Schedule A to Staff Report 2021-0257

TOWN OF CALEDON
REPORT NUMBER: 20M-01190-00

TOWN OF CALEDON GREEN FLEET STRATEGY

MAY 28, 2021

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DATE: MAY 28, 2021

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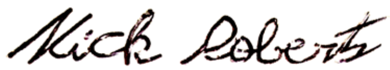

May 28th, 2021

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TABLE OF CONTENTS

TABLES

FIGURES

ABBREVIATIONS LIST

Abbreviation	Definition
ASTM	American Society for Testing and Materials
AVL	Automatic Vehicle Location
BAU	Business as Usual
BEV	Battery Electric Vehicle
BTU	British Thermal Unit
CAPEX	Capital Expenditure
CNG	Compressed Natural Gas
CO_{2e}	carbon dioxide equivalent
CPI	Consumer Price Index
dBA	decibel
dLe	diesel litre equivalent
DEF	Diesel Exhaust Fluid
DPF	Diesel Particulate Filter
EGR	Exhaust Gas Recirculation
EIA	Energy Information Administration
EV	Electric Vehicle
FCEV	Fuel Cell Electric Vehicle
FCM	Federation of Canadian Municipalities
hp	horsepower
IEA	International Energy Agency
kg	kilogram
km	kilometer
km/h	kilometers per hour
KPI	Key Performance Indicator
kW	kilowatt
kWh	kilowatt hour
L	litre
lbs	pounds
MJ	mega Joule
mph	miles per hour
MSRP	Manufacturer Suggested Retail Price
NOx	Nitrogen Oxides
NRCan	Natural Resources Canada
OEM	Original Equipment Manufacturer
OPEX	Operational Expenditure
PCF	Pan-Canadian Framework
PERC	Propane Education & Research Council
PHEV	Plug-in Hybrid Electric Vehicle

Abbreviation	Definition
PM	Particulate Matter
PPE	Personal Protective Equipment
RFP	Request for Proposal
RNG	Renewable Natural Gas
SAE	Society of Automotive Engineers
SCR	Selective Catalytic Reduction
SOx	Sulphur Oxides
SUV	Sport Utility Vehicle
TAC	Transportation Association of Canada
V	volt

EXECUTIVE SUMMARY

The Town of Caledon is a lower tier municipality, located in Peel Region with a population of approximately 71,600 residents. In 2020, Caledon Council declared a Climate Emergency and passed a community-wide GHG reduction of net zero emissions by 2050 (refer to the Town of Caledon's Community Climate Change Action Plan, Resilient Caledon 2021 for additional information) as part of this greenhouse gas (GHG) reduction target the Town's corporate fleet will play an essential role in reducing emissions.

The Town also approved a Corporate Greenhouse Gas Reduction Framework (2019-2024). This framework outlines a target to reduce corporate emissions 24% by 2024 below 2017 levels. According to this strategy, 2017 fleet emissions accounted for 42% of the Town's corporate emissions, or 1,519 tonnes of CO_2e. A target was established to reduce fleet emissions to 1,063 tonnes of CO2e, which is a 30% reduction from the 2017 emissions baseline level.

The Town of Caledon has a diverse fleet of over 170 vehicles including light-duty car, pickup trucks, cargo vans, medium and heavy-duty landscaping trucks, dump trucks and fire service vehicles. The majority of the Town's fleet are diesel and gasoline-powered, with a small portion of hybrid and plug-in electric cars.

To address the challenge of GHG reduction for the corporate fleet a Green Fleet Strategy has been developed to position the Town on a strategic pathway to adopting "green" vehicle technology with lower emissions, while being proactive in preparing for technology changes available on the market. The methodology of developing this strategy is outlined in Figure 1 and explained below.

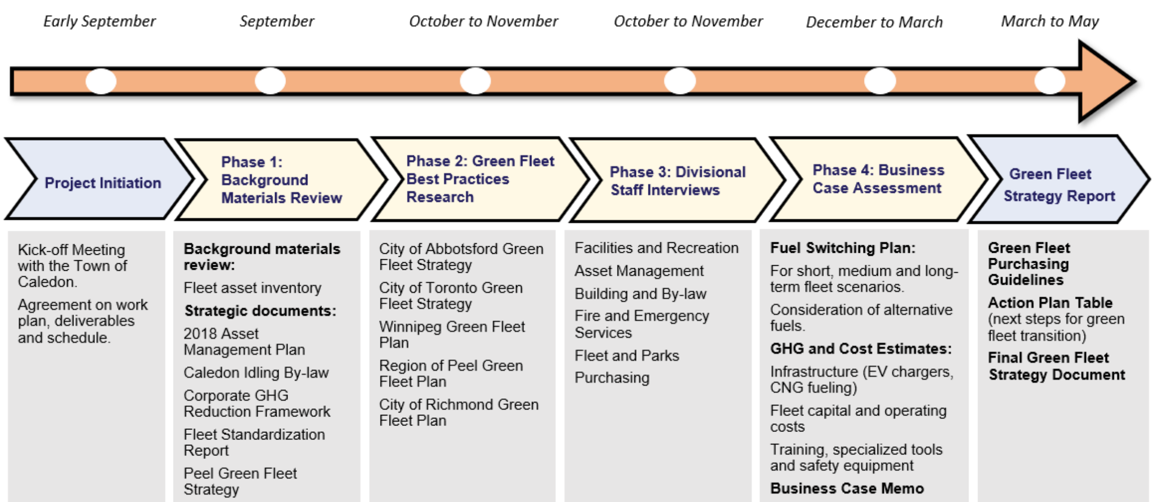

Figure 1 Project Timeline

1. **Phase 1** - background materials review of the Town's fleet asset inventory, fleet data, strategic plans and other relevant materials to develop a comprehensive understanding of the Town's fleet and strategic plans.
2. **Phase 2** - best practice research scan of Green Fleet Strategies from peer municipalities to develop actions that will reduce the GHG emissions from the Town's fleet.
3. **Phase 3** - divisional staff consultations with staff from different user groups that own and operate the Town's fleet. The goal of this phase was to develop an understanding of each user group's vehicle needs and views on green fleet, current fleet purchasing practices as well as to identify any opportunities and constraints in the current operations.
4. **Phase 4** – developing a Fuel Switching Plan and Green Fleet Purchasing Guide from the information gathered in Phases 1 to Phase 3. A business case analysis was also developed, based on the Fuel Switching Plan, to assess the capital cost, operating cost and estimated GHG emissions reduction of transitioning to recommended green fleet technologies under short-term (< 5 years), medium term (5 to 10 years) and long-term (10+ years) scenarios for the Town of Caledon.

Fuel Switching Plan

The Fuel Replacement Plan, outlined in Table 1 below, presents a strategy to transition all light-duty vehicles to battery electric vehicles (BEV) in the short term (2024 horizon) where mature technology is available (i.e. cars, SUVs and cargo vans). Hybrid and plug-in hybrid technologies can be used to bridge this transition in the interim, where fully battery electric options are still emerging (i.e. pickup trucks). All other diesel vehicles are planned to transition to biodiesel during this same timeframe. For larger heavy-duty plow trucks, compressed natural gas (CNG) has presented to be an alternative to diesel fuel, with lower GHG emissions. This is recommended in the short term through a pilot with a single plow truck.

There are some exceptions, including fire trucks, which are to remain operating on diesel or limited biodiesel (B5) in the short term, due to limited proven BEV alternatives. The fire service vehicles are operations critical assets and as such the rollout of new fuel types and technologies is planned to first be tested and implemented in other areas of the fleet. Refer to Section 2.2.8 for a future outlook on these technologies.

As an overall strategic direction, the fleet is planned to move towards fully battery electric vehicles over the long-term, where mature options exist, and rely on lower emission fuel sources including CNG and biodiesel. There can also be future opportunities to consider renewable diesel and renewable natural gas (RNG) as the commercial availability of these fuel sources continue to develop in Ontario. Both renewable diesel and RNG can be used interchangeably with CNG and diesel vehicles respectively, thereby leading to near zero GHG emissions.

Table 1 Fuel Switching Plan Summary

Vehicle Type	Vehicle Count	BAU	Short Term (2024) Count:	Short Term (2024) Change to:	Medium Term (2029) Count:	Medium Term (2029) Change to:	Long Term (2030 +) Count:	Long Term (2030 +) Change to:
Mowers	12	Diesel	12	Biodiesel (20%)			12	BEV
Loader	7	Diesel	7	Biodiesel (20%)				
Sidewalk Tractor	8	Diesel	8	Biodiesel (20%)				
Tractor	1	Diesel	1	Biodiesel (20%)			1	BEV
Hybrid Car	6	PHEV	3	BEV	3	BEV		
Hybrid Car	2	HEV	2	BEV				
SUV	9	Gasoline	7	BEV	2	BEV		
Utility Vehicle	2	Gasoline			2	BEV		
Pickup truck gas	21	Gasoline	15	HEV	6	BEV	15	BEV
Pickup truck	23	Biodiesel (5%)	21	HEV	2	BEV	21	BEV
Van gas	1	Gasoline	1	BEV				
Van	2	Biodiesel (5%)	2	BEV				
Pickup truck	2	Diesel	2	Biodiesel (20%)	2	BEV		
Landscape Truck	11	Biodiesel (5%)	11	Biodiesel (20%)			11	CNG
Plow Truck Pilot	1	Biodiesel (5%)	1	CNG				
Plow Truck	26	Biodiesel (5%)			11	CNG	15	CNG
Gradall	1	Diesel	1	Biodiesel (20%)				
Fire Truck	31	Diesel			31	Biodiesel (20%)		
Grader	4	Diesel	4	Biodiesel (20%)				
Sweeper	1	Diesel	1	Biodiesel (20%)			1	BEV

Business Case for Green Fleet Technologies

The business case assessment includes preliminary estimates on vehicle replacement costs, CNG fueling infrastructure, EV charging stations, training and specialized tooling. Overall, a higher capital cost compared to business-as-usual (BAU) fleet is expected due to the needed infrastructure investment and cost premium for green vehicles.

This capital cost can be partially offset by operational cost savings from the fleet (i.e. reduced fuel and maintenance costs on the part of green technologies). In addition, there are several grants and funding opportunities which the Town could pursue (refer to Section 2.5). Table 2 provides a summary of the key capital and operating costs as well as the magnitude of GHG emissions reduction, representative of this Green Fleet Strategy. Further details on the business case assessment are included in Section 2.3.

Table 2 Summary of Financial and Environmental Green Fleet Strategy Estimates

Green Fleet Strategy Estimates	Short-Term (2024)	Medium Term (2029)	Long-Term (2030 onward)
GHG reduction (relative to 2017)	13%	22%	45%
Total Incremental CAPEX	$1.2 million	$2.4 million	$5.4 million
Annual OPEX Savings[2]	$10,000	$112,000	$504,000
Payback Period	N/A	N/A	10.7 years

Overall, this Green Fleet Strategy strongly positions the Town of Caledon to make actionable progress to achieving GHG emissions reduction, especially in the medium and long term. The Town can begin making progress over the next few years, however it is important to realize that there are several risk factors which can challenge GHG emissions reduction in the short-term. These include:

1. **Infrastructure Requirements:** the need to purchase, setup charging and fueling infrastructure prior to the procurement of alternative green vehicles. Consultation with utility providers (i.e. Hydro One and Enbridge Gas) to potentially upgrade electrical feeds and natural gas delivery to sites will also need to be planned.
2. **Change Management:** the need to train staff in all aspects of a technology change including but not limited to safety, vehicle maintenance, charging and refueling as well as driving behaviours all need to be planned for a successful rollout.
3. **Technological Maturity of Heavy-Duty Vehicle Alternatives:** there are several BEVs coming available in the market for heavy-duty trucks. However, there is currently limited availability for these models to factor into short-term fleet plans in large scale (i.e. prior to 2024). Furthermore, these vehicles do not have the demonstrated deployment history and technological maturity as BEVs in the light-duty passenger vehicle class. However, the expectation is that heavy-duty BEVs will be more available for medium and long-term horizons and play a pivotal role in cutting GHG emissions from the fleet.
4. **Market Availability of EVs:** there can be long lead times associated with EV procurements, particularly in the class of newer models such as heavy-duty trucks, in some cases being up to 1-year or more. These supply challenges can limit the uptake of EV adoption in the short-term but are expected to be less of a concern in medium and long-term horizons.

[2] Includes cost savings in terms of the environmental cost avoidance through use of fuels with lower CO_2e emissions and thereby incurring a lower cost from the carbon tax.

To address these risks an Action Table has been developed with key next steps identified to enable the success of a green fleet transition. These risks can all be overcome in the medium and long-term along with leveraging future technology developments to position the Town to achieve their long-term goals.

In addition, the Town is recommended to revisit their Green Fleet Strategy on a 5-year basis or earlier as new information and/or vehicle technologies come available which can further support the Town's strategic direction on green fleet adoption. The 5-year benchmark is referenced from peer municipalities which use this cycle to set their capital replacement plan over the following 5-years.

1 BACKGROUND AND CURRENT STATE

The Town of Caledon is located in the northern area of the Region of Peel in Ontario. The Town is a lower tier municipality comprised of a population of 71,600 residents. The Town's population is expected to grow to 108,000 residents by 2031 and reach a population size of 132,000 by 2041.

1.1 CORPORATE OBJECTIVES FOR EMISSIONS REDUCTION

In 2019, Caledon Council passed a 5-year Corporate Greenhouse Gas Reduction Framework, with a focus on reducing emissions from the Town's buildings, vehicle fleet, waste and water consumption. The framework targets a reduction of 24% below 2017 levels in corporate greenhouse gas (GHG) emissions by 2024 and is in support of the Paris Agreement, as well as the Pan-Canadian Framework (PCF) for Clean Growth and Climate Change's goal of 30% reduction of 2005 national GHG emissions by 2030.

In 2017, Caledon's Corporate Fleet emissions were 1,519 tonnes of CO_2e, which was 42% of the Town's total corporate emissions. The 2024 target is set to 1,063 tonnes of CO_2e, which is a 30% reduction from the 2017 emissions level. The framework requires the development of Green Fleet and Fuel Reduction Strategy with identification of fuel switching and saving opportunities and a purchasing guide with key stakeholder consultation.

In 2020, Caledon Council declared a Climate Emergency and passed a community-wide GHG reduction of net zero emissions by 2050. The Town's Green Fleet Strategy long-term plan was developed to target the transition of all possible Town vehicles to zero emission vehicles by 2050, aligned with the Resilient Caledon Plan targets.

1.2 CORPORATE FLEET EMISSIONS REDUCTION

The Town of Caledon has a diverse range of fleet including light-duty vehicles, pickup trucks, cargo vans, medium and heavy-duty trucks, construction equipment, trailers and mounted equipment. Most of the Town's fleet are diesel and gasoline-powered, with a small portion of hybrid and plug-in electric vehicles.

Currently, the Town has implemented the following efforts to reduce GHG emissions from their fleet:

- Integrated biodiesel (B5 – 5% blend) fuel into vehicle fleet
- Purchased six (6) plug-in hybrid electric vehicles (PHEVs) for staff operations;
- Expanded its electric vehicle (EV) charging network to 22 EV charging connectors;
- Implemented an Automatic Vehicle Location (AVL) system;
- Conducted a Fleet Life Cycle Analysis;
- Passed an Idling Bylaw that applies to Town vehicles, and the community; and,
- On-going efforts to promote sustainable travel options to Town staff.

