Zero Emissions Bus Transition Plan

2023-2033

Anne Arundel County
Authored by: Samuel D. Snead
Director of the Office of Transportation

The Smart Way To Get There

Section A Transit Agency Information

1. Transit agency's name Anne Arundel County Office of Transportation
2. Mailing address Number, street: 2664 Riva Road Annapolis MD 21401
3. Name of transit agency's air districts "Central Maryland" Air Quality Management District
4. Name of Transit agency's air basin(s): Baltimore Region
5. Total number of buses in Annual Maximum Service: 47
6. Population of the urbanized area transit agency is serving as last published by the Census Bureau: 588,261
7. Contact information of the general manager, chief operating officer, or equivalent

A: Contact name: Samuel D. Snead

B: Title: Director

C: Phone number: 410.222.3294

D: Email trsnea19@aacounty.org

8. Is your transit agency part of a Joint Group? No

Section B: Rollout Plan General Information

1. Does your transit agency's Rollout Plan have a goal of full transition to zero-emission technologies by 2040 that avoids early retirement of conventional transit buses? Yes.

2. The Maryland Transit Administration regulation requires 100% ZEB purchase in 2030 but currently LOTS are exempt. Anne Arundel County has committed to purchasing only Zero-Emission Buses (ZEB) and Hybrid-Electric Buses (HEB) from 2023 onward. All procurements are planned in corresponding end-of-life years for its historical fleets of diesel and gasoline hybrid buses. Anne Arundel County will begin to purchase Battery Electric Buses (BEB) in 2023 to achieve the duty cycles of longer routes and blocks with larger energy demands than the current Battery Electric Bus (BEB) achievable ranges on the market allow. Transitioning the traditional, non-zero-emission vehicles in service to Hybrid Electric until their natural end of life allows the time to build infrastructure and acquire enough BEBs to support the more demanding routes.

3. When did your transit agency's county executive or governing body approve the Rollout Plan?

a. Rollout Plan is pending Council and/or CE approval

b. Resolution number (optional)

c. Is a copy of the board approved resolution attached to the Rollout Plan submitted to MDOT-MTA? Yes

4. Please provide contact information to follow up on details of the Rollout Plan, if needed.

a. Contact name: Samuel Snead

b. Title: Director, Office of Transportation

c. Phone Number: 410.222.3294

d. Email: trsnea19@aacounty.org

5. Who has created the Rollout Plan? This rollout plan was created by Anne Arundel County Office of Transportation with assistance from the Department of Public Works and the Department of Central Services.

Section C: Technology Portfolio

1. **What type(s) of zero-emission bus technologies does your transit agency plan to deploy through 2040? Anne Arundel County will deploy both BEBs and HEBs.**

   Figure 1 displays the projected procurement schedule that supports a realistic timeline for infrastructure build, considers route achievability, and will not retire any vehicles before their useful life. Anne Arundel County is committed to purchasing Zero Emissions Buses (ZEBs) and transitioning to Hybrid Electric Buses (HEBs) from 2023 onward and retiring non-zero-emission buses at the end of their useful lives, eventually achieving a blended fleet by 2033 with a combination of BEBs and HEBs. BEB purchases are to begin in 2023 to give Anne Arundel County Transit (AACT) time to prepare for receiving and supporting new technology for the agency's operations and maintenance teams. An initial BEB procurement is already planned and in progress. HEB conversions will be covered under operations and maintenance costs.

