Maryland Energy Administration Clean Fuels Technical Assistance Program: Prince George's County

May 19, 2023

Submitted to:

Maryland Energy Administration

and

Prince George's County

Submitted by:

ICF

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Acronyms

CARB	California Air Resources Board
CFTA	Clean Fuels Technical Assistance
DCFC	Direct Current Fast Charger
DOE	United States Department of Energy
EV	Electric Vehicle
EVSE	Electric Vehicle Supply Equipment
FY	Fiscal Year
GHG	Greenhouse Gas
ICE	Internal Combustion Engine
Li-ion	Lithium-ion
MEA	Maryland Energy Administration
MT	Metric Tons
MWCOG	Metropolitan Washington Council of Governments
OEM	Original Equipment Manufacturer
PHEV	Plug-In Hybrid Electric Vehicle
RRD	Resource Recovery Division
SUV	Sport Utility Vehicle
TCO	Total Cost of Ownership
ZEV	Zero Emission Vehicle

Executive Summary

The Maryland Energy Administration (MEA) Clean Fuels Technical Assistance (CFTA) Program has provided this fleet advisory service for Prince George's County (County), through a partnership with ICF, and support from Maryland Clean Cities. ICF analyzed the County Resource Recovery Division's (RRD) Brown Station Road Sanitary Landfill on-road fleet comprised of 41 vehicles, recommending 16 internal combustion engine (ICE) vehicles for electrification based on available electric vehicle (EV) make and model availability. The conversions would take place over a five-year timeframe[1], 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 16 ICE vehicles to EVs is estimated to produce the following impacts over 19 years[2] of vehicle ownership[3]:

$962,878 total cost of ownership (TCO) savings over **19** years of vehicle operations

$1,032,273 fuel cost savings over **19** years of vehicle operations

$246,359 maintenance savings over **19** years of vehicle operations

4,019 metric tons (MT) of greenhouse gas (GHG) eliminated over **19** years of vehicle operations

5,974 gallons of gasoline and **22,576** gallons of diesel displaced annually

Equivalent to eliminating **462** homes' energy use annually

[1] 2024 to 2028
[2] 2024 to 2042
[3] Based on the Assumptions and Calculations outlined in Appendix A, as then applied to the U.S. Environmental Protection Agency's Greenhouse Gas Equivalencies Calculator, https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator

Introduction

The State Fiscal Year (FY) 2022 CFTA Program aims to provide eligible local government and municipal fleets with technical assistance as they consider alternative transportation fuel options. This program is a continuation of MEA's FY 2021 CFTA Pilot Program and complementary to FY 2022 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 for on-road light-, medium-, and heavy-duty vehicles. Possible alternative fuels for evaluation include electricity, ethanol, hydrogen, natural gas, propane, and other biofuels. The participating local government or municipal fleet chooses their preferred fuel for technical evaluation. Prince George's County RRD selected fleet electrification for their technical assistance, specifically for their Brown Station Road Sanitary Landfill vehicles.

This assessment includes vehicle electrification recommendations, an economic analysis of vehicle electrification, an emissions analysis of electrification recommendations, an overview of charging infrastructure needed to support the electrification recommendations, and best practices based on the County's primary concerns.

Overview of Motivations and Priorities

In 2014, the County adopted a Green Fleet Policy, which prioritizes the adoption of cleaner, energy efficient vehicles to improve public health, minimize pollution, and conserve resources.[4] The Green Fleet Policy outlines a fleet purchasing requirement that instructs the applicable portion of the fleet be replaced with smaller, more fuel-efficient vehicles, prioritizing California Air Resources Board (CARB) certified zero emission vehicles (ZEVs) and partial-ZEVs. Purchasing goals are set as percentages of fiscal year vehicle acquisitions, using 2015 as the baseline year:

- By 2020, 25% of applicable vehicle purchases must be ZEVs or partial-ZEVs and,
- By 2025, those vehicles must account for 50% of purchases.

The Green Fleet Policy also requires the reduction of vehicle GHG emissions while improving vehicle fuel economy. The GHG goal is a 25% reduction in vehicle GHG emissions by FY 2025, using 2015 as the baseline year. Similarly, the County has a goal to reduce fleet petroleum consumption by 20% by 2018. As of FY 2021, the County has achieved a 13% reduction in petroleum consumption. At a higher, County-wide level, the County is aiming to reduce GHG emissions to 80% below 2008 levels by 2050.

[4] Prince George's County. 2014. "Green Fleet Policy." Retrieved from: https://princegeorgescountymd.legistar.com/View.ashx?M=F&ID=4034915&GUID=BBCE02B5-A0B3-4926-8FF6-9F21293E1105

In addition to meeting their own goals, the County is also pursuing fleet electrification to help the Metropolitan Washington Council of Governments (MWCOG) meet its regional GHG emission reduction goals:

- 50% below 2005 levels by 2030; and
- 80% below 2005 levels by 2050.[5]

Within Prince George's County, RRD is responsible for the collection, recycling, reduction, and disposal of municipal solid waste and the maintenance of solid waste facilities. Independently, RRD is pursuing a goal to reduce GHG emissions from the operation of the County-owned and managed landfill through vehicle electrification. In addition to meeting new emissions standards established at the local and state levels, the motivation to electrify a portion of RRD's fleet stems from the cost of new vehicles, high fuel prices, and high operation and maintenance costs.

The County is utilizing the CFTA Program to help plan fleet electrification, summarize general charging needs, estimate TCO savings potential, and improve the environmental health of the community. Ultimately, this report will provide a roadmap for procuring EVs and support RRD in its mission to serve as a model for other local governments in adopting emerging vehicles and fuels to minimize their impact on the community and environment.

Current Fleet Inventory

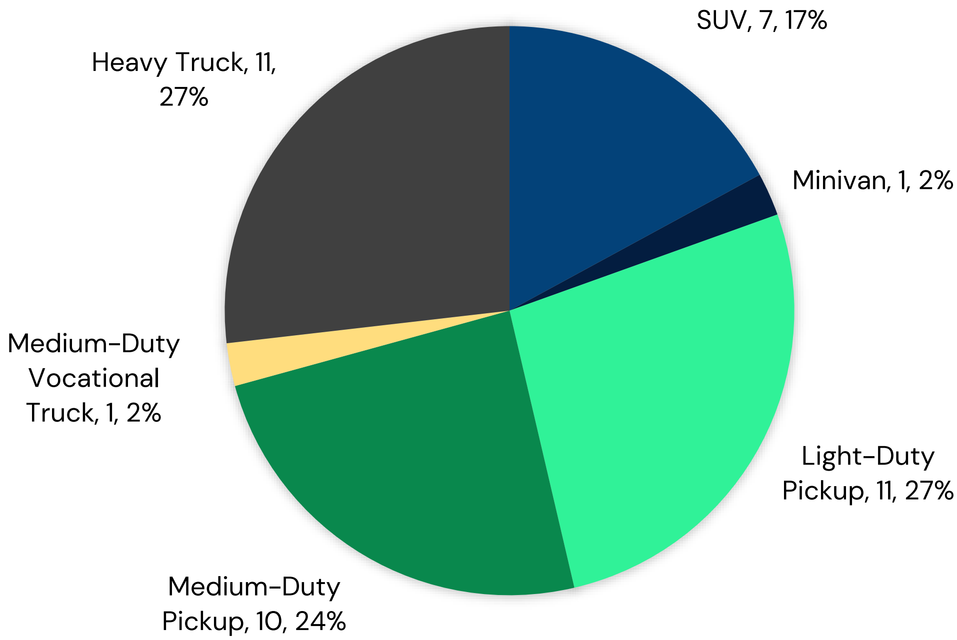
The County provided fleet data for 41 RRD vehicles.[6] ICF's evaluation included all 41 on-road light-, medium-, and heavy-duty fleet vehicles located at the Brown Station Road Sanitary Landfill. All vehicles operate on gasoline or diesel fuel and there are no EVs or plug-in hybrid electric vehicles (PHEVs) currently in the RRD fleet. To support future RRD EVs, the County is installing 220-volt electricity lines to power Level 2 electric vehicle supply equipment (EVSE). The evaluated fleet is primarily composed of heavy trucks, sport utility vehicles (SUVs), light-duty pickups, and medium-duty pickups. Table 1 and Figure 1 break down the RRD Brown Station Road Sanitary Landfill on-road fleet by vehicle type.

