Anne Arundel County Transit: Fleet Transition to Zero- and Low-Emission Vehicles

Zero-Emission Transition Plan

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List of Acronyms and Abbreviations

BEB	Battery-Electric Bus
CNG	Compressed Natural Gas
DC	Direct Current
DOE	Department of Energy
DOT	Department of Transportation
EPA	Environmental Protection Agency
FTA	Federal Transit Administration
GHG	Greenhouse Gas
ICE	Internal Combustion Engine
IIJA	Infrastructure Investment and Jobs Act
kWh	Kilowatt Hour
MDOT	Maryland Department of Transportation
MTA	Maryland Transit Administration
YOE$	Year of Expenditure
ZEB	Zero-Emission Bus

1. Transition Plan Context and Purpose

The transportation sector is a significant contributor to greenhouse gas (GHG) emissions in Maryland[1]. Transit plays an important role in reducing GHG emissions by reducing vehicle miles traveled by the public. Transitioning the vehicle fleets of transit agencies to electric vehicles reduces GHG emissions, improving local air quality and public health.

Reducing emissions has been of increasing concern nationally and locally as research continues to demonstrate the wide range of environmental and health benefits associated with GHG reductions. National initiatives such as the 2021 Infrastructure Investment and Jobs Act (IIJA[2]), state legislation (the Zero-Emission Bus Transition Act), and local policy (Anne Arundel County's mandating that its light- and medium-duty vehicles need to be 100% zero emission vehicles by 2032[3]) would all help facilitate the County's future transition of its transit fleet to cleaner propulsion.

Anne Arundel County Transit is making a commitment to minimizing the environmental impact of its transit operations while maintaining a quality, equitable service to its riders. The County is achieving this by evaluating the potential for zero-emission vehicles and implementing a zero-emission Plan.

The Plan will guide the County in decision-making processes and appropriate phasing to transition from a conventional fossil fuel-powered fleet to zero-emission alternatives. It is the final output for a year-long study of the potential for transitioning Anne Arundel Transit's fleet from the internal combustion engine vehicles it currently operates to zero-emission vehicles[4].

This document is organized so that it adheres to the Federal Transit Administration's criteria for receiving a Low- or No-Emission Vehicle grant to help facilitate the transition to zero-emission transit operations.

The Plan covers:

1. A long-term fleet management plan (see "Fleet Transition Cost and Timeline")
2. The availability of current and future resources to meet costs for the transition and implementation (see "Funding Availability")

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[1]Maryland's transportation sector accounted for nearly 42 percent of the state's greenhouse gas emissions in 2020 (Maryland Department of the Environment - Greenhouse Gas Inventory).

[2] Since the current administration assumed control of the Executive Branch in January 2025, federal policy and funding for green technology, lower-emission transportation, and climate change measures have been in a state of flux. References in this Plan to the IIJA and FTA Low-No Grants, for instance, assume that federal dollars would remain available for the procurement of electric buses, or become available again in 2029.

[3] https://www.aacounty.org/county-executive/news/county-executive-pittman-announces-new-initiative-convert-county-fleet-all

[4] Zero-emission vehicles include battery-electric and hydrogen fuel cell buses. Anne Arundel Transit has ruled out hydrogen as a propulsion method in the near future; therefore, references in this document to zero-emission vehicles assume the propulsion method to be battery-powered.

3. Policy and legislation impacting relevant technologies (see “Existing Policies, Initiatives, and Studies”)
4. An evaluation of existing and future facilities (see “Service and Fleet Analysis”)
5. Partnership between Anne Arundel Transit and the electricity provider (see “Utility Coordination”)
6. Impact of the transition on the applicant's current workforce (see “Workforce Development”)

2. Fleet Transition Cost and Timeline

This section outlines a long-term fleet management plan with a strategy for how the County intends to use the current request for resources and future acquisitions. This helps predict the time and cost associated with a zero-emission transition Plan.

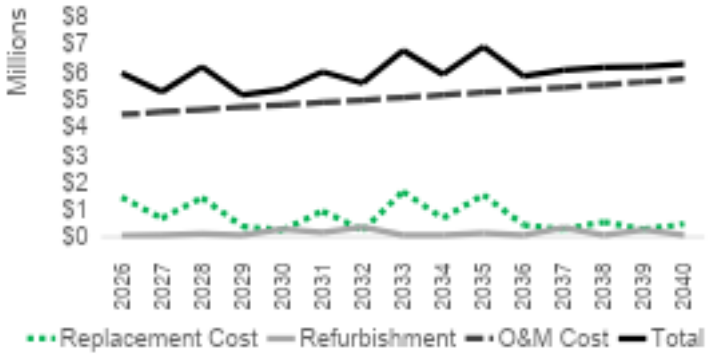
Four scenarios were explored to determine the most optimal combination of technology and opportunity charging possibilities. These included:

1. Existing Fleet Scenario,
2. Current Technology / Opportunity Charging Scenario,
3. Moderate Technology / No Opportunity Charging Scenario, and
4. Moderate Technology / Opportunity Charging Scenario.

