

Sustainable Green Fleet Strategy

Town of Ajax

October 9, 2024

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Acronyms

AC	Alternating Current
ACRRP	Ajax Climate Risk and Resiliency Plan
BAU	Business-as-Usual
BEV	Battery Electric Vehicle
CCS	Carbon Capture and Storage
CCUS	Carbon Capture Utilization and Storage
CNG	Compressed Natural Gas
DC	Direct Current
DCFC	Direct Current Fast Charging
EV	Electric Vehicle
EVSE	Electric Vehicle Supply Equipment
FCEB	Fuel Cell Electric Bus
FCEV	Fuel Cell Electric Vehicle
GHG	Greenhouse Gas Emissions
GLGE	Gasoline-powered Lawn and Garden Equipment
HEV	Hybrid Electric Vehicle
ICE	Internal Combustion Engine
ICEV	Internal Combustion Engine Vehicle
KPI	Key Performance Indicators
LIB	Lithium-ion Battery
LNG	Liquid Natural Gas
MHDV	Medium- and Heavy-Duty Vehicle
NGV	Natural Gas Vehicle
OEM	Original Equipment Manufacturer
PHEV	Plug-in Hybrid Electric Vehicle
SMR	Steam Methane Reforming
VOC	Volatile Organic Compound
ZEV	Zero Emissions Vehicle

Executive Summary

Electric vehicles (EVs), which include battery electric vehicles (BEVs), plug-in hybrid electric vehicles (PHEVs), and hydrogen fuel cell electric vehicles (FCEVs), are being adopted by many fleet operators as part of long-term strategies to reduce or eliminate fleet-related emissions, reduce maintenance activities, and align with climate targets from all levels of government. The Town of Ajax is advancing the deployment of EVs and battery-powered maintenance equipment within its fleet to achieve emissions reduction targets set by Council, including a 40% greenhouse gas (GHG) emissions reduction from all sources by 2030, and 100% GHG emissions reduction by 2050, below 2019 levels.

AECOM was retained by the Town to develop a Sustainable Green Fleet Strategy which establishes recommendations to reduce corporate GHG emissions of city-owned fleets and equipment. The Sustainable Green Fleet Strategy builds on early fleet and equipment electrification efforts. It provides a framework for the transition to EVs including anticipated costs and replacement timelines, and precedes detailed design work for charging stations and selection of individual EVs to replace existing models.

Best practices from other Canadian jurisdictions were reviewed to inform the strategy, and technical research was conducted into suitable EV and battery-operated equipment which could be added to the fleet beginning in the near-term to support meeting Town Council's emission reduction targets. Overall, the Town is making good progress and building on early fleet and equipment electrification efforts. As the market for EVs grows, and federal zero-emission vehicle (ZEV) regulations come into play in the next decade such as the phase-out of internal combustion engine vehicles (ICEVs), building on early efforts and accelerating infrastructure deployment will be needed to maintain operational resiliency while reducing emissions.

Today's fleet of 126 on-road vehicles and 92 motorized off-road/unlicensed vehicles emits about 822 tonnes of CO₂ per year. Many of these vehicles are overdue for replacement based on the Town's holding policies, with the average age of the fleet approaching 10 years. Though some vehicles are ready to be electrified, the market for EVs is still maturing and many heavy-duty vehicles and other equipment do not have suitable EV alternatives yet available.

AECOM evaluated two transition scenarios; the first, a Cost Optimized scenario where EVs are added to the fleet only when they have a lower total cost of ownership than an ICEV, and the second, a Technology Leadership scenario where ICEVs are replaced with EVs more quickly. The Town is scheduled to replace about 15 vehicles per year over the lifetime of the plan. Early in the transition to EVs, a higher number of ICEVs are replaced by either new ICEVs, hybrid electric vehicles (HEVs), or PHEVs. Over time, more EVs are added to the fleet as parity of cost and performance is achieved relative to ICEVs. By the mid-2030s, very few non-electrified new models are planned to be added to the fleet.

Regardless of scenario, light-duty vehicles such as passenger cars and equipment such as mowers and golf carts are recommended for immediate electrification when they come due for replacement. In the medium term, light- and medium-duty trucks, fire apparatus, and some equipment like forklifts are recommended for electrification. In the long-term, heavy-duty vehicles and equipment like snow plows, large trucks, and road repair equipment is recommended for electrification, with the market expected to mature for these assets.

A significant investment in infrastructure will be required to accomplish the fleet transition goals. The majority of infrastructure will be required at the Town's Operations Centre, where 89 vehicles and 75 powered equipment assets are stored. The majority of infrastructure will be Level 2 charging stations supporting overnight charging, but some higher output DC Fast Charging will be required to support assets like fire apparatus, heavy-duty vehicles, and high-mileage vehicles. Other facilities will also require charging infrastructure to support new EVs and equipment.

The total cost of the program between 2024 and 2039 is estimated to be between \$29.8 million and \$36.4 million, depending on whether a Cost Optimized or Technology Leadership scenario is pursued. This includes residual values for fleet vehicles, which reduces the cost of the program once the Town auctions

used vehicles at the end of their service life. If business as usual (BAU) operations were maintained, with no EVs added to the fleet, the total fleet related capital and operating costs between 2024 and 2039 would be expected to cost \$31.6 million. This indicates that despite significant investment being required, a transition to EVs could save the Town some capital and operating expenses over the lifetime of the plan.

Between 2024 and 2039, the Technology Leadership scenario is expected to result in about \$6.6 million of additional capital and operating costs relative to the Cost Optimized scenario, and \$5.0 million additional capital and operating costs relative to BAU. The Cost Optimized scenario, in contrast, is expected to result in about \$1.6 million in cost savings relative to BAU between 2024 and 2039. The additional costs of the Technology Leadership scenario are associated with additional EV procurements and charging infrastructure, which are not offset sufficiently by slight maintenance and fuel costs savings to achieve cost parity or savings with the Cost Optimized scenario or BAU.

Both scenarios help achieve a GHG emissions reduction. The Technology Leadership scenario achieves Council's 2030 emissions reduction target between 2029 and 2030, while the Cost Optimized scenario achieves the full 40% reduction below baseline emissions between 2031 and 2032. This indicates that a more aggressive EV and electric equipment adoption, in line with the assumptions of the Technology Leadership scenario, is required to achieve the desired emissions reduction goal established by Council.

Given that some vehicles are not yet ready to transition to EVs, because of their duty cycle, some on-road vehicles could be transitioned more gradually (in line with a Cost Optimized scenario) while others, such as off-road/unlicensed assets could be transitioned more aggressively (in line with a Technology Leadership scenario) to achieve the desired emissions reduction. With both scenarios, deploying adequate charging infrastructure will be critical to ensure EVs and electric equipment is ready for operation once procured.

In addition to the costs of vehicles and infrastructure to support fleet transition, operational changes within the organization will be required to manage the new EV fleet. Managing the Town's new fleet will carry unique considerations relative to the current ICEV fleet to ensure consistent delivery of services. Namely, the maintenance and servicing of EVs will require specific care and attention to the lithium-ion battery packs, and charging at the end of a driver's shift will require a change in daily habits.

The electrification of the fleet and equipment will occur in various phases, which can be broken into four phases, as described below. The percentage of the on-road fleet that is low- and zero-emissions, and anticipated emissions reduction from baseline, will depend on the scenario that is pursued.

Phase	Anticipated Period	Percentage of On-Road Fleet that is Low- and Zero-Emissions (EV, PHEV, and HEV)	Anticipated Emissions Reduction from Baseline	Considerations
Phase 0 – Existing Infrastructure and Pilot Deployments	2024-2025	25%	6-8%	- Leverage existing infrastructure for charging and monitor pilot deployments to gather lessons learned. - Advance Yard Utilization Study to understand where charging can be accommodated at Operations Centre. - Coordinate with local utility Elexicon for long-term planning.
Phase 1 – Early Deployments and Preparatory Works	2026-2029	47-50%	27-35%	- Plan and undertake more significant upgrades to support early EV deployments. - Based on the Yard Utilization Study recommendations, preparatory works should be undertaken for future infrastructure upgrades.

				- Upgrades to fleet maintenance facilities may be required at this stage. - Coordinate further with Elexicon regarding a DC Fast Charging Hub at the Operations Centre and the requirements for a new utility connection.
Phase 2 – Major Deployments	2030-2032	60-66%	43-55%	- Undertake the larger deployment of charging stations and operationalize the DC Fast Charging Hub. - Electric and/or hydrogen fuel cell heavy-duty vehicles should be available on the market, and begin to be introduced into the fleet.
Phase 3 – Final Deployments	2033-2039	78-100%	61-87%	- By this time, most models should be electrified. - Final infrastructure deployments will take place and operational challenges should be fully addressed by this stage.

A variety of recommendations to help build on the early fleet electrification efforts, in order to meet Town Council's GHG emissions reduction targets and manage the transition effectively, include the following. They are described in detail within this report.

Management Activities

1. Evaluate current fleet policies including Policy 053 – Mileage Reimbursement, Policy 080 – Use of Municipal Vehicles, and Fleet Utilization Policy to identify which driver duties may need to be adjusted, changes to mileage reimbursement rates given the different cost of ownership of EVs, and vehicle retirement ages for EVs.
2. Establish appropriate vehicle lifecycle standard for municipal EVs, based on early EV deployment. EVs may have a longer or shorter lifespan than ICEVs, depending on the nature of their use.
3. Assess End of Life planning impacts of EVs compared to ICEVs, and implement any necessary procedures to accommodate these impacts.
4. Monitor emerging technologies such as solid state batteries, hydrogen vehicles, and other emerging fuel types through industry engagement and peer networks with other municipalities and agencies to evaluate which EV solutions may present the best opportunities for vehicles that remain difficult to transition, such as those in the medium- and heavy-duty segments.
5. Undertake a Yard Utilization Study to determine how the Operations Centre yard is being used and could be optimized, including where EV charging stations could best be located to avoid operational conflicts.
6. Stay informed about local, provincial, and federal regulations related to EVs and fleet management and ensure that fleet operations comply with the latest safety standards, environmental regulations, and industry best practices.
7. Identify key stakeholders within the Town who will act as EV champions and coordinate a team to engage with staff at each site location where corporate vehicles and equipment are being converted to EVs.
8. Consider how leasing an FCEV or medium-/heavy-duty EV could enable a streamlined and lower-risk pilot project for the Town, prior to a potential larger investment in FCEVs and associated infrastructure.
9. Evaluate whether other municipalities move to a leased vehicle ownership model for some fleet vehicles and use this to inform the Town's own planning process.

Outreach and Engagement

10. Educate drivers and fleet managers about the unique fire risks associated with EVs and lithium-ion batteries. Ensure fire extinguishers are accessible near fleet vehicles and charging stations. Train personnel on how to safely extinguish EV fires and evacuate affected areas.
11. Develop and communicate clear emergency response protocols for EV-related incidents, such as accidents, fires, or vehicle malfunctions. Ensure drivers are aware of emergency procedures and receive training on how to safely evacuate or respond to different scenarios.
12. Coordinate with the Fire Department to make them aware of the locations for EVs, in case firefighting is needed. Review and update as needed fire fighting procedures to address the different approach for EV fires.
13. Develop a series of educational and awareness materials and programs for Town staff that aims to promote the positive impacts of transitioning corporate fleets to EVs and equipment and overcome any knowledge barriers regarding EV technology.

Infrastructure

14. Evaluate DC Fast Charging needs for the fleet and the infrastructure implications of necessary electrical upgrades to accommodate these needs, including coordinating a potential new utility connection with Elexicon for the Fire Headquarters and/or Operations Centre.
15. To ensure the EV fleet can support emergency operations in the event of a power outage, establish the minimum duration of backup power required, based on the expected duration of power outages and the power demands of critical fleet assets. Then, evaluate emergency backup power requirements based on the maximum energy demand of critical fleet assets and use this information to size backup generators and alternative energy solutions.
16. Deploy networked/smart charging stations for the Town's fleet to enable monitoring of utilization, remote monitoring and diagnostics, and manage energy use. By strategically managing charging loads and charging times with these stations, the Town can avoid excessive energy consumption at peak demand periods.
17. For electric vehicle supply equipment (EVSE) maintenance and servicing, prior to the RFP phase for EVSE design and installation, establish a minimum uptime requirement for EVSE and determine whether routine EVSE maintenance will be conducted by the vendor or vendor's third party, a third party contracted by the Town, or by Town staff.
18. For EVSE maintenance and servicing on an ongoing basis, after EVSE design and installation, conduct regular maintenance and inspection for all EVs and EVSE to identify any potential issues before they escalate. For EVs, this includes checking battery healthy, tire pressure, brake systems, and other critical components. For EVSE, this means conducting routine functional testing of the equipment to ensure it is operating properly. Train drivers on correct EVSE usage, including correct charging port seating and cable management.
19. When facilities are retrofitted to implement EVSE and maintenance infrastructure, evaluate technologies that can monitor and mitigate potential EV fires such as thermal imaging cameras and gas sensors to identify sudden fluctuations or irregularities that can indicate potential issues leading to thermal runaway.

Operations and Education

20. Take the first step towards EV deployment by leveraging the existing PHEV fleet and underutilized charging infrastructure. Encourage minimizing the use of the gasoline engine in PHEVs to maximize GHG emissions reductions and cost savings.
21. Implement protocols for monitoring and managing battery health of EVs such as establishing a minimum state-of-charge for plugging in, optimizing charging schedules, monitoring driver usage and correcting behaviour if necessary, and identifying signs of battery degradation or malfunction early.

22. Provide comprehensive training to drivers on the safe operation of electric vehicles including understanding EV-specific features, charging procedures, regenerative breaking, and emergency protocols. This can be incorporated into the Town's Vehicle Use Policy which should be updated to reflect operation of EVs, such as driver expectations and charging etiquette.

1. Introduction

The Town of Ajax declared a climate emergency in 2019 and established new corporate greenhouse gas (GHG) emissions reduction targets in 2021. The new targets commit the Town of Ajax to achieve 100% GHG emissions reductions by 2050 (below 2019 levels), as well as incremental targets of 20% and 40% GHG emissions reductions by 2025 and 2030 (below 2019 levels), respectively. The Town has since implemented and prioritized a series of GHG-reducing projects, including the Town's Sustainable Green Fleet Strategy. Additional initiatives include the Town's early investments in low- and zero-emission vehicles and infrastructure include charging stations deployed at the Town's Operations Centre (Figure 1) and various hybrid/plug-in hybrid vehicles currently in operation (Figure 2). In summer 2024, the Town added four new Dodge Hornet plug-in hybrid electric vehicles to the fleet, a variety of electric lawn maintenance equipment such as zero-turn mowers, and an electric Zamboni. For 2025, a second electric Zamboni has been ordered.

Although the Town must consume energy in order to carry out the operation and maintenance of buildings, fleet, equipment, and streetlights, the Town has been exploring innovative strategies to reduce energy consumption and transition to low- and zero-carbon alternatives where possible. Between 2011 and 2018, the Town has seen a reduction in GHG emissions by 259 tonnes in relation to facilities, outdoor lighting, and fleet fuel consumption.



Figure 1 - ChargePoint Level 2 Charging Station at Town of Ajax Operations Centre



Figure 2 - Plug-in Hybrid Vehicle at Town of Ajax Operations Centre

The opportunity to reduce the emission contribution of municipal fleets and equipment is an important step in reducing overall GHG production, but it also has the potential to act as a catalyst for promoting community-wide emissions reduction, such as the transition of personal light-duty vehicles and equipment to zero-emission vehicle (ZEV) technologies. The Sustainable Green Fleet Strategy will allow the Town of Ajax to kickstart the transition of existing gas-powered vehicles and equipment to zero-emission equivalents such as electric vehicles (EVs) and reach carbon-neutral status by 2050.

In addition to the Town's emissions reduction goals, The Government of Canada has set a goal for 100% of vehicle sales to be ZEVs by 2035. As vehicle manufacturers respond to this goal, it is anticipated that the vehicle market will shift significantly in coming years. As a result, the Sustainable Green Fleet Strategy will ensure that the Town is ready to transition corporate fleet vehicles as more options become readily available.

Purpose and Scope

As a proactive response to the Town's climate emergency declaration and subsequent GHG reduction goals, Town staff established action plans for the development of a Sustainable Green Fleet Strategy to reduce corporate GHG emissions of municipal fleet and equipment.

There are approximately 200 on- and off-road vehicles and a variety of other gas-powered equipment managed through the Town's Fleet Services Department. These vehicles and equipment mainly use gasoline or diesel fuel and account for an estimated 36% of the total corporate GHG emissions. Previously, the Town has successfully reduced its fleet emissions through its Green Fleet Initiative, involving strategies to transition town vehicles to hybrid vehicles, "right-sizing" the fleet, and promoting an anti-idling campaign. The 2019 Energy Conservation and Demand Management Plan Update established fleet replacement and acquisition plans between 2020 and 2024, which included several hybrid vehicles.

While the Town has demonstrated its leadership in reducing corporate fleet GHG emissions, the Sustainable Green Fleet Strategy will be a critical component in accelerating the transition to ZEVs and realizing the Town's corporate GHG reduction targets.

The purpose of the Sustainable Green Fleet Strategy is to:

- Reduce GHG emissions and air pollution from municipal vehicles and equipment, which account for a significant share of corporate emissions and contribute to climate change.
- Ensure that the most fuel-efficient, low-carbon, and economically feasible options are considered in all new vehicle and equipment purchases.
- Reduce corporate fleet lifecycle operating costs, while maintaining operational suitability and levels of service.
- Maximize the utilization of the Town's vehicles and equipment through fleet and asset right-sizing.
- Monitor and track usage of existing hybrid vehicles to ensure optimal operation.
- Show leadership and commitment to environmental sustainability, climate resiliency, and social responsibility, by setting an example for other organizations and individuals to follow and aligning with the Town's vision and goals.

The Sustainable Green Fleet Strategy has been developed around the following steps and processes to reach a series of recommendations regarding how to progress the Town's transition to low emissions vehicles and equipment.

- A review of the existing low- and zero-emissions technologies, particularly those relevant for the Town due to the varying types of assets within its existing fleet, from light, medium, and heavy-duty vehicles, assets used in firefighting, and landscaping and maintenance assets (such as mowers and trimmers).
- Background review and stakeholder workshops are conducted to develop a policy framework for the Strategy and determine key inputs for the project including user groups and subsequent vehicle needs, as well as the opportunities and constraints of department operations and subsequent needs.
- A model-led exercise to analyze existing municipal fleet to understand existing usage, fuel, and emissions patterns. The model outputs are used to determine a preferred path forward for the transition of the municipal fleet and equipment and includes a phased asset replacement plan, potential emissions savings, and total cost of ownership evaluation.

Objectives and Performance

Specific objectives are established in the Sustainable Green Fleet Strategy to enable the development of quantifiable individual measures the Town can employ to monitor progress towards the overall goal of reducing fleetwide greenhouse gas emission and air pollution from municipal vehicles and equipment.

Objectives are specific, supported by Key Performance Indicators (KPIs) and quantifiable Metrics which will enable the Town to meet its goals and overall vision.

- **Objective:** Results the Town plans to achieve through the Sustainable Green Fleet Strategy, based on the goals the Town has already established.
- **Key Performance Indicator:** Allow the Town to measure overall performance or progress towards the objectives.
 - **Useful for:** reporting progress upwards within the organization – are we on track towards the objective?
- **Metric:** Quantifiable; allow the Town to measure specific business activities in support of the objectives.

Useful for: internal tracking within Fleet Services on more granular timelines.

Table 1 provides a summary of the objectives, KPIs, and metrics for the Sustainable Green Fleet Strategy.

Table 1 - Summary of Objectives, KPIs, and Metrics for Sustainable Green Fleet Strategy

Objective Category	Number	Objective	Key Performance Indicator	Metric
Emissions	E.1	20% GHG emissions reduction by 2025, below 2019 levels	Fleetwide GHG emissions by 2025	Tonnes of CO2e emitted
	E.2	40% GHG emissions reduction by 2030, below 2019 levels	Fleetwide GHG emissions by 2030	Tonnes of CO2e emitted
	E.3	100% GHG emissions reduction by 2050, below 2019 levels	Fleetwide GHG emissions by 2050	Tonnes of CO2e emitted
Financial	F.1	Reduce fleet fuel costs	Fleetwide fuel costs	Fleetwide fuel costs
	F.2	Identify funding opportunities for fleet capital and operating expenditures	Amount of funding provided by external sources	Percentage of capital and operating budget met through external funding opportunities
Optimization	O.1	Replace vehicles overdue for replacement	Fleetwide quantity of overdue vehicles or overall fleet age	Number of vehicles overdue for replacement
	O.2	Increase average fleetwide fuel efficiency	Fleetwide fuel consumption	Litres of fuel used
	O.3	Improve overall asset management	Incorporation of fleet telematics software in on-road vehicles	Number of vehicles equipped with fleet telematics software
	O.4	Deploy adequate, reliable charging infrastructure	EVSE reliability	EVSE uptime (hours per month)

	O.5	Achieve optimal fleet utilization	Vehicle mileage/equipment runtime	Kilometres per year/hours per year
	O.6	Complete fleet right-sizing strategy	Overall fleet size	Suitability of vehicle class/type for purpose EV uptime ¹
	O.7	Enable use of fully electrified off-road and hand-held equipment	Hand-held equipment in use	Quantity of gas-powered off-road and hand-held equipment
Leadership	L.1	Begin a fuel cell electric vehicle (FCEV) pilot	Deployment of FCEVs in fleet	Number of FCEVs in fleet
	L.2	Support other municipal divisions (e.g. Fire, ice resurfacers) in the transition	ZEV deployment across other municipal divisions	Number of ZEVs in other municipal divisions' fleets

Background Documents

The Town of Ajax has a rapidly growing population with over 5.8% growth rate recorded between 2016 and 2021. Moreover, the Ontario Growth Plan estimates that the population for the Region of Durham is expected to increase by 40% by 2051. Amidst this growth, the Town of Ajax has experienced impacts from climate change and extreme weather events including localized flooding, significant drought, ecosystem changes, violent storm damage, and disruptions to electricity supply, transportation, and communication services.

To meet the projected growth in energy demand, while mitigating climate change risks, the Town of Ajax has developed several strategic plans that facilitate its GHG emissions reduction and energy efficiency improvement goals. The following section reviews existing municipal and regional documents forming the policy framework of action plans and objectives that support the electrification of municipal fleet and equipment and subsequent development of the Town's Sustainable Green Fleet Strategy.

Town of Ajax Climate Risk and Resiliency Plan (ACRRP)

Ajax Town Council declared a Climate Emergency in 2019 and published the Town of Ajax Climate Risk and Resiliency Plan² (ACRRP) the same year, identifying eight objectives that will guide the Town's action plans over the next ten years. The purpose of the plan is to help the Town prepare for a wide range of climate change impacts including risks to property, infrastructure damage, service disruptions, human injury, and economic loss. The ACRRP initiatives focus on climate change mitigation and adaptation, specifically reducing the flow of greenhouse gas emissions into the atmosphere.

A Community Climate Study initiated by the Town in 2017, explored three strategic focus areas and conducted studies to assess and identify potential climate impacts within the Town of Ajax. The three strategic focus areas helped to guide the development of eight objectives presented in the ACRRP, and subsequent actions, and implementation strategies. Table 2 describes the key objectives for the three Focus Areas.

The foundation for climate adaptation planning is an understanding of the risks that threaten a community. The ACRRP is an important tool and directly supports the Town's Asset Management Plan and long-term budget forecast for matters that are specifically related to climate resiliency.

¹ A measure of the success of EV deployments (in terms of adoption and maintenance) will be the uptime of the vehicles relative to their ICE counterparts. EV uptime should be compared to historical ICEV uptime during the initial transition to ensure that selected EVs are well-suited to their purpose, are well-used by staff, and have suitable reliability.

² [Ajax Climate Risk & Resiliency Plan \(2019\)](#)

Table 2 - Ajax Climate Risk & Resiliency Plan: Three Strategic Focus Areas

Focus Areas	Key Objectives
Focus Area #1 Emergency Preparedness and Response	Better prepare Ajax for climate related disruptions to emergency services and response, including: • A focus on vulnerable populations, improving infrastructure resiliency, • Increase awareness and preparedness, • Supporting programs and policies to manage human health impacts, and • Having emergency plans in place
Focus Area #2 Natural Systems	Develop a structured, asset management-based approach to the Town's natural capital inventory to address declining natural infrastructure quality by prioritizing the health of local ecosystems and supporting a diverse range of species to thrive.
Focus Area #3 Stormwater, Flooding and Erosion	Improving the proactive planning and decision-making tools at the disposal of Town staff and investing in critical and social infrastructure resilience.

Town of Ajax Climate Risk and Resiliency Plan (ACRRP) Implementation Strategy

The eight objectives presented in the ACRRP represent the measurable steps the Town of Ajax will need to take to limit climate risk and improve community resiliency. The ACRRP Implementation Strategy³, subsequently presents Guiding Actions for each of the eight Objectives, outlined in Table 3, including estimated cost of implementation, implementation timelines, departments leading the action, community partners to be involved, and primary sources of funding.

The Implementation Strategy provides the Town with a strategic planning framework for addressing current and predicted future climate change risks. Ongoing monitoring and evaluation of actions will ensure that objectives are achieved in a timely manner and the Implementation Strategy will be updated every five years. The ACRRP and ACRRP Implementation Strategy does not include specific goals and objectives regarding the transition of municipal fleet and equipment to low-emissions alternative, but rather it lays the groundwork for taking coordinated action towards multiple climate change threats across a variety of sectors.

Table 3 - ACRRP Implementation Strategy - Eight Objectives

ACRRP Objectives	
Objective #1	Town residents, priority populations and businesses are communicated with about emergency preparedness and have access to emergency resources and information.
Objective #2	Existing and future critical and social infrastructure is adapted to withstand the impacts of climate change.
Objective #3	The Town has implemented supporting plans, programs, and policies to manage human health impacts resulting from climate change.
Objective #4	Emergency plans are in place for transportation and accessibility within the Town.
Objective #5	Naturalized urban areas and green infrastructure within the Town are enhanced to be resilient and supportive of biodiversity and are planned and maintained to limit conflicts with critical infrastructure.

³ [Ajax Climate Risk & Resiliency Plan – Implementation Strategy \(2019\)](#)

Objective #6	Natural heritage systems across the Town have been protected, restored, and expanded to support biodiversity and improve their overall resiliency to climate change impacts.
Objective #7	Town staff are equipped with improved decision-making tools to identify areas of high vulnerability and risk of flooding and erosion.
Objective #8	Stormwater Infrastructure resiliency has been enhanced across areas of known high flooding risk.

Corporate Energy Conservation and Demand Management Plan (2019)

The Corporate Energy Conservation and Demand Management Plan 2019 Update, was developed to help Ajax better understand and manage their energy consumption and is utilized to meet energy conservation goals, monitor progress, and implement innovative strategies that will support Ajax in becoming a more sustainable municipality.

The Town of Ajax is committed to developing a culture of energy conservation, reducing the demand for energy production, and minimizing greenhouse gas emissions while improving air quality. Table 4 outlines the Town's principal goals for reducing GHG emissions and conserving energy through this Plan.

Table 4 - Town of Ajax GHG Emissions and Energy Conservation Goals

Sector	Goal	Goal Year
Air Quality	Good quality air that is clean to breathe and supports healthy ecosystems	2055
Energy	Conserve energy and generate most of the energy consumed from clean and renewable sources	2055
Transportation	Develop and integrated, efficient, and accessible transportation system with sustainable options.	2055
Greenhouse Gas Emissions	Reduce corporate GHG emissions by 20%	2020

The primary focus of the Plan is to monitor and improve the energy consumption of municipally owned and operated facilities, infrastructure, and vehicles. The following sources of energy consumption are included in the Corporate Energy Conservation and Demand Management Plan:

- 48 buildings including municipal buildings, community centres, libraries, recreation buildings and fire stations.
- Outdoor lighting including streetlights, traffic lights, parks, and outdoor sports-fields lights.
- Approximately 159 vehicles and 100 pieces of equipment ranging from small hybrid vehicles to large trucks used for snow removal that mainly use gasoline or diesel fuel.

Using a baseline year of 2011, the Plan estimates that corporate GHG emissions have reduced by 259 tonnes between 2011 to 2018.

Table 5 outlines the percentage of total corporate GHG emissions and estimated reductions between 2011 and 2018 for the primary municipal energy sources.

Table 5 - Corporate Greenhouse Gas Emissions Reduction Between 2011-2018

Energy Source	Total Corporate GHG Emissions (%)	GHG Emissions Reduction between 2011 - 2018
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Facilities	46%	188 tonnes ⁴
Outdoor Lighting	18%	18 tonnes
Vehicles & Equipment	36%	53 tonnes
Total	100%	259 tonnes

The Town of Ajax has been proactively improving energy efficiency by implementing energy reduction and conservation initiatives within its facilities, outdoor lighting, and fleet. Initiatives include numerous retrofits and energy savings projects at town facilities, replacement of streetlights to low-emitting diode (LED) fixtures between 2017 and 2021, and implementation of the Green Fleet initiative to transition the Town's vehicles with hybrid, electric, or clean diesel where possible. The Plan outlines the completed, current, and future projects, measures, and initiatives the Town is undertaking to achieve its energy conservation and GHG emissions reduction goals.

Ajax Energy Management Strategy (2024-2029)

The Ajax Energy Management Strategy (2024-2029) serves as an update to the Town's 2019 Energy Conservation and Demand Management Plan. This strategy will be updated in 2024 to identify zero carbon and low carbon energy generating solutions in alignment with the asset management plan to achieve net zero GHG emissions by 2050.

The Strategy will establish energy efficiency targets and reduce GHG emissions with a focus on the following aspects:

1. Long-term planning through the establishment of a Corporate Net-Zero Emissions Plan (CNZEP).
2. Strategic energy management through energy conservation.
3. Capacity building of Town staff through continuous engagement and training.
4. Establishment of energy monitoring and tracking systems.

Council Resolution – Corporate Green House Gas Emissions

Since the Town of Ajax declared a Climate Emergency in 2019, the Town's GHG emissions targets had not been updated. During this time, the Region of Durham completed their Community Energy Plan, which outlines a region-wide goal of reducing GHG emissions by 10% below 2019 levels by 2025, 30% below 2019 levels by 2030, and 100% below 2019 levels by 2050. Moreover, a 2021 study by The Atmospheric Fund found that emissions increased by 5.2% across the Greater Toronto and Hamilton Area (GTHA) between 2017 and 2018.

Recognizing the growing impacts of climate change and rising GHG emissions within the GTHA, in April 2021, the Town of Ajax reaffirmed its commitment to the environment by endorsing the Region of Durham's community GHG emissions reduction targets, and establishing the following new Corporate Greenhouse Gas Emissions⁵ reduction targets, below 2019 levels:

- 20% GHG emissions reduction by 2025
- 40% GHG emissions reduction by 2030
- 100% GHG emissions reduction by 2050

⁴ Based on estimate, as actual GHG emissions reduction for facilities was not provided.

⁵ [Town of Ajax – Corporate Greenhouse Gas Emissions \(2021\)](#)

Durham Region Corporate Climate Action Plan (CCAP) (2021)

The Region of Durham declared a state of Climate Emergency in January 2020 and established the Durham Region Corporate Climate Action Plan ⁶ in March 2021 to develop an approach to reduce corporate GHG emissions by 100 percent by 2045. This includes the transition of corporate fleets, such as public transit vehicles, to low carbon alternatives.

The Plan identifies five priority actions to be implemented between 2021 to 2025 and establishes a four-part Corporate Carbon Budget Management Framework that consists of: emissions reduction targets that chart a trajectory to net zero corporate GHG emissions; business planning tools and actions for climate-informed decision-making; and a governance structure identifying roles and responsibilities for implementation of the carbon budget management framework.

The Plan also outlines implementation strategies for key regional operating areas including solid waste management, regional facilities, corporate fleets, and water supply and sewage infrastructure. The Region's strategy to reduce corporate fleet emissions is described below. If initiatives are implemented successfully, the Region will have achieved between 40% to 75% of its 2025 target. The following are Durham Region's corporate fleet strategies to achieve GHG emissions reduction goals.

- Corporate Fleets:**
- Target an annual average of 75% of new unmodified light-duty vehicle purchases will be ZEVs or hybrids between 2022-2025
 - Target an annual average of 100% of new unmodified light-duty vehicle purchases will be ZEVs or hybrids between 2026-2030, with priority given to ZEVs across all fleets where operationally feasible.

The Region published the **2023 Annual Corporate Action Plan Update Report & Light Duty Fleet Electrification Plan**⁷ in April 2023, which provides an update on the implementation of the CCAP (2021). The CCAP Update includes a high-level strategy for transitioning the Region's light duty vehicle fleets to low and zero carbon options. The report was developed by Dunskey Energy Consulting (Dunskey) in collaboration with fleet managers of the Region's four fleet groups: Paramedics, Police, Transit, and Works. The report identified the following key takeaways:

- **100% by 2030** is a viable and cost-effective pathway to accelerate GHG emissions reductions in the Works, Paramedics and Transit fleets. However, a more moderate scenario may be preferred for the Police fleet.
- A **proactive vehicle procurement strategy** will be necessary to implement the recommended pathways to fleet electrification.
- More than **426 charging ports** will be required to support this transition, 36 of which are already installed and/or planned.

Town of Ajax Integrated Transportation Master Plan (2019)

The 2019 Integrated Transportation Master Plan⁸ (ITMP) was developed to address growth, align the Town's policies with Provincial and Regional policies, enhance community benefits, respond to new transportation trends, and to encourage community involvement in the decision-making process. The objective of the ITMP is to update and merge the 2010 Ajax Pedestrian and Bicycle Master Plan and the 2013 Transportation Master Plan, into one all-encompassing planning document.

The ITMP vision is to enhance the sustainable and multi-modal transportation system for the Town of Ajax. The Town's transportation system will be accessible to all users and all modes of transportation that that supports pedestrian, cyclists, transit, and vehicular traffic. The ITMP sets ambitious goals to increase the percentage of commuters taking sustainable modes of transportation to 26% by 2031.

⁶ [Durham Region Corporate Climate Action Plan \(2021\)](#)

⁷ [2023 Annual Corporate Action Plan Update & Light Duty Fleet Electrification Plan](#)

⁸ [Town of Ajax - 2019 Integrated Transportation Master Plan](#)

The ITMP was prepared using a holistic multi-modal approach that considers the interaction of non-motorized and motorized modes within a single transportation system and provides recommendations for future walking, cycling, and road infrastructure improvements as well as a toolkit of six policies to support infrastructure investments (Table 6).

Table 6 - ITMP - Six Policies to Support Transportation Infrastructure Investment

Policies	Recommendations
Complete Streets	Continue promoting complete street design guidelines including Town departments and with private developers to integrate efforts towards a common goal.
Multi-modal Transportation	Improving multi-modal transportation by building accessible sidewalks and bike facilities at transit stops, optimizing traffic signals to enhance access to and from GO stations, and promote Mobility as a Service (MaaS).
Transportation Demand Management (TDM)	Strengthen TDM through infrastructure improvements and land use planning and promote TDM through education and outreach programs.
Vision Zero	Develop a Town of Ajax Road Safety Action Plan, Road Safety Management Steering Committee, as well as monitoring and evaluation framework for Vision Zero and the Road Safety Action Plan.
New Mobility Technologies	Prepare for new mobility technologies by identifying strategies to reduce parking demand, implement electric charging infrastructure at public parking lots, undertake an AVs pilot project, and track new mobility trends and appropriate policy responses.
Intelligent Transportation Systems (ITS)	Develop an ITS Strategic Plan, conduct a data needs assessment to determine key data needs, and analyze real-time data to understand the performance of existing infrastructure.

Town of Ajax Transportation Demand Management Plan (2023)

Auto dependency is quite high in Ajax and Durham Region compared to GTHA as a whole, while transit use is significantly less. The Town's overall goal for transportation is to make it easier for residents who cannot drive or who choose not to drive to be able to move through the community safely and conveniently. The Transportation Demand Management (TDM) Plan⁹ is a series of strategies and policies that aim to influence travel behaviour and encourage greater use of sustainable modes of transportation, while reducing the use of private vehicles. To achieve the Town's transportation objectives, this TDM Plan establishes the following goals:

1. Improve Mobility Choice
2. Building a Culture of Sustainable Transportation
3. Collaborate with Stakeholders and Community Leaders
4. Improve Transportation Equity
5. Measure and Communicate the Impacts of TDM

The TDM Plan identifies approximately 19 action plans that are categorized into four theme areas described in Table 7.

