Western Reserve Transit Authority

Zero Emission Transition Plan

Report 4 of 4

FINAL DRAFT

DELTA | DEVELOPMENT | GROUP
INC.

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EXECUTIVE SUMMARY

Western Reserve Transit Authority's (WRTA) vision is to support environmentally sustainable initiatives by converting its fleet from fuel to 100 percent electric over the next 10 years. Initiatives described in WRTA's Zero Emission Transition Plan (the Plan) reduce greenhouse gas emissions, advance equity, maintain and create good-paying jobs with a free and fair choice to join a union, and connect communities.

To accomplish this transition by 2031, WRTA intends to replace vehicles at the expiration of their useful life with battery electric buses and electric support vehicles with associated charging equipment at the Authority's headquarter and future hubs. The Plan is based on a strategic approach that enables WRTA to utilize the current fleet through its useful life while simultaneously replacing aged vehicles with electric vehicles (EVs). This process allows WRTA to gradually introduce EVs into communities throughout its service area and prepare its workforce for the transition. This methodical launch also enables WRTA to modify its Plan as EV technologies change or emerge and adjust its transit services to meet the community's needs.

The cost of EVs is significantly higher, based on 2022 prices, than diesel-fuel vehicles. Procuring and deploying EVs gradually over the next 10-years results in about $51 million more in expenditures than standard diesel-fuel vehicles. Plus, EV equipment, infrastructure, training and hiring additional employees to support EV infrastructure and service plan costs about $28 million more. These capital and operating costs, however, are offset by a minimum of $11 million in savings from fuel, emissions, and maintenance over the same period not to mention other benefits like a cleaner environment, social equity, job creation, and modernization.

WRTA's vision and objective, therefore, is to transition to EVs and resultant zero emission because the benefits in the long-term outweigh the costs and EV technology is advancing and continually being refined.

- Actual costs of EVs, chargers and equipment are expected to decline.
- As technology evolves, the distance a vehicle can travel will increase resulting in reduction of the number of EVs needed to operate the service.
- Based on current trends, diesel fuel costs are anticipated to significantly increase; and
- Revenue can be generated by WRTA selling electricity back to the utility company.

This Plan is an active document that WRTA will update annually to adjust for emerging EV technologies. It is projected that the long-term costs of purchasing, operating, and maintaining EVs will ultimately be more cost efficient than diesel buses. Diesel emissions have a significant negative impact of the environment and health of residents particularly underserved populations. WRTA, by transitioning to 100 percent EVs, will be able to provide clean, equitable, and sustainable public transportation services without negatively impacting the environment or the communities and residents it serves.

INTRODUCTION

This Zero Emission Transition Plan (Plan) was developed for WRTA to transition to 100 percent electric vehicles (EV) by 2031. This is a final report summarizing the Plan which is supported by three in-depth reports (Baseline Conditions Report, Impact Analysis Report, Feasibility Analysis Report).

WRTA is committed to providing environmentally friendly public transit services to the communities it serves. To support President Biden's goal for the United States to achieve a 50-52 percent reduction in greenhouse gas (GHG) pollution in 2030, WRTA signed the Federal Transit Administration's (FTA) Sustainable Transit for a Healthy Planet Challenge Pledge.

The purpose of this Plan is to effectively guide WRTA's procurements to transition its entire fleet to electric vehicle (EVs) by 2031. The Authority is committed to reducing emissions; procuring EVs and charging stations are part of its long-range plan.

This Plan enables WRTA to achieve its mission – "to provide safe, secure, equitable, reliable, affordable, environmentally conscious, and sustainable public transit services to meet the needs of the communities WRTA serves." This Plan was developed to achieve the Authority's strategic goal to "reduce energy consumption, reduce harmful emissions and reduce direct carbon emissions" by replacing WRTA's entire fleet at the end of their useful life with zero emission vehicles by 2031. EVs are included in the Metropolitan Planning Organization's (Eastgate), Transportation Improvement Program.

Talks have been initiated and are ongoing with Ohio Edison (WRTA's electric provider), an energy consultant and Eastgate. These partners are supportive of WRTA's strategic goal.

EVs deployed in underserved or disadvantaged communities can provide focused environmental benefits by reducing harmful GHG emissions. WRTA's service area includes severely disadvantaged census tracts according to the Climate and Economic Justice Screening Tool supported by the Council on Environmental Quality.

WRTA's mission to provide safe reliable public transportation also includes the responsibility to preserve the environment. As an advocate of green initiatives, WRTA explores opportunities to support environmentally friendly vehicles, technology, and facilities.

In addition to supporting FTA's Sustainable Transit for a Healthy Planet Challenge Pledge, WRTA has implemented other environmentally sustainable initiatives.

- April 2022 procured two non-revenue electric vehicles *(Ford Mustang Mach E)*.
- Expects delivery in April 2023 of one Sunsetter electric light transit vehicle.
- Working with CALSTART *(a leading organization that fosters clean transportation initiatives)*.
- Expects delivery in April 2023 of a GreenPower electric vehicle for an autonomous project *(Enhancing Life with Automated Transportation for Everyone or "ELATE")* in downtown Youngstown.
- 2024 delivery of a second automated electric vehicle that will be deployed in downtown Youngstown.
    - WRTA is part of a team with Eastgate Regional Council of Governments, Mercy Health, Western Reserve Port Authority, Young State University and Youngstown Warren Regional Chamber that is bringing this project to Youngstown as part of BUILD grant.
- Three public charging stations *(six ports)* were installed and are operating at WRTA's administrative offices and maintenance facilities approximately one mile from downtown Youngstown.

- Funding is in place for WRTA to issue a procurement for an all-electric paratransit bus.
- Procuring a private level two *(higher output and faster charge than level one)* charging station that will be stored in WRTA's bus maintenance facility.
- Requesting funds for upgrading WRTA's maintenance facility (bus barn), which includes a complete make over, five charging stations with 10 ports and ability to add charging stations and solar panels for renewable energy source.
- Obtained state funds for a solar canopy over WRTA's parking area that will reduce energy costs.

WRTA's Plan is consistent and supports its Transit Development Plan strategic goal ""To provide a transit system that is economically efficient and environmentally friendly." It also supports regional and local initiatives such as The Power a Clean Future Ohio (PCFO), which the cities of Youngstown and Warren *(location of WRTA's two hubs)* joined to foster clean communities and reduce GHGs.

ABOUT WRTA

WRTA is a regional transit agency headquartered in Youngstown, Ohio and provides fixed route and shared ride public transportation services in Mahoning and Trumbull counties. WRTA has two facilities. Its headquarters consists of administration/maintenance and a bus barn. Located less than one-half mile away, is Federal Station, a passenger transfer hub where most of WRTA's fixed routes begin and end.

MISSION

TO PROVIDE SAFE, SECURE, EQUITABLE, RELIABLE, AFFORDABLE, ENVIRONMENTALLY CONSCIOUS, AND SUSTAINABLE PUBLIC TRANSIT SERVICES TO MEET THE NEEDS OF THE COMMUNITIES WRTA SERVES.

STRATEGIC GOAL

REDUCE ENERGY CONSUMPTION, REDUCE HARMFUL EMISSIONS AND REDUCE DIRECT CARBON EMISSIONS BY REPLACING WRTA'S ENTIRE FLEET BY 2031 AT THE END OF THEIR USEFUL LIFE WITH ZERO EMISSION VEHICLES.

WRTA's mission to provide safe reliable public transportation also includes the responsibility to preserve the environment. As an advocate of green initiatives, WRTA explores opportunities to support friendly vehicles, technology, and facilities.

SERVICE

Annually, WRTA transports over 900,000 riders and operates 1.7 million revenue vehicle miles. Service as it is currently operated is the baseline of WRTA's zero emission plan. WRTA has 28 fixed routes, 19 primarily operate in Mahoning County, one route operates between Mahoning and Trumbull counties, seven fixed routes dedicated to Trumbull County and one route serving the City of Akron in Summit County. Demonstration funds enabled WRTA to initiate and operate those seven routes entirely in Trumbull County. There are an additional six routes that operate partially in Trumbull County: four routes (1, 6, 10 and 14) operate from downtown Youngstown to destinations in Liberty Township, Trumbull County; and two routes, 28 and 80, are express routes that also operate into Trumbull County. Express route 81 provides service between City of Youngstown and Akron, Ohio. WRTA leases and maintains vehicles to Youngstown State University (YSU), which plans and operates its own service. *(The service section of this report excludes YSU services.)*

In Mahoning County, WRTA operates fixed route, ADA paratransit and Countywide service on weekdays and Saturdays. Late night on weekdays, a shared-ride service is available. Currently, Trumbull County service operates on weekdays and includes fixed route and ADA paratransit.

In addition to fixed route, WRTA operates three types of shared ride services: ADA All-Access, Countywide and Late-Night Service.

- ADA All-Access is door-to-door advanced reservation shared ride transportation service available to senior citizens *(65 and over)* and certified ADA disabled customers who are travelling within ¾-mile of WRTA's routes and unable to utilize fixed-route services.
- Countywide is curb-to-curb 24-hour advanced reservation shared ride transportation service that is available to destinations throughout Mahoning County.
- Late night is WRTA's new scheduled curb-to-curb service requiring a minimum of 24-hour advanced reservation that runs between 9:15 pm and midnight Monday through Friday in Mahoning County. Using Late Night, customers can travel to any destination that is within the areas served by WRTA's Mahoning County fixed routes. Late night picks up passengers at their home or other locations and takes them anywhere within these areas.

Table 1 summarizes routes, hours, miles, and peak vehicles for WRTA's fixed route service by county and Table 2 depicts annual ridership for each route.

TABLE 1: WRTA WEEKDAY AND SATURDAY FIXED ROUTE SERVICE SUMMARY

	NUMBER OF ROUTES	REVENUE HOURS	VEHICLE HOURS	REVENUE MILES	VEHICLE MILES	PEAK VEHICLES
BASE ROUTES						
MAHONING COUNTY	21	316.93	393.15	6,413.39	6,507.40	26
TRUMBULL COUNTY	6	28.55	40.29	567.32	866.22	6
LIMITED/PEAK SERVICE ROUTES						
MAHONING COUNTY	2	9.00	12.94	377.33	379.83	2
TRUMBULL COUNTY	1	2.80	5.02	94.48	172.78	1
TOTAL						
MAHONING COUNTY	23	325.93	406.09	6790.72	6887.23	28
TRUMBULL COUNTY	7	31.35	45.31	661.8	1039	7
GRAND TOTAL:	**30**	**357.28**	**451.4**	**7452.52**	**7926.23**	**35**
SATURDAY FIXED ROUTE SERVICE SUMMARY						
	Number of Routes	**Revenue Hours**	**Vehicle Hours**	**Revenue Miles**	**Vehicle Miles**	**Peak Vehicles**
BASE ROUTES						
MAHONING COUNTY	21	217.59	279.45	4361.51	4643.08	24

TABLE 2: CALENDAR YEAR 2021 RIDERSHIP BY ROUTE

ROUTE NUMBER	ROUTE NAME	RIDERSHIP	ROUTE NUMBER	ROUTE NAME	RIDERSHIP
1	Elm	34,140	**25**	Boardman/Canfield Loop	6,961
2	Oak	55,606	**26**	Boardman East Loop	9,784
3	Wilson	16,243	**27**	Austintown Loop	5,766
4	Steel	37,232	**28**	Warren Express	60,624
5	South	70,381	**70**	Southeast	2,767
6	Fifth	36,802	**71**	North	598
7	Glenwood	56,878	**72**	Southwest	5,873
8	Market	125,370	**73**	East	762
9	Austintown	65,791	**74**	Elm	7,606
10	Belmont	113,117	**75**	Northwest	5,717
11	Cornersburg	19,876	**76**	North Jackson Express	0
12	Albert	20,015	**80**	Lordstown	1,308
13	McGuffey	37,156	**81**	Akron Express	33
14	Mosier	17,333		Other	1,562
15	Struthers	20,469		Shared Ride	24,554
16	Buckeye	21,554		Countrywide	11,577
24	Midlothian Loop	7,856		**GRAND TOTAL:**	**901,311**

TRANSIT ASSETS

This section summarizes WRTA's transit assets derived from the Authority's Calendar Year 2022 Transit Asset Management Plan (TAM Plan). The TAM Plan follows FTA's final rule *(e 49 CFR Parts 625 and 630) and*, for the asset condition, it uses the Ohio Public Transportation Facilities and Equipment Management System (PTMS) scale of condition.

WRTA's Zero Emissions Transition Plan focuses on three primary assets *(rolling stock, equipment, and facilities)* which is summarized in Table 3. Table 4 summarizes the useful life classifications its vehicles.

TABLE 3: ASSET INVENTORY

ROLLING STOCK, EQUIPMENT AND FACILITIES ASSETS	
ASSET	TOTAL
ROLLING STOCK	
Rolling Stock	**TOTAL**
Heavy Duty Bus	46
Modified Minivan	6
Light Transit Vehicle (LTV)	25
Support Vehicles	12
TOTAL:	**89**
EQUIPMENT	
In-Ground Lifts	8
Fare Collection	1
ITS, Avail, Technology	1
Wash Racks	1
TOTAL:	**11**
FACILITIES	
Administration/Maintenance	1
Passenger Transfer Station	1
TOTAL:	**2**

SOURCES: *WRTA's Calendar Year 2022 Transit Asset Management Plan and Delta Development Analysis*

TABLE 4: USEFUL LIFE CLASSIFICATIONS

ASSET CODE	VEHICLE OR EQUIPMENT DESCRIPTION	USEFUL LIFE (YEARS)
B35-HD	Heavy Duty Bus ≥ 35'	12
LTV	Light Transit Vehicles	6
MMV	Modified Minivan	5
Support	Service Support Vehicles (non-revenue)	8

SOURCE: *WRTA's Calendar Year 2022 Transit Asset Management Plan*

WRTA has targets for its asset categories consistent with FTA's requirements. The FTA measures state of good repair (State of Good Repair Programs | FTA (dot.gov)) using age for rolling stock and equipment. The Transit Economic Requirements Model (TERM) is used for facilities requirements. TERM's five-point scale is a numerical rating of the condition of the asset (1 (Excellent) to 5 (Insufficient). Table 5 summarizes WRTA's assets and conditions. "Facilities" has the highest average value ($2.9 million) and 33 percent of WRTA's assets are at or above useful life.

TABLE 5: ASSET INVENTORY AND CONDITION SUMMARY

ASSET CATEGORY	TOTAL NUMBER	AVERAGE AGE (YEARS)	AVERAGE VALUE	AVERAGE CONDITION RATING	% AT OR PAST ULB
ROLLING STOCK	93	5	$162,862	4.0	24%
EQUIPMENT	12	10	$569,167	3.7	0%
FACILITIES	3	36	$2,935,924	3.8	33%

SOURCE: *WRTA's Calendar Year 2022 Transit Asset Management Plan*

WRTA has two facilities. Its headquarters in Youngstown, Ohio consists of administration/maintenance and a bus barn. Located less than one-half mile away, is Federal Station, a passenger transfer hub where most of WRTA's fixed routes begin and end.

Table 6 summarizes the facilities and provides a condition rating using the FTA's TERM five-point condition rating scale. WRTA's bus barn is past its useful life. Equipment assets valued between $10,000 and $50,000 are included in the facility's condition rating.

