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

March 31, 2021

Submitted to:

Maryland Energy Administration

and the

City of Laurel

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 Laurel, through a partnership with ICF. ICF analyzed Laurel's on-road vehicle fleet comprised of 175 vehicles, recommending 50 to 96 internal combustion engine (ICE) vehicles for electrification based on current and announced electric vehicle (EV) make and model availability, which includes 39 to 49 battery electric vehicles (BEV) and 11 to 47 plug-in hybrid electric vehicles (PHEV). The higher end of these recommendations is reliant on Laurel applying for, and receiving, 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 50 to 96 ICE vehicles to EVs is estimated to produce the following impacts[1]:

$941,293 to 2,372,399 total cost of ownership (TCO) savings over **15** years of vehicle operations

$1,231,485 to 1,514,357 fuel cost savings over **15** years of vehicle operations

$178,971 to 273,090 maintenance savings over **15** years of vehicle operations

5,228 to 6,554 metric tons of greenhouse gas (GHG) eliminated over **15** years of vehicle operations

588,275 to 737,482 gallons of gasoline displaced over **15** years of vehicle operations

equivalent to eliminating **50 to 63** homes' energy use annually

[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.

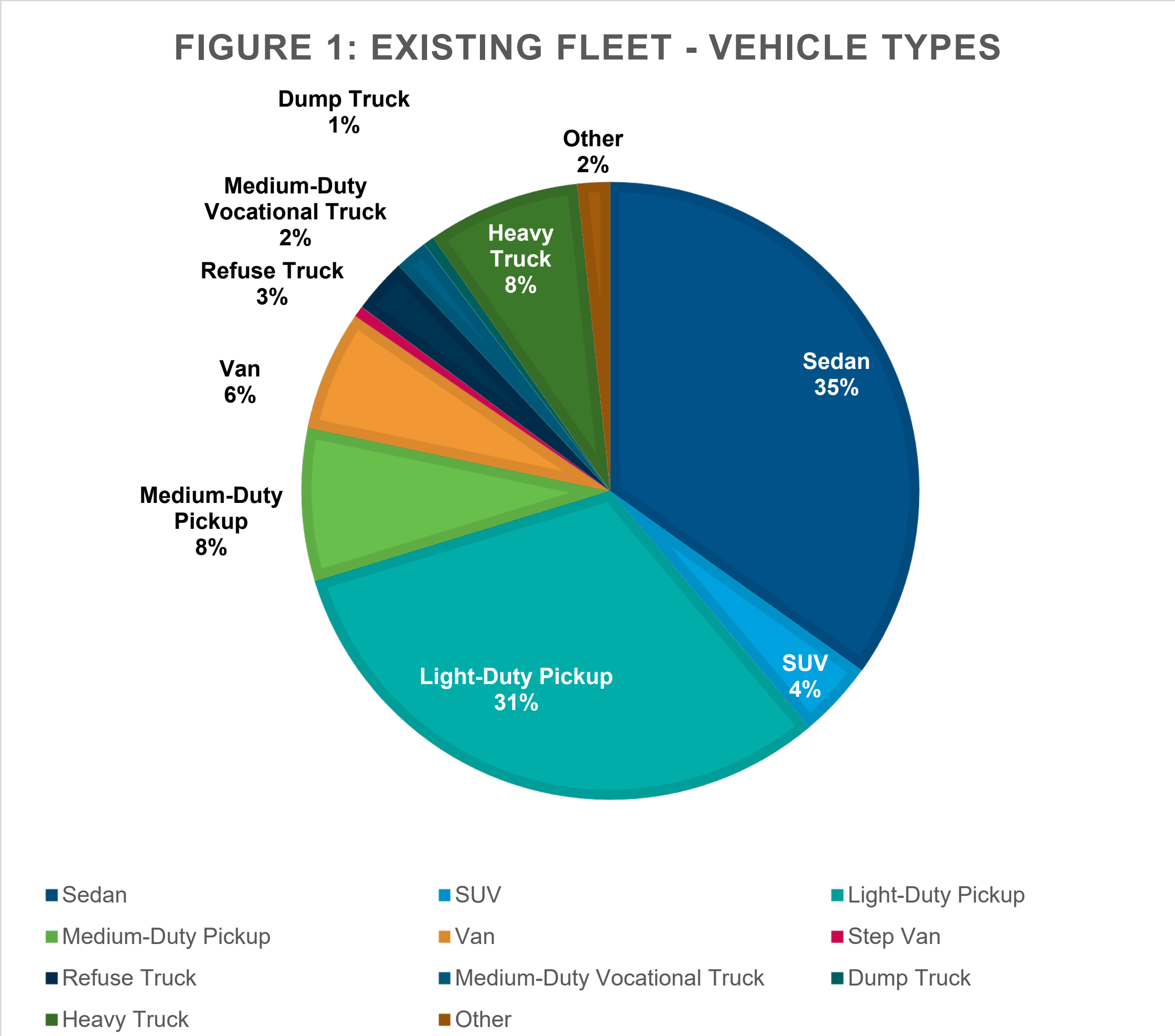
III. Overview of Motivations and Priorities

The City of Laurel is working on a framework to electrify its fleet vehicles to reduce the fleet's carbon footprint while promoting alternative energy and transportation options throughout the community. Currently, Laurel does not have any EVs in their fleet or any experience purchasing or maintaining EVs. The City is aiming to convert a majority of its light-duty fleet vehicles to electric in the next 10 years and 75% of its entire fleet in the next 20 years. Per these recommendations, 59% of the fleet could be converted in the next 15 years. This is reliant on the current vehicle model availability and incentive funding, both of which are forecasted to increase over the next 20 years.

If the City chooses to electrify its fleet, Laurel will need EV and EVSE training for drivers, fleet, and facilities staff to ensure proper usage and maintenance of the vehicles.

