Maryland Energy Administration Clean Fuels Technical Assistance Program: City of Cumberland

March 31, 2021

Submitted to:

Maryland Energy Administration

and the

City of Cumberland

Submitted by:

ICF

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I. Executive Summary

The Maryland Energy Administration (MEA) Clean Fuels Technical Assistance (CFTA) Program has provided this fleet advisory service for the City of Cumberland, through a partnership with ICF, and support from Maryland Clean Cities. ICF analyzed Cumberland's on-road vehicle fleet comprised of 205 vehicles, recommending 103 internal combustion engine (ICE) vehicles for electrification based on available electric vehicle (EV) make and model availability, which includes 54 battery electric vehicles (BEV) and 49 plug-in hybrid electric vehicles (PHEV). These recommendations are reliant on Cumberland applying for EV and charging station incentives. The conversions would take place over a 15-year timeframe, with the actual number of vehicles eligible for electrification likely increasing over this time as more EV makes and models become available.

Based on our analysis, converting 103 ICE vehicles to EVs is estimated to produce the following impacts[1]:

$2,172,000 total cost of ownership (TCO) savings over **15** years of vehicle operations

$1,306,086 fuel cost savings over **15** years of vehicle operations

$379,403 maintenance savings over **15** years of vehicle operations

5,937 metric tons of greenhouse gas (GHG) eliminated over **15** years of vehicle operations

668,054 gallons of gasoline displaced over **15** years of vehicle operations

Equivalent to eliminating **46** homes' energy use annually

Over **300,000** kWh needed to charge the 123 recommended EVs cumulatively for **15** years

[1] Based on the Assumptions and Calculations outlined in Appendix 2, as then applied to the U.S. Environmental Protection Agency's Greenhouse Gas Equivalencies Calculator, https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator

II. Introduction

The State Fiscal Year 2021 (FY21) CFTA Program is a new pilot, test-of-concept program which aims to provide eligible local government and municipal fleets with technical assistance as they consider alternative transportation fuel options. This program is complementary to the MEA's FY21 Clean Fuels Incentive Program. Through CFTA, a technical assistance contractor (ICF) employed by MEA was tasked to work directly with eligible fleets, selected via an application process, for the purpose of developing potential alternative fuel fleet strategies. Possible alternative fuels for evaluation include electric, ethanol, hydrogen, natural gas, propane, and other biofuels, with the selected local government or municipal fleet choosing their preferred technical for evaluation, after discussions with ICF.

III. Overview of Motivations and Priorities

The City of Cumberland is working on their Capital Improvement Plan and preparing for the installation of electric vehicle supply equipment (EVSE) to charge future fleet EVs. Cumberland does not currently have EVs in their fleet. The City does not have sustainability staff and is relying on the CFTA Program to help plan for potential fleet electrification. Under the MEA MSEC program, which the City of Cumberland is an active participant, energy reduction and renewable resource policies have been adopted. Several efforts have been put forward towards the City's energy reduction goals and there has been a good faith effort to discuss and educate staff on potential renewable resource projects. Currently there are no policies or requirements adopted by the City impacting transportation-related purchases; however, as trends begin to shift in planning towards savings and conserving resources, goals related to greening transportation purchases are on the horizon.

This fleet electrification evaluation factored in the unique temperatures and terrain needs for the vehicles in the Cumberland fleet, with the fleet primarily located at three main municipal properties. If the City chooses to electrify the fleet, Cumberland will need EV and EVSE usage training for drivers and fleet and facilities maintenance training for anyone responsible for maintaining EV and EVSE.

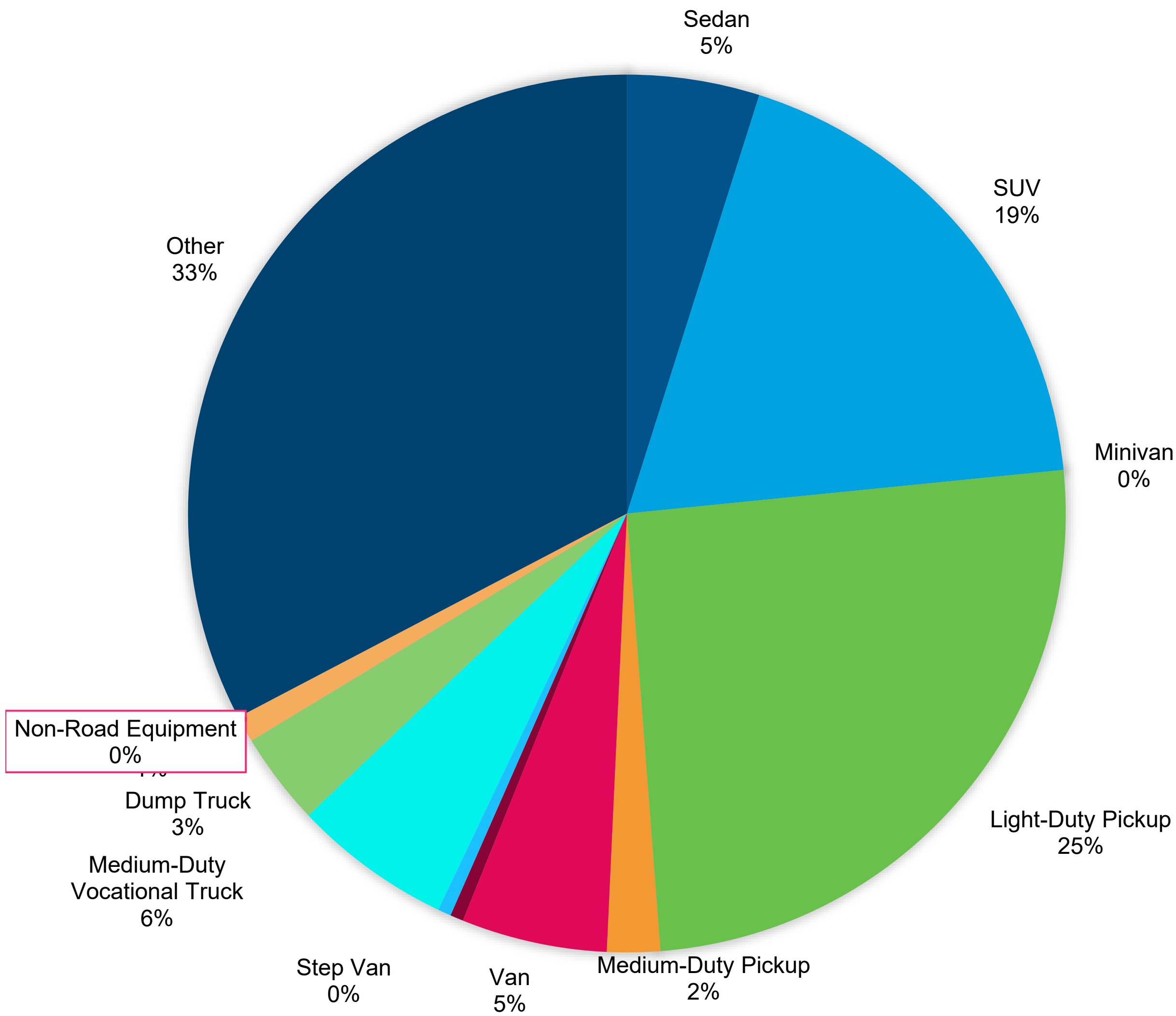
Additionally, Potomac Edison has installed their first public EV charging station on City land under their EV Driven program, helping spur the evaluation for EVSE on City property.