The most optimal scenario which was recommended and outlined in the Final Report was the Moderate Technology / Opportunity Charging Scenario. Each scenario is outlined below.

2.1. Existing Fleet Scenario

Figure SEQ Figure * ARABIC 1: Baseline Cost Scenario



Under the Existing Fleet (Baseline) Scenario, gasoline buses would continue to be purchased and replaced based on the current procurement schedule. Figure 1 shows the annual costs under the Baseline scenario for replacement, refurbishment, and O&M costs. The Existing Fleet Scenario would cost an estimated $6.0 million per year on average and totals $89.6 million for 2026-2040 Year of Expenditure (YOE$).

2.2. Current Technology / Opportunity Charging Scenario

Under the Current Technology / Opportunity Charging Scenario, a total of 111 vehicles would be initially purchased for full transition between 2026 and 2032. In addition, purchases of charging

infrastructure would begin in 2025 and be completed by 2030. Over the analysis period, this scenario would cost $240.5 million, $150.9 million higher than the Baseline cost of $89.6 million.

Replacement of large vehicles would only be assigned to routes 201, 202, and 203, whereas small vehicles would be assigned to all other routes.

2.3. Moderate Technology / No Opportunity Charging Scenario

Under the Moderate Technology / No Opportunity Charging Scenario, a total of 91 vehicles would be initially purchased for full transition between 2030 and 2036. In addition, purchases of charging infrastructure would begin in 2029 and be completed by 2035.[5] Over the analysis period, this scenario would cost $165.4 million, $75.8 million higher than the Baseline cost of $89.6 million.

Replacement of large vehicles would only be assigned to routes 201, 202, and 203, whereas small vehicles would be assigned to all other routes.

2.4. Moderate Technology / Opportunity Charging Scenario

Under the Moderate Technology / Opportunity Charging Scenario, a total of 78 vehicles would be initially purchased for full transition between 2030 and 2036. In addition, purchases of charging infrastructure would begin in 2029 and be completed by 2035. Over the analysis period, this scenario would cost $149.3 million, $59.7 million higher than the Baseline cost of $89.6 million.

Replacement of large vehicles would only be assigned to routes 201, 202, and 203, whereas small vehicles would be assigned to all other routes.

Of the three transition scenarios presented, Moderate Technology / Opportunity Charging is the least costly at $149.3 million which is $59.7 million higher than the Baseline. Moderate Technology / No Opportunity Charging falls into the mid-range at $165.4 million, being $75.8 million higher than the Baseline. The most expensive option adopts Current Technology / Opportunity Charging primarily because of the higher replacement ratio of ICEs to BEBs. This option costs $241.0 million and is $151.4 million higher than the Baseline. Table 1 summarizes the cost across each scenario as well as the expected year of completion.

[5] *For the purpose of this analysis, infrastructure cost expected to be incurred in 2025 will be reflected in 2026 to be consistent with the forecast period.*

Table 1: Cost Comparison Summary and Timeline, by Scenario

	Replacement	Refurbishment	O&M	Infrastructure	Total	Year
Baseline	$11.2	$2.2	$76.2	$0.0	$89.6	2025
Moderate Tech. No Opp Charging	$94.1	$20.1	$49.4	$1.8	$165.4	2036
Moderate Tech. Opp Charging	$81.7	$17.0	$48.3	$2.4	$149.3	2036
Current Tech. Opp Charging	$160.2	$37.4	$39.6	$3.8	$241.0	2032

Source: AECOM

If fiscal constraints are the main consideration in the selection of a transition scenario, the transition scenario based on Moderate Technology / Opportunity Charging would rank the highest but would require a shift in the transition timeline to 2036.

The cost of this transition scenario is the least costly option being $59.7 million higher than the base and averages $10.7 million per year in total cost. Under this transition scenario, the fleet reaches 100 percent zero-emission by 2036. Pricing of vehicles, fuel, and infrastructure should be monitored because the market may look much different from what this analysis shows in the next 5 years.

This zero-emission transition Plan is reflective of zero-emission technology as it exists in 2024. The technology is rapidly evolving, and with the increased acceptance of these vehicles into large fleets, performance can be expected to improve, and costs decrease.

Table 2 shows the distribution of buses and opportunity chargers (OC) across locations for each scenario.

Table 2. Distribution of Buses and Opportunity Chargers, by Facility and Scenario

	Dorsey Road	Millersville Maintenance Facility	Arundel Mills Mall	Riva Road	Future Parole Transit Facility	Total Level 2 only	Total w/ OC[6]
Moderate Tech, No OC	39	6	5	26	15	91	
Current Tech, OC	39	6	14	26	26	111	113
Moderate Tech, OC	39	0	5	26	8	78	80

Source: AECOM

[6] *Under the scenarios with opportunity charging, one opportunity charger is installed at Arundel Mills Mall and another at the Future Parole Transit Facility.*

3. Funding Availability

This section outlines the availability of current and future resources to meet costs for the zero-emission transition Plan and implementation is addressed.