Table 1. Existing Fleet by Vehicle and Fuel Type

Vehicle Type	Gasoline	Diesel
SUV	7	0
Minivan	1	0
Light-Duty Pickup	11	0
Medium-Duty Pickup	9	1
Medium-Duty Vocational Truck	0	1
Heavy Truck	0	11
TOTAL	**28**	**13**

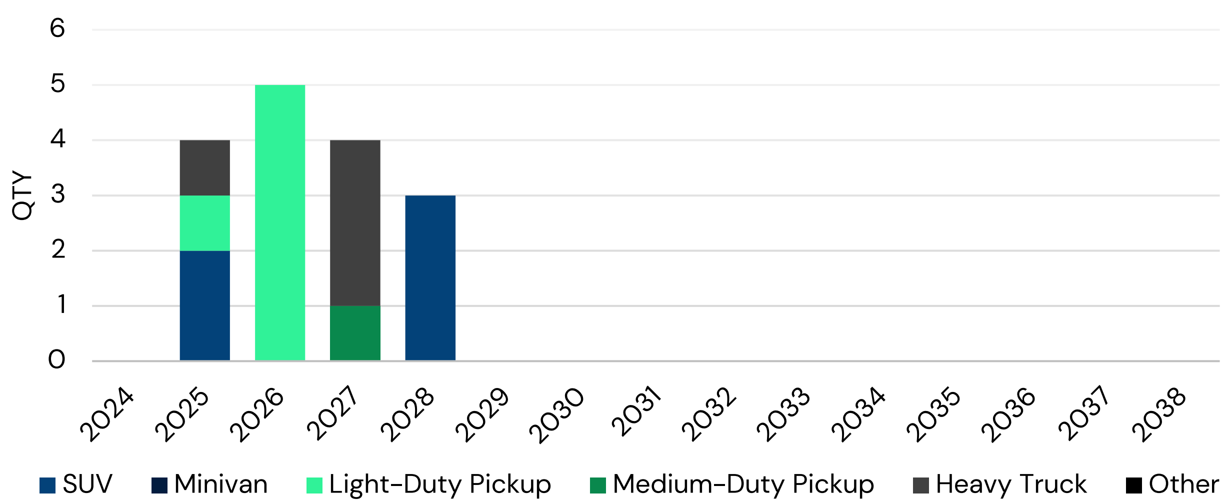
[5] MWCOG. 2020. "Metropolitan Washington 2030 Climate and Energy Action Plan." Retrieved from: https://www.mwcog.org/documents/2020/11/18/metropolitan-washington-2030-climate-and-energy-action-plan/
[6] RRD has a total of 70 fleet vehicles. Only Brown Station Road Sanitary Landfill vehicles are included in this assessment.

Figure 1. Existing Fleet by Vehicle Type



This assessment assumes vehicle replacement and electrification will begin in 2024, so ICF identified all vehicles eligible for retirement beginning in 2024. Figure 2 shows the breakdown of the existing fleet's retirement schedule.

Figure 2. Existing Fleet Retirement Schedule



The vehicle retirement schedule used in this assessment is based on the assumptions identified by ICF and the County, as shown in Appendix A.[7] The exact vehicle replacement schedule is determined by RRD and the County's fleet manager. Actual vehicle retirement and replacement may vary considerably from the proposed retirement schedule due to feasibility, lead times for new vehicles, and potential financial constraints. While vehicle retirement criteria will be met in 2025, the County and RRD may not be able to feasibly take vehicles out of rotation and purchase new vehicles for a few more years, especially if the County is willing to wait for EVs with longer lead times.

Fleet Electrification Assessment

Overview

This fleet electrification assessment includes all 41 vehicles provided to MEA and ICF. ICF examined all vehicles eligible for retirement beginning in 2024 and evaluated opportunities for electrification, based on EV model availability as announced through the end of October 2022. Because the assessment begins in 2024, only 16 vehicles are considered for electrification since they are set to retire in 2024 or later. The 25 vehicles set to retire before 2024 are not included in the analysis, and it is assumed that the County will replace these vehicles with equivalent ICE vehicles. Only one round of vehicle retirements and replacements is included in this assessment, and the current fleet is assumed to be entirely replaced by the end of 2028.

Recommendations are based on comparing the TCO of EVs versus ICE vehicles. The assessment considers one TCO scenario set at a 10% threshold.[8] A 10% TCO threshold means that any vehicle with an EV equivalent whose TCO is less than or up to 10% more than an equivalent ICE vehicle will be recommended for electrification. In future years, it is assumed that the County will continue to replace electrified vehicles with EVs. Similarly, as the EV market develops, more models will become available, vehicle purchase prices will decrease, and the County will likely be able to obtain more EVs.

This fleet electrification evaluation also assumes that all RRD vehicles are parked on government property at the location provided in the fleet data.[9] This consideration is particularly important in determining fleet EVSE needs, including general charging assumptions and infrastructure costs that may be required to support electrification recommendations. The results within this report can be used as a preliminary guide for EVSE planning, but a detailed siting assessment should be completed before the County begins installation.

[7] Due to the timing of this report, the County may choose to delay implementing the recommended fleet retirement and electrification schedule.
[8] The County also originally requested a TCO threshold scenario of 0%, but it yields the same recommendations.
[9] 3500 Brown Station Road, Upper Marlboro, MD 20774

The County worked with ICF to set assessment assumptions, including assessment start year, fuel prices, and standardizations for fleet data outliers. A full list of assessment assumptions is located in Appendix A. As the County RRD fleet changes, the EV market evolves, and new financial incentive programs become available, the County should revisit the following recommendations and reevaluate electrification opportunities. For a simple approach to TCO assessments, the County can utilize Argonne National Laboratory's AFLEET Tool.[10]

Recommendations

All 16 vehicles eligible for retirement based on fleet data, assessment assumptions, and EV make and model availability are recommended for electrification. Table 2 shows the recommended quantities, by vehicle type, to be replaced by EVs.

