling 324,300km per year. However, for the purposes of this study this was not be considered when assessing potential pool vehicles.

[10] Based on emission factors given in Table 24 of "2017 BC Best Practices Methodology for Quantifying Greenhouse Gas Emissions"

Although not the primary purpose of this study, staff vehicles used for personal purposes (i.e. commuting to work) is the second group the District would like to consider for future EV charging infrastructure. As the District does not have direct influence on the type of vehicle employees drive, generic EV growth models were used to estimate the potential uptake of EVs by employees.

Figure 2 shows the forecasted proportion of light-duty EVs in BC based on three different growth models:

- Low: BC misses 100% EV sales target by 2040
- Moderate: BC meets 100% EV sales target by 2040
- Aggressive: BC meets 100% EV sales target by 2037

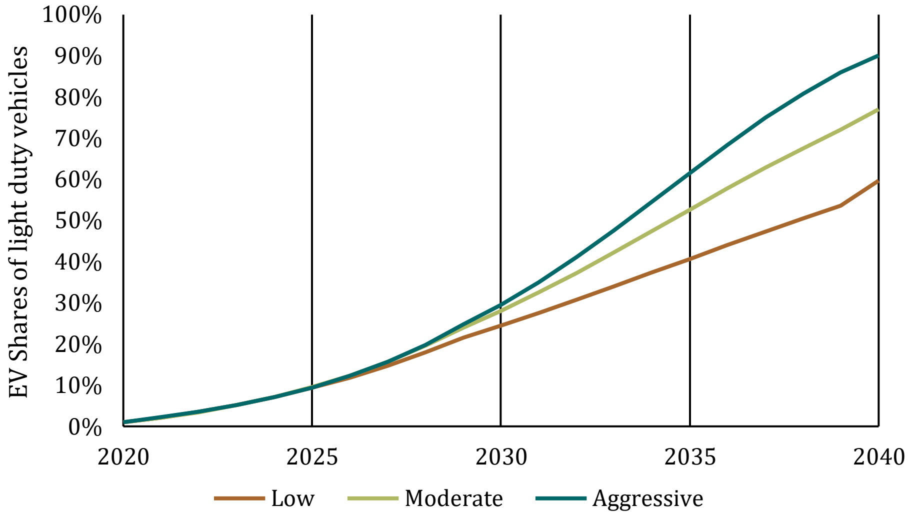


Figure 2 - Forecasted proportion of light-duty EVs within BC

Based on these forecasts, it is estimated that around 30% of staff will drive EVs by 2030, increasing to 75% by 2040.

Visitor Vehicles

Although not the primary purpose of this study, visitor and public vehicles parking at District facilities is a secondary user group to consider in future EV charging infrastructure. Using Figure 1 as a guide, it is estimated that 30% of visitors at District facilities will drive EVs by 2030, with this number increasing to 75% by 2040.

3. EV Technology Trend Review

a. Electric Vehicles

The District would like to account for the future electrification of medium and heavy-duty fleet vehicles in the 20-year charging infrastructure strategy. This section reviews the current and future market for these vehicles, proposed specifications, applicability to the corporate fleet vehicles and commercial availability.

There is growing demand for electric vehicles (EVs) across all sectors to tackle rising greenhouse gas emissions and local pollution. This is being primarily driven by people / corporate responsibilities and governments, however, is now also being driven by the operational cost savings of EVs. Consequently, vehicle OEMs are switching their manufacturing processes to supply this demand.

Although, passenger electric cars have been around for many years, there has been a lack of available EVs in other categories. Fortunately, several vehicle OEMs (Original Equipment Manufacturers) have recently announced plans to roll out EVs across the light to heavy-duty truck categories and within construction equipment. A summary of these EVs and when production is expected to start is provided in Table 4. It is noted that these EVs may not be widely available in Canada for a couple of years after production starts due to high demand and low initial industry production capacity.

An alternative option to a full electric vehicle is a plug-in hybrid electric vehicle (PHEV). The advantage of a PHEV is the ability to use the electric drive for small distances and then have the internal combustion engine (ICE) kick in when the vehicle needs to drive longer distances. This means that the risk of having a stranded vehicle is minimized while also theoretically[11] lowering GHG emissions. However, PHEVs are not expected to be a viable option for all vehicle types that are included in the District's fleet. For example, there are some articles talking about a Ford F-150 PHEV, however rumors have been debunked as Ford never announced a PHEV F-150 but did announce a pure electric version[12].. Alternatively, vehicles can be retrofitted with hybrid powertrains. For example, Wrightspeed builds range-extended electric vehicle powertrains[13] to be retrofitted to a variety of heavy-duty truck platforms.

In summary, if there is an equivalent PHEV available, it can offer one potential solution to lower GHG emissions in those situations when a full EV cannot practically replace an existing fossil fuel vehicle. Although, the actual reduction in GHG emissions would require a detailed analysis of the daily utilization data of each vehicle and the specifications of the PHEV.

[11] A PHEV will lower emissions if it is charged after every use. If it is not re-charged, the PHEV will use its internal combustion engine. Furthermore, it is harder to model GHG impact of PHEVs accurately, as they will only run off the battery for a limited distance each trip and then the internal combustion engine will kick in.
[12] https://insideevs.com/news/408914/ford-f150-phev-electric-range-low/
[13] Electric powertrain with an on-board diesel or CNG-powered generator.

Table 4 - Future EV models

Vehicle Type	Vehicle makes & models	Anticipated production start	Anticipated battery size (kWh)
VAN	- Ford E-Transit	2020	67
CARGO VAN	- Ford E-Transit[14] - Lighting Systems: Conversion of Transit 350 Cargo Van - Motiv: Conversion of E450	2022 2020 2020	- 86 127
LIGHT DUTY TRUCK	- Ford F-150 Electric - Rivian R1T - Lordstown Endurance - Tesla Cybertruck - Bollinger B2 - Chevrolet EV Truck - GMC Hummer EV	2022 2021 2021 2022 2021 2023 2021	- 135 - - 120 50 - 200 -
MEDIUM DUTY TRUCK	- Lighting Systems: Conversions of Ford E450 cutaway cargo truck & F-550	2020	128 - 160
HEAVY DUTY TRUCK	- Kenworth T680E - Kenworth K270E - Kenworth K370E - Freightliner eCascadia - Freightliner eM2 - Peterbilt 579EV - Peterbilt 220EV - BYD Class 8 Day Cab - BYD Class 6 Truck - Tesla Semi - Volvo FL & FE Electric - Lion 8 - Lion 6 - Rosenbauer Fire Truck PHEV[15]	2021 2021 2021 2022 2022 2021 2020 2020 2020 2021 2020 2020 2021 -	- 141 - 282 141 - 282 475 315 396 128 - 256 435 277 - 200 - 300 336 168 - 252 50
SHUTTLE BUS	- Proterra / Optimal-EV S1LF	-	113
OFF ROAD	- Case 580EV backhoe - Kovaco Elise 900 bobcat - Bobcat E-10 mini excavator - Caterpillar excavator - Volvo ECR25 Electric mini excavator - Volvo L25 Electric front end loader	2021 - - - 2021 2021	90 40 12.7 - - -

[14] Ford announced that there will be three sizes for the electric Transit and it is assumed that the specs
[15] The Rosenbauer Fire Truck is a plug-in hybrid electric vehicle that has a range of 30km on electric mode.

b. EV Charging Infrastructure

The Electric Vehicle Ecosystem

Electromobility (e-Mobility) is the integration of many technologies and services that delivers value to EV owners and various stakeholders. At scale, charging infrastructure needs to be carefully planned to optimize cost, maximize user experience and potentially generate revenue. It is therefore important to understand the current and future technologies and services.

The e-Mobility ecosystem is constantly evolving with EV sales growth and as new types of vehicles become commercially available. The figure below illustrates the variety of services e-Mobility contains. The charge points are standardized and not expected to physically change in the coming years. However, the upstream services (to the right of the charge points in Figure 3) are still evolving, as many working groups develop standards and these services become commercially available.

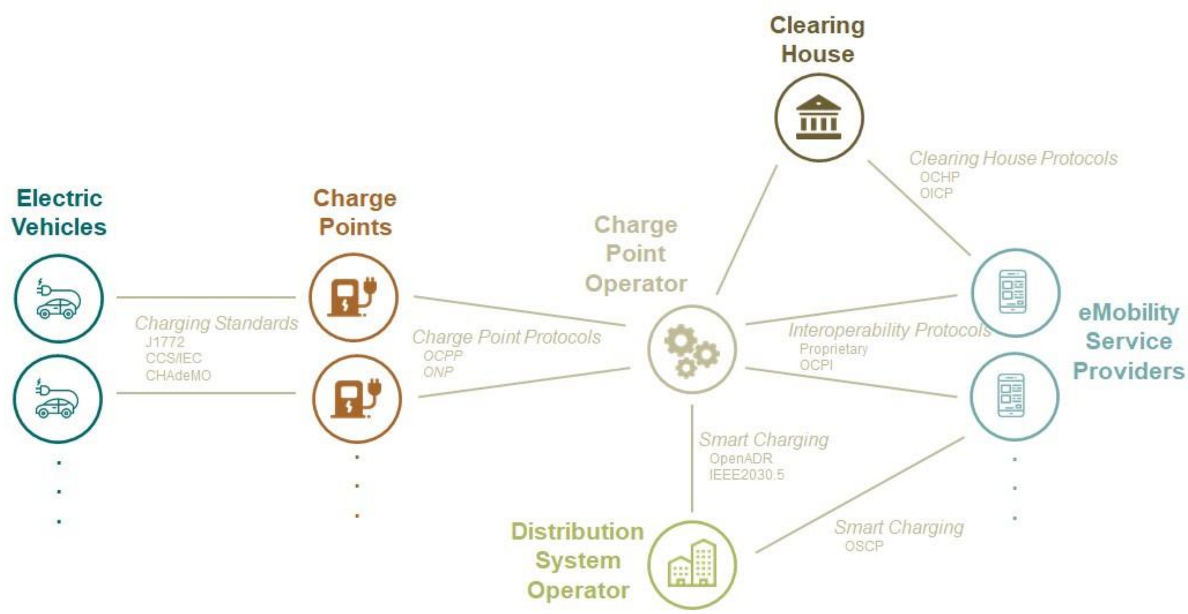


Figure 3 - e-Mobility services

Electric Vehicles (EVs)

EVs have two options to recharge: AC charging (<19kW) or DC charging (>20 kW).

For AC charging, the SAE has developed the J1772 standard (also standardized under the IEC known as Type 1) in North America[16]. Typical chargers output 6 to 7 kW but the standard allows charge up to 19.2 kW, which will be good for charging medium and heavy-duty vehicles.

For DC charging, two standards are widely deployed in Canada and the US. The SAE has developed the CCS Combo which adds two DC pins to the J1772 plug to deliver higher current and voltage up to 350 kW. Due to the early sales of Japanese EVs (e.g. Nissan Leaf), the CHAdeMO standard has been widely deployed and can charge up to 50 kW. However, recent announcements from automakers strongly indicate that CCS Type 1 Combo is going to widely dominate the market.

In addition to the two standards, some automakers are pushing their own charge plugs:

- Tesla offers an adapter to use J1772 charging and CHAdeMO charger. In Europe, Tesla uses CCS Combo Type 2, however, there is no indication that the Californian automaker will transition to CCS Combo Type 1 in North America.
- BYD, Chinese automaker, is delivering medium and heavy duty vehicles in North America with the IEC Type 2 which makes the vehicles incompatible with J1772 and CCS Combo Type 1. The automaker usually supplies the charging station with the vehicle.

Charge Points (Charger)

The simplest charge point is communicating to the EV and delivering electricity safely to the vehicle without any additional service. This technology can be sufficient for a single EV but does greatly limit the operations at a fleet level.

The most sophisticated charge points have an internet connection to a central system to monitor, control, and authenticate charging sessions. These types of chargers are referred to as "connected charger" or "networked charger":

- Level 2: Goes up to 80 Amp (16.6 kW on 208 V or 19.2 kW on 240 V) with J1772
- Level 3/DC Fast Charger: Varies from 20 kW to 350 kW with CCS Combo Type 1

Charge Point Operator (CPO)

The Charge Point Operator is the central system that directly connects to the Charge Points and verifies the driver authentication, controls the charging session, etc. Two approaches can be used by the central system to communicate with the Charge Points:

- *A proprietary protocol from a specific vendor.* Flo and ChargePoint are using this approach to connect their software with their hardware. This limits the charging infrastructure to one provider. This solution is also known as "vertically integrated".

[16] Standards are regionally different, for example, Europe uses IEC Type 2.

- *Open protocol (e.g. OCPP).* The syntax of the communication is public and any suppliers of hardware and software can use it. This allows the use of one software provider integrating with a variety of hardware providers. It offers greater flexibility in scaling the infrastructure with hardware or software features that are not available from a single service provider. This solution is also known as "horizontally integrated".

In addition to the Charge Points connection, the CPO can be connected to a variety of other services via other communication protocols.

e-Mobility Service Provider (eMSP)

The electromobility service providers are responsible for the end-user services. They handle payment and billing, provide a mobile application for the user to locate the chargers, receive notifications, etc.

Most providers offer both CPO and eMSP services. However, these services can also be integrated between different providers (e.g., HydroQuebec and its Circuit Electrique mobile app connected to the AddEnergie CPO).

A CPO can be connected to multiple eMSPs via multiple roaming agreements or indirectly via a clearing house system.

Clearing House

Clearing House is a service that connects public CPOs to many eMSPs without having to negotiate individual roaming agreements with each of them. It has been popularised in Europe through Hubject and is playing the role of handling financial transactions between different charging platforms.

The Canadian company, ChargeHub received NRCan funding to develop a clearing house type of services in Canada and potentially the US.

Distribution System Operator (DSO)

In the District's situation, the DSO is the utility BC Hydro and potentially PowerEx. A fleet the size of the District will represent more than 1 MW of electrical load and tens of MWh of energy storage. Combined with all the municipalities and fleet owners, the electrical load can be significant and providing load flexibility service is valuable to the utility. Utilities have a variety of services to incentivise fleet charging such as peak mitigation and power exchange trading opportunities, which can generate new revenue for the District.

Several existing communication protocols can connect the CPO to the utility. Some of the popular ones are OpenADR and IEEE2030.5.

Additional Services

An architecture leveraging open protocols offers the possibility to add any type of services that would add value to the District operations. Some of the services can be:

- Smart Charging: Companies like ampcontrol.io connect to a CPO and prioritize the charging sessions to minimize the peak demand, integrate with the Building Management System or charge the vehicles when renewable energy is abundant.
- Fleet Telematics: Companies like Geotab (ex Fleetcarma) integrate with Flo and ChargePoint CPO to more intelligently charge the vehicles.

Case study - BC Hydro

Figure 4 shows an example of the (simplified) BC Hydro EV network. The chargers are from the ABB and BTC Power manufacturers, the CPO is Greenlots[17] and the e-MSP is the BC Hydro EV App[18].

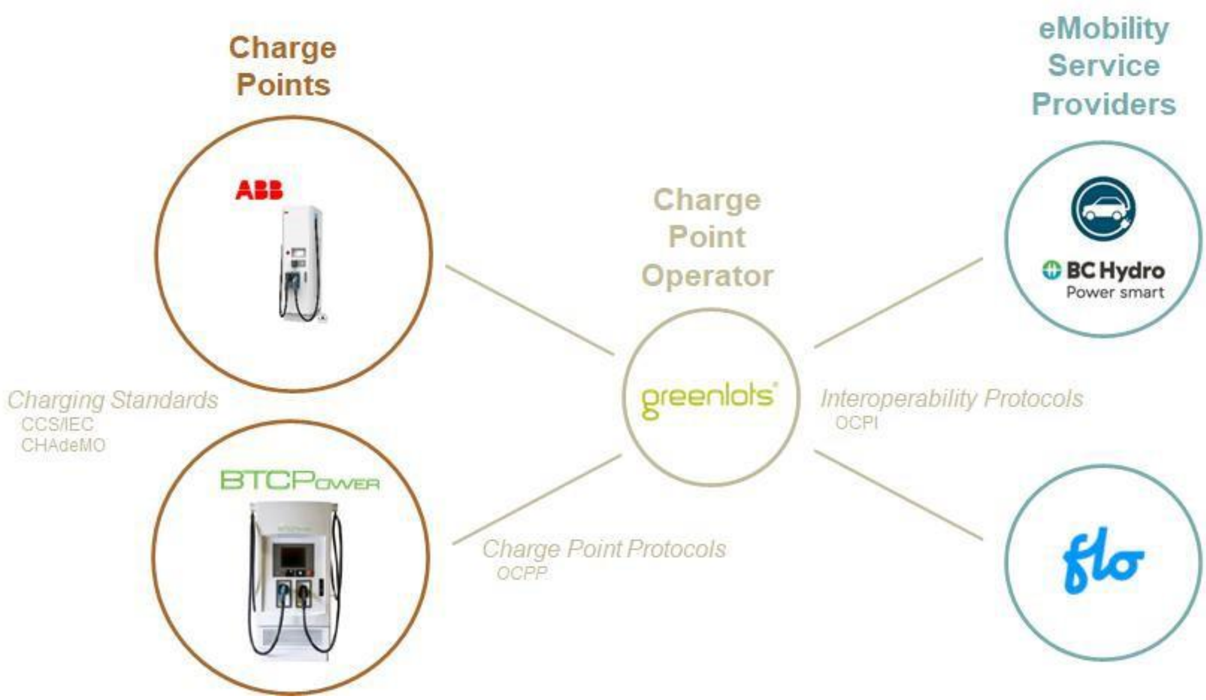


Figure 4 - BC Hydro EV network

[17] Some charging stations in the BC Hydro EV network are not operated by Greenlots but are actually a mix of horizontal and vertical integration. For the sake of simplicity, we ignored those.
[18] BC Hydro has roaming agreements with Flo (and ChargePoint) to operate the charging station from their mobile App.

Status of EV Charging Solution Providers in North America

Main actors

Vertically integrated actors who own both chargers and software are outlined in Table 5.

Table 5 - Vertically integrated charging solution providers

Provider	Level 2 Chargers	Level 3 Chargers	Services
ChargePoint	7.2 kW	62.5 - 125 kW	CPO / eMSP / DSP
Flo / AddEnergie	7.2 - 19 kW	50 - 100 kW	CPO / eMSP / DSP

Horizontally integrated actors who use open protocol (i.e. OCPP) are listed in alphabetical order in Table 6. New players come in regularly, the market is quite dynamic and constantly offering new solutions:

Table 6 - Horizontally integrated charging solution providers

Manufacturer	Level 2	Level 3
ABB	7.2 - 19 kW	20 - 350 kW
BTC Power	7.2 - 16.8 kW	50 - 350 kW
Delta	7.2 - 19 kW	25 - 200 kW
Efacec	None	50 - 350 kW
EV Box	7.2 kW	100 kW
Lite-On	7.2 kW	None
Schneider	7.2 kW	50 kW
SMPC	14.4 kW	None
Tritium	None	50 - 350 kW

CPO and eMSP providers that can integrate with the chargers outlined in Table 2 is listed below:

- ChargeLab
- EV Connect
- Ev Gateway
- Greenlots
- Open Source based (BCIT OpenOCPP)
- SWTCH

Observed Trends: Future Services & Functionalities

While two big players such as ChargePoint and Flo are vertically integrated providers, other big players such as Greenlots, Electrify America/Canada are using horizontally integrated approaches. In California, open protocols and more specifically OCPP are generally specified in RFPs.

Plug and Charge - User Experience

Plug and Charge is a highly anticipated functionality that facilitates the authentication and initiation of the charging session. Via the charging cable, the vehicle will automatically authenticate the driver and start charging. This feature requires both hardware and software upgrades.

ISO15118 is the international standard developed by the IEC defining the communication interface between the Electric Vehicle and the Electric Vehicle Supply Equipment.

Vehicle to X - Backup power

Vehicle to X is a service the charging infrastructure and the vehicles can offer to the grid operator as part of a virtual power plant ecosystem. The vehicles have the capability of sending power back to the grid (Vehicle to Grid) or another load (Vehicle to Load), which makes it a bidirectional power flow. Some commercial vehicles already have this capability but the technology has not been widely demonstrated.

Credit Cards - User Experience

Payment per credit card is a convenient way of performing a transaction. California is mandating that payment per credit card be available on public charging stations. Electrify Canada has started implementing this solution in Canada.