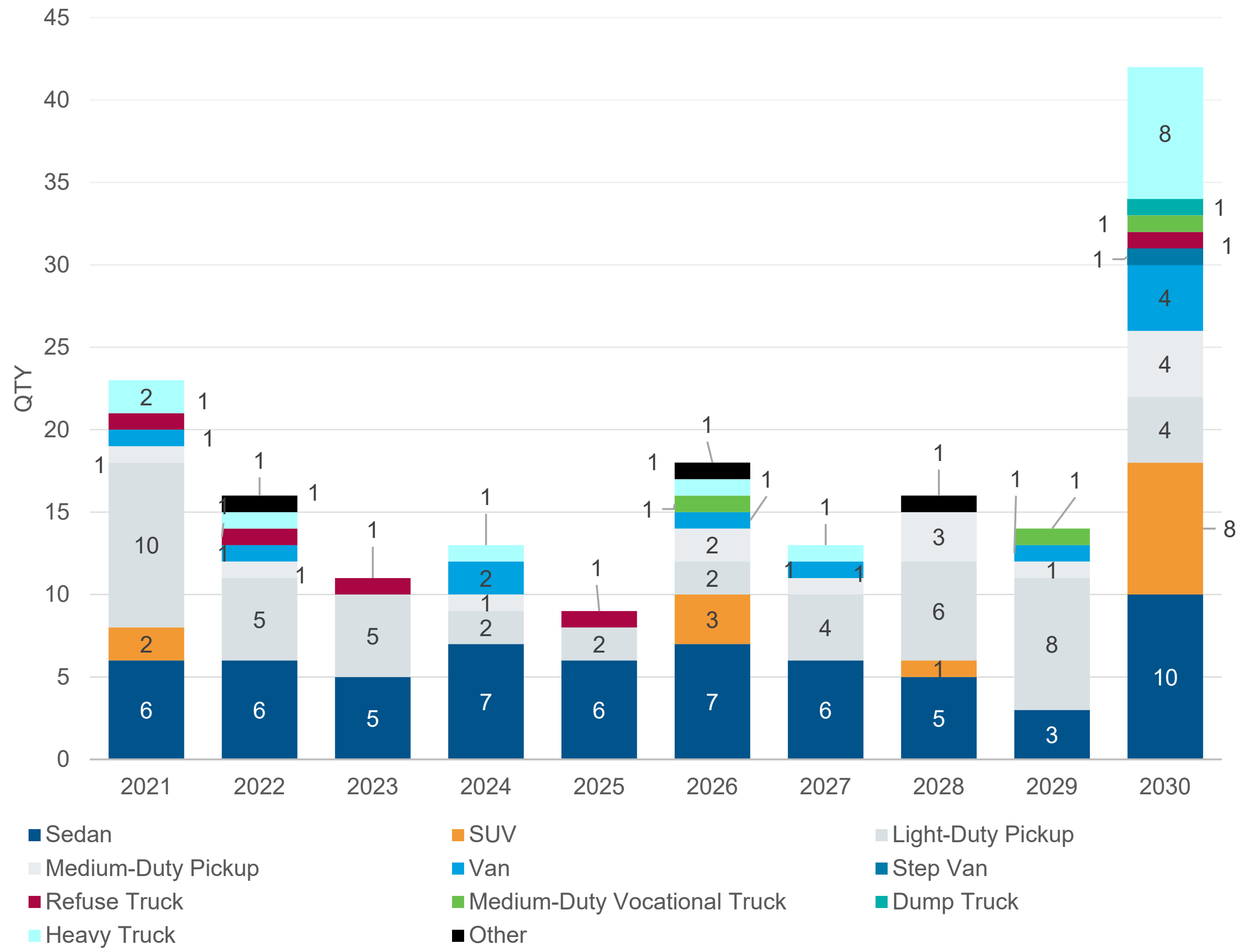
IV. Current Fleet Inventory

When applying to the CFTA Program, Laurel provided fleet data from 4 City fleet departments. ICF evaluated on-road vehicles for electrification opportunities, recognizing that first responder vehicles will not be converted to EVs at this time. First responder vehicles, particularly electrifying the fleets Chevrolet Impalas, becomes more affordable when police vehicles are able to share established direct-current fast charging (DCFC) stations, and when police-specific EVs become available.



Laurel's fleet is 35% sedans, 4% SUVs, and 31% light-duty pickups, as seen in Figure 1. ICF did not evaluate the off-road vehicles categorized under "other". 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 Laurel, as shown in Appendix 2.

FIGURE 2: EXISTING FLEET RETIREMENT SCHEDULE



V. Electrification Best Fit and Availability Assessment

Overall, 50 to 96 vehicles were identified for electrification based on current and announced EV make and model availability, which includes 39 to 49 BEVs and 11 to 47 PHEVs. Table 1 shows the recommended quantities, by vehicle type, to be replaced by EVs over the next 15 years. Surprisingly, the sedan conversion rate is extremely low due to most of Laurel's sedans belonging to the police fleet.

TABLE 1: 15-YEAR ELECTRIFICATION RECOMMENDATIONS, WITH INCENTIVES

Current Fleet			Electrification Recommendations		
	Total Quantity	**Quantity Up for Retirement**	**Recommended Electrification Quantities**	**Financial Savings**	**Lifetime GHG Emission Reductions (MT)**
Sedan	61	61	2	$10,720	15
SUV	7	7	6	$24,001	74
Light-Duty Pickup	55	55	45	$436,890	2357
Medium-Duty Pickup	14	14	14	$377,277	506
Van	11	11	11	$310,144	795
Step Van	1	1	1	$18,433	34
Refuse Truck	5	5	5	$860,094	2077
Medium-Duty Vocational Truck	3	3	3	$25,472	137
Heavy Truck	14	14	9	$309,367	561
TOTAL			**96**	**$2,372,399**	**6,554**

TABLE 2: 15-YEAR ELECTRIFICATION RECOMMENDATIONS, WITHOUT INCENTIVES

Current Fleet			Electrification Recommendations		
	Total Quantity	**Quantity Up for Retirement**	**Recommended Electrification Quantities**	**Financial Savings**	**Lifetime GHG Emission Reductions (MT)**
Sedan	61	61	1	$4,626	11
SUV	7	7	1	$9	14
Light-Duty Pickup	55	55	25	$256,410	2027
Medium-Duty Pickup	14	14	4	$12,540	139
Van	11	11	6	$87,251	479
Refuse Truck	5	5	5	$497,529	2077
Heavy Truck	14	14	8	$82,928	480
TOTAL			**50**	**$941,293**	**5,228**

The replacement timeline for these 96 vehicles can be seen in more detail below in Figure 3.