Table 2. Electrification Recommendations by Vehicle Type

Vehicle Type	Total Quantity	Electrification Recommendations
SUV	7	5
Minivan	1	–
Light-Duty Pickup	11	6
Medium-Duty Pickup	10	1
Medium-Duty Vocational Truck	1	–
Heavy Truck	11	4
TOTAL	**41**	**16**

This assessment provides a list of EV make and model recommendations that the TCO analysis is based on, shown in Table 3. However, these vehicle recommendations are examples not requirements. The County may adopt similar vehicles and achieve similar savings outlined in the Economic Analysis and Emissions Analysis sections of this report. If the County uses any federal funding to acquire vehicles, the purchased vehicles must meet applicable Buy America requirements.[11]

Table 3. EV Recommendations by Vehicle Type

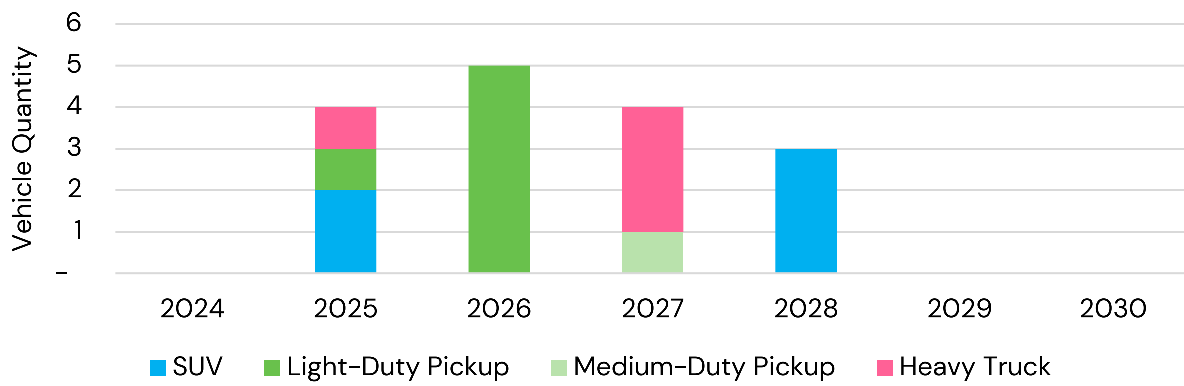
Vehicle Type	Vehicle Recommendations – Or Similar
SUV	Chevrolet Equinox EV 1LT
Light-Duty Pickup	Chevrolet Silverado EV
Medium-Duty Pickup	ZEVx Ford F-350
Heavy Truck	Peterbilt 220 EV Class 7

[10] The AFLEET tool may be found here: https://greet.es.anl.gov/index.php?content=afleet. Additional information is available in Appendix E.

[11] Per the County's Fleet Management Division, the Buy America Policy takes effect when Federal funds are used, which are mostly transit-related procurement. In the case of the County's Department of Public Works and Transportation, its Buy American Policy applies regardless of funding type. The requirement is at least 70% of the vehicle components must be made in America. A pre-award audit is performed by a third party to ensure compliance.

The replacement timeline for the 16 fleet vehicles recommended for electrification can be seen in more detail below in Figure 3. In Figure 3, vehicle replacements take place over four years due to the assumptions and data identified by ICF and the County. However, a number of barriers (e.g., financial constraints, slow supply chains, etc.) could extend the replacement timeline.

Figure 3. Recommended EV Replacement Timeline by Vehicle Type



The EV replacement schedule is also broken down in Table 4 below.

Table 4. Recommended EV Replacement Timeline by Vehicle Type

Vehicle Type	2024	2025	2026	2027	2028
SUV	-	2	-	-	3
Light-Duty Pickup	-	1	5	-	-
Medium-Duty Pickup	-	-	-	1	-
Heavy Truck	-	1	-	3	-
TOTAL	**0**	**4**	**5**	**4**	**3**

For future models recently announced and currently nascent EV types, electrification recommendations do not take place until price parity between EV and ICE vehicles is achieved. However, while EV TCO may be more favorable than ICE TCOs, purchase price may still present a large barrier to adoption, limiting the County's ability to electrify in the short-term. If the County needs to delay electrification for any reason, it will likely result in larger first-generation electrification TCO savings for the fleet due to market gains. For example, there will be a larger number of EVs to choose from, potentially shifting or expanding vehicle replacement recommendations and saving opportunities. Similarly, as the EV market develops and continues making technological advancements, the County can expect the purchase price of EVs to drop and more favorable electricity rates (i.e., time-of-use rates, managed charging programs, etc.) for EV charging to become readily available. Any delay in the electrification timeline presented in this report means that, while the County will still see TCO savings, they would not be realized until the electrification begins.

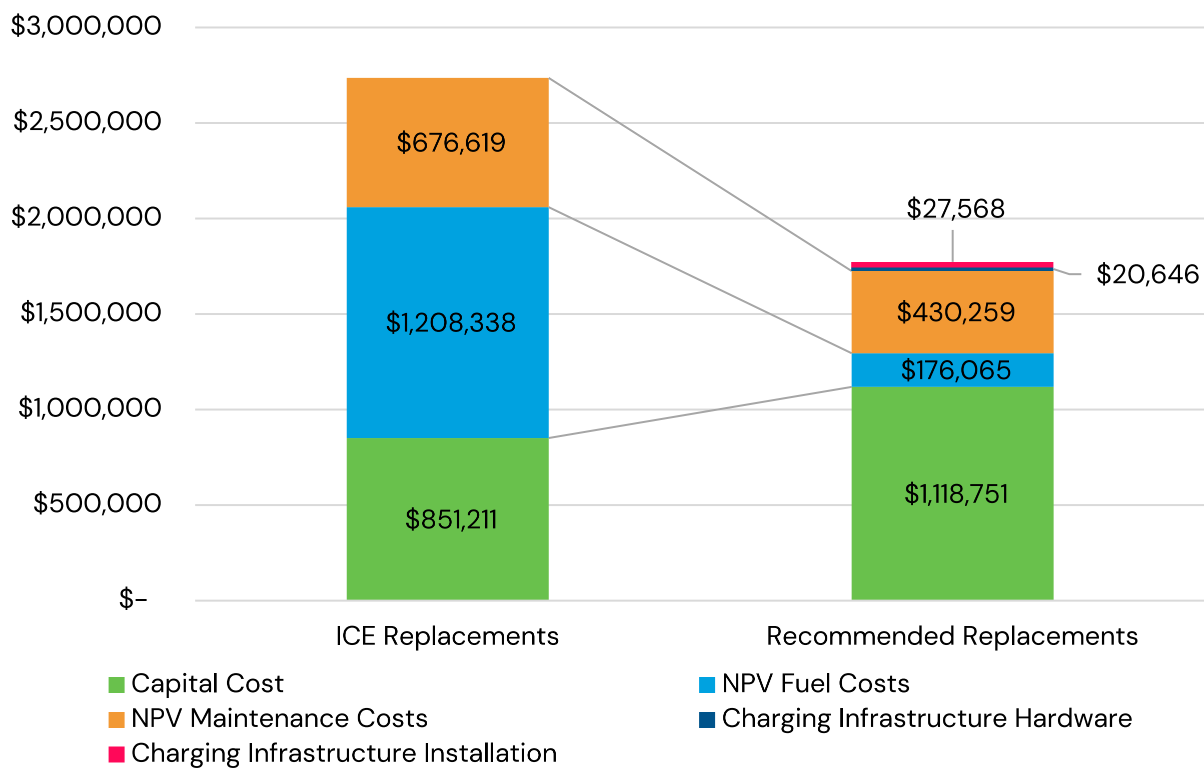
A full list of vehicle recommendations is available in Appendix B.