Figure 1: AACT's Fleet Composition Over 10-Year ZEB Transition Period

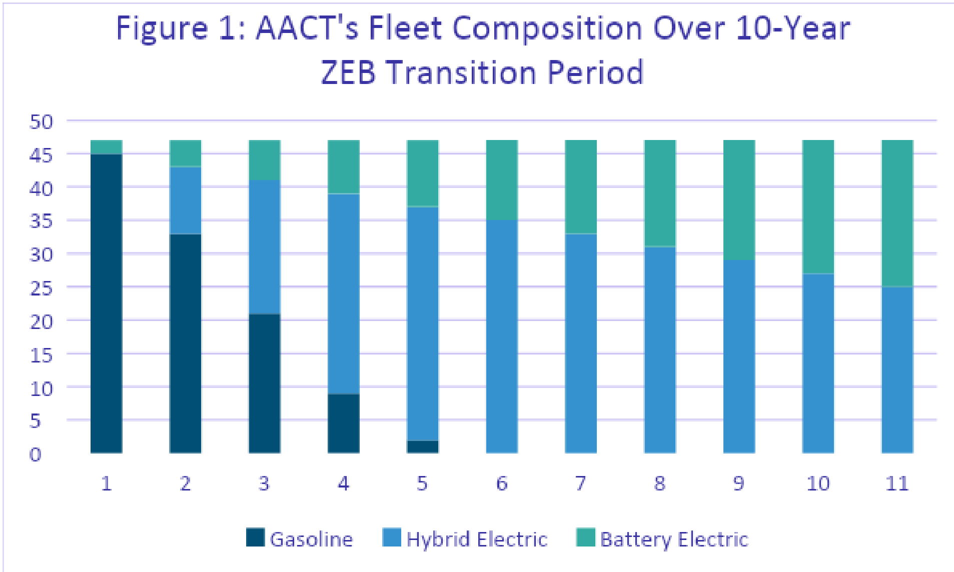


Table 1: AACT's Fleet Composition Over the 10-Year ZEB Transition Period

Timeline (Year)	Cumulative Number of Buses converted to HEB*	Cumulative Number of BEB Buses Purchased	Cumulative Number of Conventional Vehicles
2023	5	2	40
2024	10	4	33
2025	20	6	21
2026	30	8	9
2027	35	10	2
2028	35	12	0
2029	35	14	0
2030	35	16	0
2031	35	18	0
2032	35	20	0
2033	35	22	0

*XL Fleet Conversion of pre-existing gasoline vehicles

Section D: Current Bus Fleet Composition and Future Bus Purchases

Table 2 is representative of the AACT fleet as of the second quarter of 2022. It lists vehicles that are routinely operated in service, as well as a supporting contingency fleet.

Table 2: Individual Bus Information for Current Bus Fleet*

Unit #	Date of Service	Year	Make	# Reg Pass	# W/C Pass	Vehicle License #	Serial Number	Fixed or Paratransit	Mileage
172301	42899	2013	Ford	12	2	34140HT	1FDFE4FL6DDA50867	F	180371
172302	42899	2013	Ford	12	2	34139HT	1FDFE4FL8DDA50868	F	204565
172303	42899	2013	Ford	12	2	34134HT	1FDFE4FLXDDA50869	F/P	170837
172304	42899	2013	Ford	12	2	34132HT	1FDFE4FL6DDA50870	P	173745
172306	42899	2013	Ford	12	2	34143HT	1FDFE4FL2DDA53040	F/P	201395
172307	44360	2013	Ford	12	2	34144HT	1FDFE4FL8DDA53043	P	177965
172310	42899	2013	Ford	12	2	34161HT	1FDFE4FLXDDA53044	F/P	226893
172402	43022	2014	Ford	12	2	41052HT	1FDEE4FL8EDB10368	F	205783
172403	43022	2014	Ford	12	2	41059HT	1FDEE4FLXEDB10369	F	161888
172404	43022	2014	Ford	12	2	41060HT	1FDEE4FL6EDB10370	P	167807
172405	43022	2014	Ford	12	2	41061HT	1FDEE4FL8EDB10371	F	180340
172406	43022	2014	Ford	12	2	41062HT	1FDEE4FLXEDB10372	F/P	205208
172505	42781	2015	Ford	12	2	41625HT	1FDEE4FLXFDA19880	F	171026
172506	42781	2015	Ford	12	2	41626HT	1FDEE4FL1FDA19881	F	210502
172507	42781	2015	Ford	12	2	41627HT	1FDEE4FL3FDA19882	P	176893
172508	42781	2015	Ford	12	2	41628HT	1FDEE4FL5FDA19883	F	169120
172712	44425	2017	Ford	12	2	60987HT	1FDFE4FS6HDC57286	P	84057
172713	44425	2017	Ford	12	2	60986 HT	1FDFE4FS4HDC57285	F/P	141441
172714	44425	2017	Ford	12	2	60985 HT	1FDFE4FS2HDC57284	F/P	115579
172715	44425	2017	Ford	12	2	60930HT	1FDFE4FS9HDC57279	P	82894
172716	44425	2017	Ford	12	2	60929-HT	1FDFE4FS0HHDC57283	F/P	134052
172717	44425	2017	Ford	12	2	64327-HT	1FDFE4FS7HDC57281	F	110951
172718	44425	2017	Ford	12	2	64328HT	1FDFE4FS7HDC57282	P	96989
172806	44487	2018	Ford	12	2	12635LG	1FBZX2CM4JKB15899	P	39351
172807	44487	2018	Ford	12	2	12634LG	1FBZX2CM9JKB06793	P	67415
172808	44487	2018	Ford	12	2	12636LG	1FBZX2CM8JKB15906	P	58929
172900	44305	2019	Ford	12	2	68503HT	1FDFE4FS6KDC17668	P	54187
172901	44305	2019	Ford	12	2	68504HT	1FDFE4FS8KDC17667	P	58023
172902	44305	2019	Ford	12	2	68501HT	1FDFE4FS4KDC17666	P	54962

