Maryland Energy Administration Clean Fuels Technical Assistance Program: Anne Arundel County

September 29, 2021

Submitted to:

Maryland Energy Administration

and

Anne Arundel County

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 Anne Arundel County, through a partnership with ICF, and support from Maryland Clean Cities. ICF analyzed Anne Arundel County's on-road vehicle fleet comprised of 1,600 vehicles, recommending 1,489 internal combustion engine (ICE) vehicles for electrification based on available electric vehicle (EV) make and model availability, which includes 1,289 battery electric vehicles (BEV) and 200 plug-in hybrid electric vehicles (PHEV). These findings do not include any EV or 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 1,489 ICE vehicles to EVs in the next 15 years is estimated to produce the following impacts over 31 years of vehicle ownership[1]:

$47,214,853 total cost of ownership (TCO) savings over **31** years of vehicle operations

$28,612,302 fuel cost savings over **31** years of vehicle operations

$32,869,646 maintenance savings over **31** years of vehicle operations

228,709 metric tons of greenhouse gas (GHG) eliminated over **31** years of vehicle operations

23,882,617 gallons of gasoline displaced over **31** years of vehicle operations

Equivalent to eliminating **26,302** homes' energy use annually

[1] Based on the Assumptions and Calculations outlined in Appendix B, 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 electricity, ethanol, hydrogen, natural gas, propane, and other biofuels. The participating local government or municipal fleet chooses their preferred fuel for technical evaluation, after discussions with ICF. Anne Arundel County selected fleet electrification for their technical assistance assessment.

III. Overview of Motivations and Priorities

In 2020, Anne Arundel County's Executive released a memo[2] that directed the Office of Central Services (OCS) to begin the replacement of existing ICE fleet vehicles with EVs, with the goal of transitioning all procurement of new, non-emergency light-duty vehicles (LDVs) and sport utility vehicles (SUVs) to 100% EVs by FY37. The OCS also directed the County to begin long-range planning to identify vehicles, infrastructure, maintenance, and personnel needed to successfully electrify the fleet over the next 15 years.

As of August 2021, Anne Arundel County does not have any EVs in their fleet and is utilizing the CFTA Program to help plan fleet electrification, provide an overview of general charging needs, and estimate TCO savings potential. This fleet electrification evaluation factored in Arundel County fleet vehicles primarily being collocated on government property and domiciled at employee homes. As the County begins fleet electrification, it will need EV and electric vehicle supply equipment (EVSE) usage training for drivers and maintenance training for fleet and facilities responsible for maintaining EV and EVSE.

The County plans to complete an EVSE siting analysis to meet the needs of their fleet electrification plans. Currently, the County has not purchased or installed any county-owned EVSE on government property. Baltimore Gas & Electric (BGE) has installed several EVSE in the County, helping provide short-term charging opportunities for early electrification.

IV. Current Fleet Inventory

Anne Arundel County provided fleet data for 1,600 vehicles. ICF's evaluation included all 1,600 on-road light-, medium-, and heavy-duty fleet vehicles. All vehicles operate on gasoline or diesel fuel. No emergency response vehicles were evaluated in this study. The County has no EVs in the fleet and does not own or operate any EVSE but is working on launching five EVSE pilots at the health department, schools, and offices across the county.

Anne Arundel's evaluated fleet is primarily composed of SUVs (61%) and light-duty pickups (18%), as seen in Figure 1. All fleet vehicles evaluated have been purchased by the County, no leased vehicles are included in this fleet.

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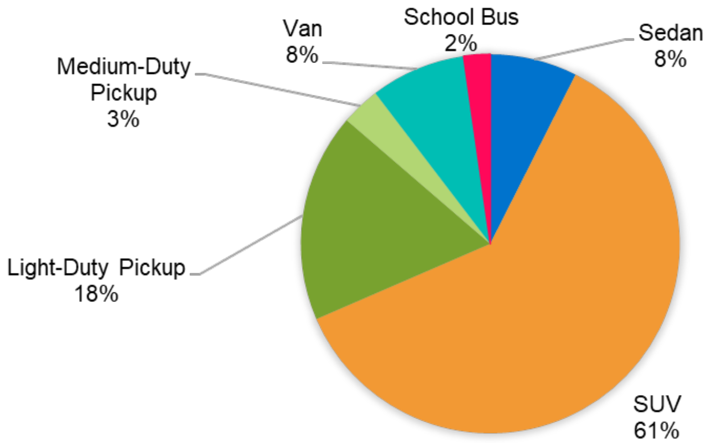
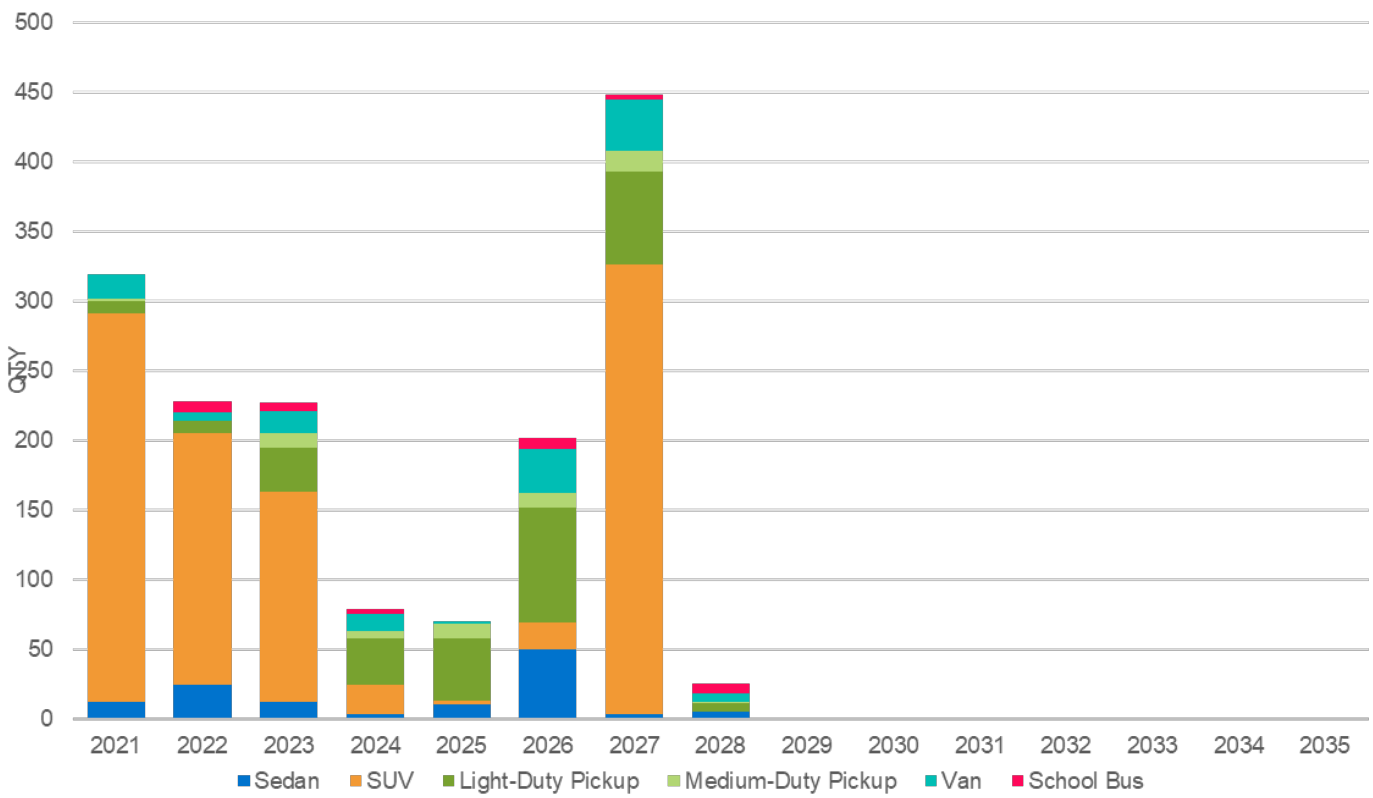
[2] See Appendix A.