TABLE 6: FACILITIES INVENTORY

ASSET CODE	AGE	CONDITION RATING	REPLACEMENT COST/VALUE	PAST ULB
ADMINISTRATION/ MAINTENANCE	38	4.5	$3,707,773	No
PASSENGER TRANSFER STATION	34	4.3	$2,100,000	No
BUS STORAGE BARN	48	2.7	$3,000,000	Yes

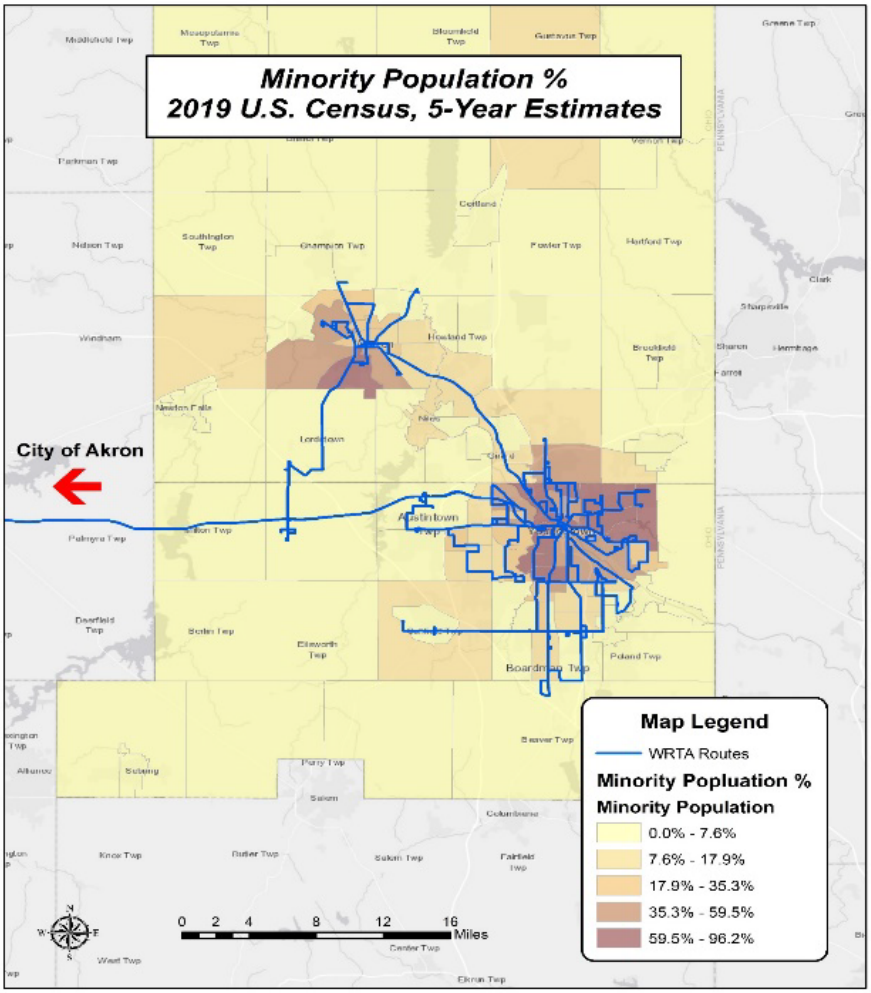
SOURCE: *WRTA's Calendar Year 2022 Transit Asset Management Plan*

KEY DEMOGRAPHICS

WRTA's service area includes underserved populations summarized below.

MINORITY POPULATION

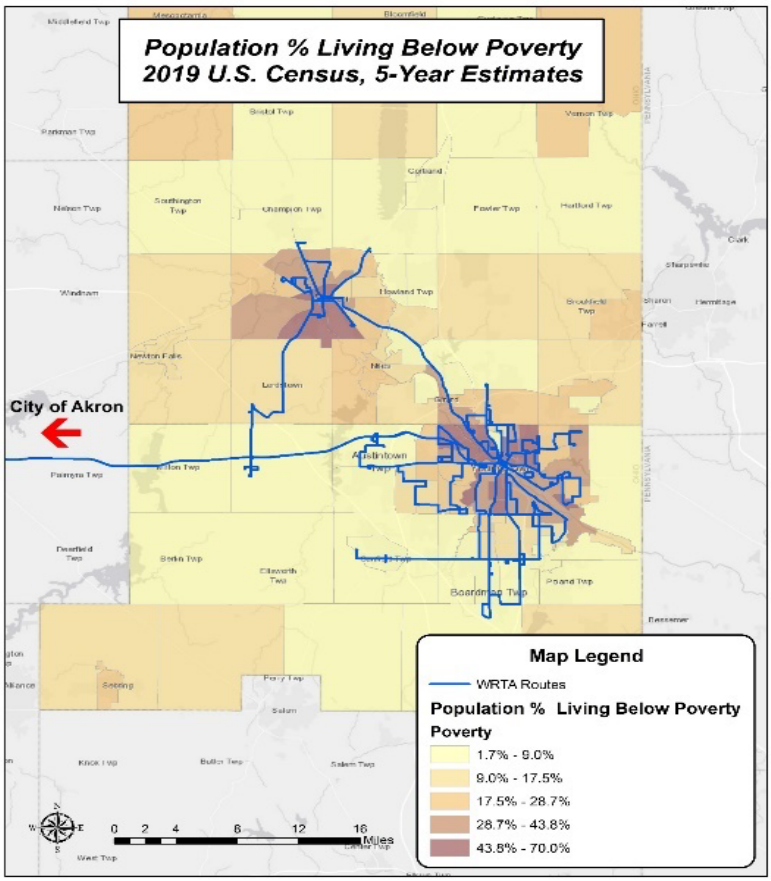
MAP 1: MINORITY POPULATION WITH FIXED ROUTE OVERLAYS



- The City of Youngstown *(64.3 percent)* and City of Warren (34.9 percent) both have minority population percentages that are higher than their respective counties.
- The City of Youngstown's population is the most diverse with a Hispanic population *(10 percent)* and black population *(45.6 percent)* that are comparatively high with respect to minority populations in City of Warren, Mahoning and Trumbull counties, and the state of Ohio.

INCOME

MAP 2: POPULATION LIVING BELOW POVERTY WITH FIXED ROUTE OVERLAY



- The City of Youngstown and City of Warren have a high number of low-income residents earning less than $15,000 a year as compared to the counties and the state.
- The distribution of household incomes in Mahoning County shows the highest category percentage between $50,000 – $74,999, which is far higher than in Youngstown and Warren.
- Median household incomes (2019) in Youngstown ($27,433) and Warren ($31,673) were lower than that of Mahoning County ($44,202).
- Poverty levels in Youngstown and Warren were twice as high as that of Mahoning County.
- Data for Mahoning County shows that there is a concentration of lower-income residents in Youngstown.

OTHER DEMOGRAPHICS

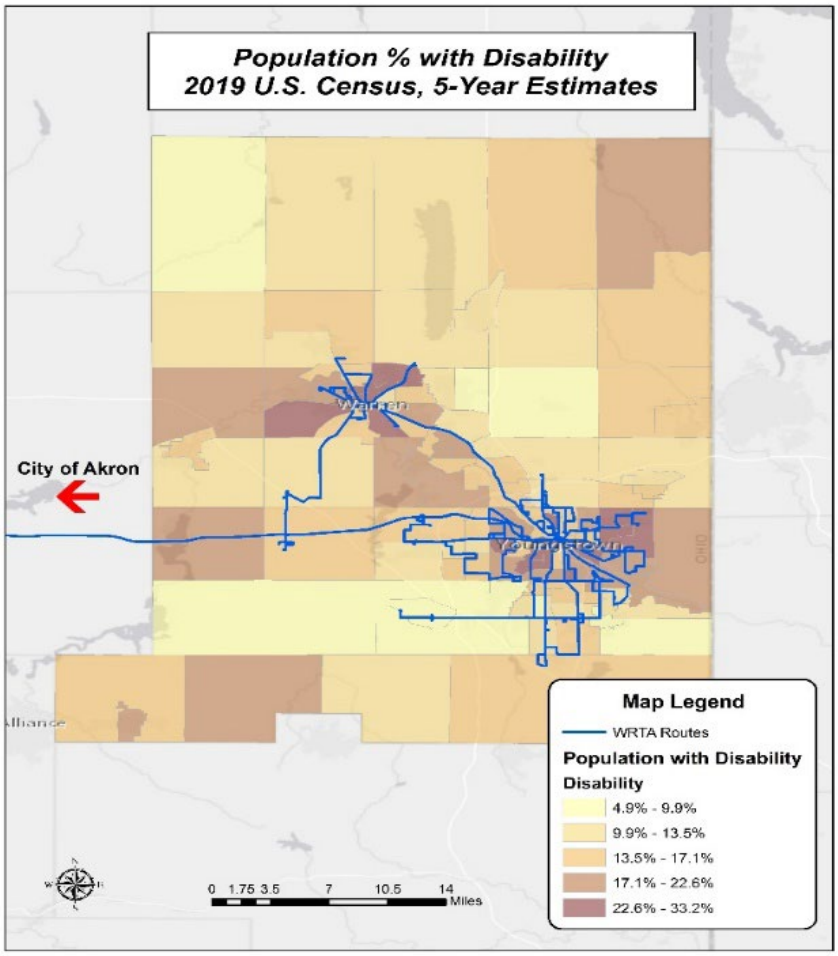
TABLE 7: PERSONS WITH DISABILITIES DATA

	YOUNGSTOWN	WARREN	MAHONING COUNTY	TRUMBULL COUNTY	OHIO
HOUSEHOLDS WITH 1+ PERSONS WITH A DISABILITY	36.6%	31.4%	28.1%	27.8%	27.0%

SOURCE: *ESRI Business Analyst; U.S. Census Bureau ACS 2018 5-Year Average*

- WRTA's service area consists of dense residential areas with high percentages of households with 1 or more persons with a disability.
- The highest percentages of households with one or more persons with a disability are within the City of Youngstown *(36.6 percent)* and the City of Warren *(31.4 percent).*

MAP 3: DISABLED POPULATION WITH FIXED ROUTE OVERLAY



- As shown in the map, there appears to be opportunity in the south and southwest areas of Warren to expand fixed route services for persons with disabilities.

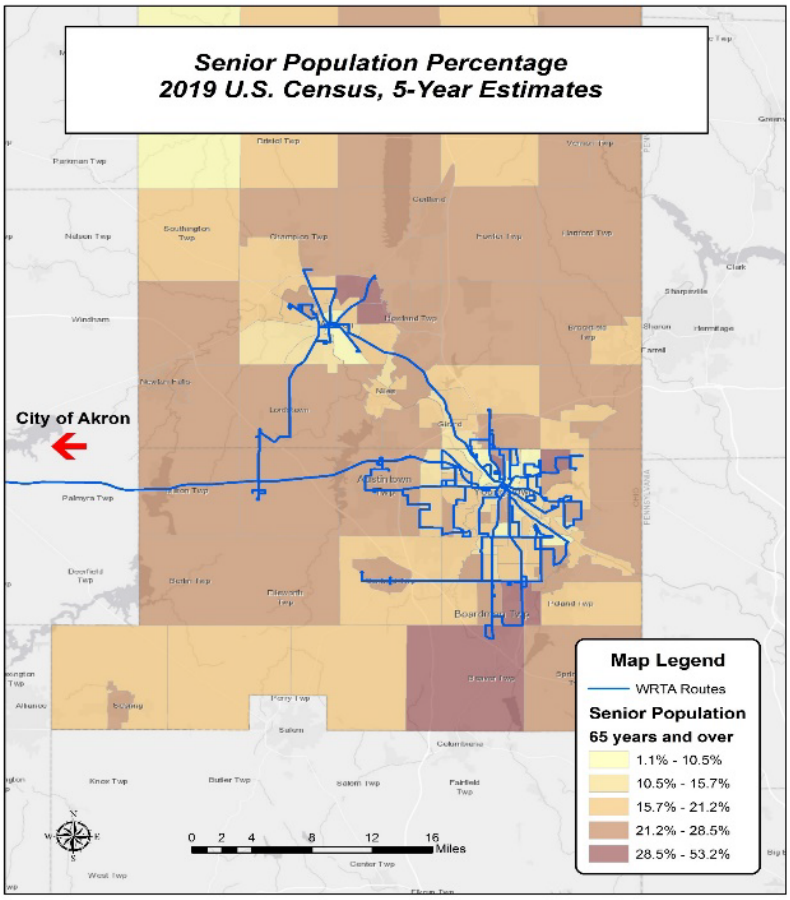
TABLE 8: SENIOR CITIZEN POPULATION DATA

	YOUNGSTOWN	WARREN	MAHONING COUNTY	TRUMBULL COUNTY	OHIO
Residents Age 62+	20.9%	20.9%	24.3%	24.8%	20.1%

SOURCE: *ESRI Business Analyst; U.S. Census Bureau ACS 2018 5-Year Average*

- Senior populations in the service area range from 20.9 percent to 24.8 percent which are slightly higher *(20.1 percent)* that the State of Ohio.

MAP 4: SENIOR POPULATION WITH FIXED ROUTE OVERLAY



- The densest senior populations within Mahoning and Trumbull counties are served by WRTA.
- The highest percentage of senior populations are covered by fixed route in Mahoning County.
- Area's northeast of the City of Warren in Trumbull County are another potential growth area for WRTA's services.

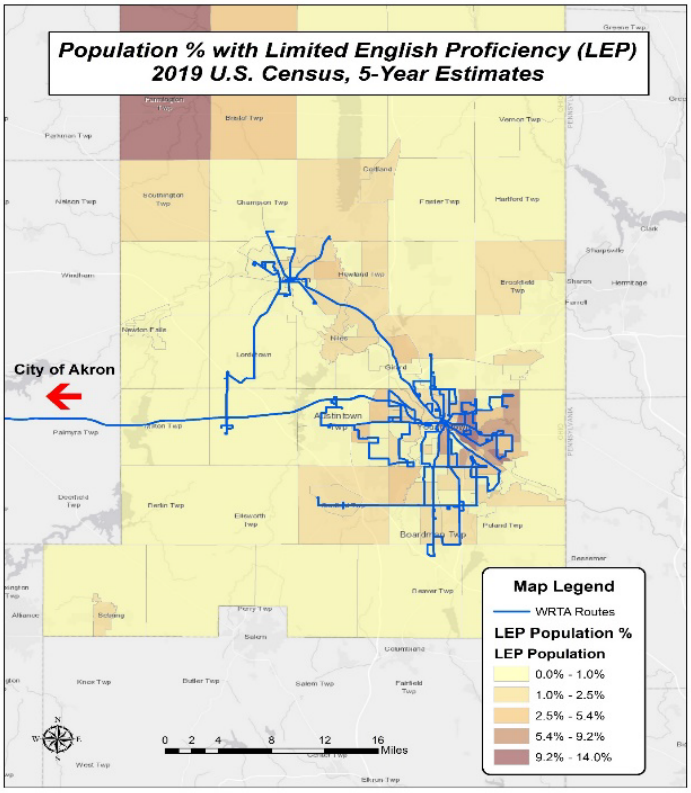
TABLE 9: LIMITED ENGLISH PROFICIENCY POPULATION DATA

	YOUNGSTOWN	WARREN	MAHONING COUNTY	TRUMBULL COUNTY	OHIO
SPEAKING ENGLISH "LESS THAN VERY WELL"	3.2%	1.0%	1.9%	1.4%	2.5%

SOURCE: *ESRI Business Analyst; U.S. Census Bureau ACS 2018 5-Year Average*

- The City of Youngstown has the highest percentage of population that speaks English "less than very well" at 3.2 percent. Comparatively speaking, that's three times more than the City of Warren and both Mahoning and Trumbull counties and also higher than Ohio *(2.5 percent).*

MAP 5: LEP WITH FIXED ROUTE OVERLAY



- The highest percentage of LEP population is in Mahoning County and is served by WRTA's fixed routes.