IV. Current Fleet Inventory

When applying to the CFTA Program, Cumberland provided fleet data from 14 City fleets, comprising of 205 total vehicles as seen below in Figure 1. ICF evaluated the 138 on-road vehicles for electrification opportunities, including some light-duty vehicles for the Fire fleet, as well as some PHEV police vehicles.

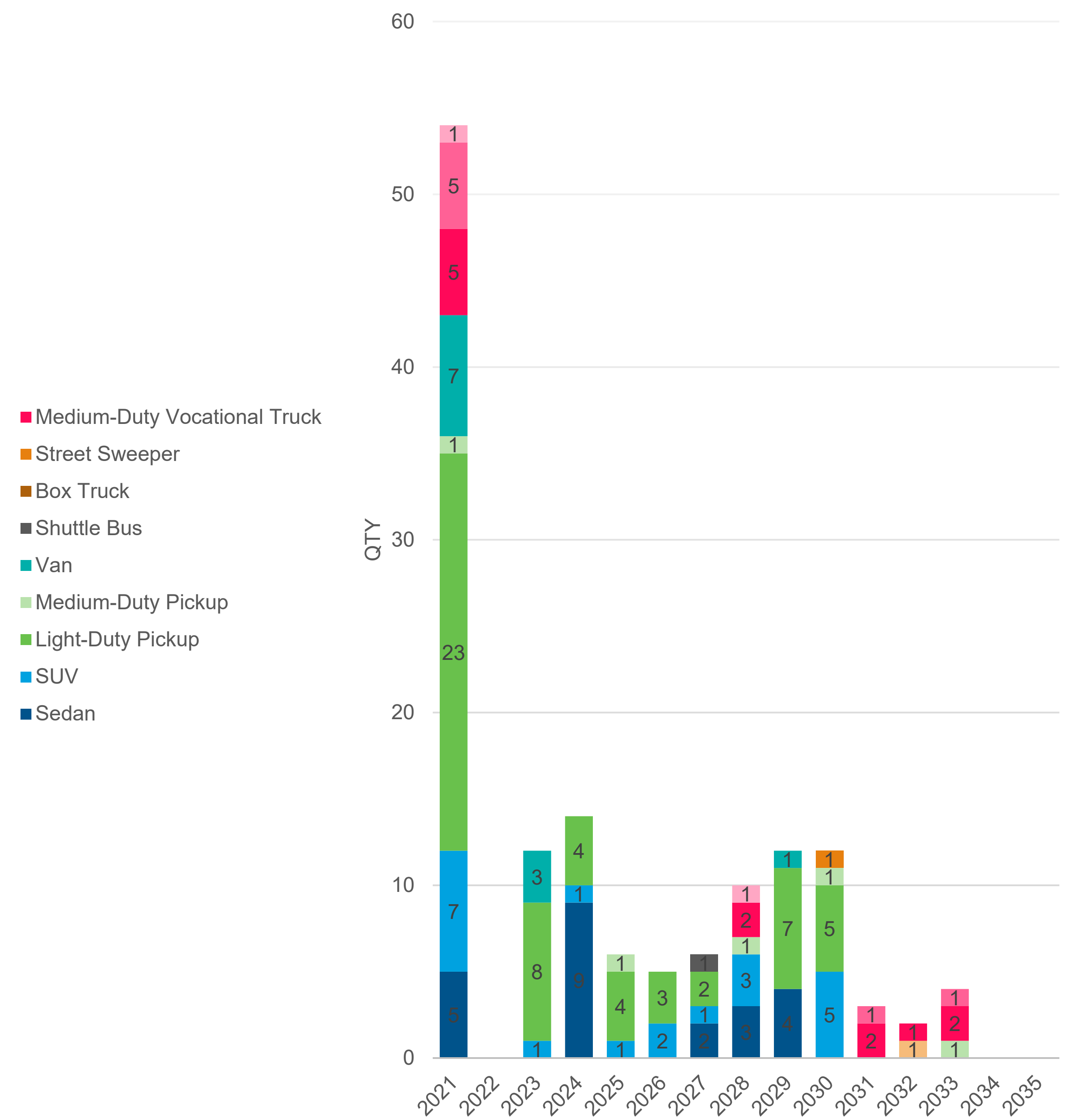
Cumberland's fleet is 5% sedans (10 vehicles), 19% SUVs (38 vehicles), and 25% light-duty pickups (52 vehicles), as seen in FIgure 1. ICF did not evaluate the off-road vehicles categorized under "other".

FIGURE 1: EXISTING FLEET - VEHICLE TYPES



ICF did not limit this electrification study to light-duty vehicles. ICF also looked at all vehicles eligible for retirement over the next 15 years, as shown in Figure 2, and evaluated electrification opportunities based on EV model availability as announced in December 2020. The exact vehicle retirement schedule is based on the assumptions identified by ICF and Cumberland, as shown in Appendix 2.

FIGURE 2 EXISTING FLEET - RETIREMENT SCHEDULE



V. Electrification Best Fit and Availability Assessment

Overall, ICF identified 103 vehicles for electrification based on current and announced EV make and model availability, which includes 54 BEVs and 49 PHEVs. Table 1 shows the recommended quantities, by vehicle type, to be replaced by EVs over the next 15 years.

TABLE 1: 15-Year Electrification Recommendations

Current Fleet			Electrification Recommendations		
	Total Quantity	Quantity Up for Retirement	Recommended Electrification Quantities	TCO Financial Savings	Lifetime GHG Emission Reductions (MT)
Sedan	23	23	8	$41,478	172
SUV	21	21	20	$168,564	638
Light-Duty Pickup	56	50	$389,009	2466	50
Medium-Duty Pickup	5	4	$146,347	86	4
Van	11	11	$351,245	511	11
Shuttle Bus	1	1	1	$48,093	145
Street Sweeper	1	1	1	$320,826	1504
Bucket Truck	1	1	0	-	-
Medium-Duty Vocational Truck	12	12	8	$460,961	556
Dump Truck	7	7	0	-	-
Heavy Truck	2	2	1	$29,075	2
Other	65	65	0	-	-
TOTAL	**205**	**205**	**103**	**$2,172,000**	**7,313**

The replacement timeline for these 103 vehicles can be seen in more detail below in Figure 3.