Figure 1. Existing Fleet by Vehicle Type



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 through the end of April 2021. Only one round of vehicle replacements was evaluated for this assessment, and it was determined the current fleet will be entirely replaced by 2028.

Figure 2. Existing Fleet Retirement Schedule

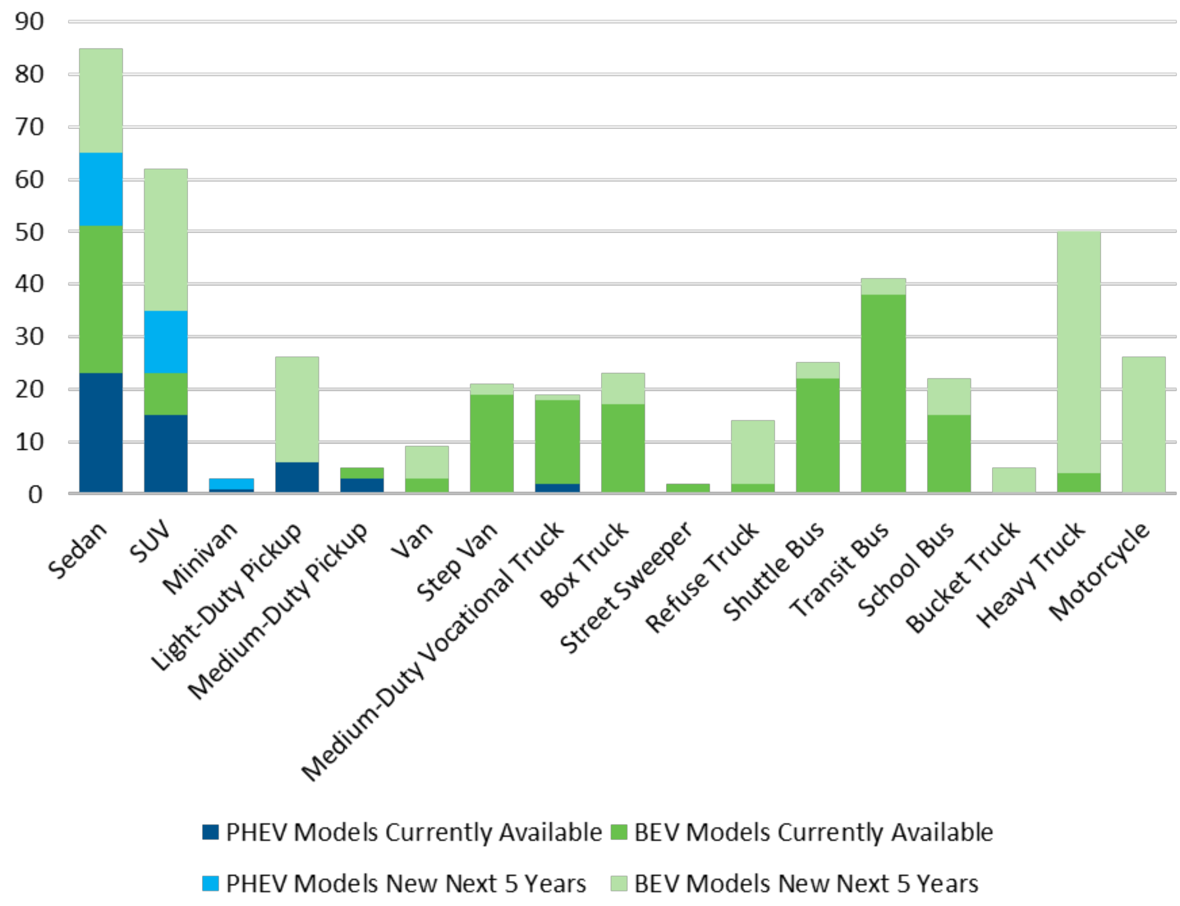


The exact vehicle retirement schedule is based on the assumptions identified by ICF and Anne Arundel County, as shown in Appendix B.[3] The exact vehicle replacement schedule will likely vary considerably from the proposed retirement schedule due to feasibility and financial constraints, with larger numbers of vehicle retirements beginning in 2024. While County vehicle retirement criteria will be met in some cases prior to 2022, 2023, and 2024, the County may not be able to feasibly take vehicles out of rotation and purchase new vehicles for a few more years.

V. Electrification Best Fit and Availability Assessment

ICF utilized the market mix[4] of existing and future EV model available, as outlined in Figure 3, for Anne Arundel's fleet electrification analysis.

Figure 3. EV Model Availability by Vehicle Types



Overall, up to 1,489 vehicles are eligible for electrification based on current and announced EV make and model availability. Table 1 shows the recommended quantities, by vehicle type, to be replaced by EVs over the next 15 years.