Extreme Charging - User Experience

DC Fast Charger can deliver up to 350 kW of power to a vehicle, however most electric vehicles cannot charge at this amount of power. Commercially available EVs have 400 V battery packs, which are limited to approximately 140 kW of charging power. To support a higher charge rate, the vehicle battery pack needs to be of 800 V+.

Open Protocol – OCPP

There are heating debates around opening the charging infrastructure to allow more competitions. Governments organizations are getting stricter about the use of open protocol and will provide funding only if the charging infrastructure is OCPP compliant. This trend seems to grow across North America.

4. EV Charging Systems Recommendations

a. Charging Infrastructure - District of West Vancouver analysis

EV Drivers Requirements

The charging infrastructure operated by the District will primarily service the fleet vehicles, but could be adapted to servicing three types of consumers:

- Fleet
- Employee
- Visitor / Public

The table below summarizes the specifications for each type of EV driver. The rationale behind the requirements are explained below.

Table 7 - Charging specification requirements for different EV drivers

	Fleet	Employee	Visitor/Public
Charger L2 - 6.2 kW	✓	✓	✓
Charger L2 - 13 kW+	✓	X	X
Charger Top-Up DCFC	✓	✓	✓
Energy reporting	✓	✓	✓
Load control	✓	O	X
Authentication	O	✓	✓
Billing	X	✓	✓
Reservation	X	O	X
Scheduling	O	X	X
Roaming/Interoperability	X	O	✓

V: Required
O: Optional
X: Not required

Fleet

To service the EV fleet, the following specifications are to be considered:

- Overnight charging capable of delivering between 3 and 19 kW.
- Top up charging with DCFC. The final number of chargers and their output power will be determined in the final report.
- Report kW & kWh per charger and vehicle
- Load control: Controlling the power of the charger will minimise demand charges and reduce electrical cost when the fleet becomes important.
- Authentication: To track the energy consumption per vehicle, an authentication system is required.
- Schedule charging: The new approved BCUC Fleet Electrification Overnight rate for depot fleet charging removes demand charges between 10pm and 6am under the Large General Service rate[19]. This rate can be of interests to the District because demand charges can be a significant portion of the total electricity cost.

Employee

To service the employees for their personal EV, the following specifications are to be considered:

- Day charging capable of delivering between 3 and 7 kW.
- Use of available top up DCFC.
- Report kW & kWh per employee.
- Authentication: The chargers will not be accessible to the public and will only deliver energy to authorized users.
- Optional Billing.
- Reservation: To facilitate stall turnover, a reservation system can be implemented if an honour system is not effective.
- Load control: As building energy consumption is higher during the day, load control capability will help reduce peak electrical demand.

Visitor

To service the visitors and the public at the different District locations:

- Day and evening charging
- Report kW & kWh
- Authentication: The visitor will have to authenticate to be billed.
- Billing
- Roaming: This is the capability of using an external eMSP to use the District public charger. Roaming improves the user experience by avoiding dedicated mobile App to use the charger. For

[19] MATTH to include comments as per discussion with Emily

example, the existing Flo and ChargePoint chargers of the District are available on the BC Hydro EV app through a roaming agreement between the three services.

District Operational Requirements

Tracking Energy

Every networked charger is able to provide the energy it delivers during the charging session transaction (either OCPP based or vertically integrated).

For the District to efficiently operate the fleet, the CPO needs to have appropriate reporting capabilities. As every charging session will be recorded per charger and per driver / vehicle identification, the system needs to have an easy way to summarize the information on a periodic basis, either by building a template report or by automated emails.

Typically, a CPO would structure the charging infrastructure by sites, charge points and connectors. A site can have multiple charge points and a charge point can have multiple connectors.

Tiered users

The CPO will store a list of users authorized to use the charging stations. The ideal structure would permit the users to have different privileges to use the charging stations. For example, a fleet EV would be authorized to use any chargers for free and an employee personal EV would be authorized to use only certain chargers at a specific charging rate. It is unclear if many CPOs support this functionality already. Failing to deliver this functionality, each charger will have its own list of authorized users. This setup would not allow different pricing for each tier.

Visitor / Public Requirements

Billing

For some selected chargers, the District can make them available to the public. This would increase the availability of public charging within the District but also generate some revenue to cover the operating costs of the infrastructure.

b. Charging Platform Recommendations

Charger Requirements - J1772 and CCS Combo Type 1 and connected

Recommendation: The District standardizes the charging infrastructure and deploys the J1772 AC Charger and CCS Type 1 Combo.

This will minimize cost of deployment and provide access to most of the vehicles available. The chargers should have an internet connection to monitor, control and authenticate the charging session. This communication should use open protocol (preferably OCPP) to enable interoperability of hardware and software. As the charging infrastructure grows, the needs of the District will evolve and potential new entrants will enter the market. Using open protocol will allow the District to use new vendors and not be locked-in by one provider.

However, there are two notable exceptions where the J1772 AC Charger and CCS Type 1 Combo will not currently work. These are:

- BYD vehicles. If the District purchases BYD vehicles, the associated charging stations will have to be managed separately, unless the manufacturer switches to J1772 and CCS Combo Type 1.
- Tesla. Although Tesla vehicles can use a J1772 adapter for a slow charge (AC charging), they have to use a public Tesla supercharging station for fast charging.

Software Architecture - Open Protocol based

Recommendations:

- The District procures a Charge Point Operator (CPO) / e-Mobility Service Provider (eMSP) system bundle.
- The District uses an open approach with their charging platform based on the OCPP communication protocol. As explained in Table 4 below, it is the most flexible and standardized approach that will support the growth of the District fleet electrification

.

CPO

The most important decision for the District is to choose what protocol to use to communicate between the Charge Points and the CPO. The decision will create the core of the District charging infrastructure. Table 8 compares both vertically integrated (i.e. proprietary protocol) and horizontally integrated (i.e. OCPP) approaches. This table can be used by the District during the procurement process to evaluate the proponents.

Table 8 - Comparison between vertically integrated and horizontally integrated approaches

	Proprietary	OCPP	Notes
Hardware diversity	3	5	The table above shows that OCPP based chargers support a wider variety of power output.
Third party integration	3	4	Both solutions have existing third-party integration, however some OCPP based solutions offer public APIs that ease custom integration.
Future services	4	5	As future services are developed, if the District existing solution does not provide them, the OCPP approach can switch to another CPO while keeping the chargers (no stranded assets).
Support	5	3	The vertically integrated approach can be quick to fix problems on both hardware and software as there is a single provider. OCPP approach requires involvement of multiple stakeholders which can delay repairs if the maintenance processes are not properly set.
Total Score	**15**	**27**	

1: Poor; 5: Excellent

eMSP - Same provider as the CPO

Our recommendation to use the same provider for the eMSP and the CPO will simplify the charging infrastructure for the District.

A specific eMSP is mostly useful when a large public network such as Circuit Electrique or BC Hydro EV is operated and specific marketing and communication needs are required.

DSO - Optional

While the fleet of the vehicles will not be significant in the coming years, many providers already support grid service protocols (e.g., OpenADR or IEEE2030.5).

We advise the District to request information on the proponents' capability to support grid service protocols. Although, note that this should not be a decisive requirement for the selection of a CPO. Once the system has been selected and implemented, the District can inform BC Hydro of its capabilities and potentially work on piloting grid services for the fleet.

Other services

Because the public facing part of the charging infrastructure will be limited, we suggest not pursuing any clearing house strategy at the moment as they are at their inception in North America and it does not bring value to the District's fleet operation.

Integrating and standardizing the existing charging service

The selected CPO may not be ChargePoint or Flo[20], which already have several chargers installed at the District. It is very likely that the communication protocols of these chargers will not be compatible with the future chosen CPO. To facilitate the operation of the charging infrastructure and avoid running multiple software, the District could explore the following solutions:

- Ask Flo and ChargePoint if their hardware can be upgraded to support OCPP and connected to the selected CPO. Announcements[21] have been made by these companies to partially adopt OCPP.
- Move the chargers (Municipal Hall) to a public or employee facing location. The chargers will not be used by the fleet vehicles but mainly by the public and possibly the employees. The District will then run the fleet & public charging infrastructure independently until they can be combined.

[20] They are vertically integrated but their software can integrate some third-party OCPP chargers
[21] https://www.chargepoint.com/about/news/chargepoint-adopts-ocpp-its-charging-stations/ & https://www.newswire.ca/news-releases/hydro-quebec-renews-its-confidence-in-addenergie-for-another-extension-of-the-electric-circuit-690808331.html

c. Fleet Management Systems for Tracking Costs

EV authentication system

Monitoring the charging transactions between the fleet vehicles and chargers will be essential for the District to effectively operate an electric fleet.

An RFID card should be attached to every new EV keychain. To initiate a charge, the RFID card needs to be tapped in front of the charger and the CPO will identify the vehicle and authorize the charge. The CPO will collect data from each charging station that can be broken down on a per charger and per vehicle basis.

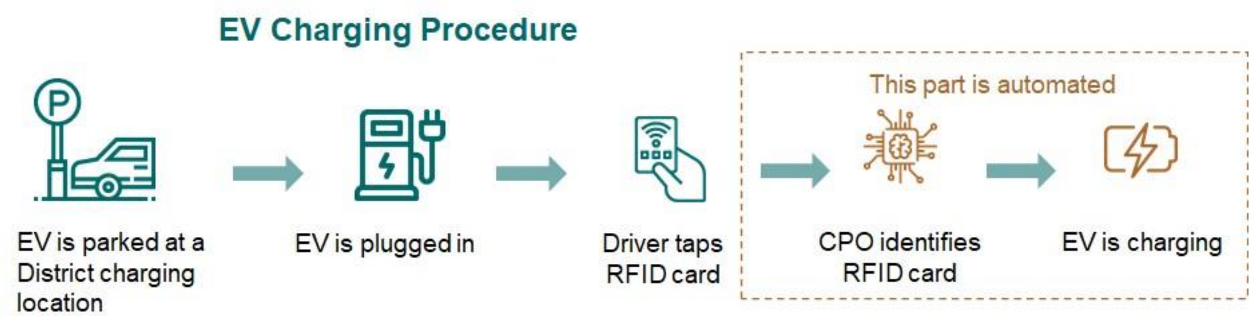


Figure 5 - EV charging procedure

The same system of RFID cards can be implemented for the employees. An employee who desires to charge their EV using the District charging infrastructure will receive an RFID card and be registered into the system. If the District is not willing to offer the charge for free, the CPO will be configured to charge a fee to specific users / chargers. A mobile app can be used in place of the RFID card for the employee. We do not recommend mobile apps for fleet vehicles as it may result in the wrong account being identified.

The set of RFID cards will be provided by the selected CPO. In the spirit of standardization and interoperability, it is preferable to use RFID that is ISO 14443a/b or ISO15693 as it is the most commonly used by EV chargers. Using other RFID standards may prevent some chargers from recognizing the card.

In the coming years, it is expected that vehicles, chargers and software will support ISO15118 Plug & Charge functionality. At that stage, the RFID card will not be needed as the authentication will be done directly by the vehicle.

Administration of the charging infrastructure

The District will require one or more administrative staff within the organization to access and manage fleet EVs, chargers and employee personal EVs in the CPO system. The access to the CPO will also provide access to the reporting functionalities.

Depending on the level of reporting and associated data manipulation required, it is anticipated that this administrative task should not take more than a few days per year.

EV Charging Etiquette document

To familiarize the District personnel with the new procedures associated with EVs, the District could develop a document summarizing all the necessary information. This document will contain explanation such as:

- How to charge a fleet EV (using the RFID card on the keychain).
- How to charge a personal EV (using mobile app or assigned RFID card).
- Stall turnover policy.
- The locations of the chargers that can be used for fleet, employees and the public.

Adding new EV in the District system

When a new fleet EV is acquired by the District, the administrative person will attach a new RFID card and create the vehicle profile into the CPO. A test charge can be performed to validate that the authorization and reporting is properly associated with the new vehicle. Figure 6 shows this process.

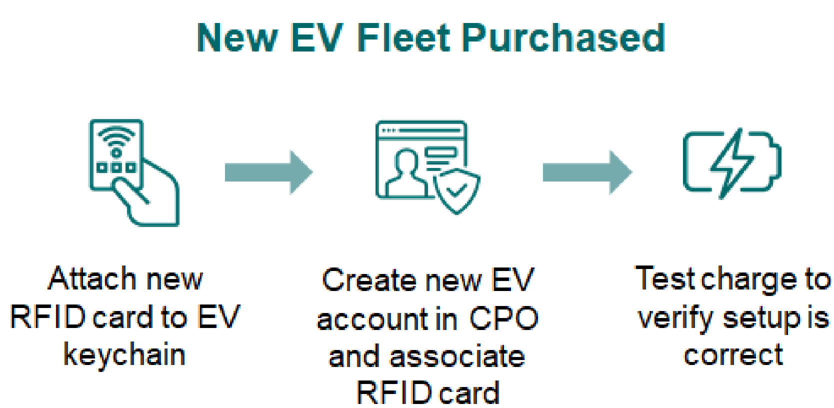


Figure 6 - Process flow for adding a new EV to system

Employee EV used for work purposes

Currently, the District is reimbursing employee's kilometers at $0.58/km, this amount is based on what the CRA considers 'reasonable'. It includes fuel, insurance and estimated maintenance costs of an average vehicle (tire wearing, oil changes, brakes, etc.).

Fuel cost of personal EV can be directly managed by the District via the CPO. The employee only has to plug in his vehicle and authenticate to start the charge.

In British Columbia, the energy cost of an EV is less than $0.002/km, which is much less than the current allowance. Therefore, to incentivize employees to switch to an electric vehicle, the existing automobile reimbursement allowance can be kept and in addition, the District can offer the employees to charge their vehicles for free.

Employee EV used for personal purposes

When an employee acquires a personal EV and would like to access the chargers available for the employees, the administrative staff member will create the employee account in the CPO, provide an RFID card and/or provide instructions to use the eMSP mobile app. During this process, the employee will receive the "EV Charging Etiquette" document. Figure 7 shows the process flow for creating a charging account for an employee.

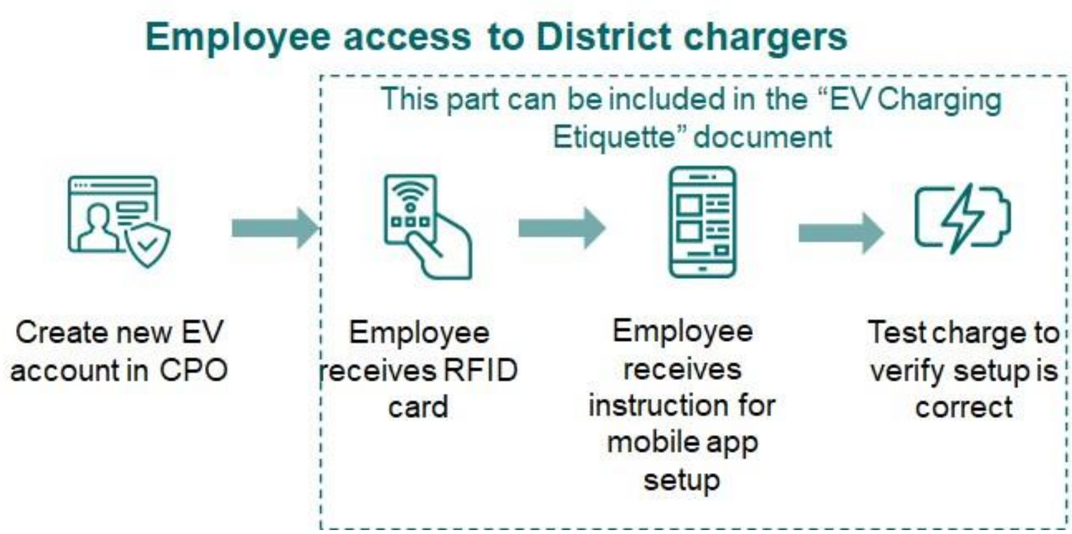


Figure 7 - Process flow for adding a new employee to system

Stall turnover

For employees working in the District buildings and driving a personal EV, the possibility to charge the vehicle at the workplace is a great incentive. As indicated in the automobile allowance, the cost of offering a free charge is extremely low and we therefore suggest to offer the charge for free to incentivize all employees to buy electric vehicles (not limiting it to the employees who are performing off-site duties and receiving automobile allowance).

To maximize utilization of the charging infrastructure and limit capital expenditures, stall turnover can be implemented when there is less than one charger per employee electric vehicle. We recommend an incremental approach to manage stall turnover. The simplest turnover strategy is to use an honour system where employees are asked to move their vehicle when finished charging. In addition, signs should be installed to remind EV drivers the maximum charging period. It is considered that 12 kWh of electricity per working day is sufficient for the average need of an employee. This represents a charging session of 2 hours. We do recommend the District to start with a 4 hours limit when the charging infrastructure is not saturated (4 hours correspond to half a day which makes it easy for the employees to use a block of morning or afternoon and move their vehicle during the lunch break).

If the honour does not work and complaints are made, we recommend the District to create a booking system within the District IT, similar to the meeting room booking. From their calendar, employees can book a specific charging station timeslot.

If this system is not effective, then the District can leverage the CPO to introduce a reservation system and an idle fee system to charge employees automatically if they do not move their vehicles once they are done charging.

We are recommending this incremental approach to limit the amount of effort required to manage stall turnover. From our experience, an honour system is already effective if implemented early and clearly communicated.

New charger commissioning

When a new charger is installed, it needs to be connected and registered to the CPO. The installer should be responsible for connecting the charger. The registration of the charger into the system is done by the CPO provider who needs to receive the following information:

- Charger name
- Location (GPS)
- Site (Building or subdivision of a building)
- Type (Level 2 or Level 3)
- Brand
- Tariff
- List of authorized users

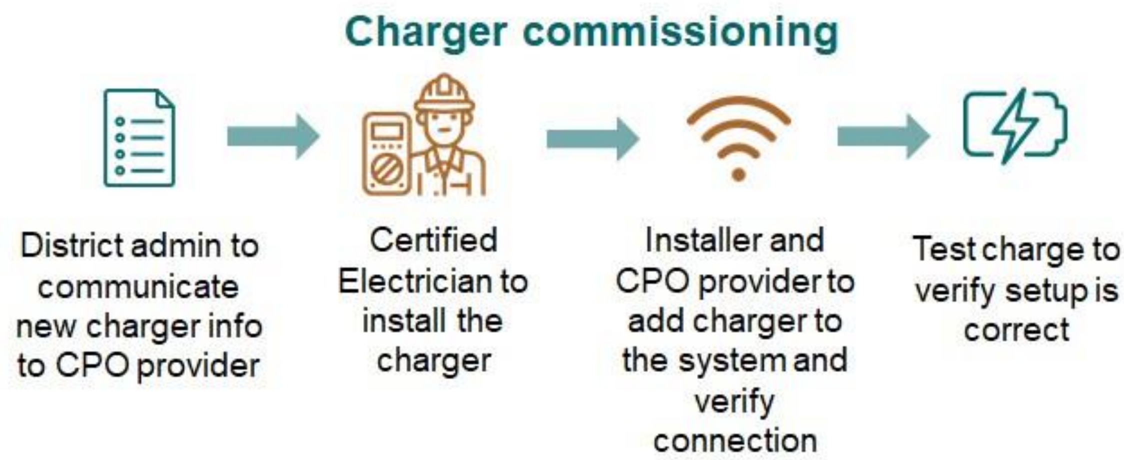


Figure 8 - Process flow for commissioning a charger

d. EV Charging Billing Systems

Billing functionality will be primarily used for the public and potentially for the employees also. Most CPOs support a variety of tariff structures that the District will have the flexibility to define these. Below is a proposed fee structure inspired from similar fees applied in other public charging stations in the region (i.e. City of North Vancouver).

Table 9 - Proposed fee structure for EV charging

	Fleet	Employee	Public
Type	To be confirmed with fleet analysis	Level 2 - 7 kW	L2 Potentially L3
Fee	Free	Free OR 7am-5pm: Free 5pm-7am: $2/hr	$2/hr L2 $12/hr L3 <60 kW $24/hr L3 >60 kW
Access	Fleet accounts only	Employee & Fleet only	Public. Potential roaming with other eMSP. In the short term, public station may be a separate system (legacy Flo/ChargePoint)

The District needs to clearly monitor how the energy is distributed across the fleet (individual vehicles), the employees and the public. The CPOs will capture the charging session for each charger and each user. However, each provider will have their own way of providing this information. Our recommendation is to have automated reporting emails and a reporting capability using filters to easily select the information as required. During the procurement process, the District could ask for a sampled report from the proponent to evaluate how the data is structured.