172903	44305	2019	Ford	12	2	68500HT	1FDFE4FSXKDC176669	P	50881
172904	44305	2019	Ford	12	2	68505HT	1FDFE4FS6KDC17670	P	51020
172910	44459	2019	Ford	12	2	77232HT	1FDEE4F63KDC75430	P	16994
172911	44459	2019	Ford	12	2	77237HT	1FDEE4F61KDC71425	P	22592
172912	44397	2019	Ford	26	2	77227HT	1FDAF5GY8KEG59599	F	27183
172913	44397	2019	Ford	26	2	77226HT	1FDAF5GT9KEF90586	F	5167
172914	44397	2019	Ford	26	2	77225HT	1FDAF5GT9KEF90585	F	15131
172915	44276	2019	Ford	26	2	79808HT	1FDAF5GY1KEG59590	F	3181
172916	44276	2019	Ford	26	2	79807HT	1FDAF5GY5KDA27777	F	1343
172917	44276	2019	Ford	26	2	79806HT	1FDAF5GY6KEG59598	F	7383
172101	44490	2021	Ford	12	2	80176HT	1FDEE4FK0MDC07196	P	5136
172102	44490	2021	Ford	12	2	76949HT	1FDEE4FK8MDC17541	P	10885
172103	44490	2021	Ford	12	2	80175HT	1FDEE4FKXMDC17542	P	4599
172104	44490	2021	Ford	12	2	76948HT	1FDEE4FK1MDC17543	P	4872
499221	44488	2017	Ford	16	2	08706LG	1FDFE4FS4HDC51339	F	97422
499222	44488	2017	Ford	16	2	08705LG	1FDFE4FS0HDC51340	F	124186
499223	44488	2017	Ford	16	2	08704LG	1FDFE4FS2HDC51341	F	118228
499224	44488	2017	Ford	16	2	08703LG	1DFE4FS9HDC52728	F	125482
498200	44490	2021	International	20	2			F	2482
								Total	4693278

*All gasoline powered vehicles

**Highlighted cells are eligible for conversion. Those not highlighted will be retired after useful life is achieved or replaced with HEB or BEB vehicles.

Table 3: AACT Projected Annual (Cumulative %) Bus BEB and HEB Procurement Details

Timeline (Year)	Annual HEB Conversions	Annual BEB Purchases*	Percentage BEB Purchases	Percentage HEB Conversions
2023	5	2	100%	0%
2024	10	2	29%	71%
2025	10	2	23%	77%
2026	10	2	21%	79%
2027	5	2	22%	78%
2028	0	2	26%	74%
2029	0	2	30%	70%
2030	0	2	34%	66%
2031	0	2	38%	62%
2032	0	2	43%	57%
2033	0	2	47%	53%

*Optimal-EV's S1LF will feature a battery system from Proterra, featuring 113 kWh of energy capacity and over 125 miles of driving range. The vehicle can charge in about two hours with optional DC fast charging.

Figure 2: AACT's Projected Bus Procurements & Conversions

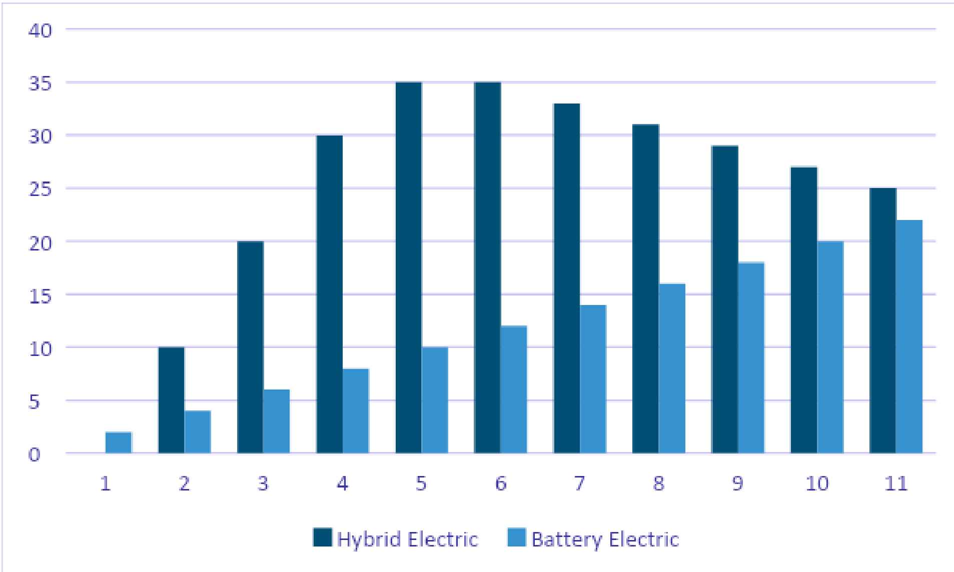


Table 3: Verifying Block Achievability Throughout Fleet Transition

Timeline (Year)	Number of HEBs in Fleet	Number of BEBs in Fleet	Total Number of Buses in Fleet	Proportion of BEBs in Fleet	Proportion of HEBs in Fleet	Proportion of BEB Achievable Blocks*
2023	5	2	47	11%	4%	60%
2024	10	4	47	21%	9%	63%
2025	20	6	47	43%	13%	66%
2026	30	8	47	64%	17%	69%
2027	35	10	47	74%	21%	73%
2028	35	12	47	74%	26%	77%
2029	35	14	49	71%	29%	80%
2030	35	16	51	69%	31%	84%
2031	35	18	53	66%	34%	89%
2032	35	20	55	64%	36%	93%
2033	35	22	57	61%	39%	98%

*A block is considered achievable if the strenuous energy requirements for the block are within the average degraded services capacity (72% of total capacity) of onboard battery storage. The estimated total battery capacity for 2023 is 450kWh and is expected to improve by 5% every two years. This chart does not include 24-hr contingency vehicles.

