EXECUTIVE SUMMARY

CITY OF OTTAWA
GREEN FLEET STRATEGY

WSP PROJECT NUMBER: 231-01434-00

ISSUED: DEC 2024 (updated Jan 2025)

EXECUTIVE SUMMARY

WSP has undertaken a Green Fleet Study on behalf of the City of Ottawa, focusing exclusively on the City's diverse fleet assets. Ottawa, the fourth-largest Canadian city by population, faces unique fleet challenges due to its extensive land area, which surpasses the combined size of several major Canadian cities. This study addresses the City's sustainability initiatives, especially since the last Green Fleet Plan in 2009, and a subsequent report to council in 2016, and responds to the climate emergency declared by Ottawa City Council in 2019. The Climate Change Master Plan outlines ambitious greenhouse gas (GHG) emissions reduction targets, and this study aims to guide the city in achieving its goal of zero-emissions fleet by 2040. As part of this strategy, the City's Energy Evolution transportation sector targets are to convert the City's vehicles to hybrid and electric vehicles where possible, following an updated plan to achieve corporate emissions reduction of 100% below 2012 levels by 2040. The study's objectives include developing a phased Green Fleet Strategy, and assessing various low-carbon technologies based on capital and operating costs, technology maturity, operational impacts, and GHG reduction potential. The ultimate goal is to provide Ottawa with a realistic and actionable plan to transition to a low-carbon and zero-emission fleet over the next two decades.

BASELINE

A baseline analysis and business-as-usual scenario to 2040 was created for the City of Ottawa's fleet assets to serve as a baseline for comparing green fleet scenarios. The baseline analysis encompasses cost estimations, vehicle classifications, asset replacement plans, fleet capital costs, operating costs, fuel costs, total cost of ownership, and greenhouse gas (GHG) emissions projections. The analysis classifies the City's vehicles into light (LDV), medium (MDV), and heavy-duty (HDV) vehicle categories and the fleet plan reflects annual purchasing objectives under the business-as-usual scenario.

GHG EMISSIONS

The annual emissions from 2022 to 2023 of the City's current owned fleet is estimated to be 30,700 tonnes of carbon dioxide equivalent (tCO_2e). Among all service areas, Roads, Solid Waste, Land Paramedics, Fire, and Motor Pool are the highest contributors to GHG emissions. This is because these service areas have the highest number of heavy-duty vehicles within the fleet, which contribute to the highest share of emissions annually, followed by specific light-duty classes and equipment.

The 2022 to 2023 GHG emissions are comparable to the 2012 baseline emissions levels at 29,500 tCO_2e, reported in 2021 by the City[1]. The baseline projection over the 2023-2040 timeframe is a forecast based on the current conditions of the fleet (as of 2023), considering the improvement of the internal combustion engine (ICE) technology, represented on the fuel economy, as well as the improvement in the carbon intensity of the fuels used as business as usual (BAU). The 2012 GHG emissions levels are taken as a reference point to the former Corporate GHG emissions inventories and is not a projection.

GHG emissions are projected to decrease from 30,700 tCO_2e in 2023 to over 24,000 tCO_2e by 2040 primarily due to expected improvements in internal combustion engine (ICE) vehicles because of the Federal Clean Fuel Regulations. Given these improvements, compared to the 2012 GHG emissions levels, the projected GHG emissions by 2040 would be 18.2% lower. This marginal improvement, however, is not sufficient for the City to reach its GHG reduction targets. Therefore, it will need to invest in greater measures to reduce fleet emissions.

2012 Baseline (based on Ottawa's GHG Inventory Report): 29,500 tCO_2e reference point

2023 Baseline for this study: 30,7000 tCO_2e. Within the Reduced Emissions and Toward Zero Emissions Pathways, the 2023 baseline is used.

[1]City of Ottawa, Results of the 2020 Community and Corporate Greenhouse Gas (GHG) Inventories, Sept. 2021

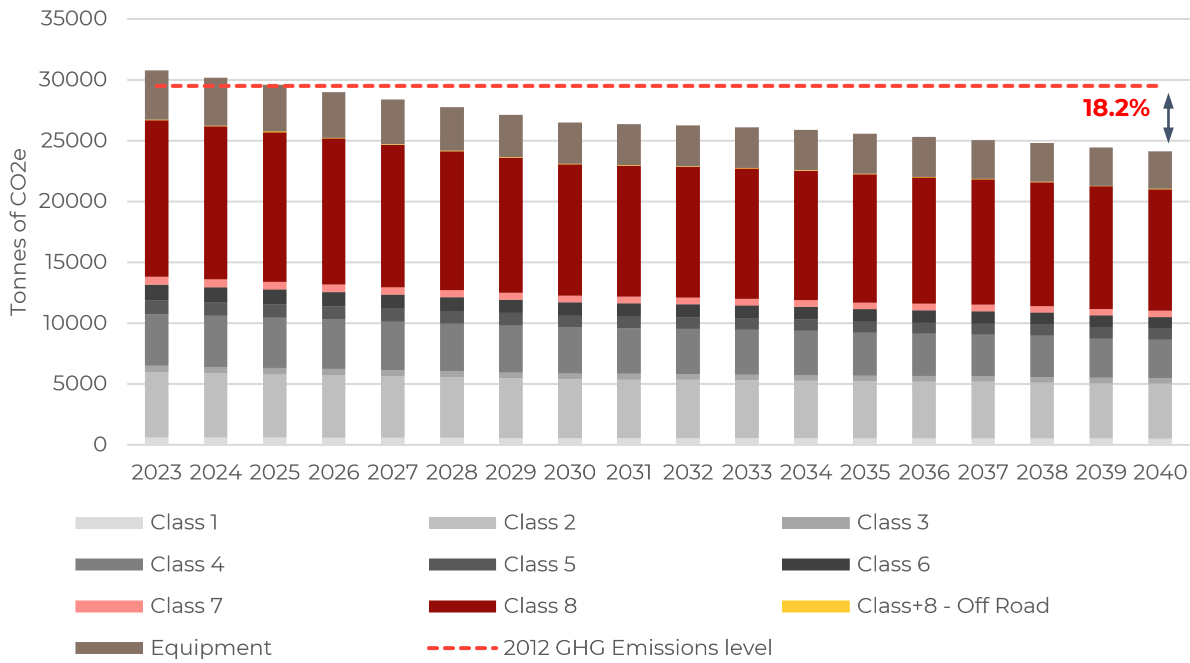


Figure ES - 1: City of Ottawa Vehicle Classes and Associated GHG Emissions to 2040 under the BAU scenario

COSTS

The heavy-duty vehicle segment leads in capital asset investment, with an average annual cost of approximately $20.5 million, which is more than double that of the medium-duty category. Despite heavy-duty's higher capital cost, medium and light-duty assets see a greater number of annual purchases, contributing to the projected peak in total capital investment in 2034.