Cost Tracking

Reporting Mileage

The District collects vehicle mileage for maintenance purposes. It is currently done via the ProFuel system at the pump for the ICE (internal combustion engine) vehicles. The current electric vehicles are based on time (i.e. maintenance performed every 6 months).

The mileage information is not communicated by the J1772 charging standard, therefore the CPO cannot collect this information directly from the charger. A fleet management system is required to collect the mileage, which is done via an Electronic Logging Device (ELD) plugged into the OBDII port of the vehicle. Some companies integrate ELD and CPO such as GeoTab (ex-Fleetcarma), ViriCiti, and ElectriPhi. Telematics companies offer a wide variety of fleet services such as route and schedule integration, vehicle status, etc. Those systems are subscription based and mostly designed for delivery companies or transit buses.

Integrating a telematics system for the sole purpose of collecting mileage seems to be an expensive solution. As a first step in the electrification process, we would recommend the District to schedule their

EV maintenance using the kWh delivered to the vehicle. This information will be directly accessible from the CPO. From the energy data, the vehicle mileage can be estimated using its energy efficiency. For example, a Nissan Leaf has an average energy consumption of 160 Wh/km. If the car needs to be serviced every 10,000 km, service can be scheduled when the vehicle has consumed 1.6 MWh. As the technology evolves with functionalities such as Plug & Charge, the odometer information may become available at a reasonable price.

Downtime & maintenance of chargers

To avoid setting up an additional software / system, the District's existing process to track vehicle downtime & maintenance should be appended to include the chargers as separate assets.

Software cost / revenue tracking

The typical cost structure of a CPO/eMSP includes a fixed annual cost and different monthly variable costs such as fee per transaction, and fee per charge point type/connector. These costs should be reflected at least at the site level and if possible by the existing cost tracking system, at the charger level by reconciliation of the monthly report produced by the software.

5. EV Charging Conceptual Designs

This section outlines the high-level concept designs for charging infrastructure to support the electrification of vehicles at the different facility sites over the next 20 years. Charging station locations are recommended for the Municipal Hall and Operations Centre. Although, it is noted the location of stations could be adjusted to respond to parking layout changes, better access to electrical connections, or facility upgrades. Additional recommendations regarding timeline for installation can be found in Section 6.

The recommendations outlined in this section have been based on the data provided by the District and the operational assumptions listed in Section 2. Any operational change that impacts the assessed fleet vehicle utilizations may impact these recommendations. Consequently, these recommendations should be re-evaluated after the District collects more data as EVs are integrated into the fleet.

Furthermore, frontline police vehicles, snow and/or debris clearing vehicles and emergency vehicles were excluded in the development of the conceptual designs. This is because of the large battery requirements, high power demand and fast charging requirements of these vehicles, making them challenging to electrify with currently available technology (i.e. during their peak usage periods, these vehicles would have very little downtime that would allow for re-charging).

a. Municipal Hall Complex

The Municipal Hall Complex is divided into three parking areas outlined in Table 10. The table also shows the recommended primary users in each area and the associated number of parking stalls. The final column of the table has the recommended number and type of charging stations to be installed in each area over the following 20 years.

Table 10 - Municipal Hall Complex - Parking areas and charging stations

Parking area	Number of parking stalls	Assumed primary users	Recommended charging stations
Surface Lot	42	Visitor and staff fleet vehicles	- 20 Level 2 Chargers (6.2kW)[22]
Level P1	58	Municipal fleet vehicles (11) + staff vehicles	- 12 Level 2 Chargers (6.2kW)
Level P2	39	Police vehicles (30) [23]	- 16 Level 2 Chargers (6.2kW)[24]

It is noted that the Municipal Hall Complex already has 2 Level 2 Flo chargers located on one pedestal in the Surface Lot and 4 Level 2 ChargePoint chargers located in the Level P1 parking area. Based on the recommendations to use OCPP based chargers for fleet and staff vehicles (refer to Section 4), it is recommended that the ChargePoint chargers are relocated to the Surface Lot to be used by visitor vehicles. This solution facilitates the use of a single charging management system for the fleet and employee.

Based on the recommended charging stations, there could potentially be a peak electrical load from charging EVs of 291kW. This load is lower than the 653kVA spare capacity of the service feeding the Municipal Hall Complex (refer to the AES report: "West Vancouver Municipal Hall EV Infrastructure Assessment"). Therefore no new service to the Municipal Hall is anticipated to meet the power demands of this charging infrastructure conceptual design.

The details and high-level 20-year masterplans of the recommended charging stations are provided below.

[22] The existing Flo and ChargePoint chargers will supply 6 of these, assuming the ChargePoint chargers are single port, like the Flo chargers installed in the Surface Lot.
[23] Due to the specific Police vehicle operations and security requirements, it is assumed the this parking area level is dedicated to their use.
[24] Excludes frontline vehicles.

Surface Lot

It is assumed the surface lot parking area is used in future by visitors and the approximately 12 existing staff owned vehicles with fleet passes. This will help mitigate any conflicts with fleet EV charging infrastructure while improving visibility of public charging offered by the District. Fleet EVs can use the Level 1 and Level 2 parking areas. A visitor is estimated to stay up to 2 hours at the Municipal Hall, resulting in a steady rotation of vehicles throughout the day. Therefore, not all parking stalls should need to be electrified to offer a good level of charging for visitor vehicles. The 12 existing staff owned vehicles with fleet passes will have dedicated parking spots that are serviced by 6 Level 2 chargers operating under OCPP to be aligned with the rest of the fleet chargers.

It is recommended 20 Level 2 chargers (6.2kW) are installed over several years to service the 42 parking stalls in the Surface Lot as shown in the layout plan of Figure 8. This comprises of:

- Splitting the 2 existing Flo chargers onto two pedestals.
- Relocating the 4 existing ChargePoint chargers onto four pedestals (or two pedestals if there are 2 chargers per box).
- Supplying and installing 14 Level 2 chargers onto fourteen pedestals (or 16 chargers depending on the ChargePoint charger configuration). This installation can occur once the existing public chargers start to be highly utilized.

Due to the turnover of visitor vehicles, this configuration is considered sufficient to deliver charging services for the public as more and more EVs are on the roads in the next 20 years.

As a general rule for charger installation, the chargers should be mounted on a pedestal installed between two parking stalls (similar to the current position of the Flo Smart2 chargers). The charging cable length is 7.62 metres (25 foot) which should be sufficient to reach the port of the vehicle on both stalls. The District indicated that the current stalls are narrow and future work may reduce the number of stalls to facilitate parking manoeuvre and access.

This configuration will offer the greatest utilization of the charging stations as one charger will have two stalls it can supply. The exception to this configuration are two pedestals in the west side of the Surface Lot that will supply three stalls (refer Figure 9).

In the future, if this configuration cannot supply the complete demand, the District can install additional chargers on the pedestals to have one charger per parking stall in a 2-shared configuration, which will not increase the required electrical capacity.

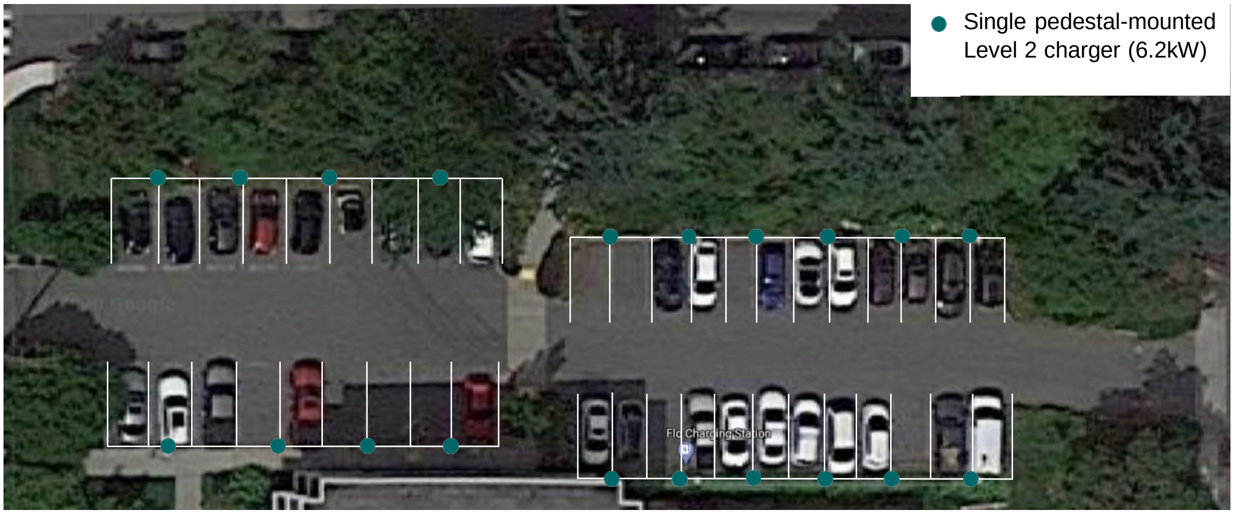


Figure 9 - High-level layout plan showing recommended charging stations in the Surface Lot of the Municipal Hall Complex over the next several years

Accessible parking

To facilitate access to every visitor at the Municipal Hall, a cable management system should be used for the accessible parking stalls in order to avoid any cable laying on the ground. This system will minimize the risk of tripping hazards from the cable by facilitating the retraction of the cable.

The position of the chargers will have to be accessible to a person in a wheelchair. The height of the charger should be at a level where the RFID card can be tapped at approximately 1 metre above the ground. The charger could be placed in between the tire stops of the two stalls with additional bollard protection.

Level P1

There are 11 Municipal Hall fleet vehicles. Based on the available data, equivalent electric fleet vehicles will on average use between 3 and 24kWh of energy per day and require 1 - 2kW of charging power overnight. During the assumed peak utilization periods, all but one of these vehicles require less than 5kW of charging power overnight. This means that Level 2 chargers (6.2kW) should be sufficient to meet the varying demands of 10 Municipal Hall fleet vehicles.

The remaining vehicle (M043 - Ford E-250 van), would require 13kW of power to fully recharge an equivalent EV overnight after a peak utilization period. However, a Level 2 charger (6.2kW) would still supply enough energy to charge approx. 50% of the battery, which is sufficient to meet the average daily demands of the vehicle. The vehicle can also be fully recharged over the weekend. Discussion with the District confirmed M043 vehicle will likely be replaced by another type of vehicle, confirming this will not be a long term problem.

Over the next several years it is recommended that 11 Level 2 chargers (6.2kW) are installed for the fleet vehicles and 1 Level 2 charger is installed to service two accessibility parking stalls. Similar to the Surface Lot, the chargers can be located between two parking stalls so that EVs parked in either stall can be charged. Figure 10 shows the charging station layout plan in Level P1 parking area.

The layout allows vehicles to be parked side by side and share a charger.

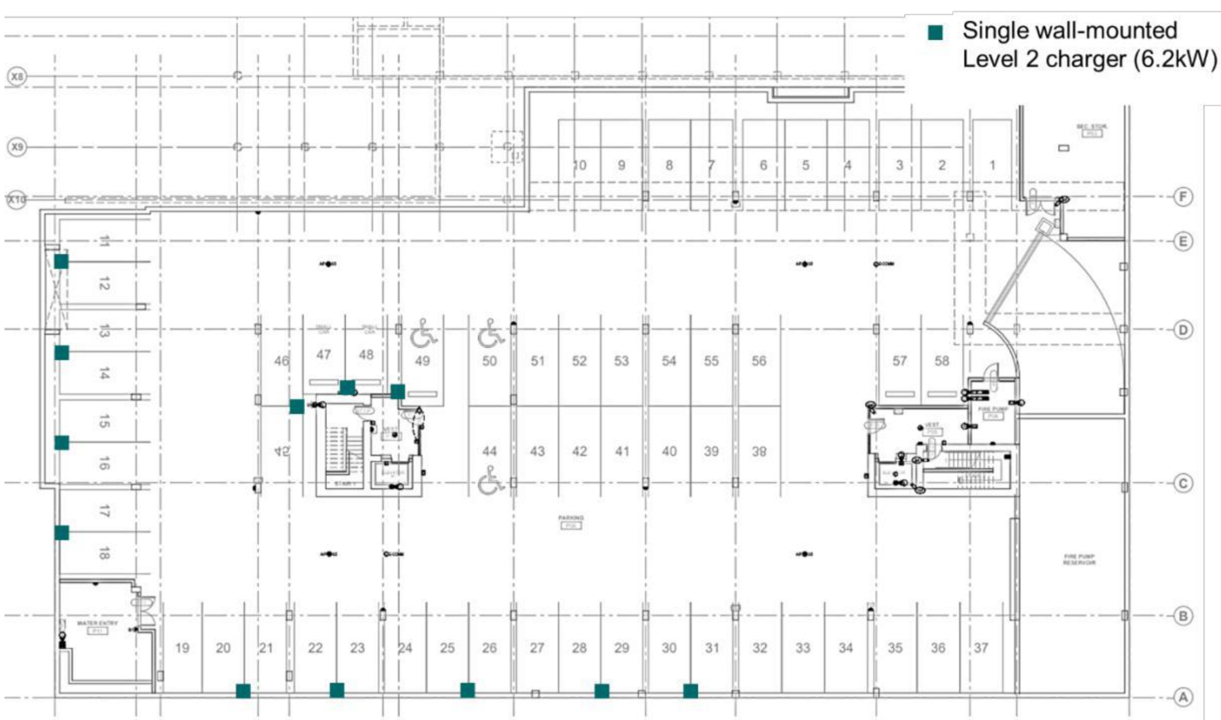


Figure 10 - High-level layout plan showing recommended charging stations in Level P1 of the Municipal Hall Complex over the next several years

As highlighted in Figure 11, the fleet vehicles will be out of the site during the day may leave the charging stations available for staff vehicles. These 12 chargers can service up to 24 staff vehicles if a stall turnover policy is introduced. If the chargers start to become saturated with staff vehicle demand, the District could increase the number of stall turnovers per day to 3 or 4 before needing to install additional chargers.

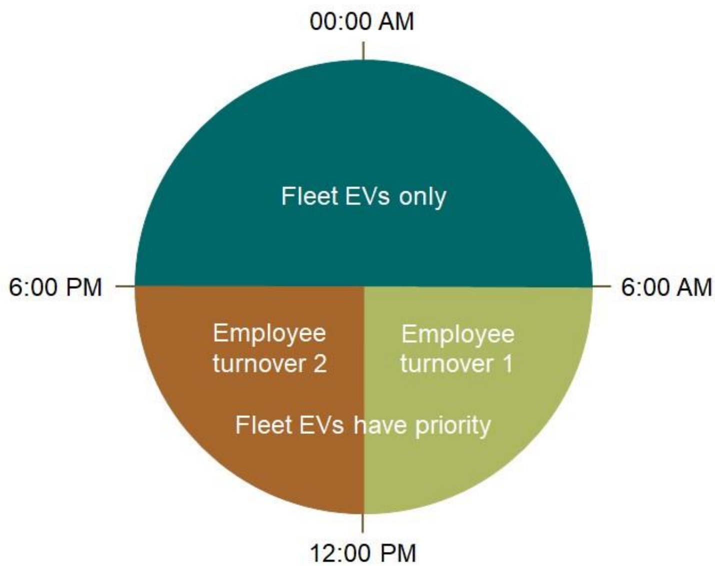


Figure 11 - Charging station 24-hour turnover design

Level P2

There are 30 Police fleet vehicles. For the purposes of assessing future EV charging requirements, these have been divided into two categories which are discussed separately.

- 16 Non-frontline police vehicles.
- 14 Frontline police vehicles

Non-frontline police vehicles:

Based on the available data, equivalent EVs for the 16 non-frontline vehicles will on average use between 1 and 24kWh of energy per day and require 1 - 2kW of charging power overnight. During the assumed peak utilization periods, all of these vehicles require less than 7kW of charging power overnight. This means that Level 2 chargers (6.2kW) should be sufficient to meet the varying demands of these 16 fleet vehicles.

It is noted the 2 of these 16 vehicles are motorbikes. Electric motor bikes are already commercially available and support the charging standard J1772. In order to simplify and standardize the charging infrastructure, Level 2 chargers are recommended for these motorbikes.

Over the next several years it is recommended that 16 Level 2 chargers (6.2kW) are installed for the non-frontline police vehicles. Figure 12 shows a draft charging station layout plan in Level P2 parking area that allows for a dedicated charger per parking stall for non-frontline police vehicles. This layout allows for fast charging stations to be installed in the future along the left hand side of the building for frontline vehicles.

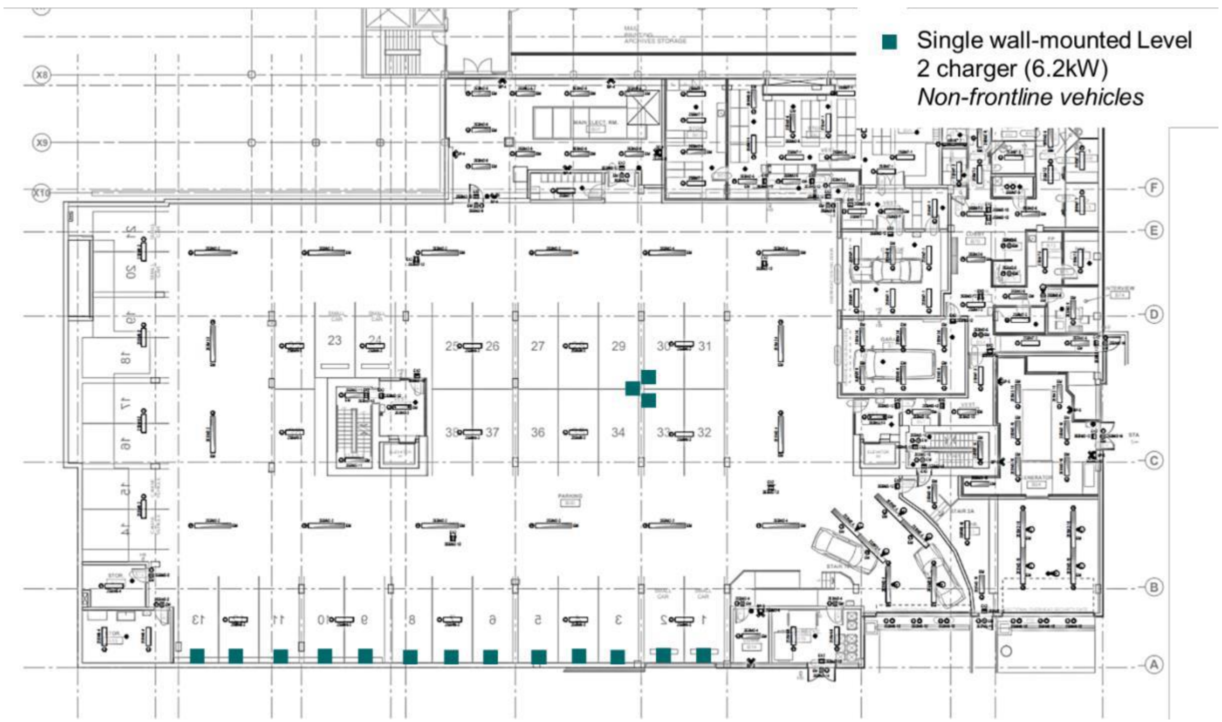


Figure 12 - High-level layout plan showing recommended charging stations in Level P2 of the Municipal Hall Complex over the next several years

Frontline police vehicles:

Based on the available data, equivalent EVs for the 14 frontline vehicles will on average use between 16 and 110kWh of energy per day and require 1 - 7kW of charging power overnight. However, during the assumed peak utilization periods (i.e. when these frontline vehicles are out on shifts for up to 22 hours a day), these vehicles will need large battery packs and require fast chargers capable of supplying an average of 50 - 80kW of power.

Installing several fast chargers capable of supplying this power will cost the District a lot of money and would be a poor utilisation of an expensive asset. Increasing utilisation of the charger by sharing it with the public is also not realistic as the main users of the infrastructure provide a critical service that cannot "wait" for a member of the public to free the charger before charging the police vehicles. Also, there may be security risks with allowing the public to use the chargers depending on where they are located.