EV VEHICLES, EQUIPMENT AND INFRASTRUCTURE

Based on costs, benefits, current conditions, analysis, and feasibility detailed in the Plan's supporting reports, WRTA has chosen to convert their fleet to battery electric buses rather than fuel cell electric. This section provides a summary of zero-emission transit buses, equipment and infrastructure needs. More detailed information is available in Reports 1, 2 and 3.

ZERO-EMISSION TRANSIT BUSES

Zero-emission technologies considered for deploying zero emission buses (ZEB) include battery electric buses (BEBs) and hydrogen fuel cell-electric buses (FCEBs). The charging/fueling process is the primary difference between BEBs and FCEBs and, in general, the FCEBs can travel a longer distance once fueled than BEBs. Batteries in BEBs require recharging and are dependent of the location of chargers. Most BEBs use large capacity lithium-ion battery systems. Charging stations can be located at the transit agency's depot, park and ride lots, and partner businesses along transit routes. Enroute overhead conductive charging as well as wireless inductive charging are other options. FCEBs combine hydrogen fuel cell with a small battery that recharges through the fuel cell. In general, FCEBs require hydrogen fuel, which is pumped into high-pressure tanks typically mounted on the roof of the bus. The FCEBs fueling process is like fueling vehicles with compressed natural gas.

According to Doug Parker, IBI Group, there are "some inherent drawbacks to using FCEBs as a clean energy alternative to diesel buses." The drawbacks are related to the production of hydrogen through electrolysis which "still involves emissions unless this electricity is generated from a renewable source such as wind or solar."

Table 10 extracted from Transit Cooperative Research Program (TCRP) Research Report 219, Guidebook for Deploying Zero-Emission Transit Buses, 2021 *(https://www.trb.org/ Publications/Blurbs/180811.aspx) (TCRP Report 219)* summarizes BEB and FCEB technology.

TABLE 10: SUMMARY COMPARISON OF BEB AND FCEB TECHNOLOGY

CONSIDERATIONS	BATTERY ELECTRIC BUS	FUEL CELL ELECTRIC BUS
RELIABLE RANGE	Likely less than 150 miles in transit service on a single charge (or indefinite range with on-route charging).	Between 200 and 320 miles in transit service before refueling.
FUELING TECHNOLOGY	Depot or on-route charging: ▪ Plug-in charging. ▪ Overhead conductive charging. ▪ Wireless inductive charging.	▪ Hydrogen storage and fueling station: ▪ Purchase delivered gaseous or liquid hydrogen. ▪ Produce hydrogen on-site through electrolysis or natural gas reformation.
CAPITAL COSTS	▪ BEBs are more expensive than diesel buses in 2020. ▪ Charging infrastructure costs vary and may not scale easily; incremental costs or space requirements increase with fleet size.	▪ FCEBs are more expensive than BEBs in 2020. ▪ Fueling infrastructure costs vary and depend on the required fueling rate. ▪ Infrastructure is scalable; additional buses may not require additional infrastructure.
REFUELING CONSIDERATIONS	▪ Depot-charged buses may require hours to fully recharge. ▪ Electricity rates will have a significant impact on operational costs. ▪ AC or DC charging options available depending on bus OEM.	▪ Refueling procedure and time required are slower than diesel buses, but similar to CNG fueling. ▪ Electricity costs may be significant if producing hydrogen on site.

SOURCE: *National Academies of Sciences, Engineering, and Medicine. 2021. Guidebook for Deploying Zero-Emission Transit Buses. Washington, DC: The National Academies Press*

VEHICLES

BATTERY ELECTRIC BUSES (BEB)

BEBs use onboard battery packs to power the bus and its systems. Basically, there are two types of BEBs: 1) long or extended range, and 2) fast charge. Chargers can be plug-in, overhead conductive, or inductive. Any type of charger may be used at the depot or on-route. Both types have advantages and disadvantages, and an agency's decision will be primarily based on the evaluation of operations of the services it provides and desired infrastructure.

1) Long or extended range BEBs use larger battery packs and slowly charge batteries using lower power. According to TCRP Report 219, "buses are typically charged one or two times per day. Fully recharging a battery can take up to 8 hours or more, depending on the size of the bus battery and the power output of the charger."
2) Fast/rapid-charge BEBs use smaller battery packs and charge faster using a higher power. Strategically deploying on-route charges throughout an agency's service area can increase operational efficiencies because the vehicles does not need to return to the depot for charging.

According to the Traffic21 Institute Policymaker Guide *((alternative-fuels-policy-brief-buses_web.pdf (cmu.edu),* BEBs *(long range and fast charge)* have the lowest life cycle costs when compared to conventional buses. Fast charge buses have a slightly lower life cycle cost than long range BEBs. Traffic21's analysis included the following conventional buses: diesel, diesel-hybrid electric, compressed natural gas, liquified natural gas and biodiesels *(20% and 100% biodiesel).*

EQUIPMENT

BEB CHARGING TECHNOLOGY

Three options exist for BEB charging technology: 1) plug-in charging, 2) overhead conductive charging, and 3) wireless inductive charging. An agency will select one or more charging options based on the design of its services. Selection will be based on multiple factors including passenger loads, route characteristics (length, speed, distances between stops, terrain, weather, infrastructure and costs). Typically, plug-in chargers are used to charge buses at the depot, and overhead conductive or wireless inductive chargers are used to charge buses on-route.

In April 2021, the National Renewable Energy Laboratory (NREL), operated by Alliance for Sustainable Energy, LLC, for the U.S. Department of Energy (DOE) published a *Guidebook for Implementing Battery Electric Buses (Electrifying Transit: A Guidebook for Implementing Battery Electric Buses (nrel.gov)),* and found that "depot charging is commonly preferred by smaller-scale transit providers because the infrastructure requirements are less expensive when compared to on-route charging infrastructure." TCRP Report 219 summarized the three BEB charging options:

1) Plug-in chargers require space for charging equipment. Most transit agencies select ground-secured plug-in chargers for slow charging buses. Many agencies have one charger for each bus. Other alternatives include using a higher-powered charger that can charge two buses at a time *(increases charging time)* or has multiple dispensers that can charge several buses sequentially. Challenges to this type of charger are adequate space for the chargers, length of time to fully charge the bus and designing services to return to depot for charging.
2) Overhead conductive chargers are used to fast charge vehicles. A vehicle is charged by connecting a bus mounted pantograph or an inverted pantograph to the charging unit. The inverted pantograph is attached to the charging unit. This type of charging is not available from all EV manufactures. Maintaining pantographs and on-route overhead conductive charges increase

costs. Challenges include infrastructure costs, proper alignment of pantograph, and impact of malfunctioning charging stations and pantographs.

3) Wireless inductive charges are inductive chargers that are built into roadway surfaces and a vehicle is parked on the surface and charged through a transmitter. Inductive charge "eliminates any concerns about overhead clearances, does not obstruct sidewalks or roads, and may be more aesthetically pleasing. There are no moving parts with an inductive charger, which may lower maintenance requirements. Drivers will need to be trained how to park properly and in the right position, generally to within a tolerance of less than a foot. Challenges include cost, maintenance, repair, and the need for a site that is clear of metal obstructions."

The location and size of WRTA's headquarters *(including the bus depot)* coupled with its service design make plug-in charges a viable option. Buses can be consistently charged with lower output levels.

AUXILIARY BUS HEATER

Outdoor parking of BEBs in cold weather, on-route charging in hot weather, driving styles due to ice, snow and rain, extreme heat and cold impact battery usage. For WRTA's service area, cold weather is the most significant impact on reducing BEB bus range. WRTA's vehicles will be parked indoors and on-route chargers are not planned at this time. Adding an auxiliary heater that uses a fuel such as diesel can reduce impact of weather on the battery.

TECHNOLOGY

It will be important for WRTA to invest in a computer-based charge management system to maximize performance of its EVs and charging equipment. These systems use multiple criteria to maximize vehicle and energy performance.

BACK-UP EQUIPMENT

To ensure WRTA is prepared for power outages, it is recommended that WRTA purchase on-site generators, which will enable the Authority to continue operations and provide service during emergencies and power outages.

INFRASTRUCTURE

The primary infrastructure needs are space for EVs and charging equipment. WRTA's initial plan is to store vehicles and charging equipment at its headquarters in Youngstown. In the future, the Authority may expand the level of service in Trumbull County necessitating the need to add charging stations and a storage facility near the City of Warren *(Trumbull County's service hub).* WRTA is currently in the process of updating its bus maintenance facility which includes planning for 100% deployment of zero emission vehicles.

WRTA's bus facility project includes solar panels and more bus bays (8 to 11). Funding application is planned to be submitted December 2022. Bus storage area is planned to be constructed in 2023 and completed in late 2024. Main shop and administration areas are planned to follow with construction in 2024 and completed December 2025.

WRTA is also exploring the possibility of adding charging stations at its North Jackson Park and Ride Lot in two to three years and rehabilitating Federal Station. Both of these initiatives will support and enhance WRTA's transition to EVs.

ZERO EMISSION SERVICE PLAN

SERVICE OVERVIEW

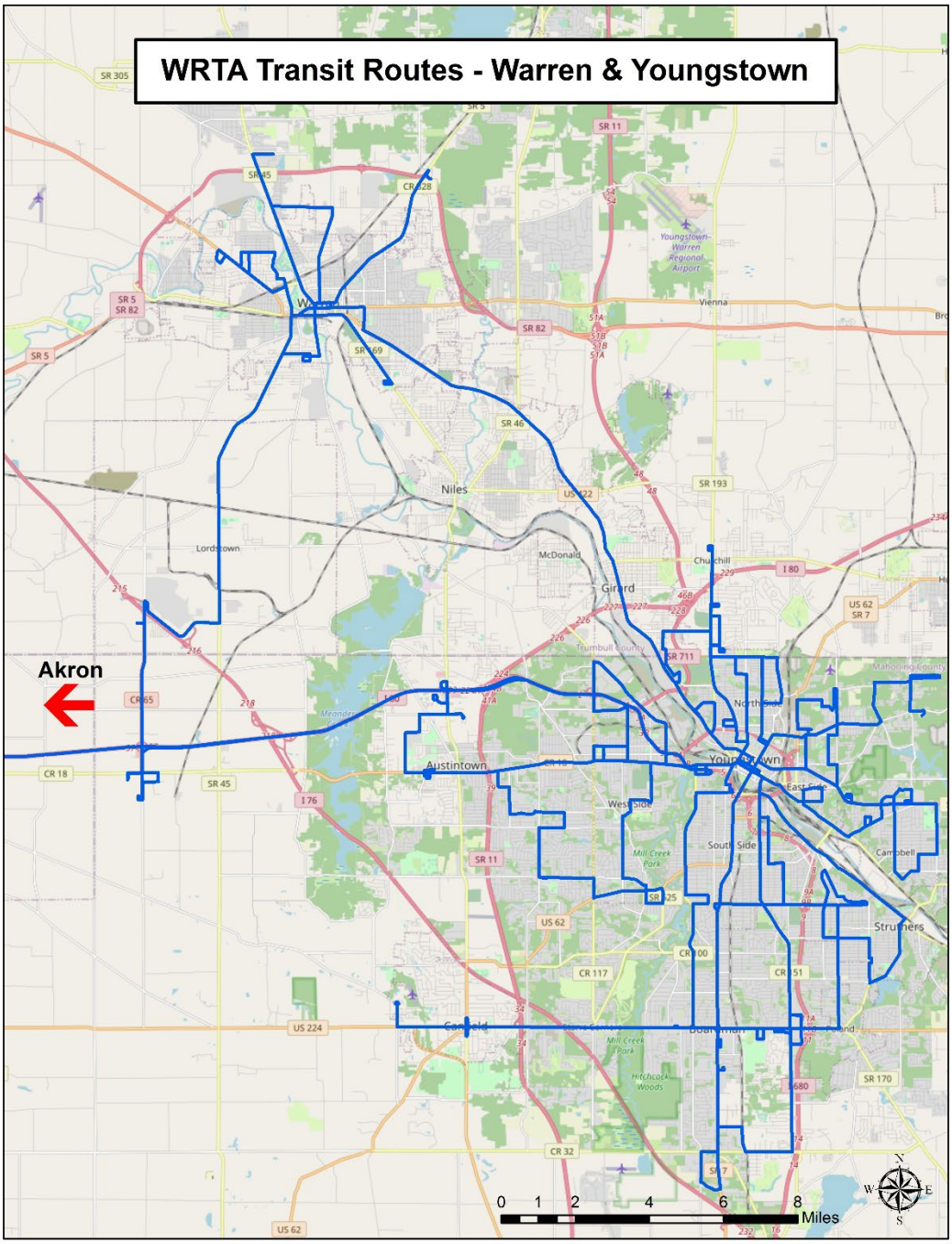
The Zero Emission Service Plan (ZESP) is based on WRTA's December 2021 service plan. The Authority will review the ZESP annually to ensure it meets the communities needs and will modify the ZESP to account for service adjustments and advancements in EVs and supporting equipment technologies.

WRTA operates public transit services primarily in Mahoning County and secondarily into Trumbull County. Trumbull County is a potential future growth area for WRTA. WRTA operates fixed route and shared ride services. Service is provided on weekdays and Saturdays in Mahoning County and weekday only in Trumbull County. The primary charging site for EVs will be at WRTA's headquarters in Youngstown, Ohio.

WRTA's fixed route service is primarily a hub and spoke system. The hub for Mahoning County routes is Federal Station in downtown Youngstown. Federal Station is located four-tenths of a mile *(2 minutes)* from WRTA's headquarters. Twenty of the 23 Mahoning County routes serve Federal Station. Three of four suburban routes do not serve Federal Station *(Routes 24, 25 and 26)* and have terminuses that are 3.2 to 6.4 miles *(8 to 15 minutes)* away from WRTA's headquarters. These three suburban routes serve large retail operations *(Wal-Mart or Southern Park Mall)* and, as such, there are opportunities for charging sites at these locations. Most operator assignments split mid-day and return to WRTA's headquarters.

All Trumbull County routes serve downtown Warren. The terminus is located on-street at High Street NE and N Park Avenue. The terminus is 16 miles *(22 minutes)* from WRTA's headquarters. Trumbull County service was implemented in March 2020 as a demonstration project and therefore fairly new and still evolving. Financial local commitment is needed to retain and advance public transit services in Trumbull County. Once local commitment is secured, to maximize efficiency, WRTA will locate a charging station near this terminus. If regional expansion is achieved, the Authority plans to locate a maintenance facility with charging stations near the terminus. Other options that will be considered include working with nearby businesses for a charging site.

MAP 6: WRTA'S FIXED ROUTE TRANSIT SYSTEM



Tables 11 and 12 summarize WRTA's current fixed routes and shared ride services, respectively, which form the basis of the ZESP.