Full details on opportunities to fund Anne Arundel County Transit's transition to a zero-emission fleet and facilities can be found in the Task 8 report: Grants; Rebates, and Funding Opportunities, from early 2024.

To achieve agency and regional strategic and visionary goals, the County must identify and secure the necessary funding to implement the proposed recommendations.

3.1 Federal Opportunities

Competitive funding through the IIJA prioritizes projects that take steps toward tackling the climate crisis through electrification, advance equity through the Justice40 Initiative, and provide access to jobs and workforce training. Additionally, the IRA provides funding to address the climate crisis and promote a clean energy economy.

The Department of Energy (DOE), Environmental Protection Agency (EPA), Department of Transportation (DOT), Federal Highway Administration (FHWA), Federal Railroad Administration (FRA), Federal Transit Administration (FTA), and Internal Revenue Service (IRS) all offer funding programs for Zero Emission Vehicle (ZEV) transition.

In regard to federal funding opportunities the following should be considered:

- Some IRA funding opportunities continue to be refined. Key details such as timing, funding guidance, and eligibility may vary as the funding agency develops guidance in response to the IRA. In future years, Anne Arundel County should continue to confirm their eligibility for the program.

- Some funding opportunities may be well positioned for state or local agencies such as the State of Maryland or utility providers. Anne Arundel County should explore opportunities to coordinate with these agencies to reach shared goals or incorporate Transition Plan project elements. For example, under the National Electric Vehicle Infrastructure (NEVI) grant program, Anne Arundel County may want to consider how to work with the state for the placement of charging stations.

- Anne Arundel County may consider partnerships, coalitions and associations that are created to facilitate communication and knowledge about emerging opportunities, such as hydrogen fueling, where it may be useful to position for future funding as guidance is developed.

- Federal sources can provide funding at a scale that is not typically seen at a local or state level. While the award thresholds may be appealing, consider the level of effort to secure that funding and if the project scale matches that level of effort. For example, if the agency is consider purchasing electric charging infrastructure for one facility it might be worthwhile to bundle that as part of an existing grant application such as RAISE that feature many components at a regional level rather than applying to a competitive program for a small ask alone.

- Consider monitoring key Notice of Funding Opportunities (NOFOs) and announcements that are updated frequently for the most up to date information.[7]

3.2 State Opportunities

The State of Maryland offers funding opportunities through the Maryland Energy Administration. A variety of funding programs are available to upgrade to and implement newer, cleaner technology. Maryland provides rebates and discretionary funding opportunities to promote clean technology adoption and construction.

Anne Arundel County is well-positioned to receive federal funding through the IIJA and the IRA to fund its ZEV transition. In 2022, the agency was awarded $1.9 million from the FTA. Funding opportunities exist across several federal agencies.

The state of Maryland offers a variety of funding opportunities that can be leveraged for the Transition Plan. There are four funding programs that post NOFOs. All four funding programs are sponsored by the Maryland Energy Administration that has a stated objective of managing grants, loans, rebates, and tax incentives designed to help attain Maryland's goals in energy reduction, renewable energy, climate action, and green jobs. Three of the four funding programs are active or are in the process of being revised for FY24.

One program – the Electric Vehicles Supply Equipment (EVSE) Rebate Program – has noted that funding for both residential and commercial applicants for FY24 is estimated to be fully exhausted based on the applications received to date that are still under review. Anne Arundel County should review the details of each grant program as they are made available.

Anne Arundel Transit's Zero-Emission Plan components and funding opportunities are listed in Table 3.

[7] *U.S. Department of Transportation resources can be found at: https://www.transportation.gov/bipartisan-infrastructure-law/key-notices-funding-opportunity.*

Table 3: Funding Opportunity Summary

Funding Opportunities	Agency	Vehicles	Infrastructure & Equipment	Facilities	Planning, Design & Construction
State					
Clean Fuel Incentive Program	MEA	X			
Electric Vehicle Supply Equipment (EVSE) Rebate Program	MEA		X	X	X
Maryland Smart Energy Communities (MSEC) Grant Program	MEA		X	X	
Solar Canopy and Dual Use Technology Grant Program	MEA			X	
National Electric Vehicle Infrastructure Grant Program			X		
Federal					
Grid Resilience and Innovation Partnerships (GRIP) Program	DOE		X		X
Energy Efficiency and Conservation Block Grant	DOE	X	X		
Clean Heavy Duty Vehicle Program	EPA	X	X		
Diesel Emission Reduction Act	EPA	X			
Multimodal Project Discretionary Grant (MPDG)	DOT		X	X	X
Rebuilding American Infrastructure with Sustainability and Equity (RAISE)	DOT	X	X	X	X
Transportation Infrastructure Finance and Innovation Act (TIFIA)	DOT	X	X	X	X
Charging and Fueling Infrastructure (CFI) Discretionary Grant Program	FWHA		X		
PROTECT	FHWA			X	X
Buses and Bus Facility/Low No Emissions	FTA	X	X	X	X
Alternative Fuel Vehicle Refueling Property Credit	IRS		X	X	X

4. Existing Policies, Initiatives, and Studies

This section examines policies, legislation, and programs that could impact the implementation of Anne Arundel Transit's Zero-Emission Plan.