⁹ [Town of Ajax Transportation Demand Management Plan \(2023\)](#)

Table 7 - Ajax TDM Plan - Summary of Four Action Categories

Action Categories	Description
Foundations	Important first steps to set the TDM plan in motion for long-term success, such as securing funding, and developing a TDM Communications Plan.
Partnerships	Collaborating and strengthening partnerships on TDM initiatives to share knowledge and increase impact such as implementing a TDM Community Fund, public transit marketing programs, and shared micro-mobility pilot
TDM Integration with Town Policies and Practices	Embed TDM into site design and street improvement guidelines to promote greater update of sustainable transportation modes such as developing a Bicycle Parking Implementation Plan and including TDM requirements in new developments.
Transportation Equity	Expand mobility choice where auto-centric design has created barriers for marginalized communities to access essential services, programs, and opportunities by engaging equity-deserving communities, and investigating opportunities for creating a bike library.

Fleet Utilization Study

The 2020 Fleet Utilization Study evaluated utilization of the Town's fleet and recommended measures to right-size and reduce the number of vehicles. The Study also recommended the completion of a Sustainable Green Fleet Strategy for the entire fleet (the present study). Stakeholder engagement was undertaken throughout the study to understand the operations and current service levels of Fleet Operations, review the existing asset inventory for the Town fleet, and identify opportunities for improvements in fleet operations.

As a means of reducing emissions, before transitioning a current internal combustion engine vehicle (ICEV) to EV, the most sustainable alternative may be right-sizing a vehicle for its actual use or eliminating it entirely from the fleet. Right-sizing and retirement of vehicles is recommended when a vehicle is oversized for its typical duties or is not often utilized. Some vehicles do have low utilization by nature of their use profile, however, such as specialized equipment.

The Study found that 22 vehicles could be right-sized for work and the fleet could be reduced by eight vehicles based on a low-utilization analysis of generally fewer than 5,000 km per year. Right-sizing was estimated to save approximately \$207,000 based on 2020 replacement costs.

Current Fleet Policies

Policy 053 – Mileage Reimbursement

When employees need to use personal vehicles for Town business, reimbursement of mileage is permitted for those without a corporate vehicle allowance. The Town's Mileage Reimbursement Policy establishes the compensation rate for when an employee conducts travel for work related activities. It also lists the various procedures required for submitting mileage claims for reimbursement. The reimbursement rate is equivalent to the current Canada Revenue Agency (CRA) rate which is set for each province and territory by year. For 2024 in Ontario, the rate was \$0.70 per kilometre for the first 5,000 kilometres¹⁰.

Mileage reimbursement rates are intended to reflect the average operating costs of a passenger vehicle, based on the cost of gasoline, wear and tear, and vehicle depreciation. Given the EVs generally have a lower cost of ownership, mileage reimbursement rates may be adjusted over time to reflect these changing ownership costs. The CRA has not adjusted its rates to reflect changing ownership costs. In the future, the Town may consider developing a custom rate that better reflects the lower operating costs of EVs, once EVs have reached a majority of the market share, or once the majority of the Town's fleet is converted.

¹⁰ [CRA Automobile Allowance Rates](#)

It is recommended that the Town continue to encourage staff travelling on Town business more than 200 kilometres in one day to use a fleet vehicle, and that this fleet vehicle be an EV. This will contribute to lower emissions associated with Town business and can help demonstrate the benefits of an EV to Town staff. To assist staff with charging, the Town can consider making EV network payment cards available for use with the vehicle. For example, the FLO and ChargePoint networks allows members to activate their charging stations and pay for sessions using an app or physical card, with funds pre-loaded on a membership account, which would eliminate the need for staff to use their personal credit card for payment. The Town may consider a corporate membership to an EV charging network that has widespread availability in Ontario to support convenient use by staff.

Policy 070 – Use of Municipal Vehicles

The Town's Use of Municipal Vehicles Policy outlines the rules and expectations for Town employees who operate municipally owned, leased, or rented vehicles. The Policy aims to ensure the safe, appropriate, and consistent use of these vehicles. It applies to all Town employees using fleet vehicles managed by the Fleet Services section of the Operations and Environmental Services Department.

The Policy defines key terms, including licensed and unlicensed vehicles, fleet vehicles, employees, drivers, and valid driver's licences. It also covers various driving-related definitions such as accidents, incidents, distracted driving, and on-call duties. The Policy mandates adherence to several governing rules, statutes, and regulations, including the Highway Traffic Act, Occupational Health and Safety Act, and various internal policies related to vehicle operation and safety.

Responsibilities are detailed for management, Fleet Services, and employees. Management must ensure policy compliance, support CVOR standards, and provide necessary training and supervision. Fleet Services is responsible for vehicle acquisition, maintenance, repairs, and key management, among other tasks. Employees must participate in training, report hazards, maintain vehicle cleanliness, and ensure safe and responsible operation of fleet vehicles.

Drivers have specific duties, such as completing pre-trip inspections, operating vehicles safely, reporting malfunctions or damage, and following all relevant legislation and policies. The Policy also includes guidelines for key management, emphasizing the use of the electronic Key Management System for storing and retrieving vehicle keys.

The Policy states that municipally owned vehicles should primarily be used for Town operations and not for personal purposes, with specific conditions under which vehicles may be taken to personal residences for on-call duties. Additionally, the Policy addresses taxable benefits for personal use of Town vehicles, aligning with CRA definitions and requiring detailed recording of personal and business use to accurately calculate and report taxable benefits.

It is recommended that the driver duties be evaluated for their application to EV operations, including pre-trip inspections, safe vehicle operations, and damage/malfunction reporting. For example, pre-trip inspections for EVs should include assessment of battery state-of-charge in lieu of fuel level and confirmation that charging cables are correctly hung up and are not obstructing the vehicle's movement.

Fleet Utilization Policy (Draft)

The Town is currently drafting a new Fleet Utilization Policy. As drafted, the Policy aims to maximize the efficiency of the Town's vehicle fleet while minimizing operational costs and environmental impacts. This Policy is applicable to all Departments that use municipal vehicles and outlines the management practices of the Fleet Services Department.

The Policy defines various vehicle types and establishes criteria for their utilization. Light-, medium-, and heavy-duty vehicles are categorized based on their weight and functionality, with specific definitions provided for marked and shared vehicles.

Fleet Services is responsible for annually reviewing all vehicles to determine which ones should be replaced, retired, or reassigned. Utilization targets are set, with specific criteria to identify underutilized vehicles. If a vehicle is found to be underutilized, Fleet Services will consult with the user Department to decide on retention based on several criteria such as the necessity of a marked vehicle or special

modifications required for the job. If retention is not justified, alternatives such as shared vehicles, personal vehicle compensation, or other transportation means will be explored. Many of these actions were evaluated through the 2020 Fleet Utilization Study.

Vehicles are considered for retirement based on their age, mileage, and maintenance costs. The Policy sets specific lifecycles for light-, medium-, and heavy-duty vehicles and includes a detailed Vehicle Assessment Model for Replacement, which assigns points based on age, usage, type of service, reliability, maintenance costs, and condition. Requests for new vehicles or changes in vehicle specifications must be submitted through a Fleet Request form. Fleet Services has the final decision on vehicle assignments, sizes, and management. Fleet Services will annually review vehicle utilization and adjust the fleet as needed to ensure efficiency and cost-effectiveness.

As drafted, the Policy effectively builds on the recommendations of the 2020 Fleet Utilization Study. As the Town adopts EVs, it is recommended that certain elements of the Policy be evaluated alongside EV performance, such as:

- **Vehicle lifecycle:** currently seven years for light-duty, nine years for medium-duty, and 12 years for heavy-duty vehicles. If battery degradation impacts performance of early EVs, the lifecycles may need to be adjusted.
- **Planned usage level:** currently 175,000 km for light-duty vehicles. Similarly to vehicle lifecycle, if battery degradation impacts performance of early EVs, planned usage levels may need to be adjusted.

2. Best Practice Review

Climate change initiatives around the world have included ambitious goals to transition to 100 percent ZEVs in the next 20 to 30 years. There is unprecedented momentum around the transition to ZEVs, with a particular emphasis on EVs, and the role this will play in creating a cleaner and sustainable transportation system within municipalities.

Many municipalities began their EV transition journey by implementing strategies to procure EVs for their municipal fleets. Although transitioning municipal fleets to EVs can present challenges such as issues with procurement and supply chain, insufficient infrastructure, and lack of suitable vehicles, cities are using innovative approaches to achieve their municipal fleet electrification goals. Municipalities that have been experiencing success in converting fleets to EVs have been able to accelerate EV adoption more broadly, thereby supporting both corporate and community GHG emission reduction goals. The following section reviews corporate fleet transition policies being implemented in municipalities across Canada.

Town of Oakville

The Town of Oakville has implemented a Sustainable Green Fleet (SGF) Procedure¹¹ to guide fleet greening and support the Town's GHG emissions reduction goals, improve fuel efficiency, and mitigate climate change impacts. All Town departments and staff are required to follow the SGF procedure to maintain consistency and compliance including Oakville Transit, Roads and Works, Parking Operations, parks and Open Space, Fire Departments, and other Departments. The procedure requires all decisions regarding fleet to consider the following:

1. Promote and encouraging sustainable green fleet practices to all town staff on an ongoing basis.
2. Replace identified fleet vehicles with fuel efficient, low emission, and/or electric alternatives, in accordance with the most efficient and appropriate size.
3. Continue to implement green fleet maintenance, driver training and management practices.
4. Implement and pilot the use of fuel from alternative renewable sources.
5. Promote fleet and personal vehicle use operations to achieve fuel efficiencies and support idling reduction.
6. Implement innovative carbon reduction strategies and monitoring current and upcoming green fleet technologies and management options.
7. Continue to review job function and potential transition from single occupancy vehicle use to alternative, active transportation modes, such as walking, cycling, or public transit.

Town of Whitby

The Town of Whitby established the Zero Carbon Whitby Plan¹² in 2021 to help the Town reduce its corporate GHG emissions. The Plan is a framework for staff to develop and implement actions from the bottom-up to meet GHG reduction targets by aligning capital and operating budgets with GHG emissions reduction targets. Through the Plan, Whitby adopts a target that aims to reduce corporate carbon emissions to net zero by 2045 (below 2019 levels), as well as interim four-year reduction targets that are consistent with this trajectory, as follows:

- 20% GHG emissions reduction by 2025
- 40% GHG emissions reduction by 2030
- 100% GHG emissions reduction by 2045

¹¹ [Oakville Sustainable Green Fleet Procedure](#)

¹² [Zero Carbon Whitby \(2021\)](#)

The Plan requires all Departments to identify actions to reduce GHG emissions in a manner that aligns with the corporate target and establish appropriate performance measures. Actions identified within the Plan have a primary focus on the Town's highest emission sources, including Facilities, Fleet, Waste, and Buildings. Examples of opportunity areas include decarbonization of municipal buildings, net zero new construction, renewable energy generation, fleet electrification, and waste reduction.

Through the Community Strategic Plan (2023-2026)¹³, the Town has set the following action plan and measures of progress regarding corporate fleet electrification (Table 8).

Table 8 - Whitby Community Strategic Plan - Corporate Fleet Electrification Goals

STRATEGIC PILLAR 2: WHITBY'S NATURAL & BUILT ENVIRONMENT		
Objective	Actions	Measures of Progress
2.1 Demonstrate environmental leadership in sustainability and addressing climate change	2.1.6 Promote the use of electric vehicles and lead by example by implementing electric vehicles in the Town's municipal fleet.	→ Increase electric vehicle chargers at municipal facilities by 50% → 20% of fleet passenger vehicles will be electric

Recommendations from the Zero Carbon Whitby Plan led to the development of the Zero Carbon Whitby Costing Study¹⁴, which provides a schedule of the projects to be undertaken, the anticipated costs and savings for each project, and guidance regarding potential funding options.

To achieve the Zero Carbon Whitby Plan, corporate fleets must be 100% electrified by 2035. The Costing Study included a Zero carbon modelling for corporate fleet and found that there are significant savings to be realized from converting ICEVs to EVs. Cost savings are due to avoiding gasoline, diesel, and carbon tax costs, lower and less frequent maintenance costs, and more energy efficient engines. Additionally, it is recommended that the fleets are transitioned at a more rapid pace, and the Town should aim to convert ICEVs to EV models by 2035, as opposed to the current 2040 target date. Table 9 identifies the estimated costs and timelines to convert corporate fleet to EVs. As shown, the Town expects a total incremental avoided cost of \$5.6 million due to its EV transition and associated carbon tax, fuel cost, and maintenance savings.

Table 9 - Incremental Costs of Fleet Retrofit 2022-2045 (Zero Carbon Whitby Costing Study)

Target Year	Incremental Cost	Costs Include	Avoided Costs
2022-2025	\$110,000	- Purchase of 61 EVs. - Installation of 12 chargers - Cost of charging and maintaining EVs and ICEVs.	- Existing fleet costs in the BAU for same period. - Avoid ~\$3.3 million carbon tax. - Avoid ~ \$8.4 million in fuel costs.
2026-2045	-\$5.6 million	- Purchase of 310 EVs. - Installation of 101 EV charging stations.	Avoid ~ \$3.7 million in operations and maintenance costs.

City of Oshawa

In 2010, the City of Oshawa adopted corporate GHG emissions reduction targets to achieve 5% reduction by 2015, 20% reduction by 2020, and 80% reduction by 2050, from 2007 baseline levels. In 2020, the

¹³ [Town of Whitby – Community Strategic Plan \(2023-2026\)](#)

¹⁴ [Zero Carbon Whitby Costing Study \(2022\)](#)

City adopted an interim GHG reduction target of 30% below 2007 baseline levels by 2030, to align with Federal and Provincial Government targets.

The City of Oshawa has made great strides in reducing its corporate GHG emissions and improving energy efficiency across city operations including:

- 22% reduction in energy use intensity of municipal buildings in 2022 as compared to 2007.
- 48% reduction in corporate facility related GHG emissions in 2022 (compared to 2007 levels).
- Installation of 16 EV charging stations at its facilities, of which 14 are available for public use.
- Avoided an estimated \$2.3 million in operation costs due energy capital projects completed between 2018 and 2022.

Oshawa's 2024-2028 Corporate Energy Management Plan¹⁵ develops strategies that support the goals and objectives of the City's Corporate Greenhouse Gas Reduction Plan and included measures such as vehicle fleet upgrades to energy efficient models or hybrid models, investigating alternative fuels for vehicle fleet, and providing Eco-Driver training to city staff who drive fleet vehicles. At the time of the Plan, the city had issued purchase orders for 9 electric vehicles, employed 10 hybrid drive special service vehicles, and purchased and installed conversion kits into 10 vehicles to run on propane Autogas.

In June 2023, the City of Oshawa introduced its first seven fully electric vehicles to its fleet and has ordered another four fully electric vehicles. The existing 10 hybrid vehicles are used by municipal law enforcement.

City of Mississauga

In 2020, the City of Mississauga has developed a Corporate Green Fleet and Equipment Policy¹⁶ in efforts to reduce GHG emissions and fight climate change as part of its Climate Change Action Plan. The City has set corporate and community GHG reduction targets of 40% by 2030 and 80% by 2050, below 1990 levels. The City's fleet and equipment operations account for 78% of total Corporate emissions (as of 2017). The policy aims to prioritize investment in low or zero emissions fleet and equipment, such as electric vehicles, and improve the use of existing fleet and equipment through proper vehicle allocation, route optimization, and right-sizing fleet and equipment.

The Green Fleet and Equipment Policy is a decision-making framework that has been developed as a guide for asset acquisition and optimize sustainability of assets already in service. The Policy is also supported by an Electric Vehicle Charging Station Standard that outlines specifications and design requirements for installing EV charging infrastructure at city owned facilities. Lastly, the Policy also complements the Peel Zero Emission Vehicle Strategy, which is a region-wide initiative to increase the knowledge, availability, and ownership of zero emission vehicles in the community.

In addition to greening its corporate fleet, in 2021, the Mississauga Parks Operation team launched the Green Tools pilot, which will begin transitioning all Parks and Forestry Operations small equipment from gas/diesel to battery-powered units. The pilot includes a crew of two riding lawn mowers, a push mower, a leaf blower, and two trimmers. The switch to all electric and battery powered equipment is expected to occur over the next few years once current equipment reaches the end of its lifecycle.

City of Vancouver

In 2018, the City of Vancouver's City Fleet Plan set goals to reduce fleet GHG emissions by 30% by 2020 and 50% by 2030 centred on three key pillars of electrifying, fueling, and optimizing its city fleet. To meet their fleet emissions reduction goals, the City shifted to 100% renewable diesel fuel provided by Suncor, which was a significant step as 49% of the city's fleet is fuelled by diesel. The City also currently has over 145 EVs in their fleet including:

¹⁵ [City of Oshawa – Corporate Energy Management Plan \(2024-2026\)](#)

¹⁶ [Corporate Green Fleet and Equipment Policy](#)

- 66 Engineering and Parks passenger vehicles
- 22 Vancouver Police Department (VPD) non-emergency passenger vehicles
- 55 heavy duty equipment assets
- Two VPD motorcycles
- Two Sanitation operations flat deck
- One Vancouver Public Library cube van

In 2020, the City of Vancouver exceeded its Greenest City target of a 30% reduction below 2007 levels and achieved a 43% reduction. Through the Green Fleet Plan Update¹⁷, the City has set a new goal to achieve 50% GHG reduction by 2023, and a reduction of 1,300 tonnes of CO₂e annually. The Update also sets new goals and strategies to electrify Light-Duty Vehicles, Medium and Heavy-Duty Trucks, Construction and Maintenance Equipment, and Charging Infrastructure.

To support the City's GHG emissions reduction goals, the Vancouver Board of Parks and Recreation, which represents 30% of corporate GHG emissions, set goals to reduce the department's carbon dependency, including exploring the feasibility of switching from gas-powered to electric equipment. The 2018 Greenest City Scholars¹⁸ report conducted a study to evaluate the technical and economic benefits of adopting small electric equipment for the Park Board and the community. The report analyzes the performance and usage of small gas-powered equipment including blowers, trimmers, hedge trimmers, pole pruners, cut-off saws, and chainsaws. The study estimates that annual average GHG emissions of small equipment reached almost 600 tons of CO₂ emissions, which is equivalent to CO₂ emissions of 230 gas vehicles.

Lawn and garden electric equipment that are powered with lithium-ion batteries (LIB), were found to be the best option to guarantee the best performance and durability to deliver convenient power and run time. A Life Cycle Analysis (LCA) of all electric equipment, including battery production and recycling processes, found that the GHG emissions battery-powered equipment reached only 1.5-1.8% of the emissions generated by existing gas-powered equipment. Although the cost of the electric equipment is higher, the operating costs made the options economically viable. The study estimates that by switching to battery-powered equipment, the Park Board can potentially save between \$300,000 to \$450,000 per year starting from the second year.

However, a recent City Council Memo¹⁹ published in December 2023 revealed that while the Park Board successfully converted 35% of its landscaping equipment to electric options, they faced several challenges with the electric equipment such as limited battery-charge life, limitations with charging infrastructure, ergonomic issues, limits with power and torque levels, and delays in procuring equipment.

¹⁷ [City of Vancouver – Green Fleet Plan \(2019\)](#)

¹⁸ [Reducing Vancouver Board of Parks and Recreation Emission Footprint through Utilizing Electric Small Equipment](#)

¹⁹ [City of Vancouver – Memorandum \(2023\)](#)

3. Technical Research and Review

There are several technologies in various stages of development that aim to provide low- and zero-emissions alternatives for light- to heavy-duty vehicles and equipment. In the transition to low- and zero-emissions technologies, some vehicles and engines are designed for alternative fuels and energy sources by the manufacturer, while others are converted to run on alternative fuel by modifying the engine controls and fueling system from the original configuration. Generally, retrofits are performed on large, specialized heavy-duty vehicles, whereas light-duty vehicles have many electric alternatives available for purchase and have limited value in being retrofitted.

This section provides background information regarding the current low-emissions transportation sector and alternative fuel sources that public and private sectors have investing in to reduce transport sector emissions. The fuel types covered include electric, hydrogen, and natural gas. Opportunities, constraints, and risks during the fleet transition process to low- and zero-emissions technologies are identified.

Zero and Low- Emission Fuels

When considering sustainable transport options, EVs are often the most widely discussed solution. EVs typically produce zero tailpipe emissions and use an electric motor, which can be powered by a battery (typically lithium-ion), or by hydrogen in a fuel cell. Natural gas and biodiesel-powered vehicles produce lower emissions compared to their gas or diesel-powered counterparts. Additionally, existing vehicles can be retrofitted to reduce fuel consumption and tailpipe emissions.

- Battery-electric vehicles (BEVs) are charged via charging stations or stored electric power. The charging process can be lengthy (typically overnight) for a full charge, with rapid charging being used to top-up during the day. For fleets and heavy-duty vehicles, sufficient power supply is needed, which may require substation infrastructure to be developed close to the vehicle depot, as well as charging points.
- Hydrogen is already used extensively in industry and is considered a versatile and highly combustible fuel source. A hydrogen fuel cell vehicle works much like a BEV but re-fuels with hydrogen rather than using stored electric energy. At the point of use in the vehicle, hydrogen produces water and heat, with no carbon emissions. But there may still be emissions associated with the production of hydrogen, and clean hydrogen is essential to minimal emissions from these vehicles.
- Natural gas has traditionally been used as a domestic heating and cooking fuel, and for industrial uses. Its use as a vehicle fuel is well-established and typically compressed for ease of use and transportation. Natural gas is similar to diesel, but considered to be a cleaner fuel alternative, as it is free of lead, benzene, and sulphur and reduced exhaust emissions.
- Finally, biodiesel is also considered to be a low-emissions alternative fuel for diesel-powered vehicles and can be used as a direct replacement for diesel in new engines, with no vehicle modifications required. Biodiesel is derived from fuel crops and waste vegetable fats and oils and consists of different blends: B100 is 100% biofuel, B20 is 20% biofuel and 80% fossil diesel, an B5 is 5% biofuel, and 95% fossil diesel.

Table 10 presents a summary of alternative technologies that have been explored to help reduce GHG emissions of conventional vehicles. Battery electric, plug-in hybrid, and fuel cell electric vehicles are considered feasible to support municipal fleet transition to zero emissions.

Table 10 - Comparison of Alternative Vehicle Fuel Technologies

Alternative Fuel	Emissions Reduction Potential	Performance	Estimated Cost	Availability	Constraints
Zero-Emission Vehicle Technologies					
Battery Electric Vehicle (BEV)	Zero tailpipe emissions Considerations for carbon emissions from electricity production sources 605% to 90% well-to-wheel emissions reduction	Variable charging times Cold weather (-7°C) results in ~40% battery capacity reduction Hot weather (35°C) results in ~17% battery capacity reduction	Variable cost related to charging 60% to 88% fuel savings Up to 25% overall cost savings (8 years)	Currently available commercially Short-term supply constraints in smaller markets	Not suitable for remote locations without an electric grid Not suitable for heavy-duty applications Range anxiety Charging time for some vehicles with 24-hour use
Plug-in Hybrid Electric Vehicle (PHEV)	50% to 60% well-to-wheel emission reduction	Maritime – 20% fuel economy improvement Similar effects on battery capacity as BEVs due to extreme weather conditions	Variable cost related to charging Up to 21% fuel savings	Currently available commercially	Not suitable for remote locations without an electric grid Many PHEVs do not provide the option to choose between operation modes Can be operated in gas-only mode in perpetuity, so incentive to charge can be reduced
Hydrogen - Fuel Cell Electric Vehicle (FCEV)	Zero tailpipe emissions Considerations for carbon emissions from hydrogen production sources 15% to 45% well-to-wheel emissions reduction (brown hydrogen)	Suitable for energy-intensive applications (medium- and heavy-duty vehicles) 2x efficiency of combustion engines Very safe – as demonstrated in other industries that use hydrogen Minimal performance reduction in cold climates	Price is high and limited geographically by OEMs Canada currently does not provide a rebate for FCEVs Costs would likely include supply chain of hydrogen as well as vehicle	Limited availability for purchase Limited number of fueling stations in North America	Depends on the adoption of hydrogen infrastructure and distribution network Hydrogen supply is likely to be targeted for markets without viable alternatives (rail, long-range heavy-duty vehicles)
Low-Emission Vehicle Technologies					
Natural Gas Vehicles (NGV)	Tailpipe emissions comparable to conventional fuel vehicles 15% to 27% well-to-wheel emissions reduction (LNG) 80 % to 200% emissions reduction when using liquified renewable natural gas 11% lifecycle GHG emission reduction	Similar performance as conventional vehicles Shorter range than conventional vehicles Suitable for city and commercial fleets such as refuse, transit, and trucking vehicles	NGVs can cost considerably more than conventional vehicles Acceptable ROI due to fuel cost savings Lack of government incentives	Currently available commercially Lack of sufficient refueling stations	Limited supply chain and availability

Biodiesel	B20 biodiesel blend produces similar emissions as diesel. Biodiesel reduces GHG emissions on a lifecycle basis	Performance is similar to conventional diesel engines. No long-term effects on engine lifecycle when using biodiesel blends (B20 or lower)	No capital cost as many modern diesel engines permits the use of B20 biodiesel blend or lower. Biodiesel is roughly \$0.1 to \$0.2 per gallon cheaper than regular diesel	Currently available commercially – diesel-powered vehicles. Lack of sufficient biodiesel refuelling stations	Significant issues with cold weather – similar to petroleum diesel
Aftermarket Technologies					
Idle Reduction	Dependent on the extent of idling and idle reduction technology applied	No impact on performance	\$500 installation cost for a Fuel Management System	Currently available commercially	Many new vehicles now include anti-idling devices as standard
Hybrid Conversion		Plug-in hybrid achieved 50% - 100% better fuel efficiency compared to conventional vehicles (1994 Honda Accord)	Plug-in hybrid conversion kit cost: \$10,000 + installation fee	Currently available commercially	Significantly high costs and complex processes for conversion, retrofits, or repowers and mainly performed on heavy-duty trucks

Electric Vehicles

There are three general types of EVs:

- **Battery electric vehicles (BEVs)** – powered solely using an onboard electric motor. BEVs are also commonly referred to simply as electric vehicles, or EVs.
- **Plug-in hybrid electric vehicles (PHEVs)** – use both an onboard electric motor and a small internal combustion engine that is used when more power is needed or when the battery power is low.
- **Hybrid electric vehicles (HEVs)** – use a conventional internal combustion engine and an electric driver but differ from PHEV as all the energy for propulsion is generated from fuel. Unlike BEVs and PHEVs, HEVs cannot be plugged into the electricity grid and rely fully on fossil fuels. The electrical energy is generated through a built-in alternator and/or regenerative braking.

BEVs and PHEVs generally utilize lithium-ion batteries. Lithium-ion batteries have become the frontrunners for usage in EVs due to various factors including low cost, energy efficiency, temperature performance, weight, and life cycle length. Lithium-ion batteries can hold a lot of energy for their weight, which is vital for electric vehicles, as the lower weight allows the car to travel further on a single charge.

Electric Vehicle Considerations

To determine the optimal BEV or PHEV, fleet operators should consider the battery capacity, electrical range, and level of charging infrastructure to support daily operational needs. A vehicle's towing and hauling capacity are also important in many municipal fleet applications, in addition to the range.

An EV's battery capacity is the energy contained in an electric vehicle's battery pack and is expressed in terms of kilowatt-hours (kWh). The average EV has a battery capacity of around 40 kWh, but this can vary between different models and can be anywhere from around 20 kWh to 100 kWh. Generally, the larger the battery capacity, the longer the driving range. A battery with a higher capacity is comparable to a conventional car with a larger fuel tank, providing a longer range. Additionally, all EVs have a battery management system that prevents the battery from either becoming completely charged or discharged to preserve its efficiency and extend its usable life.

While the battery capacity indicates how much electricity the battery pack can store, the range of an electric or hybrid vehicle specifies the distance it can drive before the battery needs to be recharged. The

electrical range of a vehicle can vary depending on multiple factors such as driving style, weight of the vehicle, wheel condition and size, weather conditions (both hot and cold temperatures), the size of the battery, and age of the battery.

Lastly, the battery technology in both BEVs and PHEVs requires external charging and, currently, there are three charging level classifications used in the industry that are based on the charging efficiency, required infrastructure, and cost. Below is a brief summary of the three charging levels, however further details regarding cost, power, and infrastructure requirements are discussed in the following sections of this report.

- Level 1 charging stations (120 volts) can charge via specialized power cords that can be plugged into a standard household outlet or install a public charging unit that costs between \$400 to \$1,200. Level 1 is the slowest form of EV charging, known as trickle-charging, providing between 1.4 and 1.9 kW/h charging rate, and is commonly used at residential locations for overnight charging.
- Level 2 charging stations (220-240 volts) provide faster charging rates compared to Level 1 and can provide charging rates between 3.3 and 19.2 kW/h. Level 2 charging units can cost between \$700 to \$4,000 to purchase and install and are typically used in residential homes, and public locations such as workplaces, grocery stores, and parking lots. Non-networked (i.e., internet connected) charging stations are lower cost, with networked Level 2 charging stations typically starting at \$2,500.
- Level 3 chargers (or DC Fast Chargers) are the fastest method of EV charging currently available and cost around \$30,000 to \$50,000 (not including utility connection or new substation) due to the high energy and infrastructure requirements. DC charging is mainly used for commercial applications and offers charging speeds of 50 kW/h or more. DC charging rates are often limited by the vehicle rather than the charging station, with many vehicles unable to accept a rate of charge greater than 150 kW/h.

Selecting the appropriate level of charging infrastructure is an important consideration for fleet operators and various factors including fleet size, space available for charging, and average daily usage of vehicle must be considered. Table 11 compares common BEV models in terms of battery capacity, electric range, and charging time when using a Level 2 charging unit.

Table 11 - Comparison of Battery Capacity, Range, and Charge Time of BEV Models

Model	Battery Capacity (kWh)	Electric Range (km)	Time to Charge (Level 2)
Nissan Leaf Plus	60	~340	~8.5 hrs
Chevrolet Bolt EV LT	65	~417	8.5 hrs
Hyundai Kona	39.2	~450	~9hrs
Mazda MX-30	35	~160	~5 hr
Tesla Model 3	60	~440	~8 hrs
Ford F-150 Lightning	90	~385	~11.5 hrs

Lithium-Ion Batteries

Lithium-ion batteries were developed in the early 1970s and are widely used in everyday products such as cellphones, laptops, electric scooters, and electric vehicles. LIBs have become an integral part of modern-day technology due to its light weight, high energy density, power density, and ability to recharge, which support long-term operation and high-current usage required by many of today's portable electronic devices and electric vehicles. Energy density is measured in watts-hours per kilogram (Wh/kg) and is the amount of energy the battery can store with respect to its mass. Power density is measured in watts per kilogram (W/kg) and is the amount of power that can be generated by the battery with respect to its mass. High-energy density lithium-ion batteries are considered as the ideal power source for BEVs and PHEVs in the automotive industry.

One of the current challenges facing the adoption of ZEV is the higher capital price of the vehicles, which is driven primarily by the battery component. The US Department of Energy set a cost target for all electric vehicle batteries at \$125/kWh of usable energy²⁰. At present due to technology research costs, material costs and initial start up costs, commercial battery costs are anywhere from \$150-250/kWh²¹, which reflects a significant drop from five years ago when costs exceed \$400/kWh. Most of the cost reduction that has been achieved to date has been achieved by energy density increases in the batteries which can provide better performance at similar costs. It is thought that further cost reduction is possible through the optimization of manufacturing schemes.

Lithium-Ion Battery Production

Lithium-ion batteries are manufactured in sets of electrodes and then assembled in cells, active material is mixed with polymer binders, conductive additives, and solvents to form a slurry that is then coated on a current collector foil and dried to remove the solvent and create a porous electrode coating. The solvent of choice, N-methyl pyrrolidone (NMP), is considered an indirect material (it is needed for production but not contained in the final device), but it is expensive, exhibits flammable vapors, and is highly toxic. The flammable vapors of NMP require all processing equipment during the production of electrodes to be explosion proof, meaning all spark-producing electrical components need to be shielded from the vapors and spaces need to be highly ventilated to keep vapor concentrations low. These measures increase the capital cost of such equipment considerably.

The supply chain for the various raw materials for a lithium-ion battery is still an emerging market as the various vehicle manufacturers continue to look at longer terms plans and where to locate production facilities. The key components to a lithium-ion battery are lithium, graphite, cobalt, and manganese, which must be mined in their raw form. Many of these raw materials can be found in Canada and this will help reduce some of the emission associated with the transportation of the materials to production facilities. However, the significant increase in the demand on existing mines for these materials has brought into focus existing mining practices and whether these are the most sustainable and environmentally conservative approaches currently available.

The recycling of end-of-life batteries is another area that is gaining a lot of attention as the growth of the BEV occurs. There is some early research on the usage and performance of BEV that suggests that many of the batteries being developed have several thousand charging events available during their useful lifecycle in a vehicle, which can offer many hundred of thousands of kilometres of driving. Equally the batteries will lose some of their ability to retain charges as they age and the amount of charge they can hold, although lifespans are estimated to exceed most vehicles (in the region of 15-20 years), existing samples and research has been insufficient to reach firm conclusions. At the end-of-life, despite no longer operating at peak performance, the EV battery can still hold anywhere from 50-80% of its initial capacity. These batteries have the immense potential to be repurposed into second-life batteries for use in less demanding applications (i.e., stationary energy storage).

Although secondary life is a preferred outcome, some batteries cannot be reused in a secondary application, but they still offer components that may be recycled. Through battery recycling, as many materials as possible are recovered through a series of different techniques depending on the recycling vendors facility. At present the process of “shredding” is considered to be the most common approach to recycling batteries, it involves disassembled batteries going through a thermal treatment before or after crushing to remove impurities such as the organic fraction (for example, plastic), optimize the separation of electrode active material and current collector foil, and change the phase of valuable metal to a reduced form for optimized efficiency in hydrometallurgical processing. After various screening and sorting steps leveraging physical properties of battery components such as size, shape, magnetism, density, and conductivity, the process yields multiple material fractions, which includes “black mass,” a powder containing valuable material such as nickel, cobalt, lithium, and graphite. Black mass is then used for battery reproduction once the components are separated. Alternatives such as mechanical pre-treatment do exist although without the intense thermal treatment the yield of black mass composition is more likely to have a much higher level of impurities.

²⁰ [Frontiers of Engineering: Reports on Leading-Edge Engineering](#)

²¹ [Bloomberg NEF: Lithium-ion Battery Pack Prices Rise](#)

Lithium-Ion Battery Fires

Lithium-ion batteries have become the frontrunners for usage in EVs due to various factors including low cost, energy efficiency, temperature performance, weight, and life cycle length. Lithium-ion batteries can hold a lot of energy for their weight, which is vital for electric vehicles, as the lower weight allows the car to travel further on a single charge. All BEVs and PHEVs have high-voltage electrical systems that typically range from 400 to 1000 volts. The battery packs are encased in sealed shells and meet testing standards that subject batteries to conditions such as overcharge, vibration, extreme temperatures, short circuit, humidity, fire, collision, and water immersion. Manufacturers design EVs with insulated high-voltage lines, and light-duty EVs are required to have safety features that can deactivate or isolate the electrical system when they detect collision or short circuit.

Lithium-ion battery fires are an extremely rare occurrence but can occur under the right circumstances. Depending on the battery chemistry, design, size, component types, and amount of energy stored, lithium battery failures can result in chemical and/or combustion reactions. Damage to lithium batteries can occur immediately or over a period of time, from physical impact, exposure to certain temperatures, and/or improper charging. The following are some examples potential damage to lithium-ion batteries that may lead to a fire and/or explosion hazard:

- **Mechanical Abuse or Damage** – caused by the battery pack being dropped or mishandled during the manufacturing process, shipment, or handling.
- **Manufacturing Defect** – a defect during the manufacturing process can create conditions which may make a particular battery prone to short circuit during use.
- **Exposure to high temperatures** – damage to lithium batteries can occur when exposed to significantly high temperatures or when battery is in proximity to external heat sources which can accelerate failure in battery cells within existing defects or damage from other causes.
- **Excessive Battery Overcharging** – because lithium-ion batteries are prone to overheating, leaving a rechargeable battery plugged into its charging unit for excessive periods of time is not advised, especially when the charger over-limit protection is not present²².

According to the UL Solutions Lithium-ion Battery Incident Reporting database, globally, there have been an estimated 9,320 reported lithium-ion battery-related incidents to date, including approximately 1,544 incidents reported in 2023. The database suggests that the majority of reported incidents are related to consumer products (e.g., laptops and mobile phones) and micro-mobility devices (e.g., e-bikes), while a smaller percentage of incidents are related to electric vehicles²³. A review of the latest data on car fires in the United States, obtained through the U.S. National Transportation Safety Board (NTSB), revealed that hybrid- and plug-in hybrid vehicles are at the highest risk of catching fire with a 3.4% probability rate, ICEVs are 1.5% likely, and battery-electric vehicles are only 0.03% likely to ignite. In other words, there have been approximately 25 EV fires reported for every 100,000 EV sales, 1520 ICEV fires reported for every 100,000 ICEV sales, and 3475 HEV fires reported for every 100,000 HEV sales. Lastly, the NTSB data suggests that only 3-5 electric cars caught fire while charging between 2019 and 2022²⁴.