FIGURE 3: RECOMMENDED REPLACEMENT TIMELINE FOR 96 EVS WITH INCENTIVES BY VEHICLE TYPES

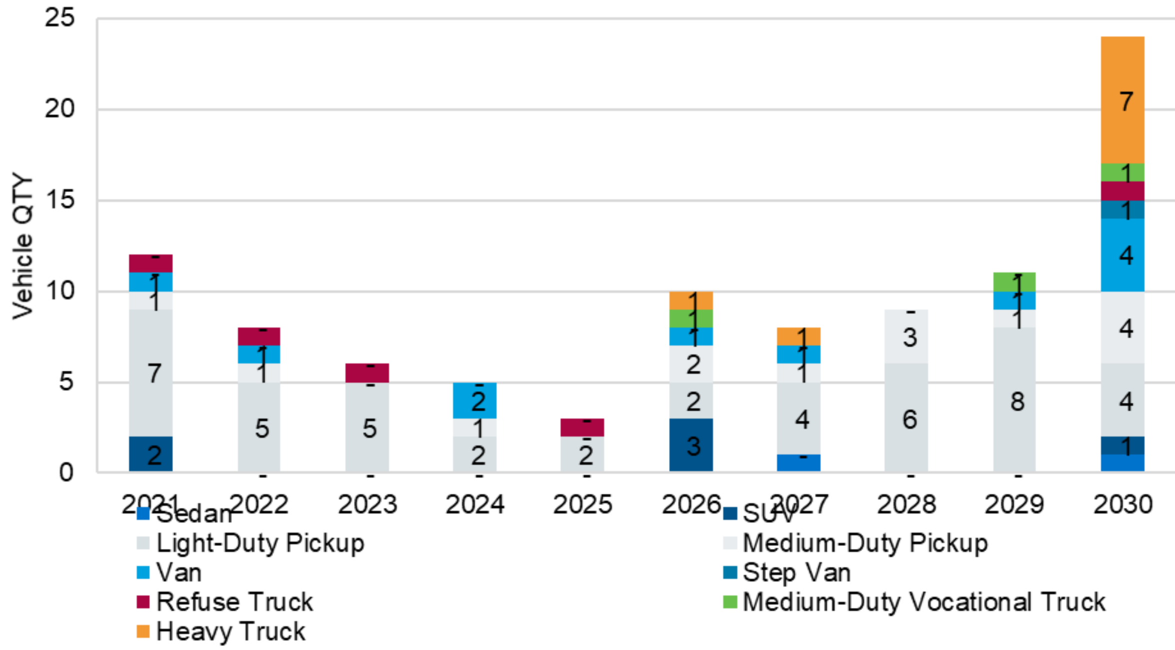
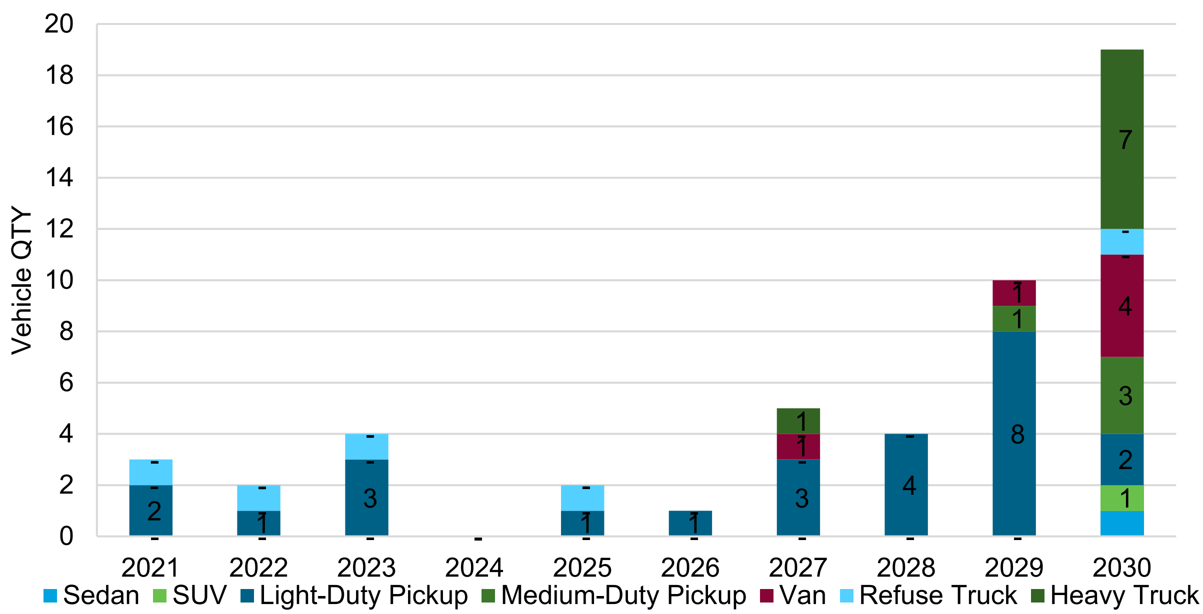
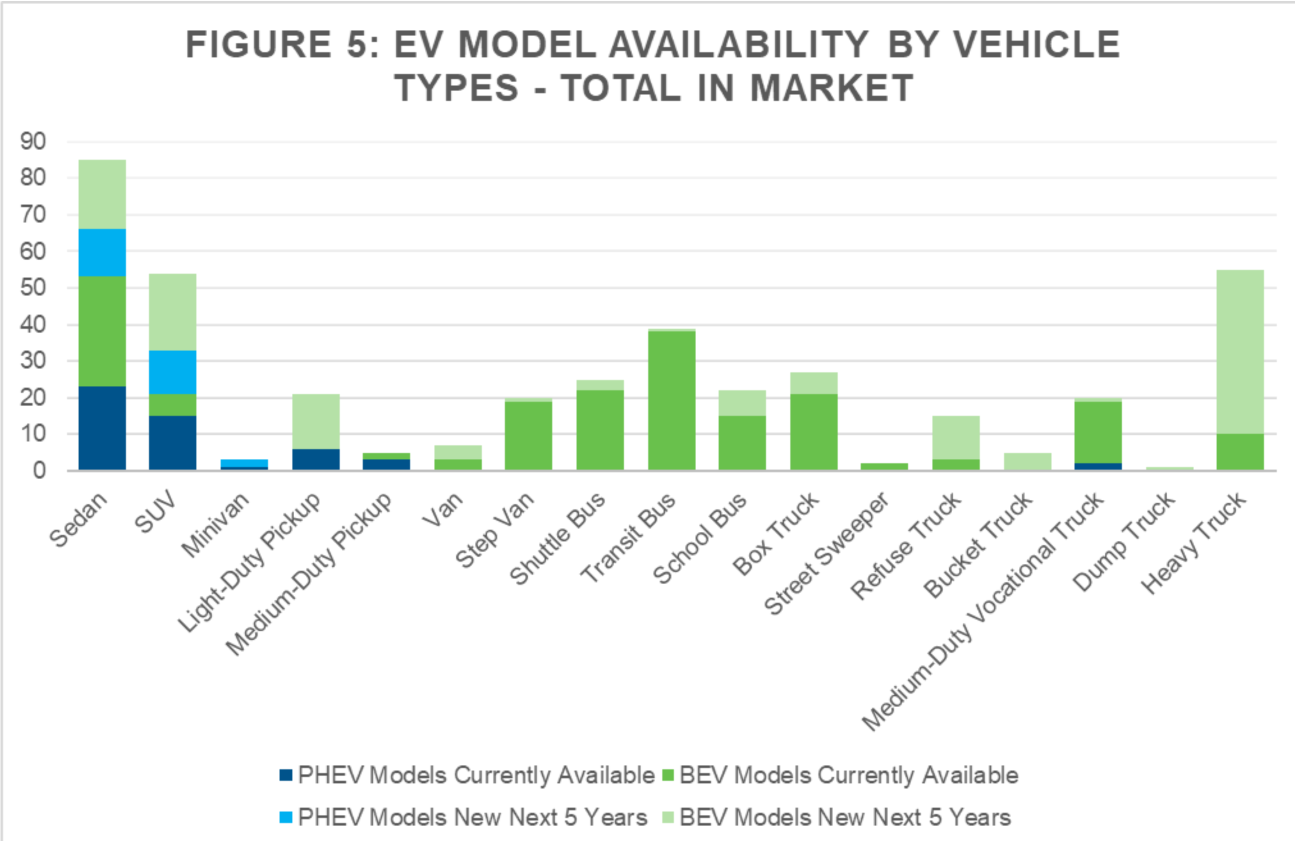