Maintenance costs, primarily for heavy-duty vehicles, average $27.3 million annually from 2023-2040[2]. Additionally, fuel costs, predominantly from diesel consumption, are anticipated to rise from $16.98 million to $23.24 million, influenced by fuel price fluctuations and carbon tax increases.

The total cost of ownership, encompassing capital expenses and operational costs (maintenance and fuel) for municipal fleet, is projected to reach $1,656 million by 2040, with an annual average of $92 million. Notably, capital investment emerges as the dominant cost component in this comprehensive assessment of the City of Ottawa's fleet operations.

[2] This was compared to the maintenance actual expenditure in 2023 to ensure accuracy. It is within the same order of magnitude, with deviation up to $4 million. Given the excluded assets for this study, this aligns with the operating actual expenditure in 2023.

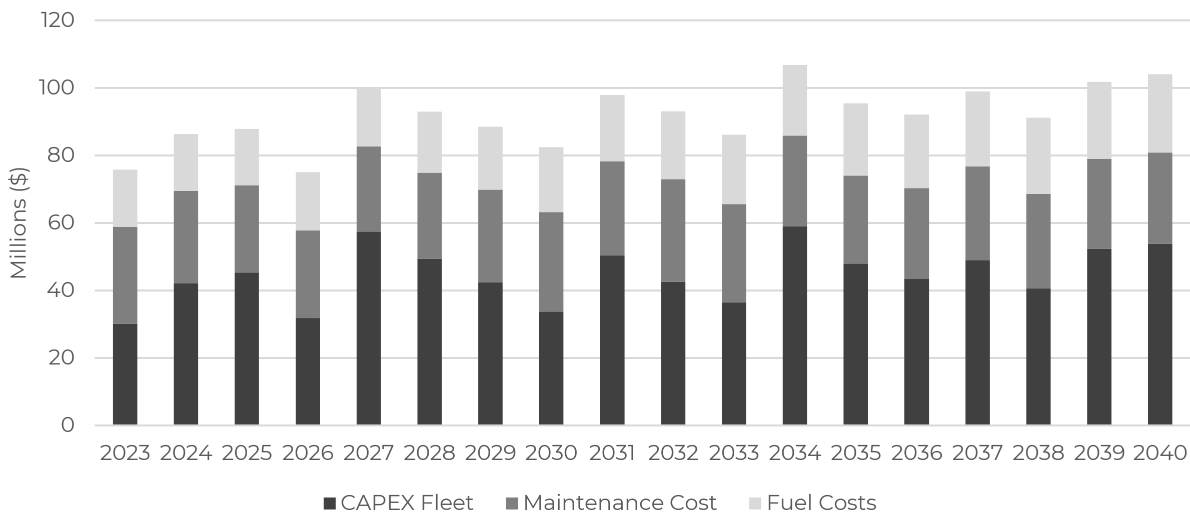


Figure ES - 2: City of Ottawa's Capital and Operating Costs to 2040 under a BAU scenario

Key Recommendation

As heavy-duty vehicles have a disproportionate effect on both emissions and capital costs, it is important to consider alternatives for these vehicles where possible. This means replacing the vehicles with zero-emissions alternatives and considering extending their useful life to reduce high capital expenditures and align with zero-emissions market readiness.

EVALUATION MATRIX

The City of Ottawa's fleet transition to low-carbon energy carriers involves evaluating various technologies for reduced greenhouse gas (GHG) emissions, considering service quality and cost-effectiveness. A comprehensive evaluation matrix, incorporating 23 criteria across light, medium, and heavy-duty vehicle segments, was developed to rank nine technologies over four time intervals (2023-2043). Battery Electric Vehicles (BEV) consistently rank as the most favourable, showcasing zero-tailpipe emissions and diverse market options. Plug-in Electric and Hydrogen Fuel Cell Electric Vehicles (FCEV) follow in suitability, with FCEV emerging as a strong contender for heavy-duty vehicles beyond 2030. The evaluation extends to a temporal analysis, highlighting BEV and FCEV as top choices from 2033 onwards. Key recommendations propose BEVs for light-duty, endorsing a combination of BEV and FCEV for medium and heavy-duty, aligning with market readiness and emission goals. Equipment transitions favor BEV technology, ensuring a diverse and efficient adoption strategy.

Key Recommendations:

1. **Light-Duty Transition:** Integrate Battery Electric Vehicles (BEV) for the transition of light-duty vehicles, considering the readily available technology, established infrastructure, and lower total cost of ownership compared to hydrogen fuel cell vehicles. While acknowledging merits of hydrogen fuel cell vehicles, BEVs stand out as the more practical choice for light-duty fleet vehicles due to extensive infrastructure, lower costs, and technological maturity.
2. **Medium and Heavy-Duty Strategies:** For medium and heavy-duty vehicles, recommend a dual approach involving both Battery Electric (BEV) and Fuel Cell Electric (FCEV) technologies. BEV is suitable for most Class 3-5 vehicles with cost-effective options available. FCEV becomes a viable option for energy-intensive assets in heavy-duty categories, where range limitations are less critical. This strategic combination ensures adaptability to various energy constraints and supports a more comprehensive transition plan.

3. **Equipment Class Transition:** While equipment categories were not explicitly part of the technology evaluation matrix, based on market readiness, Battery Electric (BEV) technology is recommended for transitioning various equipment classes. The versatility and diverse energy constraints within the equipment segment align well with the benefits offered by BEV technology, ensuring an effective transition for a wide range of applications.

AGILE GREEN FLEET PLAN

The City of Ottawa aspires to achieve zero-emissions corporate operations by 2040 (100% GHG reduction below 2012 levels by 2040). After evaluating alternative fuels and technologies, battery electric emerged as a primary solution for light, medium, and heavy-duty vehicles. An agile approach involves periodic reviews (every 5 years, or less) to adapt to evolving technologies, ensuring both short-term progress and preparation for future advancements. Based on the year set for this study (2023), the next market review would be expected by 2027, which makes 2027 a pivotal year for the strategy.