TABLE 11: WRTA WEEKDAY AND SATURDAY FIXED ROUTE SERVICE SUMMARY

WRTA WEEKDAY FIXED ROUTE SERVICE SUMMARY – CALENDAR YEAR 2021						
	NUMBER OF ROUTES	REVENUE HOURS	VEHICLE HOURS	REVENUE MILES	VEHICLE MILES	PEAK VEHICLES
BASE ROUTES						
Mahoning County	21	316.93	393.15	6,413.39	6,507.40	26
Trumbull County	6	28.55	40.29	567.32	866.22	6
LIMITED/PEAK SERVICE ROUTES						
Mahoning County	2	9.00	12.94	377.33	379.83	2
Trumbull County	1	2.80	5.02	94.48	172.78	1
TOTAL:						
Mahoning County	23	325.93	406.09	6790.72	6887.23	28
Trumbull County	7	31.35	45.31	661.8	1039	7
GRAND TOTAL:	***30***	***357.28***	***451.4***	***7452.52***	***7926.23***	***35***
SATURDAY FIXED ROUTE SERVICE SUMMARY						
	NUMBER OF ROUTES	REVENUE HOURS	VEHICLE HOURS	REVENUE MILES	VEHICLE MILES	PEAK VEHICLES
BASE ROUTES						
Mahoning County	21	217.59	279.45	4361.51	4643.08	24

TABLE 12: WEEKDAY AND SATURDAY SHARED RIDE SERVICE SUMMARY

WEEKDAY AND SATURDAY SHARED RIDE CALENDAR YEAR 2021				
TOTAL PASSENGERS	ADA TRIPS	TOTAL TRIPS	TOTAL MILES	TOTAL HOURS
42,230	16,582	37,899	455,464.76	36,940.31

ZERO EMISSION SERVICE PLAN

The ZESP is based on the following:

1) Gradual introduction of EVs.
2) Replacing vehicles at the expiration of their useful life.
3) Initial selection of services that deploy EVs will be prioritized based upon the following:
    a. Type of vehicle needed to provide the service;
    b. Trip terminus near WRTA's headquarters;
    c. Disadvantaged communities; and
    d. Ridership levels.

GRADUAL INTRODUCTION OF EVS

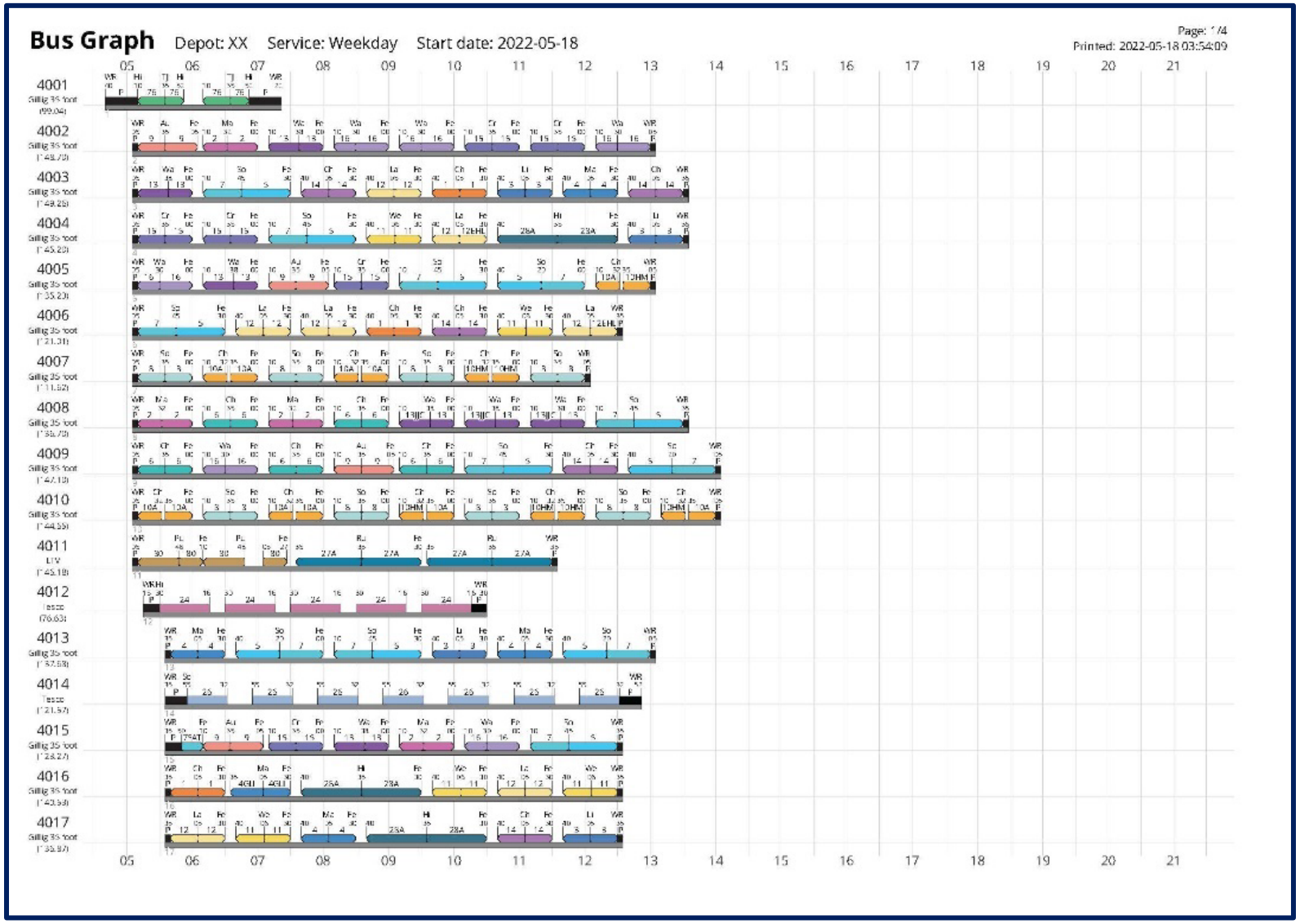
Deployment of EVs is new to WRTA. Gradual implementation will enable the Authority to employ best practices and adjust without disrupting its core services.

The ZESP will introduce EVs beginning in 2022 with full deployment by 2031. WRTA's objective is to transition its entire current fleet *(fixed route, shared ride, and service vehicles)* to EV within that timeframe. At the heart of the ZESP is replacing vehicles at the expiration of their useful life while ensuring that service to disadvantaged communities using zero emission vehicles is of the highest priority.

VEHICLE REPLACEMENT

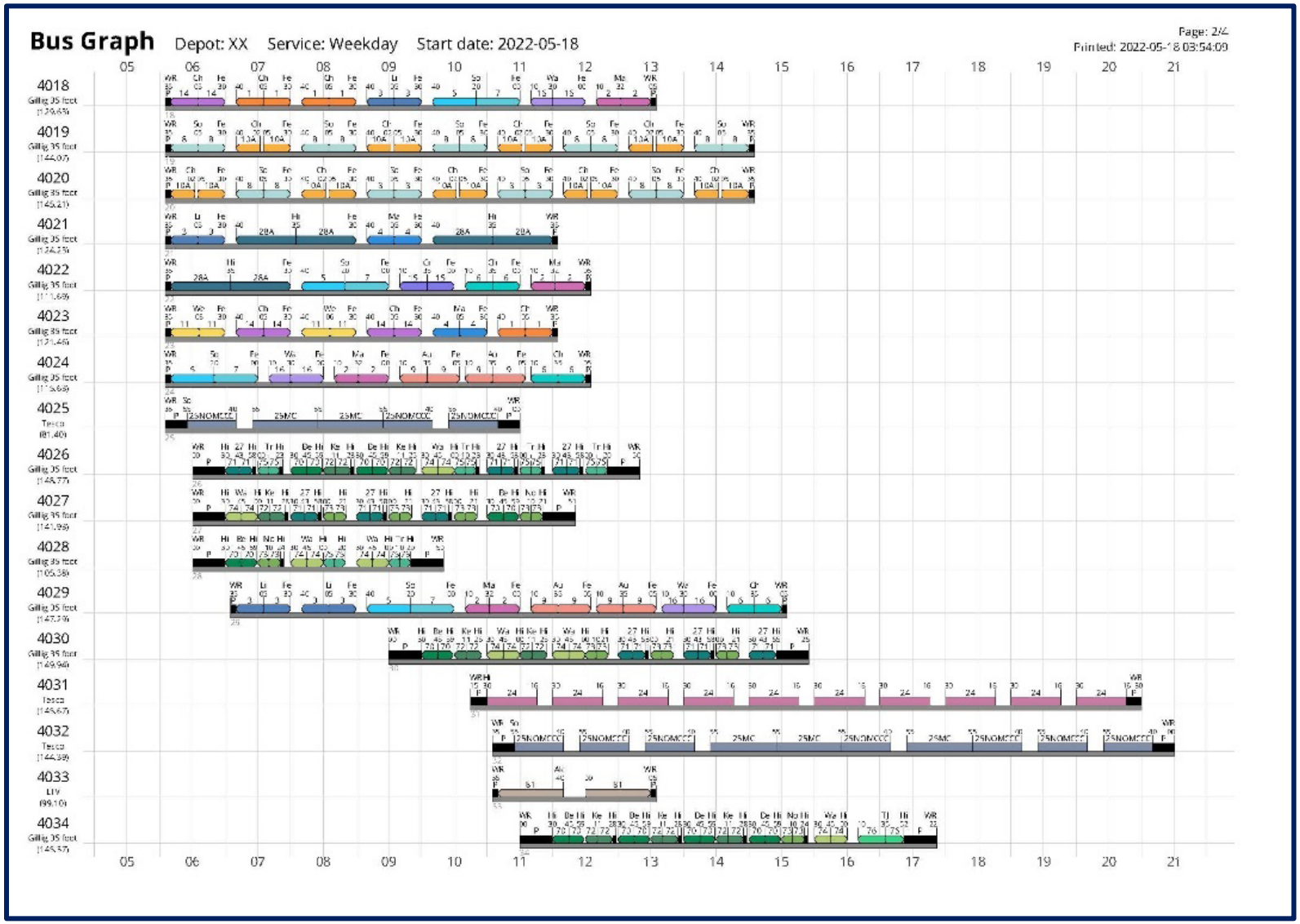
WRTA uses heavy duty buses, light transit vehicles (LTVs) and modified minivans to deliver its services. Heavy duty buses are required for most of the fixed routes. LTVs are used on shared ride services, suburban loops, and Akron Express service. Minivans are generally used for ADA shared-ride complementary service. WRTA uses Optibus software to schedule its vehicles for fixed route service. Figures 1-7 show the number of vehicles needed for full deployment of EVs on fixed route weekday and Saturdays using a maximum of 150 miles.