The Town's Fleet Standardization Report in 2020 indicated that the standardization of fleet vehicles improves maintenance efficiencies, streamlines inventory, training and purchasing processes. Moreover, the key lessons learned from the Asset Management Plan in 2018 are the importance of developing lifecycle strategies for green vehicles, establishing key performance indicators (KPIs), target levels of service and evaluating levels of service on an annual basis with appropriate target adjustments. In support of the goals of standardization and lessons learned from the Asset Management Plan, the Town's Green Fleet Strategy provides a procurement guideline that focuses on the GHG reduction targets, assists with fleet standardization goals, provides KPIs, and considers the lifecycle strategies.

The Green Fleet Strategy is segmented into short-term (2021 to 2024), medium term (2025 to 2029) and long-term (2030 onwards) actions with the following key objectives that align with existing Town strategic documents, visions and plans:

1. Target to align as close as possible with the Town's fleet emissions reduction targets of 30% by 2024 and net-zero emissions by 2050, and establish a path forward to transition all fleet to low carbon fuels;
2. Ensure the Town is proactive in preparing for emerging fleet technology transitions as it relates to commitments to phase out combustion engine vehicles;
3. Develop a framework and procedure for low-carbon fleet purchases;
4. Understand staff tasks and vehicle requirements to inform vehicle right-sizing;
5. Develop the business case associated with low-carbon sustainable fleet, including lifecycle costs and savings;
6. Understand the infrastructure requirements associated with low carbon fleet;
7. Receive Council-endorsement and staff buy-in; and,
8. Improve the resilience of the Town's future vehicle stock to the impacts of a changing climate.

1.3 FLEET ASSET INVENTORY

A review of the Town's current operations asset inventory was conducted. The assets were classified by class and vehicle type. This asset classification system was utilized to form the basis of the business case analysis conducted for examining different alternative green fleet scenarios. The Town also owns other assets such as equipment and trailers, however, they were not included in the plan as they do not directly contribute to the Town's GHG emissions. Furthermore, hand-held tools such as lawn mowers, blowers, trimmers and other landscaping type equipment are outside the scope of this study. However, there is potential for the Town to investigate battery powered hand tools for operational cost savings and GHG emissions reduction. Section 2.2.8 highlights some of the emerging technologies in this space.

Figure 2 provides a summary of the major vehicle assets that were identified from the asset inventory. The pickup truck fleet makes up the biggest segment of vehicles currently owned by the Town. The fire trucks and plow trucks are also very significant with 31 and 27 vehicles respectively.

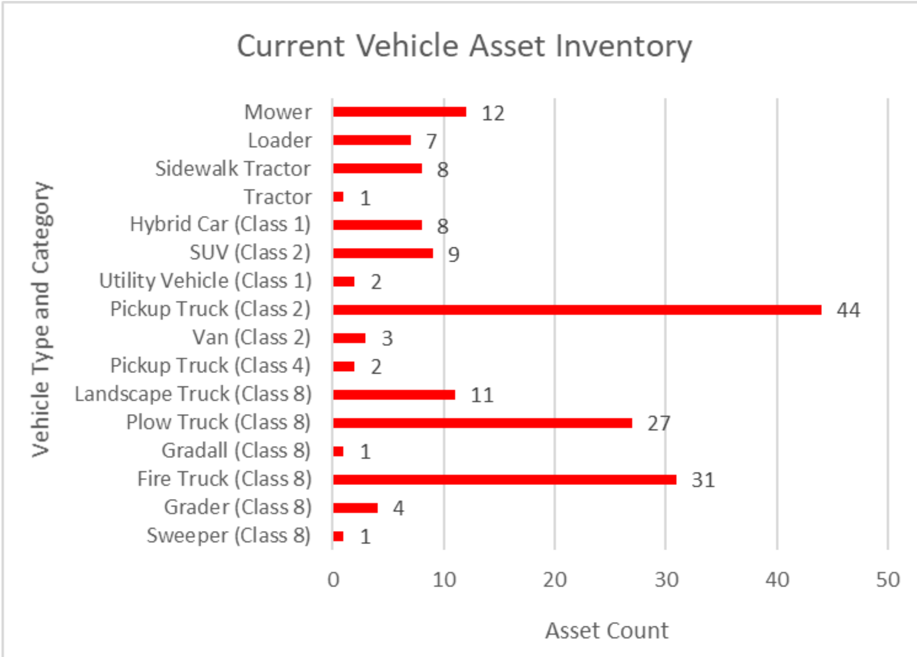

Figure 2 Existing Vehicle Asset Inventory

Table 3 provides an overview of the propulsion type, acquisition costs, and expected life of the vehicles in the existing asset inventory. According to the 2018 Asset Management Plan, 29% of vehicles are in good to very good condition, while 55% with a valuation of $22.8 million, are in poor to very poor condition. In addition, around $8 million worth of vehicle assets are beyond their service life, but 20% of the fleet assets have over 10 years of useful life remaining.

The Town of Caledon's current operations fleet is predominantly made up of conventionally fueled vehicles (i.e. gasoline and diesel), except for eight cars which are hybrid electric vehicles (HEVs) and plug-in hybrids (PHEVs). The Town's most expensive vehicle asset classes consists of the fire trucks, gradall excavator, and graders.

Table 3 Existing Vehicle Propulsion Type, Expected Life (years), Replacement Cost

Vehicle Class	Vehicle Type	Vehicle Count	Fuel	Current Estimated[3] Replacement Price ($)	Expected Life[4] (Years)
N/A	Mowers	12	Diesel	$26,000	5 years
N/A	Loader	7	Diesel	$320,000	10 years
N/A	Sidewalk Tractor	8	Diesel	$140,000	10 years
N/A	Tractor	1	Diesel	$75,000	10 years
Class 1	Hybrid Car	6	PHEV	$45,000	7 years
Class 1	Hybrid Car	2	HEV	$45,000	7 years
Class 1	SUV	9	Gasoline	$45,000	7 years
Class 1	Utility Vehicle	2	Gasoline	$30,000	10 years
Class 2	Pickup truck	44	Diesel	$55,000	7 years

[3] Referenced from Town of Caledon's Fleet Purchases 2022 and 2023

[4] Referenced from Town of Caledon Operations Department – Fleet Replacement Warrants

Vehicle Class	Vehicle Type	Vehicle Count	Fuel	Current Estimated[3] Replacement Price ($)	Expected Life[4] (Years)
Class 2	Van	3	Diesel	$50,000	5 years
Class 4	Pickup truck	2	Diesel	$75,000	5 years
Class 8	Landscape Truck	11	Diesel	$130,000	10 years
Class 8	Plow Truck	27	Diesel	$350,000 (single-axle) $370,000 (tandem)	8 years (single-axle) 11 years (tandem)
Class 8	Gradall	1	Diesel	$350,000	10 years
Class 8	Fire Truck	31	Diesel	$400,000	15 to 20 years
Class 8	Grader	4	Diesel	$530,000	8 years
Class 8	Sweeper	1	Diesel	$395,000	8 years

An assessment of the transaction reports tracked by the Town was conducted. This assessment provides a baseline for comparisons and development of the business case for different green fleet scenarios. The average annual vehicle kilometers traveled or usage hours, and the fuel efficiency of each vehicle type were established.

On the basis of annual kilometers traveled, the most utilized vehicles are the hybrid cars and the plow trucks. With respect to the annual operating hours, the most utilized vehicles are the gradall excavator and graders. The analysis also shows that the graders, gradall excavator, and the sweepers have the highest consumption in the litres of fuel used per hour. The plow trucks and fire trucks have the highest fuel consumption on the litres of fuel used per kilometre basis.

Table 4 Fleet Vehicle Average Utilization and Annual Fuel Consumption Summary

Vehicle Class	Vehicle Type	Vehicle Count	Average Vehicle Annual Usage (km or hr)	Units	Fuel efficiency	Units
N/A	Mowers	12	174	Hr	3	L per Hour
N/A	Loader	7	454	Hr	10	L per Hour
N/A	Sidewalk Tractor	8	465	Hr	5	L per Hour
N/A	Tractor	1	465	Hr	5	L per Hour
Class 1	Hybrid Car	8	17,500	km	4	L/100km
Class 1	SUV	9	14,100	km	13	L/100km
Class 1	Utility Vehicle	2	500	km	19	L/100km
Class 2	Pickup truck	44	11,700	km	17	L/100km
Class 2	Van	3	4,650	km	14	L/100km
Class 4	Pickup truck[5]	2	11,700	km	34	L/100km
Class 8	Landscape Truck	11	11,250	km	27	L/100km
Class 8	Plow Truck	27	16,200	km	55	L/100km
Class 8	Gradall	1	870	Hr	13	L per Hour
Class 8	Fire Truck	31	1,500	km	46	L/100km
Class 8	Grader	4	700	Hr	20	L per Hour
Class 8	Sweeper	1	675	Hr	11	L per Hour

[5] Average annual usage (km) estimated based on Class 2 pickup trucks. Limited fleet data available for Class 4 pickup truck utilization.

1.4 METHODOLOGY

This section provides an overview of the methodology that was used to develop the Town of Caledon's Green Fleet Strategy as well as some of the key outputs at each stage of the process. The strategy was conducted in four phases:

Phase 1 Background Review - consisted of a background materials review of the Town's strategic plans and other relevant materials to develop a comprehensive understanding of the Town's fleet and strategic plans. The background materials that were reviewed include the following:

- Town's Corporate GHG Reduction Framework (Fleet chapter)
- Region of Peel's Green Fleet Strategy (2018)
- Town's Vehicle Fleet Lifecycle Analysis Report (2019)
- Town's Fleet Standardization Report (2020)
- Town's Fleet Transaction Report (2019 and 2020 year-to-date)
- Town's past procurement documents
- Town's Idling Bylaw
- Town's Asset Management Policy (2018)

Phase 2 Best Practice Scan- entailed a best practice research scan of Green Fleet Strategies from peer municipalities to develop actions that will reduce the GHG emissions from the Town's fleet. This phase involved reviewing valuable measures and strategies in the following categories: driver efficiency, vehicle efficiency, low carbon fuel and vehicle options, and fleet management best practices.

- City of Abbotsford Green Fleet Strategy
- City of Richmond Green Fleet Plan
- Region of Peel Green Fleet Strategy
- City of Toronto Consolidated Green Fleet Plan
- Winnipeg Green Fleet Plan

An alternative fuels feasibility table was also established as part of Phase 2, consisting of the alternative fuel best practice scan that analyzes the following propulsion types:

- Compressed Natural Gas (CNG)
- Renewable Natural Gas (RNG)
- Biodiesel
- Propane
- Battery Electric Vehicles (BEVs)
- Hybrid Electric Vehicles (HEVs)
- Plug-in Hybrid Electric Vehicles (PHEVs)
- Hydrogen Fuel Cell Electric Vehicles (FCEVs)

Each propulsion type was evaluated on the following aspects:

1. Vehicle Suitability
2. Market Readiness
3. GHG Reduction Potential
4. Estimated Costs
5. Operating Range
6. Maintenance & Operations Impact
7. Infrastructure Requirements
8. Risks

Phase 3 Staff Consultation - consisted of divisional consultations with staff from different user groups that own and operate the Town's fleet. The goal of this phase was to develop an understanding of each user group's vehicle needs and views on green fleet, current fleet purchasing practices as well as to identify any opportunities and constraints in the current operations. Moreover, findings of the best practice research scan and potential actions were discussed for staff input, the feasibility of potential actions was also determined. The user groups that were interviewed include representative staff from the following departments:

- Facilities and Recreation
- Asset Management
- Building and By-law
- Fire and Emergency Services
- Fleet and Parks
- Purchasing

Phase 4 Fuel Switching Plan- consisted of the development of the Fuel Switching Plan and Green Fleet Purchasing Guide. From the information gathered in Phases 1 to Phase 3, as well as a review of the Town's most recent fleet vehicle and equipment inventory and fleet lifecycle analysis, a fuel switching plan was developed for the short, medium and long-term for the Town of Caledon.

The fuel switching plan (Section 2) provides high-level infrastructure requirements, estimated costs and cost savings as well as GHG reduction. In addition, a Green Fleet Purchasing Guide was also developed as part of Phase 4 to support the processes and decision-making of purchasing alternative green vehicles.

1.5 STAKEHOLDER FEEDBACK

During Phase 3 of the project, a set of stakeholder consultations were scheduled with the Town of Caledon. The purpose was to engage user groups to understand their vehicle needs, and to determine opportunities and constraints regarding transitioning to green fleet. A summary of the feedback received is included in Table 5 below.

Table 5 User Group Feedback

Stakeholder Group: Facilities and Recreation
General Feedback: • Some vehicles are under-utilized due to the current working from home conditions. • Most vehicles work well and are right-sized. • Some vehicles are required to travels long distances (some around 1,000 kilometers per week) **Green Fleet Opportunities:** • Consulted battery companies to determine the optimal use procedure for charging, which made a huge difference. • Want to see light-duty vehicles transitioned to electric. This would be feasible as most light-duty vehicles only need to operate for the 8-hour shift. • The few high mileage vehicles must be reliable. • Hesitant to be the trial run group for new technologies. • Training is important as there is a huge learning curve for certain vehicles (such as battery electric ice resurfacer).
Stakeholder Group: Asset Management
General Feedback: • Estimated useful life is based on financial values and not actual condition. • Asset Management department has resourcing issue, current focus is on core assets such as roads, bridges. In 2022, will shift focus more to non-core assets.

- Desire for every department to have asset management resource, replacement cost, condition age, advantage on cost savings, risk, climate change, etc.
- Moving forward it is a good idea to look at different metrics, find an intersecting way to assess the state of the assets.

Stakeholder Group: Building and By-law

General Feedback:

- Buildings currently only have one fleet vehicle; one inspector gets to use the Town's vehicle and the rest of the six inspectors use their personal vehicles. The Town's vehicle is shared on a rotating basis. However, they would like to shift away from that and have all inspectors use Town vehicles.
- Buildings department is looking at vehicle pool opportunities.
- Opportunity to explore options for pickup trucks.
- Currently using a mobile application (AMANDA platform) for building permits and complaints, etc. The mobile app can be used for optimization of routes and trip planning. This can also be explored as an opportunity for other departments.

Green Fleet Opportunities:

- Hybrid Toyota Prius was a great vehicle for parking control, but had ground clearance issues, especially during winter and heavy snows.
- 2016 Chevy Volts had really good usability in terms of driving, but difficult to get in and out the car for some of the inspectors.
- Goal is to have small compact cars with good ground clearance for snow.
- Definitely want to utilize more green vehicles in the future to have energy and cost savings. In support of the Town's strategy and commitment to reduce green house gas emissions.
- Important to keep in mind the geographic size of Caledon and ensure the vehicles acquired have the range for battery charge done in a day. Their high mileage users are parking control, drive about 75 kilometers per day, all over town.
- Meeting the range requirements and right size based on ergonomics is key.

Stakeholder Group: Fire and Emergency Services

General Feedback:

- Vehicles have various functions: for the truck fleet they haul trailers (contaminated materials and hoses), move props and larger supplies, transition to emergency response support, transport people and equipment, assist with wild land fires, bring contaminated materials back, fire prevention, inspection, enforcement, etc.
- Vehicles are right sized.
- Current maintenance consists of inspection and apparatus checks at least once a week, annual maintenance and general maintenance and repairs. Annual pump testing performed currently by third-party. These procedures take time to do as they have to simulate fighting fires. Therefore, a lot of times the vehicles are running idle under work mode to perform these checks and repairs.