The modelling was based on a review in 2027 to assess the state of battery electric and hydrogen technology. If a review is done outside of the year 2027, further evaluation may be required to determine how the City will meet its targets.

The proposed strategy outlines two phases: a 2023-2027 period focused on reduced emissions and a 2027-2040 phase toward zero-emissions (ZEV).

Description of the two pathways:

1. **2023 – 2027 Reduced Emissions**

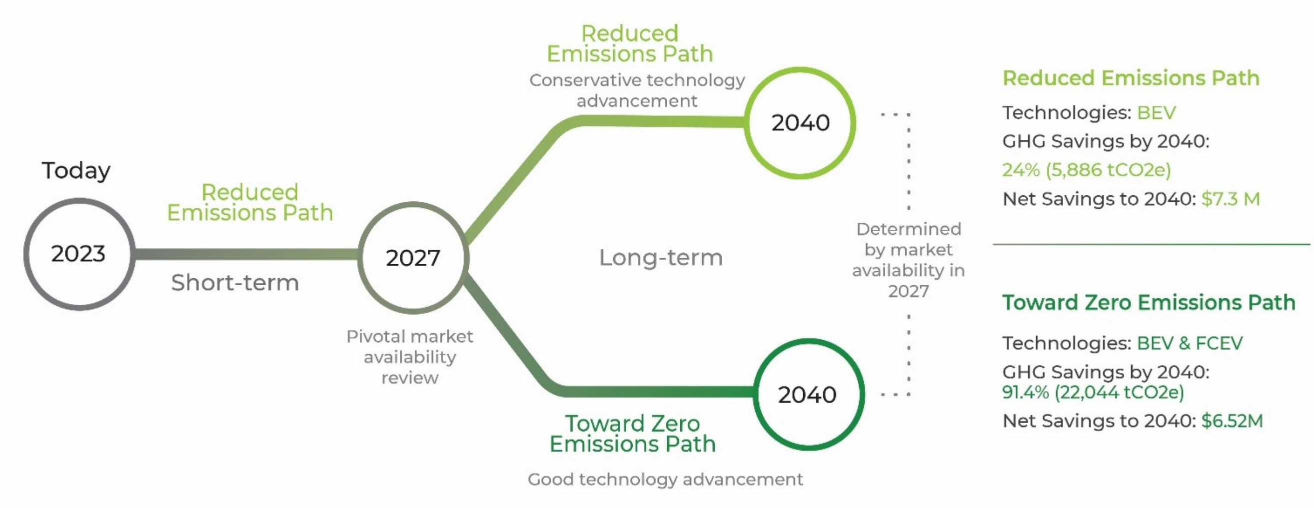
   The foreseeable feasible pathway that could be followed from 2023 onwards based on what is currently available in the market today.

2. **2027 – 2040 Toward Zero-Emissions (ZEV)**

   The potential pathway that could lead to a zero emissions fleet, should a market review in 2027 successfully reveal improvements and market share growth of ZEV technologies.

Given the rapid development of battery electric and hydrogen technologies over the last few years, there is a degree of uncertainty about what will dominate the heavy-duty vehicle sector. A short and long-term agile approach allows the City to start transitioning its fleet in the near-term while having an eye on the future and preparing itself for long-term emissions reduction.

This agile approach includes a periodic review (at least every 5 years) of the zero-emissions vehicle technology readiness and market position to adapt the strategy to what is available at the time of inquiry. It is recommended that the City follow the Zero-Emissions path, which will only be possible after a review of the market in 2027 to ensure that the technological advancement anticipated has occurred.



REDUCED EMISSIONS PATH

The proposed strategy for reducing emissions within the fleet entails a focused transition, exclusively targeting assets with Zero-Emission Vehicle (ZEV) options or those participating in pilot programs. The path prioritizes Battery Electric Vehicles (BEVs) for Light Duty Vehicles (LDVs), Medium Duty Vehicles (MDVs), Heavy Duty Vehicles (HDVs), and Equipment while adhering to a conservative purchasing plan that aligns with asset lifecycles and assumes battery replacement after eight years.

PURCHASE PLAN

The proposed purchase plan aligns with the City's replacement cycles. This plan takes into account the lifecycle requirements specified for each asset by Ottawa, assuming that Battery Electric Vehicle (BEV) technologies meet these requirements[3]. A conservative estimate includes a mandatory battery replacement after eight (8) years of operation for each asset, although not all assets will necessarily require such replacement within this timeframe.

[3] Considerations regarding future market expectations depending on the vehicle segment has been considered for this requirements assessment. Nevertheless, The study presented in this document is meant to provided an strategic vision for the transition towards zero-emission technologies. This study is not meant to provide operational direction and guidance.

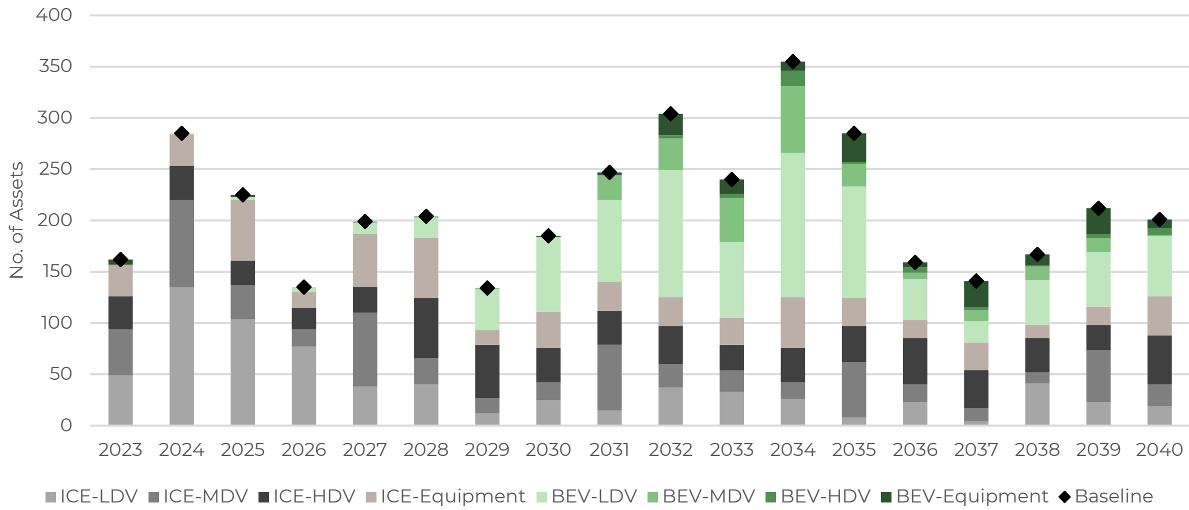


Figure ES - 3: Purchase Plan According to City's Replacement Cycles (Reduced Emissions Path)

FLEET STOCK TRANSITION

In terms of fleet composition, the plan envisions a gradual transition, aiming for a 52% electric fleet by 2040. Within this framework, LDVs take the lead with 32% transitioning to electric, followed by MDVs (10%), HDVs (2%), and Equipment (7%).

