City of Brampton
Sustainable Fleet Strategy

2021 - 2035

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Glossary

ATMP	Active Transportation Master Plan
B5	A blend of 5% biodiesel and 95% fossil fuel; in this report, B10 represents an annualized blend of B20 (used during summer months) and B5 used during winter and shoulder months)
BET	Battery-electric truck and bus
BEV	Battery-electric vehicle
BFES	Brampton Fire and Emergency Services
BMP	Best management practice
CAMPlan	Corporate Asset Management Plan
Capex	Capital expense
CEERP	Our 2040 Energy Transition: Community Energy and Emissions Reduction Plan
CNG	Compressed natural gas
Downtime	Period when a vehicle is unavailable for use during prime business hours
E85	A blend of around 85% ethanol and 15% gasoline
EMP	Brampton Grow Green Environmental Master Plan
EV	Electric vehicle
EVSE	Electric vehicle supply equipment
FAR	Fleet Analytics Review™ (Fleet Challenge Excel software tool)
FCV	Hydrogen fuel-cell vehicle
GHG	Greenhouse gas
HEV	Hybrid-electric vehicle
ICE	Internal combustion engine
KPI	Key performance indicator
kW	Kilowatt
LD	Light-duty
LPG	Liquefied petroleum gas
LRR	Low-rolling resistance
LT	Long-term
LTCP	Long-term capital planning
MD	Medium-duty
MHEV	Mild hybrid-electric vehicle
MT	Medium-term
NRCan	Natural Resources Canada
Opex	Operating expense
PHEV	Plug-in hybrid electric vehicles
PM	Preventative maintenance
RNG	Renewable natural gas
ROI	Return-on-Investment
RSI-FC	Richmond Sustainability Initiatives – Fleet Challenge
ST	Short-term
t	Tonnes

TCO	Total cost of ownership
TMP	Transportation Master Plan
TOCP	Term of Council Priorities
WPOC	Williams Parkway Operation Centre

Readers Note

This document is the culmination of detailed analysis of the two reports - the *Sustainable Fleet Strategy: Background Review and Analysis*, and the *Sustainable Fleet Strategy: Framework and Action Plan* - which were prepared by Richmond Sustainability Initiatives and its Fleet Challenge division for the City of Brampton. These reports, with a combined total of over 300 pages, are available for review upon request.

Executive Summary

In June 2019, Brampton City Council joined the Government of Canada and more than 400 Canadian municipalities in declaring a climate emergency[1]. In 2020, the transportation sector accounted for approximately 25% of greenhouse gas (GHG) emissions in Canada, second only to the oil and gas sector[2]. According to corporate GHG emissions data, the City's mobile sources, including the City's vehicle fleet and associated equipment contributed to more than 50% of the City of Brampton's 2016 corporate GHG emissions.

Low-carbon transportation is essential to both short-term GHG and fuel-use reduction, and long term decarbonization of the economy. Municipalities like Brampton can play a key role in cutting emissions by transitioning their fleets to low-carbon and/or electric vehicles, while reducing fuel usage and maintenance costs. The City of Brampton aims to achieve target GHG emission reductions of 50% by 2040 and 80% by 2050 (compared to 2016 levels).

In November 2020, the City of Brampton engaged Richmond Sustainability Initiatives – Fleet Challenge (RSI-FC) to determine potential pathways towards GHG emission reduction of the City's fleet. The report is based on detailed data analysis of one-year of historical data for 625 City of Brampton fleet vehicles, which include:

Fleet Services	light-duty, medium-duty, and heavy-duty vehicles, totaling 422 owned units and 35 rental units;
Fire & Emergency Services	light-duty and medium-duty vehicles, and fire apparatus totaling 107 units; and
Brampton Transit	light-duty and medium-duty vehicles, totalling 18 owned units and 43 rental units.

Through the implementation of the Sustainable Fleet Strategy, the City's fleet can achieve 86% tailpipe GHG emission reductions by 2035 (compared to 2019 levels), with the greatest reductions from the BEV transition. The Strategy also aims to:

- reduce GHG and air pollutant emissions,
- improve fuel efficiency and reduced fuel cost,
- optimize and right-size fleet,
- enhance operation efficiency and service excellence,
- improve lifecycle asset management,
- demonstrate leadership in environmental sustainability, and
- increase opportunities for external funding.

The Sustainable Fleet Strategy identifies actions for the immediate to long-term implementation under the umbrellas of baseline data analysis, equipment upgrades and maintenance, and stakeholder collaborations:

- Group A: Best Management Practices & Additional Considerations, and
- Group B: Battery-Electric Vehicle Phase-in.

Immediate climate action is necessary. Therefore, it is critical that adequate funding of an average of $8 million per year for 15 years, inclusive of normal capital funding, be provided to implement the Sustainable Fleet Strategy to significantly reduce the City of Brampton’s GHG emissions.

Section 1
Introduction

In 2020, the transportation sector accounted for approximately 25% of greenhouse gas (GHG) emissions in Canada, second only to the oil and gas sector. According to corporate GHG emissions data, the City of Brampton's mobile sources, including its vehicle fleet and associated equipment, contributed to more than 50% of Brampton's 2016 corporate GHG emissions.

As the third-largest community in the GTHA and one of the fastest growing municipalities in Canada, the City of Brampton has three major fleets: Fleet Services (Corporate fleet), Fire & Emergency Services, and Brampton Transit. With the population projected to reach almost 900,000 by 2041, the need for these services will only grow. This in turn will increase the size, requirements, and pressures put on the City's fleet for the provision of services.

The City recognizes that fleet operations impact our environment, particularly through the generation of greenhouse gas (GHG) emissions, and has been implementing sustainable fleet practices for over 20 year. Through the adoption of the *Brampton Grow Green Environmental Master Plan*, the *Community Energy & Emissions Reduction Plan*, as well as Council's Climate Emergency Declaration, the need for a comprehensive Sustainable Fleet Strategy to guide our fleet operations using an environmental sustainability lens has never been stronger.

To reduce the GHG emissions and mitigate climate disaster risk, a transition to low-carbon transportation is necessary. Municipal efforts to cut emission through a shift toward low-carbon and/or electric vehicles and sustainable practices are key to minimizing the negative environmental impact. The City of Brampton aims to reduce its corporate GHG emissions by 50% by 2040 and 80% by 2050 (compared to 2016 levels).

The *Sustainable Fleet Strategy: Background Review and Analysis*, and the *Sustainable Fleet Strategy: Framework and Action Plan* reports prepared by Richmond Sustainability Initiatives - Fleet Challenge (RSI-FC) in 2020 and 2021 at the City of Brampton's request, review the City's fleet and outline potential pathways towards GHG emission reduction for the City's fleet. They form the foundation of this City of Brampton Sustainable Fleet Strategy.

Based on the detailed data analysis of one-year of historical data for 625 City of Brampton fleet vehicles, this Sustainable Fleet Strategy aims to reduce 86% of tailpipe GHG emissions by 2035 (compared to 2019 levels) through short- to long-term implementation. The fleet vehicles considered in the report include the Corporate Fleet (light-duty, medium-duty, and heavy-duty vehicles, totaling 422 owned units and 35 rental units), Fire & Emergency Services (EMS) Fleet (light-duty and medium-duty vehicles, and fire apparatus, totaling 107 owned units), and the non-revenue Transit Fleet (light-duty and medium-duty vehicles, totaling 18 owned units and 43 rental units). RSI-FC's software tool Fleet Analytics Review™ (FAR) was used to estimate the cost-benefit and GHG emissions-reduction potential of many best management practices (BMPs), low-carbon fuels, and a transition to battery-electric vehicles (BEVs) over the next 15 years, and all estimates were supported with published studies, research and data.

Section 2
Current State

The City of Brampton serves its large population of 593,638 (as of 2016 Census) residents through the operation of three major sub-fleets: Fleet Services (Corporate Fleet), Fire & Emergency Services, and Brampton Transit. The fleet and mobile sources collectively contributed to more than 50% of Brampton's 2016 corporate GHG emissions. The City has set a target for a reduction of 50% of GHG emissions by 2040, and 80% by 2050 based on the 2016 levels. By following the framework set in this Sustainable Fleet Strategy, the City will be able to reduce tailpipe emissions by 86% by 2035 (based on 2019 levels).