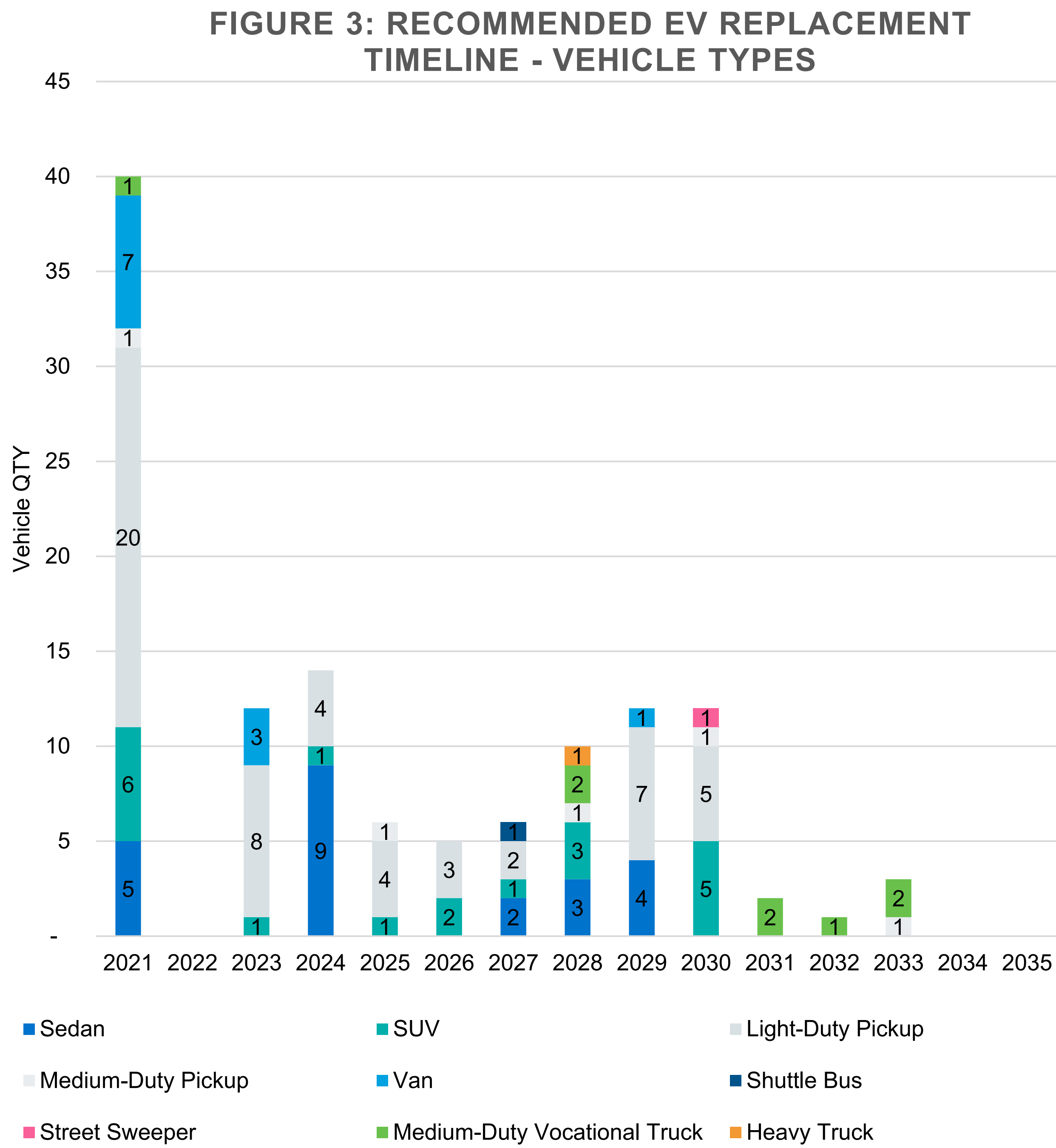
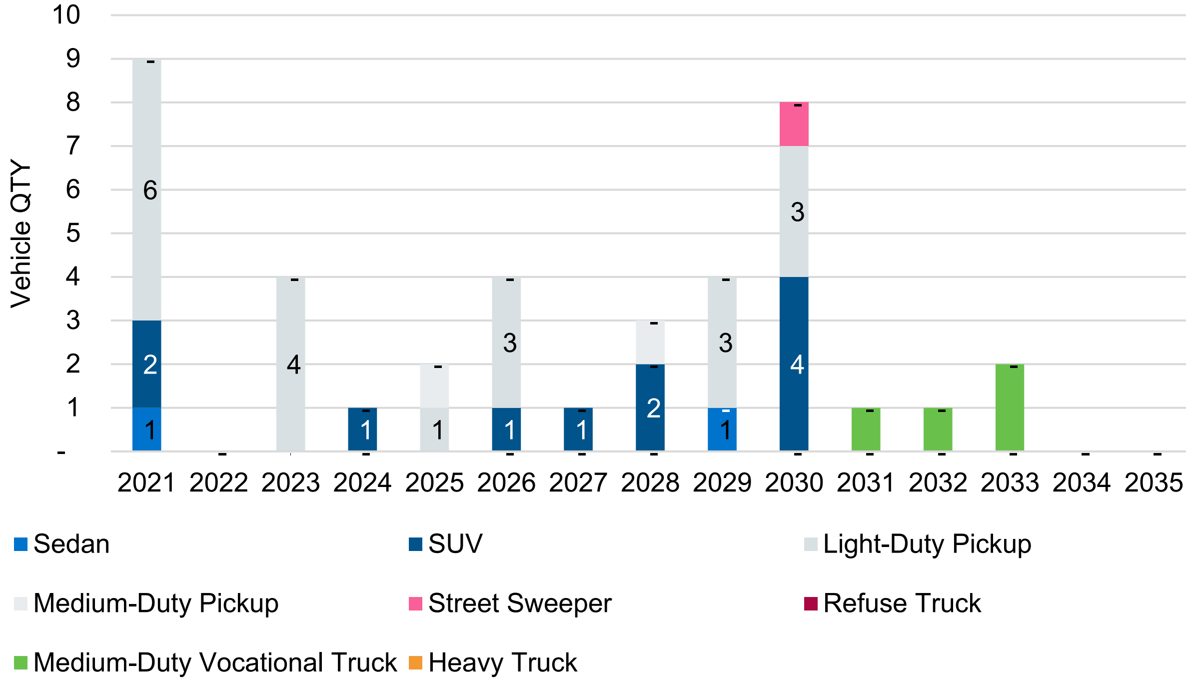
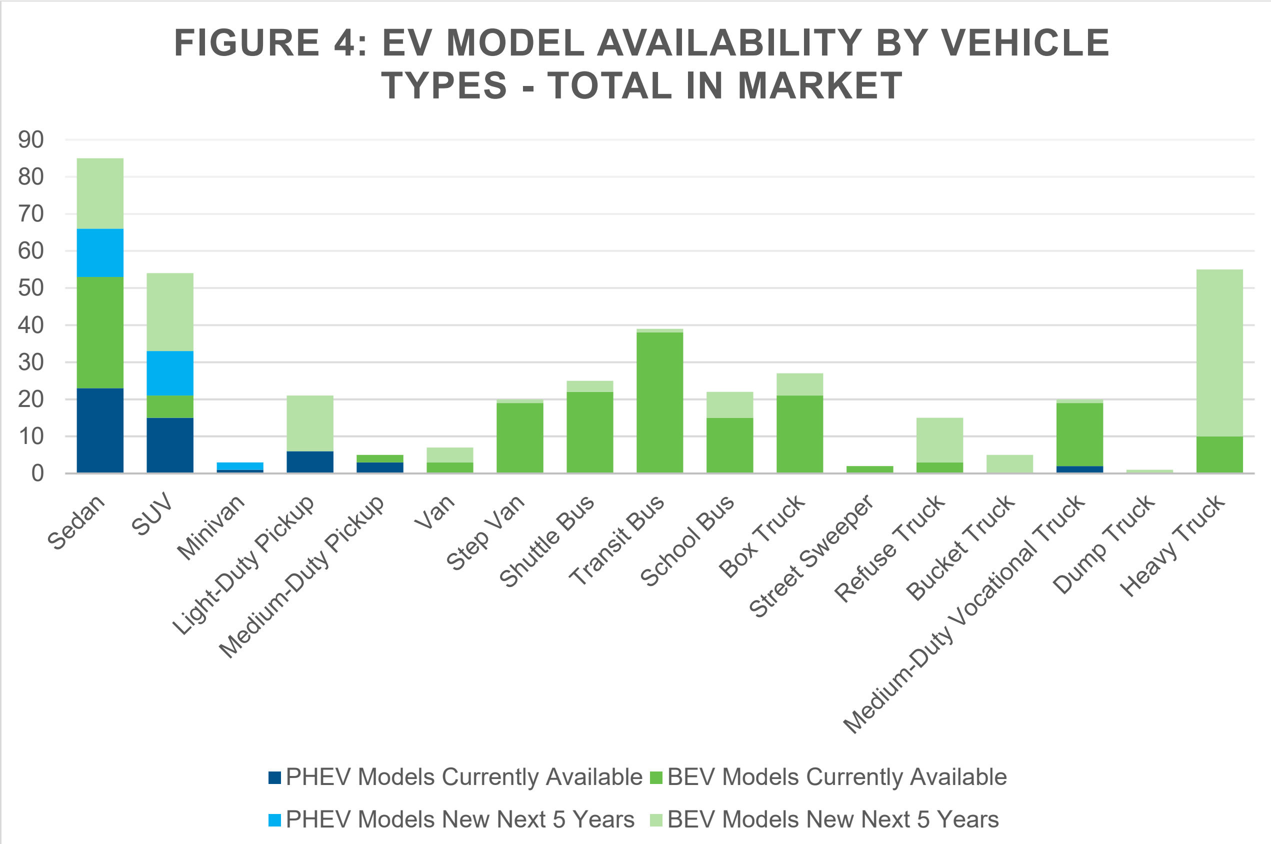