Although electric vehicles are less likely to catch fire than traditional ICEVs, when they do, EV fires burn longer and hotter, and are difficult to suppress, which presents significant safety concerns. While water is currently the primary method for extinguishing a lithium-ion battery fire, it requires an enormous amount of water to cool the battery pack and stop the thermal runaway. The International Association of Fire and Rescue Services reported that firefighters need approximately 40 times more water to put out an EV fire compared to a standard ICEV²⁵. In some cases, adding water to a LIB fire may lead to additional chemical reactions that could further fuel the fire rather than suppressing it. This is because the water can react with the lithium metal anode and produce flammable hydrogen gas.

²² [OSHA – Preventing Fire/Explosion Injury from Lithium Battery Powered Devices](#)

²³ [Lithium-ion Battery Incident Reporting](#)

²⁴ [NTSB – Safety Risks to Emergency Responders from Lithium-Ion Battery Fires in Electric Vehicles](#)

²⁵ [CTIF – Up to 150,000 Liters of Water Needed to Put Out a Fire in an Electric Car](#)

Safety Risks for First Responders

Fires in EVs powered by lithium-ion batteries pose two primary dangers to emergency responders:

1. Risk of electric shock from exposure to high-voltage connections in a damaged battery.
2. Risk that the damaged cell in the battery will experience uncontrolled increases in temperature and pressure, known as thermal runaway, leading to venting and combustion of toxic gases, cell rupture and explosion hazards, and battery fires.

Additionally, lithium-ion battery fires can release potentially toxic gases, which may pose toxicity concerns for first responders or the public, as well as a broader spectrum of environmental impacts of such fires.

Thermal Runaway

When a lithium-ion battery is exposed to abnormal operating conditions, including mechanical damage, internal short circuit, overcharging/discharging, and thermal abuse, the release of heat during cell failure triggers a chemical reaction, resulting in a self-enhanced, increasing temperature loop known as “thermal runaway”. The excess heat triggers an uncontrolled chain reaction that spreads throughout the rest of the EV battery pack, causing the release of flammable gasses such as hydrogen, volatile hydrocarbons, and carbon monoxide, which can lead to battery fires and explosive hazards. Thermal runaway can occur in the absence of an active fire and can be recognized as a distinct white or grey battery gas leaking from the structure, forming low-hanging clouds.

Explosion Hazards

The timing and severity of a battery gas explosion is unpredictable, and an explosion hazard can develop before any exterior indicators are shown. An explosion hazard begins the instant batteries undergo thermal runaway and release gas without burning. Additionally, unburned battery gas ignites readily and can increase the flammability of the smoke in a ventilation-limited fire. Firefighters are at greatest risk for explosion hazards in the driveway, and at doors, windows, or other vent points. As such, it is recommended to avoid parking the fire apparatus immediately in front of a burning EV to avoid explosions damaging firefighting equipment and vehicles.

Advances in Battery Chemistry

Recent advances in battery chemistry have focused on improving energy density, safety, and sustainability. Some notable developments include solid-state batteries, which use a solid electrolyte instead of liquid, enhancing safety and energy density. Solid-state batteries are seen as a potential key advancement for EVs due to their potential for faster charging times and longer lifespans. Whereas typical lithium-ion batteries require 30+ minutes to charge on a DC Fast Charger, or many hours on a Level 1 or Level 2 charging station, solid-state batteries can achieve a full charge in as little as 10 to 15 minutes²⁶. Their higher density allows for greater range and efficiency. As of 2024, manufacturers including Toyota and Nissan are estimating these batteries will start to be rolled out beginning in 2027 and 2028, respectively, as part of the next generation of their commercially available vehicle batteries²⁷.

As the Town expands its EV fleet, changes in battery chemistry such as the potential for more widespread adoption of solid-state batteries could have a variety of implications: there may be less need for charging stations, since vehicles will not need to charge as often due to higher ranges, or vehicles charging more quickly may change some operational protocols such as requiring all vehicles to be plugged in at the end of a driver's shift.

²⁶ [Solid-State EV Battery Technology: Range, Improved Safety, and Faster Charging](#)

²⁷ [Toyota confirms 750 mi range solid-state EV battery plans](#)

Hydrogen Fuel

Hydrogen has the highest energy per mass of any fuel; there is an equal amount of energy in 1 kg of hydrogen as there is in roughly 2.8 kg of conventional gasoline, which has led to a significant level of interest in developing vehicles that utilize Hydrogen as a fuel source. Hydrogen can be produced from clean energy sources and is carbon and pollutant-free at the tailpipe when used in a fuel cell. The chemical reaction between hydrogen and oxygen produces electricity, heat, and water with no other by-products or carbon emissions, making hydrogen an attractive alternative fuel.

Today's growing interest in the widespread use of hydrogen for clean energy systems rests on two primary attributes:

- Hydrogen can be used without direct emissions of air pollutants or greenhouse gases.
- It can be made from a diverse range of low-carbon energy sources. Its potential supply includes production from renewable, electricity, biomass, and nuclear sources. Low carbon production from fossil fuels is also possible, if combined with carbon capture, use and storage (CCUS) and emissions during fossil fuel extraction and supply are mitigated.

Hydrogen Fuel Production

Despite being the most abundant element in the universe, hydrogen is rarely found in its natural state on earth, rather it is found bonded to other common molecules such as water (H₂O) and methane (CH₄) and needs to be separated from other elements. Hydrogen can be produced through several methods; however, each method requires energy to drive the chemical reaction to isolate hydrogen from water, coal, methane, or ammonia. There are two processes commonly used to produce hydrogen: electrolysis and steam methane reforming (SMR). As illustrated in Figure 3, these methods are given “colours” that indicate how hydrogen is produced and how environmentally friendly each method is.

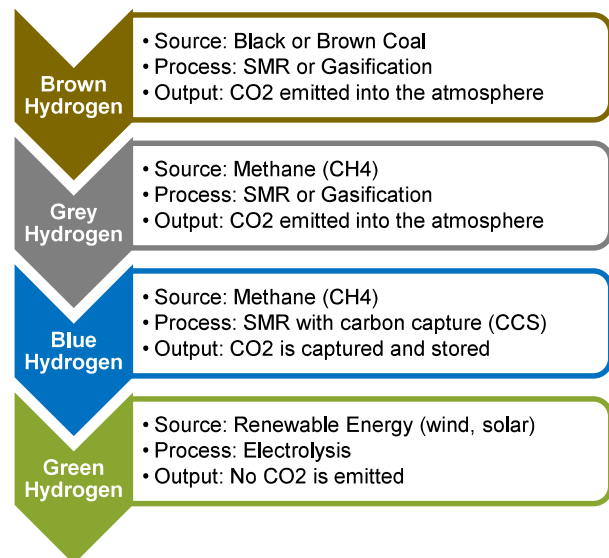


Figure 3 - Types of Hydrogen Production Processes

Natural gas contains methane (CH₄) that can be used to produce hydrogen through thermal processes. Currently, most industrial hydrogen is produced via steam methane reforming (SMR), a mature production process in which high-temperature steam is used to produce hydrogen from a methane source, such as natural gas. Methane reacts with steam in the presence of a catalyst to produce hydrogen, carbon monoxide, and a relatively small amount of carbon dioxide. Following the SMR, additional processes are performed to remove all carbon dioxide and other impurities from the gas stream, leaving essentially pure hydrogen. Although this is the most cost-effective method to produce hydrogen, the process does produce carbon emissions (grey hydrogen), however the impact can be lessened through the use of carbon capture and storage (CCS) technology or it can be reused as a chemical agent in other processes, thereby turning it into “blue” hydrogen.

Hydrogen can also be produced using electricity from the grid or using renewables to electrolyze water. Electrolysis involves splitting water into its constituents, oxygen, and hydrogen, by running a low-voltage electrical current through the water, separating the oxygen molecules at the anode (negative electrode) and hydrogen molecules at the cathode (positive electrode). As the cost of renewables continues to fall, hydrogen production using electrolysis will allow the production of “green” hydrogen to be competitive with production via reforming fossil fuels.

Canada is one of the top ten global producers of hydrogen today, producing an estimated 3 million tonnes annually via steam methane reformation (SMR) of natural gas. Although SMR is not considered a clean hydrogen pathway without carbon capture, Canada is well positioned to transition to clean pathways moving forward.

Hydrogen in Transportation

Hydrogen can be used directly within FCEVs and is quickly becoming an attractive zero-emissions alternative for transportation, especially for heavy-duty vehicles and buses which require energy-dense fuels. FCEVs have two times the efficiency of combustion engines and zero emissions at the tailpipe. FCEV performance is not impacted to the same extent as BEVs are and waste heat from the fuel cell can be used to heat the cabin thereby reducing the demand posed on the fuel cell within cold climates. With regards to emissions, FCEVs only emit water vapour and warm air and produce no tailpipe emissions. Similar to electricity, hydrogen is an energy carrier that can be produced through various methods. However, such methods and their related emissions should be considered when evaluating hydrogen emissions, as the hydrogen source can impact the lifecycle carbon emissions numbers.

Light-duty passenger FCEVs are commercially available globally but have limited deployment in Canada. However, provinces such as British Columbia and Quebec have started to deploy hydrogen fueling infrastructure and light-duty FCEVs. Although BEVs are expected to take a significant portion of the market share for light-duty ZEVs in Canada, FCEVs offer a choice for vehicle owners that prefer larger vehicles, longer range, faster refueling times, and minimal performance reduction in cold climates.

Fuel cell electric buses (FCEBs) also have significant potential for public transit agencies looking to shift towards low- and zero-emissions vehicles. There are currently more than 2,000 FCEBs commercially available today, and approximately half of them are powered by Canadian technology. FCEBs are well suited for the longer routes and cold weather climate that Canadian transit agencies service. Companies such as New Flyer Industries, Ballard Power Systems, Hydrogenics, and Dana TM have taken significant positions in FCEV technology and offer true, made-in-Canada solutions. In January 2024, a new deal between two Canadian companies will result in Ballard supplying 100 fuel cell modules for New Flyer buses. New Flyer currently has purchase orders from Winnipeg Transit, Edmonton Transit and Strathcona County in Alberta. Once completed, the fuel cell buses will be deployed across Canada and several U.S. states²⁸.

FCEV Infrastructure and Market Growth

The infrastructure required for hydrogen distribution has also been growing worldwide, however faces several challenges for widescale deployment. In many regions, hydrogen fueling stations are being built to support the roll-out of fuel cell automobiles as well as at industrial operating centres for transit buses, heavy-duty trucks, or material handling fleets. To reach these stations, the fuel can be distributed via ship, pipelines, liquified tanker-trucks or high-pressure tube trailers similar to natural gas. Hydrogen's unique characteristics make it one of the safest energy sources when compared to flammable fuels such as gasoline, diesel, or natural gas. As a result, hydrogen has been safely produced, stored, transported, and used in large amounts in industry for years.

Although light-duty FCEVs are currently available on the market, they are produced at a small scale and two major obstacles to deployment in Canada is the near-term supply issue and availability of refuelling infrastructure. The two issues are intertwined as vehicle supply is limited in part due to original equipment manufacturers (OEMs) delivering a limited number of vehicles to regions with existing retail fueling networks. Because FCEVs are currently produced in small volumes, they are more expensive compared to conventional combustion vehicles and BEVs. Until advancements in technology and improvements to production scale decrease costs, consumer subsidies will be important to drive the adoption of FCEVs.

On the global market, FCEVs are showing significant growth potential. In 2021, FCEV sales reached approximately 16,000 units, and the FCEV market is showing potential to take off at a rapid pace. Several European countries have announced or are planning hydrogen- and FCEV-based targets. The European

²⁸ [Ballard-New Flyer Deal for Zero-Emission Buses](#)

Union has set a target to deploy an estimated 750 hydrogen refuelling stations by 2025, and 300 hydrogen fuel cell buses by 2023. France and Germany have also set ambitious targets to deploy passenger vehicles and hydrogen-based passenger trains respectively, by 2023. South Korea, currently the largest FCEV market, aims to deploy approximately 3 million passenger and light-duty commercial vehicles, as well as close to 70,000 trucks and buses by 2040. The United States also announced its intention to drive the adoption of FCEVs. California has set goals of 1,000 hydrogen fuelling stations and one million FCEVs by 2030.

Emerging Fuel Types

Other emerging low- and zero-emission technologies include ammonia fuel cell technology and methanol biofuel. Direct Ammonia Fuel Cells (DACFs) use ammonia as fuel and convert ammonia to electricity. DACFs produce only water vapour and nitrogen as byproducts, and ammonia can be stored in liquid form, making it a practical fuel source. Green ammonia, synthesized from renewable energy, has been gaining attention as a potential sustainable fuel option, but does not have any mass market applications in vehicles to date. Methanol biofuel is an alternative biofuel used in internal combustion engines, which can be used in combination with gasoline or independently. It is less expensive to sustainably produce than ethanol fuel and can be made from renewable resources, making it a sustainable option. The primary application of methanol biofuels is in racing vehicles and the maritime industry, but has limited mass market applications.

These and other emerging fuel types may gain traction in more traditional, mass market applications such as municipal fleets, though more widespread adoption of EVs and FCEVs continues to be the most likely scenario.

Natural Gas

Natural gas is an odourless, gas mixture of hydrocarbons and is made up predominantly of methane (CH₄). Because natural gas is made of mainly hydrogen, it produces few harmful emissions (such as carbon monoxide and carbon dioxide) than gasoline or diesel fuel.

Canada is one of the largest producers of natural gas in the world as it is found in abundance in porous rock formations across the country. The fuel source is extracted from the ground, processed to remove impurities, and compressed to be stored and transported by pipeline. Today, natural gas is delivered to almost 6.8 million homes, businesses, and institutions, providing 20 million Canadians from coast to coast with a clean, affordable, safe, and reliable energy solution.

Natural gas is also an alternative fuel source that can be used in various ways within transportation. It can be used to generate electricity, which in turn can charge batteries or power heavy-duty vehicles and trains. However, natural gas has also been used more directly as vehicles have been modified to use natural gas as an alternative to gasoline for internal combustion engines. When used as an onboard vehicle fuel, natural gas can be carried as a cryogenic liquid (LNG), but it is more commonly carried as a high-pressured compressed gas (CNG). Vehicles powered by liquefied natural gas or compressed natural gas produce less emissions than cars running on gasoline or diesel. Using natural gas as a transportation fuel has many benefits:

- Reduced greenhouse gas emissions by 10-25%.
- 10-20% less expensive than diesel and gasoline.
- Quieter vehicles providing less noise in urban settings.
- High performance similar to diesel or gasoline powered vehicles.
- Secure and long-lasting fuel supply.

Natural Gas in Transportation

There are three types of natural gas vehicles (NGVs): dedicated, dual-fuel, and bi-fuels. Dedicated NGVs are built to operate exclusively on natural gas. Bi-fuel vehicles are equipped with two distinct fueling systems that allow them to operate on either gasoline or natural gas; this system extends the range by adding the distances that the NGV can run on each fuel separately. Dual-fuel vehicles run on natural gas, while diesel fuel is used to assist the ignition, allowing them to operate similar to conventional compression-ignition engines. Light-duty vehicles are typically configured as either dedicated or bi-fuel whereas heavy-duty vehicles are configured as either dedicated or dual-fuel. Dual-fuel engines are designed exclusively for heavy-duty trucks and can be more fuel-efficient than the spark-ignited dedicated system. However, dual-fuel systems are more complex as it requires diesel exhaust after treatment and onboard storage of both fuel types.

Natural gas vehicles (NGVs) are useful for high-mileage (high fuel use) fleets such as buses, medium- and heavy-duty trucks, and refuse vehicles since they are centrally fueled or operate within a limited area or along a route with natural gas fueling stations. NGVs perform like conventional fuels in terms of power, acceleration, and cruising speed. Natural gas has a higher pump octane number than gasoline (120+ compared to 84-93) and original equipment manufacturers (OEMs) offer dedicated engines that are optimized to take advantage of higher ratings, resulting in improved performance and fuel economy over non-optimized engines. NGVs generally have a shorter driving range than comparable conventional fuel vehicles because natural gas has less overall energy content. However, the installation of additional storage tanks or the use of LNG can help improve vehicular range.

Tailpipe emissions from new NGVs are comparable to those of similar conventional fuels equipped with modern emissions controls. Light-duty vehicles running on natural gas can reduce lifecycle greenhouse gas emissions by 11%. Additionally, CNG fuel systems are completely sealed therefore the vehicles produce no evaporative emissions. In efforts to reduce GHG emissions in B.C.'s commercial transportation sector, BC Ferries introduced three new vessels to its fleet which run on LNG as a fuel source. The use of natural gas in these vessels resulted in a reduction of approximately 9,000 metric tonnes of carbon dioxide equivalent per year per ferry, which is the equivalent of taken 1,900 passenger vehicles off the road annually.

In 2020, natural gas vehicle sales reached over 29 million units globally and is expected grow at a 3.3% annual growth rate between 2021 and 2028. NGV market growth is most prominent in East and Asian countries like China, India, and Pakistan, due to an increase in production and sales of NGV passenger vehicles in these regions. In North America, NGV options are commonly sold by truck and van manufacturers such as Ford, GM, and Ram and are mainly operational within commercial fleets, buses, and medium- to heavy-duty trucks.

Municipal Fleet and Equipment

The Town of Ajax currently operates 126 vehicles and 92 pieces of equipment that mainly use gasoline or diesel fuel. Propane is also used in the Town's ice resurfacers. Additional non-motorized equipment brings the Town's total fleet assets to around 250. The Town's fleet emissions account for approximately 36% of total corporate GHG emissions. The majority of the fleet GHG emissions come from the Operations Department as a result of the use of heavy-duty vehicles such as snowplows, forestry vehicles, and construction equipment. The following sections explore commercially available options for low- and zero-emissions medium- and heavy-duty vehicles (MHDVs) as well as off-road equipment and tools to be considered for municipal fleet electrification.

Medium- and Heavy-Duty Electric Vehicle Technology

The International Energy Agency (IEA) reported that in 2022, nearly 66,000 electric buses and 60,000 medium- and heavy-duty trucks were sold worldwide, representing approximately 4.5% of all bus sales and 1.2% of truck sales worldwide. The transition towards cleaner technologies in the MHDV sector is crucial for reducing emissions and promoting a more sustainable future. As such, there has been an

increasing amount of funding and collaborative initiatives being explored to develop innovative technologies and increase adoption of electric MHDVs.

MHDVs within the municipal fleet can include waste management vehicles, street sweepers, utility trucks, snowplows, public works vehicles, and fire and emergency vehicles. These vehicles are critical for cities and must be reliable to manage day-to-day operational needs. Electrification of municipal MHDVs can produce several benefits such as a reduction in GHG emissions and noise pollution, lower operating costs and potential energy savings, as well as allowing cities to meet their air quality improvement and climate targets. Cities are also taking advantage of federal and provincial incentives that support the transition to cleaner technologies. For example, Calgary received funding from the Federation of Canadian Municipalities' Green Fund and Alberta's Electric Vehicles for Municipalities Program, to cover up to 80% of the costs to purchase one battery electric refuse truck and one hybrid-electric truck. The pilot project will determine the long-term feasibility of implementing hybrid and/or electric refuse-collection trucks into the City's fleet, and how the results can be applied to other types of heavy-duty trucks for City operations, such as snowplows or dump trucks.

Challenges to electrification can include high upfront costs to purchase electric MHDV models, installation of sufficient charging infrastructure to support day-to-day operations, potential limitations in range and battery technology, and potential limitations in vehicle weight and payload capacity. Nonetheless, cities across North America have begun to introduce electric MHDVs into their municipal fleets in efforts to test vehicle functionality and overall reliability. Table 12 identifies some common municipal MHDVs, their general purpose and some examples of electric model equivalents currently in the market.

Table 12 - Municipal MHDV Electric Models

Municipal MHDV	Purpose	Electric MHDV Models
Refuse/Garbage Truck	Waste management vehicles such as garbage trucks, recycling trucks, and compost collection trucks	Lion8 All-Electric Refuse Truck BYD Electric Refuse Trucks Effenco Hybrid -Electric Garbage Truck
Utility Trucks	Used for various maintenance tasks including repairing roads, streetlights, traffic signals, and utilities.	BYD Electric Trucks GreenPower Motor Company – EV Star Stakebed Truck Lion Electric – All Electric Bucket Truck Terex Fully-Electric Bucket Truck
Snowplows / Gritters	Used to clear roads and apply salt or sand to improve track on roads and sidewalks during winter weather conditions	Swap Robotics – 100% Electric Snow Robots (Sidewalk Snow Plowing/Salting)
Public Works Vehicles	Specialized vehicles for tasks such as road maintenance, pavement repair, bridge inspection, and tree trimming	Fulongma Electric Road Maintenance Truck Series Edison Motors – Electric Semi-Trucks
Fire and Emergency	Used to respond to emergencies and ensure public safety such as fire trucks, ambulances, and rescue vehicles	Rosenbauer RT REV Group Pierce Volterra eFX Electric Ambulance

Electric MHDV Companies and Models

While there are a growing number of companies that have been entering the electric MHDV market, the following are examples of notable companies that have been recognized as leaders in the North American markets.

Lion Electric

Lion Electric is a Québec-based manufacturer of zero-emission vehicles. The company creates, designs, and manufactures all-electric class 5 to class 8 commercial urban trucks and all-electric buses and minibuses for the school, paratransit, and mass transit sectors. Lion Electric is a leader in electric transportation and the company designs, builds, and assembles many of its' vehicle components, including chassis, battery packs, truck cabins and bus bodies. Lion's truck chassis are designed to

accommodate a multitude of specialized upfitting equipment such as refrigerated boxes, aerial buckets, refuse bins, stake beds, and flat beds, utility upfits, and more.

Lion Electric collaborated with Boivin Evolution, also a Québec-based company, to develop the first Lion8 zero-emissions refuse truck. The EV Class 8 chassis is made by Lion Electric, while Boivin Evolution makes the fully electric waste collection body and automated arms. The refuse trucks are designed to be emission-free and offer a quieter operation compared to conventional diesel-powered trucks. The Lion8 Electric Refuse Truck accommodates both Level 2 and Level 3 charging and is designed to service approximately 1000 'doors' – houses or organizations – on a full charge²⁹. Waste Connections Inc., a major North American waste management company, was one of the first to purchase two electric refuse trucks for use in two locations – Washington and Florida³⁰.

In 2022, Lion Electric also collaborated with Posi-Plus to develop the first all-electric bucket truck that is capable of performing a full range of work that electric utilities require of such vehicles. The bucket truck and its auxiliary systems run entirely off the vehicle's battery pack, eliminating emissions and noise pollution³¹. Green Mountain Power, of Vermont, was the first to purchase two of the Lion8 bucket trucks for line crews as well as the Lion6 stake body trucks for electrical maintenance field crews.

Finally, Lion Electric partnered with Demers Ambulance, another Québec-based company, to develop a purpose-built all-electric ambulance. The two companies have been working together since 2016 and collaborated with paramedics to reinvent emergency transportation while ensuring the new design would meet the needs of paramedics operating the vehicles. The first few vehicles are expected to be on the road between 2023-2024, and the two companies are aiming to deploy at least 1,500 ambulances across North America before 2026³².

BYD

BYD, a China-based company, was founded by a Chinese chemist in 1995, specializing in the production and sales of rechargeable batteries in four core areas: electronics, automobiles, new energy, and rail transit. The Company has a distinct business model as it manufactures its own chips and batteries, as well as electric vehicles³³. By the end of 2023, BYD overtook Tesla to become the world's biggest electric car company.

In additional light-duty electric vehicles, BYD manufactures a host of MHDVs including battery electric buses and coaches, logistics and construction, and sanitation vehicles. BYD electric trucks are clean and quiet, operate with fewer moving parts and reduced vibration, and use BYD's lithium-iron-phosphate battery technology. In 2019, BYD opened a bus manufacturing plant in Newmarket, Ontario, to assemble buses for the Toronto Transit Commission, as well as other cities across Canada.

In 2017, BYD delivered the first all-electric automated side loader refuse truck in Palo Alto, California, and the first all-electric refuse truck was delivered to Seattle in 2019. In 2022, BYD sold two BYD 8R refuse trucks, and three BYD 6R models to Jersey City. The BYD 8R carries a 250-kWh battery pack and has a range of 600 pick-up plus 60 miles, while the BYD 6R has a 211-kWh battery pack and a range of 80 miles. BYD electric trucks require 2.5 hours for a full charge (Level 3) and can reach top speed of 62 mph³⁴.

Effenco

Effenco is a Montreal-based company that has been working on electrifying heavy-duty vehicles, including garbage trucks. Their technology includes hybrid-electric and fully electric solutions aimed at reducing emissions and improving efficiency of waste collection operations. The company retrofits existing garbage trucks into hybrid-electric using its own patented technology. Instead of using the typical lithium-ion batteries that are common in EVs and hybrids, the trucks use ultracapacitors, which store relative quick-use bursts of electricity. The power is used to operate functions like compaction and other high-energy jobs generally needed when the vehicle is not moving. Effenco has also developed an

²⁹ [E-Mobility Engineering – Lion8 Refuse Truck](#)

³⁰ [Québec Partners Secure First U.S. Deal for Lion8 Refuse Truck](#)

³¹ [Posi-Plus: First-of-its-Kind, All-Electric Utility Bucket Truck](#)

³² [Demers and Lion Electric Unveil State-of-the-Art Electric Ambulance](#)

³³ [BYD Leads the E-Truck Industry on American Roads](#)

³⁴ [BYD 8R Refuse Truck](#)

electric powertrain system that enables the full electrification of heavy-duty vocational trucks for the same prices as a diesel, while significantly reducing GHG emissions. New York City's Sanitation Department retrofitted 12 refuse collection trucks with Effenco technology and after seeing very positive results, the company ordered 14 more trucks with factory-installed Effenco technology³⁵.

Snowplows

Transport Canada has been working with Swap Robotics, a Kitchener-based company, for several years to experiment with zero-emission robot plows. The first "real-world" test was just outside of Ottawa's downtown core in 2021-2022 winter³⁶. The semi-autonomous electric snowplows were found to make less noise than gas-powered ones, runs approximately 15 to 20 hours on one charge, and can yield to people, animals, or other vehicles that come within 10 feet of the vehicle. The Town of Innisfil also collaborated with Swap Robotics in 2021 to test vehicle for sidewalk snow plowing and salting on city streets. Swap Robotics manufactures both electric grass-cutting and snow removal robots, as robots have a "quick swap" system that make it easy to switch between grass cutting blades and snowplow attachment.



Swap Robotics 100% Electric Snow Robots

Electric road clearing snowplows have not yet been implemented by cities due to some limitations of electric technology and the energy required for snow clearing. These challenges stem from the specific characteristics of EVs and the rigorous demands of snow removal tasks. For example, EV battery efficiency can decrease rapidly in low temperatures, which is typical of snow removal operations, and this impacts the ability to perform extended or intensive snow removal tasks. Additionally, traditional, heavy snow removal equipment and operations require considerable energy and power to plow through snow and ice, especially in northern regions. Despite ongoing advancements, many electric vehicles still don't match the power and torque of diesel vehicles, which is crucial for effective plowing and hauling.

In 2023, the New York Department of Sanitation attempted to test electric snowplows by retrofitting one of their existing Mack LR Electric garbage trucks with a snowplow. However, they found that it could not plow the snow effectively as the electric vehicle's power supply was insufficient for the demands of a New York winter, which is known for its heavy snowfall³⁷. Most recently, in early February 2024, Norway piloted a semi electric truck with 1,000 kWh battery capacity to clear heavy snow along challenging mountain passes. So far, the project has been successful, and the electric truck was able to operate in light to heavy snow, gusty winds, and below-freezing temperatures, while maintaining battery capacity after almost nine hours on the road³⁸.

Street Sweepers

Street Sweepers are an essential municipal asset used to clear streets, roads, and public spaces of debris, litter, and other pollutants. Over the past few years, US cities have been exploring opportunities to electrify their street sweepers for a variety of benefits such as reduced emissions and noise during operation as well as lower long-term operating and maintenance costs. Although the current cost of electric street sweeper models are considerably higher than their diesel-fuel counterparts, some cities have been able to take advantage of federal and state incentives that support the transition to cleaner technologies.

In 2022, Global Environmental Products (GEP) and US Hybrid collaborated to build 62 electric and hybrid/electric, zero emission, street sweepers. The vehicles were built using US Hybrid's proprietary electric and hybrid electric propulsion kits, and GEP's hybrid and fully electric street sweepers. A significant portion of the 62 street sweepers are earmarked for New York City and California's Department of Transportation, while a few will go to cities in San Francisco, Washington D.C., and Montana. GEP also offers the first Heavy-Duty Hydrogen Fuel-Cell Street Sweeper, which replaces the battery pack with a

³⁵ [New York City Begins Electrifying Its Garbage Truck Fleet](#)

³⁶ [Transport Canada Tests World's First 100% Electric Snowplow and Salting Robot](#)

³⁷ [DSNY's Electric Trucks Not Effective for Snow Plowing](#)

³⁸ [Electrek – World's First Semi-Electric Snow Plowing Truck](#)

fuel cell and hydrogen tank. During operation, the water produced through the electro-chemical reaction is diverted to the sweeper's water tank system, providing an additional 43 galls of water per shift to sue for dust suppression.



GEP/US Hybrid - M4EV and M3EV Electric 100% Plug-in



GEP - M4/M4HSD Hydrogen Fuel Cell Street Sweeper

The City of Los Angeles unveiled its first all-electric street sweeper in August 2023, to test how it would work within the city's fleet. The model was built by Elgin and Battle Motors and includes benefits such as customized drive software for easier operation, whereby software can be configured by the operator to automatically drive at a consistent speed. The Battle Motors/Elgin Electric Broom Bear cost the city approximately \$800,000, which significantly higher than the cost of diesel street sweepers, but will have lower fuel and maintenance costs, and qualifies for both federal and state incentives³⁹. Although Elgin is a US-based company, its vehicles can be purchased in Ontario through Joe Johnson Equipment Inc.

Table 13 - Low and Zero Emissions Municipal Street Sweeper Models

Company	Low and Zero-Emissions Products	Benefits
ELGIN Sweepers ⁴⁰	100% Electric Broom Bear - Plug-In Hybrid Electric Broom Bear - Plug-In Hybrid Electric Pelican - CNG Sweepers	- Customized drive software - Reduced vibration and noise - Eliminate tailpipe pollution - Lower fuel and maintenance costs - Qualify for federal incentives
Global Environmental Products ⁴¹	- M3EV and M4EV Electric 100% Plug-in - M4/M4HSD Hydrogen Fuel Cell - M4/M4HSD CNG	- No transmission costs and reduced maintenance and operation costs - Smooth electric drive system with infinite speed control 11 hours operation time

Electric Fire Engines

Electrification of emergency response vehicles such as fire engines can have many potential benefits such as eliminating tailpipe emissions, eliminating diesel engine noise, improving firefighter safety, minimizing fuel cost, and innovative vehicle designs. However, the most common challenge to electrification is to ensure that emergency vehicles can perform continuously without worrying about the battery storage being depleted during an emergency. Additionally, the electrification of emergency fire trucks poses concerns such as cold weather performance, battery temperature management, and infrastructure requirements:

³⁹ [Electrek – First All-Electric Street Sweeper Coming to Los Angeles](#)

⁴⁰ [ELGIN Sweepers](#)

⁴¹ [Global Environmental Products](#)

- **Cold Weather Performance** – cold climates pose challenges for electric fire trucks because low temperatures can adversely affect battery performance and reduce battery range.
- **Infrastructure Requirements** – charging infrastructure needs to be in place at fire stations or other locations where electric fire trucks operate and fire departments must plan for adequate charging stations to keep their fleet operational.

Rosenbauer, an Austria-based firm, created the world's first electric fire truck in 2021 at the price of \$1.6 million. The Los Angeles Fire Department was the first to purchase and operate the electric fire truck in North America in 2022. The City of Vancouver introduced Canada's first electric fire engine in December 2023, based out of Firehall No. 1 in Strathcona⁴². The Rosenbauer RTX Pumper Truck cost the city approximately CAD \$1.8 million and is estimated to be between \$300,000 and \$500,000 more expensive than traditional diesel-powered engines. In addition to being electric, the vehicle was redesigned to meet modern urban conditions, such as a narrower and shorter size to access tighter spaces, the ability to kneel or lift, and equipped with four-wheel drive. The vehicle has a battery range of about 100 kilometres on a full charge, and an onboard diesel charger that can be used to recharge the battery in the field if necessary. Table 12 highlights the latest innovations in Electric Fire Engine models and the cities that have acquired them.

Table 14 - All-Electric Fire Engine Models

Manufacturer	EV Firetruck Model Features	Cities with EV Model
Rosenbauer RT	• Revolutionary Technology (RT)⁴³ – runs on electricity with charging capacity of up to 150 kW and built-in Energy Backup System that can run on diesel when needed. • All air suspension features enable trucks to be lifted or kneel to provide ease of access for the crew or adaptability in various emergency situations.	Los Angeles, CA Vancouver, BC Brampton, ON
REV Fire Group (E-ONE, KME, Ferrera, Spartan, Emergency Response)	• VECTOR⁴⁴ - a fully electric North American designed fire truck. • High-capacity batteries delivering 327 kWh/ of total power at 800 volts DC. • Battery Thermal Management System (BTMS) keeps the EV battery at optimal temperature for best performance. • The Vector can be customized to meet department requirements, including body configurations, pump capacity, and water/foam tank options.	Toronto, ON Mesa, AZ
Pierce Volterra	• Oshkosh⁴⁵ patented parallel-electric drive train featuring an electro-mechanical infinitely variable transmission (EMIVT) which allows zero-emissions operation when powered by the integrated onboard batteries. • Sophisticated thermal management system that monitors and effectively regulates the battery temperature at all times. The system includes a coolant loop which circulates around the battery area, and a small electric heater.	Madison, Wisconsin Gilbert, Arizona

Electric Landscaping Equipment and Tools

Gasoline-powered lawn and garden equipment (GLGE) ranging from trimmers, blowers, and tractors are a source of high levels of localized emissions that includes carbon monoxide (CO), volatile organic compounds (VOCs), particulate matter, and carbon dioxide (CO₂). A 2015 U.S. study found that GLGE is a prevalent source of toxic and carcinogenic emissions that contributes substantially to nonroad

⁴² [City of Vancouver – Welcomes Canada's First Electric Fire Engine](#)

⁴³ [Rosenbauer RT](#)

⁴⁴ [Spartan Emergency Response – VECTOR Fire Trucks](#)

⁴⁵ [Pierce Volterra Electric Fire Trucks](#)

emissions of benzene, 1,3, butadiene, formaldehyde, CO, and fine particulate matter⁴⁶. Municipal workers using commercial equipment are exposed to these air pollutants for several hours per day during the spring/summer seasons. Members of the public may also be exposed to high levels of emissions from commercial landscape maintenance equipment used routinely around public spaces such as residential neighbourhoods, schools, and parks. Alternatively, electric powered equipment such as electric lawn mowers, leaf blowers, and trimmers produce few emissions and are quieter and safer to operate compared to their gas-powered counterparts.

Many municipalities across Canada are exploring opportunities to electrify their light-duty equipment fleet and reduce exposure to harmful emissions. Cities such as Vancouver, Mississauga, Toronto and Hamilton are working towards adopting battery-powered equipment to demonstrate leadership. Table 13 below lists some commonly used municipal equipment, their electric-powered equivalents, battery capacity and runtime, and estimated costs, where available.

Table 15 - Summary of Zero-Emissions Equipment Models and Estimated Costs

Equipment Type	Zero-Emissions Models	Battery Capacity & Runtime	Estimated Costs (CAD) ⁴⁷
Large Area Mowers			
Zero Turn Mowers	EVO – Electric Zero Turn	35-kWh battery – 8 hours	\$51,300
	RIVAL – Electric Commercial Zero Turn	22-kWh battery – 7 hours	\$40,500
	Troy-Bilt Mustang Z42E XP	60Ah/3.36 kWh – up to 1.5 hours/3.5 acres per charge	\$7,500
	OptimusZ Stand-On Zero Turn	24-kWh – 8 hours	\$35,100
	Toro TimeCutter Electric Zero Turn	Up to 3.6 kWh – up to 1.6 to 2.3 acres per charge	\$8,775
	John Deere Z370R Electric ZTrak Mower	3.2-3.56 kWh – up to 2 acres per charge	\$8,575
LAM Mowers Units	VANQUISH Electric Stand-On	22-kWh – 7 hours	\$39,150
	Swap Robotics – 100% Electric Solar Vegetation Cutting Robots	8-12 hours	N/A
Sportsfield Mowers	SLF1 ELITE	25.5-kWh – 5.5 hours	N/A
	FireFly Automatrix MV100-AV	35-kWh (26 acres) – 6 acres/ hour	N/A
Off-Road Vehicles			
Asphalt Roller	Wirtgen Group – Electric Rollers	23.4-kWh – average working day	N/A
	Volvo CE DD25 Electric	20-kWh – up to 4 hrs	N/A
Mini Utility Vehicles	CanEV – Might-E Trucks	Driving Range – 90 km	N/A
	MAX-EV Utility Truck	40 – 195 km (depends on model and payload)	N/A
	82V Utility Vehicle	8-kWh – 90 km	\$39,150
Hand-Held Equipment			
Lawn Mower	82V 30" Self-Propelled Lawn Mower	3x 82V Batteries - 110 mins	\$3,500
	Stihl – FSA 200	40 mins	\$880
Trimmers	Stihl – HAS 66	144 min	\$380
	82V Short Pole Hedge Trimmer	2.5 Ah (Amp-hours) – 205 min	\$180
Chainsaws	Husqvarna T540i XP	NA	\$1,430
	Stihl - MSA 220 TC-O	NA	\$825

⁴⁶ [National Emissions from Lawn and Garden Equipment \(2015\)](#)

⁴⁷ Note that where only USD pricing was available from vendors, the USD pricing has been converted to CAD at a rate of 1.35. Actual retail pricing may vary.