2.1 Fleet Profiles

The City of Brampton's non-revenue fleet is comprised of 625 vehicles of varying sizes used for a range of operations and the delivery of services across the city. These vehicles are categorized into 3 sub-fleets: Fleet Services (Corporate Fleet), Fire & Emergency Services, and Brampton Transit. The fleet composition that was utilized to prepare the Sustainable Fleet Strategy is described below in *Table 1*, and baseline results for Fleet Services, Fire & EMS, and Transit are provided in *Tables 2-4*

Table 1: City of Brampton's Fleet Composition.

Sub-Fleet	Vehicle Classification(s)	Unit Count (Owned)	Unit Count (Rental)	Unit Count (Total)
Corporate Fleet	Light-, medium-, and heavy-duty vehicles	422	35	457
Fire & Emergency Services	Light- and medium-duty vehicles, and fire apparatus	107	0	107
Brampton Transit	Light- and medium-duty vehicles	18	43	61
Total		**625 vehicles**		

Table 2: Baseline Results for Brampton Fleet Services. Values are for the entire fleet for the one-year review period (2019).

Fleet Breakdown by Fuel Type[5]	Fleet Breakdown by Ownership	Original Purchase Price	Estimated Replace Cost	Estimated Market/ Trade- In Value	Total Cost (R&M, Fuel, Capital & Downtime)	Total KM-Travelled	Total Fuel Used (litres)	Total GHG Emissions (tonnes CO2e, combustion – fossil diesel)	Total GHG Emissions (tonnes CO2e, combustion – B5[6])
231 G units, 225 D units, 1 BEV	422 owned units, 35 rentals	$24,786,291	$31,610,118	$2,478,629	$4,205,465	4,217,024	1,063,788	2,744	2,663

Table 3: Baseline Results for Brampton Fire & EMS. Values are for the entire fleet for the one-year review period (2019).

Fleet Breakdown by Fuel Type[7]	Fleet Breakdown by	Original Purchase Price	Estimated Replace Cost	Estimated Market/	Total Cost (R&M, Fuel,	Total KM-Travelled	Total Fuel Used (litres)	Total GHG Emissions
69 G units, 37 D units, 2 PHEVs	All 107 units owned	$24,500,175	$41,174,687	$3,062,522	$1,855,564	892,422	294,258	775

Table 4: Baseline Results for Brampton Transit (non-revenue units). Values are for the entire fleet for the one-year review period (2019).

Fleet Breakdown by Fuel Type[7]	Fleet Breakdown by Ownership	Original Purchase Price	Estimated Replace Cost	Estimated Market/ Trade-In Value	Total Cost (R&M, Fuel, Capital & Downtime)	Total KM-Travelled	Total Fuel Used (litres)	Total GHG Emissions (tonnes CO2e, combustion)	Total GHG Emissions (tonnes CO2e, combustion– B5[6])
51 G units, 10 D units	18 owned units, 43 rentals	$620,367	$1,242,000	$62,037	$314,962	1,276,710	171,241	425	413

In addition to these vehicles, a fully-electric fire truck is expected to join the fleet at the end of 2022 and be operational by early 2023.

2.2 Current Fleet Greening Initiatives

The City of Brampton's fleet has been gaining recognition as a leading fleet amongst North American municipalities. In 2020 and 2021, the City was recognized by the American Public Works Association (APWA) as one of 50 Notable Fleets for municipalities across North America, one of only five Canadian cities to do so in 2020, and one of three in 2021.

Some of the green fleet practices already undertaken by the City include, but are not limited to, right-sizing, use of alternative fuels, driver training, strategic vehicle replacement, and use of hybrid vehicles.

The City of Brampton's fleet also recently added a solar-powered all-electric equipment trailer. A greenworks machine – the City's second all-electric utility vehicle [8]. Further, the future build of a total of 183 electric vehicle (EV) charging stations for Williams Parkway Operation Centre (WPOC), Sandalwood Parkway (SW) and Flower City Community Campus (FCCC) is currently under Building Design and Construction (BDC) review, with potential Natural Resources Canada (NRCan) funding. One hundred and seventy one of these charging stations will be Level 2, and 12 of the charging stations will be Level 3. The Level 2 charging stations currently being installed at the Fire Campus have been partially funded by NRCan's Zero Emission Vehicle Infrastructure Program. The expansion of the EV charging station network will make EV ownership more convenient the City, its residents and businesses.

In May 2021, Brampton Transit launched the world's largest deployment to date of fully interoperable, high-powered (450 kW) on-street chargers from multiple charger and bus original equipment manufacturers (OEMs).

2.3 Greenhouse Gas Emissions (GHGs)

Fossil fuel use reduction directly translates into reduction of GHG emissions[9]. Thus, the Sustainable Fleet Strategy aims to reduce 86% of tailpipe GHG emissions by 2035 (compared to 2019 levels of emission), through reduced fossil fuel usage and increased dependency on alternative green energy sources.

To model vehicular GHG emissions, there are two standard reporting methods: (1) tailpipe combustion, and (2) fuel lifecycle (also referred to as fuel cycle or well-to-wheel). Fuel cycle emissions assess the overall GHG impacts of the fuel from production to vehicular use, whereas tailpipe emissions only assess the fuel use by the vehicle through combustion. Thus, lifecycle GHG emissions are usually greater than tailpipe emissions[10]. However, lifecycle emissions are often difficult to quantify because of the different mixes of electricity sources in different jurisdictions and at different times of day (i.e., fossil fuel based, nuclear, and renewables). For the development of the Sustainable Fleet Strategy, the tailpipe combustion method was utilized.

Using this method, battery-electric vehicles (BEVs) emit zero tailpipe emissions[11].

2.4 Stakeholder Engagement

Stakeholder engagement are critical for the successful development of a strategy in every organization. Employee performance and loyalty is improved when their organization makes them feel engaged, empowered and valued. Moreover, residents appreciate hearing success stories, whether regarding new cost-saving measures, safety, good deeds by its drivers, or eco-successes, all of which impact their lives both directly and indirectly. As such, stakeholder engagement and user group participation to guide plans under construction is invaluable. In person discussions are the preferred engagement platform. However, due to restrictions resulting from the COVID-19 pandemic, surveys and virtual meetings were the primary forms of stakeholder engagement relied upon for the development of the Sustainable Fleet Strategy.

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Over 270- City of Brampton Fleet users were engaged through uniquely designed web-based surveys specifically catered to each sub-fleet (Fleet Services, Transit (non-revenue units), and Fire & EMS), as well as separate surveys catered to management and staff. All survey respondents were ensured that responses remain confidential and anonymous and encouraged to freely express their opinions.

Participants were asked about their opinions on various pollution factors, fuel-switching options (i.e., alternate/renewable fuels), and battery-electric vehicles (BEVs), to gain a perspective of views and predominant concerns to address in the City of Brampton's Sustainable Fleet Strategy.

Overall, there was strong support for and understanding of sustainable fleet practices s from survey participants, particularly in regards to BEVs and their range capabilities, power, heating/cooling, and pollution prevention. There is some doubt surrounding operating cost savings, as well as the availability of models now and in the near future to fulfill the City's requirements. The challenges of upfront costs and infrastructure, as well as new training and maintenance practices were also highlighted.