FIGURE 4: RECOMMENDED REPLACEMENT TIMELINE FOR 50 EVS WITH INCENTIVES BY VEHICLE TYPES



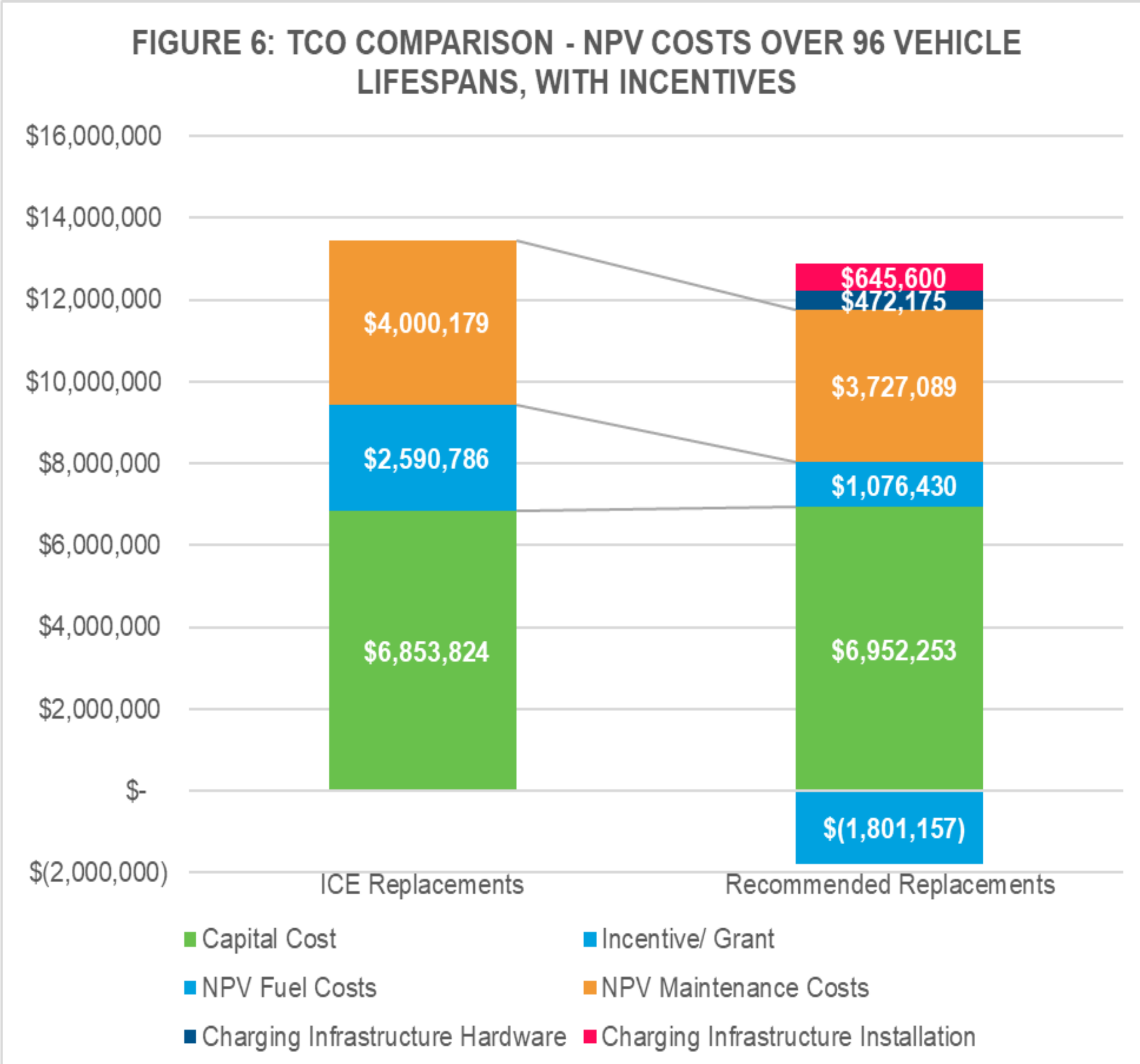
The electrification schedule begins with refuse trucks, vans, pickups, and SUVs. It then progressed to add in sedans, medium-duty pickups, and medium-duty trucks in the later years. PHEVs were recommended for vehicles requiring a larger vehicle range than currently available in an equivalent BEV model. 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 5, below, shows the mix of existing and future EV models availability utilized for this analysis.