While the recommendations listed in Table 3 and Appendix B list specific vehicle makes and models, the County is not obligated or required to purchase the exact vehicles recommended or purchase them in the year listed. Similar vehicle makes and models will offer similar opportunities for electrification as well as cost and emission savings.

Economic Analysis

Electrification recommendations are based on a TCO assessment. RRD vehicles are recommended for electrification if there is an EV option available that has a TCO less than, equal to, or up to 10% more than the ICE equivalent. To determine the TCO, costs accumulated over fleet vehicle lifespans were evaluated. Beyond the cost to acquire, charge or fuel, and maintain vehicles, the TCO calculations also include the charging infrastructure necessary to support recommended EVs. These cost assumptions assume installing non-networked Level 2 and direct current fast charging (DCFC) EVSE at a ratio of four vehicles to one charger. Figure 4 includes the cost of all 16 EVs and recommended EVSE over the entire vehicle lifespans compared to the traditional ICE vehicle replacement.

Figure 4. Fleet TCO Comparison - Net Present Value Costs Over Vehicle Lifespans



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.

Different vehicle types are responsible for different average electrification TCO savings. Electric heavy-duty vehicles typically have much larger capital costs than their traditional counterparts and are less frequently available. While heavy-duty EVs typically present more opportunities for long-term cost savings, their high purchase prices present a barrier that limits electrification potential for many fleets that do not have the financial flexibility for a large upfront investment. The County's RRD fleet consists of mostly light-duty pickups, medium-duty pickups, and heavy trucks. Heavy trucks represent 25% of the electrification recommendations, but account for 64% of potential TCO savings, making the opportunity to capitalize on existing TCO savings potentially more difficult to achieve. Of the vehicles eligible for replacement, the majority are SUVs, light-duty pickups, and heavy trucks. Table 5 outlines the TCO savings projected for the County by vehicle type.

Table 5. TCO Savings by Vehicle Type

Vehicle Type	TCO Savings
SUV	$64,644
Light-Duty Pickup	$239,786
Medium-Duty Pickup	$15,243
Heavy Truck	$643,205
TOTAL	**$962,878**

If the County decides to pursue new financial incentive programs as they become available, additional vehicles and vehicle types may become financially beneficial for electrification. Moving forward, the County should continue to monitor incentive program availability to take advantage of additional electrification opportunities.

As vehicles are replaced through 2028, lifespans and TCO calculations extend out to 2042.[12] The TCO comparisons in Figure 5 and Figure 6 show that TCO savings will be realized in all years following 2028. After the initial capital costs associated with purchasing EVs to replace existing ICE fleet vehicles, the years following 2028 will all provide TCO savings.

[12] The TCO calculation extends through the last replacement vehicle's lifespan. RRD indicates that their goal replacement threshold is seven years, but actual replacement timeline may be significantly longer based on vehicle availability and vehicle wear and tear. Notably, some vehicles in the fleet data have planned retirement years before 2015 but are still active in the fleet.

Figure 5. Cumulative TCO Comparison From 2024 to 2042

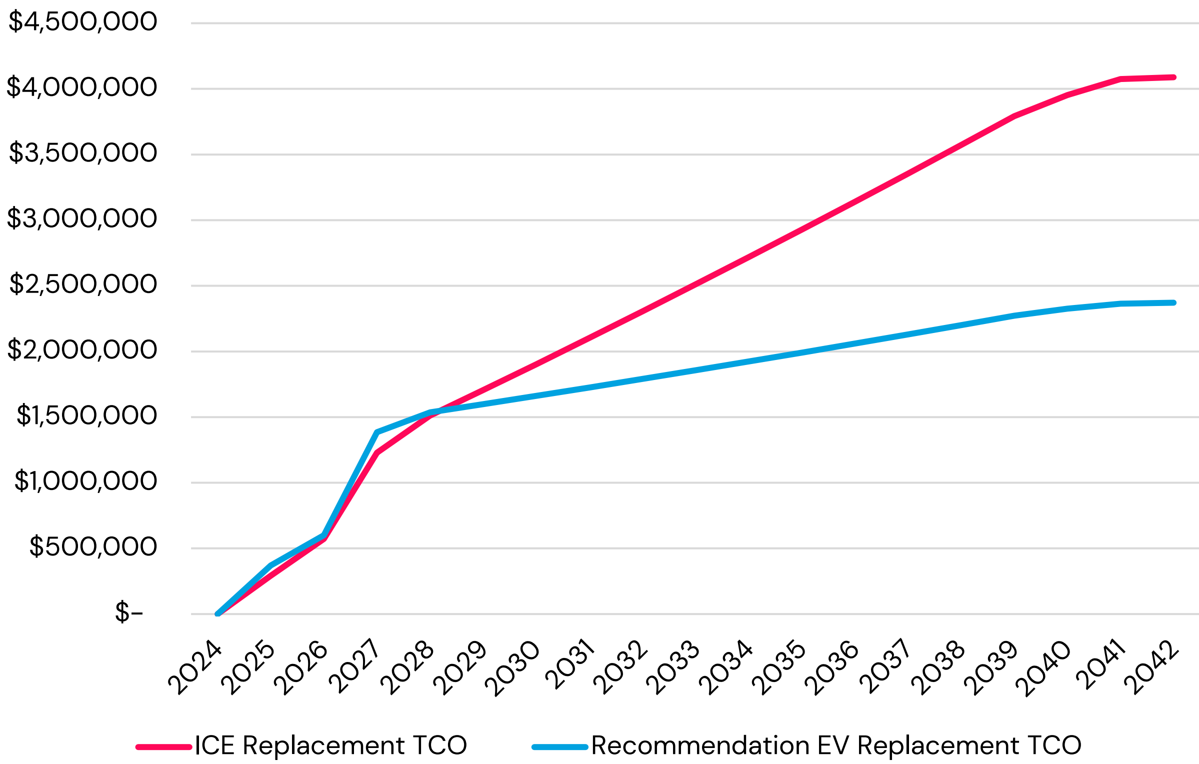
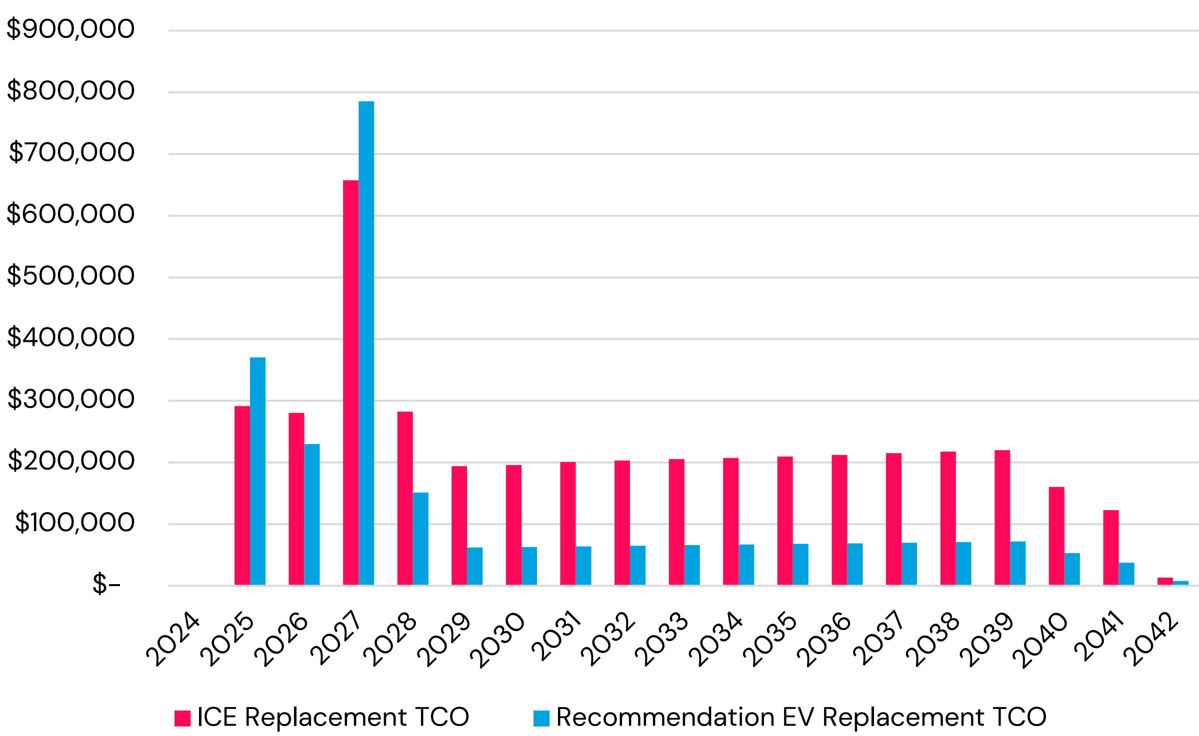