Section 3
Sustainable Fleet Framework

3.1 Guiding Documents

The Sustainable Fleet Strategy accounts for City of Brampton's existing visions for sustainable development. These include:

Brampton Grow Green Environmental Master Plan (EMP)	The EMP outlines corporate and community level environmental sustainability goals, actions, and targets, and was approved by City Council in 2014 and refreshed in 2020. The development of the Sustainable Fleet Strategy was prioritized in the 2020 report, noting that the City's fleet was a primary contributor to increasing GHG emissions, and it is critical to reverse this trend as service demand is projected to increase with population growth. Additionally, EMP advised revision of parking at City facilities (10% for EVSE and 25% for future EVSE installation), and the continued application of an anti-idling policy.
Living the Mosaic: Brampton 2040 Vision	Completed in 2018, the 2040 Vision is an aspirational document to guide what Brampton can become over the next two decades.. Vision 1 (Sustainability and the Environment), Vision 4 (Transportation and Connectivity), and Vision 6 (Health) support the Sustainable Fleet Strategy.
Our 2040 Energy Transition: Community Energy and Emissions Reduction Plan (CEERP)	The CEERP provide a roadmap that will improve energy efficiency, reduce GHG, create economic advantage, ensure energy security, and increase Brampton's resilience to climate change. It notes that 35% of energy used and 59% of GHG emissions in Brampton are transportation related. The CEERP recommends the expansion of the EV charging station network, development of a Green Purchasing Strategy and by-law, and GHG emission reduction oriented updates to Fleet planning and operation procedures.
Corporate Energy and Emissions Management Plan 2019-2040: A Zero-Carbon Transition	The Zero-Carbon Transition Plan has three key objectives for City-owned buildings/facilities: (1) minimize energy intensity, (2) minimize emissions intensity, and (3) maximize cost recovery. The current and future expansion of the City's EV charging station network (52 stations across 13 municipal lots, as of 2019) is of particular relevance to the Sustainable Fleet Strategy.
Corporate Asset Management Plan (CAMPlan)	CAMPlan assesses the current state of all infrastructure and fleet assets to ensure cost-effective levels of service and maintenance. Key findings for vehicles in poor to very poor conditions in 2019 include: (1) 16% of Corporate Fleet – off-road and not in-scope units, (2) 17% and 29% of the Parks and Recreations fleets,

	respectively, (3) 93% of Animal Services fleet, (4) 21% of Fire Services vehicles and apparatus, and 39% of fire apparatus (not in-scope).
Transportation Master Plan (TMP)	The TMP of 2015 (currently being updated) addressed existing transportation challenges and viable solutions based on projected 2041 population and employment growth. The need for a low-carbon transportation system (HEVS, EVs, and EV infrastructure) to mitigate climate change and improve air quality was emphasized.
Active Transportation Master Plan (ATMP)	The ATMP, released in 2019, prioritizes active transportation and development of complete streets with improved integration of transportation choices.
Light Duty Fleet Management Review	Conducted by WSP (an engineering consulting firm) in 2019, this review intended to provide cost-saving, service efficiencies, and potential green fleet recommendations. Relevant findings include: (1) conducting GHG baseline for all fleet vehicles, (2) a holistic green fleet strategy for all fleet vehicles, (3) greater EVs and EV training implementation, and (4) increased funding for EVs fast-charging stations expansion.
Fire Master Plan	Developed by Brampton Fire and Emergency Services (BFES), this plan outlines the strategy for BFES for 2021 to 2025. This includes strategic investment to reduce the environmental footprint of BFES, specifically through investigation of electric fire trucks, BEV vehicles and Fire Apparatus for purchase.

3.2 Goals, Objectives, Targets

The City of Brampton strives to be exemplary in operational excellence and environmental sustainability. The City aims to uphold its reputation by achieving its target GHG emission reductions (50% reduction by 2040 and 80% by 2050, based on its 2016 levels). The Sustainable Fleet Strategy strives to provide a viable path to achieve and exceed the City of Brampton's goal through the transition towards a green fleet that would result in 86% emission reductions from its fleet by 2035 (based on 2019 levels).

The Sustainable Fleet Strategy outlines four key objectives (see below). RSI-FC has conducted extensive fleet data analysis to identify areas of operation improvement and applicable new technologies for the strategy.

The Sustainable Fleet's Strategy key objectives are to:

1. Data-model all potential fuel-reduction solutions and estimate their impacts (reductions of Operating expenses, Capital expenses, and GHG emissions) relative to the baseline.

2. Create a battery-electric vehicle (BEV) transition plan and estimate the cost impacts and GHG-reduction potential relative to the baseline over a 15-year budget cycle.

3. Estimate additional capital required for electric vehicle supply equipment (EVSE) over a 15- year budget cycle, and recommend solutions for offsetting these charging infrastructure costs through government funding, reduced operating budgets, and fleet reserve.

4. Create a sustainable fleet action plan to improve the sustainability performance of the City's fleet, including short-term (1-2 years), mid-term (3-5 years), and long-term (5-10+ years).

3.3 Technical Analysis

A baseline analysis and a lifecycle analysis (LCA) study of select vehicle categories in the City of Brampton's fleet were used to determine optimal economic lifecycles for specific vehicle types. Using RSI's Fleet Analytics Review™ (FAR) software, year-over-year capital budgets were balanced over a 15-year budget horizon using optimized economic lifecycles and by considering return-on-investment (ROI) for units due for replacement.

An impact assessment of various fuel-reduction solutions on the City's fleet operations and capital budgeting was conducted to develop the recommendations for the Sustainable Fleet Strategy. The analysis in the Framework and Action Plan Report included:

- the development of 10 data models to evaluate the impacts (operating expenses, capital expenses, and GHG reductions) of proposed go-forward fuel-reduction solutions relative to the baseline over a 15-year budget cycle, which resulted in a long-term capital planning (LTCP) outlook;

- estimations for electric vehicle supply equipment (EVSE) requirements to model the cost of a charging infrastructure over a 15-year budget cycle, in consideration of the specific needs of Brampton's fleets;

- a review of low-carbon fleet options and recommendations for a structured, phased-in transition to battery-electric vehicles (BEVs) with consideration of LTCP; and

- an overview of purchasing versus leasing versus renting fleet assets and discounted cash flow analysis (DCA) for the rental units in the Transit (non-revenue) fleet.

The recommendations explored in the Sustainable Fleet Strategy balance cost-effectiveness, timeliness, and sustainability goals. The transition away from fossil fuels, optimization of capital towards BEV replacement and charging infrastructure, and deep decarbonization must be achieved whilst maintaining stability in capital budget planning and service delivery[12].

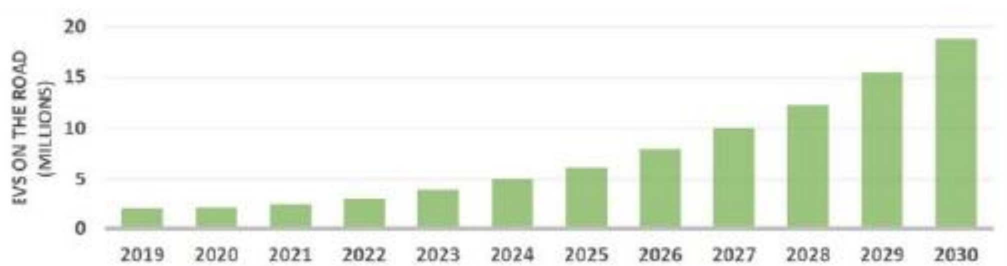
Section 4
Industry Advancements

A portion of the recommendations of the Sustainable Fleet Strategy rely on environmentally-conscious advancements to operational equipment, including medium- and heavy-duty vehicles, lower carbon fuels, vehicle sizes and shifts in purchasing policies and practices reflective of increasing environmental knowledge.

4.1 Electric Vehicle Technology

Electric transportation technologies have seen immense advancement over the past decade. Various electric vehicle (EV) technologies offer zero to little tailpipe emissions and improved energy efficiency, and the application of EVs is forecasted to grow significantly, *as shown in Figure 1*.

Figure 1: Forecasted EV Growth in US (Source: Edison Electric Institute)



Between 2015 and 2019, the City of Brampton significantly expanded its EV charging station network. The City (as of 2019) owns and operates 52 EV charging stations across 13 municipal parking lots consisting of Level 2 chargers operating at 208 or 240 V AC. A total of 183 charging stations are slated for future build (171 Level 1, and 12 Level 2). With rapidly expanding charging infrastructure, a transition to battery electric, hybrids, and plug-in hybrids are a good investment with return on annual fuel budget and corporate emission reductions. Applications of these vehicles can offset upfront cost through fuel cost savings and net cost savings until the end of their economic lifecycle (often ~10 years).