If these frontline police vehicles are sequenced to return to the Municipal Hall at staggered times during peak periods, then the number of fast chargers can be minimized as they will be shared between multiple frontline vehicles. Alternatively, the Police could increase the number of frontline EVs for the same operation, which would increase the time each EV is available for charging.

Further analysis and discussion with the Police department of their operations is required to provide practical and low risk recommendations around EVs and charging infrastructure for the frontline vehicles.

b. Operations Centre

The Operation Centre is divided into four parking areas outlined in Table 11. The table also shows the assumed primary users in each area and the associated number of parking stalls. The final column of the table has the recommended number and type of charging stations to be installed in each area over the following 20 years.

Table 11 - Operation Centre - Parking areas and charging stations

Parking area	Number of parking stalls	Assumed primary users	Recommended charging stations
Top Lot	80	Staff vehicles	- 0
Back Lot	65	Fleet + staff vehicles	- 36 Level 2 (6.2 kW) - 13 Level 2 (13 kW)
Main Lot	17	Staff + visitor vehicles	- 0
East Lot	16	Fleet vehicles	- 3 Level 3 (25 kW) - 9 Level 2 (6.2kW) + 1 Level 2 (13kW) for Off-Road Vehicles.

Based on the recommended charging stations, there could potentially be a peak electrical load from charging EVs of approximately 300 kVA. This load is higher than the 223 kVA spare capacity of the service feeding the Operations Centre (refer to the AES report: "West Vancouver Operations Centre EV Infrastructure Assessment"). Therefore a new service to the Operations Centre may be required in the future to meet the power demands of this charging infrastructure conceptual design. The charging infrastructure concept design does include load sharing and highlights the potential opportunity for smart charging intelligence to reduce peak demand.

It is noted that there are 88 fleet vehicles that have been assessed for future electrification at the Operations Centre. These comprise of an SUV, light to heavy-duty trucks, vans and off-road vehicles. For the purposes of assessing future EV charging requirements, these have been divided into three categories which are discussed separately.

- 55 Standard operational vehicles.
- 26 Snow and/or debris clearing vehicles[25].
- 7 Emergency off-road vehicles[12].

Future charging requirements are then discussed for staff and visitors in the Top Lot and Main Lot parking areas. Finally, a new electrical service to the site is discussed.

[25] It is noted that these vehicles will perform standard operational duties most of the time. However, they must be able to operate to full functionality when snow clearing or in an emergency

Back Lot and East Lot - Standard Operational Vehicles and Staff Vehicles

The vehicles under this category are operated on average between the hours of 0700 and 1600. During peak periods they are assumed to travel up to 150km per day or be in running operation for 8 hours per day and return to the Operations Centre for 13 hours overnight. These vehicles comprise of 3 vans, 1 SUV, 25 light-duty trucks, 12 medium-duty trucks, 3 heavy-duty trucks and 11 off-road vehicles.

Vans, SUV and Light-Duty Trucks

Based on the available data, equivalent EVs will on average use between 5 and 42kWh of energy per day and require 1 - 3kW of charging power overnight. During the assumed peak utilization periods, these vehicles require 5 - 10kW of charging power overnight. This means that Level 2 chargers (6.2kW) should be sufficient to meet the average demands of these 29 fleet vehicles, while Level 2 chargers (13kW) are required to fully recharge the vehicles during peak periods.

Figure 13 shows an example distribution curve for one of these vehicles, highlighting the proportion each type of charger is required to fully recharge the vehicle overnight. Assuming the vehicles won't be highly utilized at the same time, the number of 13 kW chargers can be minimal. Also, due to the average utilization, a vehicle does not have to be fully recharged to perform its duty the next day. A weekly simulation shows that Level 2 chargers (6.2kW) are generally sufficient during peak periods as the vehicle can be fully recharged over the weekend (refer to Figure 14).

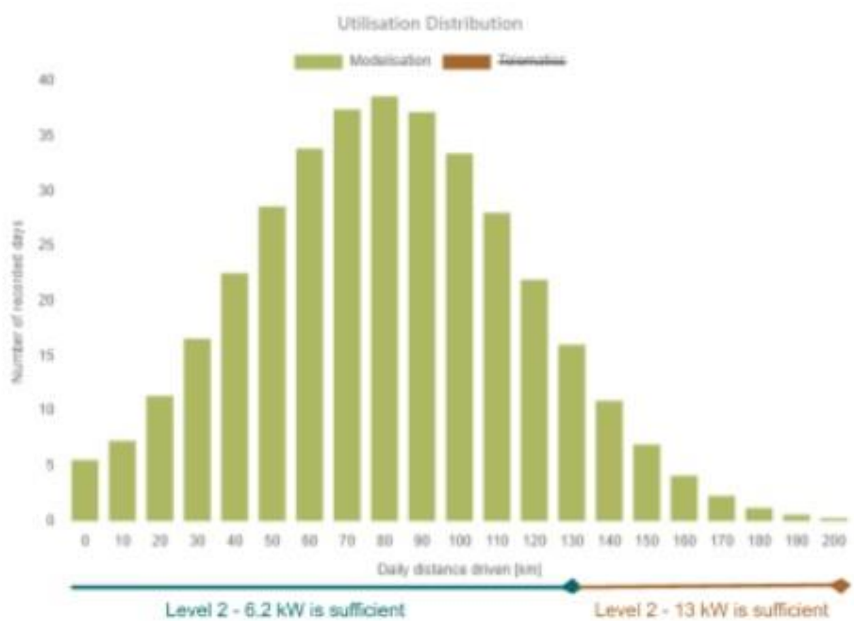


Figure 13 - Daily utilisation distribution across 1 year for an example vehicle

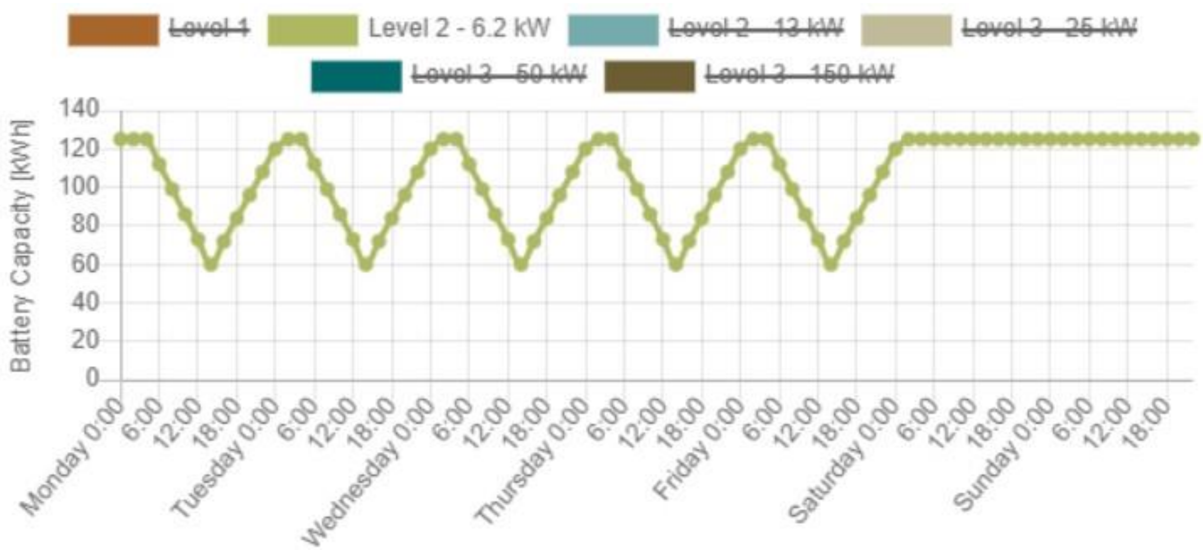


Figure 14 - Weekly charging simulation for example vehicle

Over the next several years it is recommended that 28 Level 2 chargers (6.2kW) on a 2-shared configuration and 1 Level 2 charger (13kW) are installed to account for these 29 equivalent EVs. An EV fleet management system will need to notify the driver of the vehicle that requires the 13kW charger before the vehicle comes back to the site.

Medium-Duty Trucks

Based on the available data, equivalent medium-duty EVs will on average use between 11 and 66kWh of energy per day and require 1 - 4kW of charging power overnight. During the assumed peak utilization periods, these vehicles require 10 - 12kW of charging power overnight. This means that Level 2 chargers (6.2kW) should be sufficient to meet the average demands of these 12 fleet vehicles, while Level 2 chargers (13kW) are required to fully recharge the vehicles during peak periods. Due to the minimal cost different between 6.2kW and 13kW chargers, and the risk that the EV will not be fully recharged, it is recommended to use 13kW chargers.

However, the electrification of medium duty vehicles is complicated and should be deprioritized compared to the light and heavy-duty vehicles. Medium duty vehicles require a significant amount of energy but do not have the size of heavy-duty vehicles to house these batteries. To perform the same duty as the 12 diesel medium-duty trucks, an equivalent EV should have battery capacity of up to 200kWh. Medium-duty vehicles with this size battery are not available on the market at the moment. Current conversion models (Motiv and Lighting System) have a battery with around 125kWh capacity.

For these medium-duty trucks, it is recommended:

- To perform a right-sizing assessment to see whether a light-duty electric truck can perform the same duties as these medium-duty trucks. If this is the case, these vehicles could be electrified sooner.
- If medium-duty trucks are required, then gradually install 12 Level 2 chargers (13kW) on a 3-shared configuration as equivalent EVs become available in several years' time.

Heavy-Duty Trucks

Based on the available data, equivalent heavy-duty EVs (M005, M020, M065) will on average use between 49 and 86kWh of energy per day and require 3 - 6kW of charging power overnight. During the assumed peak utilization periods, these vehicles require 10 - 20kW of charging power overnight. This means that Level 2 chargers (6.2kW) should just be sufficient to meet the average demands of these 3 fleet vehicles, while Level 3 fast chargers (25kW) are required to fully recharge the vehicles during peak periods.

For these 3 heavy-duty trucks, it is recommended that 3 Level 3 fast chargers (25kW) on a 2-shared configuration is installed. Although Level 2 chargers would be sufficient most of the time based on the data provided by the District, they may not be capable of supplying enough energy if these vehicles increased their average daily distance. Also, there is only a small cost premium for Level 3 fast chargers (25kW) relative to the purchase cost of the vehicle. Therefore, this recommendation is based on a risk assessment accounting for these factors.

Off-Road Vehicles

Construction and off-road vehicles are a great case for electrification to eliminate idling emissions, and improve local air quality and construction noise. Also, several manufacturers have announced electric versions of their popular products as highlighted in Section 3.

Our research has found that the charging standard used on the off-road vehicles is unclear as they are still at the prototype stage. For example, the Case 580 EV Backhoe vehicle is stated to charge on 220 V using three-phase power which is a European standard system. J1772 does not have the connectivity for three-phase power. We anticipate vendors will adapt to the North American standard used by on-road vehicles. The District should pay particular attention to the charging standard when procuring the vehicles to make sure the charging infrastructure can be integrated into the platform.

Forklifts have been electrified for a long time because of their indoor application and does not use J1772.

Based on the available data, equivalent off-road EVs will on average use between 2 and 29kWh of energy per day and require 1 - 2kW of charging power overnight. During the assumed peak utilization periods, these vehicles require 5 - 10kW of charging power overnight. This means that Level 2 chargers (6.2kW) should just be sufficient to meet the average demands of these 11 fleet vehicles, while Level 2 chargers (13kW) are required to fully recharge the vehicles during peak periods.

Over the next several years it is recommended that 9 Level 2 chargers (6.2kW) on a 3-shared configuration and 1 Level 2 charger (13kW) are installed to account for these 11 equivalent EVs. The electric forklift would require a separate charger not accounted for here. Similar to the charging of the light-duty trucks, an EV fleet management system will need to notify the operator of the off-road vehicle that requires the 13kW charger before the vehicle comes back to the site.

Concept Design Layout

Figure 15 shows a draft charging station layout plan for the standard operational vehicles in the Back Lot and East Lot parking areas.

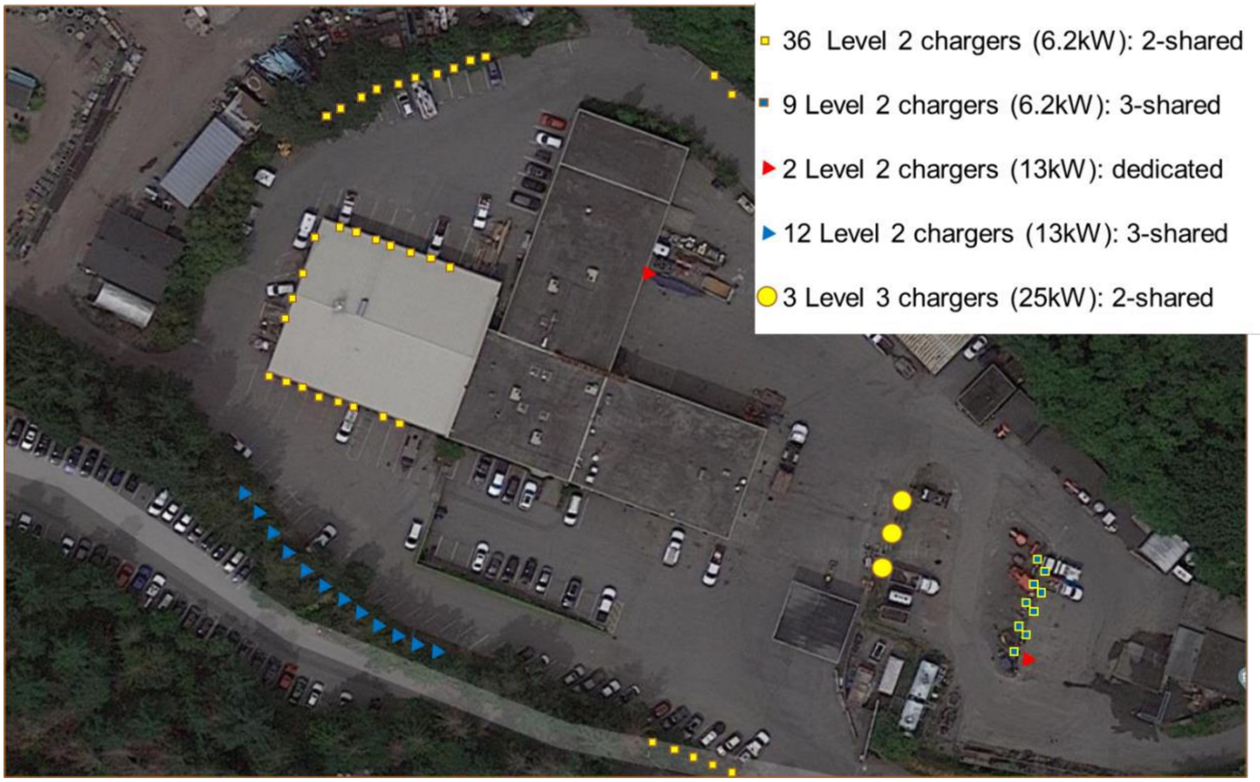


Figure 15 - High-level layout plan showing recommended charging stations at the Operations Centre

Snow and/or Debris Clearing Operational Vehicles

The vehicles under this category are operated on average between the hours of 0700 and 1600. During peak periods:

- Heavy-duty trucks are in running operation for 20 hours a day and can return to the Operations Centre for 2 hours per day.
- Light and medium-duty trucks used for snow and debris clearing travel up to 250km per day and can return to the Operations Centre for 2 hours per day.

These vehicles comprise of 14 light-duty trucks, 6 medium-duty trucks and 6 heavy-duty trucks.

Based on the available data and assumptions made, equivalent EVs would require between 50kW (light-duty) to 350kW (heavy-duty) to recharge the vehicles during peak snow and/or debris clearing periods. Furthermore, these vehicles would require battery packs that exceed the size of those in future announced vehicles (i.e. 600 to 900kWh for heavy-duty vehicles).

Even if equivalent EVs with large enough batteries become available, the District would need to install several ultra-fast chargers capable of supplying this power, which will cost a lot of money and would be a poor utilization of an expensive asset.

For these vehicles, it is recommended that:

- Further discussions and detailed analysis of the utilization of these vehicles is performed to better understand the requirements during snow and/or debris clearing periods. This could involve installing data loggers on these vehicles.
- Assess and compare different zero-emission technologies, like hydrogen or renewable fuels, with battery electric to provide practical and low risk recommendations.

Emergency Off-Road Vehicles

The vehicles under this category are operated on average between the hours of 0700 and 1600. During peak periods they are assumed to be in running operation for 20 hours a day and can return to the Operations Centre for 2 hours per day. These 7 off-road vehicles comprise of 3 backhoes, 2 bobcats, an excavator and a front end loader.

Based on the available data and assumptions made, equivalent EVs would require between 50kW to 150kW to recharge the vehicles during emergency periods. Furthermore, these vehicles would require very large battery packs in the order of 150 to 400kWh.

Similar to the snow and/or debris clearing vehicles, ultra-fast chargers would be required for these vehicles. Also, in a significant emergency, such as an earthquake, there could be a loss in electrical power at the Operations Centre resulting in EVs being unable to recharge.

For these vehicles, it is recommended that:

- Further discussions with the District around the specific requirements of these vehicles during an emergency.
- Assess and compare different zero-emission technologies, like hydrogen or renewable fuels, with battery electric to provide practical and low risk recommendations. This assessment should also include plug-in-hybrid electric equivalents, if available, or having portable generators to recharge these vehicles at site during operations.

Main Lot / Back Lot - Staff and Visitor Vehicles

To meet the future demands of electric staff and visitor vehicles, it is recommended to install 8 Level 2 chargers (6.2kW) over the next several years to service 16 parking stalls in the Main Lot as shown in the layout plan of Figure 14. Assuming that 10 of these parking stalls are for staff, then 5 of the Level 2 chargers can service 10 staff vehicles if a stall turnover policy is introduced. The stall turnover would only require the charging cable being moved between the two parking stalls it services. The remaining 3 chargers can service visitor vehicles.

This configuration will offer the greatest utilization of the charging stations as one charger will have two stalls it can supply. In the future, if this configuration cannot supply the complete demand, the District can install additional chargers on the pedestals to have one charger per parking stall in a 2-shared configuration, which will not increase the required electrical capacity.

Top Lot - Staff Vehicles

If staff vehicles cannot park in the fleet vehicle stalls, then the District will need to make provisions for charging stations in the Top Lot after there are more than 10 staff EVs requiring charging services at the Operations Centre. Based on the growth of EVs outlined in Section 2 and assuming there are / will be 90 staff vehicles at the Operations Centre (80 in Top Lot plus 10 in Main Lot), it is estimated there will be around 25 staff EVs by 2030 and 70 staff EVs by 2040. These future EVs can theoretically be covered in the Main Lot and Back Lot. Also, as these staff vehicles will charge at a different time to the fleet vehicles, they will not increase the peak electrical load on the site. Therefore, it is recommended that the requirements for EV charging stations in the Top Lot are re-assessed at a later date following discussions with the District.

New Electrical Service & Backup Power

Based on the concept design outlined above, there could be a peak power demand of up to 255 kW overnight over the existing power demand. As the current spare capacity at the Operations Centre is only 223 kVA, an electrical upgrade would be required to meet this future demand. However, due to the replacement schedule of vehicles and availability of equivalent EVs, it will be several years until any upgrade may be required.

We also recommend the District implements a smart charging management system to minimize this peak demand. This could result in no electrical upgrade being required. Our preliminary simulation, shown in Figure 16, shows that there is a lot of opportunity to stagger the charging sessions of the vehicles.

Any future analysis of smart charging potential and sizing of an electrical upgrade should also include a review of the clearing and emergency vehicles. This is because the outcome of that review might result in some ultra-fast chargers needing to be installed to top up the energy of those vehicles between shifts.