FIGURE 1: WEEKDAY FULL DEPLOYMENT EV VEHICLE ASSIGNMENTS A



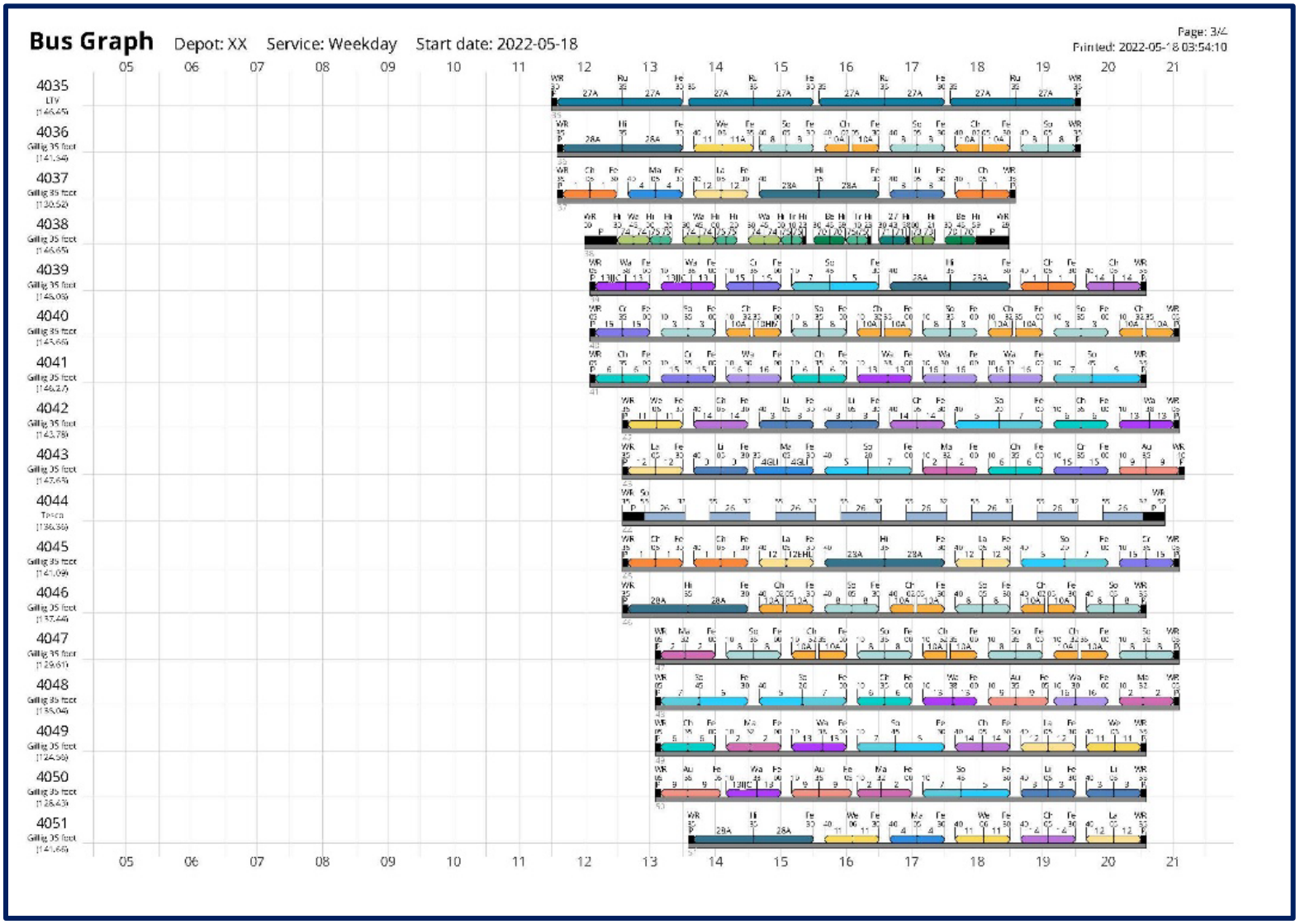
SOURCE: *WRTA and Optibus*

FIGURE 2: WEEKDAY FULL DEPLOYMENT EV VEHICLE ASSIGNMENTS B



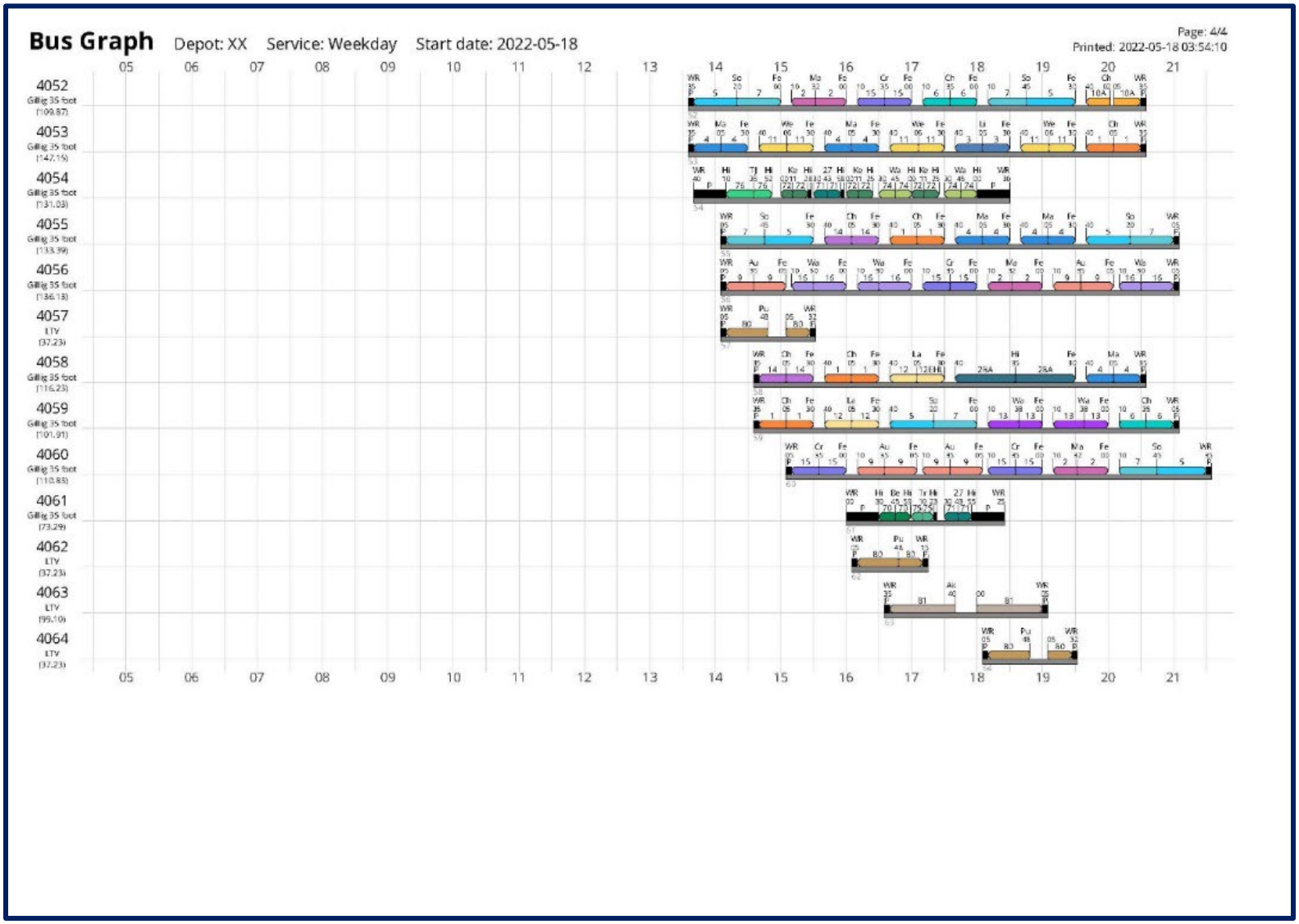
SOURCE: *WRTA and Optibus*

FIGURE 3: WEEKDAY FULL DEPLOYMENT EV VEHICLE ASSIGNMENTS C



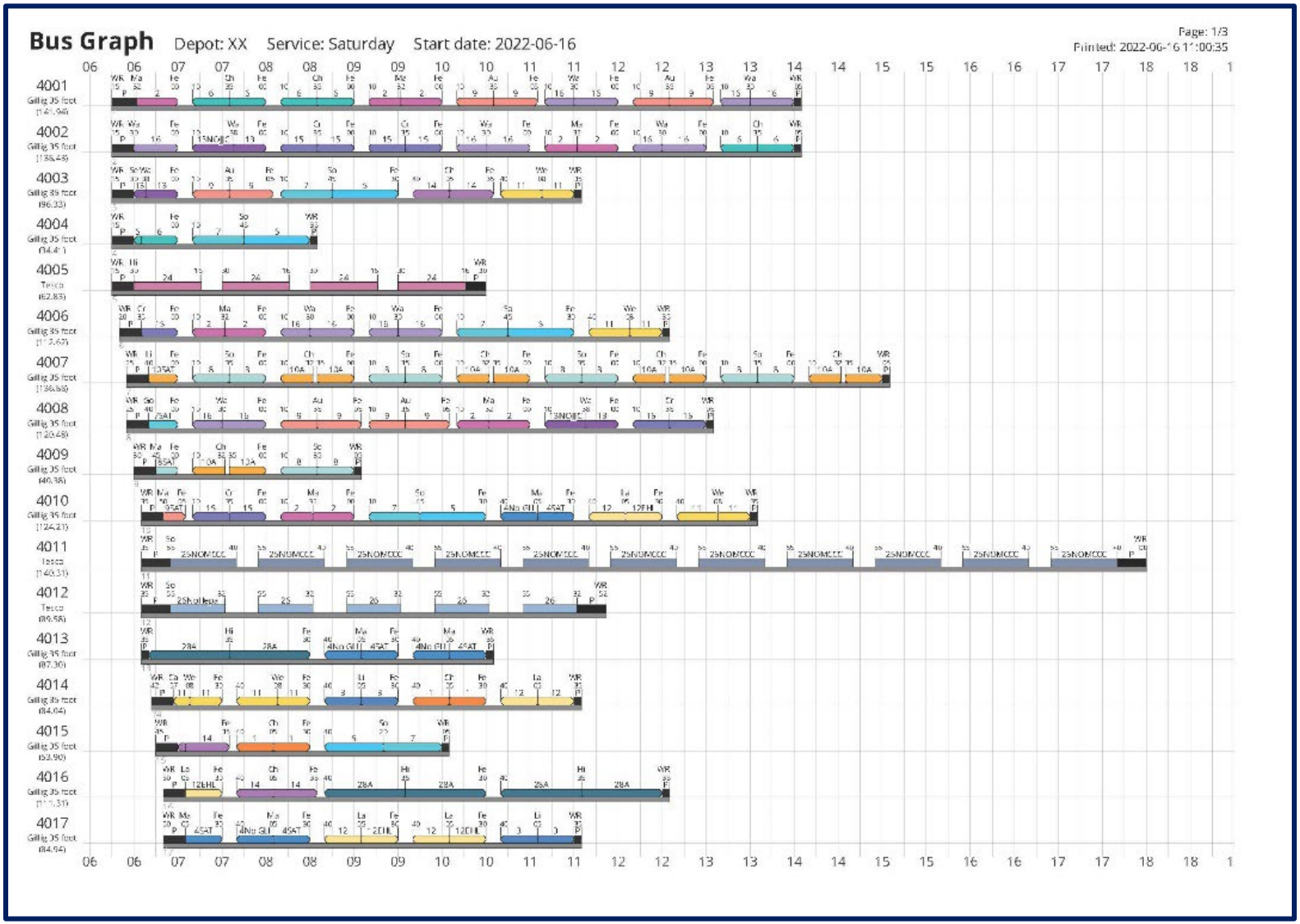
SOURCE: *WRTA and Optibus*

FIGURE 4: WEEKDAY FULL DEPLOYMENT EV VEHICLE ASSIGNMENTS D



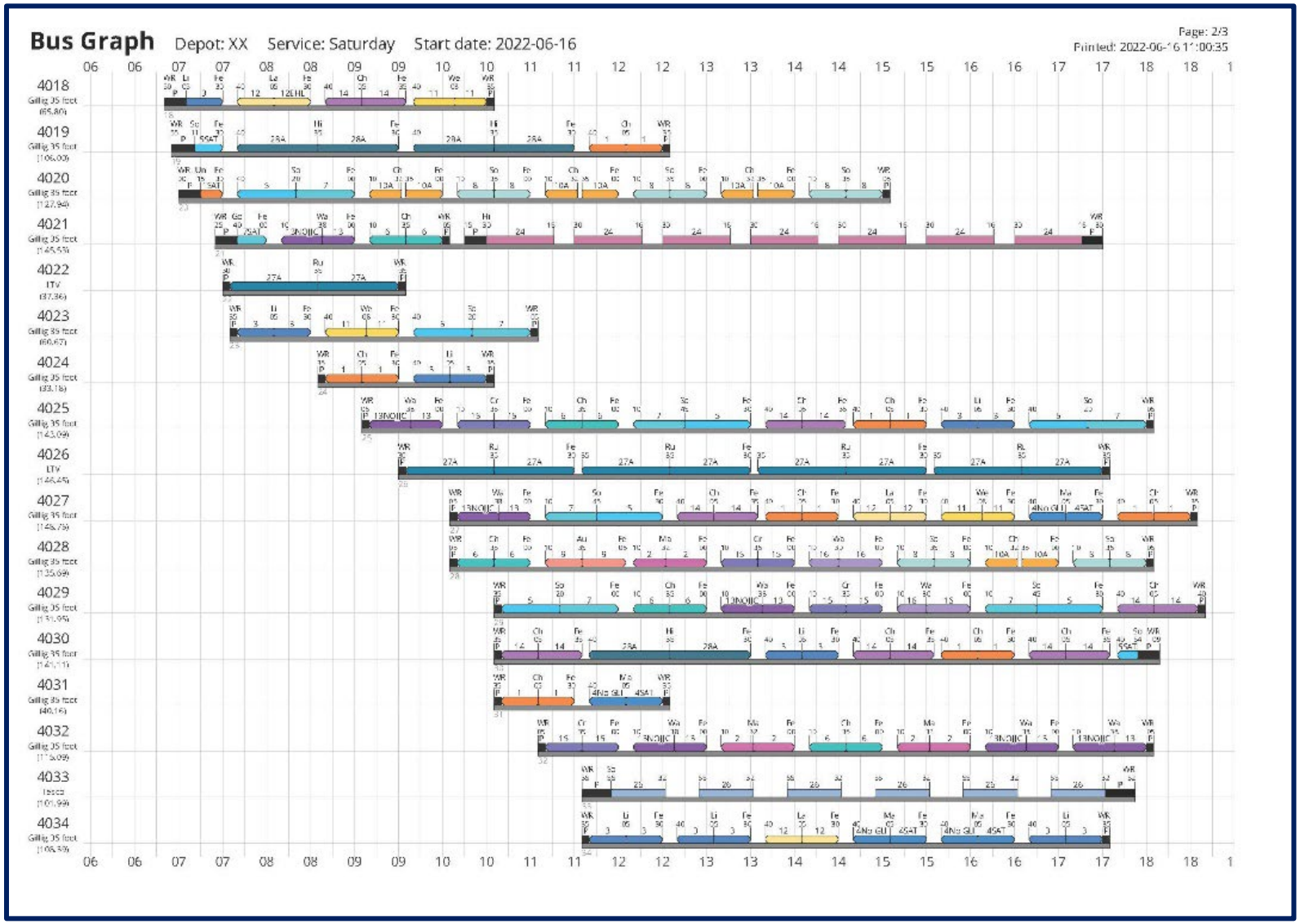
SOURCE: *WRTA and Optibus*

FIGURE 5: SATURDAY FULL DEPLOYMENT EV VEHICLE ASSIGNMENTS A



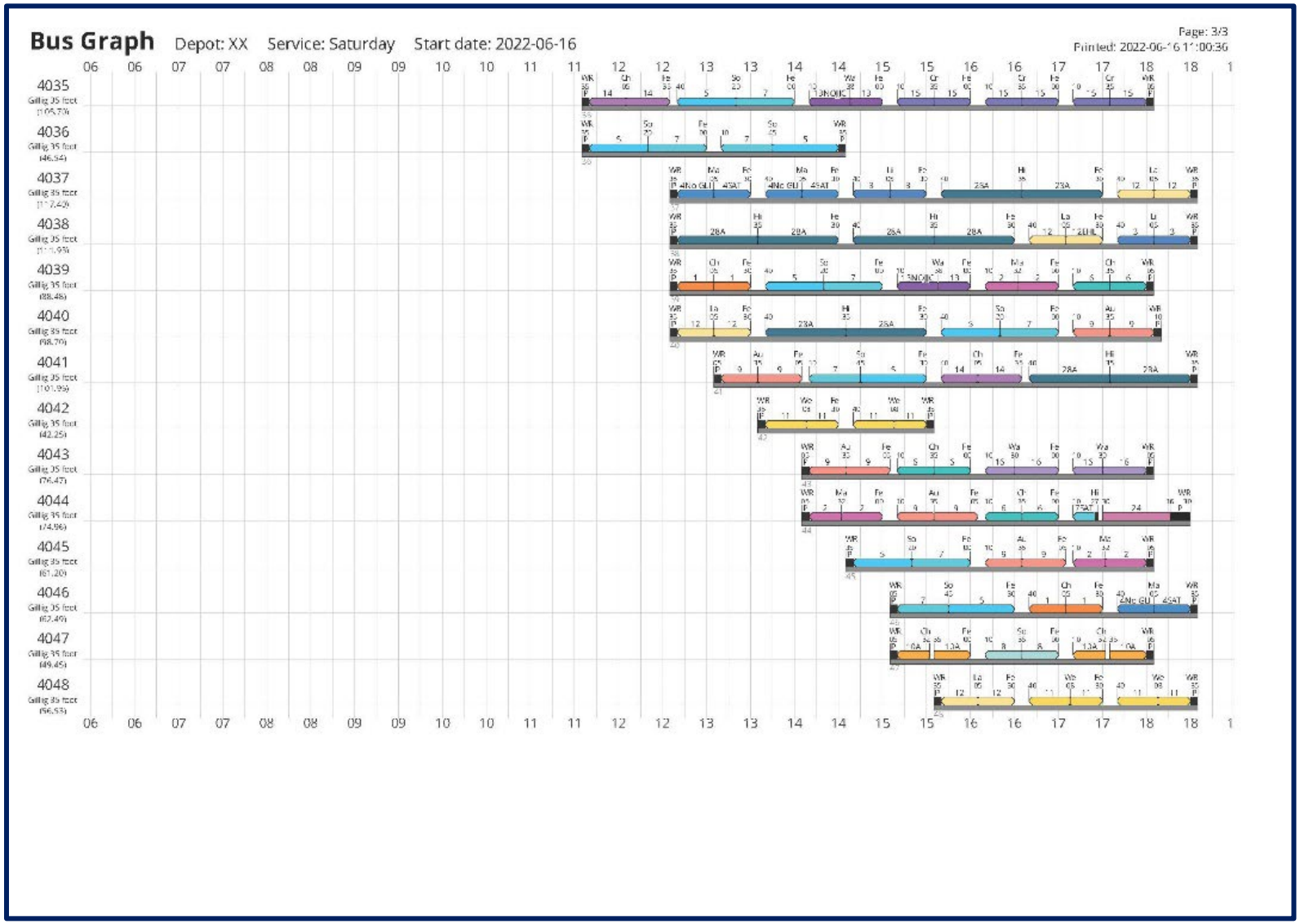
SOURCE: *WRTA and Optibus*

FIGURE 6: SATURDAY FULL DEPLOYMENT EV VEHICLE ASSIGNMENTS B



SOURCE: *WRTA and Optibus*

FIGURE 7: SATURDAY FULL DEPLOYMENT EV VEHICLE ASSIGNMENTS C



SOURCE: *WRTA and Optibus*

Table 13 shows the current number of vehicles required to provide service and the projected number of vehicles that will be required when the Authority's fleet is 100 percent electric. The projections *(using Optibus software*) are based on current service, current technology, and associated performance of EVs.

TABLE 13: VEHICLE REPLACEMENT SUMMARY

VEHICLES	CURRENT NUMBER	NUMBER NEEDED FOR 100% EVS
Heavy Duty Bus *(Seating Capacity 31)*	46	62
Light Transit Vehicle *(LTV) (Seating Capacity 12-14)*	25	40
Modified Minivan *(Seating Capacity 5)*	6	6
Support Vehicles	12	12
TOTAL:	**89**	**120**

Excluding heavy duty buses, in some instances, vehicles will be replaced more than once during the 10-year transition period. Table 14 illustrates the replacement schedule for vehicles based on their useful life without transitioning to EVs.