VI. Economic Analysis

To determine the TCO, the vehicle lifespans of the 50 to 96 vehicles suggested for electrification was evaluated. As Laurel 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 6 includes the cost of all 96 EVs and EVSE over the entire vehicle lifespans compared to the traditional ICE vehicle replacement.



The EV replacement TCO is further lowered by available EV and EVSE incentives for government fleets, based on currently available incentives. The TCO of replacing 50 vehicles with EVs is shown below, in Figure 7.

> **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.**

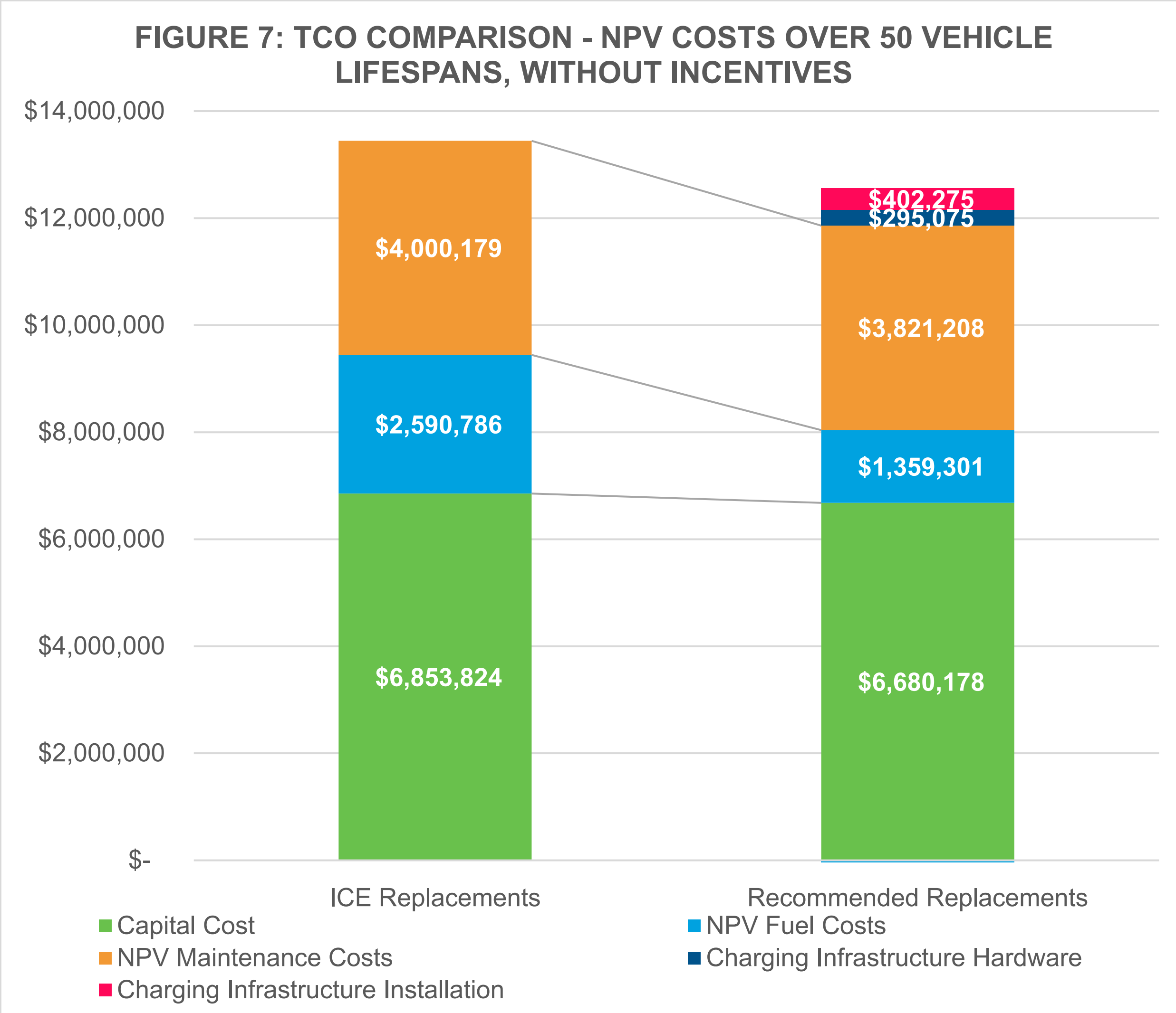


Table 3 provides a breakdown of the assumptions made in TCO modeling, to allocate EVs and EVSE plugs. Using Table 3 as a potential guide can help Laurel strategically plan EVSE installation to limit infrastructure costs. Depending on vehicle duty cycle, more or less vehicles could charge per plug. If 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 3. NUMBER OF EVS PER EVSE PLUG