Green Fleet Opportunities:

- Aware of the following industry news: LA county running trials using Rosenbauer fire trucks that are principally electric with diesel as secondary support. Interested to see how the trial runs in year two. Greater London Fire Service is trialing CNG platforms. City of Toronto fire services will trial electric fire trucks.
- Key criteria for the vehicle requirements include safety, performance, durability, pump capacity.
- Open to switch for the training, prevention and logistics vehicles but must ensure that they meet regulatory standards.
- Not willing to pool vehicles at this time.
- Would be open to pilot vehicle technology.
- If CNG was considered refuelling would be done at the yard. It would be important to know if there is a possibility for remote station to have an onsite CNG resupply since there is no commercial supply.
- Typically, high usage, low frequency, and the capacity of pumping water up on elevation is critical.

Stakeholder Group: Fleet and Parks

General Feedback:

- Vehicles are right sized; all are utilized to their capacity in terms of ability.
- Auto shutoff enabled on trucks; however, this can be disabled by drivers, but the lighter duty trucks do not have that.
- Typically try to follow idling protocols however, exemptions exist in certain cases due to the nature of work.
- Already have pool vehicles in practice.
- Currently, have ethanol E10 at the pumps right now, the issue with ethanol fuel is shelf life.

Green Fleet Opportunities:

- Have used biodiesel fuel since the mid 2000s, generally B5 for winter operation B20 in summer for heavy plow trucks and medium duty as well as some medium size diesel pickup trucks.
- B20 caused problems, including engine issues, clogging up of diesel particulate filters (DPFs), exhaust gas recirculation (EGR) failures. Therefore, started using B5 year-round few years back to mitigate problems, using B5 year-round has been good.
- Back to 2007 and 2008, Toyota Prius hybrids worked well, replaced with 2013 Camry hybrids also worked well.
- Added six Chevrolet Volt cars in the past few years, there are a couple Chevrolet Volts used for inspection and coordinator type of work.
- For the next 10 years, would like to see a long-term strategy with council buy in for long-term commitment of funding for green fleet.
- Want to see measurables on GHG reduction from the strategy, on-going monitoring, priority plan both high (smaller vehicle) and low, possibility for green hand-held tools, trimmers or chainsaws.
- Desire to see smaller vehicles transition to alternative fuels or battery powered and want to see strategy for larger fleet and how to replace them. Would like to see light-duty vehicles including pick up trucks transition to electric, medium duty truck, ¾ ton and 1-ton transition to CNG.

- Key is to make sure the green fleet vehicles are sustainable and reliable, winter is a big factor, and risk management is important. Hesitant to be a test market for new technology. If unreliable technologies are causing problems, there are no resources to spare.
- Key info needed to switch to BEV include the reliability of the vehicle and if it meets requirements. Must know the range, ability to haul weight, tow capacity. Piloting BEVs first would make sense.
- For CNG or RNG trucks, refueling and training, infrastructure spacing requirements are the most significant challenges.
- Dedicated resources are needed to spearhead the program and assist implementation from a long-term perspective.

Stakeholder Group: Purchasing

General Feedback:

- Current purchasing process is very clear to the bidders. There are lots of interest from bidders, high competition, and very few questions.
- Procurement procedure versus the timing and availability of vehicles is a huge challenge. Every manufacturer has a different request to delivery time frame as every manufacturer has a different production window.
- A challenge with the request for proposal (RFP) process is that new vehicles do not have a fuel rating associated with them, a lot of them are unknown until they have been in use after some years (due to technology evolution). This leads to a challenge with standardization, and a lot of back and forth with council.
- A challenge is that by setting standards, as well as including demonstrations (by having people test drive the vehicle and rate them against criteria) takes a lot more time in the RFP process. Usually, a tender can be completed in 6 to 8 weeks, but an RFP would result in an additional 3 to 4 weeks.
- The expectation for the green fleet strategy is to develop specifications to standardize or determine the appropriate minimum thresholds for green fleet. However, the benchmark established must be achievable by a large group.
- Usually purchasing requirements are provided by the user group, no current policies from council indicate that the vehicles should be green.
- A statement of work template would be the easiest way to incorporate green fleet requirements. It can be used to procure, issue as a bid document, any learning in terms of green fleet can be added and fine tune the document.
- Car sharing internally is already implemented for a few vehicles in some departments, however, it was discovered that damages happen more frequent on shared vehicles.
- Do not see car sharing with external stakeholders being feasible in terms of risk management.
- Council was initially pushing for sharing vehicles; however, the current pandemic may have changed this view.

2 FUEL SWITCHING PLAN

The Fuel Switching Plan is to be viewed as a strategic direction and ideal transition case based on the data available at the time of preparing this Green Fleet Strategy. It is understood that some factors could change the transition timing (i.e. budget constraints, future decisions on vehicle lifecycle retirements/replacements).

Table 6 provides a summary of the green fleet scenarios for the cost benefit analysis that was conducted to assess the applicability of green fleet technology to the Town of Caledon's fleet. The modelled transition plan consisted of the current fleet for a baseline comparison Business-As-Usual (BAU), and three (3) additional plans detailed below:

i. Short-Term Transition Plan (2021-2024): This scenario considered transitioning all Class 1 and 2 vehicles to battery electric vehicles (BEV) or hybrids. All other diesel vehicles/equipment are planned to transition to biodiesel before 2025. The CNG adoption will start with one plow truck as a pilot. There are exceptions for the fire trucks which are to remain operating on diesel in the short-term.

ii. Medium-Term Transition Plan (2025-2029): This scenario considers transitioning all Class 1 and 2 vehicles as well as the sweeper to BEVs and the plow trucks to CNG before 2030.

iii. Long-Term Transition Plan (2030 and Beyond): This scenario considers the case of maximum electrification of the fleet, transitioning the mowers and tractor to BEVs from 2030 onwards.

The ideal transition plan was determined in consultation with the Town and the adjusted transition plan considers the remaining useful life of the current fleet to provide the Town with a more realistic transition plan. The adjusted transition plan accounts for the schedule of asset lifecycle replacements and aligns new technology adoption with their replacement cycle.

Table 6 Modeled Fuel Switching Plan

Vehicle Class	Vehicle Type	Vehicle Count	Ideal Transition BAU	Ideal Transition Short	Ideal Transition Medium	Ideal Transition Long	Adjusted Transition: Short	Adjusted Transition: Medium	Adjusted Transition: Long
Class 0	Mowers	12	Diesel	Biodiesel	Biodiesel	BEV	12 Diesel to Biodiesel		12 Biodiesel to BEV
Class 0	Loader	7	Diesel	Biodiesel	Biodiesel	Biodiesel	7 Diesel to Biodiesel		
Class 0	Sidewalk Tractor	8	Diesel	Biodiesel	Biodiesel	Biodiesel	8 Diesel to Biodiesel		
Class 0	Tractor	1	Diesel	Biodiesel	Biodiesel	BEV	1 Diesel to Biodiesel		1 Biodiesel to BEV
Class 1	Hybrid Car	6	PHEV	BEV	BEV	BEV	3 PHEV to BEV	3 PHEV to BEV	
Class 1	Hybrid Car	2	HEV	BEV	BEV	BEV	2 HEV to BEV		
Class 1	SUV	9	Gasoline	BEV	BEV	BEV	7 Gasoline to BEV	2 Gasoline to BEV	
Class 1	Utility Vehicle	2	Gasoline	BEV	BEV	BEV		2 Gasoline to BEV	
Class 2	Pickup truck gas	21	Gasoline	Hybrid	BEV	BEV	15 Gasoline to Hybrid	6 Gasoline to BEV	15 Hybrid to BEV
Class 2	Pickup truck	23	B5	Hybrid	BEV	BEV	21 B5 to Hybrid	2 B5 to BEV	21 Hybrid to BEV
Class 2	Van gas	1	Gasoline	BEV	BEV	BEV	1 Gasoline to BEV		
Class 2	Van	2	B5	BEV	BEV	BEV	2 B5 to BEV		
Class 4	Pickup truck	2	Diesel	Biodiesel	BEV	BEV	2 Diesel to Biodiesel	2 Biodiesel to BEV	
Class 8	Landscape Truck	10	B5	Biodiesel	Biodiesel	CNG	10 B5 to Biodiesel		10 Biodiesel to CNG
Class 8	Landscape Truck	1	Diesel	Biodiesel	Biodiesel	CNG	1 Diesel to Biodiesel		1 Biodiesel to CNG
Class 8	Plow Truck Pilot	1	B5	CNG	CNG	CNG	1 B5 to CNG		
Class 8	Plow Truck	26	B5	B5	CNG	CNG		11 B5 to CNG	15 B5 to CNG
Class 8	Gradall	1	Diesel	Biodiesel	Biodiesel	Biodiesel	1 Diesel to Biodiesel		
Class 8	Fire Truck	31	Diesel	Diesel	Biodiesel	Biodiesel		31 Diesel to Biodiesel	
Class 8	Grader	4	Diesel	Biodiesel	Biodiesel	Biodiesel	4 Diesel to Biodiesel		
Class 8	Sweeper	1	Diesel	Biodiesel	BEV	BEV			1 Diesel to BEV

Note: Biodiesel blends are presented based on their blend percentage (i.e. B5 is a 5% blend and Biodiesel refers to a B20 or 20% blend). The Town of Caledon currently has some of their pickup trucks, cargo vans and plow trucks running on a B5 blend.

The transition plan provides a framework for comparison of the estimated economic and environmental impacts of adopting different green technologies. The transition plan will assist in determining the appropriate strategy for the Town of Caledon to adopt to support its sustainability and emissions reduction targets.

2.1 CONSIDERATION OF ALTERNATIVE FUELS

Gasoline and diesel vehicles have progressed with notable improvements in engine technology for better fuel economy and exhaust aftertreatment systems to capture harmful emissions. Diesel vehicles in particular have systems including selective catalytic reduction (SCR), diesel particulate filters (DPF), diesel exhaust fluid (DEF) and exhaust gas recirculation (EGR). These systems are focused on producing cleaner fuel combustion and reducing harmful air contaminants, most notably particulate matter (PM), sulphur oxides (SOx) and nitrogen oxides (NOx).

Engine and overall drivetrain efficiency gains have helped moderately reduce GHG emissions. However, there are several opportunities to consider alternative fuels from biological and renewable sources in order to further reduce CO_2e emissions. The following sections discuss the feasibility of the most prominent alternative fuels.

2.1.1 BIODIESEL AND RENEWABLE DIESEL

Biodiesel

Biodiesel is a substitute for diesel fuel that has the potential to reduce GHG emissions. Biodiesel is produced from renewable feedstock, vegetable oils such as soy and corn, through a chemical reaction process called transesterification with alcohol and a catalyst in order to produce the fuel. As the feedstock grows it absorbs carbon dioxide from the atmosphere thereby reducing upstream emissions contributed to the production of the diesel fuel.

Biodiesel can be blended with conventional diesel fuel. The blend is noted by a B-index (i.e. B20 is 20% biodiesel blend). In North America, all major diesel engine manufacturers have approved the use of B5 biodiesel. Furthermore, biodiesel levels of up to a maximum blend of B20 can be used in any standard diesel engine without modifications.

Vehicle and engine warranty should still be consulted with the OEMs for use of a biodiesel blend above B5. The National Biodiesel Board is one reference which can be consulted for OEM statements on approved usage of various biodiesel blends with their engines. The ASTM 6751 standard governs quality acceptance for biodiesel blends and ASTM D7467 standard prescribes quality standards specifically for the B20 blend.

Biodiesel can cost slightly more than regular diesel. The US Department of Energy states there can be an incremental cost of 20 cents per gallon for B20 fuel which is approximately an 8% premium. This benchmark cost premium for B20 fuel has also been used by peer municipal green fleet assessments in southern Ontario.

Biodiesel can offer a simple approach to lowering the GHG emissions of fleet vehicles where limited options are available. However, the biodiesel should come from a reputable source as there is a risk of damage to engine components from particulate matter if not processed at a high standard. Natural Resources Canada (NRCan) references the BQ-9000 certified list of producers and marketers in North America.

There are some concerns with the use of higher concentrations of biodiesel use in cold winter months. Fuel gelling in cold weather could lead to increased maintenance on fuel filters. However, performance issues, such as fuel gelling, can be mitigated by using a lower blend (i.e. B5) or fuel additives.

Renewable Diesel

Renewable diesel is another alternative fuel which is made from waste agricultural products including natural fats, vegetable oils, and greases. The main difference between renewable and biodiesel is the chemical process of producing the fuel. Renewable diesel is processed through hydrogenation making it more chemically similar to conventional diesel and is subject to the ASTM D975 standard for petroleum fuels.

Both renewable and biodiesel offer similar GHG emission reduction benefits. However, one advantage of renewable diesel is that it can be used in higher concentrations and can directly replace conventional diesel. Renewable diesel does not have the same concerns as higher blend biodiesel fuels in cold weather use.

One drawback it that renewable diesel is currently not as commercially available in Canada as biodiesel. However, there has been recent interest and investment from the Canadian government to scale renewable diesel production in Southern Ontario to commercial levels.

In 2020, the Federal Economic Development Agency for Southern Ontario announced a $5 million investment to FORGE Hydrocarbons, located in Sombra, ON, for scaling their renewable diesel production from 200,000 litres up to commercial levels at 28 million litres per year. This type of investment and similar developments could open the opportunity for renewable diesel fuel to be used in the Town of Caledon's fleet.

2.1.2 NATURAL GAS

Natural Gas

As a fuel source, natural gas is a mature technology for use in heavy-duty trucking fleets including long haul transport, municipal waste collection and snowplow fleets. Furthermore, natural gas is a widely available fuel source in Canada and Ontario, transported via tanker trucks or natural gas pipelines by utilities such as Enbridge.

The Town of Caledon has engaged peer municipalities including Oxford County and Simcoe County in Southern Ontario as well as the City of Dublin, Ohio near Columbus. The peer experience with CNG vehicles is summarized below:

- Oxford County has two CNG snowplows that have been in operation since 2017. In addition, Oxford County has a fleet of approximately 20 dual fueled CNG/gasoline light-duty pickup trucks, cargo vans and SUVs. Oxford County's CNG snowplows have been performing well and the County is set to purchase an additional two CNG snowplows in 2021.
- The City of Dublin has installed their own CNG fuel station and operates a fleet of 52 CNG vehicles, including 10 single axle snowplow trucks.
- Simcoe County has a fleet of dual fueled CNG/gasoline vehicles. Simcoe County has cited several issues around reliability and constant repairs for their dual-fuel conversions (mostly pickups) and lack of service providers.

The feedback on heavy-duty CNG vehicles has been favourable however, the dual fueled CNG/gasoline light-duty vehicles have generally not met user expectations. Therefore, the Town of Caledon is interested to pursue CNG technology for their snowplow fleet while focusing on hybrid and battery electric options for light-duty vehicles.

Renewable Natural Gas

A renewable natural gas (RNG) vehicle operates similarly as a CNG vehicle, with the main difference being the sourcing of natural gas fuel. RNG is produced from biogas created by decomposing organic waste or bio-mass such as the ones found in landfills, farms and other industries. The traditional method of producing natural gas is from underground rock and shale deposits which require a large amount of energy/work to extract. In contrast, RNG offers a carbon-neutral GHG emissions impact by recycling and repurposing gas which would have been emitted into the atmosphere.

Although there are avenues to reduce GHG emissions for natural gas vehicles by replacing the CNG with renewable natural gas (RNG), the province of Ontario currently lacks a clear path towards deploying RNG at a large scale. However, with the strategic decision to pursue a natural gas fleet for vehicles where other alternatives are limited (i.e. battery electric) this does leave the possibility open to future use of RNG for greater GHG reduction.

2.1.3 HYDROGEN

At present time the availability of hydrogen fuel and vehicles in Ontario is limited. However, there is potential for hydrogen to be revisited in future updates to the Town's Green Fleet Strategy.