4.1 Federal

When transitioning to low or zero-emission, it's necessary to understand how existing local, state, and federal policy, legislation, and programs can impact relevant technologies being explored to ultimately choose the best option(s) for the fleet. Please note that the following information was current as of late 2024, and that policies and programs may change with the new administration.

Department of Energy Programs

As part of the Investing in America agenda, the Biden Administration provided $15.5 billion in 2023[8] to support the transition to electric vehicles by retooling existing manufacturing facilities and rehiring existing workers. While the impact to Anne Arundel County is not direct, this policy indirectly benefits the agency in that the funding would boost the production of electric vehicles and batteries and strengthen supply chains.

In addition, DOE's Clean Energy to Communities (C2C) program brings together local governments and utilities to work on renewable energy and mobility issues. DOE, through the Argonne National Laboratory, helped Washtenaw County understand the benefits and challenges of electrifying its fleet of 244 vehicles by looking at the expected range of electric vehicles, potential emissions reduction, total cost of ownership, and energy savings.

Further, DOE's office of Energy Efficiency and Renewable Energy[9] offers funding opportunities for projects that move the electric vehicle industry forward. And DOE also provides research and technical assistance, via its Vehicle Technologies Office[10], to support the proliferation of zero-emission vehicles.

Infrastructure Investment and Jobs Act

Signed into law by President Biden on November 15, 2021, the Infrastructure Investment and Jobs Act (IIJA), also known as the "Bipartisan Infrastructure Law," invested "$89.9 billion in guaranteed funding for public transit over the next 5 years — the largest federal investment in public transportation history. As part of these transit investments, the IIJA includes provisions to support and increase investment in zero-emission vehicles through grant programs, studies, fleet funding, and other measures.

[8] https://www.energy.gov/
[9] https://www.energy.gov/eere/office-energy-efficiency-and-renewable-energy
[10] https://www.energy.gov/eere/vehicles/batteries-charging-and-electric-vehicles

The IIJA includes provisions to continue grants for the Buses and Bus Facilities program with increased funding levels compared to previous authorizations. The IIJA also includes funding appropriation for the Low-No Grant program at around $1.1 billion annually from 2022 through 2026. The Low-No Grant program is a program within the FTA Buses and Bus Facilities program. This discretionary grant program requires agencies to have a zero-emission fleet transition plan.

The program also requires that 5 percent of Low-No Grants related to zero-emission vehicles and related infrastructure be used for workforce development activities unless the applicant certifies that less is needed to carry out their zero-emission fleet transition plan. However, it should be noted that federal transit funding focuses on capital needs, not the costs associated with the operation and maintenance of ZEBs or other transit services.

Executive Order 14008

This executive order, Tackling the Climate Crisis at Home and Abroad[11], underscored the current administration's commitment to the Paris Agreement's objectives, and established a White House Office of Domestic Climate Policy and a National Climate Task Force. While the order is of little immediate application to Anne Arundel County, the policy sets the tone for federal government goals regarding carbon emissions.

The National Climate Resilience Framework[12], on the other hand, encourages action on sustainability and climate resilience through technologies such as solar power. Anne Arundel County may be able to leverage its plans for PV arrays on the roofs of its facilities by applying for a RAISE[13] grant if the program continues in 2025. $15 billion in RAISE grants were awarded as of 2024 to improve environmental sustainability, mobility, and innovation.

Energy Independence Security Act

The goal of the Energy Independence and Security Act of 2007[14] (EISA) is to move the U.S. toward greater energy independence and security and increase the production of renewable fuels. While not a grant program, this federal law has aggressive requirements for fuel economy standards.

4.2 State

The state of Maryland has implemented several initiatives to promote zero-emission public transit, focusing on transitioning bus fleets to electric vehicles and enhancing infrastructure.

[11] https://www.federalregister.gov/documents/2021/02/01/2021-02177/tackling-the-climate-crisis-at-home-and-abroad
[12] https://climatereadycommunities.org/learn-more/about-guidebook/?gad_source=1&gclid=EAIaIQobChMIkP6V0O2xiwMV5nBHAR0ihCaDEAAYASAAEgKDEPD_BwE
[13] https://www.transportation.gov/BUILDgrants
[14] https://www.epa.gov/laws-regulations/summary-energy-independence-and-security-act

Please note that, while these programs apply to parts of Maryland other than Anne Arundel County, they underscore the state's commitment to facilitating zero-emission transit.