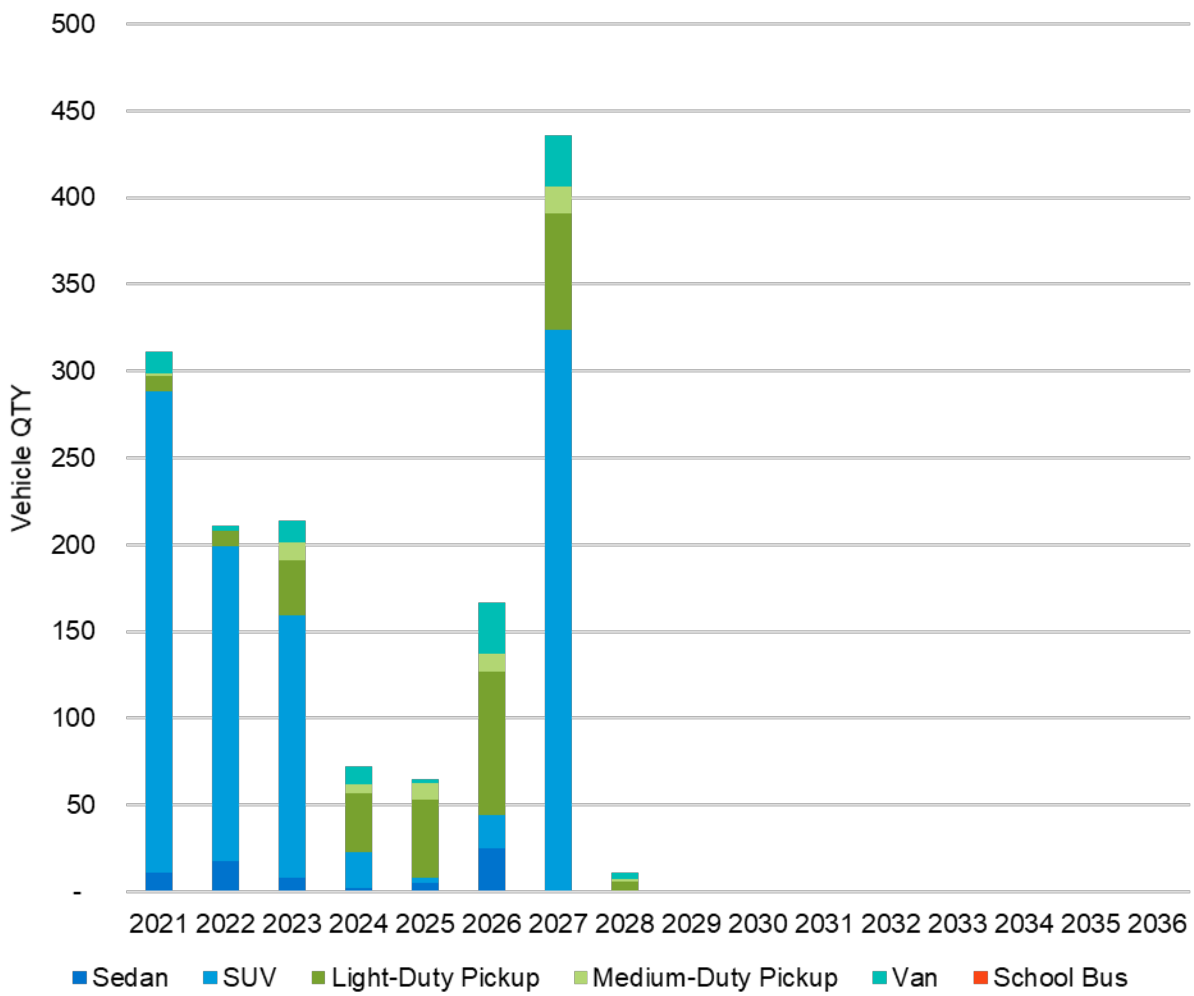
[3] Due to the timing of this report, the County may choose to wait until 2022 to begin implementing the recommended fleet retirement and electrification schedule.
[4] Through April 2021.

Table 1. 15-Year Electrification Recommendations

	Current Fleet	Quantity Recommended for Electrification
Sedan	119	70
SUV	977	975
Light-Duty Pickup	285	285
Medium-Duty Pickup	53	53
Van	130	106
School Bus	36	0
TOTAL	**1,600**	**1,489**

The replacement timeline for the 1,489 fleet vehicles recommended for electrification can be seen in more detail below in Figure 4. In Figure 4, vehicle replacements take place over 8 years due to the assumptions and data identified by ICF and Anne Arundel, but replacements may end up starting in 2024 and taking more than 8 years to complete.

Figure 4. Recommended EV Replacement Timeline by Vehicle Type



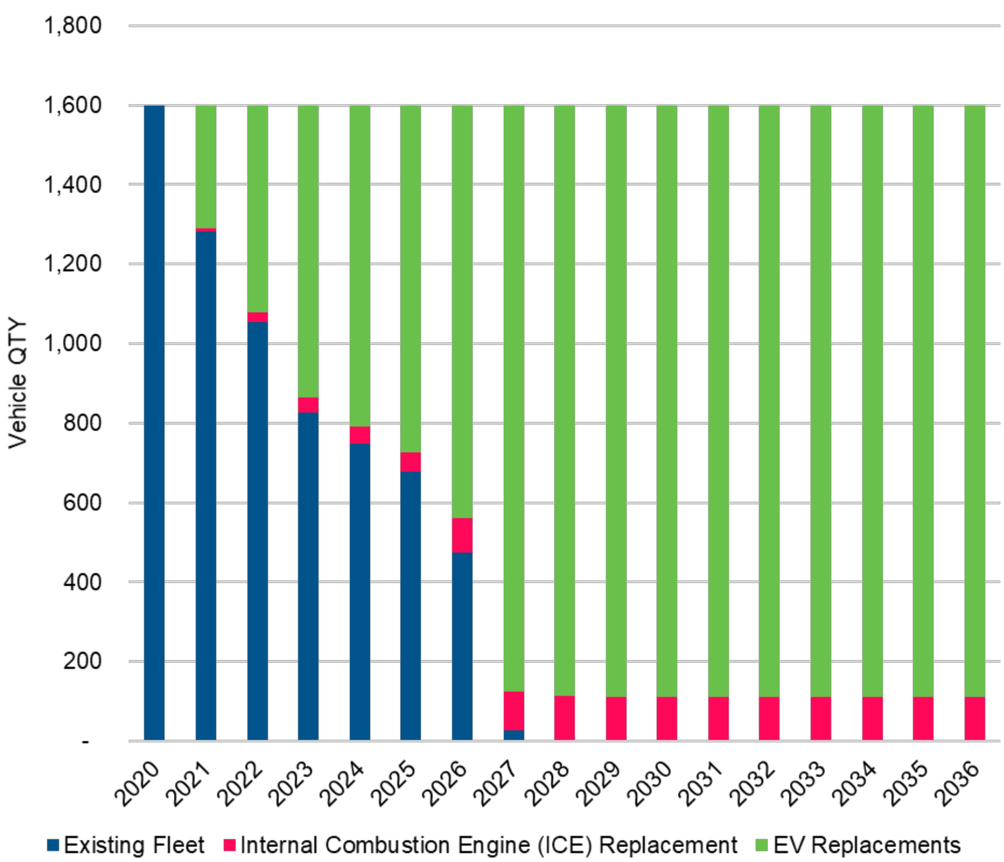
The electrification schedule begins predominately with SUVs, with ICF's analysis recommending 277 for replacement in 2021. SUVs represent most vehicle replacements in 2021, 2022, 2023, and 2027, with the remaining vehicle types being replaced in smaller amounts over time. From 2024 to 2026, light-duty pickups become the largest replacement groups. The final two years of vehicle replacements are one van per year in 2029 and 2030.