Figure 6. Annual TCO From 2024 to 2042



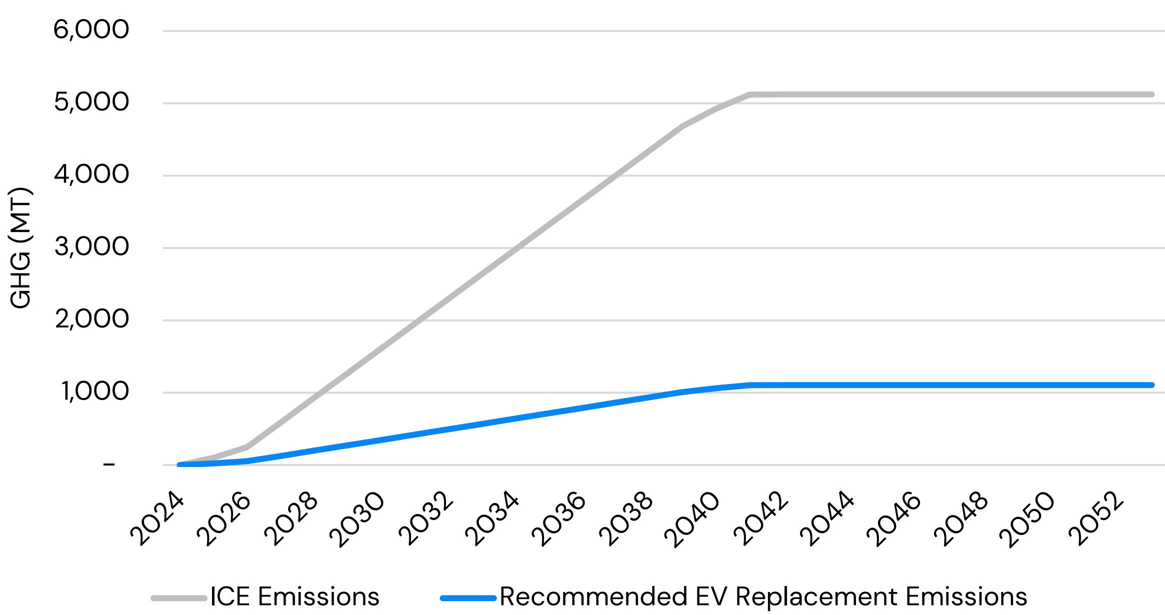
The length of the payback period can be significantly influenced by the amount of financial incentives the County pursues and wins as well as the exact EVs the County is able to acquire and the year the County acquires them. The more funding the County obtains for EVs and EVSE and the more favorable the purchase price, the shorter the payback period.

While the current analysis projects the TCO costs to break even in 2028, any delay in fleet electrification beyond 2024 will not guarantee the same results, due to changes in EV purchase prices, infrastructure costs, maintenance and training costs for employees, and more. The vehicles not currently included in the electrification analysis due to retirement years before 2024, will also likely become eligible for electrification in the future. As new makes and models become available and technology develops, it is expected that later and subsequent EV purchases will be less expensive due to more accessible and affordable EV options.

Emissions Analysis

Over the last few decades, improvements in ICE vehicle fuel economy have provided incremental vehicle emissions savings over the years. However, converting an ICE vehicle to an EV offers significant, immediate emissions savings at a much larger scale than choosing a more fuel-efficient ICE vehicle. Converting 16 ICE vehicles to EVs would potentially save the County 4,019 MT of GHG emissions over the lifespan of all converted EVs, through 2042. Figure 7 shows the emissions trajectory of replacing fleet vehicles with new ICE vehicles versus with EVs. This includes factoring in petroleum fuel reductions, offset by a potential electricity consumption increase.

Figure 7. Cumulative Fleet GHG Emissions (MT)



Fleet advisory services provided by ICF

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 County's grid generation mix. A breakdown of projected annual GHG emissions is in Appendix C.

Estimated lifetime emissions savings per vehicle type for the 16 vehicles are available below, in Table 6. Actual emissions per vehicle can vary dramatically based on the specific vehicle being replaced, average mileage, and use case.

Table 6. Lifetime Fleet Emissions by Vehicle Type

Vehicle Type	Lifetime GHG Emissions Reductions (MT)
SUV	53
Light-Duty Pickup	735
Medium-Duty Pickup	53
Heavy Truck	3,178
TOTAL	**4,019**

A quarter of electrification recommendations are heavy trucks, which account for 79% of GHG emissions savings. SUVs and light-duty pickups, which account for 69% of electrification recommendations, only account for 20% of GHG emissions savings.