Internal combustion engines (ICE) vehicles are predicted to be overtaken by BEVs, as early as 2030. General Motors pledged to cease building many gasoline and diesel models by 2035. The recent Canadian government announcement in June 2021 of its intention to ban the sale of gasoline and diesel burning vehicles from the year 2035 has further accelerated the mandatory target for all new light-duty cars and passenger trucks to be zero-emission by 2050.

The EV technologies for light-duty vehicles currently available include:

Mild Hybrid Electric Vehicles (MHEVs)	Internal combustion engines (ICEs) and motor-generator are in parallel combination to allow the engine to be turned off when vehicle is coasting, braking, or stopped, with ability to restart quickly. MHEVs use a smaller battery than HEVs, and the motor-generator is able to create electricity and boost the gas engine' output for better performance and reduced fuel use.

	They do not have exclusive electric mode of propulsion (Ex. Honda Insight and 2019 Ram 1500[8]).
Hybrid Electric Vehicles (HEVs)	Use two or more distinct types of power for propulsion mode (ICE and battery-powered electric motor) with limited range in electric mode. Acceleration using ICE creates power, which is stored in battery to use for electric motor at other times. (Ex. Toyota Prius and Ford Fusion Hybrid[9]).
Plug-in Hybrid Electric Vehicles (PHEVs)	Use rechargeable batteries or another energy storage device that can be recharged by plugging into an external electric power source to travel more than 25km (and up to 80km, model dependent) with significantly higher battery capacity than HEVs. When battery is depleted (by ~80%), the vehicle functions as a HEV with gasoline ICE. (Ex. Chevrolet Volt and Toyota Prius Prime[10]).
Battery-Electric Vehicles (BEVs)	Electric energy is stored in rechargeable batteries to power the exclusion electric mode of propulsion by one or more electric motors. BEVs are quieter than ICE vehicles, have zero tailpipe emissions, and many have EPA-estimated ranges exceeding 400km. Recharging is a significantly longer process than ICEs, dependent on the level of charging speed: a full charge at a level 2 charger takes several hours, but a 70% charge at a level 3 charger can take 30 minutes[9]. (Ex. Nissan Leaf, Chevrolet Bolt, Kia Soul, and Tesla Model 3).

The city currently has ten (15) hybrid vehicles.

- There are seven (7) Ford F-250 Hybrids with Animal Control.
- There is one (1) Ford F-250 Hybrid with Fleet services at Sandalwood.
- There is one (1) Ford F-250 Hybrid with Fleet services at WPOC.
- There is one (1) GM Chevrolet Malibu with Law enforcement.
- There are three (3) Mitsubishi Outlander PHEVs with Fire and Emergency Services.
- There is one (1) Chrysler Pacifica PHEV with Fire and Emergency Services.
- There is one (1) Ford Explorer Hybrid with Fire and Emergency Services.

Battery-electric and hydrogen fuel-cell buses are currently available for purchase, but HEV, PHEV, and BEV options for pickups, trucks, and vans are currently limited. Medium and heavy-duty battery-electric trucks are in development (by Tesla, Volvo, Freightliner, and other) with availability in the near future.

PHEV are an excellent solution for low-mileage fleet as they have a combustion engine as a backup to the batteries, eliminating any range anxiety associated with electric vehicles. For pickups – the "workhorse of the municipal fleet" which make up 39% of Brampton's fleet (244 pickups out of a total 625 units, based on data provided) – transitioning to BEVs will make a significant impact on reducing GHG emissions. Currently, there are no BEV pickups available for purchase, but General Motors, Ford, and other manufacturers are set to produce BEV pickups starting as early as 2022[12].

4.2 Alternate Lower Carbon Fuels

Hydrogen fuel-cell vehicles (FCVs) are similar to electric vehicles as they use an electric motor and have zero emissions. However, instead of charging a battery, FCVs use onboard fuel cells for electricity generation.

A fuel cell is two to three times more energy efficient than ICE vehicles; in comparison to electric vehicles, FCV also provide better range and rapid refueling capabilities. In a FCV, electricity that powers the vehicle is the electrochemical product of the combination of hydrogen from the fuel tank (filled similarly to gasoline/diesel) and oxygen from the air; water is also produced[13].

Despite its' first introduction in the 1960s (GM's Electrovan in 1966), FCV innovation has only recently gained traction. Mass vehicle manufactures including Honda, Toyota, and Hyundai have launched their first light-duty FCVs. The slow advancement of hydrogen transportation is due to the hesitancy of developers to build expensive hydrogen fueling stations (costing $2,000,000 and more), and the hesitancy of automotive manufacturers to produce FCV without adequate infrastructure in place. California has invested in expanding its hydrogen fueling station network to 33 (out of the U.S. total of 36) stations to support the 2,000 FCVs on California roads.

Fuel cell technology has a very high potential for future applications for vehicles in all classes. Nevertheless, a study of the four-year (2010 – 2014) employment of 20 fuel-cell buses (1st-generation technology) by British Columbia's Transit Fleet servicing the Whistler community determined it very expensive and unfeasible in short-term application.

Since the trial, New Flyer and ENC have made heavy duty fuel-cell buses commercially available in North America. The United States currently has approximately 35 fuel-cell buses (30 of which are by New Flyer) in revenue service, and Mississauga Transit's MiWay is partnering with CUTRIC, Cummins, and Enbridge to commence the operation of a fuel-cell electric bus (1 bus) in 2022 – with Brampton Transit and the Toronto Transit Commission (TTC) participating as advisors and observers.

FCV technology has not yet been fully commercialized (excluding Transit); caution is advised with any FCV related projections. Instead, it is recommended to monitor the development and availability for future applications.

4.3 Vehicle Sizes

To achieve the GHG emission reduction targets, careful consideration of vehicular sizing based on occupation must be administered. Two critical measures to take are:

- downsizing through the decommissioning of underutilized vehicles, and
- right-sizing vehicles based on task (and selecting smaller sizes where applicable).

Fleet and vehicle right-sizing is achieved by carefully assessing the use of fleet based on number of trips and capacity of vehicle to determine the right size (and number) of vehicles required to carry out municipal tasks. It is critical to determine whether the same job can be done using a smaller, fuel efficient vehicle. Under-utilized vehicles can act as stranded assets. To optimize vehicle and fleet use, vehicles that are identified to be underutilized should be shared with another operating division or removed from the fleet through sale or disposal, as appropriate.

Staff positions that do not require an assigned vehicle for day-to-day tasks share a vehicle. This approach should be guided by the following:

- selecting the right vehicles to share,
- selecting a reservation management system, and
- key management process.

The following are benefits of fleet right-sizing:

- greater efficiency in operating practices by reducing the number of underutilized vehicles,
- reduced level of GHG emissions and pollutants,
- reduced fuel consumption,
- lower operating and insurance costs, and
- reduced level of capital investment in the fleet.

4.4 Purchasing Policy and Practices

The City of Brampton's Community Energy and Emissions Reduction Plan (CEERP) balances the climate emergency with the socio-economic and environmental context in the transition to clean energy and a low-carbon economy. In 2016, transportation contributed 59% of Brampton's GHG emissions. Further, gasoline contributed to 42% of energy costs; gasoline contributed to 9%. With a growing population (estimated pop. 900,000 by 2041), the implementation of smarter, energy-efficient approaches is imperative. Items of relevance to the Sustainable Fleet Strategy from the CEERP include:

- increasing the number of EV charging stations at municipal facilities,
- developing a Green Purchasing Strategy and by-law to require climate change considerations,
- ensuring the Fleet Strategy reflects CEERP targets, and
- developing operational procedures to minimize GHG emissions (i.e., enforcement of anti-idling policy for Fleet)[14].

The City of Brampton's Corporate Energy and Emissions Management Plan 2019-2024: A Zero-Carbon Transition (CEEMP) consists of three key objectives for a zero-carbon transition:

- minimize energy intensity,
- minimize emissions intensity, and
- maximize cost recovery.