For future models recently announced and currently nascent EV types, recommendations for electrification do not take place until price parity between EV and ICE vehicles over TCO is achieved. Notably, no school buses are recommended for replacement at this time. If school bus-specific funding becomes available in the future, this recommendation may change.

Alternatively, there is a scenario in which many vehicles recommended for replacement in 2021 will not be replaced with EVs due to budgetary concerns and vehicle replacement cycle timing. As noted above, vehicle replacement may begin in 2024. While this timing may delay fleet electrification, it will likely result in larger first-generation electrification TCO savings for the fleet. If the County ends up beginning electrification closer to 2024, there will be a larger number of EVs to choose from, potentially shifting vehicle replacement recommendations. 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 for EV charging to become readily available. Delaying electrification means that, while the County will still see TCO savings, the County would not begin seeing savings until 2024.

Of the existing fleet vehicles, Figure 5, below, shows what fuel types could replace the existing fleet from 2020 through 2036. Most vehicle replacements will be EVs, with some fleet vehicles being replaced by ICE vehicles.

Figure 5. Recommended EV Replacement Timeline by Fuel Type



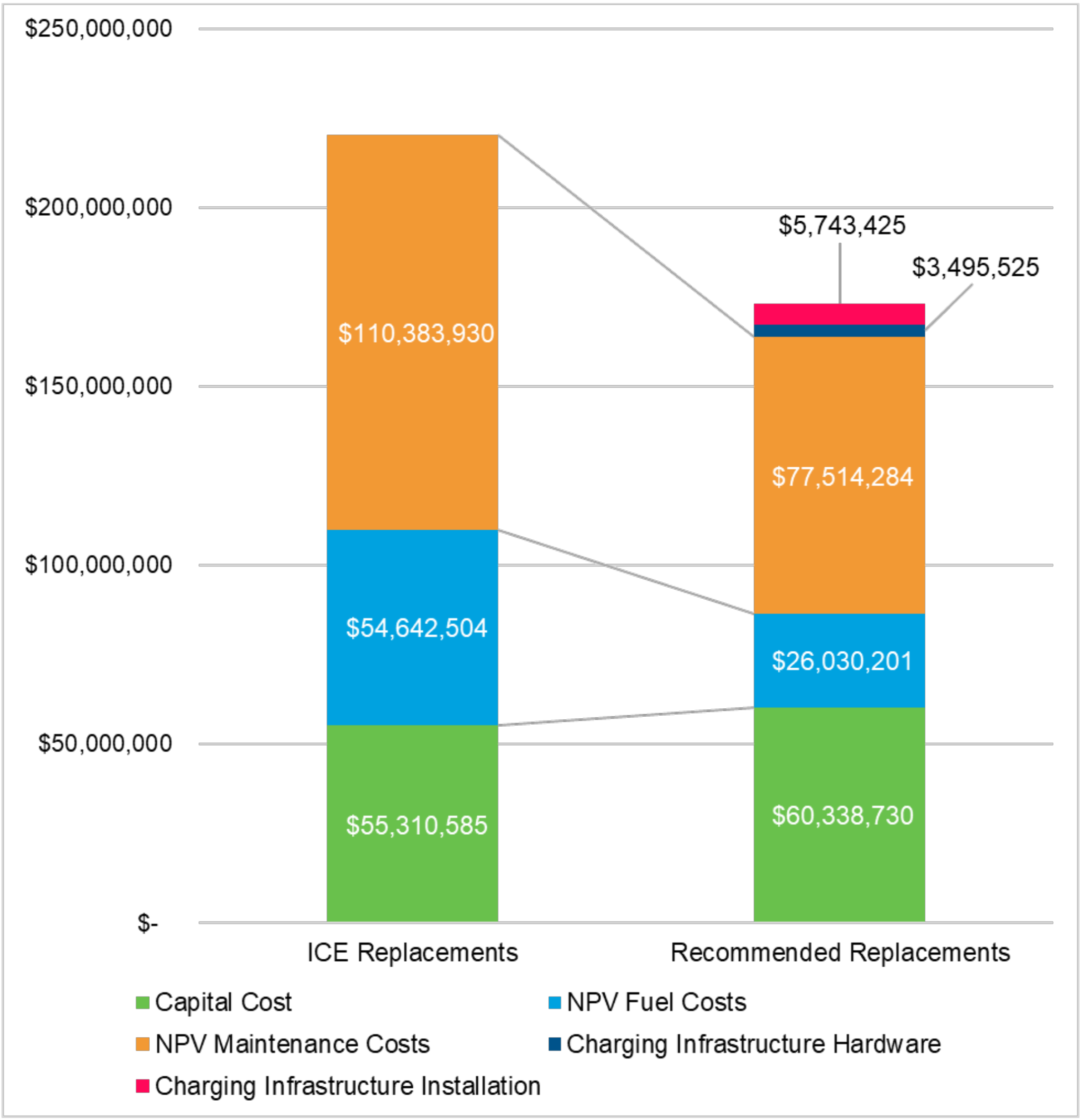
Fleet advisory services provided by ICF

VI. Economic Analysis

To determine the TCO, the vehicle lifespans of the 1,489 vehicles suggested for electrification were evaluated. The incremental EVSE needed 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 1,489 EVs and recommended EVSE over the entire vehicle lifespans compared to the traditional ICE vehicle replacement. No financial incentives were included in this TCO analysis.