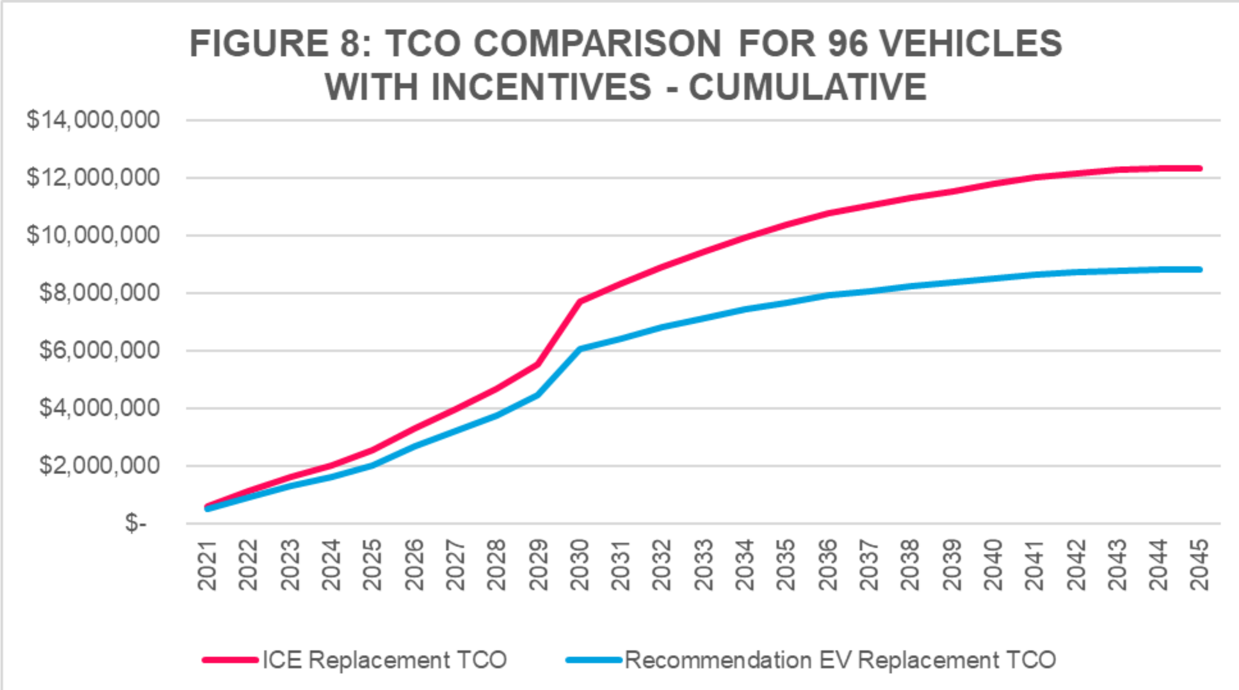
Vehicle Type	Sub Type	EVs per Plug	Charger Level
Sedan	Sedan	2	L2
SUV	SUV	2	L2
Light-Duty Pickup	Light-Duty Pickup	2	L2
Medium-Duty Pickup	Medium-Duty Pickup	4	DCFC
Van	Van	4	DCFC
Step Van	Step Van	4	DCFC
Medium-Duty Vocational Truck	Medium-Duty Vocational Truck	4	DCFC
Box Truck	Box Truck	2	DCFC
Street Sweeper	Street Sweeper	2	DCFC
Refuse Truck	Refuse Truck	2	DCFC
Shuttle Bus	Shuttle Bus	2	DCFC
Transit Bus	Transit Bus	1	DCFC
Bucket Truck	Bucket Truck	2	DCFC
Dump Truck	Dump Truck	2	DCFC
Heavy Truck	Heavy Truck	2	DCFC

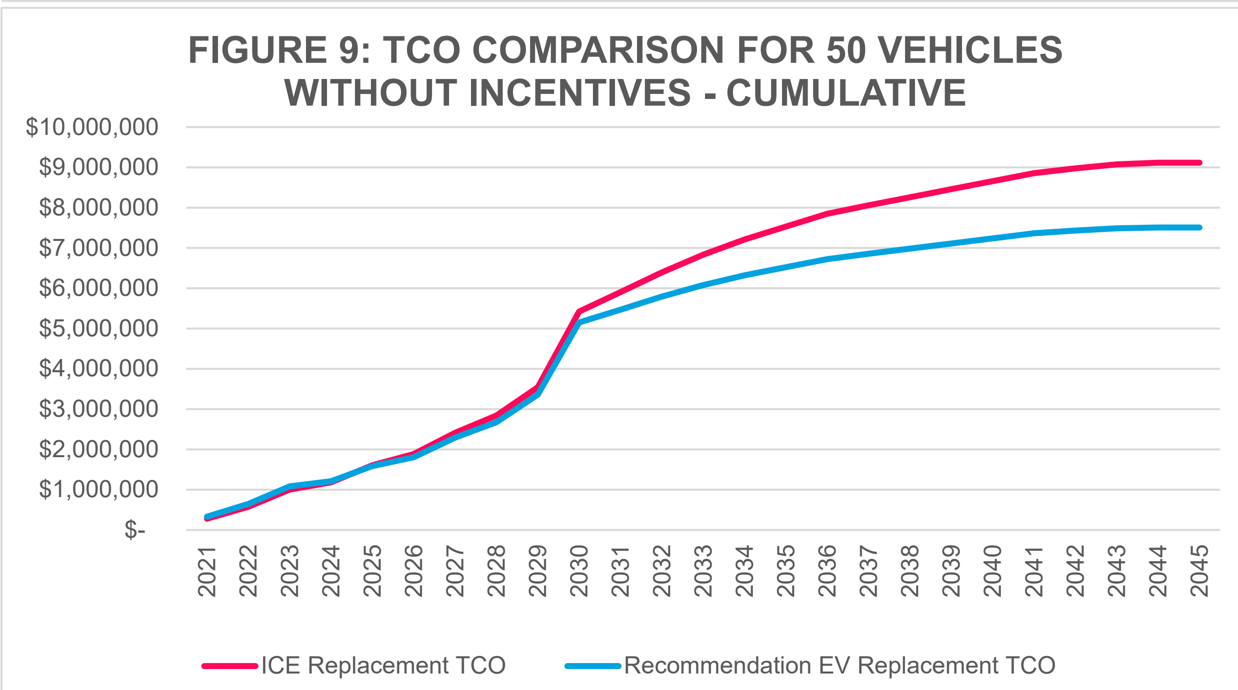
Different vehicle types are responsible for different electrification TCO savings, as shown in Table 4, below. If Laurel is able to receive incentives such as the MEA Clean Fuel Incentive Program which was available in 2021, then additional vehicle types are also financially beneficial for electrification.