Table 4: Estimated Costs of Future ZEB Purchases

	26.6' BEB	Various Models
Optimal EV S1 Low Floor Bus	$ 293,000	
Ford E-Transit	$ 100,000	
XL Fleet Conversion Kit		$ 16,125
Tax	$ 17,580.00	$ 967.50
Estimated Total	$ 310,580.00	$ 17,092.50

*Steady state pricing is assumed for modeling purposes. The general expectation is that BEB prices will remain steady, but FCEB prices will fall, although there is not enough information to make a confident projection in future pricing.

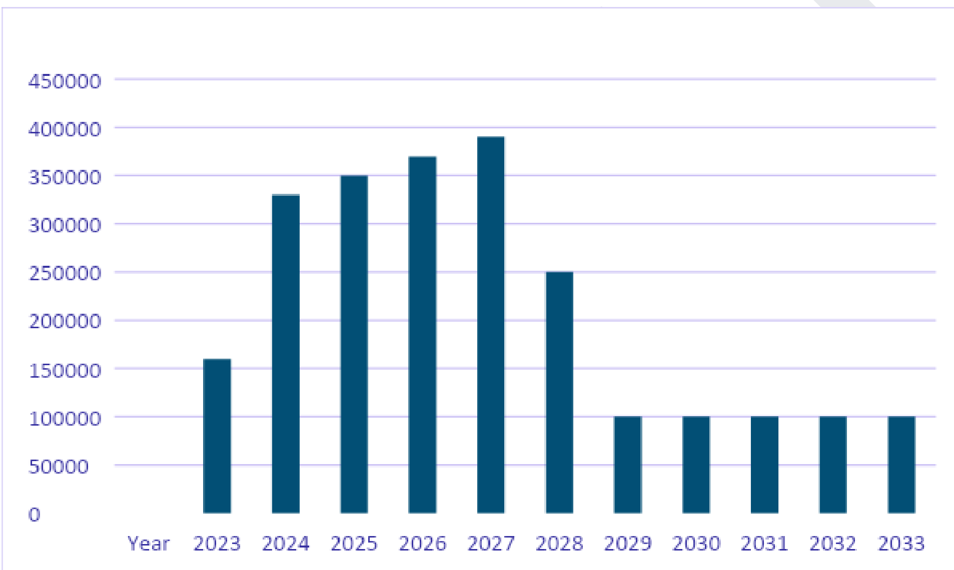
4. Is your transit agency considering converting some of the conventional buses in service to zero-emission or hybrid-electric buses? Yes

Section E: Facilities and Infrastructure Modifications

Figure 3 reflects the anticipated infrastructure builds required to accommodate AACT's fleet electrification. The initial infrastructure builds correspond to the Figure 2 procurement schedule: AACT Site 1 (7409 B&A Boulevard) will act as a BEB division with depot charging only to support the new BEBs in the fleet. Additional sites are pending approval by department of central services and MDOT-MTA. Integration of charging infrastructure at Odenton MARC station and the future Parole Transit Center are included within the initial conceptual design plans.

An assumption of $150,000 is expended for infrastructure implementation for INRUSH Amply Container charging with the capability to charge up to five vehicles. Traditional or containerized charging infrastructure is approximately $30,000 per charger based on AMPLY development and install. This also includes an annual cost of $2,000 per vehicle (or $10,000 per charging container) to utilize their software as a service which manages charging and deployment of vehicles. Depot BEB infrastructure costs include: design, construction and equipment installation costs. Figure 3 timeline and the related procurement of the vehicles that require the build.