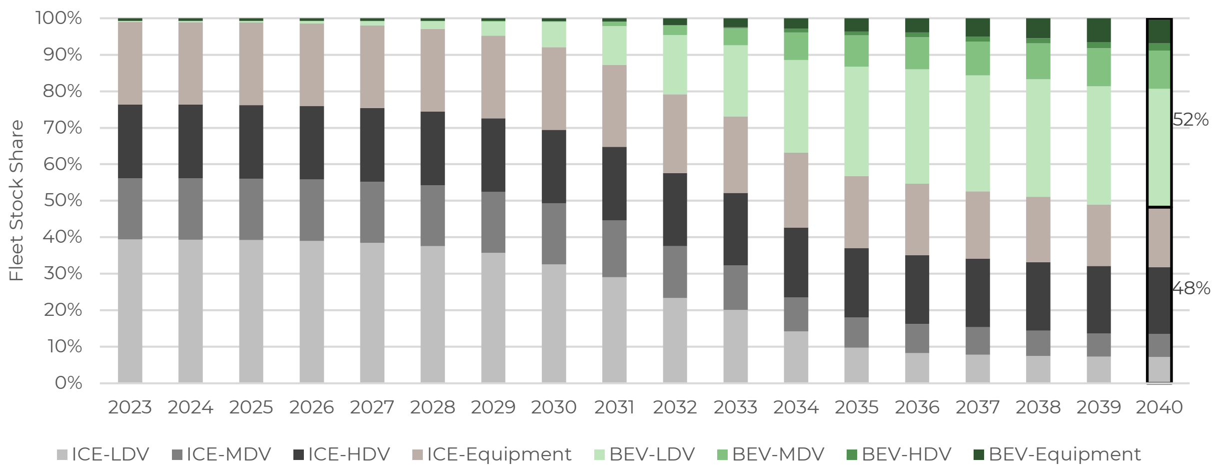


Figure ES - 4: Fleet Stock Transition Aligning with the City's Replacement Cycles (Reduced Emissions Path)

FUELING INFRASTRUCTURE

The fueling infrastructure strategy anticipates peak charging infrastructure requirements in 2033, projecting a total of 104 stations. By 2040, this number is expected to rise to 537, comprising 46 level 3 stations and 491 level 2 stations.

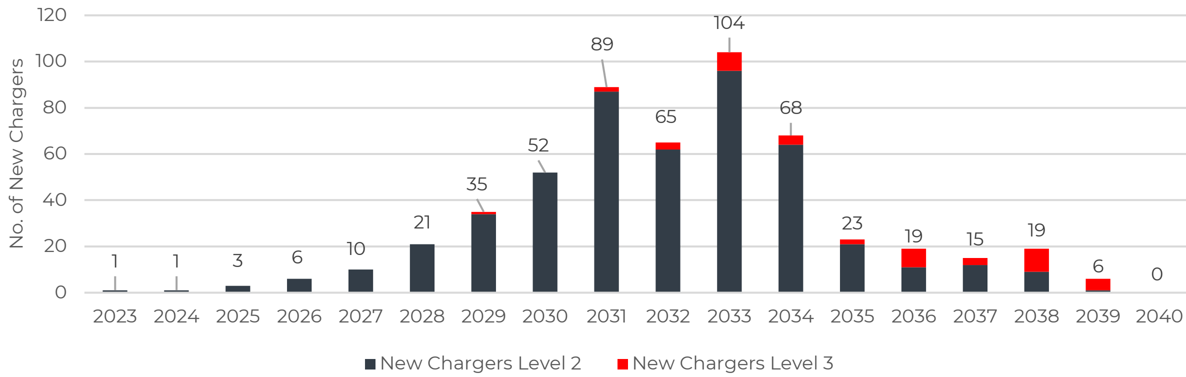


Figure ES - 5: Charging Infrastructure Needs by Year (Reduced Emissions Path)

GHG EMISSIONS REDUCTION

The impact on greenhouse gas (GHG) emissions is a notable achievement, with the Reduced Emissions path foreseeing a 24% reduction below 2023 levels by 2040. Compared to the 2012 GHG emissions levels reported in 2021 as 29,500 tonnes of $CO2_e$ by the city[4], the GHG emissions savings would amount to 38.2% by 2040. The conservative nature of this reduction is attributed to the limited availability of zero-emission options for heavier vehicles.

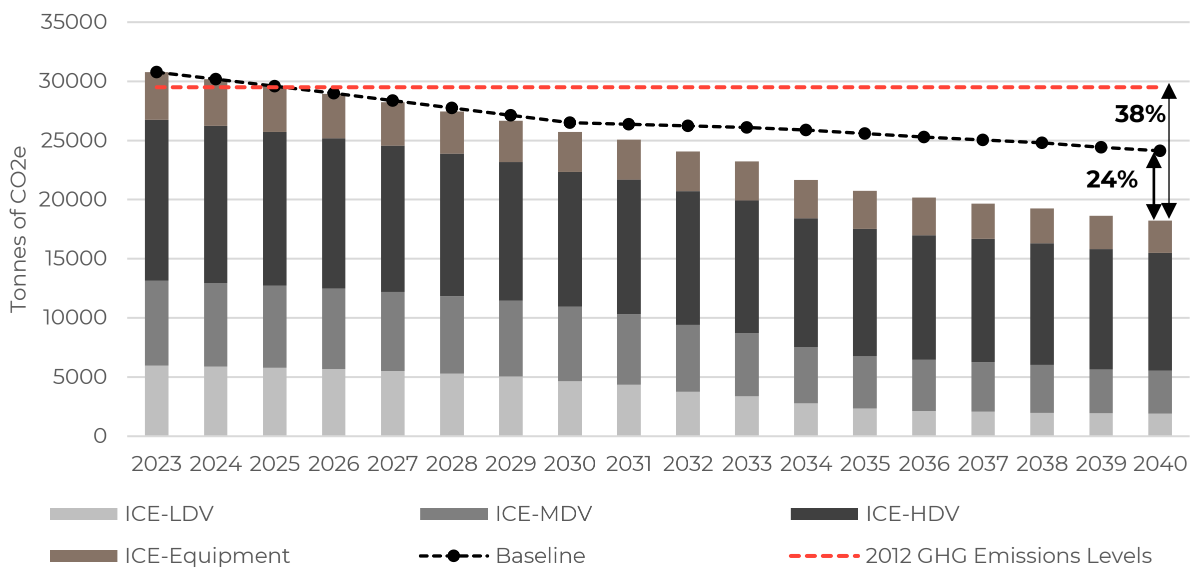


Figure ES - 6: Emissions Reduction to 2040 (Toward Zero Emissions Path)