Zero-Emission Bus Transition Act

The Zero-Emission Bus Transition Act[15] was enacted in 2020. This legislation mandates that the Maryland Transit Administration (MTA) procure only zero-emission buses starting in fiscal year 2022. The act requires MTA to submit annual reports detailing the necessary charging infrastructure, workforce transition plans, estimated carbon dioxide emissions reductions, and financial analyses of implementing and maintaining charging infrastructure.

Montgomery County's Zero-Emission Bus Transition Plan

Montgomery County[16] aims to convert its Ride On bus fleet of nearly 400 vehicles to zero-emission buses by 2035. The county has developed a master plan identifying existing infrastructure, technology options, and potential funding sources to support this transition.

Prince George's County's Zero-Emission Bus Initiative

In 2024, Prince George's County[17] secured a $25 million grant from the U.S. Department of Transportation to acquire zero-emission battery electric buses, vans, and chargers. The funding also supports the construction of a new microgrid and energy management system, aiming to reduce greenhouse gas emissions and enhance transit access.

MDOT MTA's Zero-Emission Bus Pilot Program

In early 2024, the MDOT MTA[18] launched a pilot program by adding seven zero-emission buses to its local bus fleet. This initiative seeks to reduce greenhouse gas emissions and improve air quality in the Baltimore region.

Zero Emission Bus Acquisition Requirement

Beginning in 2023, the MTA[19] is required to purchase only zero-emission buses for the state transit bus fleet. If no zero-emission buses meet performance requirements, alternative fuel buses may be procured instead.

4.3 Local

[15] https://mgaleg.maryland.gov/mgawebsite
[16] https://montgomerycountymd.gov/
[17] https://www.princegeorgescountymd.gov//
[18] https://www.masstransitmag.com/bus/vehicles/hybrid-hydrogen-electric-vehicles/press-release/53097889/office-of-the-maryland-governor-mdot-mta-launches-zero-emission-bus-pilot-program
[19] https://afdc.energy.gov/laws/12623

Many local governments are mandating that agencies switch from diesel and fossil-fuels to low- or no-emission vehicles, which would eventually produce better air quality and reduce greenhouse gas emissions into the atmosphere. This is the case with Anne Arundel County, which now has a policy of transitioning its light- and medium-duty vehicles (including its) transit fleet to 100% zero emission vehicles by 2032[20].

Because the County has a policy of transitioning to a 100% zero-emission fleet by 2032, only the hydrogen and battery-electric propulsion types are suitable in the long term.

5. Service and Fleet Analysis

This section provides an evaluation of existing and future facilities, and their relationship to providing transit service for Anne Arundel County's fleet in the zero-emission transition Plan.

5.1 Existing Facilities

Anne Arundel Transit's fleet consists of a variety of vehicles that are stored and maintained in multiple locations throughout the County, including Millersville, Dorsey Road, and Riva Road. The current fleet has 55 vehicles with future expansion planned as the County transitions their fleet to electric vehicles.

Vehicles include cutaway buses, in various sizes, and two transit vans. The County operates service between 6 am and 10:30 pm, split between on-demand and fixed routes with 30,000 riders per month across all services.

In analyzing the special requirements of the County's existing facilities for bus parking, and toward a larger fleet consisting of electric vehicles and the infrastructure needed to support them, the parking recommendations by location for a fleet of 88 buses are as follows:

- Dorsey Road: 39 parking spaces and 39 chargers
- Millersville Maintenance: 6 parking spaces and 6 chargers
- Arundel Mills Mall: 5 parking spaces and 5 chargers
- Riva Road: 26 parking spaces and 26 chargers
- Truman Commuter Lot or Westfield Mall (future Parole Facility): 15 parking spaces and 15 chargers

5.2 Future Facilities

This section summarizes the site conditions at Anne Arundel Transit's facilities and the distribution of electrical power to designated charger locations for future fleet electrification.

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https://www.aacounty.org/county-executive/news/county-executive-pittman-announces-new-initiative-convert-county-fleet-all

Existing and future sites were surveyed with County staff to determine potential charger locations and existing electrical infrastructure. Most proposed chargers would be Level 2, 19.2kW freestanding dual port chargers.

The number of direct current (DC) fast chargers may fluctuate after the future need for fast charging is determined.

Dorsey Road

Dorsey Road will be the future location of Anne Arundel County's main transit facility. In Phase 1 of construction, site parking and utilities will be installed on the property. It is recommended that EV charging infrastructure be installed while the site is still being developed. A separate BGE service would be required due to the larger charging loads needed for EV charging.

The proposed site will have EV parking stalls for 39 transit buses. The estimated load for Level 2 chargers is 749kW; therefore, 1200A, 208Y/120V service is required. There would be a total of 19 dual-port Level 2 chargers (19.2 kW per port) and one single-port Level 2 charger (19.2 kW per port).

The primary BGE utility feed is to a pad-mount transformer. The transformer secondary would serve a switchboard located in a NEMA 3R enclosure with metering equipment. The switchboard would contain a 100A branch circuit to each Level 2 charging port with #2AWG conductors in 2" conduit.

The total estimated cost for this work is $510,000.