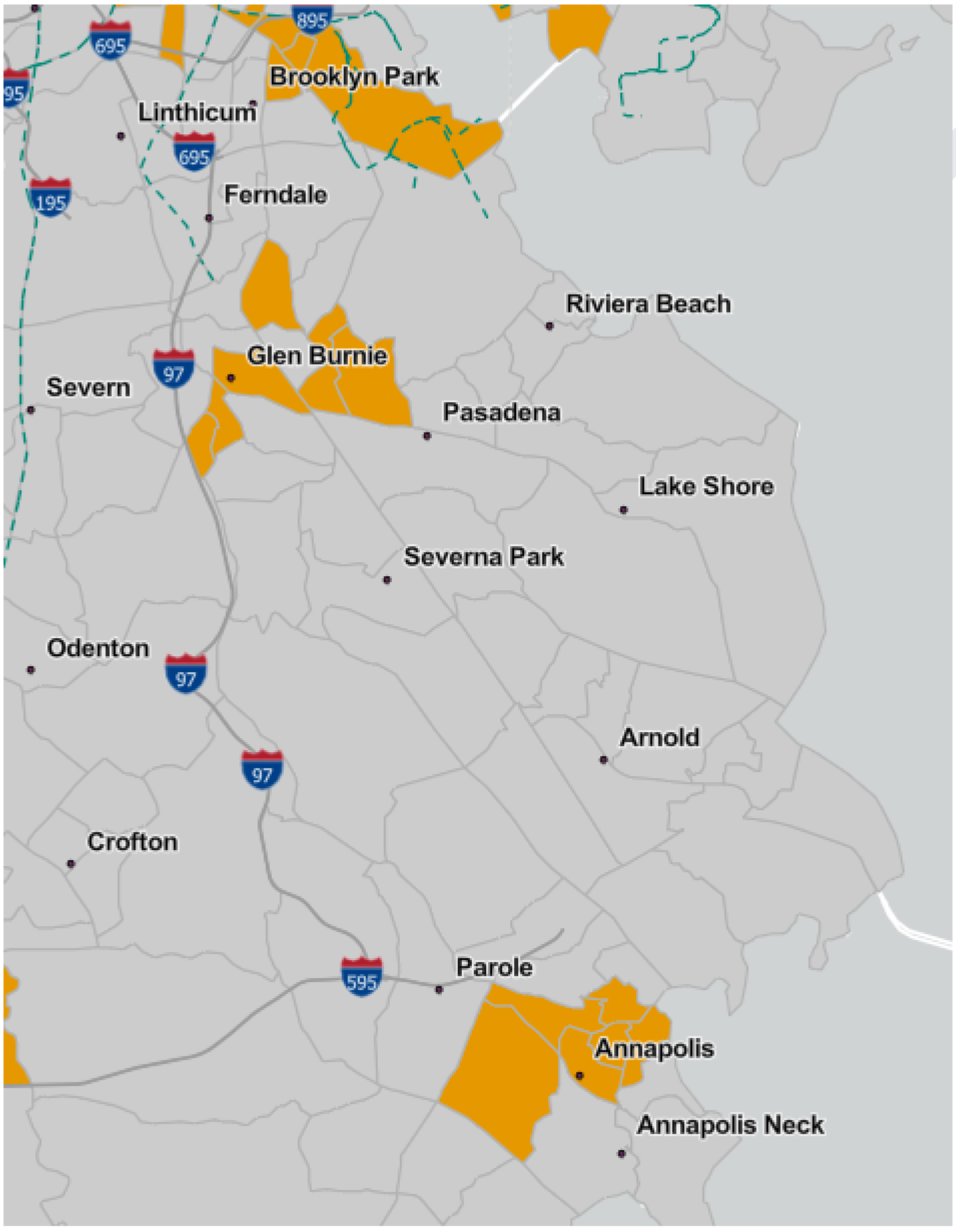
Figure 3: AACT's Estimated Annual Infrastructure Costs



Section F: Providing Service in Disadvantaged Communities

Does your transit agency serve one or more disadvantaged communities, as listed in the latest version of USDOT's Areas of Persistent Poverty? Yes.

Figure 4: Areas of Persistent Poverty Anne Arundel County



If yes, please describe how your transit agency is planning to deploy zero-emission buses in disadvantaged communities.

AACT provides service to 16 census tracts located in Brooklyn Park, Glen Burnie and Annapolis areas. Every one of AACT's routes provide connectivity to and from these communities.

AACT's planned full-fleet electrification will occur in 2033, therefore operating ZEBs in all APP communities. Due to the difficulty in assigning specific future bus procurements to routes, and with respect to AACT's needs to frequently arrange and adapt service, the Expected Year of First ZEB Deployment is indicative of when AACT expects to deploy and house ZEBs from and in each of their divisions. AACT Site 1 (7409 B&A Boulevard) will house BEBs and operate as a BEB division and to expand infrastructure with the fleet.

Therefore, routes served by vehicles from AACT Site 1 will see ZEB deployments in 2021 initially. AACT Site 2 (Veteran's Highway Millersville Facility) will also function as a depot to house vehicles. The purchasing and build of this infrastructure will occur at a later time; thus, routes primarily operated out of AACT Site 2 will begin to be served by HEBs in 2025. AACT's entire fleet will be electric or hybrid electric by 2033, which means all areas will benefit from service of ZEBs no later than 2033 and likely sooner. A map of AACT routes, can be found in Appendix A.