Pole Saws	Husqvarna 530iPT5	NA	\$700
	Stihl - HTA 135	45 mins	\$1,420
Leaf Blower	82V 755 CFM Dual-Port Backpack Blower	2x 8 Ah batteries	\$2,025
	Husqvarna Leaf Blaster 350iB	7.7 Ah	\$710 CAD

The California Air Resources Board (CARB) has studied the emissions impacts of small off-road engines (SORE), which are spark-ignition engines rated at or below 19 kilowatts and found that commercial lawn and garden equipment are significant contributors to localized air pollution and emissions during the summer seasons. CARB estimates that operating a commercial lawn mower for one hour emits as much smog-forming pollution as driving a new light-duty vehicle for approximately 480 kilometres, or about 4 hours of drive time. Similarly, operating a commercial leaf blower for one hour emits air pollution comparable to driving a light-duty vehicle for about 1770 kilometres, or over 15 hours of driving⁴⁸. Table 15 and Table 16 compare the specifications of gas and diesel-powered equipment to their electric-powered counterparts.

Table 16 - Comparison of Zero-Turn Mowers by Fuel Type

Company - Model	Power and Capacity	Additional Features
Gas/Diesel – Powered		
John Deere ZTrak™ Zero-Turn Mower	- Motor Type – 2-cylinder gas engine - Horsepower – 25.0-hp (18.6-kW) - Fuel Tank – 11.5 gal. (43.5-L)	Fuel tank capacity enables operators to mow all day without refueling. Complies with strict EPA and CARB emission standards without loss of horsepower or torque.
FERRIS ISX™ 3300 Zero Turn Mowers	- Motor Type – 2 Cylinders - Horsepower – 40 HP - Fuel Tank: 11 gal. - Max Speed – 12 MPH	Superior Suspension Technology for Turf Select models feature EFI-ETC technology for fuel savings, easy starting, and smooth, consistent productivity.
Electric-Powered		
EVO Electric Zero Turn	- Fuel Type – Electric - Battery Capacity – 35-kWh (8 hours of mowing time) - Max Speed – 13 MPH - Zero Emissions	Patented Technology that displays speed and performance of each blade to help the operator maintain optimal quality of cut and mowing efficiency.

Table 17 - Comparison of Mini Utility Vehicles by Fuel Type

Company - Model	Power and Capacity	Additional Features
Gas/Diesel – Powered		
Bobcat UV34 Diesel Utility Vehicle	- Motor Type – Three-cylinder diesel engine - Horsepower – 23.5 (17.5 kW) - Max Speed – 56 km/h - Fuel Tank – 43.5 L - Emission Tier (EPA) – Tier 4	High-output alternator, offering 140-amp peak. Automatic glow plugs warm the engine for reliable cold weather starting.

⁴⁸ [California Air Resources Board - Small Off-Road Engines \(SORE\) Fact Sheet](#)

John Deere Work Series Utility Vehicle (HPX615E)	▪ Motor Type – 2-cylinder, 4-cycle gas ▪ Horsepower – 20 hp (15.7 kW) ▪ Max Speed – 25 MPH ▪ Fuel Tank – 27.6 L	Precision-engineered drivetrain system to better utilize engine power.
Electric-Powered		
82V Utility Vehicle	▪ Motor Type – AC Induction ▪ Battery Capacity – 16 kWh, 82V (equivalent to a 31 HP gas engine) ▪ Max Speed – 29 mph ▪ Drive Distance – 75 miles ▪ Zero Emissions	Eliminates the need for fuel and fluids and reduces maintenance costs, potentially saving you up to \$3,000 over five years. Automatic control system adjusts to diverse terrains and slopes. Travels up to 75 miles on a single charge (11 hours charge time).

4. Current Fleet Review

This section includes a review of the existing fleet, including a summary of existing equipment. It provides an overview of the fleet’s age, emissions, and characteristics which inform the scenario development and results.

Existing Fleet

The Town of Ajax operates a fleet of over 250 assets, inclusive of motorized and non-motorized, on- and off-road vehicles and equipment. Of these assets, approximately 200 have a gasoline, diesel, hybrid, or electric powertrain. The remaining assets are non-motorized, such as trailers. Table 19 provides examples of current fleet vehicles, by category (as defined in the BetterFleet model).

Average utilization of the existing fleet varies depending on vehicle category, with passenger and heavy commercial vehicles averaging about 12,000 km per year, light commercial vehicles averaging 6,540 km per year, and off-road/unlicensed equipment averaging 3,100 hours per year. Table 18 summarizes the average annual utilization of the fleet.

Table 18 - Average Fleet Utilization

	Passenger	Light Commercial	SUV	Heavy Commercial	Off-Road/Unlicensed
Average Annual Kilometres/Hours	12,000 km	6,540 km	Insufficient data	12,000 km	3,100 hours

The Town’s fleet has grown over time in response to Ajax’s population growth and expansion in services. The current size of the fleet is considered suitable for current operations, meaning the fleet size is not expected to expand or contract, and vehicle utilization is expected to remain reasonably consistent. Fleet Services has managed growing demand for services by retaining some vehicles designated for replacement beyond their recommended lifespan, while procuring a replacement. Approximately 25 vehicles have been retained in this manner. These vehicles (both the newly procured vehicles and overdue, retained vehicles) will eventually be converted to ZEVs.

The average age of the fleet is approaching 10 years old, and many vehicles exceed their recommended lifespan, per Town of Ajax policies. Figure 4 shows the average age distribution of the fleet.

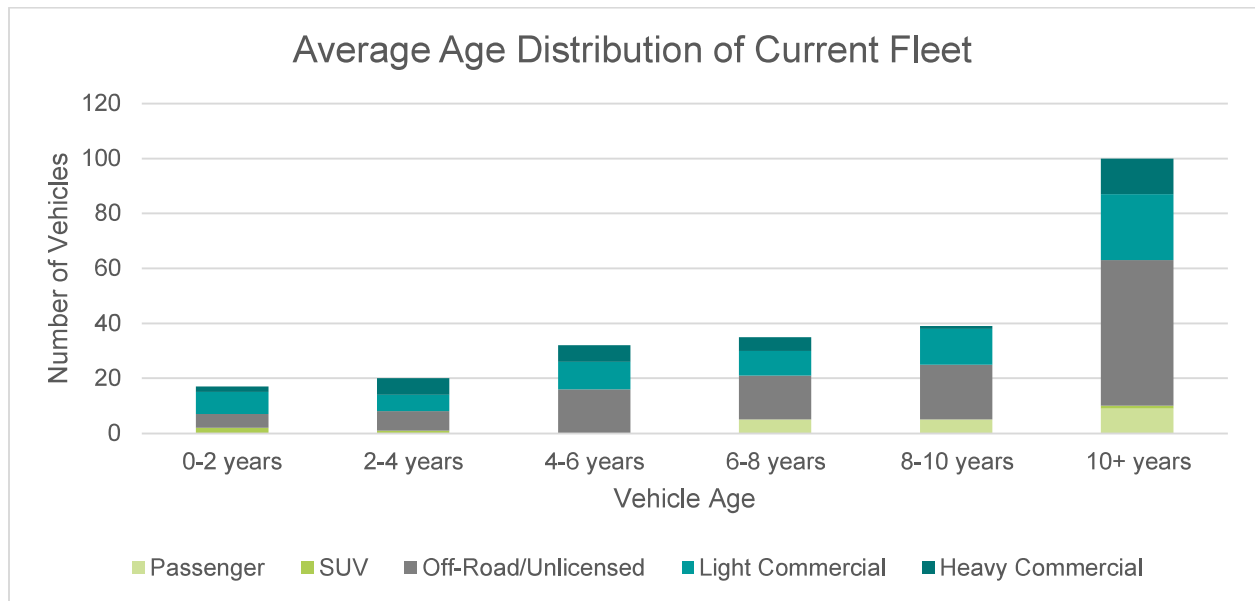
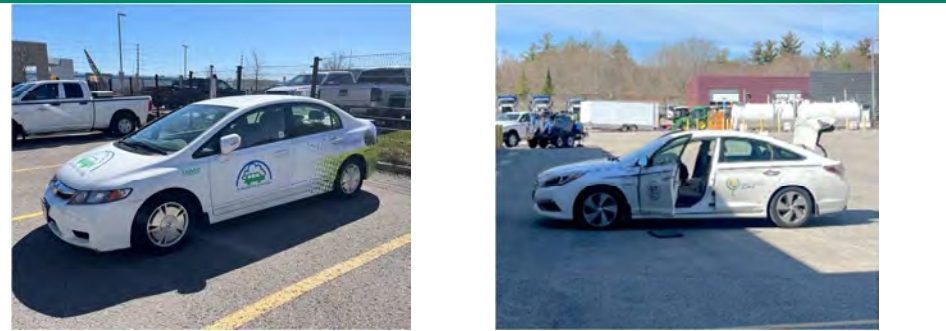
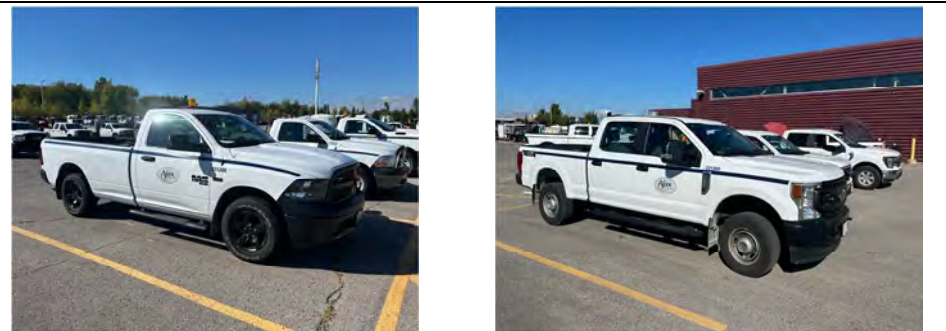
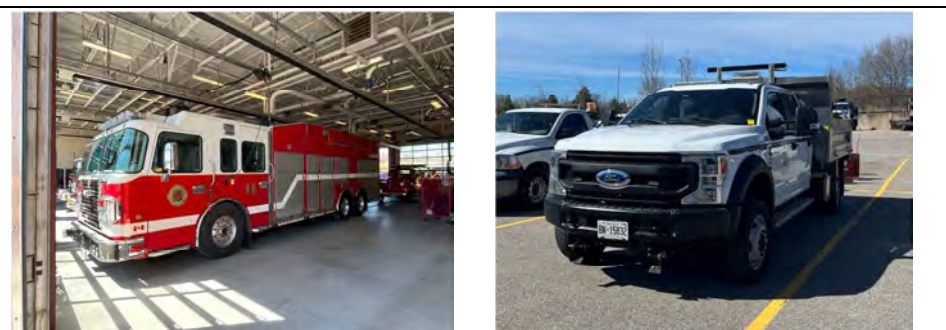


Figure 4 - Average Age Distribution of Fleet

Table 19 - Examples of Current Fleet Vehicles by Category

Category	Images of Example Vehicle(s)
Passenger	
Light Commercial	
SUV	
Heavy Commercial	

Off-Road/Unlicensed

On-Road Vehicles

There are currently 126 on-road vehicles in the Town's fleet. Most of these vehicles are light- and medium-duty trucks which have significant payload requirements, making electrification challenging as towing and hauling in battery-electric trucks significantly impacts range. Table 20 summarizes the on-road fleet (excluding all non-motorized equipment).

Table 20 - Summary of Existing On-Road Fleet

Type	BetterFleet Model Categorization	Example Vehicles	Current Electrification Potential and Progress	Count
Car/Van/SUV (Light-Duty)	Passenger/SUV	Hyundai Sonata Ford Explorer Interceptor Dodge Caravan	Highest - Electrification already in progress with some PHEVs in fleet	30
Light/Medium Trucks	Light Commercial	Ram 1500/2500/3500 Ford F-150/F-250/F-350 Mercedes Sprinter Van	Low to moderate - some Light-Duty trucks like Ford F-150 have EV alternatives available, but towing limits range significantly	75
Heavy Trucks	Heavy Commercial	Ram 4500/5500 Ford F-450/F-550 Freightliner 108SD International Single Axle Snow Plow	Low - Severe duty cycles and low market availability	10
Fire Emergency Response	Heavy Commercial	Spartan Metrostar	Low to moderate - Some BEV options available; few deployments in North America to date	11
Total				126

Off-Road/Unlicensed Equipment

There are currently 92 motorized off-road/unlicensed vehicles in the Town's fleet, split between grass cutting, miscellaneous, and heavy-duty equipment. 80 are stored at the Operations Centre, and 12 are stored at the Audley Recreation Centre (ARC) in the facility's works shed. These vehicles operate in a wide range of conditions and often have severe duty cycles such as long operating windows in harsh weather conditions. Table 21 summarizes the off-road/unlicensed equipment fleet. There are also about 40 pieces of non-motorized assets in the fleet such as trailers and seeders which are excluded from the summary since they have no emissions.

Table 21 - Summary of Existing Off-Road/Unlicensed Equipment Fleet (Excluding Non-Motorized Assets)

Type	BetterFleet Model Categorization	Example Equipment	Current Electrification Potential and Progress	Count
Grass Cutting	Off-Road/Unlicensed ⁴⁹	Zero Turn Mower Front Runner	Highest - Electrification already in progress	38
Misc. Equipment	Off-Road/Unlicensed	Golf Cart Forklift	Moderate - Some models already electric	24
Heavy-Duty Equipment	Off-Road/Unlicensed	Heavy Tractor Backhoe Grader Sweeper	Lowest - Fewer market options available	30
Total				92

Existing Emissions

The fleet is estimated to emit approximately 822 tonnes of CO₂ per year, based on fuel consumption data from the past three years. This excludes emissions associated with rental vehicles and contractor vehicles, the electrification of which is not controlled by the Town. About half the fleet's emissions come from LDVs, which have many BEV alternatives available on the market today and present a strong pathway to decarbonization where vehicles do not have significant towing or hauling requirements. Approximately 20% of the emissions come from off-road/unlicensed equipment, despite the relatively low annual mileage of these vehicles relative to the on-road fleet. Electrifying this equipment would represent a quick win, given the immediate availability of electric grass cutting and miscellaneous equipment.

Emissions are calculated for each asset individually by taking the amount of fuel consumed annually and then multiplying that number by an emissions factor in grams of CO₂ per litre of fuel consumed (or per kWh of electricity consumed for EVs). The exact emissions factor varies depending on the fuel type, for example, gasoline or diesel. In cases where fuel consumption data is limited, annual fuel consumption is first approximated by taking the annual mileage for the particular vehicle and multiplying by an assumed fuel efficiency in L/100km specific to the particular vehicle make/model. Once emissions have been calculated for each asset individually, they are summed to understand the total emissions across the Town's fleet on an annual basis.

⁴⁹ Note that within the BetterFleet software, Off-Road/Unlicensed vehicles are labelled as "Plant" vehicles.

Existing Total Cost of Ownership

The fleet's business as usual Total Cost of Ownership (TCO) was calculated based on the costs of the current fleet (and current procurement patterns) projected into the future. This TCO acts as the baseline against which the TCO for the fleet transition scenarios is compared. The TCO considers all capital costs, maintenance costs, and operating costs associated with the fleet. Together, these costs sum to a projected TCO of approximately \$39.1 million over the duration of the plan, modelled from 2024 to 2039. Incorporating fleet residual values, this falls to approximately \$31.6 million over the lifetime of the plan.

Fleet Gaps and Opportunities

Based on the review of the current fleet, best practices which pertain to the Town, and outcomes of meetings with Town staff, a series of gaps and opportunities have been identified. Many of these gaps and opportunities can be addressed via the recommendations provided in this report, while some depend on the ZEV market maturing further.

Gaps

- **Infrastructure readiness:**
 - Procurement for some EVs and battery-powered equipment is underway without a fully implemented infrastructure strategy. Advancement of infrastructure planning is recommended to ensure that convenient charging is enabled for all new vehicles and equipment.
 - Some facilities will need additional capacity to accommodate EV loads. Detailed site-specific evaluation should be conducted at facilities where EVs are planned, based on the preferred implementation scenario and adoption forecast.
 - Consider back-up power and develop a resiliency strategy to address how service will be prioritized and maintained in the event of a long-term power disruption to the grid.
- **Vehicle availability:**
 - For many of the MHDVs in the Town's fleet, EV alternatives do not yet exist to suit the severe duty cycles of the vehicles, such as snow removal and towing. EV alternatives in these segments not expected until around 2030 or later. Transition of light-duty vehicles, equipment, and certain heavy-duty vehicles where EV models exist (such as fire trucks) should be prioritized while other market segments mature.
- **Fleet utilization:**
 - Existing PHEVs may not be maximally utilized in battery-electric mode. Consider encouraging greater use of low-emissions vehicles and make charging convenient to minimize emissions while full EVs are added gradually to the fleet and more charging infrastructure becomes available.
 - Fleet right-sizing and downsizing opportunities exist. Based on the 2020 Fleet Utilization Study, about 20 vehicles could be right-sized for work, i.e. a smaller vehicle could be used to meet the same operational needs. Further, the fleet could be reduced by eight vehicles based on a low utilization analysis (generally fewer than 5,000 km travelled per year). To date, Fleet Services is planning to replace some heavy-duty pickup trucks with smaller models, such as switching Ram 4500/5500 models for 3500 models. Further right-sizing and downsizing opportunities should be evaluated.
- **Maintenance and training:**
 - In anticipation of EV adoption within the Town's fleet, maintenance staff should begin training on EV maintenance. Local programs in Ontario include Durham College's Electric Drive Vehicle Technician (EDVT) program which provide students with knowledge on EV maintenance and repair, with a focus on managing the vehicles' high voltage systems.

- As the EVSE network grows, the Town will need to decide whether in-house maintenance of EVSE is preferred, or if a contractor should be responsible for routine maintenance of the system. The Canadian Standards Association (CSA) provides training online training materials to enable engineers, electricians, and technicians to apply the requirements of CSA SPE-343:21, *Electric vehicle energy management systems* and CSA C22.1:21, *Canadian Electrical Code, Part I (25th Edition)* to the design, construction, installation, and inspection of electrical equipment that form part of an Electric Vehicle Energy Management System (EVEMS), or the systems that manage electricity for EV charging. If in-house maintenance of EVSE is planned, the Town should consider this CSA training for its staff.

Opportunities

This report provides a series of detailed recommendations for helping to implement the desired fleet transition plan and reduce the Town's GHG emissions. Additional opportunities beyond the recommendations include the following:

- Coordinate with other municipal fleet operators who are also undertaking the EV transition to share knowledge, findings, and best practices. These could include the municipalities whose practices were evaluated in Section 2 of this report.
- Continue to participate in industry groups such as national fleet maintenance associations to remain current on the state of the EV market and adoption trends. Industry events across North America including the annual Advanced Clean Transportation (ACT) Expo provide good opportunities to explore new vehicles and charging technologies. With this information, the fleet procurement plan can be adapted as needed.
- Public engagement should be conducted to build support for the Town's internal fleet electrification efforts and to gather feedback to support opportunities such as shared infrastructure.
- Continue to leverage funding opportunities such as the Federal Government's Zero Emission Vehicle Infrastructure Program (ZEVIP) to offset the significant capital costs of the EV infrastructure program. Monitor these funding opportunities on an ongoing basis.

5. Scenario Development and Results

This section describes the two scenarios being tested via the BetterFleet model and the results of the modeling including information on the number of ZEVs and associated charging equipment to be deployed each year, and the cost difference year on year versus the business-as-usual (BAU) case.

Modelling Assumptions

The aim of the BetterFleet analysis is to help the Town understand when assets are technically and commercially suitable for electrification. The methodology applied herein is presented below:

- Create a BAU scenario of continued ICEV operations by mapping procurement of like-for-like vehicle replacements in line with current asset holding periods. Where multiple vehicle makes/models are considered like-for-like in terms of vehicle specifications, the lowest TCO alternative is carried forward in the business-as-usual modeling.
- Understand if there are like-for-like ZEV replacements based on duty requirements in the market at each replacement date and the expected market timing for alternatives.
- Create ZEV transition scenarios by mapping procurement of ZEV replacements where like-for-like ZEV models exist, depending on the parameters of the different scenarios. In the ZEV transition scenarios, ICEVs may still be procured if there are no like-for-like ZEV alternatives that are appropriate given the scenario modeling parameters.
- Assemble preliminary emissions and costing information for the forecast period, excluding out-of-scope considerations such as infrastructure deployment.

A like-for-like analysis assumes the functional attributes of the existing vehicles in the fleet are optimized for particular purposes, and the need for a purpose is certain and cannot be replaced. Like-for-like LDV replacements are determined by matching existing fleet assets against all options within the same peak-body designated vehicle segment and sub-segment. HDVs are generally more customized, so replacements are identified based primarily on gross vehicle mass.

A derating factor is applied to the energy consumption rating to account for variability of battery performance in cold and hot weather conditions, and the added relative drain of heating and air conditioning systems. Modelling the peak energy consumed by EV replacements to existing fleet assets therefore presents worst-case energy consumption. Asset data from the vehicle database underpinning the BetterFleet model, including vehicle capital costs and operating/maintenance per-kilometre costs, is applied to total cost of ownership and asset replacement modeling tools, set up to compute results for each scenario. We note that this analysis is built on several assumptions based on a combination of empirical data from other jurisdictions, professional judgment, and data provided by the Town of Ajax (see Appendix A for more detail). As such, while the nearer-term years of the forecast can be expected to be relatively accurate, the future years provide a framework for analysis and will need to be updated on a regular basis as the market matures.

Key assumptions include the following:

- The Town's fleet is right-sized for current operations meaning the fleet size is not expected to expand or contract, and vehicle utilization is expected to remain reasonably consistent. This assumption has been made for the purpose of the modelling exercise, as adding additional vehicles will be dependent on the type of growth and additional services required. Since the Town has retained overdue vehicles which now require replacement, the size of the fleet has grown and some of this growth may be managed with these additional vehicles, which form part of the model and will eventually be converted to ZEVs.
- "Partial match" ZEV alternatives are not carried through in the modelling. A like-for-like EV must be matching in vehicle specifications and must be able to fully accommodate the duty cycles being operated by the existing ICE fleet.

- Modelling is based on our vehicle database, and therefore does not consider opportunities for transitioning to theoretical future ZEV models. However, the modelling does consider future technological and cost trending over time of existing ZEV models, based on economist projections. Similarly, the modeling considers future trending of diesel and gasoline fuel prices as well as electricity rates.
- ZEV matches for HDVs are based primarily on gross vehicle mass, taking into consideration that HDVs tend to be highly customized.
- Daily utilization requirements are approximated based on annual mileage figures provided. As noted above, the inclusion of fuel card data in the modeling could help to refine these estimates in the future.
- EV charging station types and quantity forecasts were completed to identify what charging stations might be needed to support the fleet's EV transition. These quantities are estimated on the high-end, as there was insufficient data to evaluate the extent to which vehicles might be able to share chargers. Undertaking this analysis would typically necessitate telematics data.
- Currently, about 20% of emissions come from Off-Road/Unlicensed assets. Emissions reductions are not modelled for these assets since they tend to be highly specialized, and electrification is often case-by-case. To assess how electrification will impact GHG emissions from these non-modelled assets, the following assumptions have been used:
 - Technology Leadership Scenario: 10% reduction in emissions per year beginning in 2024, to a maximum 80% reduction from current emissions.
 - Cost Optimized Scenario: 5% reduction in emissions per year beginning in 2024, to a maximum 60% reduction from current emissions.

Access to the dynamic BetterFleet model has been provided to Town Administration as an independent deliverable, enabling Fleet Services to incorporate any future changes, such as adjustments to the fleet size. It is recommended to periodically revisit the model to ensure it reflects more accurate data inputs.

Business as Usual

Under the BAU scenario, ICEVs are replaced with ICEVs. Current EVs are incorporated and replaced with new EVs once due for replacement. This scenario represents the lowest cost modelling and serves as the baseline against which to compare the other two scenarios.

Under the BAU scenario, total CO₂ emissions would remain similar to today, around 822 tonnes per year. Since no EVs would be added to the fleet, fleet capital costs would remain similar, and no charging infrastructure costs would be incurred. Maintenance costs would be higher than are forecasted under either transition scenario, given that ICEVs have more moving parts and require more routine maintenance than EVs. Electricity costs would not be incurred as no charging is needed.

Fleet Transition Plan – Cost Optimized

Under the Cost Optimized scenario, ICEVs are replaced with EVs only if EVs have a lower TCO⁵⁰. This scenario represents the lowest cost modelling of the two non-BAU scenarios.

This scenario yields the following results:

- By 2033, over half of the fleet vehicles are full EVs with a few hybrid vehicles remaining.
- By 2040, the end of the procurement process for this study is reached, and around 30 ICEVs remain in the fleet.

⁵⁰ TCO calculations are inclusive of salvage value of vehicles at end-of-life and are based on vehicle MSRP which may not include all upfitting costs. As such, these cost estimates are meant to compare the propulsion-technology related cost premiums and are not necessarily comprehensive budget numbers.

- By 2040, the remaining ICEVs in the fleet are mainly heavy-duty.
- Until about 2032, the scenario is more expensive than BAU due to EV cost premiums.
- Based on forecasts for EV battery costs, after 2030, it is anticipated that EVs will be cost advantageous when compared to ICEVs.

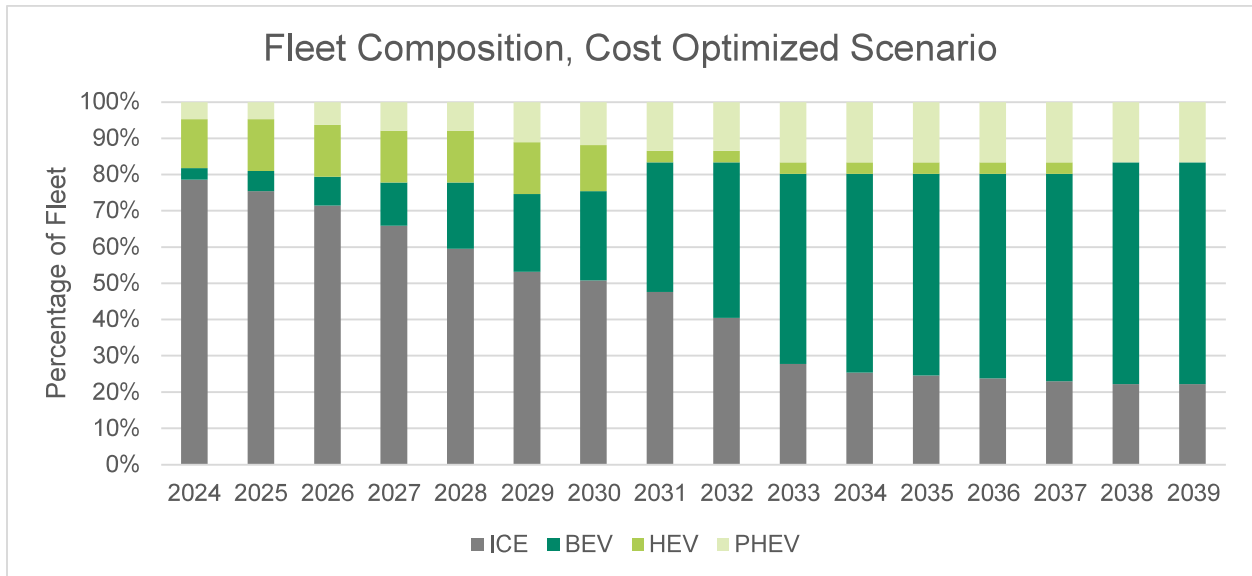


Figure 5 - Fleet Composition, Cost-Optimized Scenario, 2024 to 2039

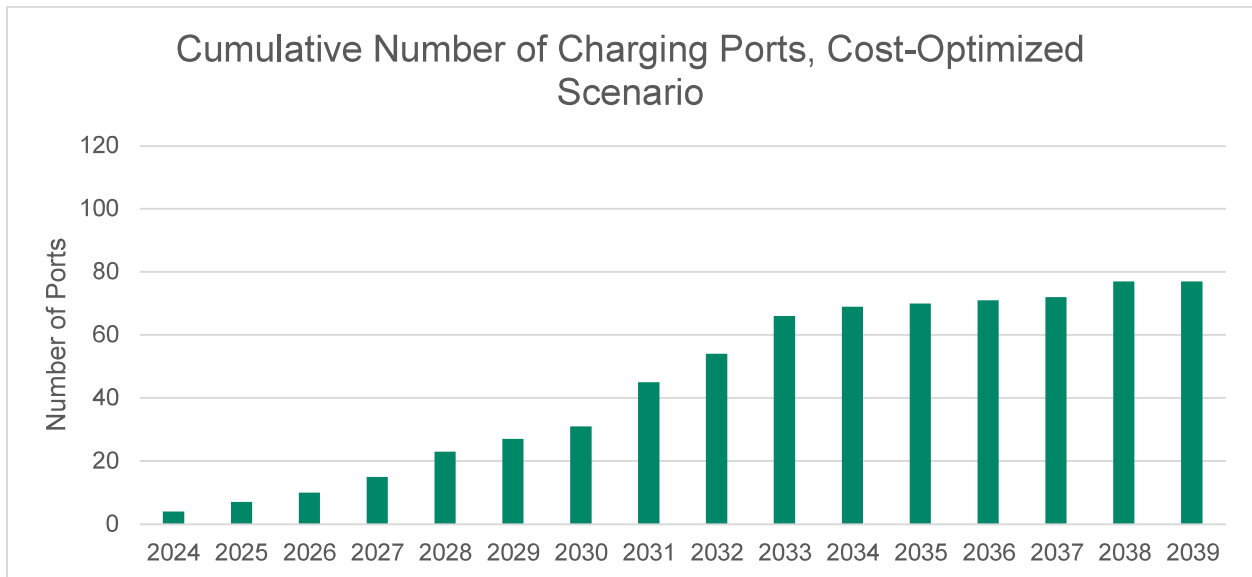


Figure 6 - Preliminary Charging Station Estimate, Cost-Optimized Scenario, 2024 to 2039

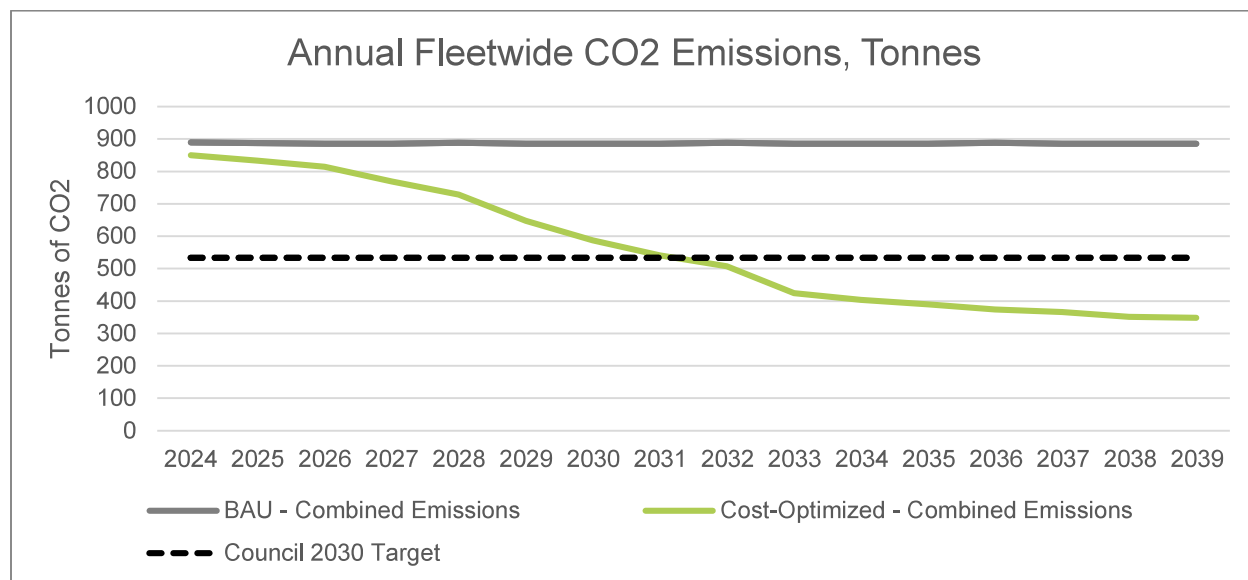


Figure 7 - Year-over-Year CO2 Emissions, Cost-Optimized Scenario, 2024 to 2039

Fleet Transition Plan – Technology Leadership

Under the Technology Leadership scenario, ICEVs are replaced with EVs whenever available, once an ICEV is due for replacement. This scenario may consider early retirement for some vehicles in order to achieve an earlier transition to EVs. This scenario represents the highest cost modelling.

This scenario yields the following results:

- By 2033, about 60% of the fleet vehicles are full EVs with a few hybrid vehicles remaining.
- By 2040, the end of the procurement process for this study is reached, and no ICEVs remain in the fleet (a complete elimination of ICEVs compared to the Cost Optimized scenario).
- By 2040, some non-modelled off-road/unlicensed heavy-duty equipment could still remain in the fleet, depending on market maturity for zero-emission HDVs at that time.
- Due to the aggressive nature of the Technology Leadership scenario, the transition is more expensive than BAU until around 2037.
- Based on forecasts for EV battery costs, after 2030, it is anticipated that EVs will be cost advantageous when compared to ICEVs.