FIGURE 3: RECOMMENDED EV REPLACEMENT TIMELINE - VEHICLE TYPES
Vehicle QTY
45
40
35
30
25
20
15
10
5
-
2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
2031
2032
2033
2034
2035
Sedan
SUV
Light-Duty Pickup
Medium-Duty Pickup
Van
Shuttle Bus
Street Sweeper
Medium-Duty Vocational Truck
Heavy Truck

FIGURE 3: RECOMMENDED EV REPLACEMENT TIMELINE - VEHICLE TYPES



The electrification schedule begins with sedans, vans, pickups, and SUVs. It then progressed to add in larger vehicles. PHEVs were recommended for vehicles requiring a larger vehicle range than currently available in an equivalent BEV model. For future models recently announced and currently nascent EV types, recommendations for electrification do not take place until it is expected that these EV types are more comparatively priced with ICE vehicles over the TCO. Figure 4, below, shows the market mix of existing and future EV models availability utilized for this analysis.



VI. Economic Analysis

To determine the TCO, the vehicle lifespans of the 103 vehicles suggested for electrification was evaluated. As Cumberland does not currently own electric vehicle supply equipment (EVSE) to charge these vehicles, the assumed cost of EVSE purchase, installation, and grant opportunities were included in TCO calculations.

These assumptions include installing Level 2 and direct-current fast charging (DCFC) EVSE charging stations. Figure 5 includes the cost of all 103 EVs and EVSE over the entire vehicle lifespans compared to the traditional ICE vehicle replacement.