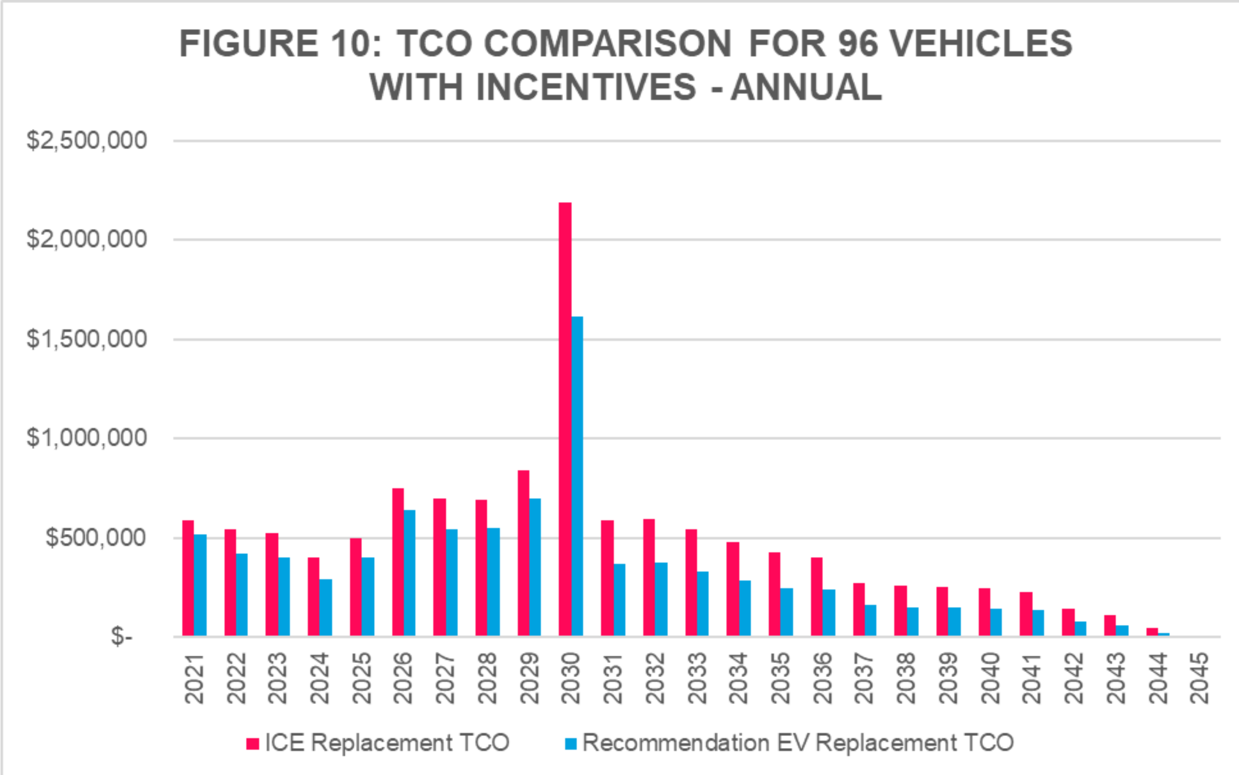
TABLE 4. AVERAGE TCO SAVINGS PER EACH VEHICLE TYPE, WITH INCENTIVES

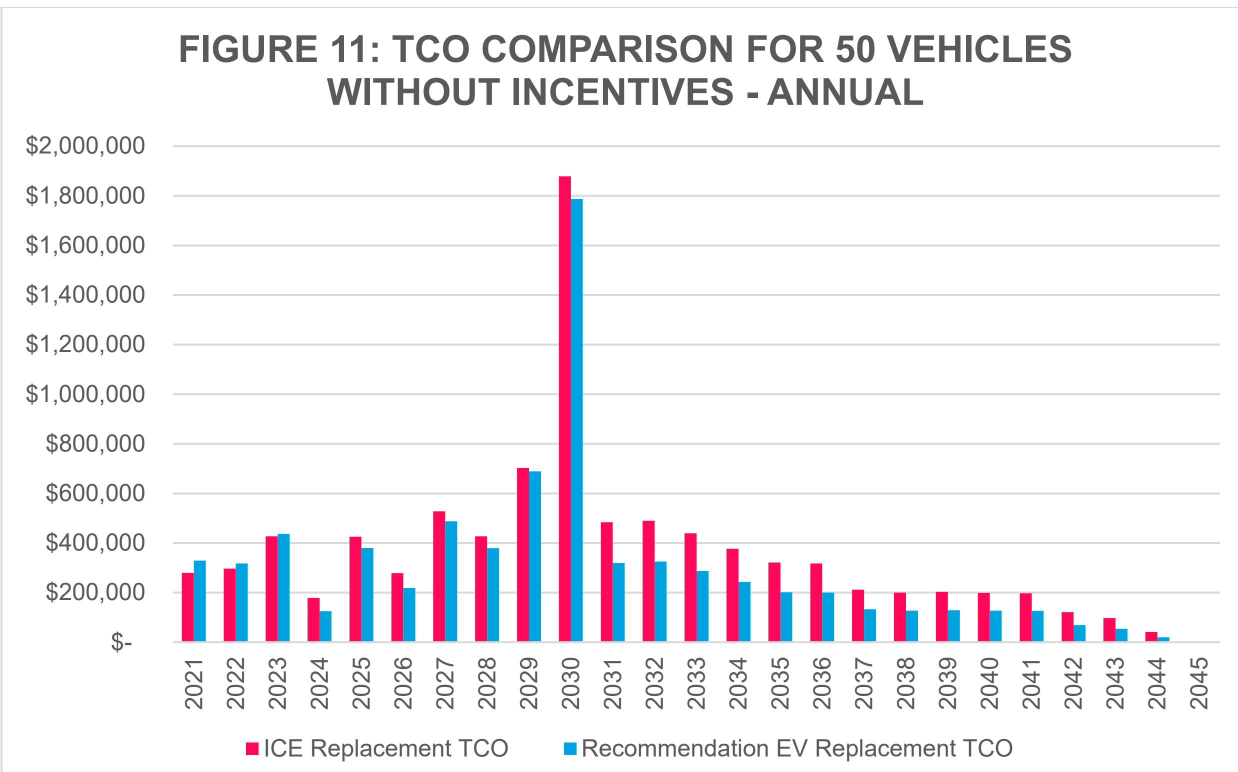
Vehicle Types	TCO Savings
Sedan	$5,360
SUV	$4,000
Light-Duty Pickup	$9,709
Medium-Duty Pickup	$26,949
Van	$28,194
Step Van	18,433
Refuse Truck	$172,019
Medium-Duty Vocational Truck	$8,491
Heavy Truck	$34,374

As vehicle lifespans extend beyond 2035, TCO calculations extend out to 2045. The TCO comparisons in Figures 8-11 show that TCO savings will not necessarily be realized annually, but will fluctuate based on the suggested electrification schedule in Figures 3 and 4. After all capital expenditure is completed during the initial round of vehicle electrification, the years following 2042 will all provide operational savings.