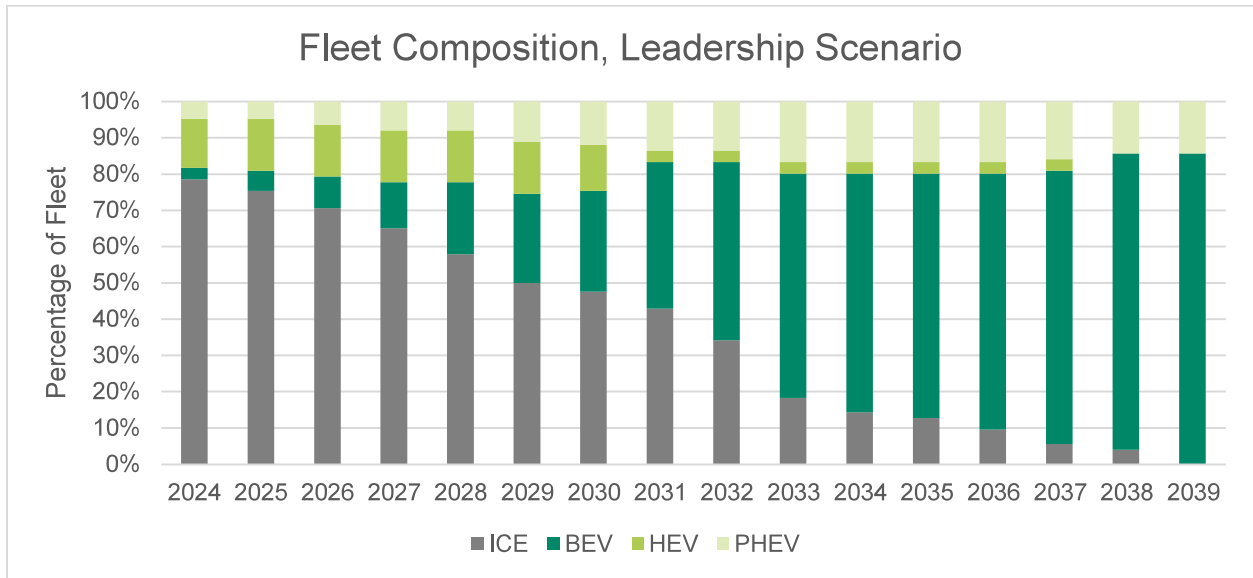


Figure 8 - Fleet Composition, Technology Leadership Scenario, 2024 to 2039

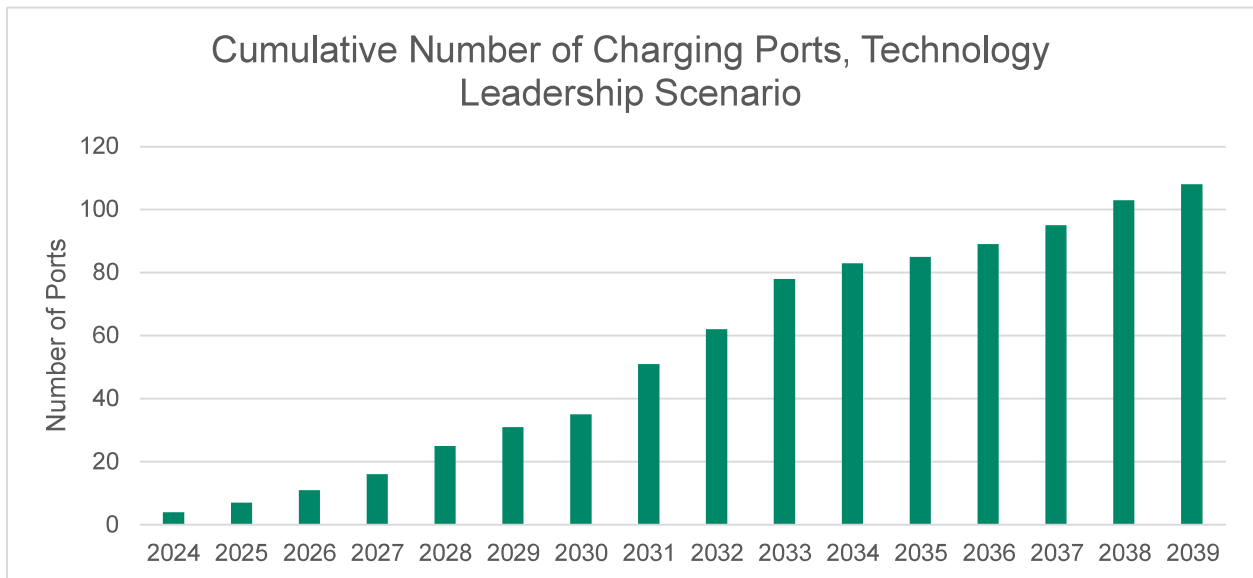


Figure 9 - Preliminary Charging Station Estimate, Technology Leadership Scenario, 2024 to 2039

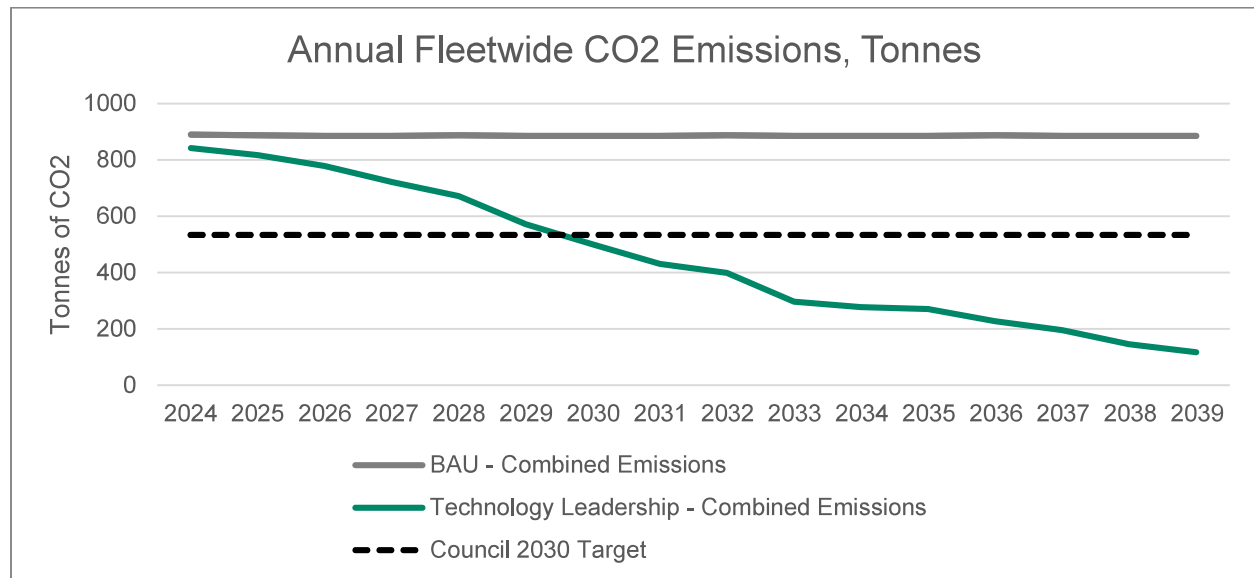


Figure 10 - Year-over-Year CO2 Emissions, Technology Leadership Scenario, 2024 to 2039

Scenario Results Comparison

While the Technology Leadership scenario replaces ICEVs with EVs whenever the original ICEV is due for replacement and a comparable EV exists to replace it, the Cost Optimized scenario only suggests this replacement when the TCO for the comparable EV is lower than that of the ICEV. As a result, the Technology Leadership scenario shows a more rapid adoption of BEVs, reaching 108 by 2039 compared to 79 in the Cost Optimized scenario. Both scenarios show similar trends for PHEVs and HEVs, with PHEVs being phased out by 2038 and HEVs remaining relatively stable. The Technology Leadership scenario phases out ICEVs completely by 2039, while the Cost Optimized Forecast retains 29 ICEVs.

Figure 11 shows the reduction of ICEVs in the fleet by scenario, with the Technology Leadership scenario resulting in a fully electrified fleet (including some HEVs) by 2039.

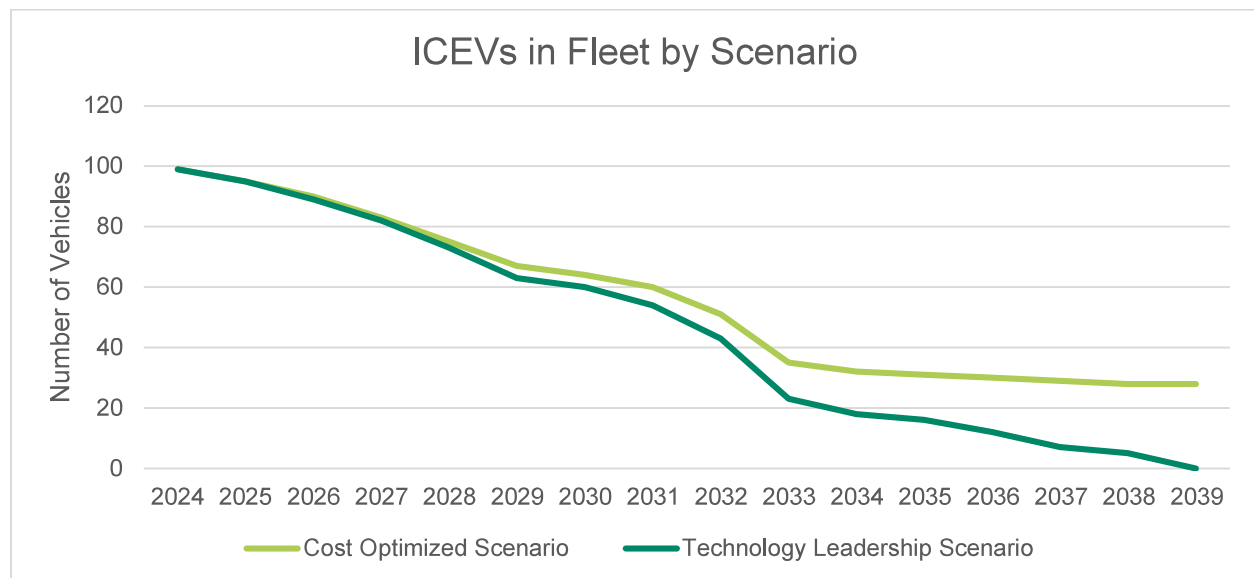


Figure 11 - Comparison of ICEVs in Fleet by Scenario, 2024 to 2039

From an infrastructure perspective, the reduced number of EVs in the fleet in the Cost Optimized scenario results in fewer charging ports being needed. Figure 12 shows this comparison. By 2039, 31 fewer

charging ports are required under the Cost Optimized scenario compared to the Technology Leadership scenario. Assuming dual-port charging stations will be deployed in most locations to reduce infrastructure costs, this would equate to about 16 fewer charging stations being needed. Additional charging infrastructure will be required for assets such as mowers and hand-held equipment, including in the ARC works shed when the equipment stored there is electrified.

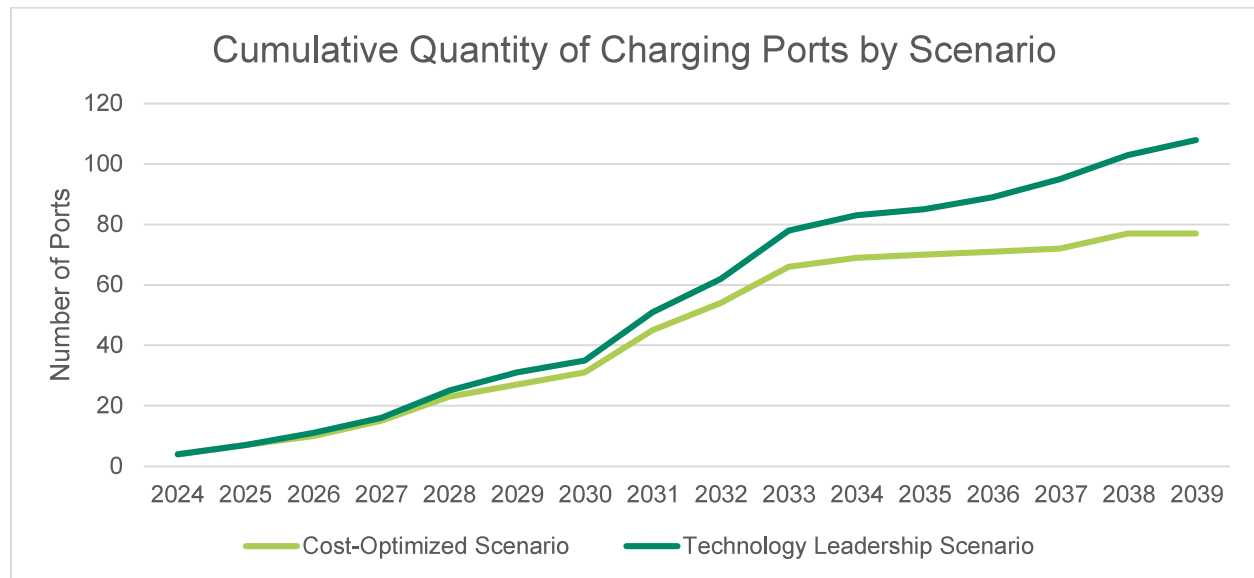


Figure 12 - Comparison of Required Charging Ports by Scenario, 2024 to 2039

With the elimination of ICEVs in the fleet under the Technology Leadership scenario, there is a corresponding reduction in fleetwide emissions, though some HEVs and equipment will continue to produce tailpipe emissions. Figure 13 compares the emissions of the Cost Optimized Scenario and Technology Leadership scenario. Both scenarios help achieve an emissions reduction that aligns with Town Council's 2030 emissions reduction target which applies to emissions from all sources.

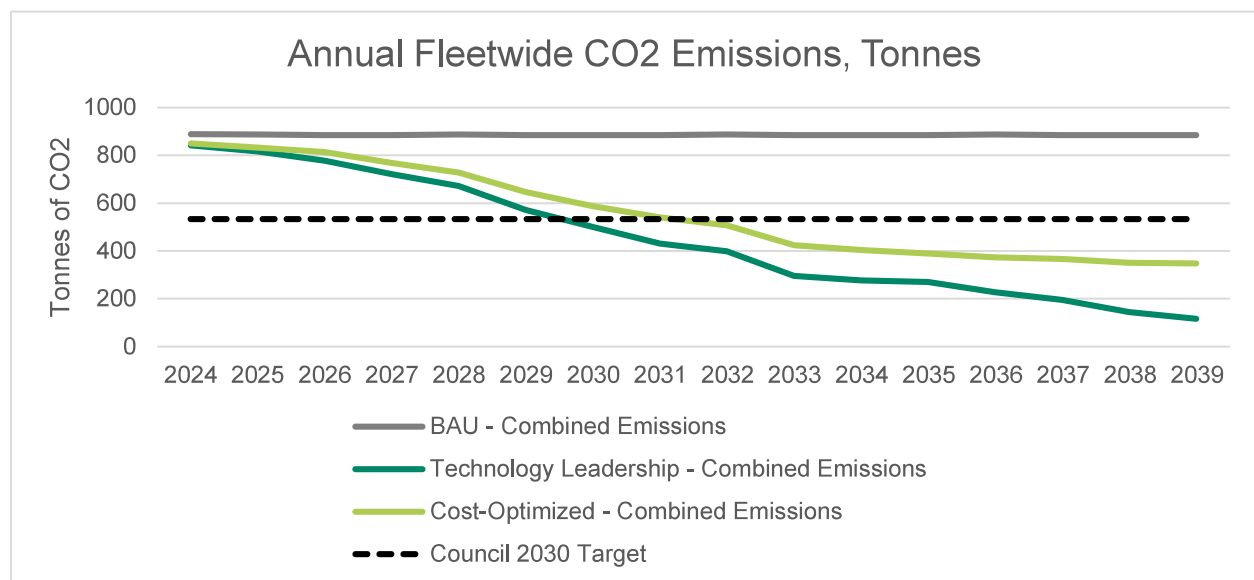


Figure 13 - Comparison of Annual Fleetwide CO2 Emissions, 2024 to 2039

Recommended Fleet Transition Plan

Though both scenarios result in significant emissions reductions, the Technology Leadership scenario achieves Council's desired 40% reduction below baseline levels about two years prior to the Cost Optimized scenario. This reduction is achieved between 2029 and 2030 in the former scenario, compared to between 2031 and 2032 in the latter.

Based on the results and the goal of supporting Town Council's emissions reduction target by 2030, the Technology Leadership scenario presents an effective path to meeting this goal. However, given the significant costs, infrastructure requirements, and fact that some vehicles are not ready to transition to EVs, elements of the Cost Optimized scenario could be retained, to balance costs, project timelines, and operational needs.

About half the Town's fleet emissions come from light commercial vehicles which include pickup trucks and cargo vans. While a handful of EV options existing on the market to replace these ICEVs today, including the Ford F-150 Lightning and Chevrolet Silverado 1500 EV, these vehicles have reduced payload and towing capacity which limits their functionality in many applications. Advances in battery technology are occurring quickly, but improved capabilities will be needed to meet some of the Town's needs. The Cost Optimized scenario presents a slightly more gradual EV adoption strategy for this category of vehicle.

Meanwhile, passenger vehicles and light duty equipment could be electrified in keeping with the assumptions of the Technology Leadership scenario, given the duty cycles of these assets are less severe and more EV/electric models are available. Light-duty passenger vehicles can generally be replaced immediately with EV options, such as the Town's Chevrolet Cruze, Honda Civic, Ford Escape, and Hyundai Sonata models. These vehicles carry passengers but do not haul significant payloads or tow, and many light-duty PHEV and EV options exist on the market today. Finally, leveraging the existing PHEVs in the fleet by ensuring they are used as frequently as possible in electric-only mode will help reduce emissions without requiring the procurement of new vehicles.

By balancing elements of both scenarios, together with leveraging the existing electrified assets the Town operates and has ordered, the Town can expect to achieve Council's emission reduction target by 2030. By 2040, under both scenarios, the Town can expect an emission reduction of between 61% and 86% and be well on the path to establishing a fully emissions-free fleet the decade thereafter.

6. Supporting Infrastructure

This section builds on the recommended fleet transition plan by providing information on the charging equipment needed, what the energy uplift will be and how this aligns with current and future utility requirements. It describes the recommended type, location, and phasing of infrastructure at Town facilities, and strategies for the conversion of smaller equipment to electric. discuss how handheld and smaller equipment will be charged and managed. Additional commentary on charging best practices is also provided, including recommendations on maintenance/servicing, safety and fire prevention, and end of life planning. To ensure that EVs are ready for operation once procured, EVSE should be planned well in advance of vehicle acquisitions based on the preferred fleet transition scenario, with charging stations operationalized ahead of a vehicle's arrival.

Recommended Charging Equipment

There are three broad categories of EV charging equipment, defined by their level of power and charging speed. These are described in Table 22. Note that power output and typical charging times will vary depending on the type of equipment and vehicle. Level 1 and Level 2 charging stations are the most widely used charging methods.

Table 22 - Charging Equipment Types and Typical Applications

Type	Voltage	Typical Power Output	Typical Charging Time (Full Battery)	Application
Level 1	120V AC	1.4-1.9 kW	8-20 hours	Overnight charging for low mileage vehicles that are parked for extended periods
Level 2	220-240V AC	3.3-19.2 kW	4-8 hours	Overnight or daytime charging for most vehicles at home, workplaces, and public facilities
Level 3/DC Fast Charging (DCFC)	Varies; typically between 200-600V DC	50-350 kW (maximum rate can be limited by vehicle's capability)	Up to 80% charge in as little as 20-30 minutes	On-the-go settings like highway rest stops, drayage truck facilities, and commercial vehicle yards where a quick top-up is required

For most of the Town's charging needs, Level 1 and Level 2 stations are recommended. Some Level 1 charging equipment is already available at the Operations Centre for PHEVs. Public Level 2 charging stations are also installed in the parking lot and are available for staff and members of the public, but are not used for fleet vehicles. Similar stations without the payment interface would be suitable for installation in the depot for the Town's light-duty fleet. Level 3/DCFC is likely to be required for some high-mileage and first responder vehicles, since vehicle turnaround time is key to the successful operation of these vehicles.

Though not modelled, additional charging infrastructure will be required for assets such as mowers and hand-held equipment. This infrastructure will be required at the Operations Centre and ARC, in the works shed.

Modelling Results

The BetterFleet model outputs a preliminary charging station estimate (number of charging ports) for the Town's fleet based on the number of EVs in the fleet, at a preliminary ratio of one EV to one charging port

(based on each transition scenario). This represents the highest cost, lowest management scenario where each vehicle requires its own charging port for overnight charging and is suitable for preliminary planning for the EV transition. A lower deployment of charging stations will save costs but come with additional management considerations, since not every vehicle would have a guaranteed parking stall and charging access.

There are benefits to a 1:1 vehicle to charging port ratio, where capacity and costs are not a concern, including:

- Reduced need for charging management.
- Greater redundancy supporting resiliency if charging equipment fails.
- Greater operational flexibility, with no need for active management of charging cables (cable swapping).
- More capacity to expand the fleet.
- Reduced likelihood of vehicles not being charged overnight due to operational process breakdown (e.g., forgetting to park in the right location to charge or needing to swap cables between vehicles).

In some cases, facilities are not able to accommodate a 1:1 vehicle to charging port ratio due to the significant energy demands and spatial limitations for equipment placement. As a result, a lower ratio of charging ports to vehicles may be needed, depending on site capacity or phasing of infrastructure. If this is the case, some level of operational management, such as cable swapping, not plugging in every vehicle every day, or alternating parking spaces would be needed. To minimize operational concerns, proceeding with a 1:1 vehicle to charging port ratio is recommended at this stage.

Table 23 summarizes the preliminary recommended charging provision for the fleet based on the BetterFleet model in 2039, excluding charging needs for electric equipment like mowers and power tools. Note that because not all vehicles will be EVs in 2039, the number of charging ports is lower than the total vehicle count. Many Level 2 charging stations have two ports, so the actual number of charging stations could be approximately half the number of charging ports recommended. This can be achieved by placing the charging station between two stalls, and having one charging cord reach each stall. The actual number of charging stations will depend on site-specific constraints including electrical and spatial capacity, and desired charging management solutions.

Table 23 - Preliminary Model Recommended Charging Provision for Fleet

Property	Address	Vehicle Count (All Vehicles)	Equipment Count (Powered Only)	Recommended Charging Port Count in 2039 (3.0 kW, 7.2 kW, and 19.2 kW)	
				Cost- Optimized Scenario	Technology Leadership Scenario
Operations Centre	800 Salem Rd N	89	75	56	75
Town Hall (incl. Library)	65 Harwood Ave S	19	0	16	18
Fire HQ	900 Salem Rd N	7	1	0	4
Fire Hall #1	40 Westney Rd N	3	0	0	3
Fire Hall #2	435 Monarch Ave	3	0	0	3

Ajax Community Centre (ACC)	75 Centennial Rd	3	3	3	3
Audley Recreation Centre (ARC) – Works Shed	1955 Audley Rd	1	12	0	1
Pat Bayly Sq.	55 Bayly St W	1	1	1	1
Total		126	92	77	108

Table 24 shows the expected demand and corresponding, in kW, associated with the Level 2 charging needs for each scenario, excluding energy demands for electric equipment like mowers and power tools. Of note, the demand assumes that not all charging stations will be used at their maximum output concurrently, but rather that the charging will be managed via charge management software that allows the Town to moderate energy consumption based on the vehicles' actual needs. The assessment excludes the demands associated with DC Fast Charging, which could increase the expected demand significantly.

Table 24 - Modelled Site Energy Demands (Level 2 Charging Only)

Property	Address	Expected Demand (kW) for Level 2 Charging	
		Cost-Optimized Scenario	Technology Leadership Scenario
Operations Centre	800 Salem Rd N	277.61	339.67
Town Hall (incl. Library)	65 Harwood Ave S	45.29	54.57
Fire HQ	900 Salem Rd N	N/A	8.33
Fire Hall #1	40 Westney Rd N	N/A	4.95
Fire Hall #2	435 Monarch Ave	N/A	4.24
Ajax Community Centre (ACC)	75 Centennial Rd	21.30	21.30
Audley Recreation Centre (ARC)	1955 Audley Rd	3.0 ⁵¹	3.0
Pat Bayly Sq.	55 Bayly St W	6.03	6.03

⁵¹ Expected demand increased to 3.0 kW to reflect assumed minimum Level 2 charging station output for both scenarios.

Operations Centre/Fire HQ Capacity Assessment

AECOM visited the Town of Ajax Operations Centre and Fire Headquarters on April 16, 2024 to review power supply and capacity to support installation of EVSE at both facilities. The Town provided electrical single line diagrams and electrical load data over a 22-month period from January 1, 2022 to October 31, 2023. Onsite results were compared against the information provided by the Town to determine the amount of spare capacity. The results of the assessment are summarized in Table 25.

Table 25 - Operations Centre and Fire HQ Electrical Capacity Assessment Summary

	Operations Centre	Fire HQ
Estimated spare capacity (April 2024)	756.24 kW	199.6 kW
Spare capacity with recommended 20% buffer	600 kW	160 kW
Incremental demand – Cost Optimized scenario	277.61 kW	0 kW
Incremental demand – Technology Leadership scenario	339.67 kW	8.33 kW ⁵²
Remaining spare capacity or capacity shortfall	260.33 – 322.39 kW	151.67 kW

As shown, the Operations Centre has spare capacity of approx. 756.24 kW which could accommodate EV charging. The analysis indicates an expected incremental demand from EV charging of 277.61 kW under a Cost Optimized scenario and 339.67 kW under a Technology Leadership scenario. With a capacity buffer included, the Operations Centre has sufficient capacity to accommodate the recommended Level 2 charging infrastructure for both scenarios. Additional demand will be imposed by the proposed DC Fast Charging Hub, which is likely to require an additional service, as discussed in the following section.

At the Fire Headquarters, though the analysis shows that the facility has sufficient capacity to accommodate the recommended Level 2 charging infrastructure for both scenarios, DC Fast Charging will likely be needed for fire apparatus. For example, the Rosenbauer RTX (deployed recently by the City of Brampton) can accept a full power input of up to 150 kW to charge its 132 kWh batteries from 50 to 80% in 15 minutes⁵³. To deliver this level of power, the Fire Headquarters would only have capacity for one charger.

Evaluation of the Town's other facilities once the preferred scenario has been identified is recommended, so that potential capacity upgrades can be fully understood. Since fewer vehicles are domiciled at other facilities, charging may be able to be accommodated within the existing electrical capacity.

DC Fast Charging Hub

While most general charging needs are likely to be met with Level 2 charging stations used overnight, some high mileage vehicles and those with severe duty cycles may require a faster or more frequent rate of charge. A DC Fast Charging Hub is recommended to be deployed at the Town Operations Centre where the majority of fleet vehicles are domiciled.

The higher capacity of MHDVs and more severe duty cycles typically require more charging power that cannot be met by Level 1 or 2 equipment. In selecting medium- and heavy-duty vehicles, the Town should review charging specifications closely with vehicle manufacturers and dealers to ensure that the Town's charging equipment deployment plans align with the needs of its medium- and heavy-duty vehicle fleet.

Further, though the electrification of the Fire Department fleet is not planned for the near-term, future fleet electrification efforts will include the Fire Department. Upgrades will also be required to the Fire

⁵² Assumes L1/L2 charging which will not be suitable for fire apparatus in all circumstances.

⁵³ [Rosenbauer – RTX Revolutionary Technology](#)

Headquarters and to Fire Halls 1 and 2 to accommodate DC Fast Charging needs for fire apparatus and other emergency vehicles requiring rapid charging. If upgrades to the Operations Centre occur earlier, DC Fast Chargers deployed at the Operations Centre could potentially be shared between the Fire Department and other municipal fleet vehicles, depending on accessibility and demand, while Fire Headquarters is upgraded.

The hub could be located outdoors or be integrated within the existing Operations Centre. An indoor hub is generally preferred by fleet management staff as it provides a weather-protected charging environment, helping minimize potential damage to equipment from severe weather, while offering greater flexibility for yard operations. Figure 14 illustrates a potential hub location in the existing maintenance area. If located indoors, a new utility connection will likely be needed between the Elexicon utility along Salem Road and the existing electrical penthouse in the Operations Centre.

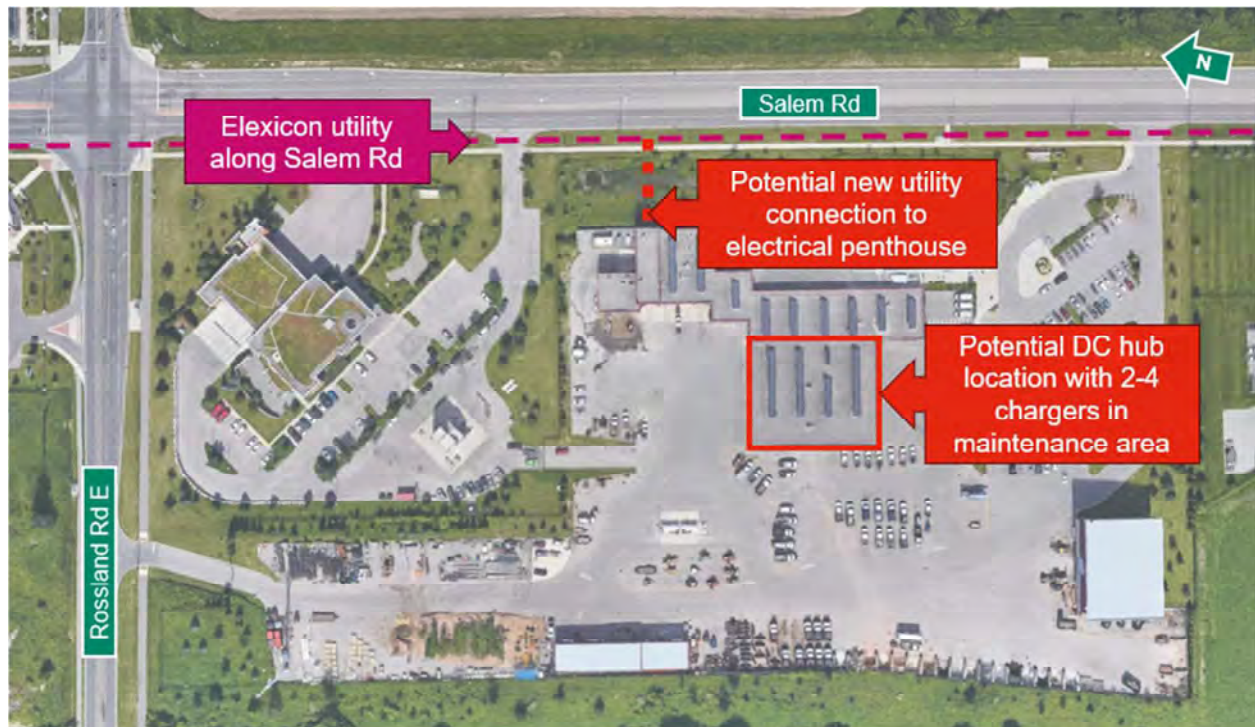


Figure 14 - Potential DC Fast Charging Hub at Operations Centre

Site Planning Considerations

General Considerations

The below are key high-level site planning considerations that should form part of the EVSE layout process:

1. Review space availability:

- a. Evaluate where space is available for the charging stations and protective infrastructure like bollards. Ideally, charging stations will be placed in or near existing parking areas where the yard's operations are minimally affected by the introduction of new infrastructure.
- b. Design the layout to minimize congestion and ensure safe maneuvering for EVs. Conduct vehicle swept path analysis on infrastructure to ensure there is no risk of vehicles damaging charging infrastructure during routine movements through the yard.
- c. Consider where electrical infrastructure like transformers will be placed, designed, and screened. Ensure there is adequate space to access equipment for maintenance.

2. Evaluate future scaling requirements:

- a. Plan for the fleet of the future, not just today's fleet. Consider that when the fleet is fully electrified, additional charging stations will be needed.
- b. Consider the flexibility to upgrade existing charging stations to faster technologies, and whether these technologies will need more space.
- c. Evaluate the Town's long-term capital plans to ensure there are no conflicts with proposed infrastructure plans (e.g., new or expanded buildings, electrical upgrades, facility disposition, etc.)

3. Consider key adjacencies:

- a. Consider proximity to existing power supply to reduce the length of conduit/trenching.
- b. Consider where electrical infrastructure like transformers will be placed, designed, and screened. Ensure there is adequate space to access equipment for maintenance.
- c. Assess where alternative fueling infrastructure, like hydrogen equipment, may be located relative to EVSE.
- d. Where possible, place conduit around the perimeter of the site, and lay it below landscaping to avoid trenching through concrete/asphalt.

4. Assess all season operations:

- a. During winter months, consider where snow will be stored onsite. Ensure snow storage does not conflict with EVSE.
- b. When winter maintenance equipment is deployed, consider how movement of this equipment through the yard may be different (e.g., different swept paths, different visibility considerations) and site charging equipment to accommodate these movements.

Operations Centre/Fire Headquarters

Because a majority of the fleet is domiciled at the Operations Centre, including most of the Town's maintenance equipment, it is a key focus of the study. A site visit was held at the Operations Centre to review space availability for charging and gather a preliminary understanding of the facility's operations. The Operations Centre adjoins the Fire Headquarters, and the facilities are connected via a ramp, though the ramp is gated and cannot be used 24/7 due to access restrictions at the Fire Headquarters while certain training exercises are taking place.

AECOM evaluated potential EV charging locations at the Operations Centre where the majority of the fleet is domiciled and where most EV charging will be needed. The Operations Centre yard was divided into four areas based on function. As shown in Figure 15, these are: front of house parking, heavy truck staging, back of house parking, and refueling and equipment staging. Of note, with the Yard Utilization Study still pending, the ultimate layout of the yard may change.

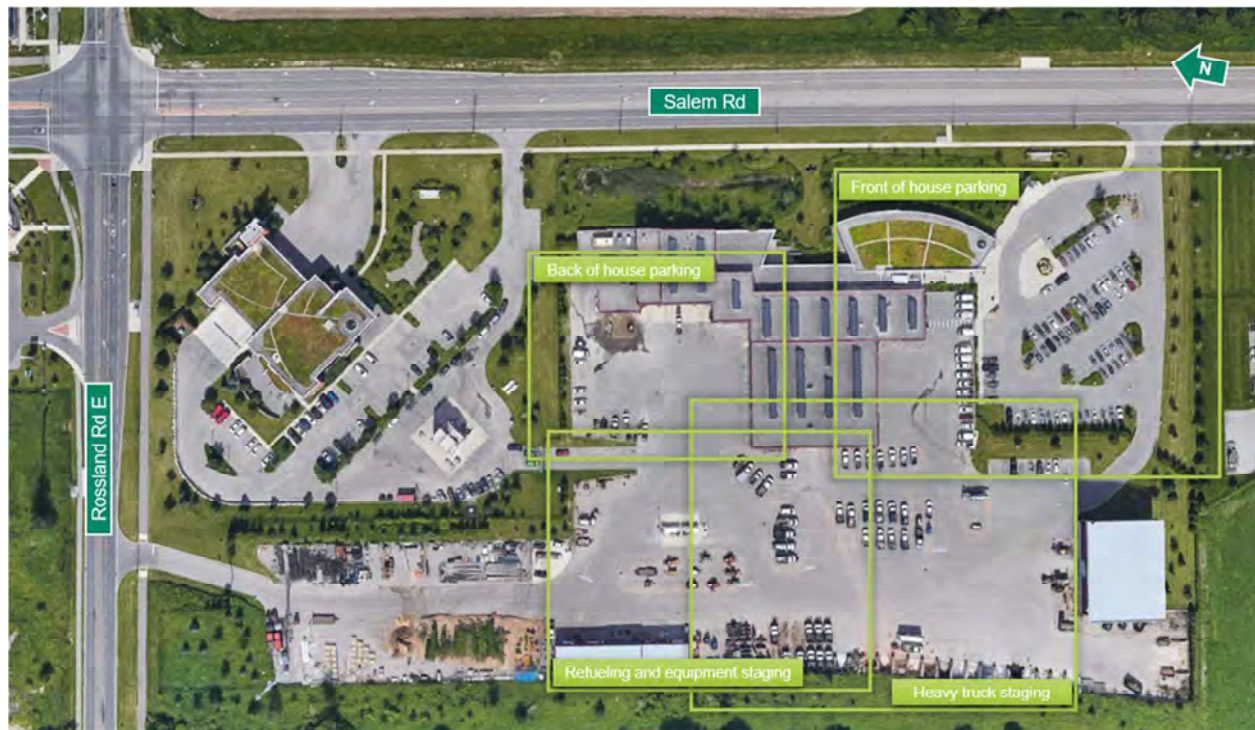


Figure 15 - Parking and Staging Areas at Operations Centre and Fire Headquarters

Front of House Parking

- Parking for light-duty fleet vehicles is provided behind a secure fence at the Operations Centre front of house. Public and staff parking is provided in the lot accessed via Salem Rd, which is not access controlled. A Level 2 ChargePoint charging station with two ports is installed in the public lot for general use.
- EVSE for up to 17 stalls could be installed behind the parking stalls opposite the Operations Centre garage, along the perimeter fence. This could require changes to the perimeter fence placement.
- The area is far from the existing electrical room, so conduit and cables would have lengthy runs.
- Additional public-facing charging stations could be added if more public or staff charging is desired.

Figure 16 illustrates the conceptual routing of conduit and potential Level 1/Level 2 EVSE installation location at the front of house parking area.