TABLE 14: VEHICLE REPLACEMENT SCHEDULE BY YEAR (NO EVS)

BASELINE REPLACEMENT SCHEDULE (NO EVS)					
YEAR	NUMBER OF VEHICLES REPLACED				TOTAL
	HEAVY DUTY BUS	MODIFIED MINI	LTV	SUPPORT VEH.	
2022	0	1	9	0	**10**
2023	0	0	8	4	**12**
2024	0	3	0	0	**3**
2025	0	0	0	2	**2**
2026	8	0	5	0	**13**
2027	5	1	3	0	**9**
2028	11	0	9	6	**26**
2029	9	3	8	0	**20**
2030	9	0	0	2	**11**
2031	4	0	0	5	**9**
TOTAL:	**46**	**8**	**42**	**19**	**115**

Deploying EVs will require additional revenue vehicles. Table 15 shows the plan for increasing vehicles to achieve 100 percent transition in 2031. The plan is based on EVs traveling 150 miles before needing to be charged. WRTA expects significant EV technology improvements during the next 10 years including an increase in mileage per charge. Because of this expectation, the additional EVs needed for full deployment have been programmed into the ZESP beginning 2027.

TABLE 15: EV SERVICE PLAN VEHICLE REPLACEMENT SCHEDULE

EV SERVICE PLAN REPLACEMENT SCHEDULE					
YEAR	NUMBER OF VEHICLES REPLACED (+INCREASE)				TOTAL
	HEAVY DUTY BUS	MODIFIED MINI	LTV	SUPPORT VEH.	
2022	0	1	9	0	**10**
2023	0	0	8	4	**12**
2024	0	3	0	0	**3**
2025	0	0	0	2	**2**
2026	8	0	5	0	**13**
2027	7	1	6	0	**14**
2028	13	0	12	6	**31**
2029	13	3	11	0	**27**
2030	13	0	3	2	**18**
2031	8	0	3	5	**16**
TOTAL:	**62**	**8**	**57**	**19**	**146**

WRTA will ensure that its spare ratio follows FTA's guidelines and does not exceed 20%.

OPERATIONAL CONSIDERATIONS/DEPLOYMENT PLANNING

BATTERY CAPACITY DEGRADATION

ZEB batteries degrade over time. Degradation of batteries results in reduction of battery power and distance and ultimately requires the battery to be replaced. WRTA can reduce degradation by implementing the manufacturers recommendations to maintain performance such as managing charging cycles. Typically, it is better to charge a bus from half to full rather than empty to full. Managing the charging of EVs can maximize the health of the batteries. An article in Air Quality News (*https://airqualitynews.com/2022/05/23/feature-how-to-avoid-battery-degradation-in-electric-buses/*) indicated that "all batteries degrade over time" and "degradation depends highly on usage." Four main factors were identified: temperature, high power, depth of discharge and the average state of the charge."

TCRP Synthesis 130 reported that "battery degradation will likely be the most significant in long-range BEBs, where higher depths of discharge are seen on a regular basis. On-route charged BEBs and FCEBs typically maintain battery state of charge (SOC) in a narrower range. Most original equipment manufacturers (OEM) battery warranties will replace batteries when they are at 70%–80% of their initial capacity over 6 or 12 years."

INCORPORATING BEB CHARGING

It is important that transit agencies follow vehicle manufacturers' instructions for charging, storing, and using batteries including preventative maintenance practices. This will require WRTA to conduct initial and ongoing training of maintenance and operating personnel adopting and implementing battery management practices, which includes cell monitoring and fault analysis.

Like all transit agencies making the transition to an EV system, WRTA will need to incorporate into the service plan the length of time to charge the battery while considering charging times relative to changing environmental conditions and service demands.

TRAINING

WRTA's employees include represented and non-represented staff. Operators and customer service staff are represented by the Amalgamated Transit Union (Local 272), and shop and garage personnel and mechanics are represented by the International Brotherhood of Teamsters (Local 377). WRTA continuously works with its employees including its union representatives and will proactively involve them in training. This Plan **does not** displace any member of the workforce. WRTA's employees will be trained to successfully deploy EVs.

EV policies and procedures including data collection will be developed and staff will be trained to ensure compliance. Safety and awareness training will also be provided to community first responders.

TCRP Report 219 recommends at least 80 hours of operations, maintenance, and safety training for operations personnel. Maintenance staff will require the most significant amount of training and training requirements. Most of the training materials should be provided by the OEMs and, as such, mandating that manufacturers provide training and training materials should be identified in EV and equipment specifications. TCRP Report 219 offers four main training focuses:

1) Making sure workforce understands and has familiarity operating pilot vehicles.
2) Placing a higher importance on new hire and refresher training.
3) Considering procedures surrounding ZEB charging and fueling stations and activities related to them.
4) Training workforce on emergency response activities related to these vehicles.

A best practice that WRTA could implement emphasizes four levels of training. 1) All employees receive an overview of EVs including high level safety information. 2) Driver training that covers operation of vehicles, safety features and emergency procedures. 3) Maintenance training tailored to each employee's position *(i.e., mechanic, fueler, etc.)* that would cover vehicle and equipment procedures, preventative maintenance, troubleshooting, maintaining, operating, specialty tools, and safety. 4) First responder training that should include safety and risk factors for vehicles and equipment.

OPERATIONS TRAINING

Typically, operations training covers the features of the bus and safety features. ZEBs will require drivers and operations' supervisors to be trained on the battery management system including battery SOC as well as remaining time and range. In addition to safety, procedures need to be in place for operators to return the vehicle for charging and equipment malfunctions. TCRP Report 219 recommends additional "training on concepts, working principles, and details of regenerative braking, mechanical braking, hill holding, and roll back. Training on the differences between regenerative braking and conventional friction braking is suggested." Driving habits affect performance. "To maximize the efficiency of ZEBs is to deliver optimal manual acceleration and deceleration rates from the drivers." ZEBs require training to emphasize safety while maintaining efficiency.

FUELING/CHARGING TRAINING

Personnel responsible for charging or fueling ZEBs need detailed training on the charging or fueling system for safe handling/dispensing as well as preventative maintenance on equipment. Safety training is a critical component that should include procedures for all processes including emergency situations. Each community's first responders need to be informed of the location(s) of the agency's fueling system and procedures to resolve unsafe emergency incidents.

MAINTENANCE TRAINING

At least two levels of maintenance training will be required to safely maintain ZEBs and associated equipment. Mechanics need the most significant training that includes preventative maintenance (vehicles and equipment), repairing, maintaining, and inspecting vehicles and equipment. Training will also cover specific tools for troubleshooting and diagnosing issues with advance systems and inventory. In comparison to conventional buses, ZEBs have unique hazards such as high voltage safety requiring personal protective equipment and/or safety procedures to accomplish tasks and handle emergency situations.

SAFETY TRAINING

Safety training is critical for all staff involved in supporting ZEB deployments. Safety training should include standard procedures, emergency procedures and best practices related to WRTA's ZEBs and associated equipment and infrastructure. TRCP Report 219 indicates that "at a minimum, safety training should include:

- Overview of hazards associated with battery chargers and hydrogen fuel cells, when compared to conventional fuels.
- Safe handling and deactivation of high-voltage components, including required personal protective equipment (PPE) for different tasks and capacitor discharge timing.
- Lockout and tagout procedures for working on energized components and systems, as specified in *The Control of Hazardous Energy (Lockout/Tagout), Title 29, CFR Part 1910.147 (OSHA, 2002).*
- Battery-specific safety hazards, such as electrocution, arcing, and fires from short circuits.

- Locations of emergency cut-off switches and fire response equipment.
- Actions to take to avoid an emergency and what to do during an emergency *(e.g., contact first responders, evacuate passengers, power off vehicle).*
- Maintenance and testing of safety critical systems like hydrogen sensors and ground-fault detection.
- Hazards associated with operating and maintaining the high-pressure hydrogen storage systems to ensure proper procedures are followed when disconnecting lines."

Safety training will also reinforce WRTA's Public Transportation Agency Safety Plan encouraging employees to report unsafe acts and unsafe conditions. TCRP Report 219 suggests "safety drills should be conducted on a regular basis and follow a schedule determined during the facility's design and hazard analysis. These drills will include all employees as well as local emergency response personnel."

ZESP IMPLEMENTATION

ZESP REPLACEMENT SCHEDULE

The foundation of the ZESP fleet implementation schedule was established utilizing the same methodology as the baseline replacement schedule *(replacing vehicles at the expiration of their useful life) and* incorporates the same targets *(100 percent electric by 2031).* The ZESP replacement schedule is based on WRTA continuing to operate service as implemented in December 2021 and incorporates the projected number of vehicles WRTA will need assuming EV maximum of 150-miles before needing to charge.

Table 16 shows the plan for increasing vehicles to achieve 100 percent transition in 2031. WRTA expects significant EV technology improvements during the next 10 years including an increase in mileage per charge. Because of this expectation, the additional EVs needed for full deployment have been programmed into the ZESP beginning 2027.

TABLE 16: EV SERVICE PLAN VEHICLE REPLACEMENT SCHEDULE BY YEAR

EV SERVICE PLAN REPLACEMENT SCHEDULE					
YEAR	NUMBER OF VEHICLES REPLACED (+INCREASE)				TOTAL
	HEAVY DUTY BUS	MODIFIED MINI	LTV	SUPPORT VEH.	
2022	0	1	9	0	**10**
2023	0	0	8	4	**12**
2024	0	3	0	0	**3**
2025	0	0	0	2	**2**
2026	8	0	5	0	**13**
2027	7	1	6	0	**14**
2028	13	0	12	6	**31**
2029	13	3	11	0	**27**
2030	13	0	3	2	**18**
2031	8	0	3	5	**16**
TOTAL:	**62**	**8**	**57**	**19**	**146**

WRTA will ensure that its spare ratio follows FTA's guidelines and does not exceed 20%.

Table 17 outlines the annual costs to procure these EVs, including the costs associated with procuring 16 additional heavy duty buses and 15 LTVs needed to support the ZESP. The cost assumptions for LTVs, modified minivans, and support vehicles are based on WRTA's preferred technology type (battery electric), bus length, and industry quotes from Lightning E-Motors. The purchase price of a heavy duty EVs is based on discussions with a Gillig sales representative. The actual purchase cost during each procurement phase is expected to fluctuate depending on market conditions.

TABLE 17: ZESP – EV PROCUREMENT COSTS

YEAR	HEAVY DUTY BUS	MODIFIED MINI'S	LTV	SUPPORT VEHICLES	TOTAL
2022	$0	$150,000	$2,565,000	$0	$2,715,000
2023	$0	$0	$2,280,000	$280,000	$2,560,000
2024	$0	$450,000	$0	$0	$450,000
2025	$0	$0	$0	$140,000	$140,000
2026	$7,400,000	$0	$1,425,000	$0	$8,825,000
2027	$6,475,000	$150,000	$1,710,000	$0	$8,335,000
2028	$12,025,000	$0	$3,420,000	$420,000	$15,865,000
2029	$12,025,000	$450,000	$3,135,000	$0	$15,610,000
2030	$12,025,000	$0	$855,000	$140,000	$13,020,000
2031	$7,400,000	$0	$855,000	$350,000	$8,605,000
TOTAL:	**$57,350,000**	**$1,200,000**	**$16,245,000**	**$1,330,000**	**$76,125,000**

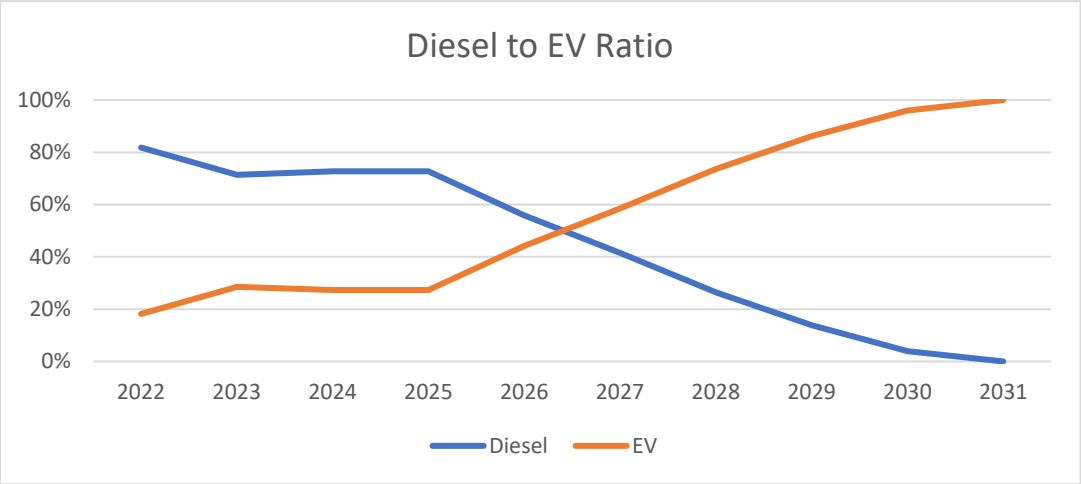
Assuming this replacement schedule is implemented, Table 18 breaks out the non-EVs *(diesel and gasoline) to* EVs ratio for WRTA's fleet until 100 percent electric is achieved in 2031.

TABLE 18: DIESEL/GASOLINE TO EV IMPLEMENTATION RATIO

FLEET	HEAVY DUTY BUS		MODIFIED MINI'S		LTV		DIESEL: EV RATIO (ENTIRE FLEET)	
TYPE	DIESEL/ GASOLINE	EV	DIESEL/ GASOLINE	EV	DIESEL/ GASOLINE	EV	DIESEL/ GASOLINE	EV
2022	46	0	1	5	16	9	82%	18%
2023	46	0	1	5	8	17	71%	29%
2024	46	0	2	4	8	17	73%	27%
2025	46	0	2	4	8	17	73%	27%
2026	38	8	2	4	3	22	56%	44%
2027	33	15	1	5	0	28	41%	59%
2028	22	28	1	5	0	31	26%	74%
2029	13	41	0	6	0	34	14%	86%
2030	4	54	0	6	0	37	4%	96%
2031	0	62	0	6	0	40	0%	100%

Figure 8 shows the gradual change in WRTA's fleet as the Authority begins implementing EVs.

FIGURE 8: DIESEL TO EV RATIO



CHARGING INFRASTRUCTURE

The ZESP replacement schedule forms the foundation of WRTA's EV implementation strategy. Assuming this schedule is implemented, and revenue vehicles are replaced with ZEBs and support vehicles with EVs, Table 19 outlines the total number of EVs that will be achieved each year.

TABLE 19: TOTAL EV'S ON SITE AT WRTA

FLEET	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Heavy Duty Bus	0	0	0	0	8	15	28	41	54	**62**
Modified Mini's	1	1	4	4	4	5	5	**6**	6	6
LTV	9	17	17	17	22	28	**40**	40	40	40
Support Vehicles	0	4	4	6	6	6	**12**	12	12	12
TOTAL:	**10**	**22**	**25**	**27**	**40**	**54**	**85**	**99**	**112**	**120**

Given the established phasing strategy of vehicles into WRTA's facility, charging equipment should be installed prior to each EV procurement. Every EV fleet is unique. Fleets vary in size and comprise varying vehicle models. Due to these differences, there is no "one size fits all" approach to charging plans. However, based on conversations with manufactures and EV charging providers, it assumed that one (1) charger is needed for every two (2) EVs. Therefore, WRTA will need 59 chargers by 2031. In addition to these 59 chargers, the need for one (1) fast-charge charger has been identified to support WRTA's ZESP once it is fully electric. This additional charger has been programmed in 2026 (*). Table 20 outlines the total number of chargers WRTA will need to purchase per fleet.