Millersville Maintenance Facility

The Millersville Maintenance Facility is a shared fleet services facility. EV charging infrastructure can be installed to allow for additional fleet overnight charging. A separate BGE service would be required due to the larger charging loads needed for EV charging.

This area would have EV parking stalls for six transit buses. The estimated load for Level 2 chargers is 115kW; Therefore, 300A, 208Y/120V service is required. There would be two dual-port Level 2 chargers (19.2 kW per port) and one single-port Level 2 charger (19.2 kW per port).

The primary BGE utility feed is to a pad-mount transformer. The transformer secondary would serve a switchboard located in a NEMA 3R enclosure with metering equipment. The switchboard would contain a 100A branch circuit to each Level 2 charging port with #2AWG conductors in 2" conduit.

The total estimated cost for this work is $77,000.

Arundel Mills Mall

A potential charging location at Arundel Mills Mall is in the parking lot outside of the casino. EV charging infrastructure can be installed to allow for additional fleet overnight charging and opportunity charging. A separate BGE service would be required due to no existing infrastructure in the area.

With No Opportunity Charging

For moderate battery technology with no opportunity charging, this area would have EV parking stalls for five transit buses. The estimated load for Level 2 chargers is 96 kW; therefore, 300A, 208Y/120V service is required. There would be two dual-port Level 2 chargers (19.2 kW per port) and one single-port Level 2 charger (19.2 kW per port).

The primary BGE utility feed is to a pad-mount transformer. The transformer secondary would serve a switchboard located in a NEMA 3R enclosure with metering equipment. The switchboard would contain a 100A feeder to each Level 2 charging port with #2AWG conductors in 2” conduit.

The total estimated cost for this work is $154,000.

With Opportunity Charging

For moderate battery technology with opportunity charging, there would be EV parking stalls for six transit buses. The estimated load for the chargers is 128 kW; therefore, 200A, 480Y/277V service is required. There would be two dual-port Level 2 chargers (19.2 kW per port), one single-port Level 2 charger (19.2 kW per port), and one single-port DC fast charger (31.25 kW per port).

The primary BGE utility feed is to a pad-mount transformer. The transformer secondary would serve a 480/277V switchboard located in a NEMA 3R enclosure with metering equipment. The switchboard would contain an 80A feeder to the DC fast charger with #3AWG conductors in 2” conduit and 150A feeder for a 100kVA, 480-208Y/120V transformer that would supply power to a 300A, 208/120V sub-panel for the Level 2 charging loads. The sub-panel would contain 100A feeders to each Level 2 charging power with #2AWG conductors in 2” conduit.

The total estimated cost for this work is $249,000.

Riva Road

Riva Road is an existing location of overnight parking for on-demand and fixed route buses. EV charging infrastructure can be installed to allow for overnight fleet charging. A separate BGE service would be required due to no existing infrastructure in the area.

This area would have EV parking stalls for 26 transit buses. Estimated load for Level 2 chargers is 500 kW; therefore, 1000A, 208Y/120V service is required. There would be 13 dual-port Level 2 chargers (19.2 kW per port).

The primary BGE utility feed is to a pad-mount transformer. The transformer secondary would serve a switchboard located in a NEMA 3R enclosure with metering equipment. The switchboard would contain a 100A feeder to each Level 2 charging port with #2AWG conductors in 2” conduit.

The total estimated cost for this work is $327,000.

Future Parole Transit Facility

The Parole Transit Facility is still in the design phase, but this would be the future location of a county transit facility housing 10 bus bays. Bus charging would be in a nearby parking lot, the location for which is to be determined. EV charging infrastructure can be installed to allow for overnight fleet charging and opportunity charging. A separate BGE service would be required as there is no existing infrastructure in the area.

With No Opportunity Charging

For moderate battery technology with no opportunity charging, this area would have EV parking stalls for 15 transit buses. The estimated load for Level 2 chargers is 288 kW; therefore, 600A, 208Y/120V service is required. There would be seven dual-port Level 2 chargers (19.2 kW per port) and one single-port Level 2 charger (19.2 kW per port).

The primary BGE utility feed is to a pad-mount transformer. The transformer secondary would serve a switchboard located in a NEMA 3R enclosure with metering equipment. The switchboard would contain a 100A feeder to each Level 2 charging port with #2AWG conductors and 2” conduit.

The total estimated cost for this work is $289,000.

With Opportunity Charging

For moderate battery technology with opportunity charging, there would be EV parking stalls for nine transit buses. The estimated load for the chargers is 185 kW; therefore, 300A, 480Y/277V service is required. There would be four dual-port Level 2 chargers (19.2 kW per port) and one single-port DC fast charger (31.25 kW per port).

The primary BGE utility feed is to a pad-mount transformer. The transformer secondary would serve a 480/277V switchboard located in a NEMA 3R enclosure with metering equipment. The switchboard would contain an 80A feeder to the DC fast charger with #3AWG conductors in 2" conduit and 250A feeder for 175kVA, 480-208Y/120V transformer that would supply power to a 600A, 208/120V sub-panel for the Level 2 charging loads. The sub-panel would contain 100A feeders to each Level 2 charging power with #2AWG conductors and 2" conduit.