There are only two commercially available passenger vehicles (sedans) available in Canada at this time. The Toyota Mirai and Hyundai Nexo are available in Canada and the Honda Clarity is available in some US states. Furthermore, there is no publicly available hydrogen fueling stations in Ontario.

Canada currently produces approximately 3 million tonnes of hydrogen annually (4% of the global total). However, this is mostly for industrial applications as only 0.01% of hydrogen fuel production globally is used to fuel road vehicles[6]. The International Energy Agency (IEA) has forecasted "grey hydrogen" as the most cost-effective means for hydrogen fuel production until 2030. Thereafter, the benefits in GHG reduction from "green hydrogen" production can be expected to become more viable. "Grey hydrogen" refers to hydrogen produced from fossil fuels, whereas "green hydrogen" produces hydrogen fuel using renewable electricity sources (i.e. solar and wind) thereby bringing the full benefit as a renewable fuel.

2.1.4 PROPANE

Propane as an alternative fuel source was reviewed as part of the Green Fleet Strategy development. While there are viable applications for propane as an alternative fuel, the Town is focused on transitioning to zero emission vehicles. Hybrid technology can be seen as an interim technology for light-duty vehicles while natural gas and biodiesel or renewable diesel fuels can help bridge the transition to fully battery electric vehicles in the heavy-duty class.

The Energy Information Administration (EIA) has published data on the carbon dioxide emissions produced from various transportation fuels. Emissions are compared across a common energy unit (i.e. BTU or MJ) as to account for the different energy densities of each fuel. For example, natural gas is primarily methane (CH_4), which has a higher energy content relative to propane (C_3H_8), and therefore, natural gas has a relatively lower CO_2 emissions-to-energy content. This comparison is shown in Table 7 below.

Table 7 Emission Comparison per Energy Unit of Fuel Sources[7]

Fuel	Emissions (lbs of CO_2 per million BTUs)	Emissions (g of CO_2 per MJ)
Diesel	161.3	69.3
Gasoline	157.2	67.6
Propane	139.0	59.8
Natural Gas	117.0	50.3

Based on this comparison, propane produces approximately 19% higher CO_2 emissions when compared to natural gas. Another drawback of the energy density of propane fuel is that propane has 27% less energy than an equivalent litre of gasoline[8]. This can lead to more frequent refueling needs and can impact fleet operations.

[6] Clean Energy Canada, Hydrogen as part of Canada's Energy Transition, July 2020

[7] US Energy Information Administration (EIA), "How much carbon dioxide is produced when different fuels are burned?" Available at: https://www.eia.gov/tools/faqs/faq.php?id=73&t=11

[8] Alternative Fuels Data Centre, "Propane Vehicles" Available at: https://afdc.energy.gov/vehicles/propane.html

Furthermore, the market, availability of fuel supply, and original equipment manufacturer (OEM) vehicles is more widely available for natural gas and diesel vehicles. Propane fuel most commonly needs to be delivered to the fueling site by a tanker truck whereas natural gas can largely be supplied via pipeline infrastructure. The reliance on tanker truck delivery can pose a risk to fleet operations if fuel deliveries are not met as scheduled. The Town of Caledon has a fleet of winter operations vehicles including snowplows for which reliability is of upmost importance during the winter season.

There is also the potential to transition to renewable diesel and renewable natural gas (RNG), as these fuel sources become more commercially available in Ontario. Both renewable diesel and RNG can be used interchangeably with their respective diesel and natural gas engines.

The marketplace for heavy-duty trucks is currently more mature for natural gas than propane. The Cummins Westport line-up of natural gas engines for heavy-duty applications is a commonly available option from major truck OEMs including Freightliner, Autocar, Mack and Peterbilt. Natural gas has been used in various fleets at large scale including municipal waste collection and snowplow fleets.

Propane has not seen a similar uptake in heavy-duty trucks. There have been some recent developments in propane engines with an announcement in early 2021 that the Propane Education & Research Council (PERC) has approved a $12 million funding request aimed to commercialize a Cummins 6.7-litre propane engine by 2024 [9]. However, with the market trending towards zero emission vehicles, and the growth of research and development in heavy-duty battery electric trucks there are likely to be more favourable technologies available to the Town of Caledon's fleet in this medium to longer term horizon.

To summarize the main strategic drivers as to why other green fleet technologies are viewed more favourably in comparison to propane at this time include the following:

1. Market availability for hybrid and battery electric vehicles in the light-duty class.
2. Reduced carbon emissions for natural gas in comparison to propane along with the potential to consider RNG as an interchangeable fuel source to further reduce emissions for heavy-duty natural gas vehicles.
3. Availability of biodiesel and emerging commercial scale of renewable diesel to serve as an interim step to reducing emissions in heavy-duty vehicles and equipment.
4. Desire to standardize the green fleet technology and fuel sources of the fleet as much as possible.
5. Market direction on OEMs developing natural gas engines for heavy trucking (i.e. Cummins Westport line of natural gas engines) and proven deployments in large scale municipal fleet operations including waste collection and snowplows.
6. Direction to minimize the use of carbon fuels and consider fully battery electric options for heavy-duty vehicles as the market continues to evolve.

Overall, the Town of Caledon is encouraged to stay informed on the latest developments in alternative fuels as there may be future opportunities to revise the Green Fleet Strategy and re-evaluate the potential use of propane fuel.

2.2 VEHICLE TECHNOLOGY MARKET OUTLOOK

The purpose of the following section is to provide an overview of the current market and planned developments in green vehicle technology. This market outlook can support the feasibility of the Green Fleet Strategy for the Town of Caledon. As technology is constantly evolving, a market review of available technologies is recommended to be updated each year for the potential of discovering new opportunities, which could be incorporated into the Town's plans.

[9] LPGas, "Cummins propane engine project holds promise" Available at: https://www.lpgasmagazine.com/cummins-propane-engine-project-holds-promise/

2.2.1 CARS & SUVS

The market for light-duty cars and SUVs has several plug-in hybrid (PHEV) and BEVs already available. There are several BEV models available ranging from a MSRP at $38,000 up to $45,000.

The electrical efficiency typically ranges from 0.14 to 0.18 kWh/km for cars and 0.18 to 0.22 kWh/km for SUVs. Vehicle range has been constantly improving from battery technology. Vehicles in this class can now achieve an operating range up to and exceeding 400 km (dependent on battery size). Some of the most prominent BEV models available include the Chevrolet BOLT, Hyundai Ioniq, Nissan Leaf and Volkswagen eGolf. SUV models include Ford Mustang Mach-E, Hyundai Kona and Kia Soul EV.

2.2.2 LIGHT-DUTY PICKUP TRUCKS

OEM Vehicles

The market for battery electric pickup trucks has been experiencing significant development. Although the availability of the BEV pick-up trucks is limited in the short term, most models are expected to be coming available in late 2021 and 2022.

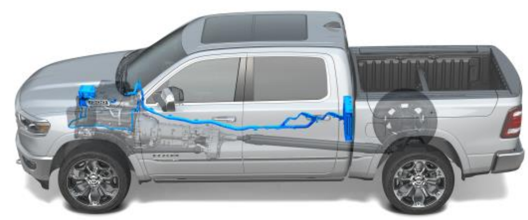

Figure 3 RAM 1500 eTorque Hybrid System

Some of the models that are anticipated to be available within the next two years include the Ford F-150, GMC Electric Hummer, Tesla Cybertruck, Havelaar Bison and Rivian R1T. Chevrolet is also stated to be developing an electric version of their Silverado pickup. The price estimates of these models range from the Ford F-150 Lightning and Havelaar Bison $60,000 (est.)[10] to $85,000 for the GMC Electric Hummer. The electrical efficiency ranges are expected to be around 0.25 kWh/km to 0.54 kWh/km.

As a technology bridge to BEV pickups, there are options for non plug-in hybrid pickup trucks. The Ford F-150 hybrid and the RAM 1500 eTorque mild hybrid are two models available today. Their respective MSRPs are $43,000 and $34,000. The Ford F-150 hybrid is available on any of the F-150 trim levels and adds an approximate premium of $4,500 to the base price. The F-150 hybrid has an EPA rated fuel economy at 24 mpg (9.8 L/100km) a 20% improvement. The RAM 1500 hybrid was rated at 20 mpg (combined) or 10.7 L/100km[11].

Aftermarket Systems

XL Fleet is one aftermarket provider of hybrid drive systems on Class 2 to 6 municipal and commercial fleet vehicles. XL Fleet offers two drivetrain options, a plug-in and non plug-in, which are designed for compatibility with a range of different vehicle makes and models.

Figure 4 XL Fleet Hybrid System

The XL Fleet system currently has compatibility with Chevrolet Silverado and GMC Sierra 2500 / 3500 HD pickups as well as the Ford F-250. This offers an alternative hybrid option for medium and heavy-duty pickups where OEM options do not currently exist. The system can cost anywhere from $15,000 up to $30,000 depending on the plug-in or non plug-in system and make/model of vehicle.

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[10] Electrek "Tesla Cybertruck Cheaper Than Ford F-150 Cost of Ownership". Available at : https://electrek.co/2019/12/05/tesla-cybertruck-cheaper-than-ford-f150-cost-of-ownership/

[11] Car and Driver, Tested: 2021 Ford F-150 Hybrid Proves to Be an Electrifying Workhorse; Green Car Congress, 2019 RAM drops weight, gains 48V eTorque mild hybrid system; Autoblog, 2019 Ram 1500 eTorque fuel mileage numbers released

2.2.3 CARGO VANS

There are some electric cargo van models available today including Ford eTransit which has a MSRP listed at $58,000. This model has an efficiency of 0.33 kWh/km and a battery size of 67 kWh. In addition, GM also announced that they will be producing the Brightdrop EV 600 electric van in Ontario starting 2021.

Mercedes-Benz has also developed an electric model of their Sprinter cargo van. This vehicle has been in service in Europe since 2019 and will make its way to the North American market by 2023.

Figure 5 GreenPower EV Star Cargo Van

Other electric vehicle exclusive OEMs include GreenPower, Arrival and Workhorse. All have cargo van models available in Canada and the United States. GreenPower is a Canadian company. Their EV Star cargo van has a 118 kWh battery and a range up to 240 km. The EV Star has 579 cubic feet of cargo space, with a payload capacity of 2,268 kg (5,000 lbs).

2.2.4 HEAVY-DUTY TRUCKS

Battery Electric

Various companies including new entrants and well-established manufacturers are starting to produce heavy-duty electric trucks. Some of the electric trucks include the Lion Electric Lion8, Volvo FL Electric, and Freightliner Em^2 106. The battery size of these models ranges from 300 kWh to 336 kWh, and their electric range can be from 270 km up to 370 km (dependent on battery size).

Currently, there is not a feasible option for a battery electric snowplow. The key reason is the need for snowplows as an operation's critical asset in winter months. The required operating range, adverse cold weather driving conditions and vehicle weight (i.e. salt/sand hoppers) are all factors currently limiting BEVs for snowplowing applications.

Compressed Natural Gas

CNG is a relatively mature technology that has been used in heavy trucking and waste collection fleets for a number of. Cummins Westport is the primary OEM that offers natural gas engines for vehicles. The Cummins ISX12N (up to 400 hp) and the Cummins L9N (250 to 350 hp) are two engine models available.

The traditional heavy-duty truck chassis models available include Freightliner 114SD and Autocar ACMD 4X2 with tank sizes ranging from 227 L to 378 L and a range up to 550 km. Oxford County currently has two Freightliner 114SD tandem axle CNG trucks as part of their snowplow fleet which have been in operation since 2017.

Figure 6 Oxford County CNG Snowplow

Furthermore, various vendors can convert vehicles to CNG. For example, Frontier CNG Inc. located in Mississauga, offers converting light and heavy-duty vehicles to CNG fleet. In addition, they offer fuel pricing programs as well as strategies and installation of CNG fuelling stations.

The Town of Caledon has engaged several municipalities which operate CNG truck fleets as part of this Green Fleet Strategy. The City of Dublin, Ohio has shared a positive review of their CNG fleet which includes 10 single-axle plow trucks.

CNG has been viewed as a favourable technology, in comparison to diesel, for snowplow fleets in reducing GHG emissions. RNG could be used for further GHG reduction as more sources for this fuel come available in Ontario in the future.

2.2.5 LANDSCAPING EQUIPMENT

Figure 7 Ride-on Electric Lawn Tractor

For landscaping equipment, Mean Green Mowers offers a heavy-duty zero-emission commercial mower for medium to heavy duty applications, the Rival 52/60. This electric mower can last for up to 7 hours of operation and has a lower 78 dBA noise level in comparison to conventional mowers.

Another model available from Mean Green Mowers is the EVO, it is meant for heavy duty applications and has up to 8 hours of continuous mowing time. The mower can travel up to 21 km/h.

Greenworks Commercial also offers electric ride-on lawn mowers as part of their 'Zero Turn' lineup. Their products include a variety of both ride-on and stand-on self-propelled mowers.

Club Cadet has also announced a ride-on battery electric lawn tractor will be coming available. The lawn tractor will be powered by a 1.5 kWh lithium-ion battery that can be charged using a standard 110V outlet in about 4 hours. The mower will be able to mow up to 2 acres, or 1.5 hours, on a single charge without power fade. The mower features a 13-gauge, 42-inch, twin blade deck with side discharge.

2.2.6 STREET SWEEPERS

Figure 8 Boschung Electric Sweeper

In 2019, Global Environmental Products introduced the first electric heavy-duty street sweeper in the world. The vehicle has a travel speed of 25 mph and a battery that lasts up to 11 hours of operation[12]. Global Environmental Products in based in San Bernardino, California.

Boschung is another company based in the United States which has developed an electric street sweeper. The Urban Sweeper S2.0 has a gross vehicle weight of 4,000 kg and is equipped with a 54 kWh battery pack. The company is also working on development of autonomous driving technologies.

These vehicles are still limited in terms of deployment however, the technology is promising to be considered for medium and long-term green fleet plans.

2.2.7 TRACTORS

Figure 9 Case 580 EV Backhoe

The Case 580 EV introduced in 2020, is a fully electric backhoe loader that is currently under limited availability in the United States. With a 480V, 90 kWh lithium-ion battery, it has enough power for at least 8-hours of typical operation and can be charged by a 220V three phase connection. It was stated that this loader can potentially save up to 90% in annual vehicle service and maintenance costs when considering reduction and elimination of diesel, engine oil, diesel exhaust fluid, and regular preventative maintenance activities.

The John Deere All-Electric Backhoe is currently being developed, but a release date has not been announced. John Deere has developed a proof-of-

[12] Global Environmental Products, "M3 Electric Sweeper", Available at: https://globalsweeper.com/images/pdfs/Brochures/GLOBAL_M3_ELECTRIC_BRO_102220_sm.pdf

concept for the electric backhoe and is testing the vehicle on work sites in the North Eastern USA. The backhoe is targeted to achieve the same operation and performance levels of its diesel-powered counterpart, the John Deere 100 horsepower 310 L backhoe.

2.2.8 FUTURE TECHNOLOGY OUTLOOOK

There are some vehicle types listed in the Town of Caledon's fleet which are not yet identified for a battery electric or alternative zero emission technology. Examples include the fire truck fleet and gradall excavator equipment. Although there are on-going developments in zero emission technologies for these vehicle types there is limited information to accurately include cost and performance data into a business case analysis at this time.

The section below lists some on-going technology developments which may become more viable as the Town of Caledon's green fleet transition progresses. The Town is encouraged to stay updated on these technologies with the opportunity to update their Green Fleet Strategy on a 5-year cycle or earlier to capture new information and vehicle technologies coming available.