The most effective way to achieve the target GHG emission reductions is to replace all older fleet vehicles and equipment with the lowest tailpipe emitting units — estimated lifecycles are 8 years (cars) to 16 years (trailers). Fleet vehicles purchased through competitive bid process, per the City of Brampton Purchasing By-Laws may be impacted. The following should be considered for the determination of vehicle replacement:

Fleet Services	Condition assessments (especially near end-of-lifecycle), replacement plan based on approved budget, vehicle mileage (flagged at 100,00km), known mechanical condition issues, and parts availability/compatibility.
Transit	Non-revenue transit vehicles (transferred from Fleet in 2017); many rental units are driven 3,000 – 4,000 km monthly, suitable lifecycles for units and repair cost trends require reassessment.
Fire & EMS	Annually present an asset management plan to Council; larger vehicle purchases require Council approval with manufacturer quotes, lifecycles are user-group dependant (Chief vehicles are ~ 4 years, light-duty are ~ 8 years, front-line vehicles are ~12 years for primary use and ~8 years as relief spares or support vehicles) with maximum lifecycle at 20 years and immediate replacement at the failure of annual inspection.

Procurement policies' evaluation criteria should be updated to reflect the City of Brampton's sustainability goals and GHG emission reduction targets. Adding sustainability goals and emissions reductions to the evaluative criteria for procurement policies will assist in achieving the 86% GHG emissions reduction (based on 2019 levels) as outlined RSI-FC's *Sustainable Fleet Strategy: Framework and Action Plan* report . Additionally, the purchase of zero-emissions vehicles (ZEVs) should be advanced, either through prioritization or mandate; the purchase of any non-ZEV units should require thorough justification, with onus on the end user or department.

The following actions should be considered:

- employ a total cost of ownership (TCO) approach to optimize the use of capital; and
- procurement should consider TCO in its competitive bidding proposal structures instead of the lowest-compliant bid approach[15].

Additionally, the following initiatives would describe sustainable purchasing when set to a policy:

- purchasing procedures;
- fleet and vehicle right-sizing;
- the purchase of vehicles that use alternative technologies; and
- the purchase of alternative fuels.

4.5 Operational Best Practices

RSI-FC outlines 9 best practices to achieve the City's GHG reduction targets (see below):

Lifecycle Cost Assessment:	For all fleets, conduct lifecycle cost assessment using historical data to determine optimal replacement age for all vehicles (model repair, maintenance, fuel, and cost of capital over a vehicle's lifecycle); RSI-FC's lifecycle analysis software can be used.

Right-sizing:	For Fleet Services and non-revenue Transit units, ensure vehicles are appropriately sized for tasks and select a smaller vehicle size wherever applicable by carefully assessing usage patterns and demands of specific vehicles.
Down-sizing:	For all fleets, decommission under-utilized non-revenue units to reduce total number of units in fleet by monitoring maintenance costs for older, under-utilized models (potential stranded assets).
Allocate Proceeds to Reserve Fund:	For all fleets, allocate sale proceeds from used vehicle auctions into a reserve fund in order to (a) maximize sale proceeds from surplus units, (b) ensure lowest possible vehicle acquisition costs, and (c) minimize operation costs of active vehicles across their lifecycle.
Chargeback System:	For Fleet Services and Transit, consider a chargeback system for all user groups to incentive improved fuel efficiency and good driving habits while reducing operational expenses.
Light-Weighting Enhancements:	For all fleets, ensure job suitability and vehicle viability before implementing light-weighting enhancements.
Eco-Driver Training:	For Fire & EMS and Transit, implement fuel-efficient driver training for all vehicle operators.
Eco-Driver Incentive Program:	For all fleets, develop a fuel-efficient driver incentive program (similar to the one at the lake Simcoe Region Conservation Authority) to improve behaviors or reduce travel through card stamping and prize draws[21].
Virtual Meetings and Carpooling:	Continue virtual meetings (post Covid-19 pandemic) and encourage staff carpooling whenever applicable.

4.5.1 Employee Education and Training

To optimize the transition to BEVs and encourage further reduction of fuel and maintenance costs, sufficient BEV educational programs and outreach materials need to be developed.

Driver training to ongoing motivation are crucial preventative measure to overcoming the potential knowledge and motivation gaps to achieve success in idling-reduction programs. Driver training should be used alongside policy changes for most effectiveness. Driver motivation can include:

- monitoring progress and providing feedback to the drivers;
- tracking and reporting fuel consumption to establish valuable monitoring basis;
- the employment of telematics technologies to track idling using GPS systems and OBD monitoring devices;
- the implementation and effective communication of a clear idling policy;

- ongoing, low-cost information campaigns to raise awareness prior to driver training; and
- non-monetary incentives programs such as periodic recognition of high-performers and charity donations.

Driver eco-training is recommended for all drivers (existing and new) of all fleets. Driver eco-training programs may vary in length and type of activities, but all training should be fact-based and promote good practices. It is strongly recommended that online training be accompanied with discussion forums and sessions amongst driver, and in-person training to combine eco-training and professional driver improvement training to maximize success.

Typical eco-training courses consist of the follow topics:

- progressive shifting (or use of automated transmissions);
- starting out in a gear that doesn't require using the throttle when releasing the clutch;
- shifting up at very low RPM;
- lock shifting where possible (e.g., shifting from third to fifth gear);
- maintaining a steady speed while driving;
- using cruise control where appropriate;
- anticipating traffic flow;
- coasting where possible;
- braking and accelerating smoothly and gradually; and
- avoiding unnecessary idling.

In addition, NRCan SmartDriver Training Series provides free training to lower fuel consumption, operating costs, and harmful emissions, and improve fuel efficiency by up to 35 percent. The NRCAN SmartDriver training is highly recommended by RSI-FC: SmartDriver training series (nrcan.gc.ca)

4.5.2 Route Optimization

In addition to improved driving practices, route planning/optimization and trip reduction can further reduce GHG emissions and fuel consumption. The integration of route planning and GPS tracking software should be used to optimize multi-stop trips and monitor idling in real time. It is recommended that technological advances to select the lowest GHG-emission routes, such as the upcoming feature on Google™ maps, be embraced.

4.5.3 Anti-Idling Technologies

Idling increases fuel consumption and negative environmental impacts, and is damaging to the public representation of any municipality. While idling is unavoidable in some cases, the U.S. Department of Energy estimates that heavy-duty vehicles waste from half to one U.S gallon (1.89 t0 3.79 liters) or more per hour from unnecessarily idling, with some fleets idling 30 to 50% or more of their operating time[16].

Idling can be reduced through the implementation of the following:

- an idling-reduction policy;
- driver training and motivation;
- idling-reduction and awareness and fact-based training;
- incentive programs;
- ongoing driver education; and
- the use of idling reduction devices, including:
    - auxiliary power units (APU);
    - stop/start devices;
    - auxiliary cab heaters;
    - battery backup systems; and
    - block heaters/engine preheaters.

An idling-reduction policy can motivate fleet drivers but should be supported by continuous enforcement, such as spot-checks and fuel use tracking. Idling reduction devices can also be employed to maximize reduction of idling. Cases when idling is unnecessary and when idling is unavoidable should be clearly differentiated. The latter include:

- cab heating/ventilation and air conditioning (HVAC);
- power for critical equipment (such as the use of a PTO for ancillary equipment); and
- maintaining brake air pressure (mid- and heavy-duty trucks).

4.5.4 Maintenance

Good vehicular maintenance is required to ensure availability, reliability, and safety of fleet vehicles. High level of vehicle uptime is indicative of good fleet management. It can be achieved by (1) acquiring newer vehicles, or (2) through effective preventative maintenance (PM) programs. Emphasis should be placed on PM when there are insufficient funds to purchase newer vehicles. The PM levels practiced by the City are:

PM B	Major, performed on light-, medium-, heavy-duty units every 12 months or 10,000 km (oil change, front end work, tire work)
Periodic mandatory commercial vehicle inspection (PMCVI)	Performed annually on given date each year.

Maintenance scheduling, vehicle histories, profiles, and related information is stored in the City of Brampton's AssetWorks M5 Fleet Focus FMIS system, allowing for real-time repair status of all fleet. IT (Fleet Services) are currently investigation transition to electronic logging devices (ELDs).

Preventative maintenance efforts should take particular note of:

Fuel filter plugging:	Due to biodiesel's solvency, debris deposits on filters can lead to premature plugging immediately after switching to biodiesel. Thus, for biodiesel blends higher than 5%, fuel filters should be changed at ½ the recommended service intervals from the engine's manual.