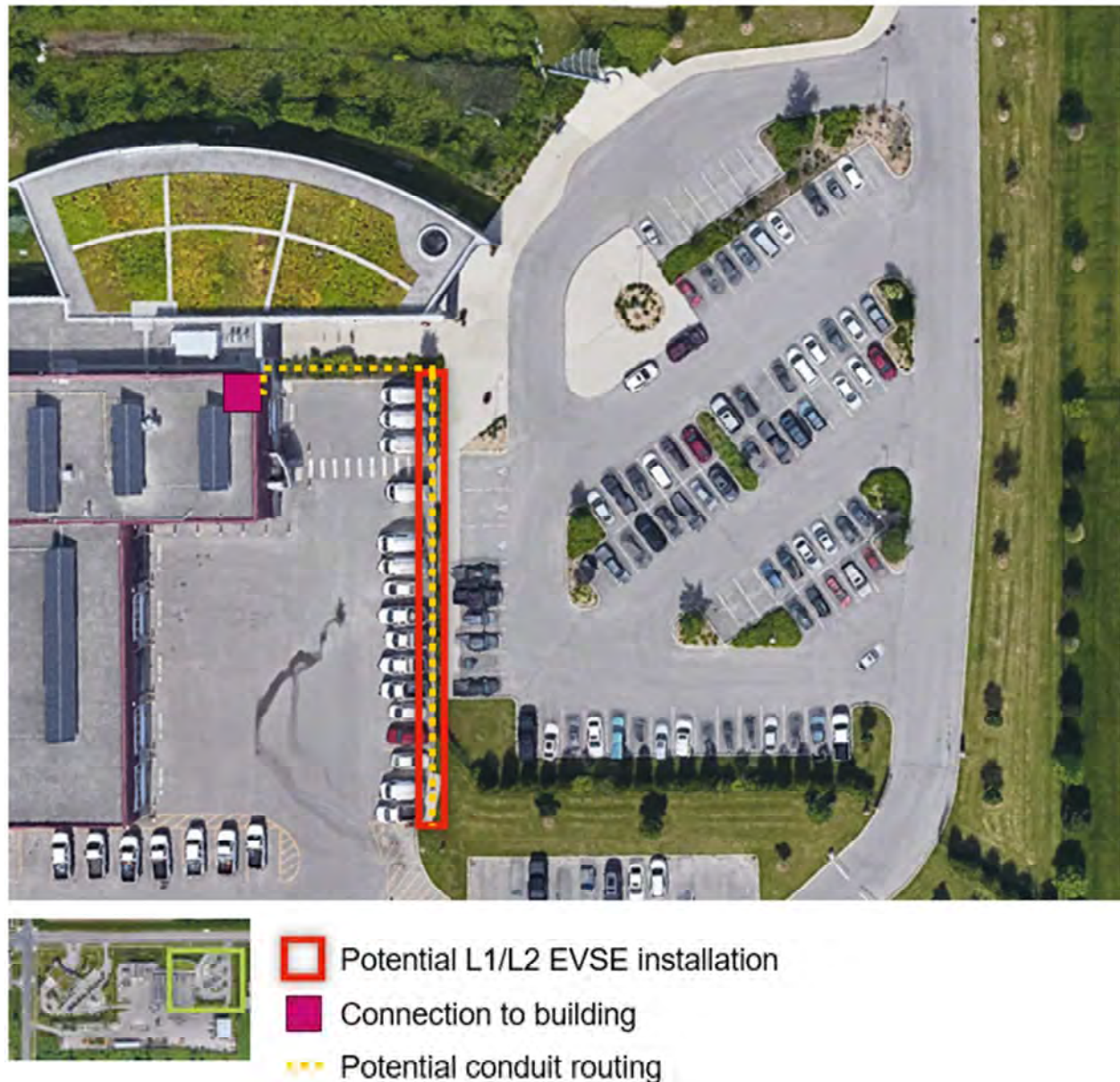


Figure 16 - Front of House Parking Concept

Heavy Truck Staging

- Light-, medium-, and heavy-duty trucks park and stage on the west side of the Operations Centre garage.
- EVSE could be installed along perimeter of Operations Centre garage to serve 8-12 stalls with minimal conduit/trenching required (A).
- 14 pull-through parking stalls are generously sized and could be equipped with EVSE on the sides of stalls to maintain pull-through operations (B). Installation would require trenching through parking lot.
- EVSE could be installed to serve 6-8 stalls in the parking area (C) in the middle of the yard.
- Consider how snow removal and heavy truck operations in this area could impact charging station placement and protective requirements (e.g., bollards).

Figure 17 illustrates the conceptual routing of conduit and potential Level 1/Level 2 EVSE installation location at the heavy truck staging area.

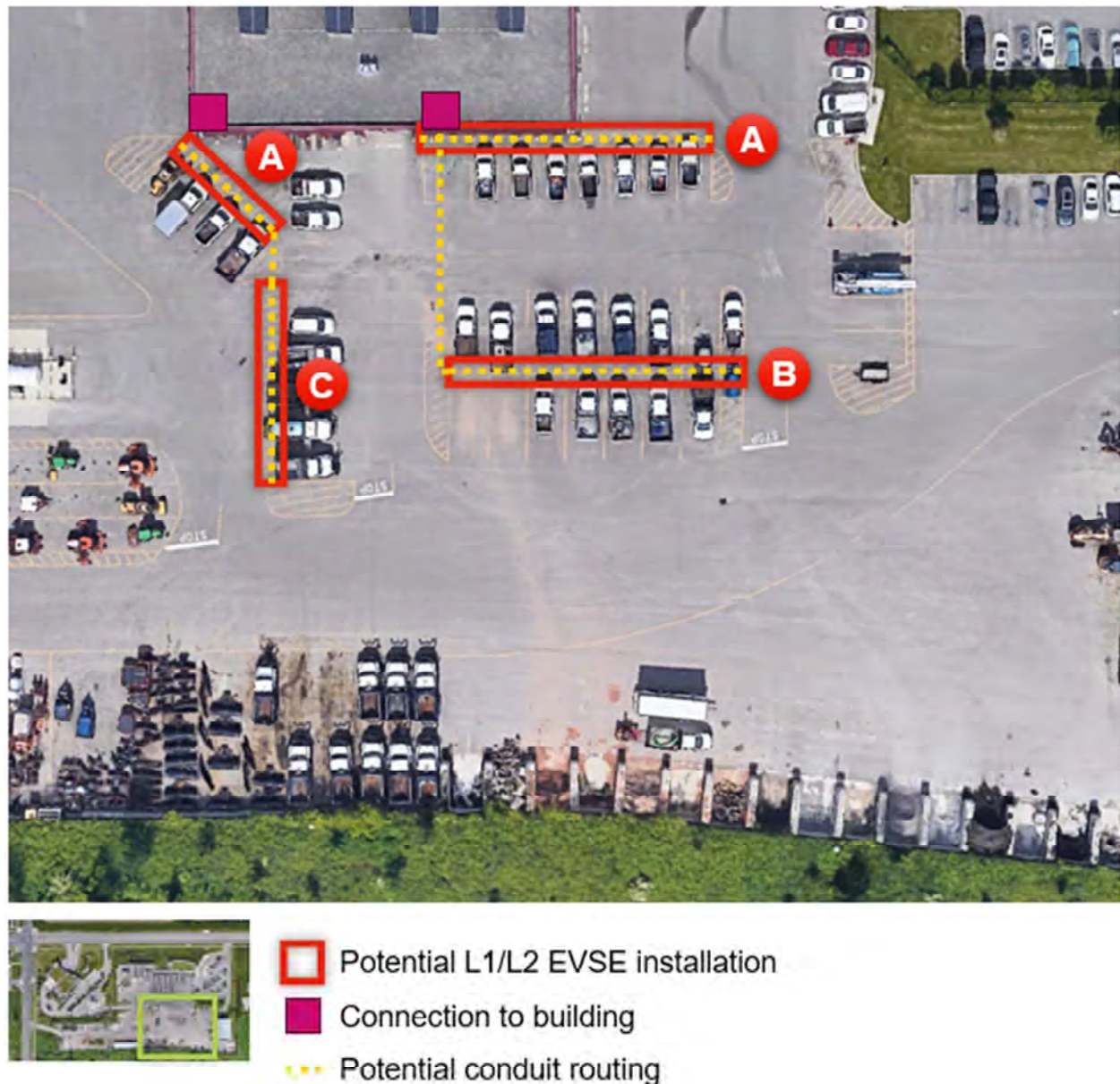


Figure 17 - Heavy Truck Staging Concept

Back of House Parking

- Vehicles are maneuvered, cleaned, and stored in the back of house parking area. There is significant activity in this area.
- There is existing electrical supply on the north perimeter of the lot (**A**). EVSE for about 9 stalls could be accommodated here, based on current striping, with minimal conduit/ trenching required.
- Adjacent the north perimeter (**B**), EVSE for about 5 stalls could be accommodated.
- The area is close to the existing electrical room, so the length of conduit and cable runs can be minimized.

Figure 18 illustrates the conceptual routing of conduit and potential Level 1/Level 2 EVSE installation location at the back of house parking area.



Figure 18 - Back of House Parking Concept

Refueling and Equipment Staging

- Existing fuel tanks are located in the northwest part of the Operations Centre lot. Staging for equipment is provided west of the fuel tanks in lanes.
- EVSE could be provided along the west side of lanes for equipment, but would require significant trenching through the paved area. There must be a minimum 25' separation between fuel pumps and EVSE.
- Consider how equipment charging may differ from vehicle charging, such as type of port, power requirements, etc.
- Consider how long-term phase-out of fossil fuels could lead to removal of fuel tanks and yard reconfiguration.

Figure 19 illustrates the conceptual routing of conduit and potential Level 1/Level 2 EVSE installation location at the refueling and equipment staging area. This may be a challenging area to accommodate

EVSE given the proximity to the existing fuel tanks and adjacency to drive aisles for large equipment including snow plows. Large bollards or other physical protection methods would be required in this area to keep EVSE from being damaged by large equipment. Greater operational flexibility may be required in this area for large equipment.

Alternatively, EVSE could be accommodated along the northern perimeter of the property (as shown in Figure 20). This would require additional conduit, which could be extended from the back of house parking area to the east. About six parking stalls could be electrified in this area, but operational changes would be required as the equipment is currently stored in lanes to charge, rather than stalls.



Figure 19 - Refueling and Equipment Staging Concept



Figure 20 - Refueling and Equipment Staging Concept (Alternative)

Overall, at the Operations Centre, modelling suggests that between 56 (Cost Optimized) and 75 (Technology Leadership) Level 1 and Level 2 charging ports will be required to accommodate EV charging by 2039. If dual port stations can be used, this would equate to 28-38 stations.

Based on a high-level site review, charging could be accommodated at about 65-71 stalls in the yard based on the current layout, generally aligning with anticipated demand. Charging could also be provided indoors within the vehicle maintenance bays to achieve the full buildout of 75 charging ports, as well as provide a weather-protected charging environment.

Some trenching would be required through the lot, but many charging stations could be installed along the perimeter of the lot to minimize trenching. The upcoming Yard Utilization Study may indicate an alternate layout is preferred. Charging station placement should be a key element of this study.

Table 26 summarizes the potential number of exterior stalls available for EVSE at the Operations Centre, pending confirmation via the Yard Utilization Study.

Table 26 - Number of Exterior Parking Stalls for EVSE at Operations Centre

Area	Vehicle Type Served	Number of Stalls for EVSE
Front of house parking	Passenger and Light Commercial	17
Heavy truck staging zone A	Light/Heavy Commercial	8-12
Heavy truck staging zone B	Light/Heavy Commercial	14
Heavy truck staging zone C	Light/Heavy Commercial	6-8
Back of house parking zone A	Passenger and Light Commercial	9
Back of house parking zone B	Passenger and Light Commercial	5
Refueling and equipment staging	Heavy Commercial and Off-Road/Unlicensed	6
Total		65-71

Recommendations

- Undertake a Yard Utilization Study to determine how the Operations Centre yard is being used and could be optimized, including where EV charging stations could best be located to avoid operational conflicts.
- Evaluate DC Fast Charging needs for the fleet and the infrastructure implications of necessary electrical upgrades to accommodate these needs, including coordinating a potential new utility connection with Elexicon for the Fire Headquarters and/or Operations Centre.

Charging Management Considerations

Because the ratio of charging stations to vehicles is suggested to be 1:1 at most Town facilities, charging management solutions are less likely to be needed. However, if more EVs than charging ports are available (either due to electrical capacity, costs, or infrastructure delays), some charging management solutions may be required to ensure that all vehicles achieve the desired charge overnight ahead of the next day's operations. Table 27 lists charging management considerations and their application to the Town.

Table 27 - Charging Management Considerations

Management Consideration	Application
Cable swapping – unplugging one vehicle and plugging in the adjacent vehicle when the desired state-of-charge is reached.	Where charging of multiple vehicles is required overnight, and a limited number of charging stations exists, a person can be tasked with cable swapping. This will ensure that all vehicles are fully charged for the next day's operations. Vehicles can also be moved across the depot to different charging stations if needed. Vehicle operations will need to be closely evaluated to determine cable swapping applications.
Charging hold-back – not charging each vehicle every night, depending on the vehicle's minimum state-of-charge for the next day's operations.	Not every vehicle will require charging each night. By establishing a minimum charging threshold, these vehicles can be kept clear of charging stations, allowing other vehicles to charge and reducing the ratio of charging ports to vehicles.
Take-home vehicles – vehicles that are not stored overnight at depots can be charged at the operator's home or other offsite location.	To reduce the required volume of charging stations, take-home vehicles can be required to charge offsite under the responsibility of the operator. For example, charging could take place in the home or at a public charging

station. A formal policy related to the provision of charging for take-home vehicles should be developed by the Town.

Station placement – stations can be located to permit charging by adjacent vehicles with a single cord, reducing costs.

A single cable charging station can be placed between two adjacent stalls to allow for two separate vehicles to charge at different times. Cable swapping may be required if both vehicles require a charge overnight.

Depot cycling – vehicles can be moved to different locations to charge or stop by the DC Fast Charging Hub based on need.

Cycling vehicles between depots where charging is available can be considered for some light-duty vehicles with similar uses cases, where charging is not available consistently at the home domicile location. Vehicles requiring DC fast charging, which will not be deployed at every facility, could be brought to the DC Fast Charging Hub at the Operations Centre/Fire HQ for charging.

Shared Charging Infrastructure Considerations

Fleet charging is generally provided “behind the fence”, i.e. not available for public access. This is done primarily to ensure equipment is secure, can be more easily managed, and does not require a public payment interface.

However, some government funding programs provide funding to support charging station deployment only if the equipment is made publicly accessible; for example, in shared staff/public parking areas at Town facilities. If Fleet Services were to deploy charging for its vehicles in publicly accessible areas (i.e. share use between fleet vehicles and members of the public), a range of considerations would apply, as listed in Table 28.

Table 28 - Pros and Cons of Shared Charging Infrastructure

Pros	Cons
Revenue generation – the Town can charge for the use of its charging stations (as is currently done at the public charging stations installed at the Operations Centre). Over time, this can provide a revenue generation opportunity, helping offset the capital and operating costs of the equipment.	Enforcement requirements – at the end of a shift, when a driver returns to a Town facility, they will need guaranteed access to charging. This means that enforcement will be required to ensure members of the public have vacated shared charging prior to the end of a driver's shift.
Funding availability – some government funding programs provide capital funding only if infrastructure is publicly accessible. Shared charging stations between the public and fleet vehicles could make the Town eligible for funding to offset the cost of infrastructure that may not be available for “behind the fence” equipment. Note that the latest round of the Government of Canada's Zero Emission Vehicle Infrastructure Program (ZEVIP) funding does <i>not</i> restrict funding on the basis of public access.	Payment interface – “behind the fence” charging does not require a payment interface, because it is for use by fleet vehicles only, and utility bills will be paid by the Town. With shared charging, a payment interface would be required to enable public use. This same payment interface would need to be operated by staff, such as via a unique operator network card. This increases the amount of time required by the operator at the end of their shift. Further, payment interfaces are the most common failure point on public charging stations, decreasing reliability of the system.
Maximize use of infrastructure – most fleet vehicles will charge at night and be on the road during the day. This means that charging stations will be unoccupied for much of the day. During working hours, members of the public could take advantage of this availability for	Greater upkeep – because they would have more users, and include potentially novice users without training on correct charging etiquette that Town staff will receive, more frequent maintenance would be required

their own charging needs, maximizing the utility of the infrastructure.

Support EV adoption in Ajax – for drivers without access to home charging, reliable access to charging at Town facilities could provide the convenient charging needed to encourage EV adoption. This can support EV adoption in the wider community and contribute to lower transportation emissions overall

of shared charging systems. There is also the greater risk of vandalism, since equipment is not secured behind a fence.

On-Route Charging

On-route charging (i.e., charging not occurring at a Town facility) has not been evaluated as part of this study. For those vehicles where on-route charging or refueling may be necessary throughout the day, the Town should evaluate what on-route charging network can accommodate its vehicles and ensure staff are trained in the proper use of this third-party equipment. To manage costs and most effectively monitor energy usage and demand, it is recommended that depot charging be used whenever possible, and on-route charging minimized.

Off-Road and Maintenance Equipment Strategy

Though on-road vehicles are responsible for the greatest proportion of the Town's fleet emissions, handheld equipment and off-road vehicles operated by the Town are also a significant source of emissions. In addition, gas powered equipment can create significant noise during operation. Types of equipment and vehicles include handheld trimmers and chainsaws, ride-on mowers, road repair equipment, and small utility vehicles. Transitioning this equipment to zero-emission technologies is an important element of the Sustainable Green Fleet Strategy which will contribute to the overall objective of achieving a 100% reduction in fleet GHG emissions by 2050, below 2019 levels. Many electric models of commonly used equipment are already available on the market, and the Town has already started procuring electric versions of some common pieces of equipment.

Most off-road and maintenance equipment is used seasonally for landscaping and property maintenance, though some is used year-round. Because most equipment is used in the summer months, there is less concern about battery longevity in the cold. For large area mowers and other large maintenance equipment, the battery runtime for many models is typically between 6 and 8 hours, allowing for daylong use on a single charge (refer to Table 15). Smaller handheld pieces of equipment typically have runtimes under two hours. However, some of these models have small batteries which can be swapped, enabling full day use.

As of spring 2024, the Town will have four zero-turn Toro electric mowers in service (Figure 21), for which field charging will be available using battery packs on a trailer which can be towed between sites (Figure 22). Monitoring the success of the electric lawnmowers will provide valuable feedback to the Town as it grows its electric fleet.



Figure 21 - Toro Electric Zero-Turn Mowers at Operations Centre Awaiting Commissioning



Figure 22 - Trailer to be Outfitted with Battery Packs for Equipment Charging

Table 29 lists some common municipal equipment, typical usage characteristics, and the recommended electrification strategy.

Table 29 - Strategies for Off-Road and Maintenance Equipment Electrification

Equipment Type	Example Models Currently in Use	Typical Duty Cycle and Usage Characteristics	Recommended Electrification Strategy
Large Area Mowers	Ferris IS5100Z Toro 7500D Toro 5910	Used seasonally. Likely to be used continuously for multiple hours during an entire workday.	Battery swapping likely not an option; equipment likely to require charging at the end of each workday.
Off-Road Vehicles	Wacker One-Ton Asphalt Roller John Deere Worksite Gator Vermeer BC1000 Chipper	Primarily used seasonally. Likely to be used continuously for multiple hours during an entire workday.	Battery swapping likely not an option; equipment likely to require charging at the end of each workday.
Hand-Held Equipment	Various lawn mowers, trimmers, chainsaws, pole saws, and leaf blowers	Primarily used seasonally. Likely to be used in short periods (<1 hour) throughout the day.	Prioritize procurement of hand-held devices with swappable batteries, if daylong usage is required. Where devices themselves must be charged (i.e. batteries cannot be swapped), use onboard mobile charging in vehicles like the Ford F-150 Lightning.

Key considerations as the Town increases its electrical equipment include the following:

1. **Charging of remote battery packs/battery trailers** – Since field charging will be required for some of the equipment, such as electric zero-turn mowers, enclosed trailers will be outfitted with remote battery packs and will be towed to sites and used for charging during the day. These battery packs will require their own charging, which may be different from the electrical equipment used for EV charging. The Operations Centre will need to be outfitted with charging infrastructure for these trailer battery packs, and placement of the infrastructure will need to consider the turning radius of the truck and trailer (Figure 23).

2. **Charging versus battery swapping** – Some small, handheld equipment will have integrated battery packs that require charging the device itself, while others may have removable battery packs that can be swapped out during the day and recharged independently. To increase flexibility for handheld equipment, it is recommended that the Town procure equipment with swappable battery packs where possible. Battery charging can occur onboard the battery trailer while the equipment continues to be used, enabling continuous use with minimal interruption (Figure 24).
3. **Vehicles with onboard charging** – Many EVs, particularly work trucks, come equipped with power outlets in the truck bed or front trunk. This can provide onboard charging for small, handheld equipment. However, use of onboard charging will deplete the vehicle's battery, so the operator must consider the vehicle's state of charge and ensure they can return to the depot at the end of their shift (Figure 25).



Figure 23 - Mobile DC Power Trailer (HM Cragg)



Figure 24 - Toro 60V Cordless Trimmer with Swappable Lithium-Ion Battery (Toro)



Figure 25 - Ford F-150 Lightning Power Outlets Accessible from Front Trunk (Autoweek)

Infrastructure Upgrades and Utility Coordination

Based on the Town's preferred strategy and current capital plans for EVSE deployment, coordination with the local utility, Elexicon, is recommended in the near term. Where significant upgrades and new utility connections may be required, such as to support the DC Hub, lead times for this work could be substantial as additional engineering and permitting will be required prior to construction. Aligning the Town's project planning cycle with Elexicon's upgrade timing will be critical to ensure the charging stations can be activated once installed and the Town is not delayed by utility upgrades.

Once contacted, Elexicon's local representative will provide the Town with an *EV ChargeON Preliminary Electrical Feasibility Assessment Form*. This form will request details on the address and facility details where EVSE is planned, including the anticipated peak demand (in kW) with all charging stations in use, the requested service size and voltage, and proposed in-service date. Completion and submission of this form is required for all applications with a total electrical load of 50 kW or greater.

Of note, the BetterFleet supporting infrastructure assessment considers the kW load of charging based on the assumption that charging will be spread over the whole night while vehicles are not in use. This assumption helps minimize peak energy demands and impacts to existing infrastructure, and is enabled with the help of charge management software with which most networked charging stations are equipped. However, if all charging stations were to be used concurrently at their maximum output, the demands would be higher than modelled. When coordinating with Elexicon, it will be important to consider the charging stations' theoretical maximum combined energy demand. Though unlikely to be needed, by planning for this level of demand, the Town can ensure maximum operational flexibility for the use of its charging stations.

Emergency Backup Power

During power outages, the ability to maintain critical fleet services with EVs is made more challenging because of these vehicles' power demands and lack of grid power. Many critical vehicles, such as fire apparatus, snow plows, and police vehicles will also have more significant power demands than regular passenger and light-duty vehicles, which are unlikely to be as operationally critical during a power outage.

Backup generators or alternative energy storage solutions, like battery energy storage systems (BESS) will be required to support fleet charging during power outage events and will need to be sized for EV loads in addition to supporting critical facility systems such as emergency lighting, security, and telecommunications. Some Town facilities, including Fire Headquarters, are already equipped with diesel generators to maintain critical systems during power outages. New or additional generators are likely to be required at other facilities to support fleet charging, namely at the Operations Centre. Generators at Fire Halls 1 and 2 should be evaluated for their capacity to charge EV fire apparatus once the replacement of ICEVs with EVs is included in the Town's fleet procurement plan.

As part of an emergency backup power The Town should identify which critical fleet assets must remain operational and for what period. Under the Ontario Building Code, emergency power supplies, such as generators, must be capable of operating under a full load for at least two hours to support building services⁵⁴. For commercial buildings, backup power is often designed to support essential services for a minimum of 72 hours. Given that critical fleet services must support Town operations during extreme weather events such as snow storms which could cause multi-day impacts to the power grid, sizing generators and/or BESS for the needs of critical fleet assets for 72 hours is advisable.

Scalability and future proofing of the backup power system are two key considerations. As the EV fleet grows, ensure that the backup power system can be scaled up accordingly, or meet the future fleet energy demands without requiring substantial modifications.

Vehicle to grid (V2G) or bidirectional charging options can also be considered, where the Town's non-critical EVs can feed power back to a BESS during emergencies to support the needs of critical fleet assets. This can reduce the required generator capacity and take advantage of existing assets, while also offering an emissions-free alternative to generator power.

Recommendations

- Establish the minimum duration of backup power required, based on the expected duration of power outages and the power demands of critical fleet assets.
- Evaluate emergency backup power requirements based on the maximum energy demand of critical fleet assets.

Codes, Standards, and Regulations

In the Town of Ajax and the Province of Ontario, several codes, standards, and regulations pertain to the installation of EVSE. Below are the key items that the Town should review and follow as part of EVSE deployment:

1. **Ontario Electrical Safety Code (OESC):** The OESC sets out the legal requirements for electrical installations in Ontario, including those related to EVSE installations. This includes circuit sizing and protection, location and mounting guidelines, wiring methods, grounding and bonding for electrical safety, disconnecting means to allow for safe de-energizing during maintenance, and labeling and marking.
2. **Canadian Electrical Code (CEC):** While Ontario has its own electrical code (OESC, described above), it is harmonized with the CEC. The CEC provides standards for the safe installation and operation of electrical equipment, including EVSE.

⁵⁴ [Ontario Building Code, S. 3.2.7.9. Emergency Power for Building Services](#)

3. **Building Code of Ontario:** The Building Code of Ontario was amended in 2018 to include new EVSE requirements for homes and workplaces. These requirements stipulate the minimum number of parking stalls that must be equipped with EVSE or have rough-ins and suitable electrical capacity to support future EVSE. The Building Code does not list any requirements for outdoor charging that would pertain to the Town's EVSE deployment for fleet vehicles, or for the retrofit of existing facilities to accommodate EV charging. However, the Town should evaluate any amendments in the Building Code pertaining to EVSE.
4. **Accessibility for Ontarians with Disabilities Act (AODA):** While the AODA does not have specific provisions tailored to EVSE, compliance with its accessibility standards and principles is crucial when installing EVSE to ensure that persons with disabilities can safely access charging equipment. Under the AODA, any new infrastructure, including charging stations, must comply with accessibility standards relating to operational accessibility (e.g., clear instructional signage, accessible payment methods if applicable), path of travel, and training and awareness. Given that fleet charging infrastructure is likely to be "behind the fence" and not publicly accessible, accessibility considerations for payment interfaces and other features of the EVSE may not apply. The Town must ensure that any training materials related to EVSE operation and safety are made accessible to all staff.
5. **Electrical Safety Authority (ESA):** The ESA plays a crucial role in ensuring electrical safety and compliance with electrical regulations, but does not have specific requirements solely dedicated to EVSE. When planning to install EVSE, the Town's local utility provider, Elexicon, provides convenient resources for identifying the necessary permits for EVSE from the ESA.
6. **Local Municipal Bylaws and Regulations:** If the Town deploys fleet charging that can also be used by the public, enforcement of Section 8.8 of the Town of Ajax By-law 45-2020 would apply: No person shall park or leave any vehicle on Municipal Property in an electric vehicle parking space without being actively connected to an electric vehicle charging station⁵⁵.

As the Town progresses its EVSE deployment, it is recommended that regular consultation occur with relevant authorities and professionals, given the rapidly changing nature of ZEV infrastructure, to ensure the Town's plans are compliant with all applicable codes, standards, and regulations.

Hydrogen Vehicle Pilot

In the current ZEV market, BEVs are more common than FCEVs. This is particularly true in the light-duty segment. BEV charging infrastructure is more widely available than hydrogen refueling stations (which are not available publicly in all provinces and territories), battery technology is more mature than FCEV technology, and BEVs are generally more energy efficient than FCEVs due to the number of energy conversion steps required to produce, transport, and convert hydrogen into electricity in a fuel cell. However, in the medium- and heavy-duty segments, there is significant interest in FCEVs due to the often severe duty cycles of these vehicles and the resultant battery capacities which would be required to power the vehicles. In these applications, the reduced weight of fuel cell systems and fast refueling time (comparable to gas or diesel) results in fewer operational limitations, with vehicles operating much like their ICE counterparts.

Given the significant capital investment that would be required to install and operate hydrogen storage and refueling equipment for the Town's fleet, a hydrogen pilot project is recommended for a limited number of heavy-duty fleet vehicles to determine the viability of an FCEV fleet. To perform this assessment, the following should be considered:

- **Retrofit versus New Vehicle Purchase –** The trial of hydrogen fuel cell technology in the Town fleet can be done in one of two ways: either through the purchase of new vehicles specifically developed to operate by fuel cell, or by retrofitting existing vehicles. Given that the retrofit of an existing vehicle involves significant costs and effort, it is not considered appropriate to transition lower value or older vehicles.

⁵⁵ [Town of Ajax By-Law 45-2020, Section 8.8](#)

- **Prioritize Assessment of Vehicle Performance** – The trial of hydrogen fuel cell technology requires both the conversion/provision of vehicles with the technology installed as well as a reliable supply chain for the hydrogen itself. As both the vehicles and the domestic hydrogen supply chain are in the early stages of development, any trial should focus on the operational parameters and performance of the technology to assess if it can be considered a viable alternative to existing combustion technology, rather than the current economics of the technology. As the FCEV market matures alongside the hydrogen supply chain, the economics of the fuel source can be more closely evaluated and compared against BEV and non-ZEV alternatives, if they are available.
- **Inter-Agency Coordination** – In addition to the trial of the vehicles, the Town should engage other local organizations/agencies with medium- and heavy-duty fleets to discuss whether they have considered hydrogen as a fuel alternative to diesel. The supply chain for hydrogen is not likely to be particularly economically viable at a small scale even in future conditions where the larger economy of hydrogen has been further developed. Given this direction, the combination of a series of users will likely be needed to gain economies of scale and develop sufficient demand to bring supply costs down and make the ongoing supply chain an attractive enough commercial offering to generate competition to provide it.
- **Hydrogen Supply Chain Assessment** – As part of this study an overview of the hydrogen market has been presented (refer to Section 3). The Town should consider whether they will become a generator of hydrogen via onsite electrolysis or whether they will purchase delivered hydrogen or use a public or shared refueling station. The procurement and operation of an onsite hydrogen electrolysis system, or management of a jointly operated hydrogen system with neighbouring municipalities, would remove the supply chain challenges that could come from shipping hydrogen from neighbouring communities or provinces. Current hydrogen electrolysis systems can produce large amounts of hydrogen that would easily meet the demands of the Town (some current market ready solutions can produce in excess of 4,000 kg of hydrogen per day). The Town could also consider whether onsite generation in sufficient capacity could present a business case for the sale of hydrogen to other users, such as other public or commercial fleets in Durham Region. Or, if the management of a system does not appear feasible, negotiating hydrogen delivery for multiple municipal fleets with FCEVs (whether permanent acquisitions or pilot projects) between a supplier and multiple municipalities could result in cost savings during the pilot.
- **Test Multiple Vehicle Types and Applications** – The trial of any hydrogen fuel cell solutions should include several vehicles and could potentially include vehicles outside the purview of Fleet Services, such as police vehicles or transit buses. Multiple vehicle segments should be considered (e.g., light-duty and heavy-duty; on- and off-road). A trial that includes several different vehicles is likely to provide a more thorough, real-world assessment of the performance of hydrogen fuel cell technology and provide greater confidence regarding the future use of the technology in the Town's fleet.
- **Ongoing Market and Dealer Engagement** – The FCEV market is evolving rapidly, with new technologies coming available each year. Close coordination with auto dealers, manufacturers, and other municipalities during the pilot would be beneficial, given the low number of FCEVs in operation relative to BEVs. Annual trade shows that offer "ride and drive" events present a good opportunity to test vehicles and speak with manufacturers. The Town should also closely evaluate the success of other FCEV pilots regionally and elsewhere in North America alongside its own pilot.

ZEV Management and Planning

Managing the Town's ZEV fleet will carry unique considerations relative to the current ICEV fleet to ensure consistent delivery of services. Namely, the maintenance and servicing of EVs will require specific care and attention to the lithium-ion battery packs. While EVs require less maintenance than ICEVs due to fewer moving parts, training will be required to ensure safe and reliable operations and maintenance. Further, supporting infrastructure will need careful planning and maintenance.

Smart Charging

One of the requirements of managing an EV fleet is to understand and manage electricity usage and charging requirements and to gather insights about fleet and energy utilization, which can assist in the optimization of the fleet. In addition to the vehicles' onboard telematics, "smart" EV charging technologies are a useful tool to ensure efficient charging of vehicles and long-term success of the Town's EV fleet.

Smart EV charging stations are networked (i.e., internet connected) and provide real-time charging management solutions which allow site hosts to fully control and operate charging stations to fit their specific needs. These charging stations typically cost more than non-networked stations but offer considerable benefits for fleet managers to ensure efficient utilization and maintenance of EVSE.

Benefits of networked/smart charging systems include:

- Charging station operators can have access to online management tools where they can collect essential data such as the utilization rate of charging units, electricity consumed per charge, and maintenance schedules.
- Enable support technicians to perform remote monitoring and troubleshooting to ensure longer uptime of EVSE.
- Internet-connected chargers allow for the possibility of load sharing, which can be beneficial when operating multiple chargers and when energy capacity is limited. Load sharing allows up to four Level 2 charging stations to run on a single circuit by fluctuating energy consumption based on the needs of the vehicles that are charging.

In addition to the operating benefits of smart EV charging, fleet managers can also use the data tracking programs to analyze driving behaviours and energy usage to provide feedback to employees on their driving habits and encourage improvements for more efficient utilization of EVSE and EVs. Moreover, data tracking software can be used to identify opportunities for further efficiency gains and tailor training programs accordingly.

Recommendation

- Deploy networked/smart charging stations for the Town's fleet to enable monitoring of utilization, remote monitoring and diagnostics, and manage energy use. By strategically managing charging loads and charging times with these stations, the Town can avoid excessive energy consumption at peak demand periods.

Battery Longevity Preservation

Most EV batteries last longer when their state-of-charge is kept within 20-80%. Frequently running a vehicle to empty and using DC Fast Charging can reduce the longevity of the vehicle's battery. The Town may wish to establish a minimum state-of-charge threshold for some vehicles above which some vehicles are not plugged in at the end of a shift, to minimize unnecessary charging and preserve battery longevity. For example, if a light-duty vehicle in the motor pool returns from a shift with a 75% state-of-charge and is anticipated to operate for fewer than 100 km the next day, the operators should not plug it in.

Conversely, for Public Safety vehicles or those with severe duty cycles requiring significant amounts of energy on a regular basis, it may be advisable to charge to 100% every night to ensure the vehicle is ready for the next shift.

Software in the vehicle and charging stations can be programmed to help keep vehicles within the optimal state-of-charge window. These features should be evaluated and discussed with manufacturers and operators and reviewed against staff schedules and vehicle duty cycles on the basis of vehicle type.

Recommendation

- Implement protocols for monitoring and managing battery health of EVs such as establishing a minimum state-of-charge for plugging in, optimizing charging schedules, monitoring driver usage and

correcting behaviour if necessary, and identifying signs of battery degradation or malfunction early on.

Maintenance and Servicing

Regular maintenance of EVSE is essential to ensure their reliability, safety, and longevity, as well as reducing replacement costs by maximizing the useful life of charging equipment. EVSE maintenance includes considerations for both initial installation and day-to-day maintenance of charging equipment.

Once charging equipment is installed, the following steps and measures are recommended before beginning regular use of the EVSE:

- Consider the **operating environment** of the charging station and take appropriate measures to protect it from potential environmental hazards such as direct sunlight, rain, snow, and extreme temperatures whenever possible.
- Develop an **emergency response plan** for handling unexpected incidents such as power outages, equipment failures, or accidents involving the charging unit. Ensure that staff is trained to respond effectively in emergency situations.
- Together with the EVSE vendor, create an **EVSE Maintenance Plan** and develop protocols to document maintenance history of charging station. Maintain accurate records of maintenance activities, including inspection reports, test results, service records, and software updates.

Once day-to-day operations begin, the following are recommended as preventative maintenance protocols for EVSE. Note that these activities can be conducted by the vendor and the frequency of cleaning agreed prior to the RFP phase, be conducted by the vendor or a contracted third party based on the vendor's recommendation to achieve a minimum uptime or performance requirement, or Town staff can be trained on routine cleaning.

- **Regular cleaning** of EVSE including cables, connectors, and filters, and visual inspections to identify any signs of physical damage.
- **Routine functional testing** to test the charging process by plugging into an EV and monitoring the charging session for proper initiation, communication, and termination. Can use tools such as an EVSE Test Adapter to conduct inspections and save time and costs for maintenance.
- Regular **electrical safety checks** to ensure charging station is operating within specified voltage, current and temperature limits. Checking for any signs of overheating, electrical faults, or insulation degradation.
- Networked charging stations will require **regular software updates** with the latest software released from the EVSE manufacturer to avoid potential bugs or security threats, and enhanced charging experience. Some systems may allow for over the air updates while others will require manual software updates by the vendor or a third party.

Ongoing maintenance and safety inspections are essential for ensuring optimal EVSE, which represents the percentage of time that EVSE is operational, while downtime represents the percentage of time that EVSE is out of service for maintenance and repair. When EVSE uptime falls below 75%, it can cause strain on remaining charging units, creating problems for fleet operations, and potentially requiring the use of public charging networks far from the vehicle's domicile location.

Recommendations

- **Prior to the RFP phase for EVSE design and installation:** Establish a minimum uptime requirement for EVSE and determine whether routine EVSE maintenance will be conducted by the vendor or vendor's third party, a third party contracted by the Town, or by Town staff.
- **Ongoing, after EVSE design and installation:** Conduct regular maintenance and inspection for all EVs and EVSE to identify any potential issues before they escalate. For EVs, this includes checking battery healthy, tire pressure, brake systems, and other critical components. For EVSE, this means

conducting routine functional testing of the equipment to ensure it is operating properly. Train drivers on correct EVSE usage, including correct charging port seating and cable management.

EVSE Maintenance Duties

Table 30 compares some of the potential benefits and challenges of having an in-house fleet maintenance team and outsourcing maintenance responsibilities to the vendor or a third-party service provider.