	BASELINE (TCO2E)	REDUCED EMISSIONS PATH (TCO2E)	SAVINGS COMPARED TO TOTAL	BEV FLEET SHARE BY 2040	# OF VEHICLES REPLACED BY BEV
LDV	5,029	1,920	12.9%	32%	713
MDV	5,469	3,620	7.7%	10%	231
HDV	10,541	9,945	2.5%	2%	43

[4]City of Ottawa, Results of the 2020 Community and Corporate Greenhouse Gas (GHG) Inventories, Sept. 2021

Equipment	3,084	2,752	1.4%	7%	152
Total	24,123	18,237	24%	52%	1139
2012 GHG Emissions level	29,500	18,237	38%		

Table ES - 1: Environmental and Financial Impact of Fleet Transition Plan (Reduced Emissions Path)

CAPITAL AND OPERATING EXPENSES

The proposed plan aligns annual investments with Ottawa's replacement schedule, with assumed BEV fleet costs approaching parity with ICE vehicles by the early 2030s. Maintenance costs are also projected to demonstrate approximately 7% savings by 2040.

Anticipated fuel cost savings stand at a noteworthy 16% reduction by 2040, with LDVs contributing the most substantial share at 9.4%. While considerable savings are expected in LDV and MDV fleets, the impact on HDV and Equipment assets is comparatively minimal.

$ MILLIONS	LDV		MDV		HDV		EQUIPMENT		FLEET TOTAL	
	Baseline	**Reduced Emissions**	**Baseline**	**Reduced Emissions**	**Baseline**	**Reduced Emissions**	**Baseline**	**Reduced Emissions**	**Baseline**	**Reduced Emissions**
CAPEX Fleet	125.1	125.6	157.8	159.0	369.3	369.9	155.3	155.8	807.53	**810.36**
CAPEX Infrastructure	-	-	-	-	-	-	-	-	-	**23.25**
Maintenance Cost	51.2	45.0	63.5	59.6	277.0	275.6	100.3	98.9	492.10	**479.11**
Fuel Costs	73.6	56.9	84.1	75.7	153.0	152.7	45.7	45.2	356.41	**330.48**
Tools, Training And PPE	-	1.0	-	1.0	-	2.6	-	0.9	-	**5.51**
Total	***249.9***	***228.6***	***305.4***	***295.3***	***799.4***	***800.8***	***301.3***	***300.8***	**1,656.04**	**1,648.72**

Table ES - 2: Financial Breakdown of Fleet Transition Plan (Reduced Emissions Path)

TOTAL COST OF OWNERSHIP

The comprehensive assessment of the total cost of ownership (TCO) reveals a net savings of up to $7.31 million by 2040, marginally below the baseline. It's crucial to note that charging infrastructure investments contribute $23.3 million to costs. However, the potential for increased savings through continuous implementation post-2040, as the ICE fleet diminishes, underscores the long-term financial benefits of this sustainability initiative.

	BAU	REDUCED EMISSIONS
CAPEX Fleet ($ Million)	807.53	810.36
CAPEX Infrastructure ($ Million)	-	23.25
Maintenance Cost ($ Million)	492.10	479.11
Fuel Costs ($ Million)	356.41	330.48
Tools, Training And PPE ($ Million)	-	5.51
Totals ($ Million)	**1,656.04**	**1,648.72**
Overall Differential ($ Million)	-	**-7.31**
Overall Differential (%)	-	**-0.44%**
CAPEX only Differential ($ Million)	-	**26.09**
CAPEX only Differential (%)	-	**1.58%**

Table ES - 3: Total Cost of Ownership (Reduced Emissions Path)

Looking ahead, the strategy emphasizes the importance of optimizing cost savings by aligning with technology parity, ensuring a gradual transition for fiscal responsibility and technology readiness. Continuous implementation beyond 2040 is suggested as a means to enhance savings, particularly as the ICE fleet diminishes over time.

TOWARD ZERO EMISSIONS PATH

Under this path, the strategy is designed to leverage emerging technologies and market trends. In 2027, a comprehensive technology review and market scan will be conducted to identify available zero-emission assets. The focus is on assets with existing zero-emission options and foreseeable future technologies, particularly emphasizing Battery Electric Vehicles (BEVs) and Fuel Cell Electric Vehicles (FCEVs). The purchase plan aligns with BEV and FCEV uptake rates, considering the aging of assets to strategically maximize zero-emission adoption.

PURCHASE PLAN

The fleet purchase plan is based on a combination of the City's current replacement plan with the BEV and FCEV uptake rates modelled in Section7.3. A subset of assets (249 out of 2,201) will be selectively aged by up to 3 years to synchronize with the acceleration of Zero-Emission Vehicle (ZEV) technology uptake.