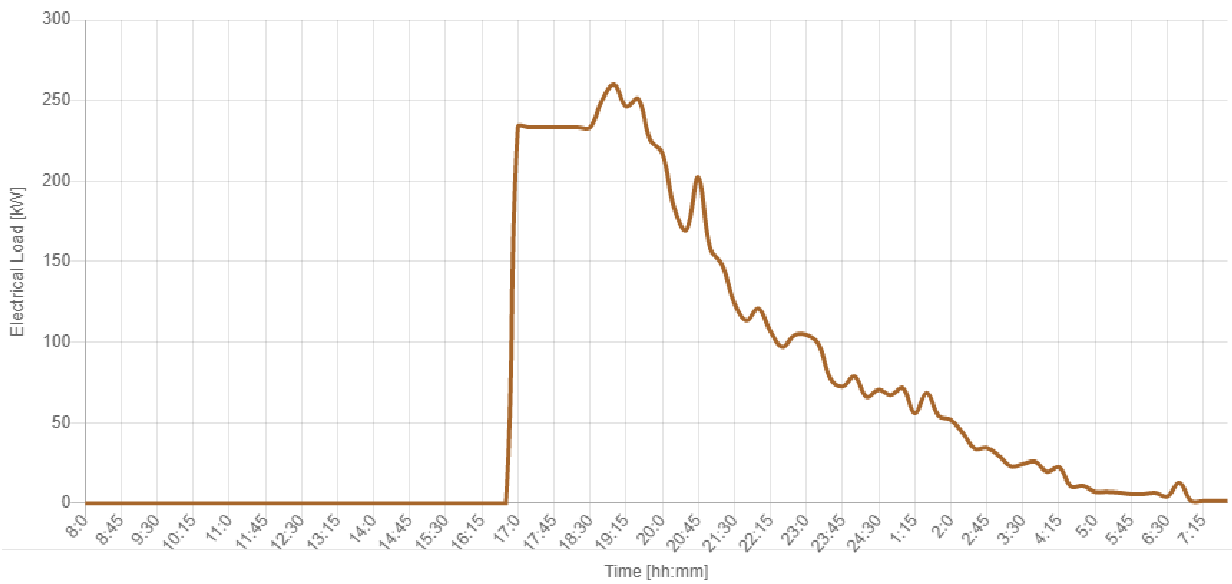


Figure 16: Simulation of most likely charging profile for the operation centre

Vehicles at the operations centre are at the core of the District's working capability and are expected to be used in case of major incidents (e.g. earthquake, snowstorm, etc.). A backup power generator is already installed at the site. An analysis of its capacity and carbon impact is required to evaluate its capability to support the fleet electrification.

c. West Vancouver Community Centre

The West Vancouver Community Centre is divided into four parking areas. A total of 6 Level 2 chargers are required to charge the shuttle buses (13 kW) and the vans (6.2 kW).

Fleet Vehicles

There are 6 vehicles located at the West Vancouver Community Centre (3 vans and 3 shuttle buses). Based on the available data, equivalent electric fleet vehicles will on average use between 6 and 71kWh of energy per day and require 1 - 5kW of charging power overnight. During the assumed peak utilization periods, the vans require less than 6kW of charging power overnight, however, the shuttle buses require 11kW. It is therefore recommended that 3 Level 2 chargers (6.2kW) for the vans and 3 Level 2 chargers (13kW) for the shuttle buses are installed to meet the demands of these future EVs.

It is understood the shuttle buses are currently parked offsite. Further discussions are required with the District to determine appropriate locations for the shuttle bus charging stations. This decision should be done in parallel with an electrical inspection to identify location where the electrical upgrade is minimal.

Staff and Visitor Vehicles

This section is a secondary focus to the study and is information to be considered by the District if there is an interest in offering charging services to staff and visitor vehicles. Based on the growth of EVs outlined in Section 2 and assuming all non-fleet parking stalls will be used by staff and visitor vehicles, it is estimated there will be approximately 60 staff / visitor EVs parking at the West Vancouver Community Centre by 2030, increasing to around 150 by 2040.

To provide charging for these future staff and visitor EVs parking at the West Vancouver Community Centre, the District may install:

- 1 Level 2 charging station (6.2kW) for every 2 staff EVs. The stations should be located between two staff parking stalls with a stall turnover policy.
- 1 Level 2 charging station (6.2kW) for every visitor EV.

d. Gleneagles Community Centre

One new fleet van is expected at the Gleneagles Community Centre in the next couple of years. Our analysis of existing vans used by the District indicates that a Level 2 charger at 6.2 kW is sufficient.

Staff and Visitor Vehicles

The staff and visitor vehicles are secondary focus of this study. Based on the growth of EVs outlined in Section 2 and assuming all non-fleet parking stalls will be used by staff and visitor vehicles, it is estimated there will be approximately 40 staff / visitor EVs parking at the Gleneagles Community Centre by 2030, increasing to around 100 by 2040.

Similar to the West Vancouver Community Centre, the District can install the following to provide charging for these future staff and visitor EVs parking at the Gleneagles Community Centre.

- 1 Level 2 charging station (6.2kW) for every 2 staff EVs. The stations should be located between two staff parking stalls with a stall turnover policy.
- 1 Level 2 charging station (6.2kW) for every visitor EV.

e. Fire Halls

The District has two fire hall sites being considered for EV charging infrastructure as outlined in Table 12. The table also shows the assumed primary users in each area and the associated number of parking stalls. The final column of the table has the recommended number and type of charging stations to be installed in each area over the following 20 years.

Table 12 - Fire Halls - Parking areas and charging stations

Parking area	Number of parking stalls	Assumed primary users	Recommended charging stations
Fire Hall #1	28	Fleet vehicles	- 6 Level 2 (6.2 kW) - 1 Level 3 (25 kW)
Fire Hall #2	15	Fleet vehicles	- 2 Level 2 (6.2 kW) - 1 Level 3 (25 kW)

Further analysis along with site visits would be required to determine if service upgrades are required in the future. Also, a reassessment of the electrification of the fire trucks should be performed before doing this analysis.

The details and high-level 20-year masterplans of the recommended charging stations are provided below.

Fleet Vehicles

There are 18 fleet vehicles that have been assessed for future electrification at the fire halls, which comprise of:

- 8 heavy-duty fire trucks; and
- 10 support vehicles (cars, SUVs, vans and light-duty trucks). It is assumed 7 of these vehicles are located at Fire Hall #1 and the remaining 3 are located at Fire Hall #2.

It is assumed in an emergency; heavy duty fire trucks are in running operation for 16 hours a day and can return to a Fire Hall site for 2 hours per day. Fire support and command vehicles travel up to 200km a day and can return to a Fire Hall site for 8 hours per day.

Support Vehicles

Based on the available data and assumptions made, equivalent EVs would require between 5kW to 15kW to recharge equivalent EVs during emergency periods. Due to the critical nature of the fire services, it is recommended that at least 1 Level 3 fast charger (25kW) is installed at each fire hall, with the balance of EVs having a dedicated Level 2 charger (6.2kW).

However, further work needs to be carried out with the fire department to confirm assumptions and undertake a detailed assessment of their operations, including a review of the heavy-duty fire trucks, before finalizing the charging infrastructure plan.

Heavy-Duty Fire Trucks

Based on the available data and assumptions made, equivalent EVs would require between 250kW to 450kW to recharge the vehicles during emergency periods. Furthermore, these vehicles would require very large battery packs in the order of 500 to 900kWh.

Ultra-fast chargers would be required for these vehicles. Also, in a significant emergency, such as an earthquake, there could be a loss in electrical power at the fire halls resulting in EVs being unable to recharge or at least being able to recharge with fast chargers (back-up generators will not have the capacity to power fast chargers).

For these vehicles, it is recommended that:

- Further discussions with the Fire Department around the operations of these vehicles. If fire trucks normally travel less than 30km per day and don't require much ancillary power when stationary, then the Rosenbauer plug-in hybrid electric fire truck may be a good solution to reduce emission. However, if fire trucks are normally idle and then travel over a long distance and use a lot of ancillary power in an emergency, then the diesel engine will be the primary power source.
- Assess and compare different zero-emission technologies, like hydrogen or renewable fuels.

Staff and Visitor Vehicles

The staff and visitor vehicles are secondary focus of this study. At each fire hall site, 5 of the parking stalls are for fleet vehicles. Therefore, there are 23 stalls at Fire Hall #1 and 10 stalls at Fire Hall #2 for staff and visitors. Based on the growth of EVs outlined in Section 2, it is estimated there will be approximately 10 staff / visitor EVs parking at the fire halls by 2030, increasing to around 25 by 2040.

To meet the future demands of these electric vehicles, the District could install 8 Level 2 chargers (6.2kW) at Fire Hall #1 and 4 Level 2 chargers (6.2kW) at Fire Hall #2 over the next 20 years.

6. 20 Year Strategic Plan

The District wants to develop a 20-year strategic plan to reduce GHG emissions through fleet electrification. In developing this plan, the District has outlined four different Scenarios to be modelled, which are outlined below.

Scenario #1 "Existing fleet policy, replacement schedule, charging infrastructure available when needed"

Scenario #2 "IPCC - What would it take to attain the targets set out by IPCC (Intergovernmental Panel on Climate Change) as applied to corporate fleet?" .

Scenario #3 "Expansion of zero-emission light duty pool vehicles"

Scenario #4 "Constrained funding"

This section outlines high-level 20-year roadmaps for the electrification of fleet vehicles under Scenarios 1 and 2, and then highlights the changes to the Scenario 1 roadmap to meet the criteria of the final two scenarios. An evaluation of the existing fleet vehicle ages, replacement schedules, utilization requirements, current and future technologies, and costs was performed to prioritize when vehicles should be replaced with EVs. A staged infrastructure development to meet the transition requirements is then provided.

The roadmaps include suggested vehicle replacements and charging infrastructure for each of the first 10 years, along with the approximate annual CAPEX requirements associated with these roadmaps. The roadmaps then have more generic suggested vehicle replacements and charging stations for the years 10 - 20. The costs of the final 10 years are not detailed because of the changing landscape in electric vehicle technologies and costs.

Independently of all the scenarios, the District should become a Part 3 Fuel supplier under the BC Low Carbon Fuel Standard in order to generate carbon credits. Preliminary estimation indicates that the District could generate approximately $50k per year of new revenue from the carbon credits by 2030, assuming the average carbon credit price in 2020[26].

[26] https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/electricity-alternative-energy/transportation/renewable-low-carbon-fuels/monthly_credit_market_report_-_2020-12.pdf

a. Assumptions

Vehicle Replacement Schedules

The replacement dates for the different types of vehicles are based on suggested replacement dates provided by the District and the following replacement schedule assumptions.

- The majority of vehicles are typically replaced every 10 years. However, this period can be extended if required for budget purposes or if the vehicle is in good condition. For the purposes of this study, this period is also extended if required to fit within the annual budget or in certain circumstances to wait until an equivalent EV is available.
- Fire trucks are in front line service for 15 years and then reserve service for 5 years before typically being replaced. Smaller fire vehicles are replaced every 10 years. The replacement of fire vehicles takes precedence over other vehicles in the fleet.
- Frontline police vehicles are typically replaced every 4 years.
- The District purchases vehicles to replace the 10 vehicles currently leased.

Cost Estimates

The high-level cost estimates used in the roadmap are based on the assumptions outlined below. However, it is noted technology is rapidly evolving making cost predictions difficult to predict beyond a 3-5 year horizon. To account for future capital costs a modest rate of inflation of 1% was assumed in the model. All cost estimates used to create the roadmaps should be confirmed before finalizing budgets.

Charging Infrastructure - CAPEX

- The high-level cost estimates include allowances for the electrical infrastructure to support the charging stations and are based on the work performed by AES[27]
- No service upgrades are required at any District facility site.
- Estimated costs for supplying and installing the recommended charging stations are outlined in Table 13. These costs include an average cost for purchasing the charger and an assumed installation cost.

Table 13 - Charging station supply and installation cost estimates

Charger Type	Supply & installation cost
Level 2 Charger (6.2kW)	$4,000
Level 2 Charger (13kW)	$5,000
Level 3 Charger (25kW)	$25,000

[27] "West Vancouver Municipal Hall EV Infrastructure Assessment" and "West Vancouver Operations Centre EV Infrastructure Assessment"

Charging Infrastructure – Maintenance

- The annual maintenance and software costs of Level 2 charging stations were assumed to be $300 per station.
- The annual maintenance and software costs of Level 3 fast charging stations were assumed to be $1,000 per station.
- These costs are included in the OPEX estimates of the roadmaps.

Vehicles - CAPEX

- The assumptions outlined in Table 14 were made regarding the cost of replacement vehicles.The vehicle cost estimates have been based on data provided by the District, published costs and "best guess" assumptions when cost information is not available.
- No rebates / grants were used in the model. Although the cost estimates for equivalent EVs are relatively high, it is noted there are a number of government incentives to help cover those costs. For example, the CleanCB Go Electric Speciality-Use Vehicle Incentive (SUVI) program offers a rebate of up to $150,000 per medium or heavy-duty EV, up to ten vehicles. The CVP program offers incentives for the charging infrastructure and vehicles up to 33% of the project cost. EVs also can result in significantly lower ongoing fuel costs, further offsetting these high costs.

Table 14 - Approximate vehicle replacement costs used to develop roadmaps

Vehicle Type	Cost of diesel / gasoline replacement	Cost of equivalent EV replacement
CAR CAR - Frontline	$30,000 $60,000	$45,000 -
SUV SUV - Frontline / Emergency	$40,000 $60,000 - $70,000	$100,000 -
VAN	$40,000	$60,000
CARGO VAN	$60,000	$180,000 ($100,000)[30]
LIGHT DUTY TRUCK LDT - Frontline / Emergency	$40,000 - $60,000 $70,000 - $100,000	$70,000 - $90,000 $100,000 - $120,000[31]
MEDIUM DUTY TRUCK	$80,000 - $140,000	$250,000[32]
HEAVY DUTY TRUCK	$280,000	$400,000

[30] The estimated $180,000 price is based on the range of prices for current conversions. However, based on the estimated price for the small Ford Transit, it is expected that the price for the large Ford Transit electric will be much lower.
[31] Assumed cost based on premium for gasoline police and fire trucks.
[32] Based on range of prices for current conversions. It is expected that this price will drop significantly once manufacturers turn their attention to this class of vehicle.

Vehicle Type	Cost of diesel / gasoline replacement	Cost of equivalent EV replacement
HDT - Emergency	$930,000[33]	$1,600,000[34]
SHUTTLE BUS	$160,000	$320,000
OFF ROAD[35] Backhoe Excavator Mini-excavator Tractor Bobcat Forklift Front end loader Roller	 $195,000 $220,000 $100,000 $80,000 $70,000 $50,000 $150,000 $50,000	 $390,000 $440,000 $200,000 $160,000 $140,000 $100,000 $300,000 $100,000

Vehicles – Maintenance

- The District expects the repair and preventative maintenance costs of an electric vehicle fleet will be relatively similar to the existing vehicle maintenance costs[36]. Therefore, vehicle maintenance is excluded from the cost estimates for the purposes of this study.

Fuel

- The fuel costs are based on the assumptions outlined in Table 15.

Table 15 - Fuel price assumptions

Fuel	Price
Diesel[37]	$1.26 / L
Gasoline	$1.38 / L
Electricity - Energy[38]	$0.0606 / kWh
Electricity - Power demand	$12.34 / kW / month

[33] Based on allowed CAPEX from the District for a Spartan Pumper / Smeal Sirus Pumper / Pierce ArrowXT Pumper
[34] Based on the Rosenbauer Fire Truck plug-in hybrid electric vehicle.
[35] The battery electric versions of these off-road vehicles are assumed to be twice the price of the diesel versions for the purposes of this study.
[36] Refer Progress Meeting Minutes held on 15 October 2020.
[37] Price based on average of monthly prices in Vancouver from January 2019 to December 2020 https://www150.statcan.gc.ca/t1/tbl1/en/cv.action?pid=1810000101
[38] Based on BC Hydro rates for Large General Service Rate, which the District facilities will likely fall into with demands higher than 150kW. It is noted that BC Hydro announced a demand charge holiday for fleet electrification.

- For the purposes of this study, the cost of renewable diesel was assumed to be at least 50% more than the cost of diesel shown in the table above. The actual cost of renewable diesel would be based on a specific supply contract similar to the one the City of Vancouver has with Suncor.
- Annual fuel costs were assumed to remain constant for the purposes of this study.

Greenhouse Gas Emissions

The estimated GHG emissions outlined in the scenarios were calculated using the default carbon intensity (CI) values from the BC "Renewable and Low Carbon Fuel Requirements Regulation" as shown in Figure 17. The exception to these values is the CI for 100% renewable diesel (R100) in Scenario 2, which was assumed to be 35 gCO_2e/MJ based on the Canadian "Clean Fuel Standard - Proposed Regulatory Approach (June 2019).

COLUMN 1 **Fuel**	**COLUMN 2** **Carbon Intensity** **(g CO_2e/MJ)**
Renewable fuel in relation to diesel class fuel	98.96
Propane	75.35
Renewable fuel in relation to gasoline class fuel	88.14
Natural gas-based gasoline	90.07
LNG	112.65
CNG	63.64
Electricity	19.73
Hydrogen	96.82

Figure 17 - Default carbon intensity values of different fuels in BC (Renewable and Low Carbon Fuel Requirements Regulation)

b. Scenario 1

"Existing Fleet Policy, Replacement Schedule, Charging Infrastructure available when Needed"

An electrification roadmap to meet the criteria of Scenario 1 is shown on the following pages. After discussions with the District, a modest annual CAPEX budget of around $2M was used as a guideline for creating this roadmap. It is noted that not all years fit directly within this budget due to the high capital costs associated with replacing certain vehicles. In summary, the roadmap:

- Replaces 55 existing fleet vehicles with EVs by 2030, increasing to 99 by 2040.
- Replace remaining vehicles (i.e. frontline, clearing and emergency) with either ICE (internal combustion engine vehicles) equivalents or PHEV (plug-in hybrid electric vehicle) equivalents if available (refer to Section 3). Further discussions and detailed analysis of the daily utilization is recommended to assess different zero-emission technologies for these vehicles.
- Over the next 20 years, install 105 Level 2 chargers (6.2kW), 17 Level 2 chargers (13kW) and 5 Level 3 chargers (25kW) at District facilities.
- Reduces annual greenhouse gas emissions by 310 tonnes by 2030 and by 580 tonnes by 2040 (approximately 20% and 35% respectively relative to the 2020 estimated emissions).
- Reduces annual fuel costs by approximately $40k by 2030 and $100k by 2040 (NOTE: these numbers are based on current energy prices). The fuel cost reductions are small, because of the potential peak power demand charges (approximately $90,000 in 2030 and $130,000 in 2040). A smart charging management system could reduce the peak power significantly, but further work is required to quantify this saving. The District should also evaluate the BC Hydro fleet electrification rate, which provides an exemption to the demand charge for overnight EV charging.

The details of the vehicle replacements in the Scenario 1 roadmap are provided in Appendix A.