These recommendations are equivalent to:
- Removing 868 passenger vehicles from the road for one year
- Planting 66,306 trees
- The energy use of 462 homes for one year
- Switching 152,704 incandescent lamps to LEDs
- Recycling 1,366 tons of waste

In terms of the County's emissions and petroleum consumption goals, these recommendations demonstrate the role electrification can play in meeting them. Using the provided fleet data as a baseline for calculating the percentage reduction of emissions and fuel consumption, current electrification recommendations offer the potential reduce RRD fleet GHG emissions by 78% and fuel consumption by 53%. These savings indicate the potential that fleet electrification has to offer the County, at both the individual vehicle and large scale.

EVSE Needs Assessment Overview

For the electrification assessment, basic infrastructure planning cost considerations were incorporated into the calculations and recommendations. This assessment assumes that the County will be able to assign four vehicles per EVSE for both Level 2 and DCFC.

Depending on vehicle duty cycle and application, charger level and the number of vehicles per plug may need to be adjusted. For example, 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 and need to charge simultaneously. Similarly, if some vehicles have higher daily mileage than others, RRD may need to install more DCFC or develop a charging schedule that would identify efficiencies and reduce the number of plugs needed. All vehicles in this assessment are parked at the same location, simplifying future siting analyses.

Table 7 provides an overview of charging recommendations incorporated in this assessment and may serve as potential guides to help the County strategically plan EVSE needs and installation.[13] While this fleet electrification analysis does not include a complete EVSE needs and siting assessment, these preliminary results can help the County begin planning for future infrastructure build out. Charging needs should be further explored by RRD and the County before widescale electrification occurs.[14] Appendix D provides an overview of EVSE types and a breakdown of how to assess EVSE needs.

Table 7. EVSE Considerations by Charger Type

Charger Type	Number of EVSE Needed	Vehicle Types Supported
Level 2	3	SUVs, Light-Duty Pickups, Medium-Duty Pickups
DCFC	1	Heavy Trucks

Currently, RRD does not have any RRD-specific chargers available, but the County is installing electrical lines capable of supporting Level 2 EVSE. Beyond this planned infrastructure development, RRD may use other EVSE owned by the County or utilize public EVSE, if necessary. There are several publicly accessible EVSE around the County that may be used for short-term charging needs. However, if the County uses public chargers, they will pay commercial rates, reducing fuel cost saving opportunities. Figure 8 shows the locations of existing EVSE in and around the County.[15]

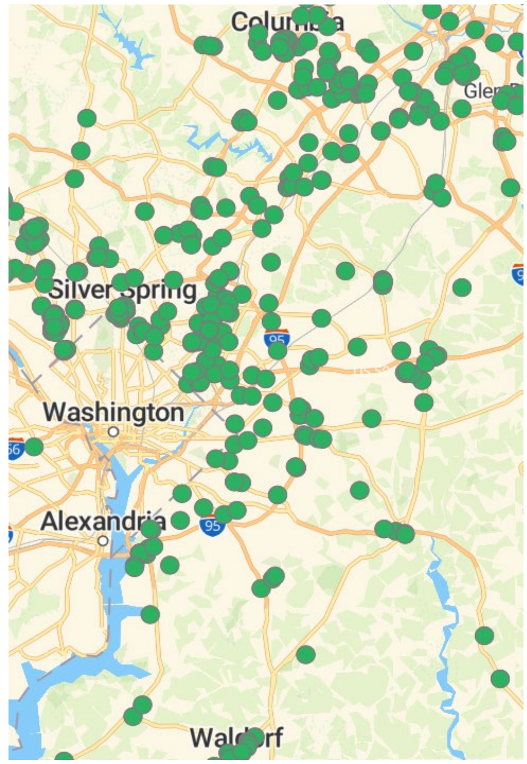
As RRD and the County begin electrifying vehicles on a larger scale and planning EVSE installations, it should assess the fleet's current and future charging needs. Recommendations on how to futureproof charging infrastructure include the following:

- Evaluate short- and long-term EVSE needs based on current fleet makeup and future fleet makeup, based preliminarily on this assessment

[13] Table 7 offers projected Level 2 and DCFC EVSE needs based on current model assumptions and number of vehicles recommended for electrification.
[14] See the DOE Alternative Fuels Data Center for more information about Charging Infrastructure Procurement and Installation, including average costs.
[15] Publicly available EVSE data and locations are available here: https://afdc.energy.gov/stations/#/find/nearest

- Consider identifying location(s) that may be used as a hub for DCFC stations to reduce the number of construction sites or identify an existing DCFC that RRD may use for fast charging
- Identify the number of existing parking spaces at each location
- Examine the existing electrical capacity and infrastructure to determine if the parking location can support the installation of and use of EVSE without infrastructure upgrades, and identify the number of parking spaces that will require infrastructure upgrades to support EVSE
- Developing plans for EVSE design, construction, and installation. These plans may include: panel upgrades, electrical capacity upgrades, utility-side infrastructure upgrades, trenching for electrical conduit, etc.
- Standardizing EVSE siting design (e.g., signage,[16] accessibility,[17] use requirements, parking space design, Americans with Disabilities Act requirements,[18] etc.) and permitting
- Adopting building codes[19] that require pre-wiring compatible with EVSE installation on government property with considerations for existing and new buildings

Figure 8. EVSE Locations in and around Prince George's County



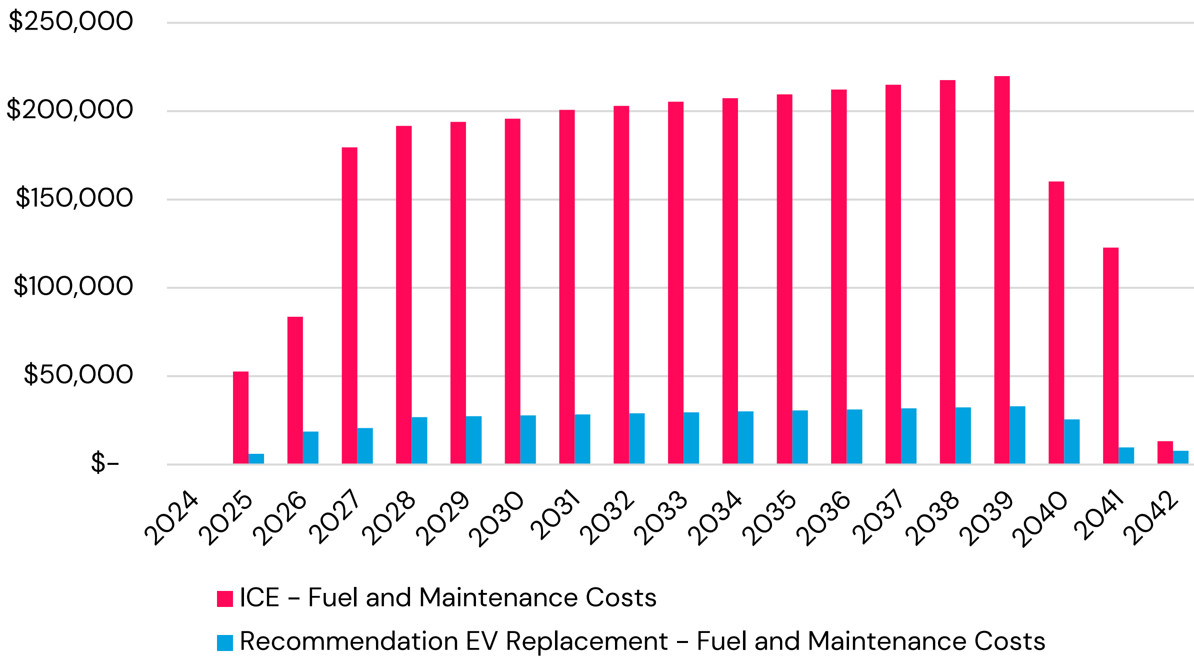
Vehicle Durability and Maintenance Costs