Plug-in Hybrid Fire Trucks

In late 2020, the fire service vehicle manufacturer Rosenbauer announced the development of a hybrid diesel-electric fire truck, in partnership with Volvo. The vehicle's electric drivetrain is provided by Volvo Penta and consists of:

- Battery pack options for 50 kWh or 100 kWh
- All-wheel drive electric in-wheel motors, total power output 360 kW (490 hp)
- 6-cylinder diesel engine (272 hp)
- Compatible SAE J1772 standard DC fast charging up to 150 kW (80% charge in 1-hour)

Figure 10 Rosenbauer PHEV Fire Truck

There are plans to launch pilot operations of this vehicle in Berlin, Amsterdam and Dubai. The City of Toronto has also mentioned interest in piloting hybrid systems on fire vehicles.

Heavy-Duty Excavation Equipment (Gradall)

Proterra is a commercial electric vehicle technology manufacturer and Komatsu is a manufacturer and supplier of construction and mining equipment. In January of 2021, the two entities announced that they would be partnering to develop all-electric construction equipment, beginning with a Komatsu battery-electric middle class hydraulic excavator.

The first joint-development is slated to undergo proof of concept in 2021, with anticipated commercial availability being 2023 or 2024. The electric-battery system is expected to incorporate high energy density and fast charging technology and will be merged within the existing body of the excavator to act as a counterweight used to balance the excavator's hydraulic arm movements.

Figure 11 Rendering of Komatsu and Proterra Battery Electric Excavator

Small Tools and Equipment

Hand-held powered small equipment was classified to be out-of-scope for this study. However, this is a future opportunity that the Town of Caledon can look into to support reducing GHG emissions. Equipment such as snow blowers, leaf blowers and push mowers are all getting viable battery electric alternatives. Some examples are noted below.

Figure 12 Ego Power Electric Snow Blower

Ego power plus offers a variety of powerful cordless electric snow blowers. These blowers utilize two lithium ion batteries and enable the clearing of heavy, wet snow. They have a 21-inch wide intake, can adjust the variable-speed auger to control how far the snow is thrown (up to 35-foot throwing distance). Ego power claims that their snow blowers offer the power and performance of gas but without associated noise and emissions (up to two 7.5 Ah battery packs available). Other comparable snow blower products are offered by RYOBI, Toro power, and Snow Joe.

Figure 13 STHL Electric Lawn Equipment

A variety of battery electric lawn tools are available in the market today including electric blowers, chainsaws, hedge trimmers, string trimmers and pole saws. Ego power offers a combined multi-head system that enables use of multiple of these tools in one.

Husqvarna also offers a variety of these battery electric products, using BLi150 batteries for quick charging of their offered tools (80% in 35 minutes). STIHL also has a product line of battery electric tools including push mowers (RMA 510), hand-held blowers (BGA 85 and BGA 100) and trimmers (FSA 56).

2.3 BUSINESS CASE ANALYSIS

2.3.1 MODELING METHODOLOGY AND INPUTS

This section provides an overview of the methodology for formulating the business case analysis of the transition plan outlined in Section 2, as well as the key modeling inputs and assumptions.

Modeling Methodology:

The business case model was constructed to evaluate the benefits and the drawbacks for each short, medium and long-term scenario compared to the BAU case. The model approach can be summarized as follows:

i. Overall Model Inputs: Determination of the input transition plan (short, medium, long) and BAU was obtained in discussion with the Town of Caledon.

ii. Existing Fleet Inputs: Input of existing fleet asset inventory data, including vehicle expected life, BAU fuel type per asset, estimated future replacement cost, annual kilometer/hour utilization, annual fuel consumption (and fuel economies) and estimated annual maintenance costs. This data was provided by the Town of Caledon and processed for input into the model.

iii. Green Fleet Technology Inputs: Input of green fleet vehicles regarding procurement costs, expected operational fuel costs, maintenance costs, fuelling/charging costs, and expected emissions for each of the technologies considered. This data was collected based on market scans of green vehicles, previous technical studies and industry datasets.

iv. Yearly Costs and Emissions Profile: The yearly expected costs pertaining to operational costs and maintenance costs, fuelling costs and federal carbon tax were evaluated for the short, medium and long-term scenarios. The estimated annual emissions were also modelled for each of the timeframes and propulsion technologies.

v. Lifecycle Capital Costs Profile: The expected lifecycle capital costs pertaining to the capital cost of the fleet and charging infrastructure were evaluated for each short, medium and long-term timeframe.

Table 8 provides a summary of the key input parameters, data and assumptions that were utilized in developing the business case model.

Table 8 Key Input Parameters and Assumptions

Input Parameter	Value	Units
Fleet Asset Inventory	171 (refer to Section 1.3)	count
Vehicle Expected Life	Dependent on Asset (refer to Section 1.3)	years
Vehicle Estimated Replacement Price	Dependent on Asset (refer to Section 1.3)	$
Vehicle Fuel/Hour Consumption	Dependent on Asset (refer to Section 1.3)	L/km or L/hour
Vehicle Annual Mileage/Hours	Dependent on Asset (refer to Section 1.3)	km or hours
EV Charging Infrastructure	$462,500 (refer to Section 2.3.1.2)	$
CNG Fueling Infrastructure	$850,000 (refer to Section 2.3.1.2)	$
Specialized Tools and Training Estimate	$76,000 (refer to Section 2.3.1.4)	$/year
Federal Carbon Price	$50/tonne in the Short Term, $110/tonne in the Medium Term, $170/tonne in the Long Term	$/tonne CO_{2e}
Gasoline Fuel Base Price	$1.25 /L	$/L (Statistics Canada April 2021)
Diesel (B5) Fuel Base Price	$1.20 /L	$/L (Statistics Canada April 2021)
Diesel (B20) Fuel Base Price[13]	$1.30 /L	$/L (8% premium over regular diesel)
CNG Fuel Base Price	$0.61/ dLe	$/dLe
Electricity Base Price	$0.17/ kWh	$/kWh (average price paid by the Town of Caledon)
Diesel Tailpipe Emission Factor	2.74 kg of CO_2e per L	(kg of CO_2e per L) (sourced from NRCan GHGenius tool)
Biodiesel (B5 – 5%) Tailpipe Emission Factor	2.58 kg of CO_2e per L	(kg of CO_2e per L) (sourced from NRCan GHGenius tool)
Biodiesel (B20 – 20%) Tailpipe Emission Factor	2.19 kg of CO_2e per L	(kg of CO_2e per L) (sourced from NRCan GHGenius tool)
Gasoline Tailpipe Emission Factor	2.29 kg of CO_2e per L	(kg of CO_2e per L) (sourced from NRCan GHGenius tool)
CNG Tailpipe Emission Factor	1.80 kg of CO_2e per dLe	(kg of CO_2e per L) (sourced from NRCan GHGenius tool)
Inflation Rate	2.1%	%/year (historical Canadian CPI)
Discount Rate	1.5%	%/year (Canada 10-year benchmark bond yield)

[13] B20 biodiesel price assumed at 8% premium over regular and B5 diesel, reference to US Department of Energy.

2.3.1.1 *CARBON TAX*

The Federal Government of Canada passed the Greenhouse Gas Pollution Pricing Act in 2018 to implement a carbon pricing system and apply this "carbon tax" to provinces without a pricing system, this include the Province of Ontario. The objective is to promote the transition to cleaner technologies and move towards Canada's GHG reduction target of 30% (relative to 2005 baseline) by the year 2030.

The carbon tax initially started at $20 per tonne of CO_2e in 2019 and is set to increase by $10 per tonne of CO_2e until the tax reaches $50 per tonne in 2022. In December 2020, the government announced a gradual hike of this carbon tax to reach $170 per tonne by 2030. This tax is factored into provincial fuel prices and is noted as the environmental cost stated in the business case analysis.

2.3.1.2 *INFRASTRUCTURE COST ESTIMATES*

The following Table 9 lists the inputs and assumptions used to derive a supporting infrastructure cost estimate for the plug-in electric vehicle fleet. The estimated total cost of $462,500 is based on the installation of 37 Level 2 EV charging stations and maintaining a vehicle-to-charger ratio of 2:1. It is assumed that the EV chargers will be installed in phases, aligning to the short, medium and long term fleet size of plug-in electric vehicles by adding more chargers as the EV fleet size scales.

Table 9 Electric Vehicle Infrastructure Cost Estimates

Parameter	Value	Source
EV Charging Station Cost (includes installation cost)	$12,500	Town of Caledon's installation of four (4) EV charging stations in recent Community Centre Build dual plug-in Level 2 charging stations
Vehicle-to-Charger Ratio	2:1	Dual plug-in Level 2 charging stations
Short-Term Scenario Additional Chargers Required	4	Calculated based on the incremental number of PHEVs and BEVs in the short-term scenario
Medium-Term Scenario Additional Chargers Required	9	Calculated based on the incremental number of PHEVs and BEVs in the medium-term scenario
Long-Term Scenario Additional Chargers Required	24	Calculated based on the incremental number of PHEVs and BEVs in the medium-term scenario
Total Number of Chargers Required	37	Sum of installations from short, medium and long term
Estimated Total Cost:	**$462,500**	**Calculated from above inputs**

Note: The supporting infrastructure cost does not include any modifications to the upstream electrical network (i.e. utility improvements for power supply to sites) as this assessment is outside the scope of this study. A detailed electrical demand assessment for each site and engagement with the Town of Caledon's electrical utility provider is recommended in the next steps detailed in the Action Plan Table.

Table 10 lists the inputs and assumptions for deriving a cost estimate for an on-site CNG fueling station. It is assumed that the station will be initially sized to accommodate the long-term scenario fleet size and fueling demand for the CNG snowplows and landscape trucks.

The capital investment, estimated at $875,000, is assumed to be required in the short-term scenario so that fueling infrastructure is in place before the start of CNG vehicle purchases, beginning with the pilot of one (1) CNG snowplow in the short-term and then scaling to the entire snowplow fleet size of 27 plow trucks throughout the medium and long-term scenarios, while also considering 11 landscape trucks transitioning to CNG.

However, it is likely that Class 8 landscape trucks which are currently identified to transition to CNG could potentially transition to BEV trucks in the long-term, should the price of BEV trucks continue to decline in the heavy-duty category as more make/models come available.

Table 10 CNG Infrastructure Cost Estimates

Parameter	Value	Source
CNG Fueling Infrastructure (sized for long-term scenario)	$875,000	Scaled from reference CNG fuel station sizing estimate based on the estimated annual fuel consumption in diesel litre equivalent of the CNG fleet.
Long-term Scenario Estimated CNG Fleet Fuel Consumption	275,000 dLe/year (750 dLe per day)	Historical Town of Caledon fleet fueling records, CNG consumption expressed in diesel litre equivalent (dLe)
Fuel Unit Conversion	1 kg of CNG = 1.462 dLe	Canadian Natural Gas Vehicle Alliance
Long-term Scenario Estimated CNG Fleet Fuel Consumption	515 kg/day	Converted based on CNGVA factor
Estimate Scaling Ratio for CNG Fuel Station	$1,700 per kg/day	CNG station sizing cost estimates calculated from a peer green fleet study in Ontario
Estimated Total Cost:	**$875,000**	**Calculated from above inputs**

Note: Supporting infrastructure costs for the CNG fleet includes a scaled estimate on the CNG fueling infrastructure only. An estimate for building modifications in fleet storage and maintenance areas is outside the scope of this study as a site visit was not conducted. A detailed gap assessment for each site on the potential to store and maintain CNG vehicles and further build out the capital cost estimate is recommended in the next steps detailed in the Action Plan.

This is a high level cost estimate only. The Town of Caledon is recommended to engage in a detailed planning and design study for the CNG fueling station prior to making any budget commitments.

2.3.1.3 *VEHICLE REPLACEMENT COST ESTIMATES*

To support capital planning the following table lists available data on the manufacturer's suggested retail price (MSRP) and cost estimates based on a market scan review of green vehicle technology. The cost figures indicated with a plus prefix (+$) are referenced as an incremental cost over the base vehicle cost (i.e. $52,000 additional cost for upfitting a heavy-duty truck with a CNG engine and fuel system in comparison to a baseline diesel truck).

The availability of market data on alternative vehicles is based on present conditions, providing a current snapshot of prices, and will likely change over time with the advancement of hybrid, battery electric and other vehicle technologies. Note the listed prices refer to representation of the base vehicle price and do not include upfitting, premium vehicle models or taxes.

Table 11 Green Vehicle Capital Replacement Cost Estimates

Parameter	Value	Source
Light-Duty Hybrid Pickup	$55,000	Ford F-150 hybrid
Medium/Heavy-Duty Hybrid Pickup Upfitting Cost	+$15,000	XL Fleet XLH system
PHEV Car	$38,000	Average of MSRP from WSP market scan
BEV Car	$45,000	Average of MSRP from WSP market scan
PHEV SUV	$40,000	Average of MSRP from WSP market scan
BEV SUV	$45,000	Average of MSRP from WSP market scan
Light-Duty BEV Pickup	$60,000	Estimate Havelaar Bison, Ford F-150 Lightning

Parameter	Value	Source
Medium/Heavy-Duty BEV Pickups	+$20,000	Estimate based on cost premium of ½ ton BEV pickup versus gasoline
Heavy-Duty BEV Truck (reference for Class 8 trucks)	$400,000	CN Rail order of Class 8 BEV trucks from Lion
BEV Cargo Van	$60,000	Estimate Ford eTransit van
Heavy-Duty Truck CNG Upfitting Cost	+$52,000	TAC Award Submission for Oxford County CNG snowplows
BEV Utility Vehicle (ATV/UTV)	$25,000	John Deere TE 4x2 Electric
BEV Mower	$30,000	Greenworks Lithium Z GZ 60R Zero Turn Mower

2.3.1.4 *TOOLS AND TRAINING COST ESTIMATES*

Training and specialized tooling costs are estimated based on the current fleet size and mechanics requiring training to service the respective propulsion types. Note training cost estimates can be impacted by staff turnover rates and certification requirements.

The training and tooling cost are factored into the business case as preliminary high-level cost estimates. Particular conditions and quotes received by the Town of Caledon may result in cost differences from those noted below.

Table 12 Tooling and Training Cost Estimates

Parameter	Value	Source
CNG Fleet Mechanics	8	Estimate based on outfitting all mechanics and lead hand on staff
CNG Training Program	$2,200/year	City of Ottawa – Business Case, Municipal Diesel Fleet Alternative Fuels CNG vs B20. Estimated at $3,500/year for a fleet size of 43 CNG refuse trucks scaled to Caledon's planned fleet size of 27 CNG snowplows in the long-term.
CNG Personal Protective Equipment (PPE) and Specialized Tools	$4,200 per mechanic	Estimated itemized list referenced from other peer strategies
CNG Tooling Replacement	3 years	Estimate
CNG Tooling, PPE and Training	$28,800/year	Calculated from above inputs
EV Fleet Mechanics	8	Estimate based on outfitting all mechanics and lead hand on staff
High Voltage Safety Training Program	$1,000 per mechanic	eHazard quote of approximately $10,000 for 2-day workshop with 11 attendees
Static-Free and Specialized Electrical Toolkit	$11,600 per mechanic	Itemized list with cost estimates
Tooling Replacement and Recertification Training	3 years	Estimate
High Voltage Personal Protective Equipment (PPE)	$1,700 per mechanic	Itemized list with cost estimates

Parameter	Value	Source
High Voltage PPE Renewal Frequency	1 year	Estimate
EV Tooling, PPE and Training	$47,200/year	Calculated from above inputs
Estimated Total Cost*:	**$76,000/year**	**Estimated from above inputs**

*Additional specialized tooling may be required depending on the scope of in-house vehicle repairs versus contracted out specialized repairs on components such as battery packs, traction motors and CNG fuel tanks. A detailed Operations and Maintenance Impact Assessment is out-of-scope for this study but could be pursued by the Town of Caledon to further assess the scope and impact of servicing alternative propulsion vehicles in-house.