Scenario 1

Annual Replacement Vehicles

Vehicles	Total No. - 2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Cars / SUVs	1 EV 34 ICEs 2 PHEVs	1 EV 3 ICEs	5 ICEs	9 EVs 2 ICEs or PHEVs	1 ICE or PHEV	3 EVs 3 ICE s or PHEVs	4 ICEs or PHEVs	1 EV 2 ICEs or PHEVs	2 EVs 2 ICEs or PHEVs	1 EV	5 EVs 2 ICEs or PHEVs
Vans / Cargo Vans	12 ICEs	2 ICEs	3 ICEs or PHEVs	1 EV				2 EVs	1 EV		2 EVs
Light-Duty Trucks	49 ICEs	2 ICEs	11 ICEs or PHEVs	5 ICEs or PHEVs	3 EVs 1 ICE or PHEV	2 EVs	4 EVs 3 ICEs or PHEVs	1 EV 2 ICEs or PHEVs	6 EVs 4 ICEs or PHEVs	1 ICE or PHEV	3 EVs 3 ICEs or PHEVs
Medium-Duty Trucks	18 ICEs	1 ICE	1 ICE or PHEV	3 ICEs or PHEVs			4 ICEs or PHEVs	1 EV	2 EVs	1 EV 1 ICE or PHEV	1 ICE or PHEV
Heavy-Duty Trucks	17 ICEs	2 ICEs	3 ICEs or PHEVs		1 ICE or PHEV	1 EV 1 ICE or PHEV	1 ICE or PHEV		1 ICE or PHEV	1 EV 1 ICE or PHEV	
Shuttle Buses	3 ICEs		1 ICE or PHEV								1 EV
Off-Road	18 ICEs	1 ICE	3 ICEs or PHEVs	3 ICEs or PHEVs	3 EVs		1 EV	1 EV 5 ICEs or PHEVs	1 ICE or PHEV		
Infrastructure											
Municipal Hall		Electrical Upgrade 3 Level 2 (6.2kW)	3 Level 2 (6.2kW)	7 Level 2 (6.2kW)	2 Level 2 (6.2kW)	6 Level 2 (6.2kW)	3 Level 2 (6.2kW)	3 Level 2 (6.2kW)	5 Level 2 (6.2kW)	2 Level 2 (6.2kW)	9 Level 2 (6.2kW)
Operations Centre				Electrical Upgrade 3 Level 2 (6.2kW)	5 Level 2 (6.2kW) 2 Level 2 (13kW)	2 Level 2 (6.2kW) 1 Level 3 (25kW)	6 Level 2 (6.2kW)	2 Level 2 (6.2kW) 1 Level 2 (13kW)	3 Level 2 (6.2kW) 2 Level 2 (13kW)	1 Level 2 (6.2kW) 1 Level 2 (13kW) 1 Level 3 (25kW)	3 Level 2 (6.2kW)
WVCC									1 Level 2 (6.2kW)		1 Level 2 (13kW)
Fire Hall #1				2 Level 2 (6.2kW)		1 Level 2 (6.2kW)		1 Level 2 (6.2kW)	1 Level 3 (25kW)		
Fire Hall #2				1 Level 2 (6.2kW)				1 Level 2 (6.2kW)	1 Level 3 (25kW)		
Gleneagles CC				1 Level 2 (6.2kW)							
CAPEX Estimate	Vehicles	$1.2M	$2.4M	$1.8M	$2.2M	$2.0M	$1.9M	$1.9M	$2.1M	$1.9M	$1.6M
	Charing infra.	$0.12M	$0.02M	$0.35M	$0.04M	$0.10M	$0.04M	$0.04M	$0.15M	$0.05M	$0.05M
OPEX Estimate	Fuel	$640k	$640k	$640k	$630k	$625k	$625k	$620k	$615k	$610k	$600k
	Charger maintenance	$1k	$1k	$5k	$7k	$11k	$14k	$16k	$21k	$23k	$27k
GHG Reductions		1 tonnes	1 tonnes	30 tonnes	70 tonnes	120 tonnes	140 tonnes	170 tonnes	230 tonnes	260 tonnes	310 tonnes

EV – Replace existing vehicle with equivalent electric vehicle
ICE – Replace existing vehicle with an internal combustion engine vehicle powered by gasoline or diesel
PHEV – Replace existing vehicle with an equivalent plug-in hybrid electric vehicle, if available

Scenario 1

2031 → 2040

Vehicles	
Cars / SUVs	Replace remaining 1 ICE with EV (excl. frontline, clearing and emergency vehicles)
Vans / Cargo Vans	Replace remaining 6 ICEs with EVs
Light-Duty Trucks	Replace remaining 15 ICEs with EVs (excl. frontline, clearing and emergency vehicles)
Medium-Duty Trucks	Replace remaining 8 ICEs with EVs (excl. frontline, clearing and emergency vehicles)
Heavy-Duty Trucks	Replace remaining 1 ICE with EV (excl. frontline, clearing and emergency vehicles)
Shuttle Buses	Replace remaining 2 ICEs with EVs
Off-Road	Replace remaining 6 ICEs with EVs (excl. frontline, clearing and emergency vehicles)
Infrastructure	
Municipal Hall	5 Level 2 (6.2kW)
Operations Centre	Plan for New Service if required 20 Level 2 (6.2kW) + 8 Level 2 (13kW) 1 Level 3 (25kW)
WVCC	2 Level 2 (6.2kW) 2 Level 2 (13kW)
Fire Hall #1	2 Level 2 (6.2kW)
Fire Hall #2	
Gleneagles CC	
GHG Reductions	Reductions increase from 330 tonnes per year in 2031 up to 580 tonnes per year in 2040

c. Scenario 2

"IPCC - What would it take to attain the targets out by IPCC (Intergovernmental Panel on Climate Change) as applied to corporate fleet?"

For Scenario 2, the roadmap was modified to align the CO_2 emission reductions for the corporate fleet with the targets set out by the IPCC (Intergovernmental Panel on Climate Change) to limit global warming to 1.5^{0}C with no or limited overshoot. The IPCC estimated that global net CO_2 emissions must decline by about 45% from 2010 levels by 2030, reaching net zero around 2050 to not exceed 1.5^{0}C temperature rise[40].

To model this scenario, the emissions from the fleet vehicles only were considered. In 2010, the CO_2e emissions were estimated to be 1,445 tonnes (based on the average of the 2007 and 2013 emissions stated in the District of West Vancouver "Corporate Energy & Emissions Plan - 2016"). Therefore, to meet the IPCC targets, the fleet emissions need to drop to 795 tonnes by 2030 and approximately 430 tonnes by 2040. Due to the technological limitations and future availability of EVs, this roadmap includes suggested operational changes and the introduction of renewable diesel[41] to meet the IPCC targets. However, further work is required to verify and confirm whether these additional measures are the best approach. Also, the International Council on Clean Transportation (icct) found the overall sustainability of renewable diesel or biodiesel is very dependent on the source used to produce the diesel (i.e. soybean crops or waste vegetable oil) and the change in land use if a crop is used *("Biodiesel carbon intensity, sustainability and effects on vehicles and emissions"*).

As noted in different sections above, it is recommended more detailed analysis of the specific requirements for certain vehicles is carried out (i.e. frontline, clearing and emergency). This will enable different zero-emission technologies to be assessed before providing practical and low risk recommendations.

In 2018, the City of Vancouver entered into a contract with Suncor to deliver 100% renewable diesel (R100) for use in their fleet vehicles. The renewable diesel is certified to the same standard as petroleum diesel meaning it can be used in existing diesel vehicles[42]. It is noted renewable diesel will likely cost more than petroleum diesel.

[40] https://www.ipcc.ch/site/assets/uploads/sites/2/2019/02/SR15_Chapter2_Low_Res.pdf

[41] Renewable diesel or hydrogenation-derived renewable diesel can be used in existing diesel engines without needing to be blended with petroleum diesel. Biodiesel (another form of renewable diesel produced through a process called transesterification) on the other hand must be blended with petroleum diesel to be used in existing diesel engines (i.e. B10 biodiesel contains 10% biodiesel and 90% petroleum diesel).

[42] https://vancouver.ca/green-vancouver/green-fleets.aspx

An electrification roadmap to meet the criteria of Scenario 2 is shown on the following pages. An overview of suggested changes to the Scenario 1 roadmap to meet the IPCC targets is outlined below. These changes will reduce annual GHG emissions by 814 tonnes down to 774 tonnes by 2030 and by 1,304 tonnes down to 284 tonnes by 2040.

- Replacing the 14 light-duty trucks used for snow and/or debris clearing with battery electric equivalents. Based on the assumptions outlined in this report, the District will need to purchase approximately 6 additional battery electric light-duty trucks to be rotated into operations during peak periods. Furthermore, an additional 11 Level 2 chargers (6.2kW) and 3 Level 3 fast chargers (25kW) are anticipated to be needed at the Operations Centre. Further discussions and detailed analysis of the peak utilization periods of these vehicles is required to confirm the assumptions and suggestions outlined.
- Purchasing renewable diesel from 2022 to replace petroleum diesel used in medium and heavy-duty trucks for snow and/or debris clearing operations and off-road vehicles used in emergencies. Further discussions and detailed analysis of the peak utilization periods of these vehicles should be carried out to assess whether alternative options are better suited to meet the climate change goals of the District (i.e. custom PHEVs, EVs with ultra-fast chargers and operational changes, hydrogen fuel cell electric vehicles, etc.).
- From 2030, replace all 14 frontline police vehicles with battery electric equivalents and install 1 Level 3 fast chargers with 2 CCS Combo type 1 connectors (150kW) at the Municipal Hall. It is assumed these frontline EVs will return to the Municipal Hall at different times throughout the day to be topped up by the fast chargers. Further discussions and detailed analysis of the peak utilization periods of these vehicles is required to confirm the assumptions and suggestions outlined.
- The suggested changes between 2021 and 2030 results in an estimated increase to the 10-year CAPEX of $1M - $1.5M (5-10% increase), and an estimated annual increase in fuel cost of at least $30k (based on the assumption renewable diesel can be purchased at 50% more than the cost of existing diesel).

The details of the vehicle replacements in the Scenario 2 roadmap are provided in Appendix A.

Scenario 2

Vehicles	Total No. - 2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
		Annual Replacement Vehicles									
Cars / SUVs	1 EV 34 ICEs 2 PHEVs	1 EV 3 ICEs	5 ICEs	9 EVs 2 ICEs or PHEVs	1 ICE or PHEV	3 EVs 3 ICE s or PHEVs	4 ICEs or PHEVs	1 EV 2 ICEs or PHEVs	2 EVs 2 ICEs or PHEVs	1 EV	5 EVs 2 ICEs or PHEVs
Vans / Cargo Vans	12 ICEs	2 ICEs	3 ICEs or PHEVs	1 EV				2 EVs	1 EV		2 EVs
Light-Duty Trucks	49 ICEs	2 ICEs	11 ICEs or PHEVs	4 ICEs or PHEVs	5 EVs + 1 EV*	2 EVs	7 EVs + 3 EVs*	2 EVs + 1 EV* 1 ICE or PHEV	10 EVs + 1 EV*	1 EV	5 EVs
Medium-Duty Trucks	18 ICEs	1 ICE	1 ICE*	3 ICEs*			4 ICEs*	1 EV	2 EVs	1 EV 1 ICE*	1 ICE*
Heavy-Duty Trucks	17 ICEs	2 ICEs	2 ICEs*	1 EV	1 ICE*	1 EV 1 ICE*	1 ICE*		1 ICE*	1 EV 1 ICE*	
Shuttle Buses	3 ICEs		1 ICE or PHEV								1 EV
Off-Road	18 ICEs	1 ICE	3 ICEs*	3 ICEs*	3 EVs		1 EV	1 EV 5 ICEs*	1 ICE*		
Infrastructure											
Municipal Hall		Electrical Upgrade 3 Level 2 (6.2kW)	3 Level 2 (6.2kW)	7 Level 2 (6.2kW)	2 Level 2 (6.2kW)	6 Level 2 (6.2kW)	3 Level 2 (6.2kW)	3 Level 2 (6.2kW)	5 Level 2 (6.2kW)	2 Level 2 (6.2kW)	9 Level 2 (6.2kW)
Operations Centre				Electrical Upgrade 3 Level 2 (6.2kW) 1 Level 3 (25kW)	6 Level 2 (6.2kW) 2 Level 2 (13kW) 1 Level 3 (25kW)	2 Level 2 (6.2kW) 1 Level 3 (25kW)	8 Level 2 (6.2kW) 1 Level 3 (25kW)	2 Level 2 (6.2kW) 1 Level 2 (13kW) 1 Level 3 (25kW)	4 Level 2 (6.2kW) 2 Level 2 (13kW)	2 Level 2 (6.2kW) 1 Level 2 (13kW) 1 Level 3 (25kW)	5 Level 2 (6.2kW)
WVCC									1 Level 2 (6.2kW)		1 Level 2 (13kW)
Fire Hall #1				2 Level 2 (6.2kW)		1 Level 2 (6.2kW)		1 Level 2 (6.2kW)	1 Level 3 (25kW)		
Fire Hall #2				1 Level 2 (6.2kW)				1 Level 2 (6.2kW)	1 Level 3 (25kW)		
Gleneagles CC				1 Level 2 (6.2kW)							
CAPEX Estimate	Vehicles	$1.2M	$2.1M	$2.1M	$2.4M	$2.0M	$2.4M	$2.0M	$2.3M	$1.9M	$1.6M
	Charging infra.	$0.12M	$0.02M	$0.40M	$0.10M	$0.10M	$0.10M	$0.10M	$0.15M	$0.06M	$0.06M
OPEX Estimate	Fuel	$640k	$660k	$660k	$660k	$660k	$660k	$660k	$650k	$640k	$620k
	Charger maintenance	$1k	$1k	$6k	$10k	$13k	$18k	$21k	$27k	$29k	$34k
GHG Reductions		1 tonnes	90 tonnes	190 tonnes	270 tonnes	330 tonnes	460 tonnes	540 tonnes	660 tonnes	740 tonnes	810 tonnes

EV – Replace existing vehicle with equivalent electric vehicle (EV* - Add new electric vehicle to fleet)
ICE – Replace existing vehicle with an internal combustion engine vehicle powered by gasoline or diesel (ICE* - Renewable diesel)
PHEV – Replace existing vehicle with an equivalent plug-in hybrid electric vehicle, if available

Scenario 2

2031 → 2040

Vehicles	
Cars / SUVs	Replace remaining 1 ICE (non-frontline) with EV. Replace 13 frontline ICEs with EVs.
Vans / Cargo Vans	Replace remaining 6 ICEs with EVs
Light-Duty Trucks	Replace remaining 14 ICEs (non-frontline and non-clearing) with EVs. Replace remaining 1 frontline ICE and 2 clearing ICEs with EVs.
Medium-Duty Trucks	Replace remaining 8 ICEs with EVs (excl. clearing and emergency vehicles)
Heavy-Duty Trucks	Replace remaining 1 ICE with EV (excl. clearing and emergency vehicles)
Shuttle Buses	Replace remaining 2 ICEs with EVs
Off-Road	Replace remaining 6 ICEs with EVs (excl. clearing and emergency vehicles)

Infrastructure	
Municipal Hall	18 Level 2 (6.2kW) 1 Level 3 (150kW)
Operations Centre	Plan for New Service if required 23 Level 2 (6.2kW) + 8 Level 2 (13kW)
WVCC	2 Level 2 (6.2kW) 2 Level 2 (13kW)
Fire Hall #1	2 Level 2 (6.2kW)
Fire Hall #2	
Gleneagles CC	

GHG Reductions: Reductions increase from 850 tonnes per year in 2031 up to 1,300 tonnes per year in 2040

d. Scenario 3

"Expansion of zero-emission light duty pool vehicles"

For Scenario 3, the roadmap includes the phased introduction of electric pool fleet vehicles for staff to use on work trips instead of their personal vehicles. As outlined in Section 2, employees were reimbursed for travelling 125,705km, in 2019, in their personal vehicles. The District reimbursed employees $72,909.02 for this travel. By using electric pool vehicles, it is estimated the District could save approximately $55k per year[43]. Based on several assumptions, the number of pool vehicles required to significantly reduce staff vehicle usage at each facility site is assessed to be:

- 13 vehicles operating over the Municipal Hall, Operations Centre and West Vancouver Community Centre.

Assuming the electric pool vehicles are purchased between 2022 and 2026, the annual CAPEX over these years would increase by approximately $150k.

Before any decision is made on pool vehicles, it is recommended that the reduced travel due to Covid is accounted for (i.e. greater remote working and video calling).

[43] Maintenance, insurance and electricity costs were estimated to determine savings. This number excludes the monthly fuel allowance.

e. Scenario 4

"Constrained Funding"

For Scenario 4, a reduced annual CAPEX budget of around $1.5M was used as a guideline for creating modifying the roadmap. It is noted that not all years fit directly within this budget due to the high capital costs associated with replacing certain vehicles. By constraining the budget, the number of electric vehicles being integrated into the fleet is lower than in Scenario 1 due to the high capital costs of EVs. In summary, the roadmap:

- Replaces 27 existing fleet vehicles with EVs by 2030, compared with 56 in Scenario 1. The reduction in EVs are in trucks and off-road vehicles, as these represent the largest CAPEX savings.
- Reduces annual greenhouse gas emissions by 110 tonnes by 2030, compared with 330 tonnes in Scenario 1. The trucks and off-road vehicles that are not electrified in this scenario contribute the largest proportion of GHG emissions.

7. Summary & Next Steps

This study provides a 20-year plan for electric vehicle (EV) charging infrastructure to support the adoption of more electric vehicles into the corporate fleet in order to achieve reductions in its corporate greenhouse gas (GHG) emissions. More specifically, the plan includes:

- Conceptual designs for charging stations, platform recommendations, and recommend administrative approaches to the EV charging system that meets the needs of the predicted expansion of our EV fleet.
- A model to predict future Greenhouse gas emissions, and emission reductions associated with the transition of its fleet to rely more heavily on EVs.

The work focused on EV charging requirements of the District's corporate fleet. A secondary focus included considerations related to building in some capacity for staff, public or visitor charging at District facilities.

There are multiple factors to consider when evaluating fleet electrification and charging infrastructure over a 20-year horizon. A summary of the main findings in this report are provided below.

Study Limitations

- Municipal fleet vehicles play a critical role during emergencies (e.g. snow, ice and extreme weather; fire and police emergency response). During simulations of the fleet electrification, the District and Hoa Cleantech identified 55 frontline police, fire and utilities vehicles used for snow/ice clearing and emergency response that would be challenging to electrify with currently available technology. During their peak usage periods, these vehicles would require large batteries[44] and have very little downtime that would allow for re-charging.
- Because their usage during emergency response would skew the District's average fleet EV charging requirements, these frontline vehicles are excluded from conceptual designs for EV charging at this time. Further data collection and analyses would help to better quantify frontline vehicle peak usage and future electrification opportunities for these vehicles. It is noted the scenario planning does include opportunities for electrifying these vehicles and installation of the associated charging infrastructure.
- Another limitation of this study is that the availability and future costs of electric vehicles are difficult to predict beyond a 3-5 year horizon, as technology in this space is evolving rapidly.

Vehicle Charging & Systems Recommendations

- The District operates 154 fleet vehicles ranging from light to heavy-duty and off-road vehicles. Based on the 2019 data provided by the District, these vehicles travel an average of approximately 48km per day or operate for approximately 1.8 hours per day, and are estimated to have emitted 1,590 tonnes of CO_2e in 2020.
- Employees claimed a total of 125,705km in 2019 for using their own personal vehicles for work purposes, which is estimated to have emitted 32 tonnes of CO_2e. Based on several assumptions,

[44] The estimated battery sizes required during peak periods are larger than forecasted battery sizes for equivalent electric vehicles.

it is assessed that 13 pool vehicles could be introduced into the fleet to significantly reduce staff vehicle usage.

- Forecasted projections in the growth of EVs within BC show that around 30% of staff / visitor vehicles will be EVs by 2030, increasing to 75% by 2040.
- The District is going to require a variety of hardware and technology as the charging infrastructure grows. A horizontally integrated approach has been recommended using open communication protocols. This architecture will offer the District the greatest flexibility in the selection of vendors, minimize the risk of relying on a single provider, and maintain a good level of technological opportunity to leverage potential new revenue streams from the fleet.
- A mixture of Level 2 (6.2 kW and 13 kW) chargers and Level 3 fast chargers (25kW) will be required to support the electrification of vehicles at the different facility sites. The deployment of the charging infrastructure should be synchronized with the electrification of the vehicles, and electrical infrastructure upgrades will be required in the coming years to support EV charging infrastructure at some sites.

20- Year Strategic Emissions Forecasts for Fleet EV Adoption

- The District proposed four different scenarios to inform a 20-year strategic plan to reduce GHG emissions through fleet electrification.
- **Scenario #1**: Existing fleet policy, replacement schedule, charging infrastructure available when needed
    - The District's annual average CAPEX budget for fleet renewal is around $2M. At this current level of funding, 55 existing fleet vehicles will be replaced with EVs by 2030 resulting in an annual GHG reduction of 310 tonnes. By 2040 the number of fleet EVs increases to 99 resulting in an annual GHG reduction of 580 tonnes. These decreases are, respectively, 25% and 35% compared to anticipated 2020 emissions and fall well short of IPCC emissions reduction targets.
    - The Scenario 1 roadmap recommended frontline emergency response vehicles be replaced with either ICE (internal combustion engine) vehicles or PHEVs if available, based on their high peak usage. However, excluding these frontline vehicles from electrification in the long term will results in the District falling short of meeting the GHG reduction targets set by the IPCC.
- **Scenario #2**: IPCC - What would it take to attain IPCC (Intergovernmental Panel on Climate Change) targets in the District fleet (45% GHG reduction by 2030, 100% by 2050)
    - The Scenario 2 roadmap included some potential options to lower the emissions of the frontline police, snow and/or debris clearing, and emergency vehicles, which will be critical in order to meet the IPCC targets.
    - To achieve IPCC targets in District fleet operations, the District would need to consider a combination of purchasing renewable diesel, operational changes, back-up EVs and ultra-fast charging stations over the 20 year horizon. Implementing these changes between 2021 and 2030 results in an estimated increase to the 10-year CAPEX of $1M - $1.5M (5-10% increase), and an estimated annual increase in fuel cost of at least $30k (based on the assumption renewable diesel can be purchased at 50% more than the cost of existing diesel).