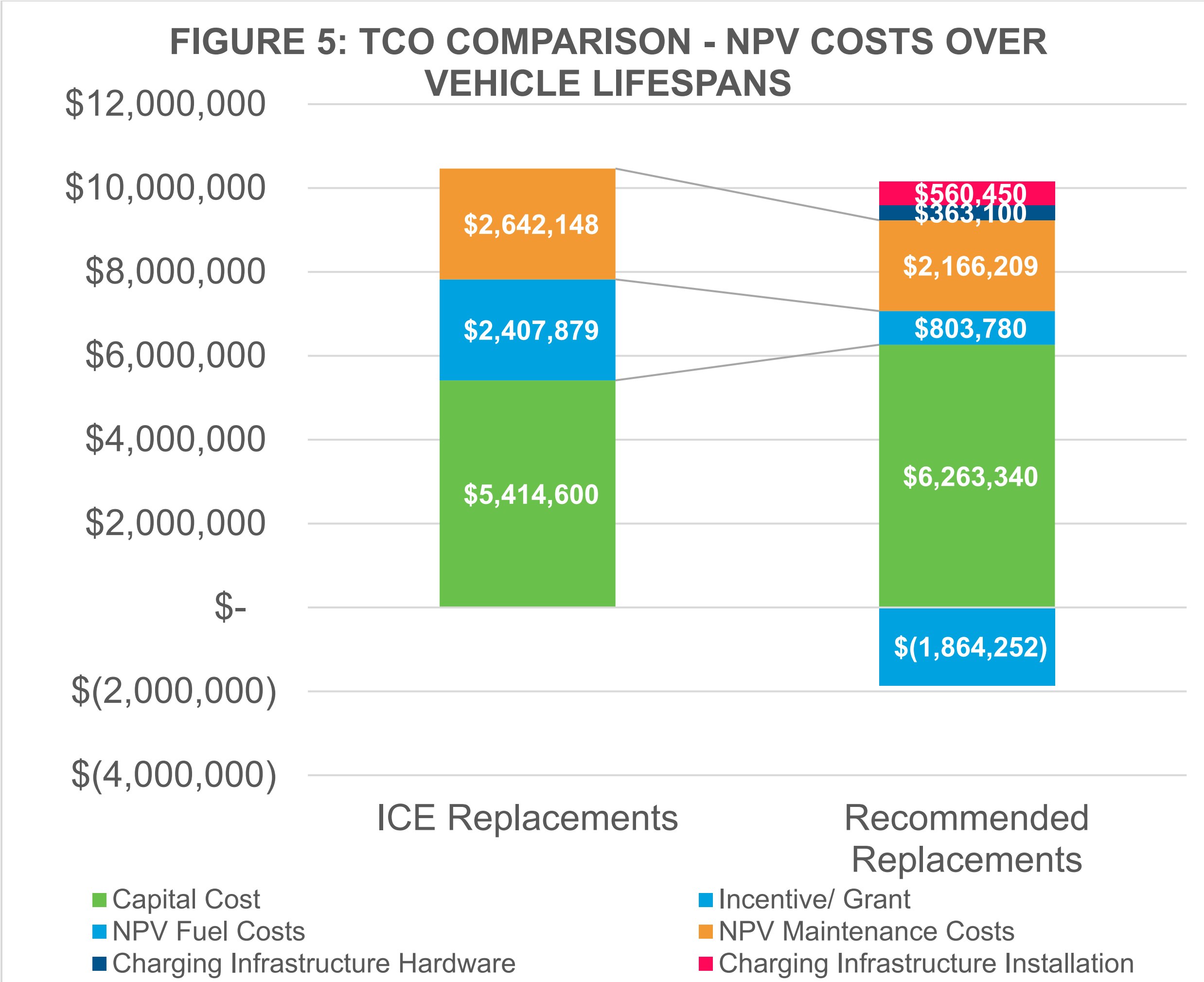
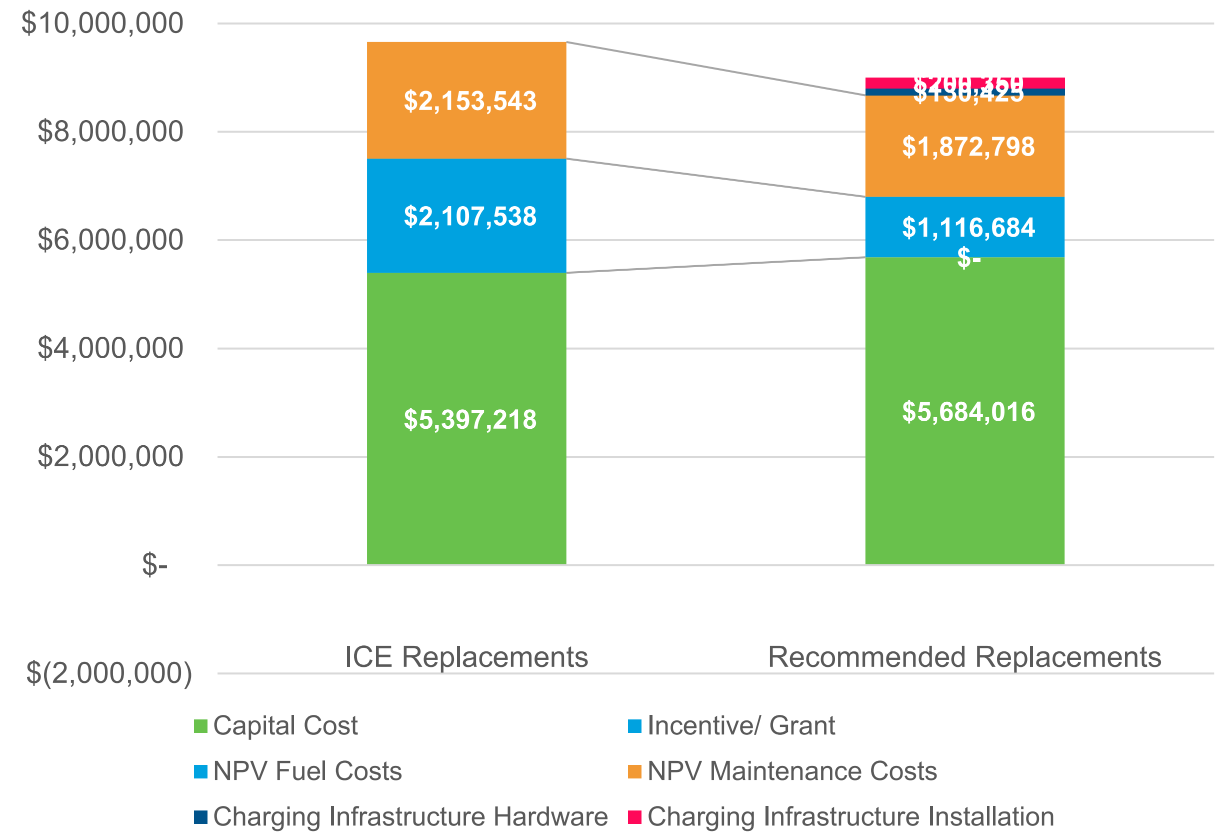


FIGURE 5: TCO COMPARISON - NPV COSTS OVER VEHICLE LIFESPANS
$12,000,000
$10,000,000
$8,000,000
$6,000,000
$4,000,000
$2,000,000
$-
$(2,000,000)
$(4,000,000)
$2,642,148
$2,407,879
$5,414,600
$560,450
$363,100
$2,166,209
$803,780
$6,263,340
$(1,864,252)
ICE Replacements
Recommended Replacements
Capital Cost
Incentive/ Grant
NPV Fuel Costs
NPV Maintenance Costs
Charging Infrastructure Hardware
Charging Infrastructure Installation

FIGURE 6: FLEET TCO COMPARISON - NPV COSTS OVER VEHICLE LIFESPANS



The EV replacement TCO is lowered by available EV and EVSE incentives for government fleets, valued at over $1 Million throughout the next 15 years, based on currently available incentives outlined in Appendix 1. While the City is not guaranteed to receive all grant funding available, strategic planning and timeline vehicle acquisition and infrastructure investment will have a significant impact on cost; raising or lowering it.

> **Please see U.S. Department of Energy's (DOE) Alternative Fuels Data Center for all currently available Maryland and Federal EV and EVSE incentives. Information is also available at MarylandEV.org.**

If the City does not receive any available incentives, then the recommendations drop to the City only replacing 43 vehicles with 27 BEVs and 16 PHEVs, for a total TCO savings of $654,026.

Table 2 provides a breakdown of the assumptions made in TCO modeling, to allocate EVs and EVSE plugs. Using Table 2 as a potential guide can help Cumberland strategically plan EVSE installation to limit infrastructure costs. Depending on vehicle duty cycle, more or less vehicles could charge per plug. If vehicles are fully rotated throughout the day, less plugs may be needed, while more plugs may be needed for vehicles on the same duty cycle which need to charge simultaneously. See the DOE Alternative Fuels Data Center for more information about Charging Infrastructure Procurement and Installation, including average costs.