Figure 6. 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. Anne Arundel's fleet consists of mostly light- and medium-duty vehicles, making the opportunity to capitalize on existing TCO savings more easily accessible. Table 2 outlines the TCO savings projected for Anne Arundel County by vehicle type.

Table 2. TCO Savings by Vehicle Type

Vehicle Type	TCO Savings
Sedan	$485,762
SUV	$29,827,668
Light-Duty Pickup	$9,593,512
Medium-Duty Pickup	$2,021,278
Van	$5,286,633
TOTAL	**$47,214,853**

If Anne Arundel decides to pursue financial incentives, such as the MEA Clean Fuel Incentive Program which was available in FY21, then additional vehicles and vehicle types are also financially beneficial for electrification.

Table 3 provides a breakdown of the infrastructure assumptions made in the TCO modeling, to allocate EVs and EVSE plugs. Depending on vehicle duty cycle and application, the number of vehicles per plug may fluctuate. 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 which need to charge simultaneously. Similarly, the analysis assumes that domiciled vehicles will have access to Level 2 chargers at their workplace or at home, requiring fewer on-site Level 2 plugs for overnight charging. 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 Plug and Charger Level Assumptions

Vehicle Type	EVs per Plug	Charger Level
Sedan	2	Level 2
SUV	2	Level 2
Light-Duty Pickup	2	Level 2
Medium-Duty Pickup	4	DCFC
Van	4	DCFC
School Bus	4	DCFC

As vehicles are replaced through 2035, lifespans extend beyond 2035 and TCO calculations extend out to 2050. The TCO comparisons in Figures 7 and 8 show that TCO savings will almost always be realized annually, except for the first 2 years of electrification. After the initial capital costs associated with purchasing EVs to replace existing ICE fleet vehicles, the years following 2022 will all provide operational savings.

Figure 7. Cumulative TCO Comparison From 2021 to 2050

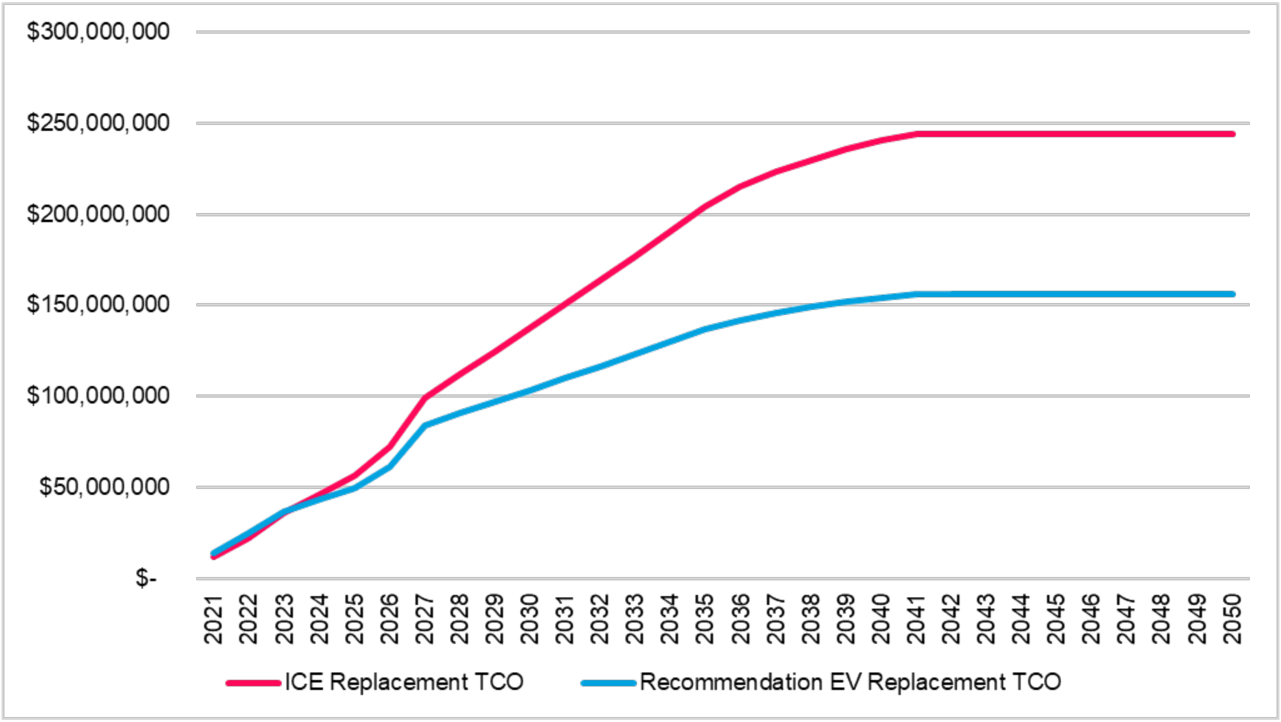
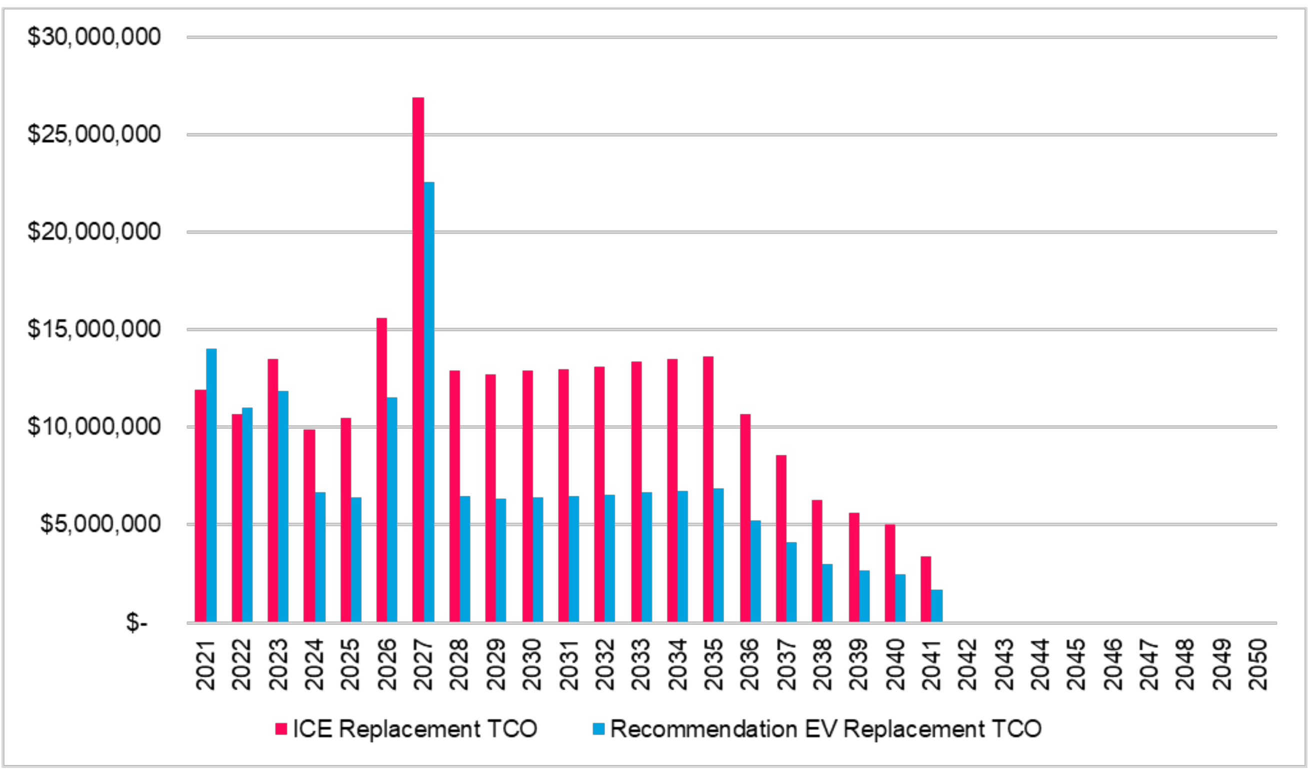