- **Scenario #3**: Expansion of zero-emission light duty pool vehicles
    - The addition of approximately 13 electric pool vehicles over the next several years should significantly reduce staff personal vehicle use for work purposes. This expansion of the District's fleet would increase fleet CAPEX of $150,000 annually from 2022 to 2026. This investment could result in an annual GHG reduction of 30 tonnes from these staff vehicles (assuming they are gasoline powered) and save the District approximately $55k per year from mileage reimbursements.
- **Scenario #4**: Constrained funding
    - If the annual CAPEX budget for District fleet vehicle renewal were constrained to approximately $1.5M, only around 27 existing fleet vehicles can be replaced by EVs by 2030, resulting in an annual reduction in GHG emissions of 110 tonnes. Fleet budget constraints could prevent the District from making progress on GHG reductions for medium and heavier duty vehicles, as well as frontline and emergency response vehicles.
- There is a potential to significantly reduce the peak power from charging EVs through the implementation of a smart charging management system, resulting in savings on the demand charges. Charging infrastructure recommended in this report would enable the District to implement such a system, which would result in savings on the electrical demand charges.
- If the District becomes a Part 3 Fuel supplier under the BC Low Carbon Fuel Standard it could generate approximately $50k per year of new revenue from the carbon credits by 2030.

Next Steps

To lower the District's GHG emissions over the next 3-5 years, it is recommended:

- Electrical infrastructure is designed and installed at the Municipal Hall and Operations Centre to accommodate future EV charging stations as per the conceptual designs.
- Vehicles at the end of their service life are replaced with equivalent electric vehicle versions, where practical and available (excluding frontline emergency response vehicles). This will start with cars and SUVs, and should include vans, light-duty trucks, heavy-duty trucks and some off-road vehicles by 2025.
- A mixture of Level 2 (6.2 kW and 13 kW) chargers and Level 3 fast chargers (25kW) are installed across facility sites as vehicles are electrified. This will start with Level 2 (6.2 kW) chargers to support the electric cars and SUVs, and include Level 2 (13kW) chargers and Level 3 fast chargers (25 kW) as larger electric vehicles are purchased.

Additional Research

The following additional research is recommended to help the District further optimize the reduction in GHG emissions and meet the IPCC targets:

- More detailed analysis of the peak usage requirements for frontline, clearing and emergency vehicles would help to refine these projections. Analysis should include in-depth discussions with the relevant departments to better understand actual peak usage requirements, complete risk assessments, and consider alternative technologies like hydrogen fuel cell electric vehicles.
- A risk analysis of vehicles utilized during emergency response, which includes resilience of electrical power, back-up power, and fuel supply systems at the Operations Centre to provide energy to vehicles in case of a major event.
- An analysis of renewable diesel including the supply availability, life-cycle cost and environmental impact.

Appendix A - Detailed vehicle replacement roadmaps for Scenario 1 and Scenario 2

Scenario 1 - Vehicle replacement roadmap

XXX *Frontline police, snow and/or debris clearing, and emergency vehicles*
BE Equivalent battery electric vehicle

Year	Replace vehicle ID	Purchase	Fuel	Facility site
2021	P024	CAR - BE	Electricity	Municipal Hall Complex
	M001	*HEAVY DUTY TRUCK*	*Diesel*	*Operations Centre*
	M023	*HEAVY DUTY TRUCK*	*Diesel*	*Operations Centre*
	M027	*LIGHT DUTY TRUCK*	*Gasoline*	*Operations Centre*
	M024	LIGHT DUTY TRUCK	Gasoline	Operations Centre
	P003	MEDIUM DUTY TRUCK	Gasoline	Operations Centre
	P043	OFF ROAD - MINI EXCAVATOR	Diesel	Operations Centre
	V005	*SUV - POLICE - Hybrid*	*Gasoline*	*Municipal Hall Complex*
	V021	*SUV - POLICE - Hybrid*	*Gasoline*	*Municipal Hall Complex*
	V011	*SUV - POLICE - Hybrid*	*Gasoline*	*Municipal Hall Complex*
	M029	VAN	Gasoline	Municipal Hall Complex
	M036	VAN	Gasoline	Operations Centre
2022	R011	CARGO VAN	Gasoline	West Vancouver Communitiy Centre
	M043	CARGO VAN	Gasoline	Municipal Hall Complex
	P016	CARGO VAN	Gasoline	Operations Centre
	M028	*HEAVY DUTY TRUCK*	*Diesel*	*Operations Centre*
	M008	*HEAVY DUTY TRUCK*	*Diesel*	*Operations Centre*
	M065	HEAVY DUTY TRUCK	Diesel	Operations Centre
	P031	LIGHT DUTY TRUCK	Gasoline	Operations Centre
	M015	*LIGHT DUTY TRUCK*	*Gasoline*	*Operations Centre*
	M002	LIGHT DUTY TRUCK	Gasoline	Operations Centre
	M032	LIGHT DUTY TRUCK	Gasoline	Operations Centre
	M021	LIGHT DUTY TRUCK	Gasoline	Operations Centre
	P007	LIGHT DUTY TRUCK	Gasoline	Operations Centre
	P013	LIGHT DUTY TRUCK	Gasoline	Operations Centre
	P020	LIGHT DUTY TRUCK	Gasoline	Operations Centre
	P022	LIGHT DUTY TRUCK	Gasoline	Operations Centre
	P029	LIGHT DUTY TRUCK	Gasoline	Operations Centre
	M031	LIGHT DUTY TRUCK	Gasoline	Operations Centre
	P019	MEDIUM DUTY TRUCK	Diesel	Operations Centre
	M053	*OFF ROAD - BACKHOE*	*Diesel*	*Operations Centre*
	P033	OFF ROAD - TRACTOR	Diesel	Operations Centre
	P044	OFF ROAD - TRACTOR	Diesel	Operations Centre
	R050	SHUTTLE BUS	Gasoline	West Vancouver Communitiy Centre
	V083	SUV - POLICE	Gasoline	Municipal Hall Complex
	V007	*SUV - POLICE - Hybrid*	*Gasoline*	*Municipal Hall Complex*
	V015	*SUV - POLICE - Hybrid*	*Gasoline*	*Municipal Hall Complex*
	V055	*SUV - POLICE - Hybrid*	*Gasoline*	*Municipal Hall Complex*
	V001	*SUV - POLICE - Hybrid*	*Gasoline*	*Municipal Hall Complex*
	F046	CAR - BE	Electricity	Fire Hall
	L001	CAR - BE	Electricity	Library
	M050	CAR - BE	Electricity	Municipal Hall Complex
	V062	CAR - POLICE - BE	Electricity	Municipal Hall Complex
	V082	CAR - POLICE - BE	Electricity	Municipal Hall Complex
	V084	CAR - POLICE - BE	Electricity	Municipal Hall Complex
	V072	CAR - POLICE - BE	Electricity	Municipal Hall Complex
	V018	*CAR - POLICE - Hybrid*	*Gasoline*	*Municipal Hall Complex*

Scenario 1 - Vehicle replacement roadmap

XXX *Frontline police, snow and/or debris clearing, and emergency vehicles*
BE Equivalent battery electric vehicle

Year	Replace vehicle ID	Purchase	Fuel	Facility site
2023	P011	CARGO VAN - BE	Electricity	Operations Centre
	P028	LIGHT DUTY TRUCK	Gasoline	Operations Centre
	F023	LIGHT DUTY TRUCK - FIRE	Diesel	Fire Hall
	F039	LIGHT DUTY TRUCK - FIRE	Gasoline	Fire Hall
	V012	LIGHT DUTY TRUCK - POLICE	Gasoline	Municipal Hall Complex
	V002	*LIGHT DUTY TRUCK - POLICE*	*Gasoline*	*Municipal Hall Complex*
	P004	MEDIUM DUTY TRUCK	Gasoline	Operations Centre
	P015	MEDIUM DUTY TRUCK	Diesel	Operations Centre
	M003	MEDIUM DUTY TRUCK	Gasoline	Operations Centre
	M068	*OFF ROAD - BOBCAT*	*Diesel*	*Operations Centre*
	M063	OFF ROAD - ROLLER	Diesel	Operations Centre
	P035	OFF ROAD - TRACTOR	Diesel	Operations Centre
	F032	SUV - FIRE - BE	Electricity	Fire Hall
	F050	SUV - FIRE - BE	Electricity	Fire Hall
	V008	*SUV - POLICE - Hybrid*	*Gasoline*	*Municipal Hall Complex*
2024	*F044*	*HEAVY DUTY TRUCK - FIRE*	*Diesel*	*Fire Hall*
	M037	*LIGHT DUTY TRUCK*	*Gasoline*	*Operations Centre*
	M084	LIGHT DUTY TRUCK - BE	Electricity	Operations Centre
	M004	LIGHT DUTY TRUCK - BE	Electricity	Operations Centre
	P014	LIGHT DUTY TRUCK - BE	Electricity	Operations Centre
	M055	OFF ROAD - BACKHOE - BE	Electricity	Operations Centre
	P032	OFF ROAD - BACKHOE - BE	Electricity	Operations Centre
	M066	OFF ROAD - FORKLIFT - BE	Electricity	Operations Centre
	V006	*SUV - POLICE - Hybrid*	*Gasoline*	*Municipal Hall Complex*
2025	M048	CAR - BE	Electricity	Municipal Hall Complex
	M030	CAR - BE	Electricity	Municipal Hall Complex
	M020	HEAVY DUTY TRUCK - BE	Electricity	Operations Centre
	F040	*HEAVY DUTY TRUCK - FIRE*	*Diesel*	*Fire Hall*
	V066	LIGHT DUTY TRUCK - POLICE - BE	Electricity	Municipal Hall Complex
	V085	LIGHT DUTY TRUCK - POLICE - BE	Electricity	Municipal Hall Complex
	F037	SUV - FIRE - BE	Electricity	Fire Hall
	V005	*SUV - POLICE - Hybrid*	*Gasoline*	*Municipal Hall Complex*
	V021	*SUV - POLICE - Hybrid*	*Gasoline*	*Municipal Hall Complex*
	V011	*SUV - POLICE - Hybrid*	*Gasoline*	*Municipal Hall Complex*
2026	*M039*	*HEAVY DUTY TRUCK*	*Diesel*	*Operations Centre*
	M052	*LIGHT DUTY TRUCK*	*Gasoline*	*Operations Centre*
	M059	*LIGHT DUTY TRUCK*	*Gasoline*	*Operations Centre*
	M060	*LIGHT DUTY TRUCK*	*Gasoline*	*Operations Centre*
	P025	LIGHT DUTY TRUCK - BE	Electricity	Operations Centre
	P027	LIGHT DUTY TRUCK - BE	Electricity	Operations Centre
	M058	LIGHT DUTY TRUCK - BE	Electricity	Operations Centre
	V022	LIGHT DUTY TRUCK - POLICE - BE	Electricity	Municipal Hall Complex
	M016	*MEDIUM DUTY TRUCK*	*Diesel*	*Operations Centre*
	M040	*MEDIUM DUTY TRUCK*	*Diesel*	*Operations Centre*
	M018	*MEDIUM DUTY TRUCK*	*Diesel*	*Operations Centre*
	M026	*MEDIUM DUTY TRUCK*	*Gasoline*	*Operations Centre*
	P041	OFF ROAD - EXCAVATOR - BE	Electricity	Operations Centre

Scenario 1 - Vehicle replacement roadmap

XXX *Frontline police, snow and/or debris clearing, and emergency vehicles*

BE Equivalent battery electric vehicle

Year	Replace vehicle ID	Purchase	Fuel	Facility site
	V001	*SUV - POLICE - Hybrid*	*Gasoline*	*Municipal Hall Complex*
	V007	*SUV - POLICE - Hybrid*	*Gasoline*	*Municipal Hall Complex*
	V015	*SUV - POLICE - Hybrid*	*Gasoline*	*Municipal Hall Complex*
	V055	*SUV - POLICE - Hybrid*	*Gasoline*	*Municipal Hall Complex*
2027	M062	CAR - BE	Electricity	Municipal Hall Complex
	FS17-1	CARGO VAN - BE	Electricity	Fire Hall
	FS17-2	CARGO VAN - BE	Electricity	Fire Hall
	M014	*LIGHT DUTY TRUCK*	*Gasoline*	*Operations Centre*
	M006	LIGHT DUTY TRUCK - BE	Electricity	Operations Centre
	V002	*LIGHT DUTY TRUCK - POLICE*	*Gasoline*	*Municipal Hall Complex*
	P001	MEDIUM DUTY TRUCK - BE	Electricity	Operations Centre
	M051	*OFF ROAD - BACKHOE*	*Diesel*	*Operations Centre*
	M054	*OFF ROAD - BACKHOE*	*Diesel*	*Operations Centre*
	M033	*OFF ROAD - BOBCAT*	*Diesel*	*Operations Centre*
	M057	OFF ROAD - EXCAVATOR - BE	Electricity	Operations Centre
	M056	*OFF ROAD - FRONT END LOADER*	*Diesel*	*Operations Centre*
	P034	OFF ROAD - TRACTOR	Diesel	Operations Centre
	V018	*CAR - POLICE - Hybrid*	*Gasoline*	*Municipal Hall Complex*
	V008	*SUV - POLICE - Hybrid*	*Gasoline*	*Municipal Hall Complex*
2028	M025	CAR - BE	Electricity	Municipal Hall Complex
	R047	CARGO VAN - BE	Electricity	West Vancouver Communitiy Centre
	M007	*HEAVY DUTY TRUCK*	*Diesel*	*Operations Centre*
	M010	*LIGHT DUTY TRUCK*	*Gasoline*	*Operations Centre*
	M012	*LIGHT DUTY TRUCK*	*Gasoline*	*Operations Centre*
	P006	*LIGHT DUTY TRUCK*	*Gasoline*	*Operations Centre*
	P009	*LIGHT DUTY TRUCK*	*Gasoline*	*Operations Centre*
	P002	LIGHT DUTY TRUCK - BE	Electricity	Operations Centre
	P005	LIGHT DUTY TRUCK - BE	Electricity	Operations Centre
	M011	LIGHT DUTY TRUCK - BE	Electricity	Municipal Hall Complex
	P046	LIGHT DUTY TRUCK - BE	Electricity	Operations Centre
	FC17-3	LIGHT DUTY TRUCK - FIRE - BE	Electricity	Fire Hall
	FS17-4	LIGHT DUTY TRUCK - FIRE - BE	Electricity	Fire Hall
	P017	MEDIUM DUTY TRUCK - BE	Electricity	Operations Centre
	P026	MEDIUM DUTY TRUCK - BE	Electricity	Operations Centre
	M074	*OFF ROAD - EXCAVATOR*	*Diesel*	*Operations Centre*
	V023	SUV - POLICE - BE	Electricity	Municipal Hall Complex
	V009	*SUV - POLICE - Hybrid*	*Gasoline*	*Municipal Hall Complex*
	V006	*SUV - POLICE - Hybrid*	*Gasoline*	*Municipal Hall Complex*
2029	M005	HEAVY DUTY TRUCK - BE	Electricity	Operations Centre
	F043	*HEAVY DUTY TRUCK - FIRE*	*Diesel*	*Fire Hall*
	M017	*LIGHT DUTY TRUCK*	*Gasoline*	*Operations Centre*
	M022	*MEDIUM DUTY TRUCK*	*Diesel*	*Operations Centre*
	M049	MEDIUM DUTY TRUCK - BE	Electricity	Operations Centre
	M019	SUV - BE	Electricity	Operations Centre
	M035	*MEDIUM DUTY TRUCK*	*Gasoline*	*Operations Centre*
	R029	SHUTTLE BUS - BE	Electricity	West Vancouver Communitiy Centre
	V003	*SUV - POLICE - Hybrid*	*Gasoline*	*Municipal Hall Complex*

Scenario 1 - Vehicle replacement roadmap

XXX *Frontline police, snow and/or debris clearing, and emergency vehicles*
BE Equivalent battery electric vehicle

Year	Replace vehicle ID	Purchase	Fuel	Facility site
2030	*V004*	*SUV - POLICE - Hybrid*	*Gasoline*	*Municipal Hall Complex*
	V034	CARGO VAN - BE	Electricity	Municipal Hall Complex
	M042	*LIGHT DUTY TRUCK*	*Gasoline*	*Operations Centre*
	P038	*LIGHT DUTY TRUCK*	*Gasoline*	*Operations Centre*
	M081	LIGHT DUTY TRUCK - BE	Electricity	Operations Centre
	P008	LIGHT DUTY TRUCK - BE	Electricity	Operations Centre
	P010	LIGHT DUTY TRUCK - BE	Electricity	Operations Centre
	V070	SUV - POLICE - BE	Electricity	Municipal Hall Complex
	V079	SUV - POLICE - BE	Electricity	Municipal Hall Complex
	V057	SUV - POLICE - BE	Electricity	Municipal Hall Complex
	V029	SUV - POLICE - BE	Electricity	Municipal Hall Complex
	V081	SUV - POLICE - BE	Electricity	Municipal Hall Complex
	V019	VAN - BE	Electricity	Municipal Hall Complex
2031 - 2040	V061	CAR - POLICE - BE	Electricity	Municipal Hall Complex
	P016	CARGO VAN - BE	Electricity	Operations Centre
	R011	CARGO VAN - BE	Electricity	West Vancouver Communitiy Centre
	M043	CARGO VAN - BE	Electricity	Municipal Hall Complex
	R030	CARGO VAN - BE	Electricity	West Vancouver Communitiy Centre
	M065	HEAVY DUTY TRUCK - BE	Electricity	Operations Centre
	M024	LIGHT DUTY TRUCK - BE	Electricity	Operations Centre
	P031	LIGHT DUTY TRUCK - BE	Electricity	Operations Centre
	M002	LIGHT DUTY TRUCK - BE	Electricity	Operations Centre
	M032	LIGHT DUTY TRUCK - BE	Electricity	Operations Centre
	M021	LIGHT DUTY TRUCK - BE	Electricity	Operations Centre
	P007	LIGHT DUTY TRUCK - BE	Electricity	Operations Centre
	P013	LIGHT DUTY TRUCK - BE	Electricity	Operations Centre
	P020	LIGHT DUTY TRUCK - BE	Electricity	Operations Centre
	P022	LIGHT DUTY TRUCK - BE	Electricity	Operations Centre
	P029	LIGHT DUTY TRUCK - BE	Electricity	Operations Centre
	M031	LIGHT DUTY TRUCK - BE	Electricity	Operations Centre
	P028	LIGHT DUTY TRUCK - BE	Electricity	Operations Centre
	F023	LIGHT DUTY TRUCK - FIRE - BE	Electricity	Fire Hall
	F039	LIGHT DUTY TRUCK - FIRE - BE	Electricity	Fire Hall
	V012	LIGHT DUTY TRUCK - POLICE - BE	Electricity	Municipal Hall Complex
	P003	MEDIUM DUTY TRUCK - BE	Electricity	Operations Centre
	P019	MEDIUM DUTY TRUCK - BE	Electricity	Operations Centre
	P004	MEDIUM DUTY TRUCK - BE	Electricity	Operations Centre
	P015	MEDIUM DUTY TRUCK - BE	Electricity	Operations Centre
	M003	MEDIUM DUTY TRUCK - BE	Electricity	Operations Centre
	M009	MEDIUM DUTY TRUCK - BE	Electricity	Operations Centre
	M013	MEDIUM DUTY TRUCK - BE	Electricity	Operations Centre
	M041	MEDIUM DUTY TRUCK - BE	Electricity	Operations Centre
	P043	OFF ROAD - MINI EXCAVATOR - BE	Electricity	Operations Centre
	M063	OFF ROAD - ROLLER - BE	Electricity	Operations Centre
	P033	OFF ROAD - TRACTOR - BE	Electricity	Operations Centre
	P044	OFF ROAD - TRACTOR - BE	Electricity	Operations Centre
	P035	OFF ROAD - TRACTOR - BE	Electricity	Operations Centre
	P034	OFF ROAD - TRACTOR - BE	Electricity	Operations Centre

Scenario 1 - Vehicle replacement roadmap

XXX *Frontline police, snow and/or debris clearing, and emergency vehicles*
BE Equivalent battery electric vehicle