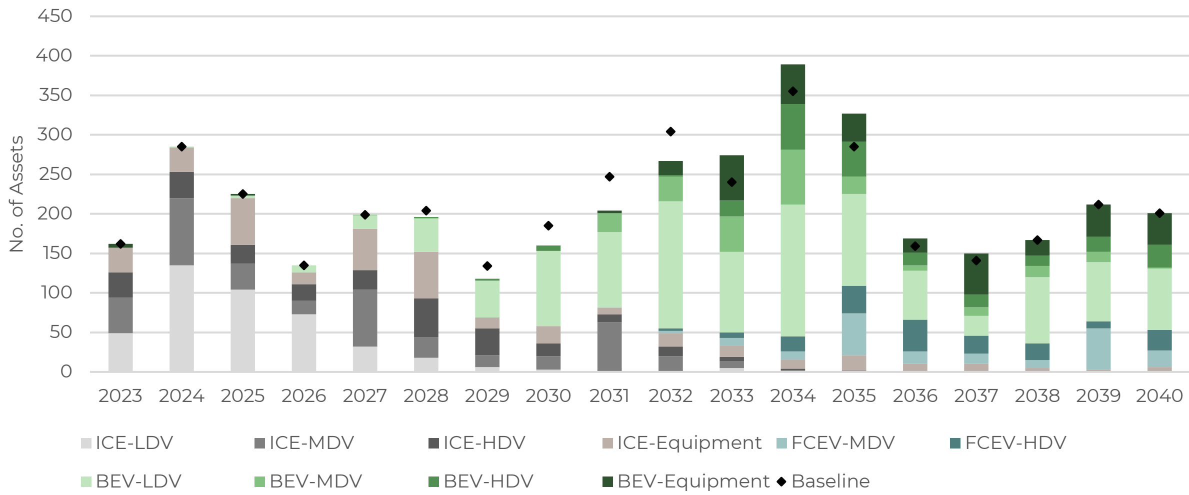


Figure ES - 7: Purchase Plan According to City's Replacement Cycles (Toward Zero Emissions Path)

FLEET STOCK TRANSITION

By 2040, the fleet composition is projected to be 75% BEVs, 13% FCEVs, and 12% Internal Combustion Engine (ICE) vehicles. This deliberate allocation is geared towards substantial greenhouse gas (GHG) emissions reductions, with 41% reduction anticipated in the Heavy-Duty Vehicle (HDV) fleet alone. The plan emphasizes the importance of the MDV and HDV segments in achieving significant environmental impact through the adoption of zero-emission technologies.

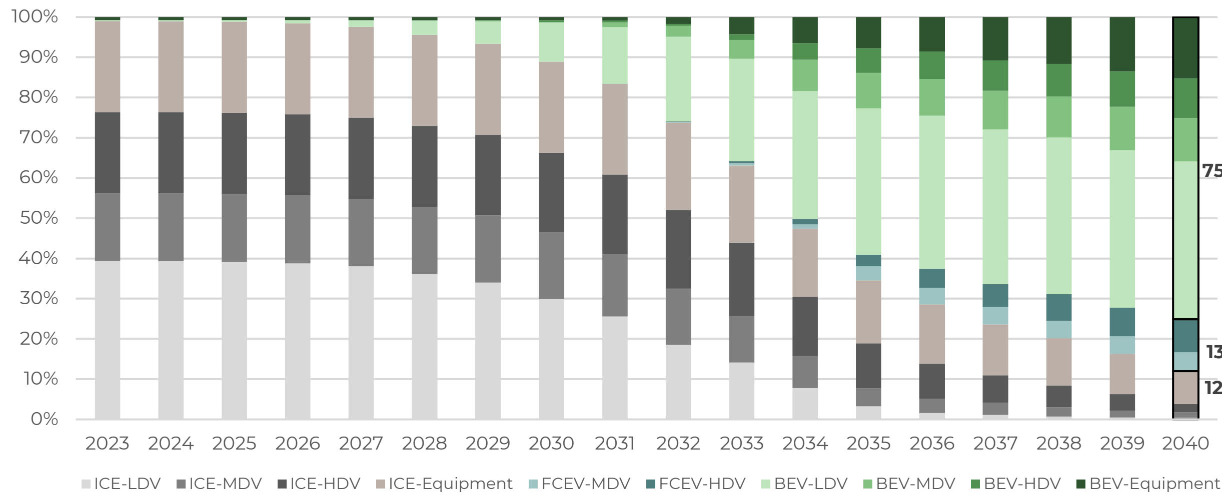


Figure ES - 8: Fleet Stock Transition Aligning with the City's Replacement Cycles (Toward Zero Emissions Path)

FUELING INFRASTRUCTURE

BEV charging infrastructure is planned based on the anticipated number of assets to be purchased, with a peak requirement expected in 2033. Concurrently, plans for hydrogen production and refueling infrastructure are laid out, with at least two operational sites expected by 2036.

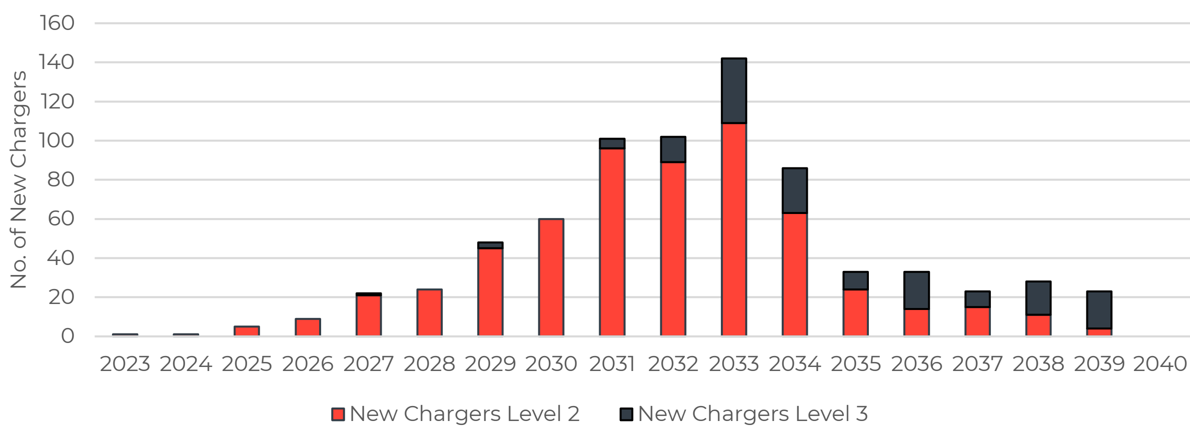


Figure ES - 9: Charging Infrastructure Needs by Year (Toward Zero Emissions Path)

H2 PLANT AND REFUELING PLANTS	YEAR TO START DESIGN AND PLANNING	YEAR TO FINALIZE CONSTRUCTION AND START OPERATION
First H2 production and refueling plant	2028	2031
Second H2 production and refueling plant	2033	2036

Table ES - 4: Planning schedule for the hydrogen production and refueling plants (Toward Zero Emissions Path)

GHG EMISSIONS REDUCTION

The GHG emissions under this path are substantial, with the transition to zero-emission vehicles forecasted to yield over 91% savings of GHG emissions compared to the 2023 baseline scenario by 2040. Compared to the 2012 GHG emissions levels, reported in 2021 as 29,500 tonnes of $CO2_e$ by the City[5], the GHG emissions savings would amount to 93%. The MDV and HDV segments demonstrate the highest impact on GHG emissions reduction.