The total estimated cost for this work is $319,000.

In congruence with the ZET Plan, the County is expanding its facilities and operations. These new facilities (and updates to existing ones) would allow for EV charging infrastructure and provide more opportunities for charging throughout Anne Arundel County.

6. Utility Coordination

The electricity provider in Anne Arundel County, BGE, is aware of the County's plans to transition its fleet to zero-emissions and has been in communication with County staff about ways the utility can participate in the process.

As the transition to a zero-emission fleet scales up and the County redesigns and begins construction at its transit facilities, BGE will have a role in facilitating the installation of electrical upgrades ahead of the commissioning of electric bus charging infrastructure.

For example, as mentioned in Section 5 of this Plan:

- A separate BGE service would be required due to the larger charging loads needed for EV charging at Dorsey Road and Millersville;
- And separate BGE service would be required due to no existing infrastructure in the areas identified as electric bus charging stations at Arundel Mills Mall, Riva Road, and the future Parole Transit Facility.

As design moves forward at these locations, BGE will be instrumental in locating locations for and installing transformers, switchgear, conduit, and other upgrades necessary for the charging of electric buses.

Further, Anne Arundel Transit will need to coordinate with BGE if plans move forward for opportunity charging stations at Arundel Mills and Parole. These stations would feature DC fast chargers (Level 3) rather than the slower Level 2 chargers recommended for overnight charging. As such, the electrical requirements would be greater, as would the need for bollards, security fencing, and potentially other civil treatments.

7. Workforce Development

This section examines the impact of the transition on the County's current workforce. This was accomplished by identifying skill gaps, training needs, and retraining needs of the existing workers of the applicant to operate and maintain zero-emission vehicles and related infrastructure and avoid displacement of the existing workforce.

Anne Arundel County would work with its operating contract and training materials from a future BEB supplier to train its operators on the differences between a diesel-powered vehicle BEBs. This includes any driving changes needed to ensure that the battery is utilized efficiently, and other considerations required to operate BEBs safely. Operators would also receive safety training on the chargers and their plug-in dispensers. These changes would be folded into the organization's onboarding training program to ensure that new operators are sufficiently educated to operate the BEBs safely.

To support the safe operation and maintenance of BEBs, the County should work with its operators to procure additional personal protective equipment (PPE), tools, and equipment that its maintenance staff would need, based on Original Equipment Manufacturer (OEM) recommendations.

When considering vehicle maintenance, the County should communicate with its frontline workers to determine whether they need additional training as they attain experience with the equipment. The County should also survey shop-floor supervisors, trainers, and leads (along with documenting technicians with Automotive Service Excellence (ASE) certifications and other training) to help the agency better understand existing electrical and ZEB skill levels among the current workforce. The County should provide surveys to existing staff to identify their aptitude with EVs and high-voltage equipment would be key to identifying skill gaps in the workforce and provide direction on where training, resources, and hands-on understanding is needed to close these gaps.

By empowering the current workforce to maintain and operate this new equipment, the County would be better able to retain its existing staff. The County's goal should be to not displace any of its employees because of the transition to zero-emissions. If vacancies arose in the future, the County should work with local trades and education centers to identify equitable workforce recruitment activities that support the development of quality employment opportunities.

Charger Maintenance

Anne Arundel currently uses conventional fueling for its fixed-route buses. There are likely numerous contractors in the area that can quickly troubleshoot any issues with fueling systems to help keep them in working order, which makes this method low-risk.

Because BEBs must be charged sufficiently to meet service demands, however, all the charging equipment must function with almost 100% uptime every night and during the midday recharge

times for the fleet to have enough power to make pullout. This means Anne Arundel Transit would need appropriate staff and parts ready to keep the system functioning, as any long-term outage could compromise the agency's ability to keep these buses in service.

There are a few options for the County to consider when deciding how to keep this equipment in a state of good repair:

- Keep It "In-House" – Due to the critical nature of BEB charging equipment, internal staff could be trained to maintain it. This would likely require additional staff and some staff to be "on-call" to quickly respond to equipment issues. Still, it would ensure there is local expertise in maintaining the chargers and dispensers regardless of contractor interest in the services.

- Contract Service Out – The County could contract out most of the maintenance needs for the chargers and dispensers to an electrical contractor. While most contractors may not be experts on this equipment, their training on high-voltage equipment should allow them to familiarize themselves quickly. Most larger companies have around-the-clock availability to deal with emergency issues, which would be a benefit due to the mission-critical nature of this equipment. However, any contractor is unlikely to stock unique parts for this equipment, so it will be necessary for the County to have spare parts they can access as needed. This spare parts list can be negotiated with the contractor when they are brought on board.