2.3.2 GREEN FLEET ANALYSIS

This section provides an overview of the expected capital expenditures (CAPEX), and the expected annual operating expenditures (OPEX), environmental costs (carbon tax) and GHG emissions (in tonnes of CO_2e) for each timeframe. It provides an overview of the expected annual costs, along with the expected change in GHG emissions as the Town of Caledon's fleet is replaced with the selected green fleet technology.

2.3.3 CAPITAL COST SUMMARY

Figure 14 shows the projected capital costs including the required acquisition costs of new vehicles, and the required charging infrastructure to support the new alternative propulsion vehicles for all scenario timeframes. The totals are highlighted in the bold callout boxes.

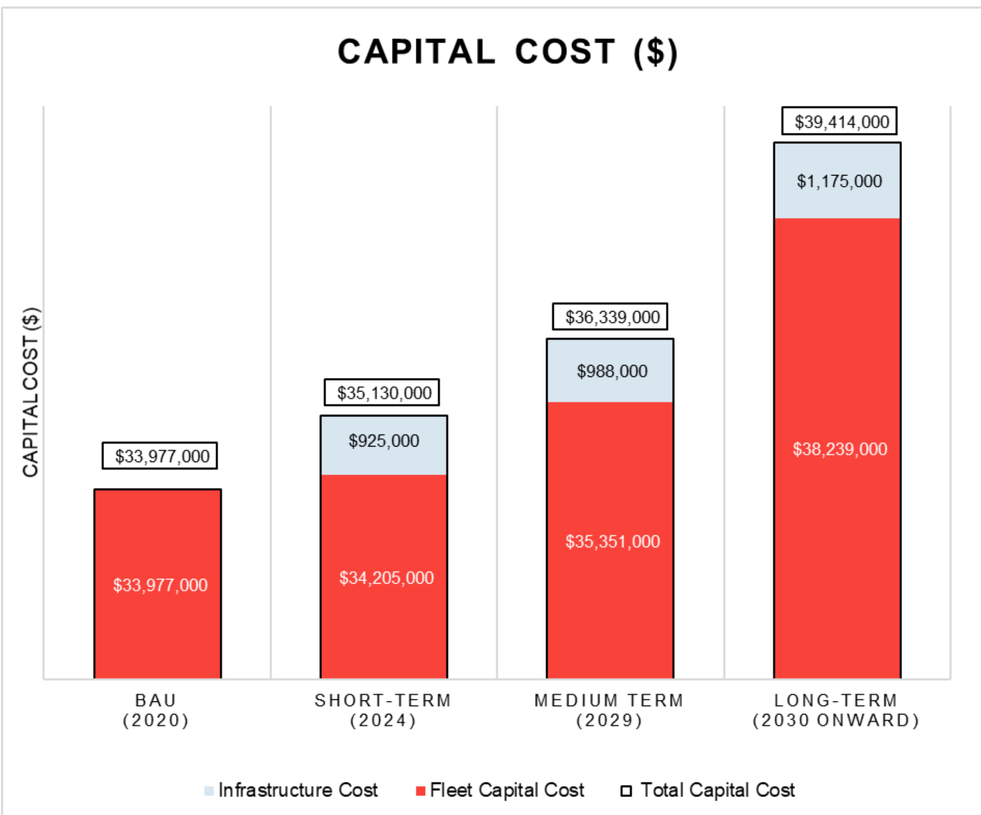

Figure 14 Capital Cost Estimates of Scenarios

The capital cost for vehicle purchases is the most significant capital cost element in all scenarios. As illustrated in Figure 14, the Town of Caledon would incur additional costs compared to the BAU case. At the time of analysis, green fleet vehicles are more expensive and will require the Town to install additional infrastructure (i.e. CNG fueling and/or EV charging stations) thereby resulting in higher capital costs.

The majority of the infrastructure capital cost in the short-term scenario would be for the installation of the CNG fueling station so that this infrastructure is in place before the large scale rollout of CNG for the snowplow fleet with eleven (11) trucks transitioning to CNG in the medium term, followed by another fifteen (15) trucks in the long-term.

2.3.4 OPERATIONS AND MAINTENANCE COST SUMMARY

The annual fuel, electricity, training and maintenance costs are presented in Figure 15 for all scenario timeframes. The totals are highlighted in the bold callout boxes.

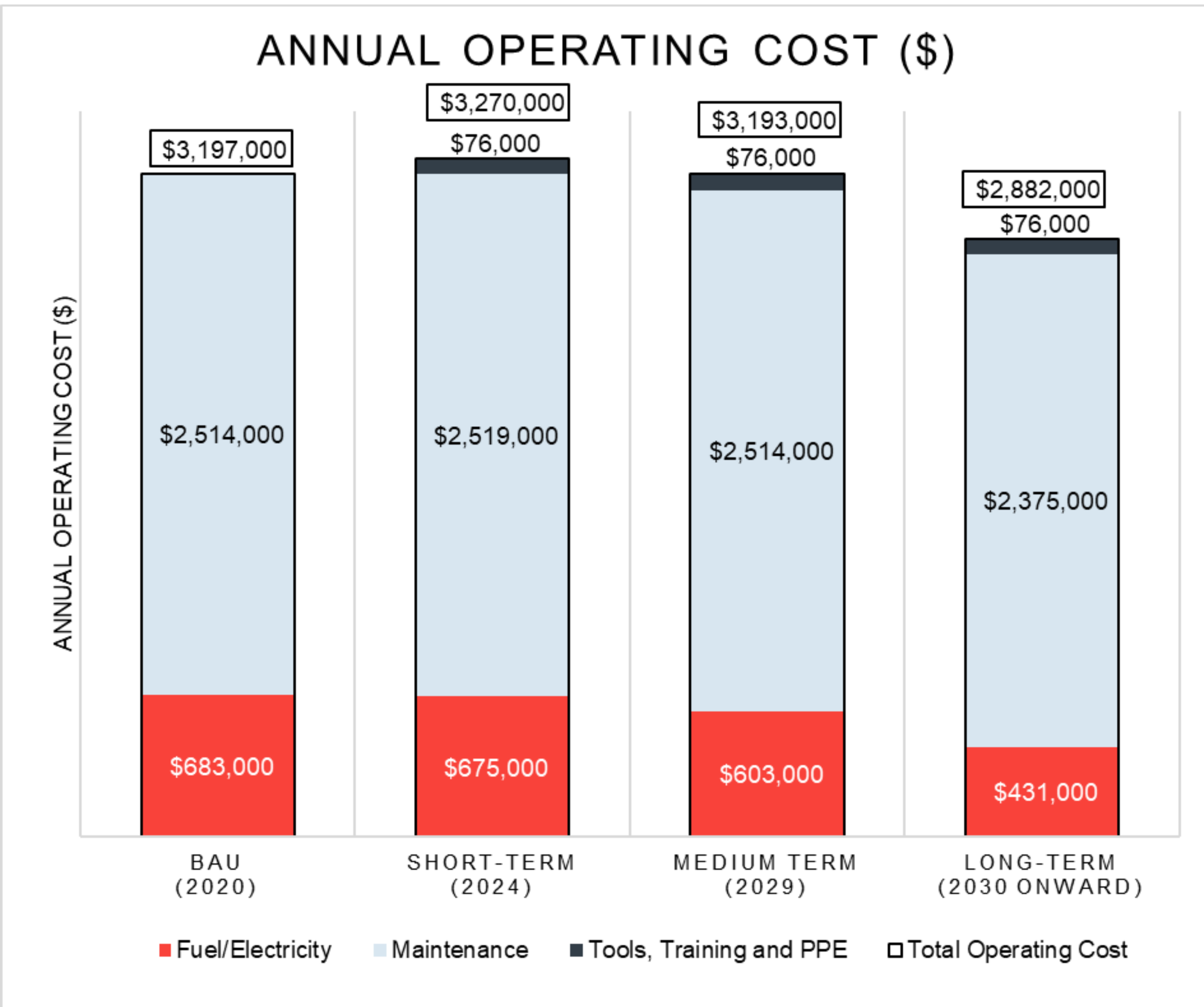

Figure 15 Annual Operating Cost Estimates

As Figure 15 illustrates, the operating cost for medium and long-term transition plans are lower than the BAU case as most vehicles are transitioning to BEVs and CNG alternatives. The key cost drivers for these technology changes are explained below.

Maintenance Impact – Biodiesel

The use of higher biodiesel blends such as B20 could lead to higher maintenance costs than conventional diesel. Higher biodiesel concentrations can potentially lead to fuel gelling in fuel systems and filters during cold weather use, if not maintained according to OEM maintenance guidelines.

Furthermore, biodiesel fuel currently comes at a cost premium over conventional diesel fuel. A B20 biodiesel can add approximately 8% in additional fuel costs over conventional diesel.

Maintenance Impact – Natural Gas Vehicles

CNG vehicles can offer maintenance cost savings over comparable diesel vehicles due to fuel cost savings and maintenance. In general, vehicles with CNG engines are simpler to maintain than those with diesel engines which translates into savings for both maintenance costs and vehicle downtime. CNG is a cleaner fuel source which produces less harmful emissions than diesel. This removes the need for diesel fuel filters and exhaust treatment components such as a catalytic converter along with their associated maintenance.

CNG engines have the addition of an ignition system with spark plugs, coils and wiring in contrast to auto-ignition in a diesel engine. This helps to eliminate cold-start problems. There is no concern of diesel fuel gelling or the need for an engine block heater. However, the CNG ignition system requires regular maintenance such as the cleaning and replacement of spark plugs and engine valve adjustment.

Maintenance Impact – Hybrid Vehicles

Hybrid vehicles offer greatly improved fuel consumption which can help reduce operational costs. However, hybrid vehicles also have dual system maintenance requirements. They require regular maintenance of internal combustion engine and drivetrain related components (similar to conventional vehicles) but also introduce the maintenance need for their electric drivetrain system. Therefore, hybrid vehicles can have slightly higher maintenance costs in comparison to conventional vehicles.

Electric systems including battery, traction motor, and accessory electronics usually require minimal scheduled maintenance. Annual brake maintenance is expected to be lower for these vehicles through regenerative braking, which reduces the use of the brake system and extends its life.

Maintenance Impact – Battery Electric Vehicles

BEVs can have significantly reduced maintenance servicing costs due to fewer mechanical and wearing parts relative to gasoline or diesel powered vehicles. Furthermore, BEVs have far fewer fluids to change, no internal combustion engine requiring maintenance, and reduced brake wear due to regenerative braking.

The cost of electricity is also generally much cheaper than petroleum fuels (i.e. gasoline and diesel). BEVs and PHEVs can benefit from reduced operational cost of running on electricity rather than paying for fuel fill ups. In addition, the low or zero tailpipe emissions from these vehicles means that the environmental cost from sources such as the federal carbon tax is substantially lower.

2.3.5 ENVIRONMENTAL ANALYSIS

A comparison of the estimated annual GHG emissions reduction for each of the modelled scenarios with respect to the 2017 baseline is presented in Figure 16. This graph showcases the annual reduction in GHG emissions as the Town transitions to its green vehicle plan as recommended in this strategy.

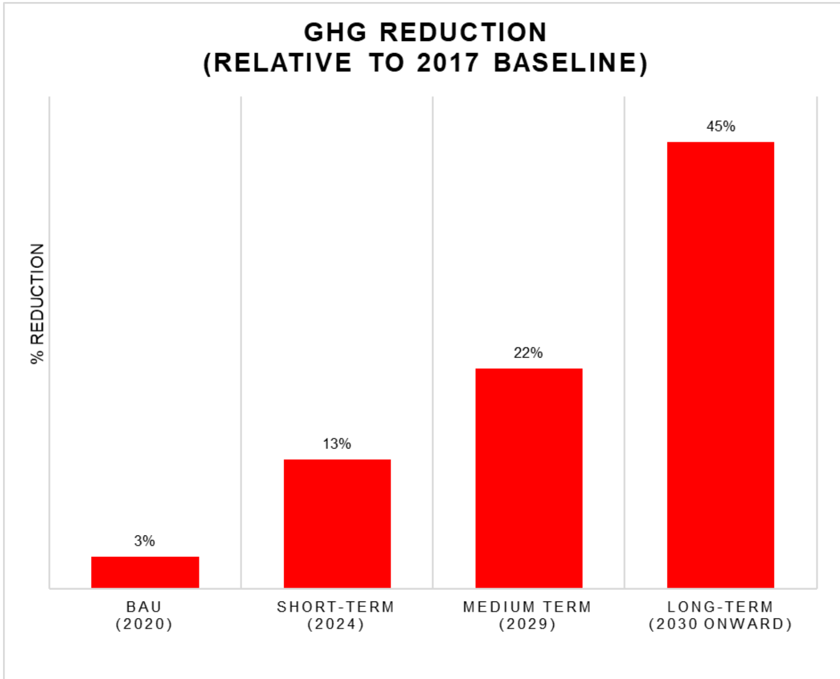

Figure 16 Annual GHG Emissions Reduction of Green Fleet Transition Plan

The Town of Caledon has noted a 3% GHG emissions reduction between the 2017 baseline and the 2020 BAU fleet data. This difference can be due to fleet retirements/purchases between 2017 and 2020 with more fuel efficient vehicles as well as some aspect of yearly seasonal variations (i.e. heavier snowfall and more usage of the snowplow fleet relative year-to-year).

The additional results demonstrate that the expected reduction in annual GHG emissions compared to the 2017 baseline are 13% in the short-term, 22% in the medium term and 45% in the long-term. Figure 17 shows the annual tailpipe GHG emissions for each scenario and Figure 18 shows the reduction of GHG emissions compared to the BAU case.