Section G: Workforce Training

1. Please describe your transit agency's plan and schedule for the training of bus operators and maintenance and repair staff on zero-emission bus technologies

AACT will implement a number of training programs attended by AACT bus operators, mechanics, utility maintenance workers, and supervisors on an annual basis, including new operator training and AACT's and any state mandated training by MDOT-MTA. These trainings are provided by experienced AACT staff. Additionally, manufacturers of the ZEB equipment such as the bus, charge management software, and charging equipment can provide training, including train-the-trainer courses, as it is often included in the procurement contract. The maintenance and operating staff have also participated in trainings

AACT's training courses include Operator Refresher Training, New Operator Training, Bus Familiarization, and Bus Refresher Training. The annual training programs reach approximately 52 operators, supervisors and on-site contractors in the department.

In the Maintenance divisions, annual trainings prepare mechanics, utility personnel, Maintenance Supervisors, two Utility Supervisors, three Quality Assurance Specialists, and the Fleet Maintenance Managers. These trainings encompass all propulsion technologies at Gas Hybrid, Diesel, and Battery Electric.

The in-house curriculum will include new bus Training, which incorporates pre-trip inspections, door operations, emergency equipment operations, steering, operational concerns, MVA pre trip, bus components, and other portions of the bus functions and operations across bus technologies. Maintenance trainings are also an imperative element of the bumper to bumper technical training curriculum for mechanics, utility workers, and supervisors that focus on preventive maintenance requirements, hazards related to high voltage, personal protective equipment as required, component training and charging and fueling source training. These curricula take approximately three weeks to develop. Curricula generally includes a train-the-trainer mechanism of generational experiential learning within the organization and takes approximately two and one-half months to reach all necessary personnel at AACT. Each session is approximately four hours, with two sessions per day for roughly four to six employees per session. Operators train to drive the ZEB buses for at least one hour, in addition to completing the content training courses which cover standard operating procedures: braking, steering, turns, bus inspections, pre-trip inspections, farebox operations, fare structure, fare media, and aiding customers with disabilities and their mobility devices. For newly hired AACT employees, there are additional standard on-boarding trainings: Civil Rights programs, such as Limited English Proficiency (LEP), ensuring meaningful access to AACT programs and services by LEP persons for whom English is not the primary language and who may have limited ability to read, speak, write or understand English; Americans with Disabilities Act (ADA) of 1990, ensuring access to AACT programs and services by persons with disabilities; Title VI, ensuring compliance with Title VI Act of the Civil Rights Act of 1964 which prohibits discrimination on the grounds of race, color, or national origin; also Title VII Equal Employment Opportunity (EEO), providing EEO for all employees regardless of race, color, religion, sex, sexual orientation, age, national origin, ancestry, mental or physical disability, veteran status, marital status, pregnancy, genetic information, or any other protected category. The aforementioned training curricula will be implemented across the organizations and will reach all necessary AACT staff annually at minimum and likely more frequently.

Section H: Potential Funding Sources

Please identify all potential funding sources your transit agency expects to use to acquire zero-emission technologies (both vehicles and infrastructure)

AACT is prepared to pursue federal grants through the following funding programs: Federal Transit Administration's (FTA) Urbanized Area Formula program, as well as discretionary grant programs such as the Bus and Bus Facilities (B&BF) program, Low or No Emission Vehicle Deployment Program (LowNo), and RAISE grant, as well as other available federal discretionary grant programs.

AACT will also seek funding from state resources through grant opportunities including, but not limited to MDOT-MTA and MEV. Additionally, AACT will utilize county budget resources to support zero-emission bus deployment such as the Capital Improvement Program. While the aforementioned funding opportunities are mentioned by name, AACT will not be limited to these sources only and will regularly assess opportunities for fiscal support for the ZEB program.