TABLE 2. NUMBER OF EVS PER EVSE PLUG

Vehicle Type	Sub Type	EVs per Plug	Charger Level
Sedan	Sedan	2	L2
Minivan	Minivan	2	L2
SUV	SUV	2	L2
Light-Duty Pickup	Light-Duty Pickup	2	L2
Medium-Duty Pickup	Medium-Duty Pickup	4	DCFC
Van	Van	4	DCFC
Step Van	Step Van	4	DCFC
Medium-Duty Vocational Truck	Medium-Duty Vocational Truck	4	DCFC
Street Sweeper	Street Sweeper	2	DCFC
Refuse Truck	Refuse Truck	2	DCFC
Shuttle Bus	Shuttle Bus	2	DCFC
Heavy Truck	Heavy Truck	2	DCFC

Different vehicle types are responsible for different electrification TCO savings, as shown in Table 3, below. Heavy-duty vehicles, such as shuttle buses and refuse trucks, are the most cost-effective electrification solutions, largely due to their mileage and fuel consumption. If Cumberland is able to receive incentives such as the MEA Clean Fuel Incentive Program which was available in 2021, then additional vehicle types are also financially beneficial for electrification, as shown in Table 3, below.

TABLE 3. TCO SAVINGS BY VEHICLE TYPE, WITH INCENTIVES

Vehicle Types	TCO Savings
Sedan	$161,671
SUV	$166,499
Light-Duty Pickup	$462,053
Medium-Duty Pickup	$190,544
Van	$341,598
Shuttle Bus	$48,093
Street Sweeper	$319,791
Medium-Duty Vocational Truck	$453,711
Heavy Truck	$28,040
TOTAL	**$2,172,000**

As vehicle lifespans extend beyond 2035, TCO calculations extend out to 2050. The TCO comparisons in Figures 6 and 7 show that TCO savings will not necessarily be realized annually, but will fluctuate based on the suggested electrification schedule in Figure 3. After all capital expenditure is completed during the initial round of vehicle electrification, the years following 2035 will all provide operational savings.

FIGURE 6: TCO COMPARISON WITH INCENTIVES-CUMULATIVE

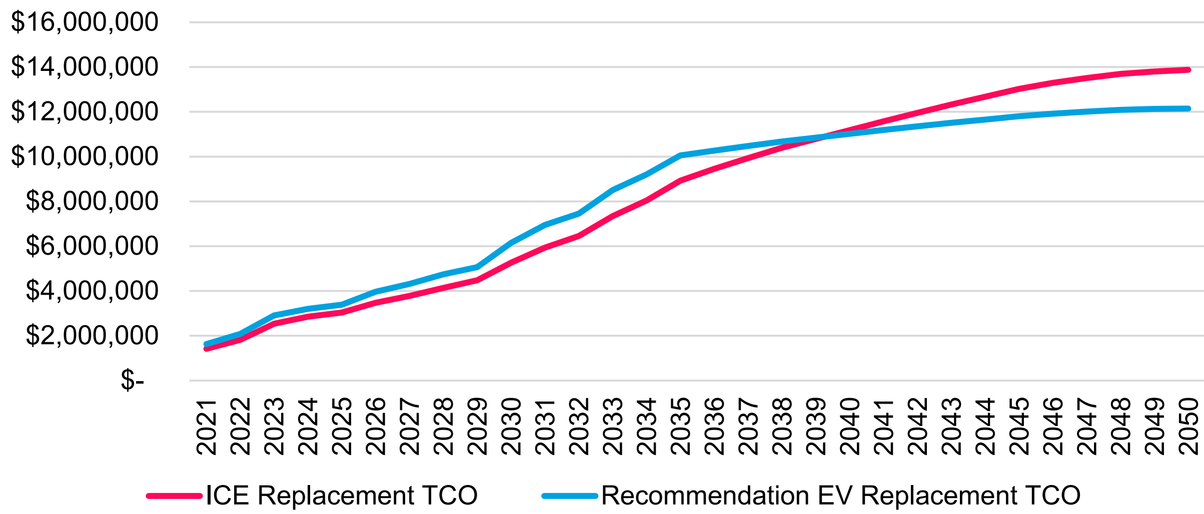
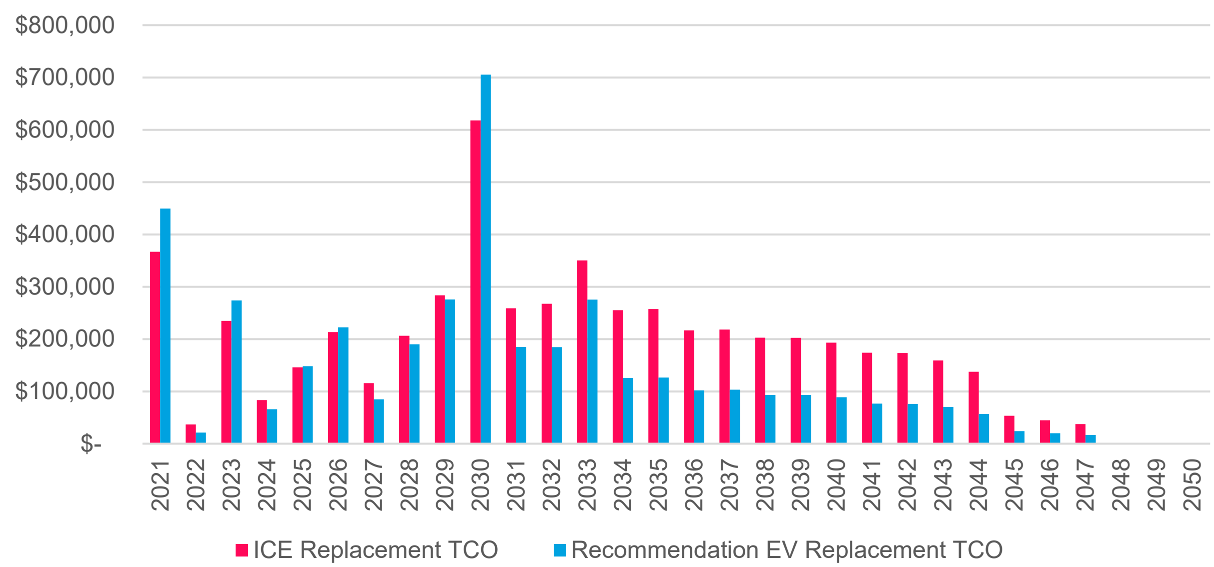