- Charging-as-a-Service – New companies are entering the market that will offer complete O&M services to keep bus chargers operating at nearly 100% uptime. These companies generally need to be involved in the design and installation of the chargers to offer such a service, and this option can be more expensive than the other two, but the responsibility for ensuring uptime is removed from Anne Arundel Transit and the financial risk of equipment failure falls to a third party. Some of these companies may even purchase the chargers and dispensers and finance the equipment to the County over a more extended period.

8. Study Results and Recommended Next Steps

To ensure a better understanding of the study's results and a smooth Zero-Emission Transition Plan, the following is a concise list of results and recommended next steps:

1. Because the County's goal is to transition its transit fleet to 100 percent zero emissions, lower-emission propulsion types, such as propane, compressed natural gas, and diesel-electric are not recommended. Hydrogen fuel cell vehicles, while a zero-emission technology, are also not recommended, owing to the expense and the challenges of obtaining a reliable source of hydrogen fuel. To achieve a fully zero-emission fleet, the County is advised to plan for battery-electric vehicles.

2. Operating a battery-electric transit fleet also has its challenges, but companies that provide Charging-as-a-Service can help. They provide the engineering, installation and commissioning of charging infrastructure, and maintenance of charging equipment for a monthly fee. Further, through the use of charge management and smart charging software, electricity bills are more predictable, and vehicles are better assured of leaving the depot in the morning with a full state of charge.

3. The County's goal should be to replace existing vehicles on a one-to-one basis with battery-electric buses. However, because some blocks are long and cover many miles in a day, it may not be possible to replace all vehicles in the fleet 1:1 with the current battery technology. One workaround is to install in-route opportunity chargers at two strategic locations: Arundel Mills Mall and the future Parole Transit Center. Another solution is to deploy electric buses on the routes and blocks that are most achievable first and wait until there are significant technology improvements (i.e., larger battery capacities) to transition the remaining scheduled blocks that are longer. The County may choose to take both approaches simultaneously.

4. Plug-in chargers are recommended, as electric cutaways are not compatible with overhead conductive charging at this time. Wireless charging technology exists, but it is less efficient than cords and not widely used. Cord maintenance, bollards, and workforce training are encouraged to protect the County's electric bus infrastructure.

5. Overnight depot charging is the charging scenario that would work best for the County. The parking recommendations by location for the County's future fleet of 88 buses are as follows:

    - Dorsey Road: 39 parking spaces and 39 chargers
    - Millersville Maintenance: 6 parking spaces and 6 chargers
    - Arundel Mills Mall: 5 parking spaces and 5 chargers
    - Riva Road: 26 parking spaces and 26 chargers
    - Truman Commuter Lot or Westfield Mall (future Parole Facility): 15 parking spaces and 15 chargers

6. If fiscal constraints are the main consideration in the selection of a transition scenario, the scenario based on Moderate Technology Improvements with Opportunity Charging would be most optimal, but it would require a shift in the transition timeline to 2036 (the year in which the transition to a zero-emission fleet is 100 percent complete).

7. The cost of this transition scenario is the least costly option: $59.7 million higher than the baseline scenario and averaging $10.7 million per year in total cost. The pricing of vehicles, fuel, and infrastructure should be closely monitored by County staff because the EV market may look much different in 5 years than it does today.

8. Many state and federal funding opportunities exist to help the County defray the cost of the transit fleet to zero-emissions. County staff are encouraged to avail themselves of available grants, rebates, and other funding sources, as shown in the Task 8 report: Funding Strategies.

9. All fleet transition scenarios yield a substantial reduction in greenhouse gas (GHG) emissions, with all scenarios decreasing annual GHG emissions by approximately 50% or above overall and over 70% on a per-vehicle basis compared to the baseline scenario. Emissions released per vehicle is similar for all of the proposed electrification pathways by the end of the fleet transition. However, the “Current Technology with Opportunity Charging” pathway reduces emissions per vehicle at a faster rate between 2026 and 2035 and ultimately ends with a 58% reduction in individual vehicle emissions. By 2040, Scenario 2 and Scenario 3 both have reduced individual vehicle emissions by 63% annually.

Having a comprehensive Zero-Emission Transition Plan in place helps set Anne Arundel County Transit up for success when it is applying for grant assistance down the road. This Plan outlined the context and purpose for a transition plan, the transition timeline, and funding opportunities. It also outlined policy, legislation, and programs that impact relevant technologies, evaluated existing and future facilities (and their relationship to the technology transition), the partnership of the County with the utility or alternative fuel provider, and the impact of the transition on the applicant's current workforce. This Plan can be used as a reference/guide when the County is applying to grants to help fund the transition to a zero-emission fleet.

This ZET Plan is reflective of zero-emission technology as it exists today. The technology is rapidly evolving and would likely improve its performance with the increased acceptance of these vehicles into large fleets. It would be beneficial for Anne Arundel County Transit to review and, if necessary, update this plan every 3 to 5 years, much like a long-range strategic plan. Such a process would help ensure that the agency maximizes the benefits of new technology and the efficiencies it would likely bring.