TABLE 20: CHARGERS TO BE PURCHASED BY YEAR

FLEET	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	TOTAL
Heavy Duty Bus	0	0	0	0	5*	4	6	6	7	4	**31**
Modified Mini's	0	0	1	0	0	1	0	0	0	0	**2**
LTV	4	4	1	0	2	3	6	0	0	0	**20**
Support Vehicles	0	2	0	1	0	0	3	0	0	0	**6**
TOTAL:	**4**	**6**	**2**	**1**	**7**	**8**	**15**	**6**	**7**	**4**	**60**

SOURCE: *Delta Analysis*

Plug in chargers are the most commonly used charger for EVs. These chargers have power output variations with AC and fast charging DC stations ranging from Level 1 to Level 3. Level 3 chargers should be purchased to support WRTA's heavy duty buses and LTVs. However, modified minivans and support vehicles do not have nearly the same battery capacity and, as such, do not require the same. Therefore, WRTA should purchase a Level 2 charger for these EVs. WRTA should consider additional expenses such as software, assurance, and infrastructure installation costs for each charger purchased.

To determine additional costs associated with deploying EVs, a discussion was held with ChargePoint®, the world's largest network of EV charging stations in North America and Europe. According to ChargePoint®, their Express 250 chargers are designed for large bus and LTVs and their CPF50 – Level 2 chargers, which *can* be used for both heavy duty buses/LTVs, are more suited for smaller vans and vehicles. To enable WRTA to quickly return a bus to service, one (1) ChargePoint® Express Plus charger *(DC fast charger)* was also included in the cost analysis below. All ChargePoint's models are supported by software that enables transit providers to remotely manage charging. Energy management software, over the long run, will have a positive impact on battery life because power supplied to the battery is continuously managed.

Once the chargers and accompanying software are purchased, WRTA will need to budget for the required supporting infrastructure, such as concrete slabs to raise the EV chargers off the ground, bollards to protect chargers from damage, and charger installation costs. In addition to installation of the charging stations, improvements to existing electrical infrastructure at WRTA's bus barn including switchgear, service connections, etc., will be needed to support deployment of EVs. Design work will be required to support EV deployment, including development of detailed electrical and construction drawings required for permitting once specific charging equipment has been selected.

To determine anticipated costs WRTA would incur should they deploy EVs, estimates provided by ChargePoint for both power output charger variations *(Level 3 and 2)* were used, as well as the accompanying software and assurances. Anticipated infrastructure and installation costs were sourced from the National Renewable Energy Laboratory's (NREL) *Financial Analysis of Battery Electric Transit Buses (technical report NREL/TP-5400-74832)* which determined the average installation and infrastructure costs for depot chargers is approximately $17,050 per charger. This cost was based on surveying 11 agencies that deployed EVs and installed depot charging infrastructure.

TABLE 21: CHARGER COSTS

ASSOCIATED COSTS	EXPRESS 250 (LEVEL 3)	EXPRESS PLUS (FAST CHARGER)	CPF50 (LEVEL 2)
Chargers	$49,500 (single port)	$120,000	$6,300 (dual port)
Software	$600	$160,000	$300
Assure	$3,400		$300
Infrastructure	$17,050	$17,050	$17,050
TOTAL PER CHARGER COST:	**$70,550**	**$297,050**	**$23,950**

SOURCE: *ChargePoint and Infrastructure and Installation Costs from the National Renewable Energy Laboratory's (NREL) Financial Analysis of Battery Electric Transit Buses (technical report NREL/TP-5400-74832)*

Table 22 depicts costs associated with purchasing each of the chargers mentioned above including software, infrastructure, and installation.

TABLE 22: ZESP CHARGING COSTS AND INFRASTRUCTURE

YEAR	EXPRESS 250	EXPRESS PLUS	CPF50 (LEVEL 2)	TOTAL
2022	-	$282,200	-	$282,200
2023	$47,900	$282,200	-	$330,100
2024	$23,950	$70,550	-	$94,500
2025	$23,950	-	-	$23,950
2026	-	$423,300	$297,050	$720,350
2027	$23,950	$493,850	-	$517,800
2028	$71,850	$846,600	-	$918,450
2029	-	$423,300	-	$423,300
2030	-	$493,850	-	$493,850
2031	-	$282,200	-	$282,200
TOTAL:	**$191,600**	**$3,598,050**	**$297,050**	**$4,086,700**

SOURCE: *ChargePoint and Delta Analysis*

GENERATORS

To ensure WRTA is prepared for power outages, it is recommended that WRTA purchase two (2) portable and two (2) fixed generators. One portable and one fixed generated is planned to be purchased in 2024 as well as 2027. Table 23 outlines the costs associated with purchasing these generators.

TABLE 23: GENERATOR COSTS

TYPE	COST PER GENERATOR	TOTAL PURCHASED	TOTAL COST
Portable	$4,000	2	$8,000
Fixed	$350,000	2	$700,000
		TOTAL:	**4**	**$708,000**

MAINTENANCE

One of the anticipated benefits of moving to an EV fleet is maintenance cost savings. This is because there are fewer fluids to replace *(no engine oil or transmission fluid),* fewer brake changes due to regenerative braking, and far fewer moving parts than on an internal combustion engine bus. Based on an analysis completed by the U.S. DOE National Renewable Laboratory (NREL) *(National Renewable Energy Laboratory, Financial Analysis of Battery Electric),* EV maintenance costs are approximately $0.64 per mile *(including labor and maintenance)* versus $0.88 per mile *(diesel).*

According to WRTA's ZESP, cumulative weekly mileage for WRTA's weekday fixed route and Saturday fixed routes is approximately 44,274 miles. Assuming this service is offered 51 weeks out of the year *(excluding one week to account for holidays),* WRTA's services total 2,257,986 miles annually *(excluding service vehicles).*

Because EVs will be gradually introduced into the fleet, WRTA will incur maintenance costs related to both diesel and EV fleet types. Therefore, a ratio was applied to WRTA's annual fleet mileage to determine a per-vehicle annual mileage. This per-vehicle mileage was then applied to the vehicle fleet ratios, based on

WRTA's replacement schedule, to determine the total miles traveled for both diesel and EV vehicles. The results of this analysis are shown in Table 24.

TABLE 24: EV VS DIESEL FLEET DEPLOYMENT ANNUAL MILEAGE

FLEET	HEAVY DUTY BUS		MODIFIED MINI'S		LTV		TOTAL MILES PER YEAR	
TYPE	DIESEL	EV	DIESEL	EV	DIESEL	EV	DIESEL	EV
2022	961,735	-	20,907	104,536	334,516	188,165	1,317,158	292,702
2023	961,735	-	20,907	104,536	167,258	355,424	1,149,900	459,960
2024	961,735	-	41,815	83,629	167,258	355,424	1,170,807	439,053
2025	961,735	-	41,815	83,629	167,258	355,424	1,170,807	439,053
2026	794,476	167,258	41,815	83,629	62,722	459,960	899,013	710,847
2027	689,940	313,609	20,907	104,536	-	585,404	710,847	1,003,549
2028	459,960	585,404	20,907	104,536	-	648,126	480,867	1,338,066
2029	271,795	857,198	-	125,444	-	710,847	271,795	1,693,489
2030	83,629	1,128,993	-	125,444	-	773,569	83,629	2,028,006
2031	-	1,296,251	-	125,444	-	836,291	-	2,257,986

Utilizing findings in Table 24, $0.64 (EV) and $0.88 *(diesel)* per mile maintenance cost were multiplied by the combined annual EV and diesel mileage for heavy duty buses, modified minis, and LTVs.

TABLE 25: ANTICIPATED MAINTENANCE COST (EV & DIESEL)

YEAR	EV MILEAGE	EV MAINTENANCE COST	DIESEL MILEAGE	DIESEL MAINTENANCE COST
2022	292,702	$187,329	1,317,158	$1,159,099
2023	459,960	$294,374	1,149,900	$1,011,912
2024	439,053	$280,994	1,170,807	$1,030,311
2025	439,053	$280,994	1,170,807	$1,030,311
2026	710,847	$454,942	899,013	$791,131
2027	1,003,549	$642,271	710,847	$625,546
2028	1,338,066	$856,362	480,867	$423,163
2029	1,693,489	$1,083,833	271,795	$239,179
2030	2,028,006	$1,297,924	83,629	$73,594
2031	2,257,986	$1,445,111	0	-
	TOTAL:	$6,824,134	TOTAL:	$6,384,245

SOURCE: *U.S. DOE National Renewable Laboratory and Delta Analysis*

WORKFORCE DEVELOPMENT

WRTA will have to increase its existing workforce to support additional EVs that are programmed in 2027. Below are the projected manpower increases:

- 22 additional operators
- 1 additional foreman
- 3 additional mechanics
- 2 additional service persons
- 1 EV Administrator

Table 26 depicts when these employees will be added to WRTA's existing workforce. The distribution of new hires reflects the increase in EVs established in the ZESP replacement schedule.

TABLE 26: NEW EMPLOYEES NEEDED TO SUPPORT ZESP

POSITION	2024	2025	2026	2027	2028	2029	2030	2031	TOTAL
New Operators	-	-	-	5	5	4	5	3	22
Foreman	-	-	-	1	-	-	-	-	1
Mechanics	-	-	-	1	-	1	-	1	3
Service	-	-	-	1	-	1	-	-	2
EV Admin	1	-	-	-	-	-	-	-	
TOTAL:	1	-	-	8	5	6	5	4	29

Table 27 breaks out annual costs to hire these additional employees. These projected costs reflect a full-time employee and are based on WRTA's current pay scale and benefits percentage.

TABLE 27: ANNUAL SALARY AND BENEFIT INCREASES FOR NEW EMPLOYEES

YEAR	NEW OPERATORS	FOREMAN	MECHANICS	SERVICE	ZEB ADMIN	TOTAL
2024	-	-	-	-	$103,709	$103,709
2025	-	-	-	-	-	$0
2026	-	-	-	-	-	$0
2027	$458,911	$103,709	$103,709	$103,709	-	$770,038
2028	$458,911	$0	$0	$0	-	$458,911
2029	$367,129	$0	$103,709	$103,709	-	$574,547
2030	$458,911	$0	$0	$0	-	$458,911
2031	$275,347	$0	$103,709	$0	-	$379,056
TOTAL:	$2,019,210	$103,709	$311,126	$207,418	$103,709	$2,745,172

Table 28 shows the cumulative annual expenses that WRTA would incur by hiring these new employees . This table includes expenses associated with new hires starting in 2024 plus additional new hires in the subsequent years until WRTA reaches 100 percent electric in 2031.

TABLE 28: CUMULATIVE EXPENSES FOR NEW EMPLOYEES

YEAR	NEW OPERATORS	FOREMAN	MECHANICS	SERVICE	ZEB ADMIN	TOTAL
2024	-	-	-	-	$103,709	$103,709
2025	-	-	-	-	$207,418	$207,418
2026	-	-	-	-	$311,126	$311,126
2027	$458,911	$103,709	$103,709	$103,709	$414,835	$1,184,873
2028	$917,823	$207,418	$207,418	$207,418	$518,544	$2,058,620
2029	$1,284,952	$311,126	$414,835	$414,835	$622,253	$3,048,002
2030	$1,743,863	$414,835	$622,253	$622,253	$725,962	$4,129,167
2031	$2,019,210	$518,544	$829,671	$829,671	$829,670	$5,026,767

TRAINING COSTS

Deploying an EV fleet will also require additional staff training so that WRTA's existing workforce can continue to operate and maintain the system. While there are fewer mechanical parts requiring maintenance or repair on an EV compared to diesel and gasoline vehicles, there is more software, electrical components and charging systems, which require specialized training and safety practices. As a result, it is anticipated that an investment in workforce development will be required to ensure maintenance personnel have the specialized training and safety equipment necessary to perform these new job functions.

All employees should receive an overview of the Authority's EVs addressing safety issues and concerns. Operators will need vehicle orientation training which includes operation of the vehicle, safety features and emergency procedures. Maintenance personnel will also require safety and orientation training; however, mechanics will need more substantial training relative to safely maintaining and repairing the vehicles and associated equipment.

Table 29 breaks out the training hours that will be needed for WRTA's existing workforce and the number of employees that will need to be trained. *(Training data was obtained through conversations with Pittsburgh Regional Transportation, formerly Port Authority of Allegheny County, headquartered in Pittsburgh, Pennsylvania.)*

TABLE 29: EXISTING WORKFORCE TO BE TRAINED

STAFF	HOURS	# OF STAFF (2022)
Operators	1.5	97
Operations Admin	1.5	7
Maintenance	1.5	10
Mechanics *(3 wks|40 hours)* - Mechanics *(annual basic training)*	120 1	8
Remaining Employees *(basic training)*	1	11

This initial training for deploying an EV fleet is anticipated to cost $36,330 in 2022. However, as new employees are added to WRTA's workforce, additional training will be required. Furthermore, annual training should be conducted to ensure existing staff are aware and well-versed in new technology.

Table 30 illustrates the anticipated training costs WRTA will incur until their entire fleet is EV in 2031. These training costs also incorporate additional employees WRTA will need to hire that are identified in Table 29.

TABLE 30: ANNUAL TRAINING COSTS

YEAR	REMAINING EMPLOYEES	OPERATORS	OPERATIONS ADMIN.	MAINTENANCE	MECHANICS	TOTAL
2022	$307	$6,420	$353	$450	$28,800	$36,330
2023	$307	$6,420	$353	$450	$240	$7,770
2024	$307	$6,420	$353	$450	$240	$7,770
2025	$307	$6,420	$353	$450	$240	$7,770
2026	$307	$6,420	$353	$450	$240	$7,770
2027	$307	$6,751*	$353	$585*	$3,840*	$11,836
2028	$307	$7,082*	$353	$585	$270	$8,597
2029	$307	$7,347*	$353	$675*	$3,870*	$12,552
2030	$307	$7,678*	$353	$675	$300	$9,313
2031	$307	$7,877*	$353	$720*	$3,900*	$13,157
TOTAL:	**$3,067**	**$68,837**	**$3,534**	**$5,490**	**$41,940**	**$122,868**

**Indicates new employee(s) being trained in addition to annual training for current employees*

SAFETY & EQUIPMENT

Deploying EVs will present new hazards which are generally associated with installation and maintenance of electrical switchgears and power cables. Implementing a proactive approach to training, tools and PPE will effectively manage the risk.

An April 15, 2019 article titled "The Need for Arc Flash Suits" *(The Need for Arc Flash Suits – Enespro PPE)* summarized the importance of PPE, specifically arc flash suite as follows:

> "Doing work on or near energized, or potentially energized equipment, threatens employees with danger from electric shock/ electrocution and arc flash. Arc flash presents a serious risk. Arc flash occurs when energy is released from an electric arc. It happens when there is a fault, or short circuit condition, which passes through the arc gap. It can happen for a variety of reasons, including accidental contact (e.g., with a tool), deterioration or corrosion of equipment or parts, underrated equipment for the available short circuit current, tracking or contamination over insulated surfaces. The energy released in an arc flash can easily cause regular, work clothing to catch on fire, which can dramatically increase the extent and severity of the of burn injury. "

Based on best practice research *(Question today imagine tomorrow create for the future (globalelectricity.org)* and a conversation with PRT's maintenance director, it is recommended that WRTA purchase minimum category 2 "flash suit" for their mechanics. Flash suits protect employees from arc flashes and includes fire rated coveralls, balaclava, face shield, hard hat, safety glasses, high voltage gloves, and electrical hazard rated boots *(insulated up to 600V).* The estimated cost is $1,704 and it is recommended that each mechanic have two (2) sets. In 2022, 16 flash suits *(8 mechanics, 2 per person)* will need to be purchased for WRTA's current mechanics. As WRTA increases the number of mechanics employed, additional arc suits will need to be purchased. In total, it is anticipated that at minimum, 22 flash suits will need to be purchased between 2022 and 2031.