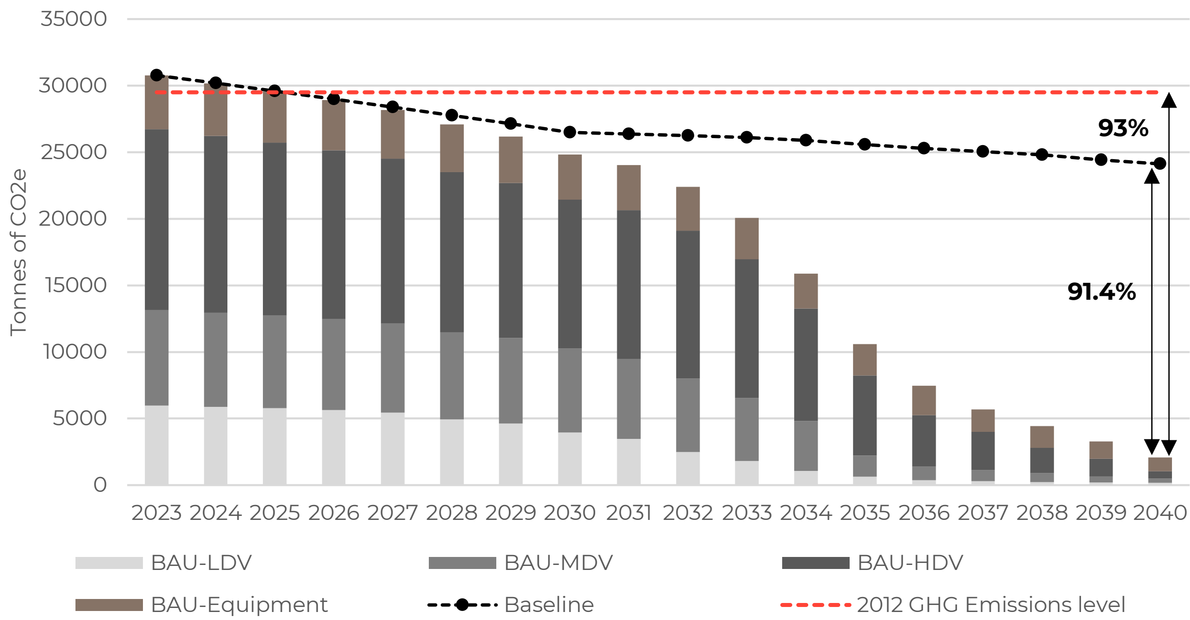


Figure ES - 10: Emissions Reduction to 2040 (Toward Zero Emissions Path)

CAPITAL AND OPERATING EXPENSES

Financial considerations align with the City's replacement plan, ensuring that fleet and infrastructure capital and operating expenses are well-coordinated. Maintenance costs for BEVs and FCEVs are estimated to be 60% and 75% of ICE maintenance costs, respectively, contributing to long-term operational efficiency[6].

Fuel costs alone contribute to significant savings of approximately $82.03 million across all vehicle categories.

[5]City of Ottawa, Results of the 2020 Community and Corporate Greenhouse Gas (GHG) Inventories, Sept. 2021

[6] EVs and FCEVs do not require maintenance related to the: transmission, spark plugs, oxygen sensor, timing belt, fuel filter, engine air filter, oil filter, engine coolant, and engine oil,

($ MILLION)	LDV		MDV		HDV		EQUIPMENT		FLEET TOTAL	
	Baseline	**Towards Zero Emissions Path**	**Baseline**	**Towards Zero Emissions Path**	**Baseline**	**Towards Zero Emissions Path**	**Baseline**	**Towards Zero Emissions Path**	**Baseline**	**Towards Zero Emissions Path**
CAPEX Fleet	125.1	125.94	157.8	159.4	369.3	377.41	155.3	157.3	807.53	**819.99**
CAPEX Infrastructure	-	-	-	-	-	-	-	-	-	**105.61**
Maintenance Cost	51.2	41.5	63.5	56.9	277.0	252.7	100.3	93.4	492.10	**444.56**
Fuel Costs	73.6	45.1	84.1	62.08	153.0	127.0	45.7	40.2	356.41	**274.38**
Tools, Training And PPE	-	0.9	-	0.9	-	2.5	-	0.8	-	**5.1**
Total	***249.9***	***213.4***	***305.4***	***279.2***	***799.4***	***759.7***	***301.3***	***291.6***	**1,656.04**	**1,649.5**

Table ES - 5: Fleet capital and operating expenses by vehicle category ($ Million)

TOTAL COST OF OWNERSHIP

In terms of the total cost of ownership, the implementation of this path could lead to net savings of approximately $6.52 million, representing 0.39% of the total baseline. While there are capital infrastructure costs, the transition to BEVs and FCEVs proves economically advantageous marginally over the long-term to 2040.

	BAU	TOWARDS ZERO EMISSIONS
CAPEX Fleet ($ Million)	807.53	819.99
CAPEX Infrastructure ($ Million)	-	105.61
Maintenance Cost ($ Million)	492.10	444.56
Fuel Costs ($ Million)	356.41	**274.38**
Tools, Training and PPE ($ Million)	-	5.1
Totals ($ Million)	**1,656.0**	**1,649.5**
Overall Differential ($ Million)	-	**-6.52**
Overall Differential (%)	-	**-0.39%**
CAPEX only Differential ($ Million)	-	**118.07**
CAPEX only Differential (%)	-	**7.13%**

Table ES - 6: Total costs of ownership comparing BAU to Towards Zero Emissions Path

COST-BENEFIT ANALYSIS

	BASELINE	REDUCED EMISSIONS PATH	TOWARDS ZERO EMISSIONS PATH
CAPEX Fleet ($ Million)	807.53	810.36	819.99
CAPEX Infrastructure ($ Million)	-	23.25	105.61
Maintenance Cost ($ Million)	492.10	479.11	444.56
Fuel Costs ($ Million)	356.41	330.48	274.38
Tools, Training And PPE ($ Million)	-	5.51	5.1
Totals ($ Million)	**1,656.04**	**1,648.72**	**1,649.5**
Overall Cost Difference ($ Million)	-	-7.31	-6.52
Overall Cost Difference (%)	-	-0.44%	-0.39%
CAPEX only Cost Difference ($ Million)	-	26.09	118.07
GHG Emissions in 2040 (Tonnes of CO2e)	24,123	18,237	2,079
GHG Emissions Savings in 2040 (%)	-	-24.4%	-91.4%
GHG Emissions Savings Compared to 2012 Reference (%)	-18%	-38.2%	-93.0%
Net $ / Tonne of CO2e saved (2023 to 2040)	-	154	37

Table ES - 7: Cost comparison between BAU, Reduced Emissions, and Toward Zero Emissions pathways

EXTENDING AN ASSET'S USEFUL LIFE

This section investigates the viability of a coordinated 'sweating' strategy for specific assets within the City of Ottawa's fleet, assessing the cost-effectiveness and greenhouse gas (GHG) emissions impacts associated with extending asset lifecycles.