FIGURE 6: TCO COMPARISON WITH INCENTIVES- CUMULATIVE



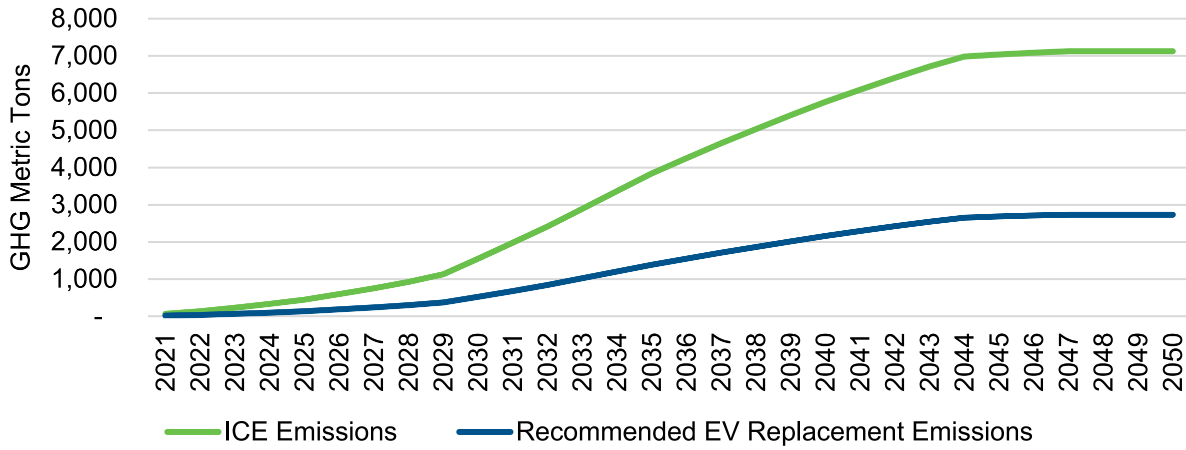
This report estimates the payback period, with incentives, for fleet electrification to end in 2035. However, the length of the payback period can be significantly influenced by the amount of financial incentives Cumberland secures. The more funding the City is able to obtain for EVs and EVSE, the shorter the payback period.

Many vehicles not recommended for electrification by 2035 will likely become eligible for electrification beyond 2035. As new makes and models become available, technology develops, and the first round of EVs reach the end of their payback period, the next round of vehicles eligible for electrification will likely be more accessible and affordable.

VII. Emissions Analysis

v Improvements in vehicle fuel economy and technologies, have provided small, incremental vehicle emissions savings over the years, however conversion to EVs will provide a significant and immediate emissions savings. Converting 103 ICE vehicles to EVs would save Cumberland 5,937 metric tons, or over 50% reduction, of GHG emissions over the lifespan of all converted EVs, through 2050. Additionally, almost 9 metric tons of NOx will be reduced over the vehicle lifespan. Figure 8, below, shows the emissions trajectory of the replacement with new ICE vehicles versus the replacement with EVs. This includes factoring in the petroleum fuel reductions, offset by a potential electricity consumption increase of over 300,000kWh total for 15 years of vehicle operations.

FIGURE 8: CUMULATIVE FLEET GHG EMISSIONS (MT)



These calculations are for wheel-to-well emissions, balancing the gasoline and diesel emissions savings with the emissions created to produce electricity, based on the Cumberland grid generation mix. Lifetime emissions savings per vehicle type is available below, in Table 4.

Table 4. Lifetime Emissions Savings per Vehicle Type with Electrification Recommendations

Vehicle Types	NOX Emission Reductions (MT)	GHG Emission Reductions (MT)
Sedan	0.1813	770
SUV	0.1174	638
Light-Duty Pickup	0.4714	2,887
Medium-Duty Pickup	1.2767	300
Van	1.7947	511
Shuttle Bus	0.5597	145
Street Sweeper	0.3780	1,504
Medium-Duty Vocational Truck	4.0227	556
Heavy Truck	0.0046	2
Total	**8.807**	**7,313**

VIII. Conclusion

This analysis identifies 103 vehicles for electrification in Cumberland's fleet over the next 15 years. If Cumberland follows the recommended replacement schedule for transitioning from ICE vehicles to EVs, the City can expect to see operational savings following 2035 and a reduction in GHG emissions by almost 6,000 metric tons.

As Cumberland begins electrifying its fleet, it should anticipate certain barriers and challenges. The largest barrier that fleets can face when electrifying their fleet is the cost of acquiring EVs and building charging infrastructure. To help minimize the incremental cost of acquiring EVs and realize all potential cost savings of fleet electrification, Cumberland should apply for grant and funding opportunities. While funding availability is not guaranteed, Cumberland should consider applying for the following financial incentives offered in Maryland:

- Clean Fuel Incentive Program (CFIP) for EVs and Charging Stations
- EVSE Workplace Charging Grant
- EVSE Rebate Program
- Maryland Smart Energy Communities (MSEC)

Incentives available to local governments in Maryland include funding from MEA, Volkswagen Settlement Funds, and potentially future federal funding. When applying for grant funding, the City needs to be strategic as some funding opportunities cannot be combined with others. For example, Volkswagen Settlement funds are distributed by the Maryland Department of the Environment and cannot be combined with other Maryland-based funding opportunities. While the City can apply for all funding opportunities, it should consider the implications of having to potentially choose between awards. Similarly, the City should monitor federal activity for new EV and EVSE incentives that are anticipated to be released. The City can continue to partner with Potomac Edison to pursue public charging stations, however these are not intended for the fleet.

Similarly, to realize the lower fuel costs of EVs compared to ICE vehicles, Cumberland should monitor their electricity use to ensure charging occurs during off-peak hours.

Along with the cost of vehicle acquisition, cold weather and range anxiety can present barriers to EV users. While range anxiety can be addressed by educating EV drivers, cold weather can impact vehicle range. Cumberland does not experience extreme weather conditions, but the temperature averages below freezing in the winter months. As Cumberland considers electrification, it should review best practices and case studies related to cold weather EV use. Resources are available at the following:

- U.S. Department of Energy (DOE) Office of Energy Efficiency & Renewable Energy's Maximizing Electric Cars' Range in Extreme Temperatures
- DOE's fueleconomy.gov's Tips for Hybrids, Plug-In Hybrids, and Electric Vehicles
- DOE's EV Everywhere: Drive Electric Vermont Case Study
- Idaho National Laboratory's Empirical Analysis of Electric Vehicle Fast Charging under Cold Temperatures
- SemaConnect Charging and Driving an EV in the Rain or Winter Snow: Answering Common Questions

To familiarize individuals in charge of operating and maintaining EVs and EVSE, Cumberland can use the following sources to develop educational materials:

- Maryland EV website
- DOE Alternative Fuels Data Center's Electricity Basics
- DOE Alternative Fuels Data Center's Developing Infrastructure to Charge Plug-In Electric Vehicles

- Calstart Zero-Emission Technology Inventory (ZETI) tool
- DOE's Electric-Drive Vehicles report
- DOE's fueleconomy.gov website for all vehicle models available
- SemaConnect Basics About Charging Stations

To ensure Cumberland is prepared for fleet electrification, the City should follow these recommended next steps:

- Identify and apply for relevant grant funding opportunities to help offset the cost of EV purchases and EVSE construction
- Begin implementing the recommended vehicle replacement schedule into the fleet vehicle acquisition plan
- Develop EV and EVSE usage training for drivers
- Develop fleet and facilities maintenance training for all employees responsible for driving or maintaining an EV or EVSE
- Determine where EVs will be housed overnight
- Begin a siting analysis to identify potential EVSE installation locations
- Prioritize vehicles, applying for funding on street sweepers, when possible.