Figure 8. TCO Comparison by Year



This report estimates the payback period, with incentives, for purchase fleet electrification to end in 2041. However, the length of the payback period can be significantly influenced by the amount of financial incentives Anne Arundel pursues and wins. The more funding the County obtains for EVs and EVSE, the shorter the payback period.

As noted in Section V, the County may not be able to replace fleet vehicles with EVs until 2024. In this case, the TCO savings noted in this report will be delayed for the first three years of the replacement cycle. Current projected TCO for 2021, 2022, and 2023 are noted in Table 4.

Table 4. Projected TCO Costs for 2021 to 2023

	2021	2022	2023
ICE TCO	$11,919,258	$22,612,216	$36,141,283
EV Replacement TCO	$14,051,620	$25,029,110	$36,913,102

While the current analysis projects the TCO costs to break even in 2024, delaying fleet electrification until 2024 will not guarantee the same results, due to changes in EV purchase prices, infrastructure costs, maintenance and training costs for employees, and more. Many vehicles not currently recommended for electrification by 2035 will likely become eligible for electrification beyond 2035. 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.

VII. EVSE Needs Assessment Overview

Table 5 provides a more in-depth breakdown of the EVSE infrastructure assumptions made in the TCO modeling. Using Table 5 as a potential guide can help Anne Arundel strategically plan EVSE installation to limit infrastructure costs. While this fleet electrification analysis does not include a complete EVSE needs and siting assessment, these preliminary results can help Anne Arundel begin planning for future infrastructure build out. Appendix C provides an overview of EVSE types and a breakdown of how to assess EVSE needs.

Table 5. EVSE Considerations by Vehicle Type[5]

Vehicle Type	Number of Vehicles Recommended for Electrification	L2	DCFC
Sedan	70	35	0
SUV	975	488	0
Light-Duty Pickup	285	143	0
Medium-Duty Pickup	53	0	13
Van	106	0	27
TOTAL	**1489**	**665**	**40**

The County plans to rely on BGE's Level 2 EVSE for short-term charging needs, however they will have to pay commercial charging rates. Installing county-owned EVSE will result in a lower cost/kWh to charge fleet vehicles in the future and should be prioritized long-term. When considering where to begin charging infrastructure construction, locations with the highest number of fleet vehicles should be prioritized to ensure charging demand is met. Table 6 provides shows the five locations with the most fleet vehicles. Appendix D provides an overview of the number of vehicles at each County parking location.

[5] Table 4 offers projected Level 2 and DCFC EVSE needs based on current model assumptions and number of vehicles recommended for electrification.

Table 6. County Parking Locations with the Most Vehicles[6]

Locations	Number of Vehicles Identified for Electrification
445 Maxwell Frye Rd, Millersville, MD 21109	59
Heritage Office Complex	59
435 C Maxwell Frye Road, Millersville, MD	25
3 Harry S. Truman Parkway, Annapolis, MD 21401	20
437 Maxwell Frye Road, Millersville, MD 21108	17

Similarly, as the County begins planning EVSE installations, it should assess the fleet's current and future charging needs. Recommendations on how to futureproof charging infrastructure include, but are not limited to, the following:

- Determine the number of vehicles that will need EVSE in the short- and long-term;
- Identify the number of existing parking spaces at various locations;
- Identify the number of parking spaces with the electrical capacity to install Level 2 EVSE;
- Evaluate electrical panel distribution voltage and capacity;
- Standardize EVSE siting design (e.g., signage,[7] accessibility,[8] use requirements, parking space design, Americans with Disabilities Act requirements,[9] etc.) and permitting; and,
- Adopt building codes[10] that require pre-wiring compatible with EVSE installation.

VIII. Emissions Analysis

Improvements in vehicle fuel economy and technologies, have provided incremental vehicle emissions savings over the years. However, converting an ICE vehicle to an EV will provide a significant, immediate emissions savings at a much larger scale than choosing a more fuel-efficient ICE vehicle. Converting 1,489 ICE vehicles to EVs would potentially save Anne Arundel 228,709 metric tons (MT) of GHG emissions over the lifespan of all converted EVs, through 2050. Additionally, 134 MT of NOx will be reduced over the lifespan of all converted EVs, through 2050. Figure 9, 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.

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[6] Provided by Anne Arundel County on May 26, 2021. This reflects the number of vehicles assigned to each parking location as provided by the County. This does not reflect the vehicle department assignments.