The analysis compares two scenarios: Scenario 1, representing the business-as-usual (BAU) model with planned asset purchases, and Scenario 2, a modified BAU where assets beyond their useful life have their lifecycle extended. The study focuses on assets showing potential for sweating based on average aging, and the comparison involved estimating total costs and GHG emissions for each scenario, considering capital expenditure (CAPEX) and ongoing operational expenses (OPEX) represented by maintenance and fuel costs. Key Highlights from this analysis:

1. **Cost Savings:** Implementing a sweating strategy suggests potential savings of approximately $125 million to 2040, equivalent to a significant 7.6% reduction in the total BAU cost.
2. **Savings Outweigh Additional Costs:** The study demonstrates that the savings from delaying asset purchases through sweating surpass the additional maintenance and fuel costs, resulting in a net gain three times higher.
3. **Negligible Impact on Emissions:** Despite sweating assets, the overall increase in emissions is minimal, less than 0.5%, highlighting the negligible environmental impact of the strategy.

KEY RECOMMENDATIONS

The following recommendations stem from the analysis, aiming to guide the City in optimizing its fleet strategy:

1. **Tailor Zero Emission Adoption by Equipment Type**

   To optimize the adoption of ZEVs, the City should evaluate equipment requirements at the category level, taking into account specific usage patterns, operational demands, and functionalities within each asset category. By conducting an examination of these factors, the City can strategically customize its approach to Zero Emission technology adoption, ensuring that the chosen solutions align effectively with the unique characteristics of different equipment types.

2. **Strategic Diversification of Zero Emission Adoption**
   To optimize the City's approach to Zero Emission technologies, prioritize the immediate implementation of commercially viable Classes 1 to 4 for the greatest near-term cost-benefits. Leverage the current readiness of these technologies for swift adoption. Simultaneously, for medium-duty Classes 5 and 6, and heavy-duty Classes 7 and 8 vehicles and equipment, plan for a gradual transition in the long term, aligning with the anticipated improvement in cost competitiveness of ZEVs. By doing so, the City will strike a balance between immediate advantages and a forward-looking perspective, ensuring an optimized and strategic adoption of ZEVs across different vehicle classes.

3. **Assess Feasibility of Sweating Strategy:**
   To optimize fleet management, conduct a detailed analysis to evaluate the feasibility of implementing a sweating strategy for assets nearing imminent replacement by zero-emission vehicles. The analysis indicates potential cost savings with minimal impact on greenhouse gas (GHG) emissions.

SITE ELECTRICAL ANALYSIS

While some facilities exhibit no infrastructure requirements for either maximum or minimum expected loads, most of the facilities will require upgrades to their electrical infrastructure due to the existing load at the site.

While select facilities were reviewed (for information purposes only), additional demand load analysis is needed to evaluate some of the sites more thoroughly and therefore future analysis may be required. The inconsistencies in demand load data for these sites prevented some sites from being included in the analysis.

RECOMMENDATIONS

The City of Ottawa's effective transition to a zero-emissions fleet by 2040, relies on the following four key recommendations:

1. **Agile Strategy Approach:**

   - Regularly review ZEV technologies every 3 to 5 years to ensure alignment with city needs and infrastructure considerations. This adaptive strategy accommodates market uncertainties and supports the city's goal of achieving over a 93% reduction in GHG emissions by 2040 compared to 2012 levels. In case of fewer feasible ZEV options, consider reverting to the more conservative Reduced Emissions Path.

- Schedule approved future pilot projects to test new technologies for all asset types. It is recommended that the City frames these pilot projects in such a manner that the necessary budget is expedited, allowing sufficient time for testing and training. This should occur with pre-approval at set time intervals to prevent delay.

2. **ZEV Purchase Plan:**
    - Adopt a phased ZEV purchase plan guided by three principles—planned uptake rates, cost parity projections, and a selective aging program. Plan for 100% ZEV purchases when cost parity with ICE options is anticipated, and leverage market reviews every 3 to 5 years for informed decision-making. Prioritize assets for selective aging, strategically delaying purchases to align with higher ZEV uptake rates.
3. **Infrastructure Planning:**
    - Proactively develop energy supply and refueling infrastructure ahead of ZEV fleet operation. For BEVs, initiate building-level upgrades and civil infrastructure, and procure charging equipment 1 year before ZEV fleet purchases. For FCEVs, consider on-site green hydrogen production facilities, initiating planning and design by 2028. Prioritize sites for chargers and ensure redundancies for electrical circuits.
4. **Keep a Long-Term Outlook:**
    - Despite initial high capital and infrastructure costs, budget early for short-term expenses and secure council approval. Recognize that long-term costs will significantly decrease due to reduced fuel and maintenance expenses. This proactive financial approach ensures a smooth transition toward a ZEV fleet.

STUDY LIMITATIONS

The findings presented in this study are based on the information and data available at the time of writing. The analysis is based on the fleet and facilities data as well as fleet user group workshops held at the beginning of the study with the City of Ottawa in June 2023. It assumed that feedback gained during these workshops provides an accurate portrayal of the City's fleet and services.

Furthermore, analysis is conducted on the assumption of the City of Ottawa assumes the responsibility for the accuracy and quality of all data provided. Historical fleet data is used to help establish a baseline on the City of Ottawa's current fleet operations to make comparisons against low carbon vehicle alternatives. Fleet statistics such as fuel economy and fleet maintenance costs are referenced from historical data to help develop lifecycle cost assessments of vehicles and equipment.

Analyses on low carbon fleet are subject to change due to the nature of continuing innovations in alternative propulsion technologies. The availability of market data on alternative vehicles is based on present conditions, providing a current snapshot of prices and specifications, and will likely change over time.