Year	Replace vehicle ID	Purchase	Fuel	Facility site
	R027	SHUTTLE BUS - BE	Electricity	West Vancouver Communitiy Centre
	R050	SHUTTLE BUS - BE	Electricity	West Vancouver Communitiy Centre
	V083	SUV - POLICE - BE	Electricity	Municipal Hall Complex
	M029	VAN - BE	Electricity	Municipal Hall Complex
	M036	VAN - BE	Electricity	Operations Centre

Scenario 2 - Vehicle replacement roadmap

XXX *Frontline police, snow and/or debris clearing, and emergency vehicles*
BE Equivalent battery electric vehicle

Year	Replace vehicle ID	Purchase	Fuel	Facility site
2021	P024	CAR - BE	Electricity	Municipal Hall Complex
	M001	*HEAVY DUTY TRUCK*	*Diesel*	*Operations Centre*
	M023	*HEAVY DUTY TRUCK*	*Diesel*	*Operations Centre*
	M027	*LIGHT DUTY TRUCK*	*Gasoline*	*Operations Centre*
	M024	LIGHT DUTY TRUCK	Gasoline	Operations Centre
	P003	MEDIUM DUTY TRUCK	Gasoline	Operations Centre
	P043	OFF ROAD - MINI EXCAVATOR	Diesel	Operations Centre
	V005	*SUV - POLICE - Hybrid*	*Gasoline*	*Municipal Hall Complex*
	V021	*SUV - POLICE - Hybrid*	*Gasoline*	*Municipal Hall Complex*
	V011	*SUV - POLICE - Hybrid*	*Gasoline*	*Municipal Hall Complex*
	M029	VAN	Gasoline	Municipal Hall Complex
	M036	VAN	Gasoline	Operations Centre
2022	R011	CARGO VAN	Gasoline	West Vancouver Communitiy Centre
	M043	CARGO VAN	Gasoline	Municipal Hall Complex
	P016	CARGO VAN	Gasoline	Operations Centre
	M028	*HEAVY DUTY TRUCK*	*Renewable Diesel*	*Operations Centre*
	M008	*HEAVY DUTY TRUCK*	*Renewable Diesel*	*Operations Centre*
	P031	LIGHT DUTY TRUCK	Gasoline	Operations Centre
	M015	*LIGHT DUTY TRUCK*	*Gasoline*	*Operations Centre*
	M002	LIGHT DUTY TRUCK	Gasoline	Operations Centre
	M032	LIGHT DUTY TRUCK	Gasoline	Operations Centre
	M021	LIGHT DUTY TRUCK	Gasoline	Operations Centre
	P007	LIGHT DUTY TRUCK	Gasoline	Operations Centre
	P013	LIGHT DUTY TRUCK	Gasoline	Operations Centre
	P020	LIGHT DUTY TRUCK	Gasoline	Operations Centre
	P022	LIGHT DUTY TRUCK	Gasoline	Operations Centre
	P029	LIGHT DUTY TRUCK	Gasoline	Operations Centre
	M031	LIGHT DUTY TRUCK	Gasoline	Operations Centre
	P019	MEDIUM DUTY TRUCK	Renewable Diesel	Operations Centre
	M053	*OFF ROAD - BACKHOE*	*Renewable Diesel*	*Operations Centre*
	P033	OFF ROAD - TRACTOR	Renewable Diesel	Operations Centre
	P044	OFF ROAD - TRACTOR	Renewable Diesel	Operations Centre
	R050	SHUTTLE BUS	Gasoline	West Vancouver Communitiy Centre
	V083	SUV - POLICE	Gasoline	Municipal Hall Complex
	V007	*SUV - POLICE - Hybrid*	*Gasoline*	*Municipal Hall Complex*
	V015	*SUV - POLICE - Hybrid*	*Gasoline*	*Municipal Hall Complex*
	V055	*SUV - POLICE - Hybrid*	*Gasoline*	*Municipal Hall Complex*
	V001	*SUV - POLICE - Hybrid*	*Gasoline*	*Municipal Hall Complex*
2023	F046	CAR - BE	Electricity	Fire Hall
	L001	CAR - BE	Electricity	Library
	M050	CAR - BE	Electricity	Municipal Hall Complex
	V062	CAR - POLICE - BE	Electricity	Municipal Hall Complex
	V082	CAR - POLICE - BE	Electricity	Municipal Hall Complex
	V084	CAR - POLICE - BE	Electricity	Municipal Hall Complex
	V072	CAR - POLICE - BE	Electricity	Municipal Hall Complex
	V018	*CAR - POLICE - Hybrid*	*Gasoline*	*Municipal Hall Complex*
	P011	CARGO VAN - BE	Electricity	Operations Centre
	M065	HEAVY DUTY TRUCK - BE	Electricity	Operations Centre
	F023	LIGHT DUTY TRUCK - FIRE	Gasoline	Fire Hall
	F039	LIGHT DUTY TRUCK - FIRE	Gasoline	Fire Hall
	V012	LIGHT DUTY TRUCK - POLICE	Gasoline	Municipal Hall Complex

Scenario 2 - Vehicle replacement roadmap

XXX *Frontline police, snow and/or debris clearing, and emergency vehicles*
BE Equivalent battery electric vehicle

Year	Replace vehicle ID	Purchase	Fuel	Facility site
	V002	*LIGHT DUTY TRUCK - POLICE*	*Gasoline*	*Municipal Hall Complex*
	P004	MEDIUM DUTY TRUCK	Renewable Diesel	Operations Centre
	P015	MEDIUM DUTY TRUCK	Renewable Diesel	Operations Centre
	M003	MEDIUM DUTY TRUCK	Renewable Diesel	Operations Centre
	M068	*OFF ROAD - BOBCAT*	*Renewable Diesel*	*Operations Centre*
	M063	OFF ROAD - ROLLER	Renewable Diesel	Operations Centre
	P035	OFF ROAD - TRACTOR	Renewable Diesel	Operations Centre
	F032	SUV - FIRE - BE	Electricity	Fire Hall
	F050	SUV - FIRE - BE	Electricity	Fire Hall
	V008	*SUV - POLICE - Hybrid*	*Gasoline*	*Municipal Hall Complex*
2024	*F044*	*HEAVY DUTY TRUCK - FIRE*	*Renewable Diesel*	*Fire Hall*
	M037	*LIGHT DUTY TRUCK - BE*	*Electricity*	*Operations Centre*
	NEW	*LIGHT DUTY TRUCK - BE*	*Electricity*	*Operations Centre*
	P028	LIGHT DUTY TRUCK - BE	Electricity	Operations Centre
	M084	LIGHT DUTY TRUCK - BE	Electricity	Operations Centre
	M004	LIGHT DUTY TRUCK - BE	Electricity	Operations Centre
	P014	LIGHT DUTY TRUCK - BE	Electricity	Operations Centre
	M055	OFF ROAD - BACKHOE - BE	Electricity	Operations Centre
	P032	OFF ROAD - BACKHOE - BE	Electricity	Operations Centre
	M066	OFF ROAD - FORKLIFT - BE	Electricity	Operations Centre
	V006	*SUV - POLICE - Hybrid*	*Gasoline*	*Municipal Hall Complex*
2025	M048	CAR - BE	Electricity	Municipal Hall Complex
	M030	CAR - BE	Electricity	Municipal Hall Complex
	M020	HEAVY DUTY TRUCK - BE	Electricity	Operations Centre
	F040	*HEAVY DUTY TRUCK - FIRE*	*Renewable Diesel*	*Fire Hall*
	V066	LIGHT DUTY TRUCK - POLICE - BE	Electricity	Municipal Hall Complex
	V085	LIGHT DUTY TRUCK - POLICE - BE	Electricity	Municipal Hall Complex
	F037	SUV - FIRE - BE	Electricity	Fire Hall
	V005	*SUV - POLICE - Hybrid*	*Gasoline*	*Municipal Hall Complex*
	V021	*SUV - POLICE - Hybrid*	*Gasoline*	*Municipal Hall Complex*
	V011	*SUV - POLICE - Hybrid*	*Gasoline*	*Municipal Hall Complex*
2026	*M039*	*HEAVY DUTY TRUCK*	*Renewable Diesel*	*Operations Centre*
	M052	*LIGHT DUTY TRUCK - BE*	*Electricity*	*Operations Centre*
	M059	*LIGHT DUTY TRUCK - BE*	*Electricity*	*Operations Centre*
	M060	*LIGHT DUTY TRUCK - BE*	*Electricity*	*Operations Centre*
	NEW	*LIGHT DUTY TRUCK - BE*	*Electricity*	*Operations Centre*
	NEW	*LIGHT DUTY TRUCK - BE*	*Electricity*	*Operations Centre*
	NEW	*LIGHT DUTY TRUCK - BE*	*Electricity*	*Operations Centre*
	P025	LIGHT DUTY TRUCK - BE	Electricity	Operations Centre
	P027	LIGHT DUTY TRUCK - BE	Electricity	Operations Centre
	M058	LIGHT DUTY TRUCK - BE	Electricity	Operations Centre
	V022	LIGHT DUTY TRUCK - POLICE - BE	Electricity	Municipal Hall Complex
	M016	*MEDIUM DUTY TRUCK*	*Renewable Diesel*	*Operations Centre*
	M040	*MEDIUM DUTY TRUCK*	*Renewable Diesel*	*Operations Centre*
	M018	*MEDIUM DUTY TRUCK*	*Renewable Diesel*	*Operations Centre*
	M026	*MEDIUM DUTY TRUCK*	*Renewable Diesel*	*Operations Centre*
	P041	OFF ROAD - EXCAVATOR - BE	Electricity	Operations Centre
	V001	*SUV - POLICE - Hybrid*	*Gasoline*	*Municipal Hall Complex*
	V007	*SUV - POLICE - Hybrid*	*Gasoline*	*Municipal Hall Complex*
	V015	*SUV - POLICE - Hybrid*	*Gasoline*	*Municipal Hall Complex*
	V055	*SUV - POLICE - Hybrid*	*Gasoline*	*Municipal Hall Complex*

Scenario 2 - Vehicle replacement roadmap

XXX — *Frontline police, snow and/or debris clearing, and emergency vehicles*
BE — Equivalent battery electric vehicle

Year	Replace vehicle ID	Purchase	Fuel	Facility site
2027	M062	CAR - BE	Electricity	Municipal Hall Complex
	FS17-1	CARGO VAN - BE	Electricity	Fire Hall
	FS17-2	CARGO VAN - BE	Electricity	Fire Hall
	M014	*LIGHT DUTY TRUCK - BE*	*Electricity*	*Operations Centre*
	NEW	*LIGHT DUTY TRUCK - BE*	*Electricity*	*Operations Centre*
	M006	LIGHT DUTY TRUCK - BE	Electricity	Operations Centre
	V002	*LIGHT DUTY TRUCK - POLICE*	*Gasoline*	*Municipal Hall Complex*
	P001	MEDIUM DUTY TRUCK - BE	Electricity	Operations Centre
	M051	*OFF ROAD - BACKHOE*	*Renewable Diesel*	*Operations Centre*
	M054	*OFF ROAD - BACKHOE*	*Renewable Diesel*	*Operations Centre*
	M033	*OFF ROAD - BOBCAT*	*Renewable Diesel*	*Operations Centre*
	M057	OFF ROAD - EXCAVATOR - BE	Electricity	Operations Centre
	M056	*OFF ROAD - FRONT END LOADER*	*Renewable Diesel*	*Operations Centre*
	P034	OFF ROAD - TRACTOR	Renewable Diesel	Operations Centre
	V018	*CAR - POLICE - Hybrid*	*Gasoline*	*Municipal Hall Complex*
	V008	*SUV - POLICE - Hybrid*	*Gasoline*	*Municipal Hall Complex*
2028	M025	CAR - BE	Electricity	Municipal Hall Complex
	R047	CARGO VAN - BE	Electricity	West Vancouver Communitiy Centre
	M007	*HEAVY DUTY TRUCK*	*Renewable Diesel*	*Operations Centre*
	M010	*LIGHT DUTY TRUCK - BE*	*Electricity*	*Operations Centre*
	M012	*LIGHT DUTY TRUCK - BE*	*Electricity*	*Operations Centre*
	P006	*LIGHT DUTY TRUCK - BE*	*Electricity*	*Operations Centre*
	P009	*LIGHT DUTY TRUCK - BE*	*Electricity*	*Operations Centre*
	NEW	*LIGHT DUTY TRUCK - BE*	*Electricity*	*Operations Centre*
	P002	LIGHT DUTY TRUCK - BE	Electricity	Operations Centre
	P005	LIGHT DUTY TRUCK - BE	Electricity	Operations Centre
	M011	LIGHT DUTY TRUCK - BE	Electricity	Municipal Hall Complex
	P046	LIGHT DUTY TRUCK - BE	Electricity	Operations Centre
	FC17-3	LIGHT DUTY TRUCK - FIRE - BE	Electricity	Fire Hall
	FS17-4	LIGHT DUTY TRUCK - FIRE - BE	Electricity	Fire Hall
	P017	MEDIUM DUTY TRUCK - BE	Electricity	Operations Centre
	P026	MEDIUM DUTY TRUCK - BE	Electricity	Operations Centre
	M074	*OFF ROAD - EXCAVATOR*	*Renewable Diesel*	*Operations Centre*
	V023	SUV - POLICE - BE	Electricity	Municipal Hall Complex
	V009	*SUV - POLICE - Hybrid*	*Gasoline*	*Municipal Hall Complex*
	V006	*SUV - POLICE - Hybrid*	*Gasoline*	*Municipal Hall Complex*
2029	M005	HEAVY DUTY TRUCK - BE	Electricity	Operations Centre
	F043	*HEAVY DUTY TRUCK - FIRE*	*Renewable Diesel*	*Fire Hall*
	M017	*LIGHT DUTY TRUCK - BE*	*Electricity*	*Operations Centre*
	M022	*MEDIUM DUTY TRUCK*	*Renewable Diesel*	*Operations Centre*
	M049	MEDIUM DUTY TRUCK - BE	Electricity	Operations Centre
	M019	SUV - BE	Electricity	Operations Centre
2030	*M035*	*MEDIUM DUTY TRUCK*	*Renewable Diesel*	*Operations Centre*
	R029	SHUTTLE BUS - BE	Electricity	West Vancouver Communitiy Centre
	V003	*SUV - POLICE - Hybrid*	*Gasoline*	*Municipal Hall Complex*
	V004	*SUV - POLICE - Hybrid*	*Gasoline*	*Municipal Hall Complex*
	V034	CARGO VAN - BE	Electricity	Municipal Hall Complex
	M042	*LIGHT DUTY TRUCK - BE*	*Electricity*	*Operations Centre*
	P038	*LIGHT DUTY TRUCK - BE*	*Electricity*	*Operations Centre*
	M081	LIGHT DUTY TRUCK - BE	Electricity	Operations Centre
	P008	LIGHT DUTY TRUCK - BE	Electricity	Operations Centre

Scenario 2 - Vehicle replacement roadmap

XXX *Frontline police, snow and/or debris clearing, and emergency vehicles*
BE Equivalent battery electric vehicle

Year	Replace vehicle ID	Purchase	Fuel	Facility site
	P010	LIGHT DUTY TRUCK - BE	Electricity	Operations Centre
	V070	SUV - POLICE - BE	Electricity	Municipal Hall Complex
	V079	SUV - POLICE - BE	Electricity	Municipal Hall Complex
	V057	SUV - POLICE - BE	Electricity	Municipal Hall Complex
	V029	SUV - POLICE - BE	Electricity	Municipal Hall Complex
	V081	SUV - POLICE - BE	Electricity	Municipal Hall Complex
	V019	VAN - BE	Electricity	Municipal Hall Complex
2031 - 2040	V061	CAR - POLICE - BE	Electricity	Municipal Hall Complex
	P016	CARGO VAN - BE	Electricity	Operations Centre
	R011	CARGO VAN - BE	Electricity	West Vancouver Communitiy Centre
	M043	CARGO VAN - BE	Electricity	Municipal Hall Complex
	R030	CARGO VAN - BE	Electricity	West Vancouver Communitiy Centre
	M024	LIGHT DUTY TRUCK - BE	Electricity	Operations Centre
	P031	LIGHT DUTY TRUCK - BE	Electricity	Operations Centre
	M002	LIGHT DUTY TRUCK - BE	Electricity	Operations Centre
	M032	LIGHT DUTY TRUCK - BE	Electricity	Operations Centre
	M021	LIGHT DUTY TRUCK - BE	Electricity	Operations Centre
	P007	LIGHT DUTY TRUCK - BE	Electricity	Operations Centre
	P013	LIGHT DUTY TRUCK - BE	Electricity	Operations Centre
	P020	LIGHT DUTY TRUCK - BE	Electricity	Operations Centre
	P022	LIGHT DUTY TRUCK - BE	Electricity	Operations Centre
	P029	LIGHT DUTY TRUCK - BE	Electricity	Operations Centre
	M031	LIGHT DUTY TRUCK - BE	Electricity	Operations Centre
	F023	LIGHT DUTY TRUCK - FIRE - BE	Electricity	Fire Hall
	F039	LIGHT DUTY TRUCK - FIRE - BE	Electricity	Fire Hall
	V012	LIGHT DUTY TRUCK - POLICE - BE	Electricity	Municipal Hall Complex
	M015	*LIGHT DUTY TRUCK - BE*	*Electricity*	*Operations Centre*
	M027	*LIGHT DUTY TRUCK - BE*	*Electricity*	*Operations Centre*
	P003	MEDIUM DUTY TRUCK - BE	Electricity	Operations Centre
	P019	MEDIUM DUTY TRUCK - BE	Electricity	Operations Centre
	P004	MEDIUM DUTY TRUCK - BE	Electricity	Operations Centre
	P015	MEDIUM DUTY TRUCK - BE	Electricity	Operations Centre
	M003	MEDIUM DUTY TRUCK - BE	Electricity	Operations Centre
	M009	MEDIUM DUTY TRUCK - BE	Electricity	Operations Centre
	M013	MEDIUM DUTY TRUCK - BE	Electricity	Operations Centre
	M041	MEDIUM DUTY TRUCK - BE	Electricity	Operations Centre
	P043	OFF ROAD - MINI EXCAVATOR - BE	Electricity	Operations Centre
	M063	OFF ROAD - ROLLER - BE	Electricity	Operations Centre
	P033	OFF ROAD - TRACTOR - BE	Electricity	Operations Centre
	P044	OFF ROAD - TRACTOR - BE	Electricity	Operations Centre
	P035	OFF ROAD - TRACTOR - BE	Electricity	Operations Centre
	P034	OFF ROAD - TRACTOR - BE	Electricity	Operations Centre
	R027	SHUTTLE BUS - BE	Electricity	West Vancouver Communitiy Centre
	R050	SHUTTLE BUS - BE	Electricity	West Vancouver Communitiy Centre
	V083	SUV - POLICE - BE	Electricity	Municipal Hall Complex
	M029	VAN - BE	Electricity	Municipal Hall Complex
	M036	VAN - BE	Electricity	Operations Centre
	V005	*SUV - POLICE - BE*	*Electricity*	*Municipal Hall Complex*
	V011	*SUV - POLICE - BE*	*Electricity*	*Municipal Hall Complex*
	V021	*SUV - POLICE - BE*	*Electricity*	*Municipal Hall Complex*
	V001	*SUV - POLICE - BE*	*Electricity*	*Municipal Hall Complex*

Scenario 2 - Vehicle replacement roadmap

XXX *Frontline police, snow and/or debris clearing, and emergency vehicles*
BE Equivalent battery electric vehicle

Year	Replace vehicle ID	Purchase	Fuel	Facility site
	V007	*SUV - POLICE - BE*	*Electricity*	*Municipal Hall Complex*
	V015	*SUV - POLICE - BE*	*Electricity*	*Municipal Hall Complex*
	V055	*SUV - POLICE - BE*	*Electricity*	*Municipal Hall Complex*
	V018	*CAR - POLICE - BE*	*Electricity*	*Municipal Hall Complex*
	V002	*LIGHT DUTY TRUCK - POLICE - BE*	*Electricity*	*Municipal Hall Complex*
	V008	*SUV - POLICE - BE*	*Electricity*	*Municipal Hall Complex*
	V006	*SUV - POLICE - BE*	*Electricity*	*Municipal Hall Complex*
	V009	*SUV - POLICE - BE*	*Electricity*	*Municipal Hall Complex*
	V003	*SUV - POLICE - BE*	*Electricity*	*Municipal Hall Complex*
	V004	*SUV - POLICE - BE*	*Electricity*	*Municipal Hall Complex*

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