Table 30 - In-House vs Outsourced Fleet Maintenance Considerations

Benefits	Challenges
In-House Fleet Maintenance	
Control – Complete control over the maintenance process, quality of work, and cost.	Labour Cost – Hiring and retaining skilled technicians can be expensive and can require significant investment in both tools and equipment.
Familiarity – The in-house team knows the company's equipment and maintenance history, which can help identify issues more quickly and accurately.	Downtime – In-house maintenance work is typically done during the standard hours of operation. When equipment is being repaired or maintained, it is not available for use, leading to downtime and lost productivity.
Cost-effective – In some cases, in-house maintenance can be more cost-effective than outsourcing, especially with a smaller fleet of EVs and EVSE.	Expertise – In-house technicians may lack specialized, or up-to-date knowledge or experience to diagnose and repair certain problems.
Outsourced Fleet Maintenance	
Reduced Cost – Can reduce labour costs by avoiding the need to hire and train in-house technicians.	Loss of Control – Outsourcing EVSE maintenance will require giving up some control over the maintenance process, including scheduling, quality of work, and cost.
Flexibility – Outsourcing provides more flexibility in scheduling maintenance and repairs, as fleet owners can work with service providers to ensure equipment is serviced at the most convenient times.	Communication – There can be communication issues between the service provider and the fleet manager, which can lead to delays and miscommunication.
Expertise – Third-party technicians typically have a deeper level of expertise in EVSE maintenance and can provide more specialized services.	Quality of Work – Fleet managers must rely on the service provider to deliver quality of work, which can be a concern if the provider is not meet these expectations.

Safety and Fire Prevention

Any damage to the lithium-ion battery can trigger a chemical reaction causing the cells inside to severely overheat and enter a state of “thermal runaway”, can lead to a fire and/or explosion hazard. EV fires are further exacerbated by the release of flammable and toxic vapour and the presence of high voltage wiring in electric vehicles used to carry electricity throughout the vehicle. Additionally, a significant concern for EV-related fires is the possibility of an EV catching fire several weeks after an incident that causes damage to an EV battery. For example, in June 2022, a crashed Tesla Model S had been sitting in a junkyard for three weeks when it spontaneously ignited⁵⁶.

Although EV fire incidents are rare, they are considerably more dangerous and difficult to extinguish. As a result, it is critical for fleet managers to implement safety and fire prevention strategies to ensure any risks of an EV-fire are mitigated as much as possible. The following sections discuss strategies for preventative measures to avoid potential lithium-ion battery fires and mitigate impacts in the event of a fire, as well as best practice review of emergency response protocols currently being implemented.

Preventing Lithium-Ion Battery Fires

Lithium-ion batteries are generally safe and unlikely to fail, however damage from improper use, storage, or charging may cause batteries to fail and become hazardous. To prevent potential damage to batteries,

⁵⁶ [CTIF International Association of Fire and Rescue Services](#)

the follow measures are recommended to incorporate lithium-ion battery safety into day-to-day operations:

- **Consult OEM Manual** – Follow manufacturer’s instructions for proper charging and maintenance of EV batteries.
- **Proper Charging** – Only charge EVs with compatible charging cables and avoid leaving vehicles on charge for longer than necessary.
- **Careful Handling** – Be careful with driving EVs to prevent physical damage. Be sure to have the battery checked or replaced in the event of any physical damage to the vehicle. If an EV experiences any damage during operation, either at the depot or in the field, park the vehicle far away from buildings in case a fire ignites.
- **Staff Training** – Train staff on EV fire awareness, warning signs, and emergency response protocols in the event of a fire.
- **Consult with Automotive Dealer** – it is recommended to consult with the automotive dealer about the EV’s battery life and the manufacturer’s battery maintenance and recycling requirements.

EV Fire Prevention Tools and Resources

A variety of resources are available to support fleet managers in developing effective safety measures and emergency response protocols. For example:

- The US National Fire Protection Association (NFPA) provides downloadable Emergency Response Guides for alternative fuel vehicles that can help EV fleet managers and operators find battery locations, fire response and post incident procedures, and other best practices for different vehicles⁵⁷.
- The National Electrical Manufacturers Association (NEMA) published a Lithium-Ion Battery Fires Guidance Document (NEMA BS 30000-2021), which can be used as a potential guideline for how LIB fires may be detected, controlled, suppressed, and extinguished.
- The CTIF Commission for Extrication & New Technology collaborated with ISO to create the International Safety Standard ISO 17840 to address all new and existing safety hazards associated with road rescue and vehicle fires and accidents⁵⁸. The standard includes critical information for first responders regarding the risks when approaching vehicles with different propulsion energy types such as electric and hybrid vehicles, hydrogen and other fuel cells, and propane and LPG powered vehicles. The standard can be used worldwide by the public transport sector, fire and rescue services, and the automotive and heavy-duty vehicle sector. The standard consists of:
 - Symbols used as “energy identification stickers” to indicate the type of propulsion energy used and location of tanks and batteries, allowing first responders to quickly identify vehicle energy source and implement appropriate emergency response protocols.
 - Rescue sheets that consist of quick info regarding the construction of the vehicle to be used by first and second responders.
 - Emergency Response Guides which are an extended version of the Rescue Sheets with more detailed information.

Recommendation

- Educate drivers and fleet managers about the unique fire risks associated with EVs and lithium-ion batteries. Ensure fire extinguishers are accessible near fleet vehicles and charging stations. Train personnel on how to safely extinguish EV fires and evacuate affected areas.

⁵⁷ [NFPA – Emergency Response Guides](#)

⁵⁸ [CTIF – ISO 17840: The First Worldwide Firefighters’ Standard](#)

Best Practices in EV Fire Safety and Emergency Response

What makes EV fires particularly dangerous compared to traditional ICEV fires is the delayed ignition, explosive hazards, copious amounts of water required to put out the fire, and the potential for the fire to re-ignite if there is damage to other cells in the battery. The difficulty in extinguishing EV fires may be due to the construction of EVs with a heavily encased battery pack, which makes it difficult for firefighters to reach the source of the fire. While a conventional ICEV may be put out with 2,000 to 4,000 litres of water, an EV typically requires a much more prolonged intervention, including nearly 40 times more water, since the battery is protected by a strong, airtight encasing. Moreover, the chemicals in the battery will continue to produce its own oxygen to some degree, even when completely soaked with water, making traditional fire extinguishing protocols less effective than they have been for conventional fuels.

Battery Submersion

According to CTIF International Association of Fire and Rescue Services, many experts have recommended the method of submerging a burning EV into a water filled container like a shipping container. However, this is not always possible or practical to arrange, and takes a considerable amount of time to fill the container, which can be counterproductive when needing to protect surrounding vehicles or buildings from an EV fire. Alternatively, firefighters responding to an EV fire in Sacramento, California, dug a small pit in the ground, filled it with water and placed the vehicle in it partly, with the side of the battery compartment submerged into the water. Although this action reduced the amount of water needed to extinguish the fire and prevented re-ignition, the time and area required to dig a pit may not be feasible in certain situations.

Cutting Extinguishers

In 2023, The Swedish Civil Contingencies Agency (MSB.se) collaborated with industry leaders to test various tools to safely put out EV-related fires. The tests were designed to examine whether injecting water into a LIB that had gone into a state of thermal runaway could effectively suppress and extinguish the fire without re-ignition. Several different kinds of extinguishing equipment were tested such as the *Cobra Ultra High-Pressure Lance (UHPL)*, and Insulated Penetrating Lance equipment, which can extinguish fires from a safe distance using a water mist that can penetrate walls and other hard surfaces.

A final full-scale EV fire test was conducted to determine the potential response time and water consumption. The vehicle cabin was extinguished using a conventional firefighting nozzle for about four minutes, then Thermal Imaging equipment was used to identify the hottest spots within the battery. The Cobra UHPL was used, for approximately 5 minutes, to penetrate both the car bodywork and the battery casing and apply water within the battery itself. The total period of fire suppression activity lasted 10 minutes and consumed a total of 750 litres of water to fully extinguish the fire. The vehicle was also lifted and dropped several times to stimulate rough handling, however no reignition occurred⁵⁹.

The new cutting extinguisher method has also been successfully tried on real EV fires in both Norway and Czech Republic. The incident in Czech Republic involved an electric vehicle fire in an underground garage in the district of Prague, and the intervention was further complicated by the elevator system for transporting vehicles. Firefighters arrived at the scene wearing protective gear and used several water nozzles, including the COBRA cutting extinguisher, to break through the battery casing to cool it down. The fire was extinguished after two hours, and the vehicle was transported to the road where it was loaded into a special container for cooling. The EV was then transported to a water filled container under constant supervision of firefighters and monitored by a thermal camera. The case study from Prague was meticulously documented, describing the scenario of the burning EV in a parking garage and provides general guidelines on what first responders should do during EV fires, including high quality photos to show how the intervention was carried out⁶⁰.

As EVs are becoming increasingly prevalent around the world, thermal runaways and fire incidents involving these vehicles can be expected to occur with greater frequency. EV fire incidents represent new hazards that fire service organizations need to understand and develop efficient, effective, and safe fire

⁵⁹ [CTIF – Safe EV Fire Extinguishing Practices with Minimal Water](#)

⁶⁰ [CTIF – New Cutting Extinguisher Method for EV Fires](#)

control strategies. While there is currently no blueprint for putting out fires involving electric vehicles, firefighting and rescue agencies have started to investigate and test specialized procedures for containing such fires. As a relatively new field of study, EV firefighting is likely to see changes in best practices in the coming years.

Recommendations

- Coordinate with the Fire Department to make them aware of the locations for EVs, in case firefighting is needed. Review and update as needed fire fighting procedures to address the different approach for EV fires.
- Develop and communicate clear emergency response protocols for EV-related incidents, such as accidents, fires, or vehicle malfunctions. Ensure drivers are aware of emergency procedures and receive training on how to safely evacuate or respond to different scenarios.
- When facilities are retrofitted to implement EVSE and maintenance infrastructure, evaluate technologies that can monitor and mitigate potential EV fires such as thermal imaging cameras and gas sensors to identify sudden fluctuations or irregularities that can indicate potential issues leading to thermal runaway.
- Stay informed about local, provincial, and federal regulations related to EVs and fleet management and ensure that fleet operations comply with the latest safety standards, environmental regulations, and industry best practices.

Workforce Training and Development

ZEV adoption is still in its early stages across Canada, and as with any new technology, staff will need to gain experience using new equipment to ensure their safety and equipment reliability and longevity. The Canadians' Awareness, Knowledge, and Attitudes Related to Zero Emission Vehicles Survey, published in 2023, found that approximately 59% of survey respondents have never driven or ridden in a ZEV, while only half of these respondents were aware of how far an EV can go on a fully charged battery ([Link](#)). The lack of education and awareness of new ZEV technologies is frequently identified as key barriers to ZEV adoption.

Similarly, municipalities looking to transition their corporate fleets to ZEVs can face barriers due to these knowledge gaps. Although municipal fleet electrification will have many long-term benefits for the Town, staff, and the wider community, the process of transitioning the fleet from ICEVs to ZEVs is likely to raise questions among staff, especially those who are required to operate municipal vehicles and equipment on a regular basis. These concerns and questions raised by staff can be partly due to the lack of knowledge and familiarity of ZEV technology.

To ensure a successful transition to ZEVs and equipment, the education and training of fleet drivers, as well as improving ZEV technology awareness among city staff in general, will play a key role in making the behavioural changes required for the Town's corporate fleet ZEV transition to be successful.

Establish a Culture within the Organization

Using EVs as part of routine operations will require a behavioural change amongst drivers. Rather than filling up a gas tank, drivers will be required to unplug their vehicle at the beginning of a shift and plug them back in at the end of a shift. To embed this routine habit among drivers, a shift in driver habits will be needed, which can be supported by establishing a culture of ZEV knowledge within the Fleet Services Department and wider organization.

For the Town's current PHEV fleet, because the vehicles can operate on gasoline and charging is optional, routinely plugging in vehicles is not a requirement for operation. As a result, many of the Town's PHEVs may be operating on gasoline alone, eliminating the emissions reduction benefits of the PHEV system. As observed during an April 2024 site visit, current charging cables for the Town's fleet of Hyundai Sonata PHEVs were not operational and had been left unplugged (Figure 26).



Figure 26 - Existing Level 1 EV Charging Cable at Operations Centre, April 2024

As the Town transitions away from PHEVs to full BEVs, charging will become a requirement. In order to ensure the success of the program and reliability of the fleet, the Town should work to establish a culture of awareness about the successful operation of ZEVs. This could begin immediately with the current fleet of PHEVs by ensuring all charging cables are operational, and by encouraging or requiring staff who operate PHEVs to plug them in at the end of a shift. This would also require designating parking stalls adjacent the charging cables for exclusive use by PHEVs.

Recommendation

- Take the first step towards EV deployment by leveraging the existing PHEV fleet and underutilized charging infrastructure:
 - Designate a handful of stalls for exclusive use by PHEVs/EVs.
 - Ensure charging equipment is plugged in and operational.
 - Encourage or require drivers of PHEVs to park in designated areas and plug vehicles in at the end of their shift.
 - Evaluate the program's success over the short term and use early lessons as the basis for developing driver training materials for the future EV rollout.

Highlight Climate Goals

Before undertaking specific ZEV education and training, it is important that staff first understand the reasons for the shift to low-carbon technology. Staff should be made aware of the Town's policies, directives, and goals towards achieving net-zero emissions. Improving awareness of the Town's broader vision for reducing GHG emissions can help motivate staff and contribute to a common understanding about the reason for the transition, while informing them how they have an individual role in making the transition to a low-carbon future a success. It is important to be transparent about the Town's fleet transition goals, including some of the challenges that are expected, how it may impact operations, and potential strategies to help overcome these challenges.

Conduct Employee Engagement

While the Fleet Services Department will generally be responsible for leading all internal fleet transition efforts, it will be important to identify all internal stakeholders and decision-makers who will be impacted by the transition and can contribute to successful ZEV adoption. Engaging Town staff early on and

keeping them informed of Fleet Services' efforts can help to foster a sense of ownership in the Town's sustainability efforts and encourage staff to embrace the Town's mission.

Open communication with Town staff throughout the transition will be essential, which can be achieved through regular progress updates and scheduled Q&A sessions to give staff an opportunity to voice questions, concerns, or feedback about operating and charging electric vehicles. The Town can work with staff to:

- Identify early challenges in the fleet transition process, such as issues related to maintenance and operations that are not captured via onboard telematics software or through the networked charging station dashboard.
- Manage charging best practices and methods to ensure all vehicles are adequately charged for their day's activities, and all vehicles that need access to a charging station can obtain access when needed.
- Make updates to education and training programs if there are any gaps in the information.
- Develop incentives and recognition programs to encourage good driver behaviour and charging etiquette, such as recognizing vehicle operators who drive most efficiently.
- Refine vehicle monitoring programs to suitably track and analyze driving behaviour, energy usage, and charging patterns to best ensure vehicle longevity and operator safety.

Recommendation

- Develop a strategy for communicating the Town's climate goals with staff and establish recurring Q&A sessions to foster more open dialogue and collect feedback on the Town's corporate fleet ZEV transition strategy.

Identify and Coordinate Team

A critical step in the fleet electrification process will be to assemble a team within the Town who will coordinate and manage the implementation of ZEVs and associated infrastructure, as well as the monitoring and reporting upwards within the organization.

The following key stakeholders and suggested roles and responsibilities can form part of the Town's ZEV and infrastructure implementation team:

- **Fleet Manager(s)** – Leverage the recommendations of the Sustainable Green Fleet Strategy, including the BetterFleet fleet transition plan, to determine which vehicles and equipment are ready for transition. Determine what parking areas should be designated for EVs with charging stations installed. Coordinate with vehicle and equipment operators. Participate in regular market and dealer engagement to ensure new fleet vehicles meet all operating requirements.
- **Facility Electrical/Energy Managers** – Help to integrate EVSE into overall facility energy plans, including reviewing the location of the EVSE placement, considering how the EVSE will affect facility energy planning, and revising the facility energy plan to account for EVSE.
- **Vehicle and Equipment Operators** – Key fleet electrification stakeholders that will be operating the electric vehicles and responsible for charging EVs at fleet facilities or while in transit. Will require mandatory education and training with regards to charging and operating EVs and battery-powered equipment.

Recommendation

- Identify key stakeholders within the Town who will act as ZEV champions and coordinate a team to engage with staff at each site location where corporate vehicles and equipment are being converted to ZEVs.

Develop Educational/Awareness Materials

The lack of knowledge and awareness with battery electric and hydrogen fuel cell technology has been recognized as one of the leading barriers to wider adoption of ZEVs. Though this is less challenging for

the Town's fleet since the vehicles are not privately owned by individual operators, lack of knowledge can still pose a challenge to some operators due to uncertainty around operation. The Town can work with fleet operators to develop education and training programs to overcome knowledge barriers and minimize impacts to day-to-day operations.

Educational materials can include information that addresses the lack of familiarity with the technologies and specific concerns such as range anxiety, how to use charging infrastructure, and how new technologies may impact day-to-day operations. Materials can also include general information such as cost-benefits of transitioning to ZEVs and equipment, environmental awareness, and shared experiences of other cities that have undergone successful early fleet transitions. Educational materials can be developed and shared with fleet managers and vehicle and/or equipment operators to reduce the learning curve on ZEVs and equipment.

Educational resources can include printed or digital materials, as well as multimedia training resources such as instructional videos that demonstrate how to use charging infrastructure or ideal EV driving and charging practices. The Town can also refer to Electric Autonomy Canada or other industry organizations that offer online learning programs and resource hubs to educate and empower fleet operators during the transition to ZEVs⁶¹. Educational programs can also include EV Drive Days, to provide staff with the opportunity to test drive EVs and operate charging infrastructure, to familiarize themselves with the new driving experience and potentially alleviate any reservations staff might have about the transition to ZEVs. This could be expanded beyond fleet operators to other Town staff to help encourage broader awareness and contribute to the corporate mission.

Overall, education and awareness programs for Town staff should:

- Provide comprehensive information about the benefits of EVs, including reduced emissions, lower operating costs, and their role in sustainability initiatives.
- Highlight the ease of use and charging infrastructure availability.
- Address common misconceptions and concerns about EVs, such as range anxiety and charging time.
- Provide links to further resources (e.g., local incentive programs) should staff be interested in learning more about ZEVs.

Recommendation

- Develop a series of educational and awareness materials and programs for Town staff that aims to promote the positive impacts of transitioning corporate fleets to ZEVs and equipment and overcome any knowledge barriers regarding ZEV technology.

Develop Driver/Operator Training Programs

In addition to educational materials and resources, a core component of effective ZEV adoption will be comprehensive training programs for vehicle/equipment operators and maintenance technicians. Training programs will demonstrate how to operate a ZEV or battery-powered equipment and how to charge them effectively while maximizing efficiency.

ZEVs and equipment have different maintenance and repair needs than traditional ICEVs. Effective driver training programs are essential for transitioning to ZEV fleets. Training programs should include:

- Basics of operating ZEVs and EVSE including safety guidelines and usage policies related to ZEVs and charging infrastructure, such as:
 - How to charge vehicles efficiently.
 - How to maximize range by reducing power consumption.
 - How to increase effectiveness of regenerative braking and one-pedal driving.

⁶¹ [Electric Autonomy Canada – EV Fleets Pro Course](#)

- The importance of slow acceleration and moderate highway speeds.
- When to charge a vehicle (e.g., minimum threshold at which to charge).
- On-road training – teaching drivers how to operate ZEVs safely and efficiently, guidance on managing and optimizing battery range. Most EVs are equipped with regenerative braking which helps charge the onboard battery when the vehicle is coasting and can sometimes be toggled on and off by the driver. Regenerative braking behaves differently to traditional braking and can sometimes bring the vehicle to a complete stop without a driver depressing the brake pedal. These sorts of features should be highlighted during training so that drivers can operate vehicles safely and comfortably on day one.
- Maintenance tasks specific to ZEVs and how they differ from traditional ICEVs. Many ZEV manufacturers offer training for mechanics to safely repair vehicles, such as managing high voltage batteries. Specialized training courses are often available via colleges and should be evaluated if broader staff upskilling is needed. The Town can consider partnering with local colleges as part of maintenance training.

Recommendation

- Provide comprehensive training to drivers on the safe operation of electric vehicles including understanding EV-specific features, charging procedures, regenerative braking, and emergency protocols. This can be incorporated into the Town's Vehicle Use Policy which should be updated to reflect operation of EVs, such as driver expectations and charging etiquette.

End of Life Planning

End of life (EoL) planning for EVs differs from ICEVs due to the additional steps for managing proper repurposing and/or disposing of EV batteries once vehicles are retired. Also, because of their rapid advancement, the next generation of ZEVs may have different infrastructure requirements than those procured in the next few years. As vehicles are being retired, EoL planning will need to consider the compatibility of new ZEVs with early infrastructures.

EV batteries are complex manufactured products that may contain, among other things, materials that are classified as “toxic” for the purposes of the Canadian Environmental Protection Act (CEPA) and other legislation. The most significant environmental, social, and health risks and impacts of battery life cycles occur during the raw materials extraction and processing phase of battery production and at EoL.

EV batteries can be considered to have reached EoL for a number of reasons. They may fail entirely and be unable to be repaired, or their performance may degrade over time and impact vehicle performance, typically in the range of below 80% of original capacity. Early projections suggested EV batteries lifespan of 7-10 years of regular use, however more recent assessments suggest that battery lifetimes in vehicle applications are likely to last much longer. This is positive, since fleet vehicles may be able to be kept longer than they are today, reducing replacement frequency and saving on capital costs.

Since the Town currently auctions off its EoL vehicles, it is unlikely that the Town will repurpose the batteries from its future EVs. However, there could be opportunities to do so. Once batteries reach EoL and are removed from the vehicle, there are three major options available for their management:

1. Repurposed for a different use or a non-vehicle “second-life application,” such as energy storage.
2. Recycled to recover and reuse source materials and components, and final disposal of remaining materials.
3. Disposed directly via storage, incineration, or landfill (in rare cases).

A recent report by the Sustainable Energy Initiative found that regulatory frameworks for EoL EV battery management are virtually non-existent in North America, however provinces such as British Columbia and Québec are considering implementing policies regarding EoL EV battery management⁶². In Ontario,

⁶² [York University Sustainable Energy Initiative - Post-Consumer Management of End-of-Life Electric Vehicle Batteries](#)

management of EoL EV batteries would typically fall under the Resource Recovery and Circular Economy Act (2016). However, the report confirmed that Ontario will not be including EV batteries under its extended producer responsibility framework for batteries due to assurances by OEMs that EV batteries will be managed properly.

Although a regulatory framework for the management and disposal of end-of-life (EoL) EV batteries are currently not available in Canada, there have been ongoing discussions among key stakeholders and experts in the industry towards developing effective policies. Furthermore, OEMs are partnering with emerging entrepreneurial firms to identify and develop safe processes that will allow batteries to be effectively recycled. As the Town's EV fleet reaches the age of retirement, it is likely that EoL battery management policy frameworks will be put into place by upper levels of government and/or by the OEMs of the vehicle industry.

Planning for the retirement of ZEVs in a fleet involves several key considerations to ensure a smooth transition and maximize the environmental benefits of these vehicles. The following are some steps to consider for the EoL planning of ZEVs in the Town's fleet:

- **Lifecycle Assessment** – Understanding the expected lifespan of ZEVs in your fleet. This includes evaluating the durability and reliability of the vehicles, as well as any warranties or guarantees provided by manufacturers.
- **Replacement Schedule** – Update the replacement schedule for ZEV fleet based on their expected lifespan and performance. Consider factors such as mileage, usage patterns, and technological advancements that may affect the optimal replacement timeframe. The BetterFleet model assumes vehicle replacements in line with the current Town practice for vehicles in that category. ZEVs may last longer (or shorter) than their ICEV equivalents, so re-evaluation of the replacement schedule over time may be required.
- **Financial Planning** – Budget for the replacement of ZEVs in the fleet. This includes the costs of purchasing new vehicles, as well as any associated infrastructure upgrades or maintenance expenses. It is important that any charging infrastructure for vehicles be installed prior to the vehicle's delivery, so it is available for use on arrival. Infrastructure delays could compromise the Town's operations by leaving a vehicle without reliable access to charging. In the long term, as ZEV prices are expected to slowly achieve price parity with ICEVs, budgets may need to be adjusted to reflect lower purchase costs.
- **Environmental Impact** – Consider the environmental impact of retiring ZEVs. Determine the most environmentally sustainable disposal or recycling options for batteries and other components and ensure compliance with any regulations or guidelines related to hazardous materials. Evaluate whether any different processes will be required for auctioning used ZEVs compared to ICEVs.
- **Infrastructure Planning** – Ensure that your fleet infrastructure, such as charging stations or hydrogen refueling stations, is compatible with the next generation of ZEVs. Plan for any necessary upgrades or expansions to support the transition to newer vehicle models. For example, many manufacturers are adopting a new North American Charging Standard (NACS) for their vehicles, which will share a common plug. Many older vehicles are not compatible with NACS or will require an adapter. Though increased standardization is expected over time, early EVs may use different equipment than those procured beyond 2030.

Recommendations

- Establish appropriate vehicle lifecycle standard for municipal EVs, based on early EV deployment. EVs may have a longer or shorter lifespan the ICEVs, depending on the nature of their use.
- Assess EoL planning impacts of ZEVs compared to ICEVs, and implement any necessary procedures to accommodate these impacts.

Purchasing versus Leasing

Fleet Services currently purchases vehicles and equipment outright. At the end of their service life, vehicles and equipment are auctioned. With a switch to EVs, and questions about how the technology will perform in certain settings, leasing has become a consideration for some municipalities and fleet operators. For example, in 2021, the City of Saskatoon leased four electric Chevrolet Bolts on a five-year term to evaluate the vehicles' performance, cost, and usefulness⁶³. Though the City ultimately intends to replace its entire fleet with ZEVs, the pilot will help shape the electrification strategy.

Particularly in light-duty applications, EVs are performing well in municipal fleets throughout North America, with lower operating costs and minimal battery degradation over the long term. For these vehicles, purchasing is likely to remain the preferred choice for most operators, given the long-term reliability that has been demonstrated, and financial advantage relative to leasing. However, EVs generally do not retain their value and depreciate faster than their ICEV equivalents. This means that the Town may not recapture as much money, on average, when EVs are auctioned. Because most municipal fleets are still early in the EV adoption phase, and EV technology is advancing rapidly, there are few data points on how this change in auction value will impact EoL planning and the matter of purchasing versus leasing.

For the recommended FCEV pilot of a medium- or heavy-duty vehicle, leasing could be considered, given that significant infrastructure investments are unlikely to be made to support one or two vehicles, and the ultimate deployment of FCEVs will depend on the performance during the pilot. If the pilot is successful, the next FCEVs could then be purchased using the Town's typical procurement model. Leasing could also be considered for some medium- or heavy-duty EVs if there is concern about performance, or a pilot project is desired.

Of note, lease durations are typically around three years, which is about a third of the average recommended vehicle retention period for the Town's fleet (seven years for light-duty, nine years for medium-duty, and 12 years for heavy-duty vehicles). This could be beneficial for a pilot deployment where a shorter trial period is desired but would increase expenditures in the long-term relative to purchasing, since vehicle turnover would be far higher.

Recommendations

- Consider how leasing an FCEV or medium-/heavy-duty EV could enable a streamlined and lower-risk pilot project for the Town.
- Evaluate whether other municipalities move to a leased vehicle ownership model for some fleet vehicles and use this to inform the Town's own planning process.

⁶³ [Saskatoon Star Phoenix - City of Saskatoon Lease Four Electric Cars for Pilot Project](#)

7. Fleet Transition Costs

This section presents the costing associated with the fleet transition scenarios, compared to business as usual (BAU) operations, and discusses where capital and operational cost savings could occur. Figures are high-level in nature and represent the anticipated rough order of magnitude costs suitable for preliminary long-term capital planning. Detailed site-specific design and infrastructure costs, vehicle costs, and energy costs should be confirmed as the plan is progressed through more detailed stages of planning and design.

Cost Estimate Assumptions

The BetterFleet model makes the following default assumptions where applicable:

- This analysis assumes that operations of today are a good representation of operations in the future, i.e., consistent fleet size and vehicle kilometres travelled.
- Where EVs are recommended, it is assumed that they can replace ICEVs on a 1:1 basis without incurring additional operating kilometres.
- Operations and maintenance (O&M) costs for existing fleet vehicles were not included; only for new ICEVs and ZEVs procured across the BAU, Cost Optimized, and Technology Leadership scenarios.
- Current year gasoline prices were modelled at \$1.75/litre for petrol and \$1.85/litre for diesel, and annual escalation of these prices were applied in line with economist projections (around 1.7% annually).
- The electricity rates were set at \$0.33/kWh.
- Annual electricity rate escalations were applied in line with economist projections.
- Purchase price, vehicle make, model, and year, annual mileage, expected retirement date, and primary parking location of each vehicle were considered in the modelling as provided by the Town in their current fleet inventory.
- For vehicles with no known purchase price, industry benchmarks for the specific vehicle were assumed with no applied discounts.
- The useful life of EVs was assumed to be equal to the useful life of ICEVs.
- To estimate the operating cost for EVs, the analysis estimates the energy use considering the average annual mileage divided by the fuel economy, both using the average value by vehicle category. The operating cost is the energy use multiplied by the electricity price.
- Considerations of charging infrastructure and site upgrades were not drivers in evaluating a vehicle's suitability for being replaced with an EV.
- Town data was used where provided, considering the fleet age, useful life, mileage, and other important inputs. Otherwise, industry standard values were used as needed.
- Fleet residual costs are derived based on depreciation of the vehicle.
- Charging infrastructure costs include both charging station capital costs and placeholder site infrastructure upgrade costs. Specific infrastructure upgrade costs are site-specific and not known at this stage.
- Maintenance costs are derived based on the service and tire cost per unit distance for the current vehicle and the replacement vehicle from the database.
- Fuel cost includes cost of petrol/diesel used for operating an ICEV. Fuel costs are configurable from the "Indices" setting under the fuel section in the online portal, for which access has been provided to the Fleet Service manager.

- Electricity costs include cost of electricity usage for operating a BEV. Electricity costs are configurable from the “Indices” setting under the Electricity section in the online portal.

Cost Optimized Scenario

The annual costs of the Cost Optimized scenario vary, with a peak at the inception year (due to the volume of overdue vehicles scheduled for replacement) and more consistent costs in following years. The average annual costs for capital, maintenance, and operating costs are \$2,347,274, which falls to \$1,864,786 when vehicle residual values are incorporated. The total cost of the scenario between 2024 and 2039 is \$37,556,389, and \$29,836,574 when vehicle residual values are incorporated. Annual costs are similar to BAU, become slightly cheaper over time, and offer cost savings over the lifetime of the plan. Figure 27 shows the annual costs of the scenario.

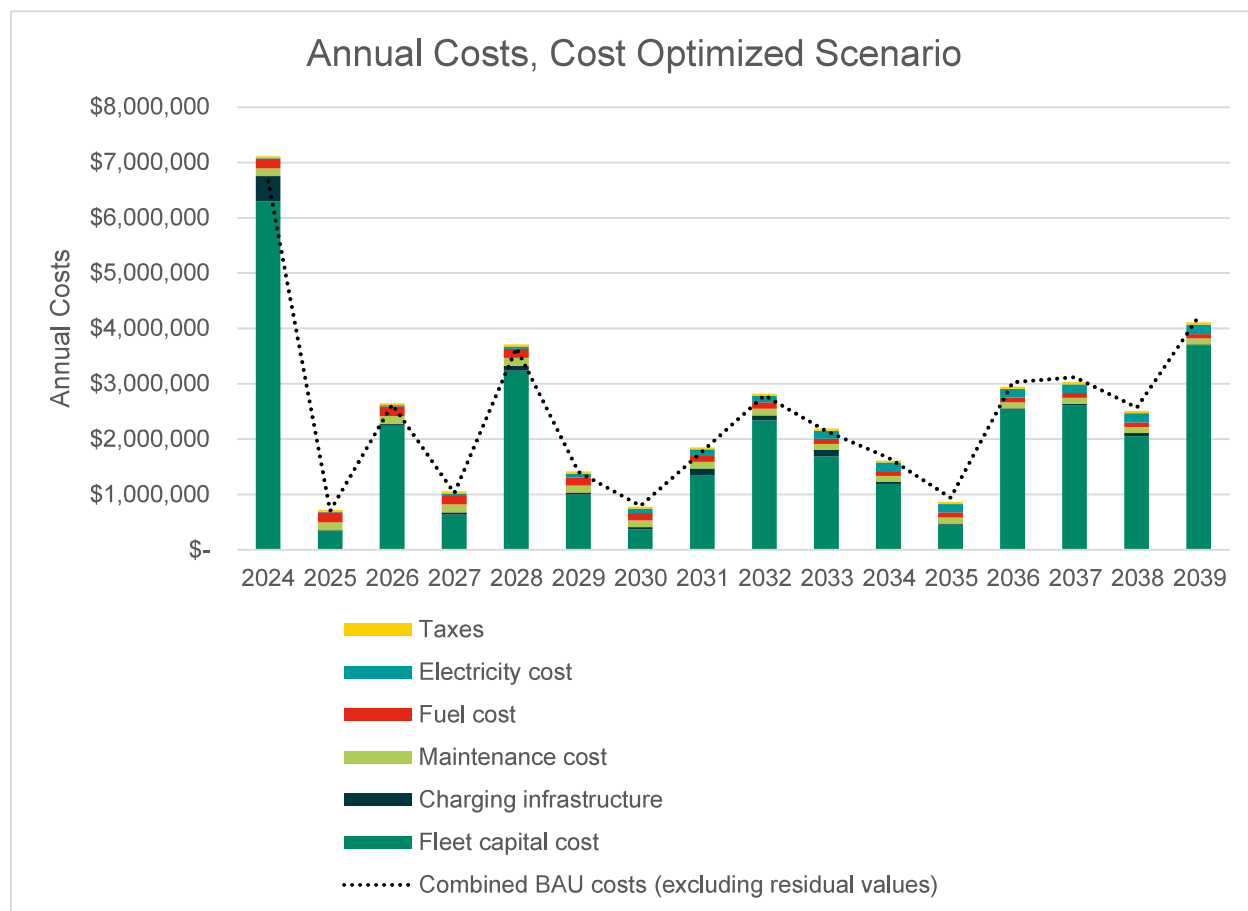


Figure 27 - Annual Costs, Cost-Optimized Scenario

Technology Leadership Scenario

Similarly to the Cost Optimized scenario, annual costs for the Technology Leadership scenario vary from year to year, with peaks at the inception year and in 2039 as a large volume of vehicles are replaced. The average annual costs for capital, maintenance, and operating costs are \$2,758,543, which falls to \$2,276,046 when vehicle residual values are incorporated. The total cost of the scenario between 2024 and 2039 is \$44,136,564, and \$36,416,731 when vehicle residual values are incorporated. Annual costs are slightly higher than BAU, with a significant capital cost spike in 2039 when a large volume of vehicles and infrastructure will be deployed. Figure 28 shows the annual costs of the scenario.

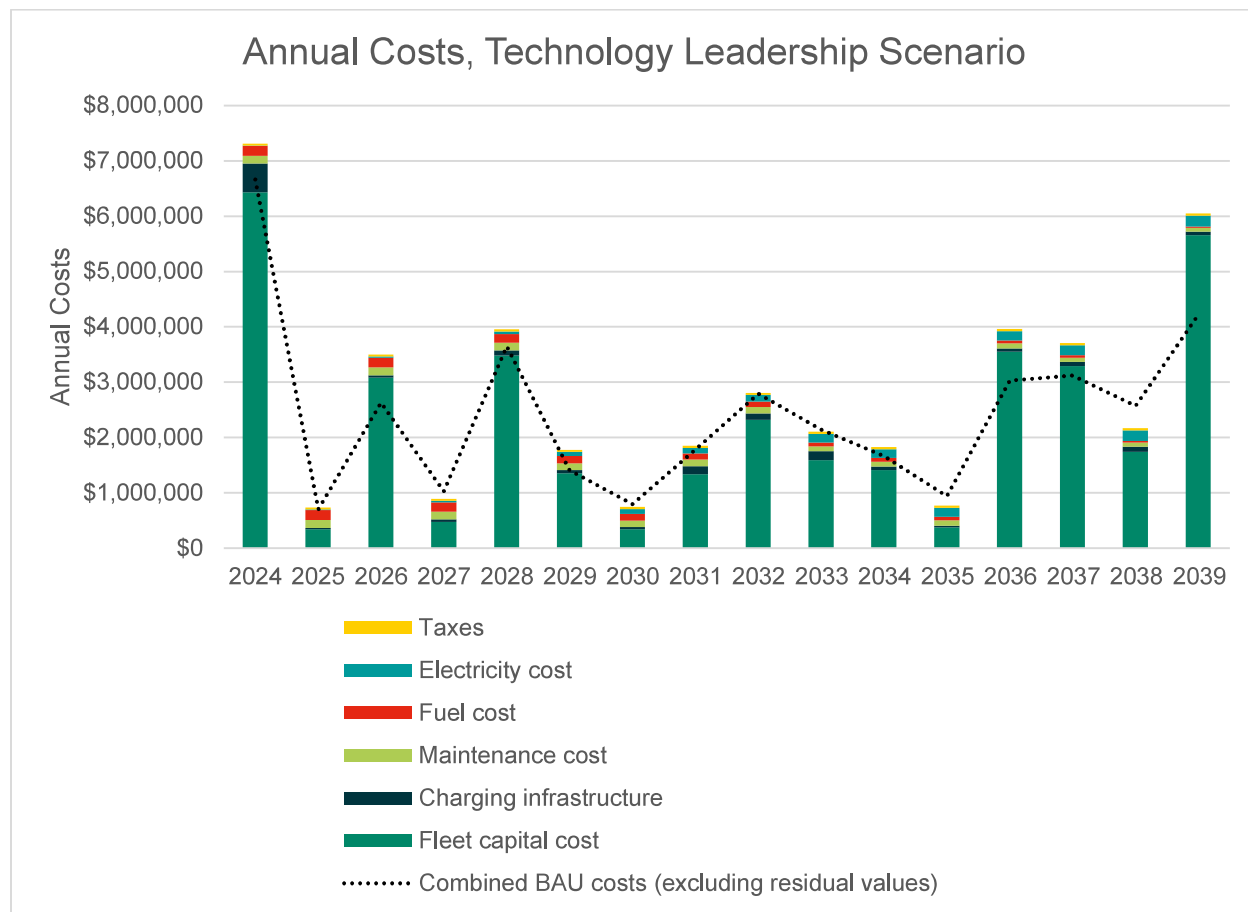


Figure 28 - Annual Costs, Technology Leadership Scenario

Scenario Results Discussion

The cost of transitioning the Town's fleet to EVs over the next 15 years will be significant, with most costs being attributed to vehicle purchases, though the Cost Optimized scenario is expected to result in some minor cost savings in the long-term relative to BAU procurement and operations. Fleet capital costs are expected to increase in the near-term due to the expense of EVs and charging infrastructure, but these costs are partially offset by an anticipated reduction in maintenance and fuel costs.