Storage & Oxidative Stability:	All biodiesel blends in the fuel system must be purged and flushed with petroleum diesel fuel before extended parking periods, as biodiesel blends are not suitable for low frequency use.
Compatibility with After-treatment Systems:	Biodiesel blends have potential to use more of parked particulate filter regeneration by reducing diesel oxidation catalyst performance, and can have various responses to cold flow or anti-gel additives; consult with the fuel supplier.
Engine Oil Analysis:	Using biodiesel blends may require more frequent oil change intervals[17].
Cold Weather Performance:	Biodiesel blends above 5% are not recommended for colder climate. Regular monitoring of the cloud point and cold filter plugging point (CFPP) properties of the fuel, and comparison to expected ambient temperature to be encountered in use are required. Consult with fuel supplier about varied responses of cold flow or anti-gel additives to biodiesel blends.

Light-weighting is an enhancement that can result in less fuel consumption, production of fewer emissions, and ability to carry larger payload. Not all vehicles can bear the stress of light-weighting, so applicable vehicles must be chosen with careful consideration to prevent increased maintenance demand.

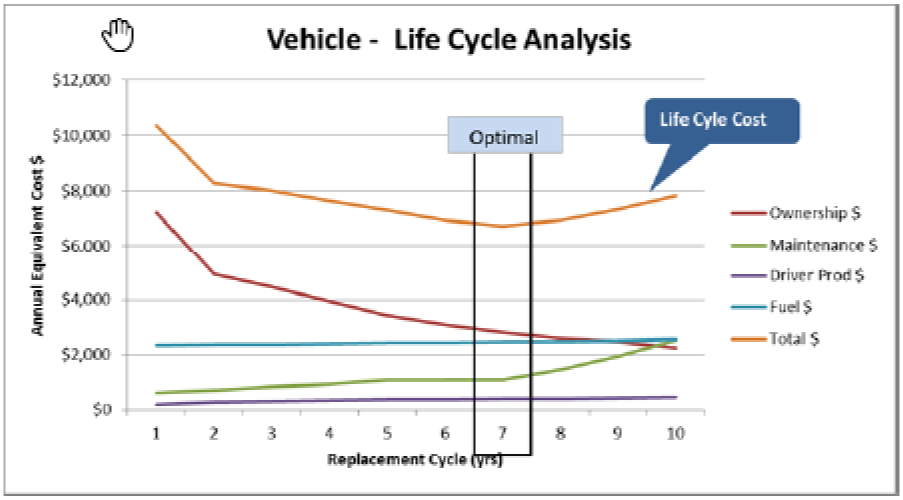
An estimated 15-30% of fuel consumption is used to overcome rolling resistance (the complex phenomenon of energy loss from friction and drag of tire rolling over a surface). The installation of low-rolling resistance (LRR) tires in either a dual or wide-base configuration and/or auto-inflation systems are considered a good investment by a North American Council for Freight Efficiency (NACFE) report, as they can reduce rolling resistance by 5% and improve fuel economy by 1.5% for light- and heavy-duty vehicles. The savings from reduced fuel consumption, reduced maintenance demands, and increased tire tread life and traction often offset the cost of LRR upgrades.

With the BEV phase-in in the short- to mid-term, maintenance costs of the BEVs will be reduced, in comparison to maintenance costs of ICEs. Much of savings and capital should be allocated towards expanding charging infrastructure aid the BEV transition. Lower capital spending during the pause on ICE pickups and medium- and heavy-duty vehicles (MHDVs) may offset initial electrical vehicle supply equipment (EVSE) costs.

In addition, existing electrical capacity at facilities should be assessed to determine whether considerable upgrades are necessary. To reduce local failure risk, the potential for two separate power supply feeds from the grid to each garage should be explored[18].

Vehicle downsizing (by decommissioning underutilized vehicles) and right-sizing (choosing the appropriate size of vehicle based on operation requirements and choosing smaller sizes when applicable) can also aid in the reduction of GHG emissions and related maintenance costs. *Figure* 2 demonstrates the positive relationship between operating costs and replacement cycle.

Figure 2: Lifecycle Analysis Example.



Further, the standardization of vehicle brands has potential to limit risk through increased knowledge of preventative measures and repairs. It is recommended that fleet managers discuss standardization to reduce required maintenance costs[19].

Continued usage of B5 biodiesel blend, – a typical finished fuel containing 5% biodiesel, is recommended for Fire & EMS and Fleet units. Transit units currently using a 10% annualized blend will continue to do so. Higher blends resulted in unacceptable levels of increased downtime and operational costs for Fleet Services and non-revenue Transit. Changes to Fire & EMS biodiesel blend are not recommended due to the tendency to crystallize (or gel) in cold-weather and the limited availability of retail services that hinder the emergency response of the fleet[7]. It is key to ensure that all new Diesel equipment is the latest technology and all dated equipment at the end of its lifecycle is replaced on time to minimize GHG emissions. The use of propane powered pickups and landscape dump trucks were discontinued in the early 2000s after issues with high downtime, and re-implementation is not recommended[20].

Section 5
Opportunities and Constraints for Greening Our Fleet

The proposed recommendations have associated challenges to implementation and overall performance, which should be carefully considered against the benefits to determine the best-suited approaches.

5.1 Battery-Electric Vehicle (BEV) Phase-In

It is recommended that BEVs are phased-in to drastically reduce overall GHG emissions through the zero tailpipe GHG and criteria air contaminant (CAC) emissions during operation, to realize maintenance and fuel cost savings due to a 99% reduction of moving parts in comparison to internal combustion engine (ICE) vehicles resulting from the elimination of oil changes and tune-ups, and diesel exhaust fluid (DEFs). However, Battery-Electric Trucks (BETs) have limited availability and an upfront price premium compared to conventional diesel trucks. Potential for government grants and incentives can aid in overcoming this constraint. Additionally, studies have found rapidly declining cost of battery packs and predicted that by 2030 or earlier, the total cost of ownership (TCO) for nearly all BEVs will be lower that ICE vehicles, even without incentives.

For the success of the BEV phase-in, adequate charging infrastructure is required. Natural Resources Canada (NRCan) is investing $130 million from 2019-2024 to significantly expand the charging network, increasing ease of BEV ownership. There is potential for collaboration with similar organization initiatives and combined municipal efforts.

5.2 Alternate Fuels

During the interim of the slow transition to BEVs, RSI-FC suggested that Fleet Services and Transit consider E85 Ethanol for factory flex-fuel units to significantly reduce GHG potential. However, Fleet Services does not currently support this option as E85 is not available in local fuel stations in Ontario, and the required infrastructure development for this option is not economically feasible. Instead, the purchase of flex-fuel units will allow the option to switch to E85, if it becomes commercially available in the future.

For all fleet (excluding transit), switching to biodiesel blends greater than B5 will not be implemented due to higher downtime and maintenance costs with minimal emissions reduction potential. For Fleet Services, CNG and LPG conversion have potential for short-term implementation, but these options will not be pursued as they challenge the longer BEV transition.

In addition, Brampton Fleet Services, Transit, and Fire & EMS will monitor new and emerging alternate fuels for potential implementation. Alternate fuel advancements include gas-to-liquid (GTL) technology as a diesel fuel substitute, as it promises significant GHG reduction over current diesel products.

Section 6

Action Plan

The Sustainable Fleet's Strategy key objectives include:

1. Data-model all potential fuel-reduction solutions and estimate their impacts (reductions of Operating expenses, Capital expenses, and GHG emissions) relative to the baseline.

2. Create a battery-electric vehicle (BEV) transition plan and estimate the cost impacts and GHG-reduction potential relative to the baseline over a 15-year budget cycle.

3. Estimate additional capital required for electric vehicle supply equipment (EVSE) over a 15- year budget cycle, and recommend solutions for offsetting these charging infrastructure costs through government funding, reduced operating budgets, and fleet reserve

4. Create a sustainable fleet action plan to improve the sustainability performance of the City's fleet including short-term (1-2 years), mid-term (3-5 years), and long-term (5-10+ years).