RRD is particularly concerned about vehicle durability and maintenance and repair costs. Current vehicles experience very high maintenance and repair costs simply due to their use case. Generally, compared to ICE vehicles, EVs have lower maintenance costs as they do not require routine maintenance including oil, filter, and timing belt changes. Similarly, EV battery, motor, and associated electric systems require little maintenance; brake wear is reduced due to regenerative breaking; and there are fewer moving parts compared to an ICE vehicle, reducing the opportunities for damage. Figure 9 provides an overview of the

[16] DOE. 2023. "Signage for PEV Charging Stations." Retrieved from: https://afdc.energy.gov/fuels/electricity_charging_station_signage.html
[17] California PEV Collaborative. 2012. "Accessibility and Signage for PEV Charging Infrastructure." Retrieved from" https://www.calbo.org/sites/main/files/file-attachments/ca_accessibility_for_ev_charging.pdf?1524861081
[18] DOE. 2014. "Guidance in Complying with ADA Requirements." Retrieved from: https://afdc.energy.gov/files/u/publication/WPCC_complyingwithADArequirements_1114.pdf
[19] International Code Council. 2019. "Proposed Changes to the 2019 International Codes." Retrieved from: media.iccsafe.org/code-development/group-b/2019-Group-B-CAH-compressed.pdf

savings opportunities that this assessment's electrification recommendations offer RRD. However, these projections are based on a combination of fleet data and assumptions, actual savings may vary. Since RRD has a specific use case that is particularly tough on vehicles, RRD should consider piloting EVs before wider scale adoption to better understand and anticipate how maintenance and repair costs will function for their fleet.

Figure 9. Annual Fuel and Maintenance Costs



Additional Best Practices and Considerations

Vehicle and Battery Warranties

EV electrical systems require little maintenance, but battery life and warranties should be understood prior to purchasing a vehicle. The batteries in EVs are generally designed to last for the expected lifetime of the vehicle, between 10 to 12 years. [20] Like engines in conventional vehicles, the advanced batteries in EVs are designed for extended life but will lose efficiency and wear out eventually. Battery warranties vary by original equipment manufacturer (OEM). However, the County should purchase vehicles from OEMs that offer a minimum warranty of 8-years or 100,000-miles on EV batteries. The County should also check with vehicle dealers about battery life and length of warranties in comparison with manufacturer policies. Before purchasing an EV, the County should be aware of the scenarios in which a manufacturer will and will not replace a battery under warranty. If the County purchases any previously owned EVs, the County should confirm whether the

[20] DOE. 2021. "At a Glance: Electric Vehicles." Retrieved from: https://afdc.energy.gov/files/u/publication/electric-drive_vehicles.pdf

warranty is transferrable between vehicle owners. Similarly, if RRD vehicles experience heavy damage and need to be retired early, but the vehicle batteries are still functional and in their useful life, RRD may find opportunities for second-life use.

Battery Life and Performance

During vehicle life, there are several factors that influence battery health.[21] These factors include ambient temperature, driver behavior, driving terrain, cargo loads, and the use of vehicle climate control. While it is unclear how each factor can influence battery longevity, there are a few best practices the County can encourage its drivers to abide by to maintain a healthy battery life, including:

- Practicing safe driving habits (i.e., avoid speeding, aggressive driving, and heavy loads).[22]
- Minimizing vehicle exposure to extreme temperatures by parking vehicles out of the sun, snow, or wind in shaded or canopied areas or by parking vehicles indoors.
- Minimizing regularly charging batteries to 100% or leaving EVs plugged in and charging at 100% for longer than necessary.
- Aiming to keep batteries at a charge between 20% to 80%, as keeping vehicles in extremely high or low states of charge puts more stress on the battery.[23]
- Emphasize to drivers that EVs should not regularly be fully discharged and that they should abide by the fleet's charging schedule.
- Using EV features like regenerative breaking or choosing vehicles with more efficient cabin heating and cooling.
- If vehicle use and duty cycle allows, use Level 2 instead of DCFC EVSE when possible.

Battery Disposal and Recycling

Both EVs and PHEVs depend primarily on rechargeable high-energy lithium-ion (Li-ion) batteries. EVs are still relatively new, with only a small number having reached the end of their useful lives. Because EV batteries are still a nascent technology, the battery disposal, recycling, and reuse market is still developing. With EV adoption growing rapidly and the market rapidly adapting and expanding, it is anticipated that, by the time the County is ready to dispose of, recycle, or reuse EV batteries, there will be many new options and opportunities.

Retiring EVs in good condition can be sold or traded for a new vehicle, but in some cases the battery can outlast the vehicles. In these circumstances, the battery can be certified by

[21] Medium- and heavy-duty vehicles may be more heavily impacted by factors that reduce range.
[22] DOE. 2021. "Electric Vehicle Basics." Retrieved from: https://afdc.energy.gov/files/u/publication/electric_vehicles.pdf
[23] Woody, et al. 2020. "Strategies to limit degradation and maximize Li-ion battery service lifetime – Critical review and guidance for stakeholders." Retrieved from: https://www.sciencedirect.com/science/article/abs/pii/S2352152X19314227?dgcid=author

Underwriters Laboratory for resale.[24] Batteries can also be recycled by entities that know how to safely disassemble and recover reusable materials. For now, RRD may pursue the following options for EVs reaching the end of their life:

- Sell or trade the retiring EV and battery;
- Sell batteries to non-County entities for second-life applications;
- Find second-life applications for batteries within the RRD fleet or County; and,
- Sending vehicles and their batteries to recycling companies to recover still-useful components and precious metals.

The DOE houses a battery policies and incentives database[25] that the County can continue to monitor for federal and Maryland policies related to battery disposal and recycling.