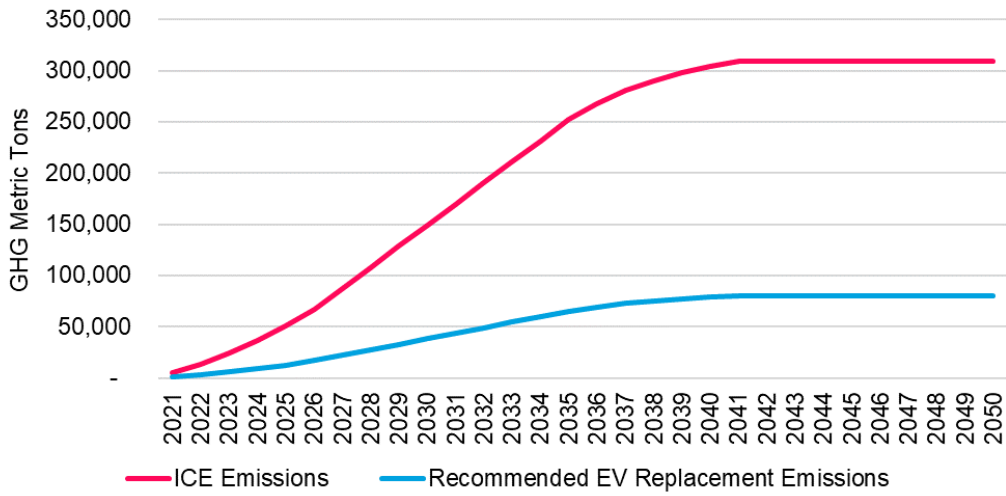
[7] U.S. Department of Energy Alternative Fuels Data Center, Signage for PEV Charging Stations, retrieved from https://afdc.energy.gov/fuels/electricity_charging_station_signage.html

[8] California PEV Collaborative, 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

[9] Guidance in Complying with ADA Requirements, U.S. Department of Energy, 2014, retrieved from https://afdc.energy.gov/files/u/publication/WPCC_complyingwithADArequirements_1114.pdf

[10] IECC, Proposed Changes to the 2019 International Codes, media.iccsafe.org/code-development/group-b/2019-Group-B-CAH-compressed.pdf

Figure 9. Cumulative Fleet GHG Emissions



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 Anne Arundel grid generation mix. A more detailed comparison of projected annual GHG emissions levels on are in Appendix E.

Estimated lifetime emissions savings per vehicle type for the 1,489 vehicles are available below, in Table 7. Actual emissions per vehicle can vary dramatically based on the vehicle being replaced and average mileage.

Table 7. Lifetime Vehicle Emissions by Vehicle Type

Vehicle Type	Lifetime GHG Emissions Reductions (MT)	Lifetime NOx Emissions Reductions (MT)
Sedan	5,038	1.3629
SUV	159,019	29.4054
Light-Duty Pickup	48,334	7.1209
Medium-Duty Pickup	2,492	5.8333
Van	13,827	90.2135
TOTAL	228,709	134

IX. Conclusion

This analysis identifies 1,498 vehicles for electrification in Anne Arundel's fleet over the next 15 years. If Anne Arundel follows the recommended replacement schedule for transitioning from ICE vehicles to EVs, the County can expect to see operational savings following 2022 and a reduction in GHG emissions up to 228,709 MT.

As Anne Arundel 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, Anne Arundel may consider applying for grant and funding opportunities. While funding availability is not guaranteed, Anne Arundel should explore the following financial incentives currently offered in Maryland:

- Zero Emission School Bus Grant Program and Study
- Solar Canopy EVSE Infrastructure Grant
- 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 County 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 County can apply for all funding opportunities, it should consider the implications of having to potentially choose between awards. Similarly, the County should monitor federal activity for new EV and EVSE incentives that are anticipated to be released.

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

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, Anne Arundel 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 PEVs
- 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 Anne Arundel is prepared for fleet electrification, the County should follow these recommended next steps:

- Determining the number of vehicles that will need EVSE
- Identify the number of exiting parking spaces at various locations

- Identify the number of parking spaces with the capacity to install Level 2 EVSE
- Complete electrical panel distribution voltage and capacity evaluations
- Standardize EVSE siting design (e.g., signage, accessibility use requirements, parking space design, Americans with Disabilities Act requirements, etc.)
- Streamline EVSE permitting
- Adopt building codes that require pre-wiring compatible with future EVSE installation
- 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

Appendices

Appendix A. Transition Anne Arundel County's Vehicle Fleet to Hybrid and EVs Memo

ANNE ARUNDEL COUNTY
MARYLAND
Office of County Executive

STEUART PITTMAN

MEMORANDUM

TO: Christine Romans, Director of Central Services

FROM: Steuart Pittman, County Executive

SUBJECT: Transitioning Anne Arundel County's Vehicle Fleet to Hybrid and Electric Vehicles

DATE: July 28, 2020

In its 2018 report, the Intergovernmental Panel on Climate Change (IPCC) recommended complete electrification of the transportation sector as a key mitigation technique to reduce greenhouse gas emissions and keep global warming below 1.5 degrees C. However, the IPCC also acknowledged that replacing internal combustion engine vehicles (ICEs) even incrementally with higher performing vehicles over the short and medium term would result is substantial greenhouse gas reductions.[1]

According to the Maryland Department of the Environment's 2017 Greenhouse Gas Emissions Inventory[2], on-road vehicles account for 36% of all carbon dioxide emissions across the State. Anne Arundel County owns and maintains over 1,600 vehicles – all of which are ICEs that burn gasoline or diesel fuel. As of the date of this memorandum, the County owns no hybrid electric vehicles (HEVs), plug-in electric hybrid vehicles (PHEVs) or battery-electric vehicles (BEVs). It is imperative that Anne Arundel County lead by example and begin to transition vehicle purchases away from ICEs toward lower emission vehicles, where operationally and financially feasible.

Fleet procurement and maintenance is complex and requires careful consideration of environmental goals, fiscal constraints, departmental needs, maintenance, infrastructure and available vehicle technology. Thus, the policies prescribed in this memo are necessarily aggressive and flexible.

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[1] IPCC, 2018. *The International Governmental Panel on Climate Change: Special Report on Global Warming of 1.5 Degrees Celsius*. Found in Chapter 2 and available at: https://report.ipcc.ch/sr15/pdf/sr15_chapter2.pdf

[2] MDE, 2019. *State of Maryland 2017 Greenhouse Gas Emission Inventory Documentation*. Report available at: https://mde.maryland.gov/programs/Air/ClimateChange/Documents/MD%202017%20Periodic%20GHG%20Emissions%20Inventory%20Documentation.pdf.