Appendices

Appendix 1: Vehicle Replacement Assumptions

**Note: These are vehicles used for comparison purpose, not an endorsement of any individual EV manufacturer or model. See DOE's fueleconomy.gov website for all vehicle models available*

Appendix redacted.

Appendix 2: Assumptions and Calculations

Key assumptions and data sources that were used in this analysis include the following:

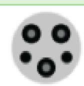
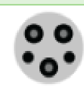
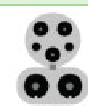
- **Recommendation Threshold:** EVs are recommended only when the EV TCO is less than the TCO of the comparable internal combustion engine (ICE) vehicle.
- **Vehicle Pricing:** The model uses manufacturer suggested retail prices (MSRPs) for EVs where available. When MSRP pricing is unavailable, the model uses average pricing based on vehicle and fuel type based on Argonne National Laboratory's Alternative Fuel Life Cycle Environmental and Economic Transportation (AFLEET) Tool and ICF's *Comparison of Medium- and Heavy-Duty Technologies in California* report for the California Electric Transportation Coalition. Vehicle pricing was escalated annually using the U.S. Energy Information Administration's (EIA) 2020 Annual Energy Outlook (AEO) and ICF's *Comparison of Medium- and Heavy-Duty Technologies in California* report for the California Electric Transportation Coalition. The model assumes that all vehicles are owned and not leased.
- **Annual Mileage:** The City of Cumberland provided mileage estimates to utilize.
- **Fuel Costs:** The existing fleet fuel costs were estimated using the vehicles' annual mileage, AFLEET fuel economy assumptions by vehicle and fuel type, and base fuel prices per gallon. The model uses $3.27 per gallon of diesel and $2.73 per gallon of gasoline rates, based on the U.S. EIA's Maryland average pricing for the past 5 years. The model escalates gasoline and diesel pricing annually using projections from the U.S. EIA's 2020 AEO Reference Case for Transportation.
- **Maintenance Costs:** Existing fleet maintenance costs were estimated using AFLEET dollar per mile assumptions by vehicle type and by fuel type. Maintenance costs were escalated 2% annually.
- **Electricity Pricing:** The model uses $0.10/kWh base rate, based on the U.S. EIA's Maryland average pricing and escalated annually using projections from the U.S. EIA's 2020 AEO Reference Case for Transportation: Electricity.[2]
- **Vehicle Replacements:** The City of Cumberland provided vehicle replacement estimates to utilize.
- **Timeframe:** Based on the vehicle retirement schedule, this analysis focuses on vehicle replacements for 2021 through 2035, with TCO calculations extending out to 2050 to capture entirety of vehicle lifespans.
- **Discount Rate:** 5% was used for net present value (NPV) calculations.
- **Temperatures:** Utilized the average annual Cumberland temperatures to calculate the impact on battery performance and reduced battery range.

[2] If Cumberland has secured a lower electricity rate from Potomac Edison, fuel cost savings will be even greater than estimated.

Appendix 3: EVSE Overview

The U.S. Department of Energy National Renewable Energy Lab Alternative Fuel Data Center offers resources to better understand EVSE and infrastructure requirements. The following information is a primer of some of the resources available:

EVSE Charging Types

	Level 1 Alternating Current	Level 2 Alternating Current	DC Fast Charging		
Description	Uses a standard plug - 120 volt (V), single phase service with a three-prong electrical outlet at 15-20 amperage (A)	Used for both battery electric (BEV) and plug-in hybrid electric vehicle (PHEV) charging 208/240 V AC split phase service that is less than or equal to 80 A.	Used specifically for battery electric vehicle charging Typically requires a dedicated circuit of 20-100 A, with a 480 V service connection.		
Connector type(s)					
	J1772 charge port	J1772 charge port	J1772 combo	CHAdeMO	Tesla combo
Use	Residential or workplace charging	Residential, workplace, or public charging	Rapid charging for transportation depots, vehicle fleets, public corridors		
Limitations	Low power delivery lengthens charging time	Requires additional infrastructure and wiring	Can only be used by BEVs currently. Higher upfront and operational costs		
Time to charge	2 to 5-mi range/1-hr charging Depending on the vehicle battery size, PHEVs can be fully charged in 2-7 hours and BEVs in 14-20+ hours	10 to 25-miles range/1-hr charging Depending on the vehicle battery size, PHEVs can be fully charged in 1-3 hours and BEVs in 4-8 hours	50 to 70-mi range/20-min charging Depending on the vehicle battery size, BEVs can be fully charged in 30-60 minutes.		

Methodology for Determining Fleet EVSE Needs

Step	Description	Calculation
1. Determine Individual Vehicle Energy Use	For each vehicle, determine its expected energy use in kilowatt-hours (kWh) by multiplying the vehicle's energy efficiency (kWh/mile) by the expected vehicle miles traveled (VMT) between charges.	Vehicle Energy Use (kWh) = Vehicle Energy Efficiency (kWh/mile) * VMT (mile)
2. Determine Fleet Energy Use	For each vehicle that requires charging within a certain window, sum their individual energy use requirements.	Fleet Energy Use (kWh) = ∑ Vehicle Energy Use$_1$ + Vehicle Energy Use$_2$ + … + Vehicle Energy Use$_n$
3. Identify Daily Charging Window	Identify the period of time that fleet vehicles are available to charge (e.g. 10 p.m.- 6 a.m.).	Hours (hr)

4. Identify Average Charging Demand	Divide fleet energy use by the charging window to determine average kilowatts (kW) of charging needed for truck operations.	Average Charging Demand (kW) = Fleet Energy Use also as kWh
5. Determine Average Per Vehicle Charging Demand	Divide average charging demand by the number of vehicles that require charging	Vehicle Charging Demand (kW) = Average Charging Demand (kW) / Vehicles

Appendix 4: Alternative Fuel Life-Cycle Environmental and Economic Transportation (AFLEET) Tool

The analysis contained within this report used assumptions and data contained within Argonne National Laboratory's (ANL) AFLEET Tool as the basis for comparison. For additional analysis, the AFLEET Tool may be used to examine the environmental and economic costs and benefits of alternative fuel and advanced vehicle technologies. AFLEET allows users to estimate vehicle and fleet petroleum use, GHG and air pollutant emissions, and TCO for light-, medium-, and heavy-duty vehicles. The tool relies on data from ANL's Greenhouse gases, Regulated Emissions, and Energy use in Technologies (GREET) model and the Environmental Protection Agency's Motor Vehicle Emission Simulator (MOVES) model.

Resources for the AFLEET Tool may be found at the following locations:

- AFLEET Tool Online
- AFLEET Tool 2020 Spreadsheet
- User Guide for the 2020 AFLEET Tool