Staff Training Resources

EVs require less maintenance than ICE vehicles, but they often involve new skills, knowledge, and techniques. To ensure the fleet maintenance staff and technicians receive adequate training on EV and EVSE maintenance, the County fleet manager should hold a mandatory training for all mechanics and consider providing additional learning opportunities throughout the year. Training and educational resources for fleet mechanics include:

- The National Alternative Fuels Training Consortium Electric Drive Vehicle Automotive Technician Training. This teaches participants the difference between EV and ICE vehicle operation and appropriate maintenance techniques.
- The Electric Vehicle Infrastructure Training Program for EVSE provides certification for electricians on, among other things, EV battery types and specifications, service-level assessments and upgrade implementation, and utility interconnection policies and requirements. To be eligible for EVITP, a participant must be a State licensed or certified electrician or if the participant works in a States that does not license or certify electricians, the participant must provide documentation of a minimum of 8,000 hours of hands-on electrical construction experience.
- The Federal Energy Management Program's fleet management training courses. This resource offers training for EV technology, EVSE power and installation requirements, EVSE site assessments, and site operations.
- The DOE's EV Training website.
- The Clean Tech Institute's Certified EV Technician Training Program, which provides training for EV repair and maintenance.

[24] Argonne National Laboratory. 2022. "EV Batteries and Recycling." Retrieved from: https://www.anl.gov/sites/www/files/2022-12/EV_Batteries_Recycling_FINAL%2012-14-22.pdf
[25] DOE. 2023. "Battery Policies and Incentives." Retrieved from: https://www.energy.gov/eere/vehicles/battery-policies-and-incentives-search#/

Along with the cost of vehicle acquisition, range anxiety can present barriers to EV drivers. To familiarize staff in charge of operating and maintaining EVs and EVSE, the County can use the following EV resources, among others, to develop educational materials:

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

Finally, in addition to EV maintenance, the County will need to develop EVSE maintenance policies. In developing them, the County should consider the following practices:

- Evaluate the EVSE OEM's maintenance and support packages and the availability of local service options.
- Develop a service agreement that outlines who (Prince George's County, the manufacturer, etc.) will perform EVSE maintenance both during and after the warranty period.
- Establish a schedule for the routine inspection and maintenance of EVSE to ensure high up-time (i.e., the percentage of time the EVSE is fully operational).
- Have both electrical and non-electrical maintenance staff available for servicing EVSE, as not all maintenance is electrical.
- Consider extended warranties for Level 2 and DCFC EVSE.

Conclusion

This analysis identifies 16 vehicles for electrification in the County's RRD fleet, with electrification beginning in 2024. If the County follows the recommended replacement schedule for transitioning from ICE vehicles to EVs, the County can expect to see operational savings following 2028 and a reduction in GHG emissions up to 4,019 MT. Electrification offers RRD and Prince George's County the opportunity to set high standards in emissions reductions, improve the health of employee work environments, and reduce the impact the fleet has on the community and environment. For simpler, future electrification TCO assessments, the County may utilize AFLEET for quick cost and emissions calculations, see Appendix E.

Appendices

Appendix A. 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 10% of the TCO of the comparable 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.
- **Current Mileage:** The County provided vehicle mileage from odometer readings in late 2021 and throughout 2022.
- **Annual Mileage:** The County provided annual vehicle milage.
- **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 fuel prices provided by the County for diesel and gasoline. Prices were set at: $4.31 per gallon of diesel and $3.41 per gallon of gasoline. The model escalates gasoline and diesel pricing annually using projections from the U.S. EIA's 2022 AEO Reference Case for Transportation.
- **Maintenance Costs:** Existing fleet maintenance costs were provided by the County. Due to high reported maintenance costs (e.g., some vehicles exceeded $10,000 annually in the original data), ICF worked with the County to set maintenance and repair cost assumptions for fleet vehicles. EV maintenance and repairs costs were estimated using AFLEET dollar per mile assumptions by vehicle type and by fuel type. Maintenance costs were escalated 2.2% 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 $0.085/kWh, as provided by the County.
- **Timeframe:** The County set 2024 as the start year for electrification.
- **Discount Rate:** 5% was used for net present value calculations.
- **Temperatures:** Utilized the average annual temperatures to calculate the impact on battery performance and reduced battery range.
- **Emissions Factor:** The assessment uses eGRID Region emissions factors, set to RFCE.

Appendix B. Electrification Assessment Results and Recommendations

Vehicle Type	Make	Model	Year	Retirement Year	Replacement Make/Model
SUV	Chevrolet	Equinox	2019	2025	Chevrolet - Equinox EV 1LT
SUV	Chevrolet	Equinox	2019	2025	Chevrolet - Equinox EV 1LT
Light-Duty Pickup	Dodge	Ram	2019	2025	Chevrolet - Silverado EV
Heavy Truck	Freightliner	114sD	2019	2025	Peterbilt - 220EV (Class 7 - 282 kW)
Light-Duty Pickup	Chevrolet	Silverado	2020	2026	Chevrolet - Silverado EV
Light-Duty Pickup	Chevrolet	Silverado	2020	2026	Chevrolet - Silverado EV
Light-Duty Pickup	Chevrolet	Silverado	2020	2026	Chevrolet - Silverado EV
Light-Duty Pickup	Chevrolet	Silverado	2020	2026	Chevrolet - Silverado EV
Light-Duty Pickup	Chevrolet	Silverado	2020	2026	Chevrolet - Silverado EV
Heavy Truck	Freightliner	M-2	2021	2027	Peterbilt - 220EV (Class 7 - 141 kW)
Medium-Duty Pickup	Freightliner	114SD	2021	2027	ZEVx - Ford F-350 (Pickup)
Heavy Truck	Freightliner	114SD	2021	2027	Peterbilt - 220EV (Class 7 - 282 kW)
Heavy Truck	Freightliner	114SD	2021	2027	Peterbilt - 220EV (Class 7 - 282 kW)
SUV	Ford	Escape Hybrid	2022	2028	Chevrolet - Equinox EV 1LT
SUV	Ford	Escape Hybrid	2022	2028	Chevrolet - Equinox EV 1LT
SUV	Ford	Explorer	2022	2028	Chevrolet - Equinox EV 1LT

**Note: These are vehicles used for comparison purposes, not an endorsement of any individual EV manufacturer or model. See DOE's fueleconomy.gov website for all vehicle models available. These vehicles may not meet applicable Buy America requirements but demonstrate that substantial opportunities for TCO savings exist.*

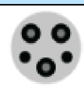
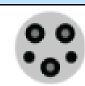
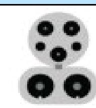
Appendix C. Projected Cumulative GHG Emissions of ICE Replacement Vehicles Versus Recommended EV Replacements

Year	ICE Emissions (MT)	EV Replacement Emissions (MT)
2024	–	–
2025	100	22
2026	246	52
2027	584	125
2028	926	198
2029	1,267	272
2030	1,609	346
2031	1,950	420
2032	2,292	493
2033	2,634	567
2034	2,975	641
2035	3,317	714
2036	3,658	788
2037	4,000	862
2038	4,342	935
2039	4,683	1,009
2040	4,925	1,061
2041	5,121	1,104
2042	5,124	1,105

Appendix D. EVSE Overview

DOE's Alternative Fuel Data Center offers resources to better understand EVSE 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 BEV and PHEV charging. 208/240 V AC split phase service that is less than or equal to 80 A.	Used specifically for BEV 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 fully charge 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 fully charge 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 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) = Σ 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 E. 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 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