To ensure a successful and feasible transition to higher performing vehicles where feasible, the Office of Central Services will:

1) Request supplemental funding for the fiscal year 2022 operating budget for an in-depth study of long-term infrastructure, charging and maintenance needs as well as for any immediate, in-house maintenance staff, training, equipment or contracted resources necessary to begin the transition;
2) Begin replacing existing ICEs by procuring HEVs, PHEVs or BEVs where procurement of such vehicles is financially, operationally and technologically feasible;
3) By fiscal year 2032, transition all procurement of new, non-emergency cars, sedans, crossovers and sport utility vehicles to 100 percent BEVs unless procurement of such vehicles would be infeasible due to financial, operational or technological constraints;
4) By fiscal year 2037, transition all procurement of new, emergency cars, sedans, crossovers and sport utility vehicles to 100 percent BEVs unless procurement of such vehicles would be infeasible due to financial, operational or technological constraints;
5) Annually track and report to the County Executive the following fleet efficiency metrics for each vehicle category:
    a. Total number of ICEs, HEVs, PHEVs and BEVs owned or leased;
    b. Total number of ICEs, HEVs, PHEVs and BEVs procured and delivered during the previous fiscal year;
    c. Total gallons of gasoline and diesel consumed;
    d. Total cost of gasoline and diesel consumed during the previous fiscal year;
    e. Total kilowatt hours consumed for vehicle charging during the previous fiscal year;
    f. Total cost of electricity consumed for vehicle charging during the previous fiscal year;
    g. Average, monitored fuel efficiency in MPGe for all vehicles during the previous fiscal year;
    h. Average, manufacturer advertised fuel efficiency in MPGe for only vehicles procured and delivered during the previous fiscal year; and
    i. Total cost of maintenance and repair costs by vehicle type;
6) Aggressively pursue grant opportunities to cover procurement of HEVs, PHEVs and BEVs, and associated needs such as infrastructure, training resources and equipment;
7) Convene an interagency workgroup that will meet periodically to:
    a. share user experiences;
    b. discuss challenges and design solutions to achieve fleet conversion goals;
    c. review budget, infrastructure, maintenance, training and operational needs; and
    d. formulate plans to increase fuel efficiency and maintain operational needs of departments that rely on pickup trucks, heavy-duty trucks, minivans, full-sized vans, minibuses and other heavy vehicles both owned and maintained by Central Services and those that are known as "direct charge vehicles";
8) Remind all departments that "idling," or leaving the vehicle's engine running while parked is against County Vehicle Policy except in extreme heat or cold where cabin temperatures must be maintained for safety purposes; and

9) As necessary, make annual recommendations to the County Executive for revisions to all policies stated herein given an assessment of current financial, operational and technological constraints.

Combined, these policies will enable Anne Arundel County to immediately reduce greenhouse gas emissions while responsibly transitioning its fleet to electric vehicles over the next two decades. Thank you for your continued efforts making Anne Arundel County "The Best Place."

cc:

Greg Africa, Director of Department of Inspections and Permits
Chief Tim Altomare, Police Department
Rick Anthony, Director of Recreation and Parks
Skip Auld, Director of Libraries
Jim Beauchamp, Budget Director
Kai Boggess-de Bruin, Chief of Staff
Preetti Emrick, Director of Office of Emergency Management
Sheriff Jim Fredericks, Sheriff's Office
Karrisa Gouin, Director of Department of Aging and Disabilities
Matt Johnston, Environmental Policy Director
Pam Jordan, Deputy Chief Administrative Officer of Health and Human Services
Nilesh Kalyanaraman, Health Officer
State's Attorney Anne Colt Leitess, Office of the State's Attorney
Bill Martin, Director of Department of Detention Facilities
Rick Napolitano, Director of Office of Information Technology
Chris Phipps, Director of Department of Public Works
Matt Power, Chief Administrative Officer
Ramond Robinson, Transportation Officer
Chris Trumbauer, Director of Policy and Communications
Carnitra White, Director of Department of Social Services
Chief Trisha Wolford, Fire Department
Steve Kaii-Ziegler, Planning and Zoning Officer

Appendix B. 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 5% 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. The model assumes a combination of owned and lease vehicles. Lease vehicle prices were based as a payment function of the 5-year lease, represented as PMT (rate, nper, pv, [fv], [type]) =PMT (4%, .33%, MSRP, (5-year lease/vehicle useful life)

- **Annual Mileage:** Anne Arundel County 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 $2.45 per gallon of diesel and $2.20 per gallon of gasoline rates, as provided by Anne Arundel County. 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 $0.13/kWh base rate, as provided by Anne Arundel County.

- **Vehicle Replacements:** Anne Arundel County provided vehicle replacement preferences to utilize. Audi, BMW, and Tesla vehicles were removed from replacement recommendation options.

- **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.

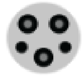
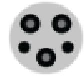
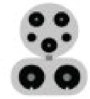
- **Discount Rate:** 5% was used for net present value (NPV) calculations.

- **Temperatures:** Utilized the average annual Anne Arundel temperatures to calculate the impact on battery performance and reduced battery range.

Appendix C. 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 D. Fleet Vehicle Parking Locations

Appendix redacted.

Appendix E. Projected GHG Emissions ICE Replacement Vehicles Versus Recommended EV Replacements

Cumulative GHG (MT)	2021	2022	2023	2024	2025	2026	2027
ICE	4,751	12,849	24,432	37,043	50,662	66,565	87,132
EV Replacement Recommendations	1,197	3,163	6,029	9,201	12,701	16,833	22,183
Emissions Reduction	397%	406%	405%	403%	399%	395%	393%

Cumulative GHG (MT)	2028	2029	2030	2031	2032	2033	2034
ICE	107,749	128,370	148,994	169,617	190,240	210,863	231,487
EV Replacement Recommendations	27,557	32,933	38,309	43,685	49,061	54,436	59,812
Emissions Reduction	391%	390%	389%	388%	388%	387%	387%

Cumulative GHG (MT)	2035	2036	2037	2038	2039	2040	2041
ICE	252,110	267,982	280,507	289,548	297,560	304,564	309,284
Recommended EV Replacement Emissions	65,188	69,368	72,777	75,287	77,491	79,368	80,612
Emissions Reduction	387%	386%	385%	385%	384%	384%	384%

Cumulative GHG (MT)	2042	2043	2044	2045	2046	2047	2048
ICE	309,341	309,347	309,349	309,349	309,349	309,349	309,349
EV Replacement Recommendations	80,637	80,639	80,640	80,640	80,640	80,640	80,640
Emissions Reduction	384%	384%	384%	384%	384%	384%	384%

Cumulative GHG (MT)	2049	2050
ICE	309,349	309,349
EV Replacement Recommendations	80,640	80,640
Emissions Reduction	384%	384%

Appendix F. 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

Appendix G. Vehicle Replacement Recommendations

**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.