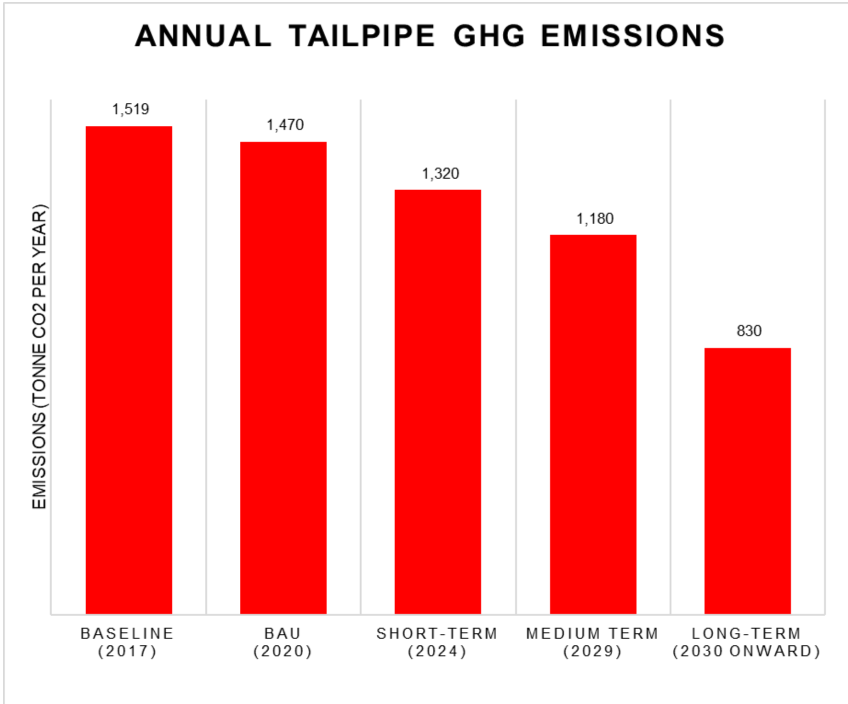

Figure 17 Estimated Annual Tailpipe GHG Emissions

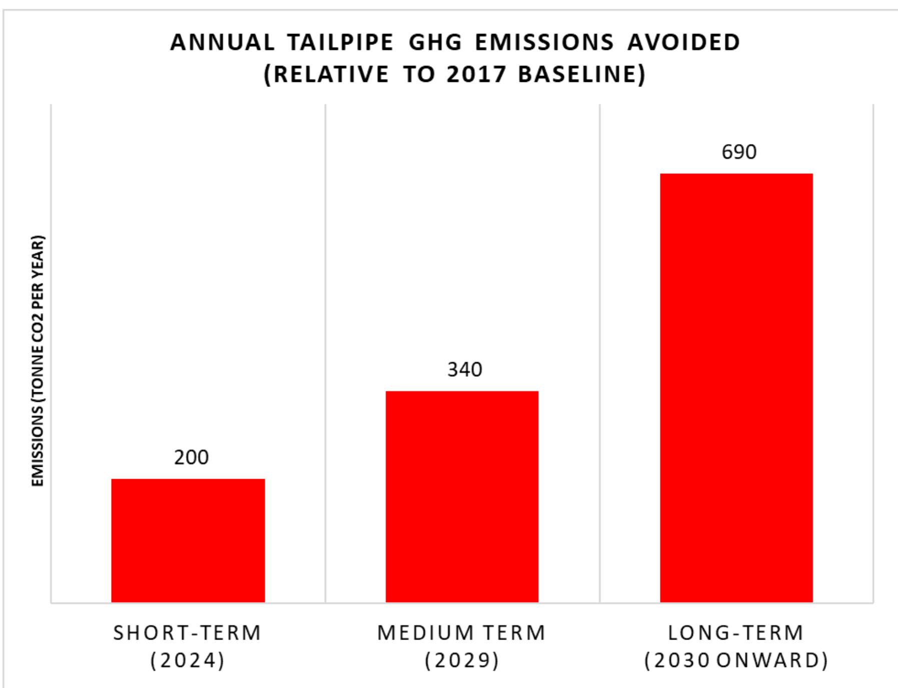

Figure 18 Estimated Annual Tailpipe GHG Emissions Reduction

Overall, by transitioning to the long-term scenario the Town of Caledon can reduce their annual fleet emissions by 690 tonnes of CO_2e, relative to the 2017 baseline. The ability to further reduce GHG emissions is limited by viable alternatives for diesel powered fire trucks, gradall excavators, graders and tractors as well as the Class 8 BEV trucks which currently have a high price point of around $400,000.

As stated in Section 2.2.8, there is on-going research and development for low emission vehicles in these classes, including PHEVs and BEVs. However, at this time there are limitations on the technological maturity and availability of reliable performance data on these vehicles to factor into the business case for a long-term scenario. As the Town of Caledon's green fleet transition progresses, the Town should track developments in these vehicle classes and update the Green Fleet Strategy.

Based on the GHG emissions estimates, Figure 19 presents an analysis of the total environmental cost avoidance, priced on the basis of the federal carbon tax. The cost savings is compared against the BAU case for all timeframes.

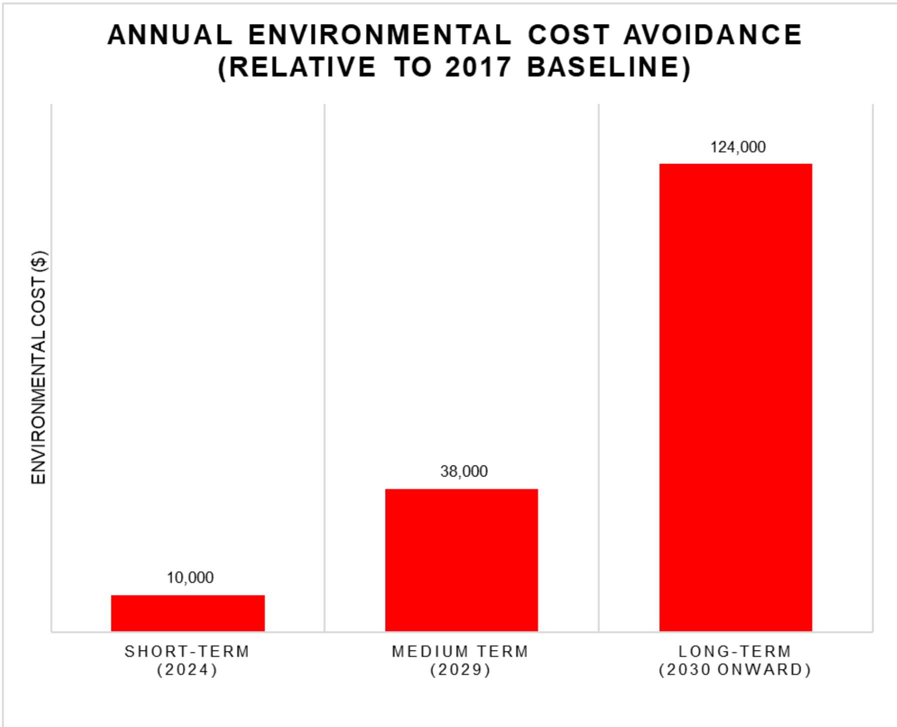

Figure 19 Annual Environmental Cost Savings

The environmental cost avoidance of transitioning to a green fleet can be significant. When the long-term scenario transition is realized the cost avoidance can total $124,000 annually (relative to the 2017 baseline). This is due to the escalating carbon tax, which is set to increase up to $170 per tonne of CO_2e by 2030.

2.4 FLEET TRANSITION PLAN PAYBACK PERIOD

The total incremental fleet and infrastructure capital costs compared to the BAU case are outlined in Figure 20. The results indicate that all timeframes would have a higher total capital cost compared to BAU due to the charging infrastructure and CNG fueling infrastructure. In terms of cumulative additional costs, the short-term would incur an additional cost of approximately $1.2 million. In the medium-term, it would incur an additional cost of $2.4 million and in the long-term it would incur an additional cost of $5.4 million.

It is important to acknowledge that these investments help to ensure the Town of Caledon is being proactive in preparing for changes in the automotive sector, namely the strategic direction of the industry transitioning away from internal combustion engine vehicles and towards battery electric options.

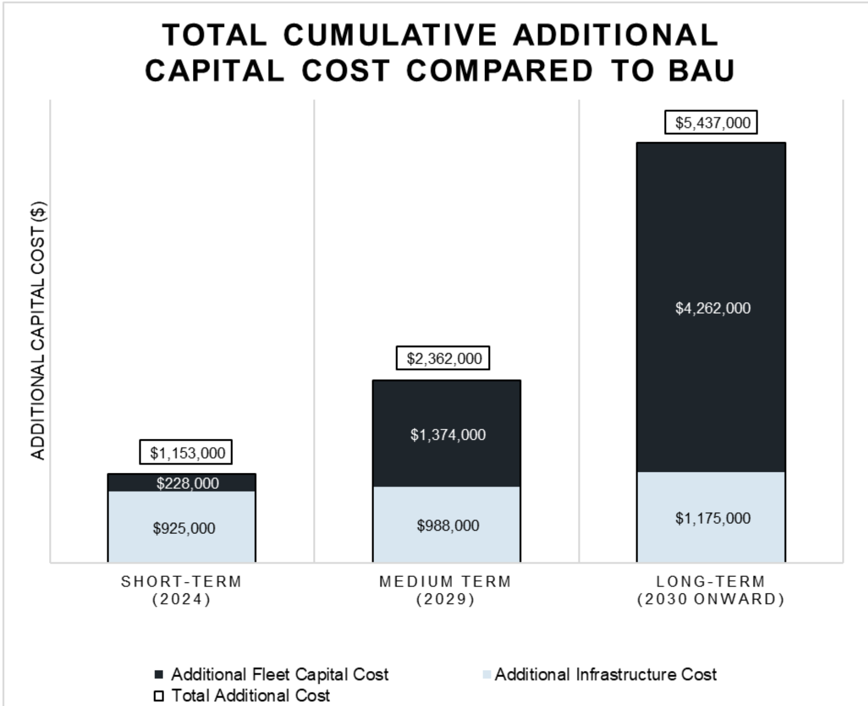

Figure 20 Additional Capital Cost (Compared to BAU)

The additional capital cost of transitioning to green fleet can be largely offset by savings in terms of fleet maintenance, fuel and environmental impacts. The annual cost savings compared to BAU for each timeframe is presented in Figure 21. Note that the annual cost savings does also include the environmental cost avoidance expressed in Figure 19.

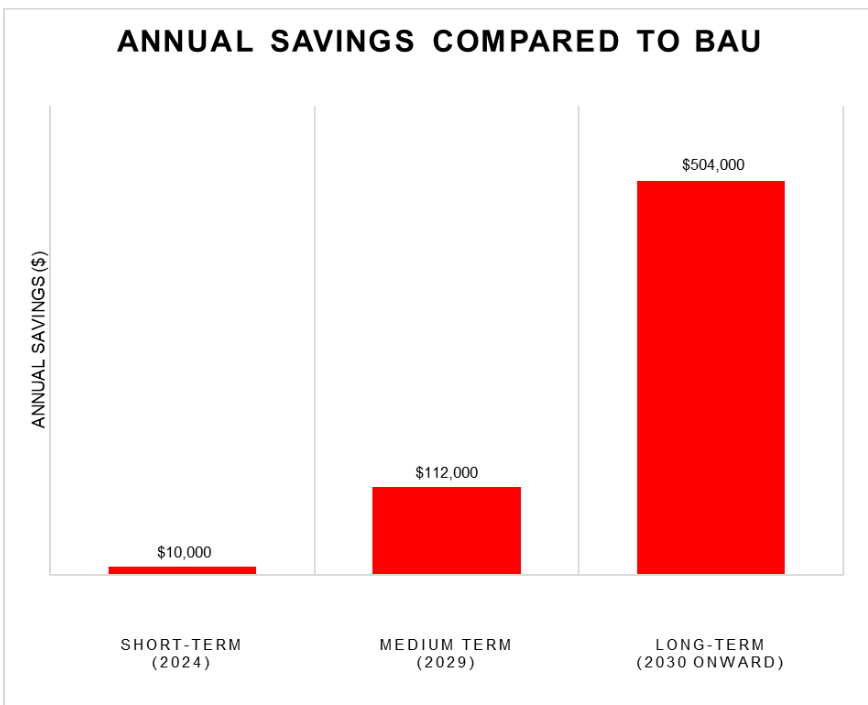

Figure 21 Annual Savings (Compared to BAU)

In the short-term, there would be minimal cost savings. This increase is largely due to the higher fuel costs and additional maintenance cost from biodiesel use in more fleet vehicles as a quick implementation to reduce GHG emissions.

However, in the medium and long-term, the estimated annual savings are approximately $112,000 and $504,000 respectively. As a result of the annual savings, the payback period for the long-term transition plan is approximately 10.7 years.

2.5 GRANT AND FUNDING OPPORTUNITIES

The initial capital expense both for vehicles and supporting infrastructure (i.e. charging stations and fueling stations) can be a barrier to green fleet transitions. To help offset the capital expenditure there are several grants and funding opportunities available which the Town could pursue. Some examples of currently available funding are included below:

- **Transport Canada:** the Canadian Federal Government via Transport Canada has incentives for purchasing and leasing of hybrid, battery electric and fuel cell vehicles in order to help promote the transition to more environmentally sustainable vehicles. Incentives of up to $5,000 are available at the point of sale for long-range PHEVs and BEVs. Shorter range PHEVs can be eligible for $2,500.
- **Natural Resources Canada (NRCan):** The Electric Vehicle and Alternative Fuel Deployment Initiative offers repayable contributions limited to a maximum of $5 million per project. For electric vehicle fast chargers, the program will pay up to 50% of the total project cost to a maximum of $50,000 per charging unit. Similarly, the program will pay up to 50% of the total project costs for natural gas and hydrogen refuelling stations, to a maximum of $1 million per refueling station.
- **Federation of Canadian Municipalities (FCM):** The FCM offers funding in the area of green vehicle pilot projects. Pilot projects examine potential solutions in real-life conditions. The pilot project can examine the financial and/or environmental performance of a new or proven initiative and the associated social benefits of the project. To apply, municipalities must review the prerequisites and required supporting documentation, complete the project workbook, confirm that other funding sources for the project are being secured, and complete the application form. Applications are accepted year-round until all the funding has been allocated. The grant offers up to 50% of eligible costs to a maximum of $500,000.

3 ACTION TABLE SUMMARY

To support the implementation of the Green Fleet Strategy and Fuel Switching Plan the following Action Table has been developed. Overall, the Action Table identifies short, medium and long-term strategic actions along with a priority ranking. In addition, the key lessons learned from the five green fleet plans reviewed from different municipalities as a benchmarking exercise are included. The summary table below highlights the best strategic actions that were determined based on this review.

Table 13 Action Table Summary

No.	Strategic Action	Description	Timeframe	Priority Rank
1.0	Establish a Green Fleet Project Team	Dedicate resources for green fleet strategy implementation. Dedicated resources will be responsible for overseeing development of strategic targets, development of the green fleet program, its implementation and its monitoring.	Immediate-Term (< 1 year)	High
2.0	Align Green Fleet Strategy into Asset Management	Ensure that the Green Fleet Strategy is an integral part of the Town's development in asset management practices. This includes incorporating the Green Fleet Strategy into the Town's new procurement strategy.	Immediate-Term (< 1 year)	High
3.0	Green Fleet Stakeholder Engagement (Internal)	Develop internally focused education and outreach with regards to green fleet program and alternative fuel vehicles among fleet user groups, maintenance staff and management. Obtain early buy-in from user groups with respect to alternative propulsion technologies. Leverage opportunities such as visiting the Electric Vehicle Discovery Centre in North York, ON to promote experience with new vehicles prior to purchasing.	Immediate-Term (< 1 year)	High
4.0	Green Fleet Stakeholder Engagement (External)	Prepare internal and external communication and outreach on sustainable transportation including stakeholder engagement, education and outreach tactics, and fleet operations best practices, staff education and engagement.	Immediate-Term (< 1 year)	High
5.0	Green Funding Opportunities	Review incentive programs for green vehicles, infrastructure and apply for grant funding when possible. Continue to review on an on-going basis and refer to Section 2.5 for current funding opportunities.	Immediate-Term (< 1 year)	High
6.0	Fuel Efficient Driver Training	Deploy fuel efficient driver training so that operators can learn specific driving techniques that can reduce fuel and energy use. Examine opportunities to embed this within existing fleet training.	Immediate-Term (< 1 year)	High
7.0	Establish Green Fleet Procurement Practices	Review the Town's current vehicle and equipment procurement practices and integrate the key elements of the Green Fleet Procurement Guide, described in further detail in Section 3.1.	Immediate-Term (< 1 year)	High
8.0	Engagement with CNG Supplier	Engage with the local natural gas supplier (i.e. Enbridge) to communicate the Town's strategic direction for CNG fuel, understand the next steps for infrastructure implementation and fuel supply.	Short-Term (1 to 5 years)	High
9.0	CNG Fuel Gap Assessment of Maintenance Facilities	Engage in detailed design work and planning for any modifications to fleet maintenance and storage facilities to ensure a CNG fleet can be supported.	Short-Term (1 to 5 years)	High
10.0	CNG Fuel Station Sizing and Design Specifications	Engage in design work and planning for CNG fueling infrastructure required to support fleet operations.	Short-Term (1 to 5 years)	High