Section I: Start-up and Scale-up Challenges

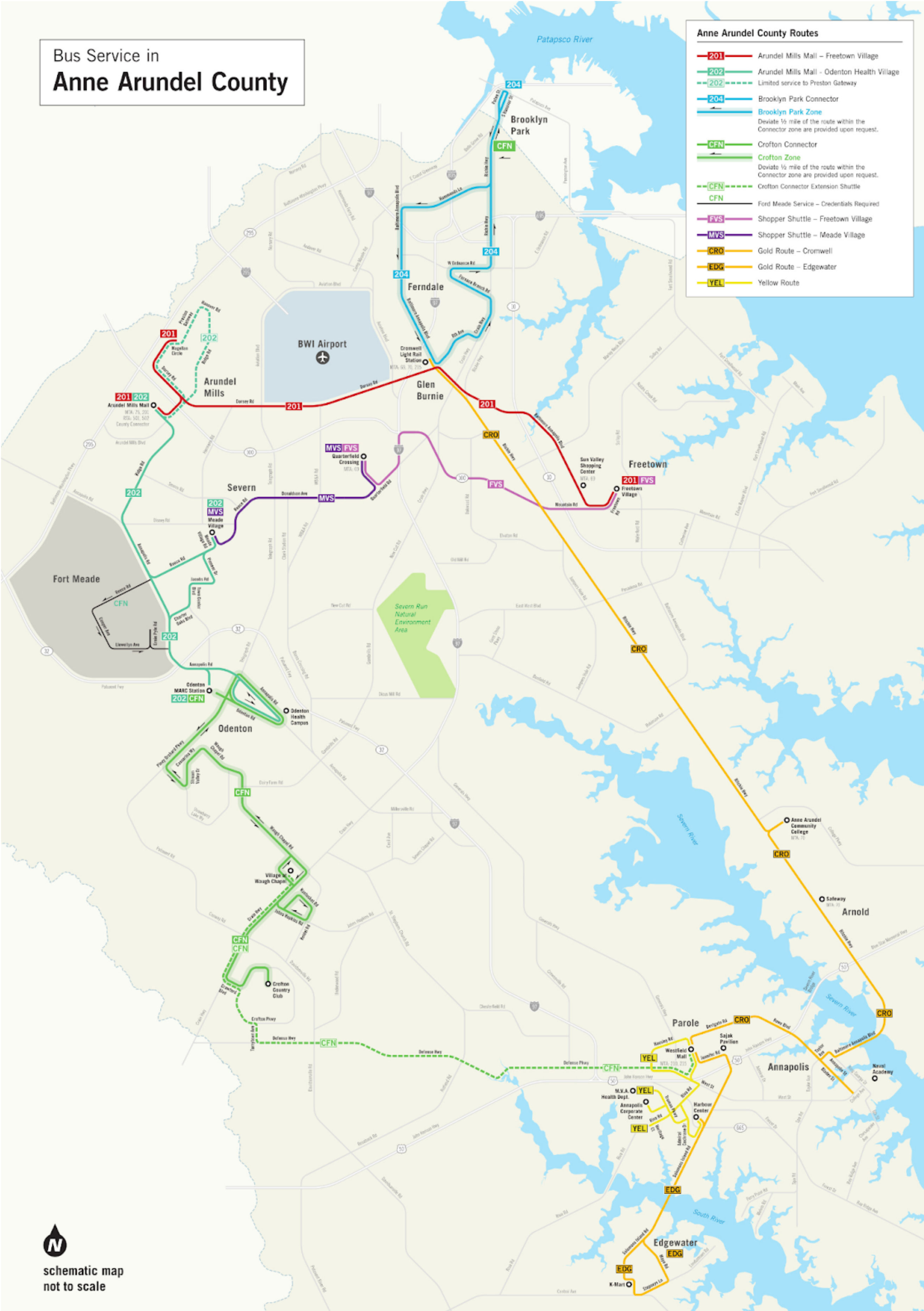
Currently, AACT is not facing nor does it anticipate any major challenges to ZEB deployment. As long as sufficient real-estate for charging fleet as well as support from the local utilities, moving forward will be feasible. As mentioned previously in order to monitor performance, an ideal solution for real-time monitoring of the BEBs, scheduling and managing depot charging, and collecting detailed data for analysis is vital. Without said system we will face challenges for the evaluation and operation of the BEB/HEB fleet.

AACT's scaled approach with its initial deployment will position the agency to manage continued successful ZEB deployments, and AACT does not anticipate any major challenges in upcoming deployments.

Challenges can arise with any new propulsion technology, its corresponding infrastructure, or in training operators and maintenance staff. These challenges are overcome through a combination of OEM offered trainings, as well as other educational avenues such as conferences, technical school programs, and agency collaboration. Financial support for educating the workforce on the deployment of these vehicles is under supported, however.

Additionally, the current market cost of ZEBs is between $293,000 and $1,200,000, which is about $250,000 to $700,000 more costly than traditional diesel buses. AACT will seek continued financial support to cover the incremental cost of ZEBs. The fueling infrastructure requirements for ZEB technology along with the construction required for installation also have an additional cost. Continued support for the capital cost of infrastructure required to deploy ZEB technology is imperative for the success of these technologies. Scaled economy of these alternative fuels and subsidized or negotiated rates for electric vehicles by state utilities will also aid in the affordability of large-scale electrification. Notably, utility compliance and infrastructure to support newly heightened energy demands at agency's maintenance divisions for stations and charging must be achieved. Often, the existing electrical infrastructure cannot support larger energy demands associated with powering an electric fleet or a station, and projects must include the installation of new 12kV switchgears and/or new transformers. Another limitation of the ZEB fleet transition is the state of industry technology available to accomplish service requirements for a transit agency's entire route duty cycles. This is mitigated through the utilizations of technical consultants and smart deployments.