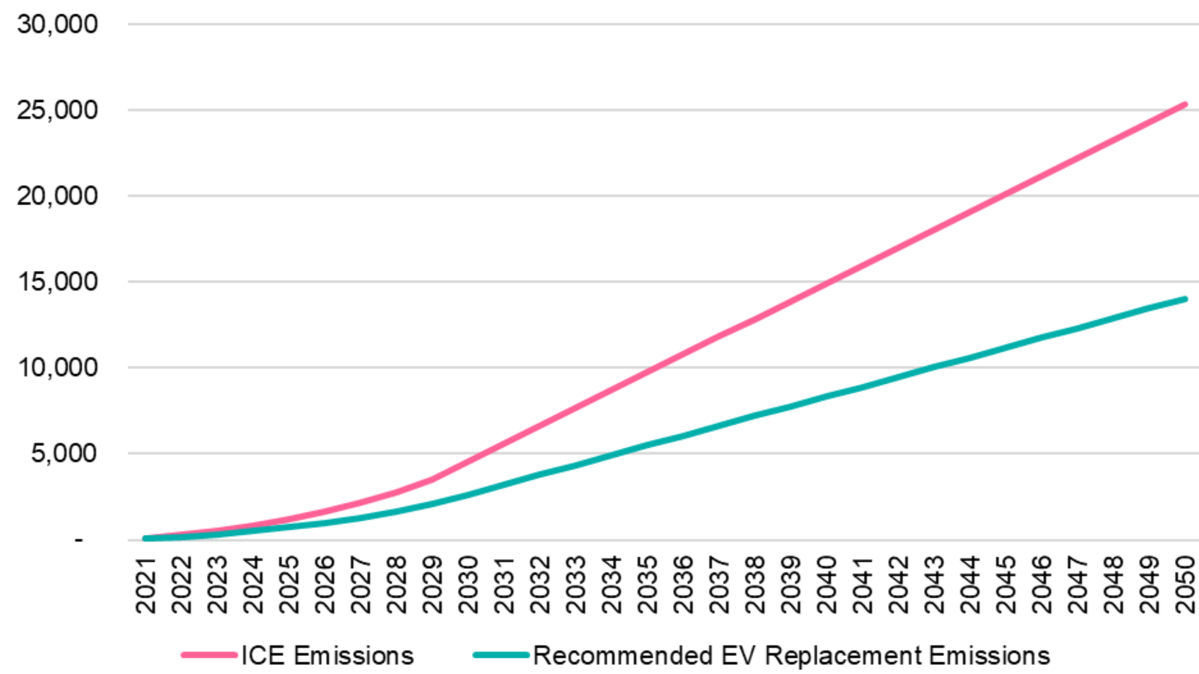
This report estimates the payback period, with incentives, for fleet electrification to end in 2045. However, the length of the payback period can be significantly influenced by the amount of financial incentives Laurel secures. The more funding the City is able to obtain for EVs and EVSE, the shorter 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

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 50-96 ICE vehicles to EVs would save Laurel 5,228 to 6,554 metric tons, or approximately 50% of GHG emissions over the lifespan of all converted EVs, through 2050. Additionally, over 9 metric tons of NOx will be reduced over the vehicle lifespan. Figure 12, 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.

FIGURE 12: TOTAL FLEET CUMULATIVE GHG (MT) EMISSIONS FOR 96 VEHICLES



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 Laurel grid generation mix. Estimated lifetime emissions savings per vehicle type for the 96 vehicles is available below, in Table 5. Actual emissions per vehicle can vary dramatically based on the vehicle being replaced and average mileage.

TABLE 5. AVERAGE LIFETIME EMISSIONS SAVINGS PER VEHICLE TYPE

Vehicle Types	NOX Emission Reductions (MT)	GHG Emission Reductions (MT)
Sedan	0.0044	15
SUV	0.0152	74
Light-Duty Pickup	0.4011	2,357
Medium-Duty Pickup	2.6151	506
Van	2.7956	795
Step Van	0.0071	34
Refuse Truck	1.3260	2,077
Medium-Duty Vocational Truck	0.9922	137
Heavy Truck	1.0793	561
Total	**9.236**	**6,554**

VIII. Conclusion

This analysis identifies 50-96 vehicles for electrification in Laurel's fleet over the next 15 years. If Laurel follows the recommended replacement schedule for transitioning from ICE vehicles to EVs, the City can expect to see operational savings following 2021, if incentives are attained, and a reduction in GHG emissions up to 6,554 metric tons.

As Laurel 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, Laurel should apply for grant and funding opportunities. While funding availability is not guaranteed, Laurel 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.

Similarly, to realize the lower fuel costs of EVs compared to ICE vehicles, Laurel should monitor their electricity use to ensure charging occurs during off-peak hours. The City can also partner with BGE to pursue public charging stations, however these are not intended for the fleet.

Along with the cost of vehicle acquisition, range anxiety can present barriers to EV users. To familiarize individuals in charge of operating and maintaining EVs and EVSE, Laurel can use the following sampling of EV resources to develop educational materials:

- Maryland EV
- DOE Alternative Fuels Data Center's Electricity Basics
- DOE Alternative Fuels Data Center's Developing Infrastructure to Charge Plug-In Electric Vehicles
- DOE's Electric-Drive Vehicles report
- DOE's fueleconomy.gov website for all vehicle models available
- SemaConnect's Basics About Charging Stations
- CALSTART's Zero-Emission Technology Inventory (ZETI) tool
- National Alternative Fuels Training Consortium's Electric Drive Vehicle Automotive Technician Training

To ensure Laurel 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

IX. 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

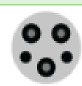
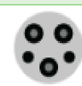
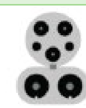
Key assumptions and data sources that were used in this analysis include the following:

- **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 Laurel 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. Additional maintenance savings for EVs may be realized over time, however an initial capital outlay is needed to train maintenance staff and adjust operations to handle EVs.
- **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.
- **Vehicle Replacements:** The City of Laurel 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 Laurel temperatures to calculate the impact on battery performance and reduced battery range.

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