No.	Strategic Action	Description	Timeframe	Priority Rank
11.0	CNG Snowplow Pilot	Initiate the Town's transition to CNG for the heavy-duty fleet (notably snowplows) with an early pilot of one (1) CNG truck to assess operational performance and stakeholder feedback for improved rollout of subsequent CNG trucks.	Short-Term (1 to 5 years)	Medium
12.0	Engagement with Electrical Utility	Engage with the Town's electrical utility (i.e. Hydro One) to communicate the Town's strategic direction for EV charging, understand the next steps for infrastructure implementation and any upstream electrical network improvements to feed power supply to desired charging locations.	Short-Term (1 to 5 years)	Medium
13.0	Implement Infrastructure Plan	Establish detailed design and construction work packages or contracts to implement the required infrastructure (i.e. CNG fuel station and EV chargers). Ensure the infrastructure is in place before the vehicles are commissioned into the fleet.	Short-Term (1 to 5 years)	Medium
14.0	Tooling, Training and Certifications for New Technology	Establish a staff training program, acquire all relevant certifications (i.e. TSSA) for safe maintenance and operation of new green technology vehicles. Ensure the training and certifications are obtained before the vehicles are commissioned into the fleet. In addition, purchase all required specialized tooling and safety gear for the scope of in-house maintenance on new vehicles.	Short-Term (1 to 5 years)	Medium
15.0	Fleet Right-Sizing Review	Right size the fleet by reducing the overall number of vehicles and fuel used while ensuring the vehicles are appropriately sized for their required job function. Examine possibility for a corporate car share program or common vehicle pool.	Short-Term (1 to 5 years)	Medium
16.0	Develop KPI Monitoring and Tracking Framework	Develop a set of key performance indicators (KPIs) and data tracking measures to assess the performance of new technologies against vehicles currently in the fleet (refer to Section 3.2 for recommendations on KPIs). Explore to what extent AVL data can be used to identify and reduce vehicle idling.	Short-Term (1 to 5 years)	Medium
17.0	Initiate Green Fleet Vehicle Procurements	Purchase, lease, or otherwise obtain the most fuel-efficient vehicles where appropriate for the Town operations, while considering lifecycle cost of the vehicle. Acquiring hybrid, plug-in and battery electric vehicles as possible for the fleet in alignment to the Fuel Switching Plan.	Short-Term (1 to 5 years)	Medium
18.0	Alternative Fuel Use	Use alternative fuels in Town vehicles when they are either mandated or have been evaluated and proven to meet operational and economic needs for the Town and whereby environmental benefits are demonstrated (i.e. CNG and biodiesel fuels for medium and heavy-duty).	Short-Term (1 to 5 years)	Medium
19.0	OEM Partnerships	Evaluate new advanced vehicles and technologies that can potentially reduce fuel use and emissions. Assess the evaluation results to consider the adoption of the vehicle or technology fleet where appropriate and establish partnerships with Original Equipment Manufacturers (OEMs) to pilot new vehicles technologies.	Short-Term (1 to 5 years)	Medium
20.0	Review Personal Vehicle Usage	Review and understand emissions associated with Town employee personal vehicle usage for work to help create business case for shared corporate vehicles and to understand the impact of teleworking.	Short-Term (1 to 5 years)	Medium
21.0	On-going Implementation of Infrastructure Plan	Review the capacity of existing infrastructure and ensure the infrastructure scales relative to the green vehicle fleet (i.e. installation of new EV chargers as the plug-in EV segment of the fleet scales).	Medium-Term (5 to 10 years)	Medium

No.	Strategic Action	Description	Timeframe	Priority Rank
22.0	ISO Certifications	Further evaluate the potential for ISO certification in the area of environmental management (ISO 14001) and quality management (ISO 9000) for fleet services division and explore the feasibility of ISO certification for the other Town fleets. The costs can range between $12,000 to $50,000 as an initial one time cost to setup formal ISO management processes and cost an additional $2,000 to $30,000 per year for registering audits[14].	Medium-Term (5 to 10 years)	Low
23.0	Green Fleet Strategy Update	Update the Green Fleet Strategy to reflect new developments in vehicle technology to incorporate into the Fuel Switching Plan. Develop a cost-benefit analysis on new technology.	Medium-Term (5 to 10 years)	Low
24.0	Fleet Optimization Through KPI Review	Review KPI data and stakeholder feedback to improve fleet usage. Consolidate and reduce unnecessary trips through IT and route optimization techniques. Improve maintenance practices by understanding root causes of unscheduled repairs. Revise procurement practices based on lifecycle cost and performance data of new vehicle technologies which have been operating in the fleet.	Medium-Term (5 to 10 years)	Low
25.0	Extended Green Fleet Strategy	Inclusion of personal vehicles use, rental vehicles and outsourced work by applying the strategies of the green fleet plan to all outsourced work involving vehicles and equipment.	Medium-Term (5 to 10 years)	Low
26.0	Green Fleet Strategy Update	Update the Green Fleet Strategy to reflect new developments in vehicle technology to incorporate into the Fuel Switching Plan. Develop a cost-benefit analysis on new technology.	Long-Term (10+ years)	Low
27.0	On-going Implementation of Infrastructure Plan	Review the capacity of existing infrastructure and ensure the infrastructure scales relative to the green vehicle fleet (i.e. installation of new EV chargers as the plug-in EV segment of the fleet scales).	Long-Term (10+ years)	Low
28.0	Fleet Optimization Through KPI Review	Review KPI data and stakeholder feedback to improve fleet usage. Consolidate and reduce unnecessary trips through IT and route optimization techniques. Improve maintenance practices by understanding root causes of unscheduled repairs. Revise procurement practices based on lifecycle cost and performance data of new vehicle technologies which have been operating in the fleet.	Long-Term (10+ years)	Low

3.1 GREEN FLEET PROCUREMENT GUIDE

A Green Fleet Procurement Guide purchasing guide was developed as part of the Green Fleet Strategy. The Green Fleet Procurement Guide helps to align future fleet vehicle replacements and growth purchases to the Fuel Switching Plan as part of the Town's Green Fleet Strategy. The overall objective is to reduce fuel consumption of the fleet and GHG emissions so that the Town can progress towards achieving their GHG reduction targets. The

[14] BDC, "4 Essential Steps to ISO certification". Available at: https://www.bdc.ca/en/articles-tools/operations/iso-other-certifications/iso-certificate-process

Green Fleet Procurement Guide is intended to serve as a supplementary decision-making tool and not intended to override any of the Town's existing procurement processes. Key elements of the guide include:

1. **Right-sizing Guidelines:** geared towards purchasing the most fuel efficient vehicles;
2. **Prompting Questions:** to aid identification of key risks, opportunities and alignment to other required actions prior to the procurement of green fleet vehicles (i.e. Is the required infrastructure in place to support the vehicle's operation? Have staff received the necessary training for maintenance of the vehicle technology?);
3. **Evaluation Criteria Framework:** used to help assess different options available through scoring criteria such as: purchase price, alignment to the Town's strategic direction, user experience with the vehicle make/model and the availability of aftersales support from the OEM or conversion/upfitting company; and,
4. **Procurement Process Guide:** which outlines the key steps (i.e. update market review of available technologies, vehicle make/models and consultation with user groups on their needs).

Overall, the most important elements of the Green Fleet Procurement Guide are to set forth processes to identify risks, opportunities, align vehicle purchases to user group needs and the Fuel Switching Plan as to best support the Green Fleet Strategy. The objective is not to recommend specific vehicle make or models for purchase as vehicle specifications are highly subject to change over time. The Town is encouraged to revisit and update this procurement guide as necessary to capture their growing experience with green fleet technology.

3.2 KEY PERFORMANCE INDICATORS

To support the rollout of the Green Fleet Strategy the Town of Caledon is recommended to establish a set of key performance indicators (KPIs) to monitor and evaluate the success of the transition. The following table provides some recommendations on KPIs along with the means of calculation and tracking.

Table 14 Recommended Green Fleet KPIs

Key Performance Indicator:	Description and Tracking Methodology:
Average Emissions per Vehicle (CO_2e per vehicle)	This KPI can be used to track the effectiveness of the green fleet transition in lowering GHG emissions. The KPI can be calculated for the overall fleet as well as by particular vehicle classes (i.e. light-duty pickup trucks). The total fleet emissions can be calculated based on fuel consumption records and the emission factors provided in this study. Then the emissions can be divided by the fleet size in order to get a benchmark CO_2e per vehicle. Thereby, this KPI accounts for the fleet size (including growth impacts) rather than just tracking the overall fleet emissions without normalizing by the total fleet size.
"Green" Vehicle Count	This metric can be used to track the number of vehicles which have transitioned to their recommended "green" alternative according to the Fuel Switching Plan. This KPI can be expressed as a percentage of the "green vehicle count" divided by the total vehicle count, calculated for the overall fleet as well as by particular vehicle classes, in order to track the progress of the green fleet strategy rollout.

Key Performance Indicator:	Description and Tracking Methodology:
Mean Kilometers Between Defect (MKBD)	This KPI is used to track the reliability of the fleet. Work order records and vehicle odometer readings can be used to calculate the MKBD for fleet vehicles focusing on the distance travelled between unscheduled maintenance. The MKBD metric can be important to evaluate success of a technology transition and improve maintenance practices by focusing on vehicle systems at the root cause of the unscheduled maintenance repairs.
Fuel Efficiency (L/100km or kg/km)	This KPI is standard to measure how the fleet is progressing towards more fuel efficient options thereby lowering the overall fleet fuel consumption and GHG emissions. Fuel efficiency can be tracked by individual vehicles and aggregated based on similar vehicle types (i.e. plow trucks). Historical fleet data on fuel fills and vehicle odometer records are required for calculation. In addition, energy conversion factors can be used to compare the fuel efficiency across different fuel types (i.e. 1 kg of CNG = 1.462 diesel litre equivalent). This type of comparison can be especially useful to study the impact of alternative fuels such as the CNG snowplow fleet.
Energy Efficiency (kWh/km)	Similar to the fuel efficiency, this KPI can be used to measure how the fleet is progressing towards more energy efficient electric vehicles. Energy efficiency can be tracked by individual vehicles and aggregated based on similar vehicle types (i.e. BEV pickup trucks). Historical fleet data on vehicle charging and odometer records are required for calculation.
Operating Cost per Kilometer ($/km)	The cost per kilometer KPI is used by fleet managers to monitor cost for vehicles as they age, or new technologies are introduced into the fleet. For a green fleet transition this KPI can be especially useful to track cost savings of new technology and update total lifecycle cost calculations. This KPI is calculated using parts, labour, fuel or electricity to calculate the total cost per vehicle and then using odometer readings to calculate the kilometers travelled denominator.
Infrastructure Availability (%)	Infrastructure such as EV charging stations and CNG fueling stations are a critical component of successful green fleet implementation. Low reliability or low availability of infrastructure can negatively impact fleet operations. This KPI can be used to track the availability of such supporting infrastructure by recording the time that infrastructure is unavailable due to repairs, then subtracting the unavailable time from the total time in a specified period (i.e. monthly) and expressing the figure as an availability percentage. If infrastructure availability is low, then maintenance practices or quality inspection may be needed.

Key Performance Indicator:	Description and Tracking Methodology:
Preventative versus Corrective Maintenance (%)	Based on vehicle maintenance work order records the historical percentage of scheduled "preventative" maintenance versus unscheduled "corrective" maintenance can be calculated in terms of labor hours or work orders created. This figure can be expressed for the overall fleet as well as for different vehicle classes as well as infrastructure. The purpose of this KPI is to monitor the amount of unscheduled maintenance and help identify recurring maintenance issues so that the scope of preventative maintenance can be adjusted. Higher than expected corrective maintenance issues can directly correlate to higher operating cost per kilometer and reduce the cost effectiveness of new technology.
Maintenance Staff Feedback	As a more qualitative KPI it is important to record dialogue and feedback from fleet maintenance staff to understand their experience with new green fleet technology. This feedback loop can help improve training, maintenance practices and decision-making on future vehicle purchases.
User Feedback	User feedback is another qualitative KPI that is important to have regarding new green fleet technology. Engagement with user groups and establishing a feedback loop can help assess vehicle and technology performance along with referencing more quantitative KPIs such as MKBD. User feedback can also support decision-making on future vehicle purchases by validating if vehicle performance has met expectations as well as relaying any concerns.

As new technologies and alternative fueled vehicles rollout for the fleet the Town of Caledon can use this list of KPIs to develop a framework of performance tracking. Benchmark values for KPIs can be set and adjusted further as more fleet data becomes available.

4 CONCLUSIONS

The magnitude of operational cost savings realized in the scenarios derived from the Fuel Switching Plan can be used to help justify the business case for transitioning to green fleet alternatives in addition to the environmental benefits. Furthermore, with the on-going trends in battery technology to reduce costs, improve energy density and range, there is a likely case that the financial assessment for medium and long-term scenarios will continue to improve over time.

There is also strategic alignment between the Town's proposed Fuel Switching Plan, the climate change targets of the Federal Government and being proactive in preparing for changes in the automotive sector, namely the strategic direction of the industry transitioning away from internal combustion engine vehicles and towards battery electric options.

The short, medium and long-term scenarios presented can reduce the fleet GHG emissions from the 2017 baseline of 1,519 tonnes CO_2e/year down to 1,320 tonnes CO_2e/year (short-term), 1,180 tonnes CO_2e/year (medium term) and 830 tonnes CO_2e/year (long-term). There is also a potential to revisit developing technology such as PHEVs and BEVs in heavy equipment (i.e. gradall excavators) and fire truck categories for further opportunities.

Overall, this Green Fleet Strategy strongly positions the Town of Caledon to make actionable progress to achieving GHG emissions reduction, especially in the medium and long term. The Town can begin making progress in the next few years as well, however it is important to realize that there are several risk factors which can challenge GHG emissions reduction in the short-term. The following barriers are listed against a more accelerated short-term green fleet adoption case:

1. **Infrastructure Requirements:** the need to setup charging and fueling infrastructure prior to the procurement of alternative green vehicles. Consultation with utility providers to potentially upgrade electrical feeds and natural gas delivery to sites will also need to be planned.
2. **Change Management:** the need to train staff in all aspects of a technology change including but not limited to safety, vehicle maintenance, charging and refueling as well as driving behaviours all need to be planned for a successful rollout.
3. **Technological Maturity of Heavy-Duty Vehicle Alternatives:** there are several BEVs coming available in the market for heavy-duty trucks. However, there is currently limited availability for these models to factor into short-term fleet plans in large scale (i.e. prior to 2024). Furthermore, these vehicles do not have the demonstrated deployment history and technological maturity as BEVs in the light-duty passenger vehicle class. However, the expectation is that heavy-duty BEVs will be more available for medium and long-term horizons and play a pivotal role in cutting GHG emissions from the fleet.
4. **Market Availability of EVs:** there can be long lead times associated with EV procurements, particularly in the class of newer models such as heavy-duty trucks. These supply challenges can limit the uptake of EV adoption in the short-term but are expected to be less of a concern in medium and long-term horizons.

Overall, the Town of Caledon is in a strong position to start actioning this Green Fleet Strategy and progress towards a more sustainable fleet. The Town is recommended to revisit the Green Fleet Strategy on a 5-year basis or earlier as new information and/or vehicle technologies come available which can further support the Town's strategic direction on green fleet adoption. The 5-year benchmark is referenced from peer municipalities which use this cycle to set their capital replacement plan over the following 5-years. In addition, the Town is encouraged to keep informed on the strategic direction and implementation progress of their regional peers including the City of Mississauga, City of Brampton and Peel Region in general to realize cooperative synergies.

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