Between 2024 and 2039, the Technology Leadership scenario is expected to result in about \$6.6 million additional capital and operating costs relative to the Cost Optimized scenario, and \$5.0 million additional capital and operating costs relative to BAU. The Cost Optimized scenario, in contrast, is expected to result in about \$1.6 million in cost savings relative to BAU between 2024 and 2039. The additional costs of the Technology Leadership scenario are associated with additional EV procurements and charging infrastructure, which are not offset sufficiently by slight maintenance and fuel costs savings to achieve cost parity or savings with the Cost Optimized scenario or BAU.

Cost are variably year over year in both scenarios, with peaks associated with new vehicles and infrastructure when a larger volume of ICEVs come due for replacement. The first peak comes in 2024 due to the large number of vehicles in the Town's fleet that are already overdue for replacement. In reality, it is likely that the Town will spread vehicle procurements over a number of years to even out the annual capital costs associated with fleet procurement.

Figure 29 compares the forecasted transition costs by scenario between 2024 and 2039.

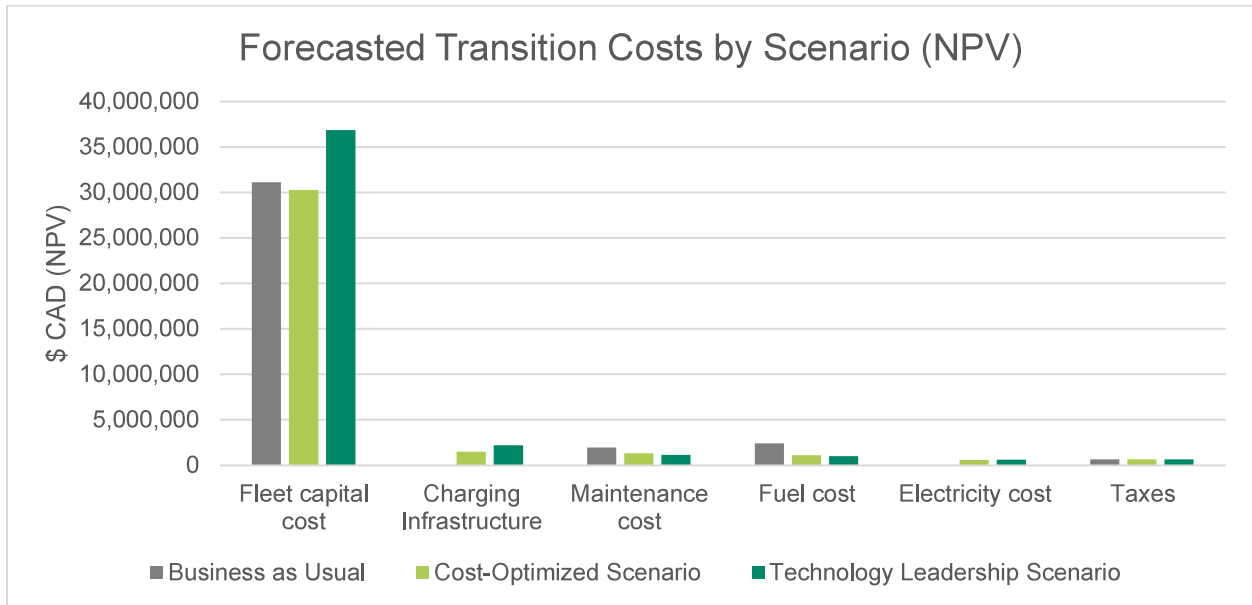


Figure 29 - Forecasted Transition Costs by Scenario, 2024 to 2039

Figure 30 shows the total transition costs between 2024 and 2039.

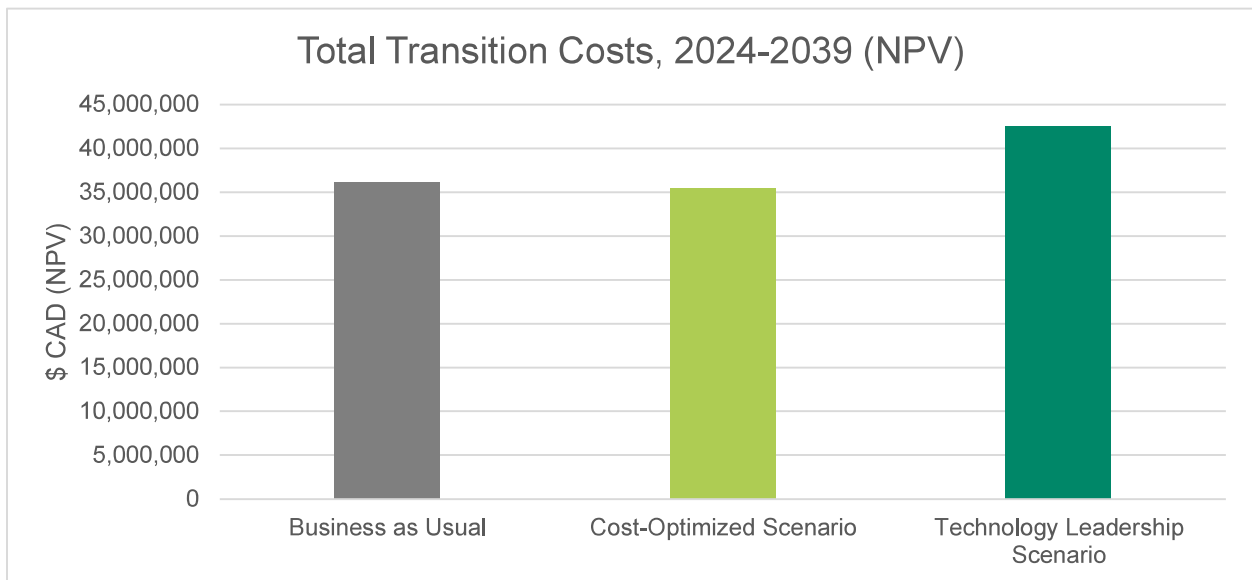


Figure 30 - Total Transition Costs by Scenario, 2024 to 2039

Incorporating the residual value of the fleet, where the Town will recoup some costs when vehicles are auctioned at the end of their service life, the total costs of the program are reduced by about \$7.7 million between 2024 and 2039. Figure 31 incorporates the residual values into the analysis.

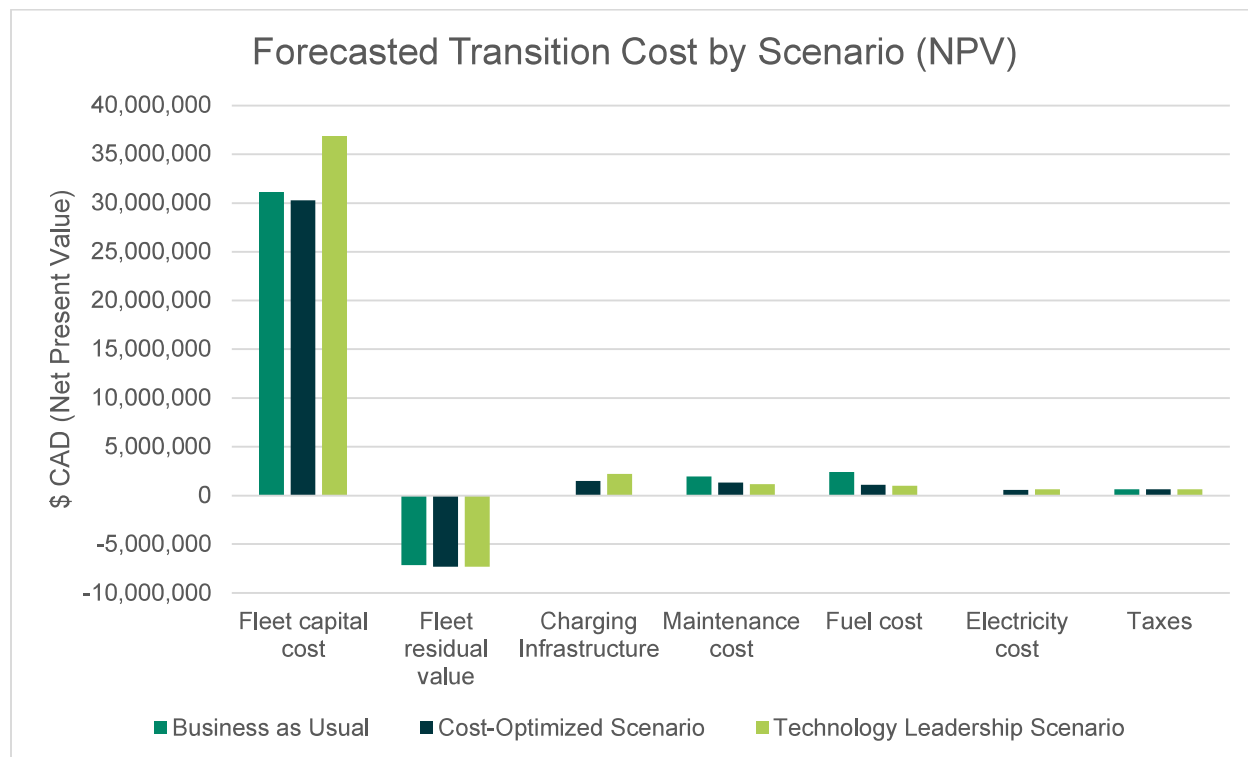


Figure 31 - Forecasted Transition Costs by Scenario, Including Residual Value, 2024 to 2039

Cost Saving Opportunities

Though the Cost Optimized scenario shows that the Town can save costs over the long term as it transitions to EVs, there are still significant capital costs associated with the program. There are several cost saving opportunities to consider, both in terms of capital and operating costs, which can help further reduce the Town's fleet-related expenditures while contributing to emissions reductions. These include fleet right-sizing and downsizing, which have already been evaluated. Beyond fleet right-sizing and downsizing, the Town may consider the cost saving opportunities listed below.

Capital Cost Savings

- Shared infrastructure:** There may be opportunities to share EV charging infrastructure, and FCEV refueling infrastructure (if pursued), between agencies and municipalities. For non depot-based charging, the Town could consider whether on-route charging infrastructure can be leveraged to reduce the amount of charging infrastructure needed and as an interim measure if there are infrastructure delays. Further, public or shared DC Fast Charging could offer quick battery top-up opportunities if the Town prefers to deploy mainly Level 2 charging stations, and could be used by law enforcement or other high mileage vehicles while on duty.
- Infrastructure planning:** With a preferred fleet transition scenario identified, the Town can begin planning for the ultimate buildout of charging infrastructure that is likely to be required in the next 15 years. The full buildout will be greater than what is required in the next few years, but planning for the final configuration at the Town's facilities will help reduce the risk of needing to redesign parking areas when additional charging stations are required. EV make-ready stalls can be included in early deployments, and charging stations added quickly, rather than re-trenching each time new charging stations are needed.
- Incentives and grants:** The Federal government regularly opens funding applications for entities including public fleet operators to support capital projects like EV charging infrastructure, such as ZEVIP. The Provincial government may also offer grants and incentives for projects, as well as the

local utility. Shovel-ready projects tend to be favoured for funding. As the Town advances this strategy, it should continue monitoring Federal, provincial, and utility funding opportunities.

- **Vehicle leasing:** Given the high costs of EVs and uncertainty about advancements in battery technology, the Town may consider leasing certain models on a trial basis instead of purchasing vehicles. This can reduce upfront costs and provide flexibility to upgrade to newer, longer range or more capable models as technology advances.

Operating Cost Savings

- **Advance fleet right-sizing and downsizing:** Based on the results of the 2020 Fleet Utilization Study, consider that reducing the overall scale of the fleet and size of some vehicles could present the greatest cost savings.
- **Leverage telematics and fleet management systems:** Monitoring vehicle and driver performance can support strategies like reduced idle time, better driver behaviour, and optimize vehicle utilization to reduce operating costs. Existing vehicles can be equipped with this software to inform future fleet procurement discussions, such as the right type of vehicle and right quantity.
- **Energy management:** Using smart charging software that is configured to take advantage of time of use rates by the local utility, managing the charging schedule for vehicles should be evaluated to leverage off-peak rates and reduce energy costs. Onsite solar and other renewable energy sources can also be leveraged to meet fleet charging needs.

8. Program Phasing and Monitoring

This section discusses the phasing of vehicles and infrastructure needed to support both transition scenarios. It also provides high-level guidelines on developing monitoring metrics for the fleet transition program, to enable the Town to track progress towards its fleet decarbonization goals.

Fleet Phasing

An average of 18 vehicles are scheduled for replacement each year. Excluding vehicles already overdue for replacement, this falls to 15 vehicles per year. Though the number of vehicles scheduled for replacement each year does not change based on scenario, the recommended fuel type does change for many of these vehicles. Early in the transition, a higher number of ICEVs are replaced by either new ICEVs, HEVs, or PHEVs. Over time, more BEVs are added to the fleet as parity of cost and performance is achieved relative to ICEVs. By the mid-2030s in both scenarios, very few non-electrified new models are being added to the fleet. The selection of individual vehicle models will be at the discretion of the fleet manager, and the fleet phasing strategies depicted below provide a high-level guideline to support that decision-making and inform the costing and emissions modelling.

Cost-Optimized Scenario

Figure 32 shows the annual number of replacements, by fuel type, from 2024 to 2039. Note the large number of overdue vehicles in 2024 is not representative of the average year.

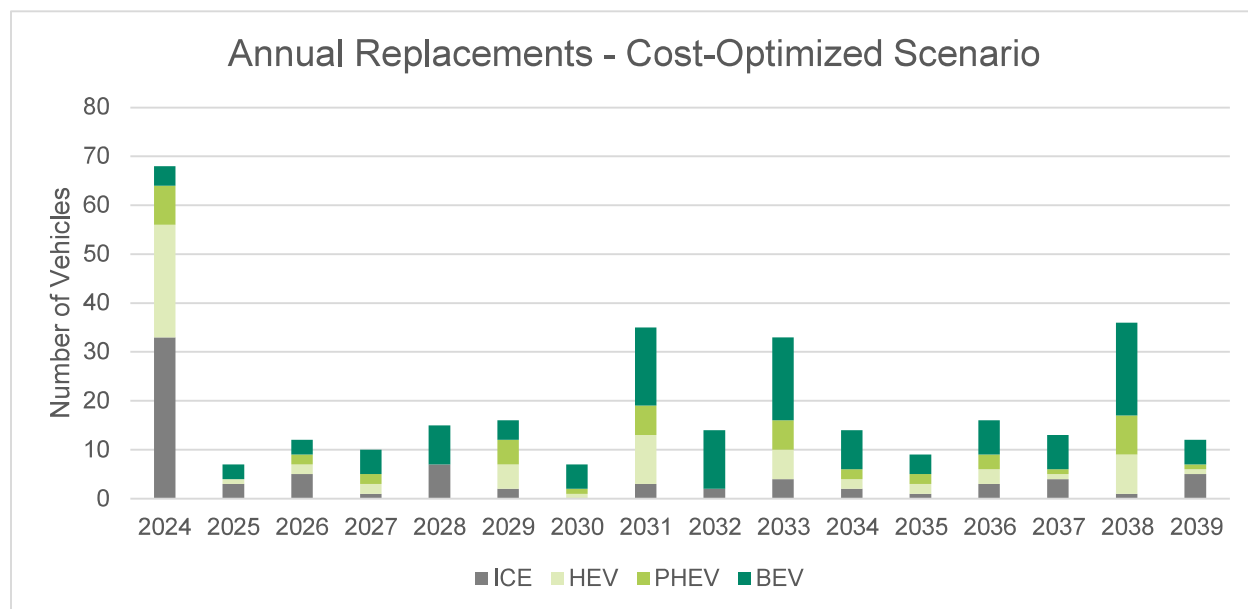


Figure 32 - Annual Replacements, Cost Optimized Scenario, 2024 to 2039

To better understand the average number of replacement vehicles each year, Figure 33 shows the annual replacement schedule from 2025 to 2039. The replacement of the large volume of overdue vehicles will theoretically be spread across the next few years, with about 15 vehicles being replaced each year.

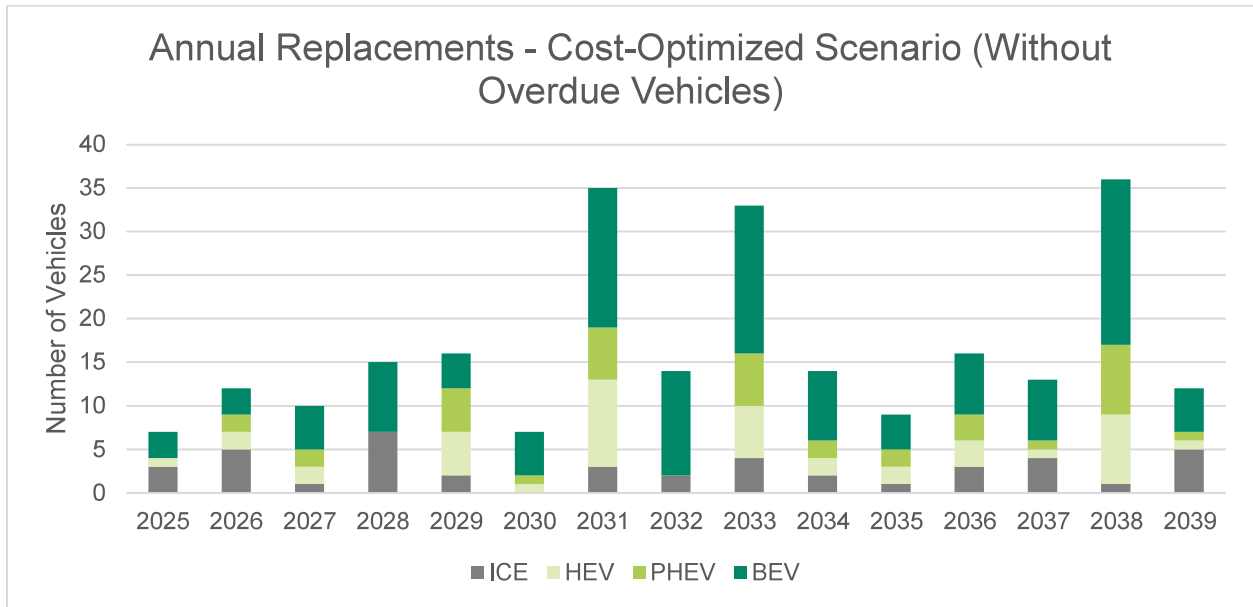


Figure 33 - Annual Replacements, Cost Optimized Scenario, 2025 to 2039

Technology Leadership Scenario

Figure 34 shows the annual number of replacements, by fuel type, from 2024 to 2039. Note the large number of overdue vehicles in 2024 is not representative of the average year.

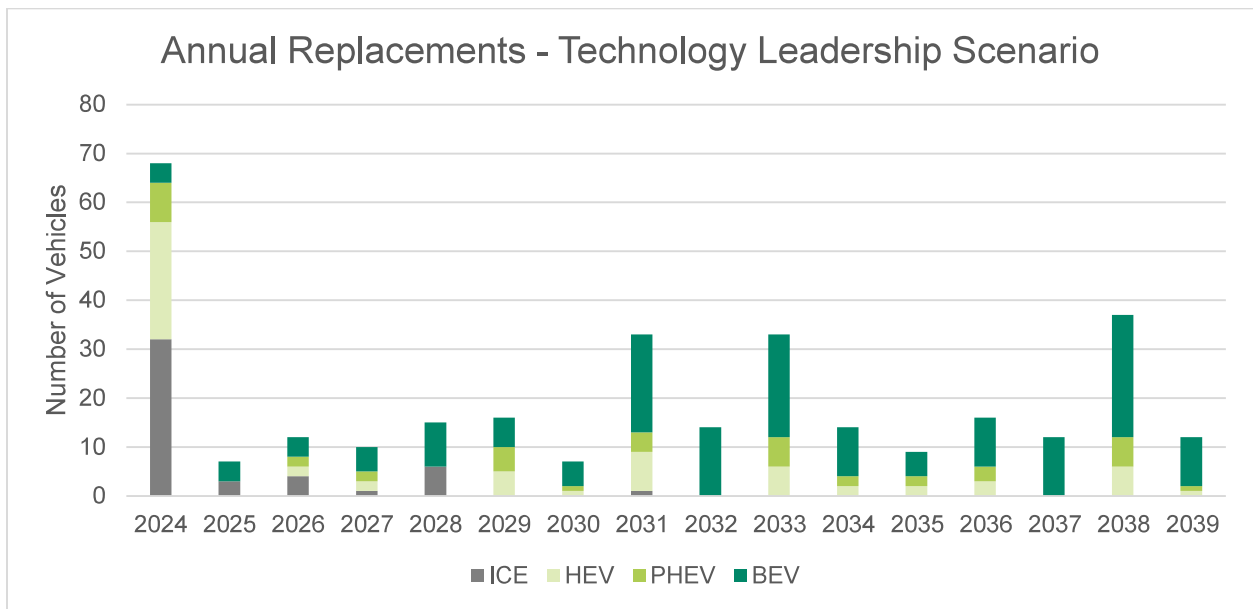


Figure 34 - Annual Replacements, Technology Leadership Scenario, 2024 to 2039

As above, to better understand the average number of replacement vehicles each year, Figure 35 shows the annual replacement schedule from 2025 to 2039.

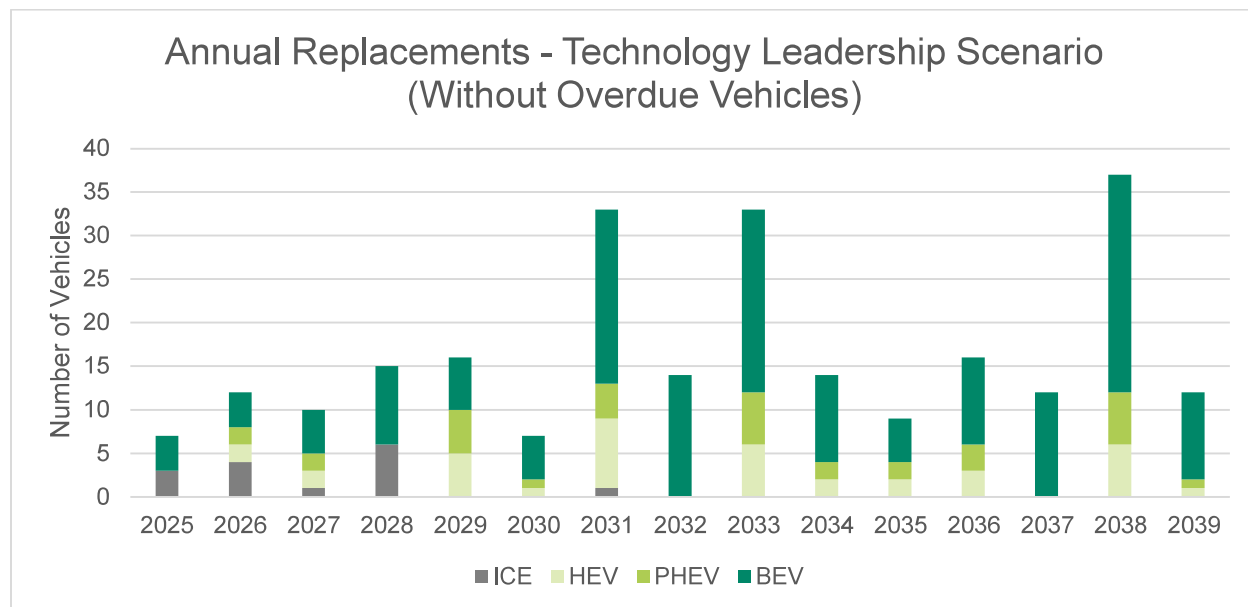


Figure 35 - Annual Replacements, Technology Leadership Scenario, 2025 to 2039

Infrastructure Phasing

The Town's charging station deployment will need to consider site electrical assessments, integration with existing electrical systems, and future expansion capabilities to accommodate additional infrastructure. Consider breaking the deployment into phased packages, aligned with vehicle procurements, such that charging stations are installed and tested for those vehicles before they are ready for service. Table 31 describes high-level infrastructure phases for the Town's deployment, and key considerations. Flexibility to changing vehicle technologies and market conditions will be key. Though the Town should prepare for significant electrical demands at its facilities to meet fleet charging requirements, the installation of charging stations should be aligned with vehicle procurements and be informed by early EV deployments and operational findings.

Table 31 - Infrastructure Phases and Considerations

Phase	Anticipated Period	Considerations
Phase 0 – Existing Infrastructure and Pilot Deployments	2024-2025	Most charging needs can be accommodated within existing electrical infrastructure, and some charging stations which exist can be used to meet most charging needs for LDVs and electric equipment. The Yard Utilization Study will help identify where charging can be placed in the long-term at the Operations Centre. Information from early pilot deployments can inform selection of new EVs and infrastructure. Early coordination with Elexicon should occur during this phase.
Phase 1 – Early Deployments and Preparatory Works	2026-2029	More significant upgrades will be required to support early EV deployments. Based on the findings from the Yard Utilization Study, preparatory works should be undertaken to accommodate future demands such as sizing electrical infrastructure and backup power, preparing the site, installing conduit for charging stations throughout the yard, etc. Upgrades to fleet maintenance facilities may be required at this stage to accommodate EV maintenance, such as new equipment, safety features, etc. More detailed coordination with Elexicon should occur during this phase, including evaluating the addition of a DC Fast Charging Hub at the Operations Centre and the requirements for a new utility connection.
Phase 2 – Major Deployments	2030-2032	Ahead of a large volume of EVs arriving between 2031 and 2034, undertake the larger deployment of charging stations. As more EV

		HDVs become available on the market, DC Fast Charging may become more operationally critical. By this phase, new battery technologies may be available which could impact the type and quantity of charging stations required. The plan developed during Phase 1 can be revisited as needed depending on how the market matures.
Phase 3 – Final Deployments	2033-2039	By this time, most models should be electric. The majority of procurements will be EVs, and some commercially available FCEVs may also enter the fleet. Based on lessons learned from Phases 1 and 2, the final infrastructure deployments can take place.

Cost-Optimized Scenario

The Cost Optimized scenario calls for a total of 77 charging ports to be deployed between 2024 and 2039 to support fleet charging, excluding DC Fast Charging ports. Table 32 summarizes the cumulative number of ports required across all facilities between 2024 and 2039 for the scenario.

Table 32 - Cumulative Charging Port Requirements by Year, Cost Optimized Scenario

	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
Ports	4	7	10	15	23	27	31	45	54	66	69	70	71	72	77	77

Technology Leadership Scenario

The Technology Leadership scenario calls for a total of 108 charging ports to be deployed between 2024 and 2039 to support fleet charging, excluding DC Fast Charging ports. Table 33 summarizes the cumulative number of ports required across all facilities between 2024 and 2039 for the scenario.

Table 33 - Cumulative Charging Port Requirements by Year, Technology Leadership Scenario

	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
Ports	4	7	11	16	25	31	35	51	62	78	83	85	89	95	103	108

Monitoring Activities

To manage uncertainty about the future of EV technology, including the performance of HDVs, battery technology, and charging needs, a series of monitoring activities are recommended to inform future phases of the plan.

- Performance Metrics and Reporting:** Establish and/or confirm performance metrics such as vehicle uptime requirements and emissions reduction targets set by Council. Track these metrics via regular reporting to demonstrate the effectiveness of fleet transition and where changes may be needed to achieve the necessary uptime or emissions savings.
- Vehicle Performance:** Leveraging fleet telematics software which should be outfitted on all new vehicles, regularly review vehicle performance data including energy consumption, charging patterns, and maintenance needs. Use this data to analyze trends and identify areas for improvement.
 - Suggested metric: vehicles equipped with fleet telematics, vehicle uptime, vehicle maintenance costs
- Operator Feedback:** Collect feedback from drivers regarding their experiences with the EVs, including any issues they encounter during driving or charging and suggestions for improvements.

This feedback is crucial for making user-centric adjustments and ensuring Town operations are adequately supported by the new fleet.

- a. Suggested metric: driver satisfaction
4. **Energy Cost Monitoring:** Monitor energy costs associated with charging the fleet. Compare these costs with those of existing diesel and gasoline to assess financial benefits and identify opportunities for cost savings, as well as inform the future fuel demands and reduction in storage capacity.
 - a. Suggested metric: energy costs and fuel costs
5. **Infrastructure Performance:** Evaluate the performance of charging infrastructure, including uptime, reliability, and capacity. Ensure that the infrastructure meets the growing needs of the fleet.
 - a. Suggested metric: charging station uptime and utilization
6. **Routine Safety Inspections:** Conduct regular safety inspections of charging equipment, and/or review contractor inspection reports, to ensure compliance with safety standards and regulations.
7. **Stakeholder Engagement:** Engage with stakeholders, including fleet managers, drivers, and the local utility provider, to gather insights and ensure alignment with program goals.

Appendix A – BetterFleet Model

Appendix A - Cost Optimized Scenario Transition Plan

Asset	Asset Class	Current Vehicle	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
10013	Passenger	Chevrolet Cruze	HEV							BEV							BEV	
11003	Light Commercial	Dodge Caravan	ICE							PHEV			BEV				PHEV	
12014	Light Commercial	Ford F150	ICE					BEV										
12512	Light Commercial	Chevrolet 1500	ICE									BEV						
12513	Light Commercial	Ford F250	ICE									BEV						
12514	Light Commercial	Ford F250	ICE									BEV						
12515	Light Commercial	Dodge 2500	ICE									BEV						
12516	Light Commercial	Dodge 1500	ICE									BEV						
12517	Light Commercial	Dodge 1500	ICE									BEV						
13006	Light Commercial	Dodge 3500	ICE									BEV						
13007	Light Commercial	Dodge 3500	ICE									BEV						
13008	Heavy Commercial	Dodge 5500	ICE									ICE						
13009	Heavy Commercial	Dodge 4500	ICE									ICE						
13010	Heavy Commercial	Dodge 5500	ICE									ICE						
14009	Light Commercial	Mercedes 2500	ICE									PHEV						
14010	Light Commercial	Mercedes 2500	ICE									PHEV						
15001	Passenger	Ford Escape	PHEV							BEV							BEV	
15301	Passenger	Hyundai Sonata	HEV							BEV								
15302	Passenger	Hyundai Sonata	HEV							BEV								
15303	Passenger	Hyundai Sonata	HEV							BEV								
15601	Light Commercial	Dodge Caravan	ICE									PHEV						
15602	Light Commercial	Dodge Promaster		ICE									BEV					
15603	Light Commercial	Dodge Promaster		ICE									BEV					
15702	Heavy Commercial	International 7400					ICE											
15948	Light Commercial	Dodge 2500	ICE									BEV						
16301	Passenger	Hyundai Sonata	PHEV							PHEV							PHEV	
16302	Passenger	Hyundai Sonata	PHEV							PHEV							PHEV	
16501	Light Commercial	Dodge 3500		ICE									BEV					
16701	Heavy Commercial	Freightliner 108SD						ICE										
17301	Passenger	Hyundai Sonata	HEV							HEV							BEV	
17302	Passenger	Hyundai Sonata	HEV							HEV							BEV	
17303	Passenger	Hyundai Sonata	HEV							HEV							BEV	
17304	Passenger	Hyundai Sonata	HEV							HEV							BEV	
17601	Light Commercial	Mercedes 2500			PHEV									PHEV				
17602	Light Commercial	Mercedes 2500			PHEV									PHEV				
17701	Heavy Commercial	Freightliner 108SD						ICE										
18501	Light Commercial	Dodge 3500				ICE									BEV			
18601	Light Commercial	Mercedes 2500				PHEV				PHEV			PHEV				PHEV	
18602	Light Commercial	Mercedes 2500				PHEV												
19001	Heavy Commercial	Ford 5500					ICE									BEV		
19002	Heavy Commercial	Ford 5500					ICE											
19501	Heavy Commercial	Dodge 4500					ICE										ICE	
19502	Heavy Commercial	Dodge 4500					ICE										ICE	

Appendix A - Leadership Scenario Transition Plan

Asset	Asset Class	Current Vehicle	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
10013	Passenger	Chevrolet Cruze	HEV							BEV							BEV	
11003	Light Commercial	Dodge Caravan	ICE							PHEV			BEV				PHEV	
12014	Light Commercial	Ford F150	ICE					BEV										
12512	Light Commercial	Chevrolet 1500	ICE									BEV						
12513	Light Commercial	Ford F250	ICE									BEV						
12514	Light Commercial	Ford F250	ICE									BEV						
12515	Light Commercial	Dodge 2500	ICE									BEV						
12516	Light Commercial	Dodge 1500	ICE									BEV						
12517	Light Commercial	Dodge 1500	ICE									BEV						
13006	Light Commercial	Dodge 3500	ICE									BEV						
13007	Light Commercial	Dodge 3500	ICE									BEV						
13008	Heavy Commercial	Dodge 5500	ICE									BEV						
13009	Heavy Commercial	Dodge 4500	ICE									BEV						
13010	Heavy Commercial	Dodge 5500	ICE									BEV						
14009	Light Commercial	Mercedes 2500	ICE									PHEV						
14010	Light Commercial	Mercedes 2500	ICE									PHEV						
15001	Passenger	Ford Escape	PHEV														BEV	
15301	Passenger	Hyundai Sonata	HEV							BEV							BEV	
15302	Passenger	Hyundai Sonata	HEV							BEV							BEV	
15303	Passenger	Hyundai Sonata	HEV							BEV							BEV	
15601	Light Commercial	Dodge Caravan	ICE									PHEV						
15602	Light Commercial	Dodge Promaster		ICE									BEV					
15603	Light Commercial	Dodge Promaster		ICE									BEV					
15702	Heavy Commercial	International 7400					BEV											
15948	Light Commercial	Dodge 2500	ICE									BEV					BEV	
16301	Passenger	Hyundai Sonata	PHEV							BEV							BEV	
16302	Passenger	Hyundai Sonata	PHEV							BEV							BEV	
16501	Light Commercial	Dodge 3500		ICE									BEV					
16701	Heavy Commercial	Freightliner 108SD																
17301	Passenger	Hyundai Sonata	HEV							HEV							BEV	
17302	Passenger	Hyundai Sonata	HEV							HEV							BEV	
17303	Passenger	Hyundai Sonata	HEV							HEV							BEV	
17304	Passenger	Hyundai Sonata	HEV							HEV							BEV	
17601	Light Commercial	Mercedes 2500			PHEV									PHEV				
17602	Light Commercial	Mercedes 2500			PHEV									PHEV				
17701	Heavy Commercial	Freightliner 108SD						BEV										
18501	Light Commercial	Dodge 3500				ICE									BEV			
18601	Light Commercial	Mercedes 2500				PHEV				PHEV			PHEV				PHEV	
18602	Light Commercial	Mercedes 2500				PHEV												
19001	Heavy Commercial	Ford 5500					ICE									BEV		
19002	Heavy Commercial	Ford 5500					ICE											
19501	Heavy Commercial	Dodge 4500					ICE									BEV		
19502	Heavy Commercial	Dodge 4500					ICE									BEV		