Appendix A: AACT Service Map



Bus Service in
Anne Arundel County
Anne Arundel County Routes
201 Arundel Mills Mall – Freetown Village
202 Arundel Mills Mall - Odenton Health Village
202 Limited service to Preston Gateway
204 Brooklyn Park Connector
Brooklyn Park Zone
Deviate ½ mile of the route within the Connector zone are provided upon request.
CFN Crofton Connector
Crofton Zone
Deviate ½ mile of the route within the Connector zone are provided upon request.
CFN Crofton Connector Extension Shuttle
CFN Ford Meade Service – Credentials Required
FVS Shopper Shuttle – Freetown Village
MVS Shopper Shuttle – Meade Village
CRO Gold Route – Cromwell
EDG Gold Route – Edgewater
YEL Yellow Route
Patapsco River
Brooklyn Park
Ferndale
BWI Airport
Arundel Mills
Glen Burnie
Freetown
Severn
Fort Meade
Severn Run Natural Environment Area
Odenton
Severn River
Arnold
Parole
Annapolis
South River
Edgewater
schematic map
not to scale

Appendix B: Containerized Charging Station

AMPLY POWER

Fleet Charging Simplified

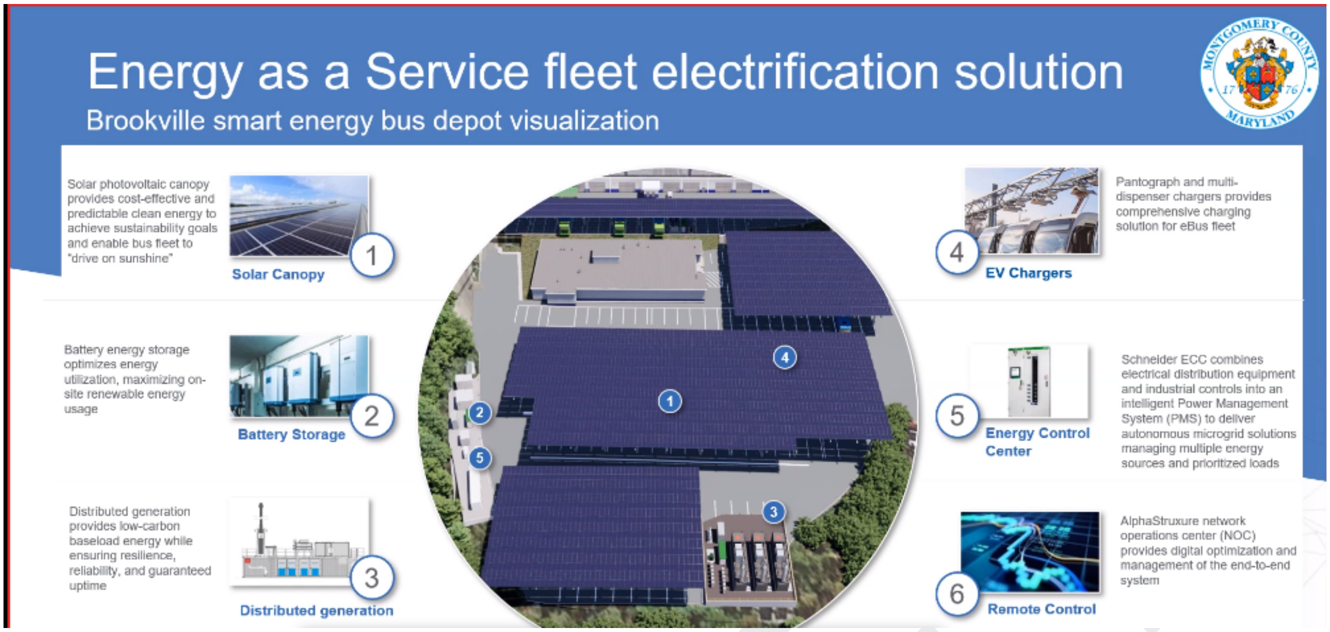
Flexible EV Infrastructure Anywhere

As an alternative to permanent infrastructure, AMPLY's INRUSH solution upcycles shipping containers to support five charging stations in a portable capsule. Assembly occurs off-site, minimizing impact to your existing operations, and can happen in parallel to any necessary utility planning. Ready to move your INRUSH equipment? Site restoration is easy, as all related electrical switchgear is housed inside your container.

Saving Half the Cost in Half the Time

In addition to site adaptability, AMPLY's INRUSH solution accommodates accelerated implementation timelines. With INRUSH, you can typically **deploy portable EVSE** for your fleet **within six months** of initial project start – half the time of traditional infrastructure installation estimates. Design, procurement, and installation of your INRUSH solution can also provide up to **50% in savings** compared to the cost of installing conventional, permanent EV charging infrastructure. INRUSH is supported by AMPLY's OMEGA Charge Management System and technical services to ensure charging operations are optimized and cost-effective.

Appendix C: MicroGrid Montgomery County



Appendix D: Overhead of Current 7409 B&A Facility (Site 1)

Appendix E: Overhead of Mixed Facility on Veterans Highway in Millersville (Site 2)