Following extensive research of known, credible, and proven solutions with potential viability for the City of Brampton RSI-FC developed three groups of solution models for the short- and medium-term:

Group One: *(preferred strategy)*	Best management practices (BMPs) or "house-in-order" strategies;
Group Two: *(City of Brampton will not implement this model)*	Fuel-switching or "messy-middle" solutions – interim, present-day strategies including renewable fuels (E85 ethanol and B10 annualized biodiesel) and alternate fuels (compressed natural gas (CNG) and liquefied petroleum gas (LPG)); and
Group Three: *(preferred strategy)*	Hybrid-electric and battery-electric vehicles (HEVs and BEVs, respectively).

The City of Brampton will implement Group One and Group Three options. As previously discussed, Group Two (fuel-switching) will not be implemented (excluding Transit) and current use of B5 will be continued. Additional actions to support the efficiency of Group One and Group Two options will also be taken.

Provided below is the City of Brampton Sustainable Fleet Strategy Action Plan to be implemented over the next 15 years.

Action #	Area/Topic	Action	Fleet Serv	Fire & EMS	Transit	Timeline	$ = low $$ = med $$$ = high
ACTION 1	Best Management Practices	Ensure vehicles are appropriately sized for tasks, and select a smaller vehicle size wherever applicable (rightsizing) by carefully assessing usage patterns and demands of specific vehicles.	X		X	Short-term	$
ACTION 2	Best Management Practices	Decommission under-utilized units to reduce total number of units in fleet (downsizing) by monitoring maintenance costs for older, under-utilized models (potential stranded assets).	X	X	X	Short-term	$
ACTION 3	Best Management Practices	Consider allocating sale proceeds from used vehicle auctions into a Fleet specific reserve fund in order to (a) maximize sale proceeds from surplus units, (b) ensure lowest possible vehicle acquisition costs, and (c) minimize operation costs of active vehicles across their lifecycle.	X	X	X	Short-term	$
ACTION 4	Best Management Practices	Expand fuel-efficient driver training for all vehicle operators to include Fire & EMS and Transit.	X	X	X	Short-term	$
ACTION 5	Best Management Practices	Develop a fuel-efficient driver incentive program to improve behaviors or reduce travel [21].	X	X	X	Short-term	$
ACTION 6	Best Management Practices	Continue to employ the three R's of waste management (reduce, reuse, recycle).	X	X	X	Short-term	$
ACTION 7	Best Management Practices	Develop a Corporate Transportation Demand Management strategy to reduce single occupancy vehicle trips generated for City operations, including continuing virtual meetings (post Covid-19 pandemic) and facilitating staff carpooling.	X	X	X	Short-term	$

ACTION 8	Best Management Practices	Conduct lifecycle cost assessment using historical data to determine optimal replacement age for all vehicles (model repair, maintenance, fuel, and cost of capital over a vehicle's lifecycle); RSI-FC's lifecycle analysis software can be used.	X	X	X	Short- to medium-term	$
ACTION 9	Best Management Practices	Consider a chargeback system(s) for all user groups to incentive improved fuel efficiency and good driving habits while reducing operational expenses.	X			Short- to medium-term	$
ACTION 10	Best Management Practices	Ensure job suitability and vehicle viability before implementing light-weighting enhancements.	X	X	X	Short- to medium-term	$
ACTION 11	Battery-Electric Vehicle Phase-In	Continue to assess the business viability of the new fully-electric fire truck (100kWh battery-electric with diesel generator range extender and Level-3 direct current fast charger), which is expected to arrive at the end of 2022 and be operational by early 2023, for potential large-scale application.		X		Short-term	$$
ACTION 12	Battery-Electric Vehicle Phase-In	Temporarily pause on purchasing new ICE vehicles, when appropriate, in the short-term (1 year for pickups, 3 years for MHDVs), while awaiting suitable BEV availability. The exception is for light-duty (LD) passenger BEVs that are currently available with sufficient range (eg. Kia Soul and the Chevrolet Bolt).	X	X	X	Short- to medium-term	$
ACTION 13	Battery-Electric Vehicle Phase-In	Conduct a pilot project(s) for several BEVs when they become available (e.g. pickups) to track range capabilities and cost savings and assess the units' performance for all seasons and varying weather conditions. Assuming the pilot project is successful, acquire BEVs in bulk to replace units that would provide the greatest ROI.	X	X	X	Short- to medium-term	$$

ACTION 14	Battery-Electric Vehicle Phase-In	Explore a pilot offering one or more BEVs at main corporate offices (e.g., City Hall, West Tower, and Williams Parkway Operations Centre) that staff can use for site visits and other City business.	X	X	X	Short- to medium-term	$$
ACTION 15	Battery-Electric Vehicle Phase-In	Provide high-voltage training for technicians and closely monitor the new BEV training programs' launch, including EV Maintenance Training Program for automotive technicians (e.g., Electric Vehicle Technology Certificate Program and MERLOT program offered by SkillCommons, managed by the California State University[20]).	X	X	X	Short- to long-term	$
ACTION 16	Battery-Electric Vehicle Phase-In	Coordinate shipment of end-of-lifecycle electric vehicle batteries to battery recycling facilities to support a circular economy.	X	X	X	Short- to long-term	$
ACTION 17	Battery-Electric Vehicle Phase-In	Allocate the majority of fleet capital spending towards the BEV transition, and prioritize ICE replacement with BEVs for the units that deliver ROI – typically units with high mileage. Closely monitor the acquisition costs for BEVs and re-evaluate cost-benefit for individual units.	X	X	X	Short- to long-term	$$
ACTION 18	Electric Vehicle Supply Equipment	Continue to pursue funding from NRCan's Zero Emission Vehicle Infrastructure Program (ZEVIP).	X	X	X	Short- to long-term	$
ACTION 19	Electric Vehicle Supply Equipment	Assess existing electrical capacity at facilities to determine whether substantial upgrades to power charging stations for multiple vehicles are required.	X	X	X	Short- to medium-term	$$
ACTION 20	Electric Vehicle Supply Equipment	Explore supplying power to each garage on two separate feeds from the grid to reduce the risk of local failure taking power away from the whole site.	X	X	X	Short- to long-term	$$

ACTION 21	Electric Vehicle Supply Equipment	Explore solar energy technology options to supply energy to EV charging stations to further reduce GHG emissions.	X	X	X	Short- to long-term	$$
ACTION 22	Electric Vehicle Supply Equipment	Allocate capital towards charging infrastructure and EVSE to support BEV transition for all vehicle categories in the short- and mid-term, with potential subset funding derived from ICE purchase pause.	X	X	X	Short- to long-term	$$$
ACTION 23	Collaboration / Partnership Approaches	Engage in internal partnerships within and across departments or fleets such as multi-departmental funding applications for charging infrastructure and BEV vehicles.	X	X	X	Short- to long-term	$
ACTION 24	Collaboration / Partnership Approaches	Engage in external partnership within the Region of Peel and/or other municipalities/region in the Greater Toronto and Hamilton Area (GTHA) for joint specification writing, joint tenders, and sharing of the BEV pilot projects.	X	X	X	Short- to long-term	$
ACTION 25	Collaboration / Partnership Approaches	Leverage the knowledge gained on BEV transition (e.g. procurement of vehicles and charging infrastructure) through organizational memberships such as the Clean Air Partnership or the Municipal Equipment and Operations Association of Ontario (MEOA) and apply any lessons learned to make informed decisions.	X	X	X	Short- to long-term	$
ACTION 26	Outreach/ Education	Promote the City's anti-idling policies to all fleet users, and ensure enforcement.	X	X	X	Short-term	$
ACTION 27	Outreach/ Education	Develop BEV educational and outreach materials for employees and operators summarizing the reasons and benefits of transitioning to BEVs.	X	X	X	Short- to medium-term	$
ACTION 28	Outreach/ Education	Provide operators with a BEV orientation before releasing new models into the fleet to enable them to become familiar with the different driving experience (e.g., instant torque, little noise, regenerative breaking),	X	X	X	Short- to medium-term	$

		as well as to alleviate/eliminate any apprehension or uncertainties.					
ACTION 29	Monitoring/ Reporting	Report KPI data to all fleet users annually.	X	X	X	Short-term	$
ACTION 30	Monitoring/ Reporting	Provide an update report to Council on the implementation of the Sustainable Fleet Strategy every two years, including KPIs.	X	X		Short- to long-term	$

Table 6 presents a scenario analysis conducted by RSI-FC to demonstrate the implementation timing and estimated GHG emissions reductions of the recommended solutions. For data-modelling purposes, “short-term” refers to a fleet-wide implementation in a one-year period following the baseline – for the same types of vehicles, the same number of vehicles, and travelling the same number of kilometers as the baseline. Data from 2019 was used as a baseline and 2020 was used as a proxy, therefore, 2021 is the first year modelled after the baseline. Average annual capital expenses (Capex) and average annual operating expenses (Opex) include compounding inflation for each year at the current rate of inflation for the entire modelling period (2021-2035). Group A results build onto the benefits of all Group B solutions, however, the majority of the emissions reductions are due to the BEV phase-in.

Table 6: Summary of fleet-wide results of scenario analysis over the period 2021-2035 relative to the 2019 baseline.

Group	FAR Scenario Description	Implementation Timing	Average Annual Vehicle Replacement Capex ($ millions)	Average Annual Opex Impacts Over 2019 Baseline ($ thousands)	Annual Tailpipe GHG Reduction over 2019 Baseline (tonnes CO_2e)	Annual tailpipe GHG Reduction Percentage Over 2019 Baseline
A	Enhanced specs: light-weighting, LRR (all units)	Short-term	7.4	+217	230	6%
	Driver behaviors: eco-training & anti-idling policy/technologies (all units)	Short-term	7.4	+205	812	21%
	Route planning/optimization & trip reduction (all units)	Short-term	7.4	+203	637	16%
	All BMPs (all solutions above, for all units)	Short-term	7.4	+227	1,372	35%
B	BEV phase-in: cars & SUVs starting immediately, pickups & vans starting in 2022, vans, and medium- and heavy-duty	Immediate – 2035	7.9	+315	3,376	86%

	(MHD) trucks starting in 2024; includes Fire & EMS light-duty (LD) phase-in only					

Table 7: Fleet-wide low-carbon fleet plan

Group	FAR #	FAR Scenario Description	Implementation Timing[1]	Annual Vehicle Replacement Capex ($ millions)	Annual Opex[2] Impacts Over 2019 Baseline ($ thousands)	Annual Tailpipe GHG Reduction Over 2019 Baseline (tonnes CO_2e)	Annual Tailpipe GHG Reduction Percentage Over 2019 Baseline
-	1	Current lifecycles	2021	28.2	-820	27	1%
	2	Optimized lifecycles	2021	25.5	-640	20	0.5%
	3	Balanced Capex using optimized lifecycles	2021	7.5	-330	5	0.1%
A[3]	4	Enhanced specs: light-weighting, LRR (all units)	Short-term	7.4	+217	230	6%
	5	Driver behaviours: eco-training & anti-idling policy/technologies (all units)	Short-term	7.4	+205	812	21%
	6	Route planning/optimization & trip reduction (all units)	Short-term	7.4	+203	637	16%
	7	All BMPs (all solutions above, for all units)	Short-term	7.4	+227	1,372	35%
B[4]	8	BEV phase-in: cars & SUVs	2021	6.0	+30	1,339	34%
		BEV phase-in: cars, SUVs, pickups, vans	2022	5.0	-352	1,658	42%
		BEV phase-in: cars, SUVs, pickups, vans	2023	6.2	-68	2,000	51%
		BEV phase-in: cars, SUVs, pickups, vans, Class 3 to 8 trucks	2024	12.0	-331	2,290	58%
		BEV phase-in: cars, SUVs, pickups, vans, Class 3 to 8 trucks	2025	9.5	+155	2,487	63%

[1] The 2019 baseline was used as a proxy for 2020; therefore, 2021 is the first year modelled after the baseline.
[2] For data-modelling purposes, Opex includes the annual cost of capital for any vehicle upgrades/conversions and fuelling infrastructure, spread over the budget cycle for the selected units. For BEV charging infrastructure, additional capital costs were estimated separately using an EVSE costing tool.
[3] Builds on FAR #3
[4] Builds on FAR #7 (all benefits of Group One solutions). EVSE costs are treated separately in an additional analysis.

Group	FAR #	FAR Scenario Description	Implementation Timing[1]	Annual Vehicle Replacement Capex ($ millions)	Annual Opex[2] Impacts Over 2019 Baseline ($ thousands)	Annual Tailpipe GHG Reduction Over 2019 Baseline (tonnes CO_2e)	Annual Tailpipe GHG Reduction Percentage Over 2019 Baseline
		BEV phase-in: cars, SUVs, pickups, vans, Class 3 to 8 trucks	2026	9.6	+368	2,748	70%
		BEV phase-in: cars, SUVs, pickups, vans, Class 3 to 8 trucks	2027	4.3	+307	2,893	73%
		BEV phase-in: cars, SUVs, pickups, vans, Class 3 to 8 trucks	2028	7.4	+491	3,012	76%
		BEV phase-in: cars, SUVs, pickups, vans, Class 3 to 8 trucks	2029	6.6	+546	3,178	81%
		BEV phase-in: cars, SUVs, pickups, vans, Class 3 to 8 trucks	2030	5.9	+478	3,311	84%
		BEV phase-in: cars, SUVs, pickups, vans, Class 3 to 8 trucks	2031	11.8	+479	3,361	85%
		BEV phase-in: cars, SUVs, pickups, vans, Class 3 to 8 trucks	2032	10.3	+622	3,375	86%
		BEV phase-in: cars, SUVs, pickups, vans, Class 3 to 8 trucks	2033	9.2	+815	3,376	86%
		BEV phase-in: cars, SUVs, pickups, vans, Class 3 to 8 trucks	2034	6.2	+522	3,376	86%
		BEV phase-in: cars, SUVs, pickups, vans, Class 3 to 8 trucks	2035	8.3	+664	3,376	86%

Section 7

Monitoring Progress

To track the progress of the Sustainable Fleet Strategy, the City of Brampton must establish key performance indicators (KPIs) and pursue data collection, analysis, and reporting protocols annually or biennially.

7.1 Key Performance Indicators (KPIs)

Use of the following KPIs is recommended:

Fuel consumption:	Include fuel consumption (L/100km), or corporate average fuel economy (CAFE) to set goals and measure progress towards targets for improved fuel efficiency and reduced GHG emissions. Implementation of this KPI requires user groups increased influence over purchase decision.
GHG intensity:	Include GHG intensity (kg CO_2e/km) as part of a benchmark to measure GHG emissions reduction accounting for potentially expanding fleet to service growing population.
Area Ratio:	Include area ration (no. of units/km^2) and/or population ratio (population/no. of units) to assess the relative size of the City's fleet proportional to its geographic size and population. It is recommended that the City downsize their fleet by examination and decommissioning of underutilized vehicles.
Electric vehicle supply equipment costing outlook:	RSI-FC's EVSE costing outlook predicts future demand for battery-electric vehicles (BEVs) in the City's fleets, and should be included to monitor the replacement of internal combustion engine (ICE) vehicles with BEVs and progress of charging infrastructure installation.

To support implementation, monitoring, and reporting of the Sustainable Fleet Strategy Fleet Service requires a new Fleet Analyst position responsible to help establish vehicle utilization baselines to better understand current state of fleet and guide strategic decisions.

Section 8

Conclusion

The City of Brampton has been a leader in green fleet practices over the last two decades. However, the City's ambitious and necessary emission reduction targets coupled with its goals for more environmentally, socially, and economically sustainable corporate practice means efforts have to be amplified and accelerated.

The Sustainable Fleet Strategy outlines a combination of short-, mid- and long-term approaches that balance the sustainable goals of the City with the respect to the socio-economic and environmental context. The most significant transition is the EV phase-in. The success of the EV phase-in relies on the concurrent implementation of operational best practices, and understanding of the current challenges. Most importantly, it is critical that adequate resource, including staffing as well as capital and operating budgets, be allocated to ensure that the Sustainability Fleet Strategy is driven forward and its GHG emission reduction potential is fully realized.

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