Based on the aforementioned article, additional PPE and tools are needed to safely repair and maintain EVs and associated equipment. "Working on EV systems requires specific and specialized tools that are typically rated for up to 1,000 volts and are either made out of a non-conductive material, such as plastic, or may be coated to insulate it from electricity. These specialized tools, also referred to as Electro Static Discharge (ESD) safe tools or Static Free toolkits, are required to safely dissipate natural buildup of static electricity charge." Specific tools that will be required for WRTA's fleet will vary based on the specific vehicles that are purchased, however on average, these toolkits will cost approximately $11,500 and include a variety of tools such as wrenches, socket sets, screwdrivers, pliers, and calipers. It is recommended that one (1) tool set be purchased for each mechanic.

TABLE 31: MAINTENANCE EQUIPMENT COSTS

YEAR	FLASH SUITES		STATIC FREE TOOLS		TOTAL
	TOTAL PURCHASED	ANTICIPATED COST	TOTAL PURCHASED	ANTICIPATED COST	
2022	16	$27,264	8	$92,000	$119,264
2023	-	-	-	-	-
2024	-	-	-	-	-
2025	-	-	-	-	-
2026	-	-	-	-	-
2027	2	$3,408	1	$11,500	$14,908
2028	-	-	-	-	-
2029	2	$3,408	1	$11,500	$14,908
2030	-	-	-	-	-
2031	2	$3,408	1	$11,500	$14,908
TOTAL:	**22**	**$37,488**	**11**	**$126,500**	**$163,988**

SUMMARY OF EV TRANSITION COSTS

Deploying EVs is a significant financial investment, and it is anticipated that WRTA will incur costs of up to $103.9 million to reach 100 percent electric by 2031. Procurement of the EV fleet accounts for 73 percent of the anticipated expenses, which will be the largest portion of this investment. Following EV procurement, maintenance expenses account for the second largest expense, followed by the costs of hiring additional employees. Table 32 provides a high-level summary of the anticipated costs to transition to an EV fleet. These categories are further detailed in Table 33.

TABLE 32: SUMMARY EV TRANSITION COSTS

COST CATEGORY	TOTAL
Fleet Procurement	$76,125,000
Chargers & Infrastructure	$4,086,700
Generators	$708,000
Maintenance	$13,208,380
New Employees Salary and Wages *(Cumulative)*	$9,536,024
New Employees Equipment	$163,988
Employee Training	$122,868
TOTAL:	**$103,950,960**

TABLE 33: DETAILED EV COST TABLE

COSTS	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	TOTAL
FLEET PROCUREMENT											
Heavy Duty Bus	$0	$0	$0	$0	$7,400,000	$6,475,000	$12,025,000	$12,025,000	$12,025,000	$7,400,000	$57,350,000
Modified Mini's	$150,000	$0	$450,000	$0	$0	$150,000	$0	$450,000	$0	$0	$1,200,000
LTV	$2,565,000	$2,280,000	$0	$0	$1,425,000	$1,710,000	$3,420,000	$3,135,000	$855,000	$855,000	$16,245,000
Support Vehicles	$0	$280,000	$0	$140,000	$0	$0	$420,000	$0	$140,000	$350,000	$1,330,000
SUBTOTAL:	**$2,715,000**	**$2,560,000**	**$450,000**	**$140,000**	**$8,825,000**	**$8,335,000**	**$15,865,000**	**$15,610,000**	**$13,020,000**	**$8,605,000**	**$76,125,000**
CHARGERS & INFRASTRUCTURE											
CPF50 (Level 2)	$0	$47,900	$23,950	$23,950	$0	$23,950	$71,850	$0	$0	$0	$191,600
Express 250	$282,200	$282,200	$70,550	$0	$423,300	$493,850	$846,600	$423,300	$493,850	$282,200	$3,598,050
Express 250 Plus	$0	$0	$0	$0	$297,050	$0	$0	$0	$0	$0	$297,050
SUBTOTAL:	**$282,200**	**$330,100**	**$94,500**	**$23,950**	**$720,350**	**$517,800**	**$918,450**	**$423,300**	**$493,850**	**$282,200**	**$4,086,700**
GENERATORS											
Portable	$0	$0	$4,000	$0	$0	$4,000	$0	$0	$0	$0	$8,000
Fixed	$0	$0	$350,000	$0	$0	$350,000	$0	$0	$0	$0	$700,000
SUBTOTAL:	**$0**	**$0**	**$354,000**	**$0**	**$0**	**$354,000**	**$0**	**$0**	**$0**	**$0**	**$708,000**
MAINTENANCE											
Diesel	$1,159,099	$1,011,912	$1,030,311	$1,030,311	$791,131	$625,546	$423,163	$239,179	$73,594	$0	$6,384,246
EV	$187,329	$294,374	$280,994	$280,994	$454,942	$642,271	$856,362	$1,083,833	$1,297,924	$1,445,111	$6,824,135
SUBTOTAL:	**$1,346,429**	**$1,306,287**	**$1,311,304**	**$1,311,304**	**$1,246,074**	**$1,267,817**	**$1,279,525**	**$1,323,012**	**$1,371,517**	**$1,445,111**	**$13,208,380**
NEW EMPLOYEES' SALARY AND WAGES (CUMULATIVE)											
Operators	$0	$0	$0	$0	$0	$458,911	$917,823	$1,284,952	$1,743,863	$2,019,210	$6,424,760
Foreman	$0	$0	$0	$0	$0	$103,709	$103,709	$103,709	$103,709	$103,709	$518,544
Mechanics	$0	$0	$0	$0	$0	$103,709	$103,709	$207,418	$207,418	$311,126	$933,379
Service	$0	$0	$0	$0	$0	$103,709	$103,709	$207,418	$207,418	$207,418	$829,670
ZEB Admin	$0	$0	$103,709	$103,709	$103,709	$103,709	$103,709	$103,709	$103,709	$103,709	$829,670
SUBTOTAL:	**$0**	**$0**	**$103,709**	**$103,709**	**$103,709**	**$873,747**	**$1,332,658**	**$1,907,205**	**$2,366,116**	**$2,745,172**	**$9,536,024**

NEW EMPLOYEES' EQUIPMENT											
Flashsuits	$27,264	$0	$0	$0	$0	$3,408	$0	$3,408	$0	$3,408	$37,488
Tools	$92,000	$0	$0	$0	$0	$11,500	$0	$11,500	$0	$11,500	$126,500
SUBTOTAL:	**$119,264**	**$0**	**$0**	**$0**	**$0**	**$14,908**	**$0**	**$14,908**	**$0**	**$14,908**	**$163,988**
EMPLOYEE TRAINING											
Operators	$6,420	$6,420	$6,420	$6,420	$6,420	$6,751	$7,082	$7,347	$7,678	$7,877	$68,837
Operations Super.	$353	$353	$353	$353	$353	$353	$353	$353	$353	$353	$3,534
All Maint.	$450	$450	$450	$450	$450	$585	$585	$675	$675	$720	$5,490
Mechanics	$28,800	$240	$240	$240	$240	$3,840	$270	$3,870	$300	$3,900	$41,940
Other (Basic Training)	$307	$307	$307	$307	$307	$307	$307	$307	$307	$307	$3,067
SUBTOTAL:	**$36,330**	**$7,770**	**$7,770**	**$7,770**	**$7,770**	**$11,836**	**$8,597**	**$12,552**	**$9,313**	**$13,157**	**$122,868**
TOTAL:	**$3,152,794**	**$2,897,870**	**$1,009,979**	**$275,429**	**$9,656,829**	**$10,107,291**	**$18,124,705**	**$17,967,965**	**$15,889,279**	**$11,660,437**	**$103,950,960**

BENEFITS

BENEFITS OF ELECTRIC VEHICLES

There are many benefits for WRTA to transition its fleet to ZEBs including health and environmental, impact on underserved populations, and operations.

HEALTH AND ENVIRONMENTAL BENEFITS

Stantec, a company that provides a wide variety of community design services *(https://www.stantec.com/en/markets/transportation/zero-emission-bus)* stated on its website that "zero-emission buses are an effective and efficient way for communities to reduce their carbon footprint. ZEB and transit system electrification help combat climate change, improve air quality, and provide a stable infrastructure that is less reliant on fossil fuels and fluctuating energy costs."

The mission of Environment America *(https://environmentamerica.org/)*, a non-profit organization is to transform the power of our imaginations and our ideas into change that makes our world a greener and healthier place for all." This organization identified the following four benefits of electric buses:

1. "By eliminating diesel exhaust emissions, particulate pollution and pollutants that contribute to the formation of ground-level ozone, they improve the air quality in our communities.
2. They produce significantly lower greenhouse gas emissions than diesel, diesel hybrid and natural gas-powered buses. Replacing all of the country's diesel-powered transit buses with electric buses could eliminate more than 2 million tons of greenhouse gas emissions each year.
3. Electric buses can deliver financial benefits, including substantially reduced maintenance costs and, in places where utility rate policies are favorable, reduced fuel costs.
4. By reducing air pollution, electric buses can also deliver significant societal benefits, including avoided healthcare expenses resulting from cleaner air."

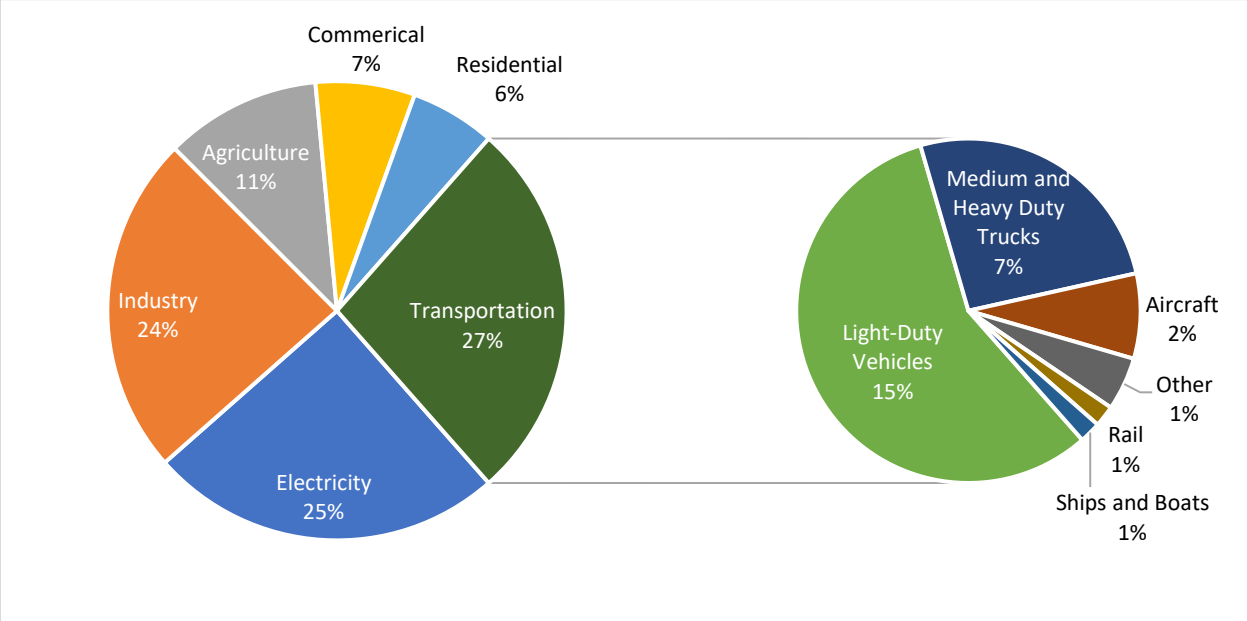
According to the Center for Disease Control (CDC) adult exposure to diesel pollution contributes to heart attacks, hospitalizations and "2.4 million lost workdays each year." The CDC further reported that "diesel emissions contain numerous pollutants, including soot, nitrogen oxides, and carbon monoxide, that adversely affect cardiovascular and respiratory health." The International Agency for Research on Cancer in June 2012 classified diesel exhaust as a "Group 1" indicating that it is a carcinogen to humans as compared to probably or not classifiable carcinogenic to humans.

The Environmental and Energy Study Institute *(https://www.eesi.org/papers/view/fact-sheet-electric-buses-benefits-outweigh-costs)* published a fact sheet indicating that "the health hazards of diesel buses (the technology currently used for the vast majority of buses) are well known among health professionals. Moreover, buses tend to be used in urban settings where there are concentrations of people and air quality is already degraded by other pollutants." This document also stated, "those who use public transit most often, including children, the elderly, and those without access to a car, are at particular risk."

The TCRP Report 130 indicated that heavy duty buses "are major contributors to pollution". BEBs would have a positive impact on the environment because they have no tailpipe emissions and if the electricity was generated from "100% renewable energy", emissions would be eliminated entirely from transit operations. This report stated that "life cycle global warming emissions are almost 75% less than CNG and diesel buses. BEB life cycle NOx emissions are significantly lower than diesel *(approximately 80% lower)* and CNG buses, including those using the new Near Zero NOx CNG engines *(less than 0.02 NOx/brake horsepower-hour)*.

The transportation sector is one of the largest contributors to anthropogenic U.S. greenhouse gas (GHG) emissions. According to the *Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990–2020 (the national inventory that the U.S. prepares annually under the United Nations Framework Convention on Climate Change),* transportation accounted for the largest portion (27%) of total U.S. GHG emissions in 2020." Of the 27%, as shown in Figure 9 within the transportation GHG sector, light-duty vehicles accounted for 15%.

FIGURE 9: U.S. GREENHOUSE GAS EMISSIONS BY SOURCE



SOURCE: *Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990–2020*

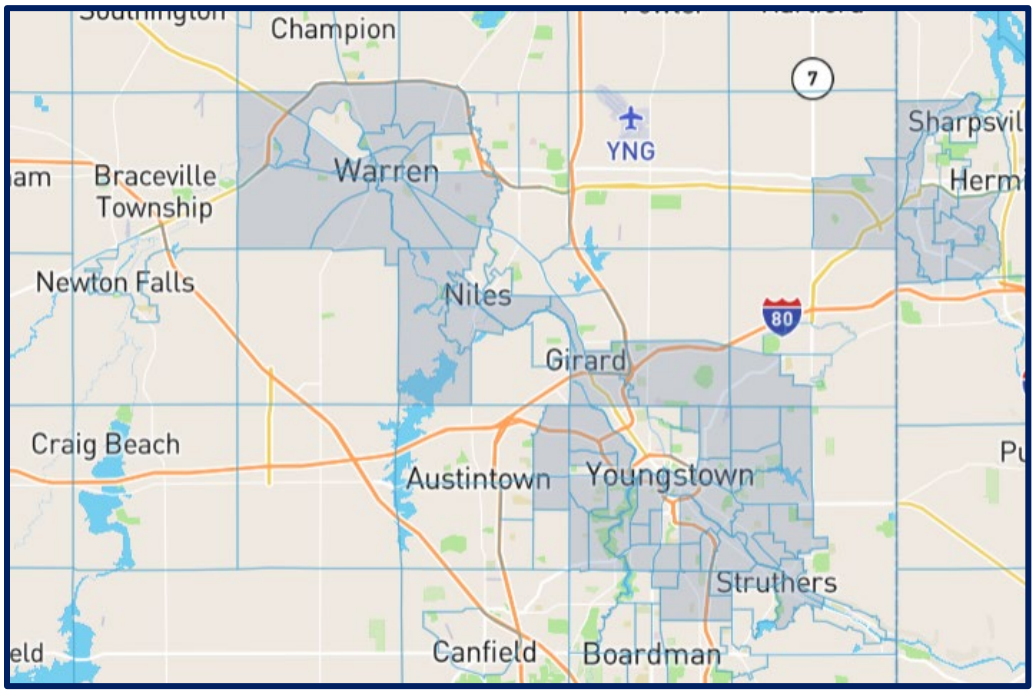
BENEFITS TO UNDERSERVED POPULATIONS

POLLUTION REDUCTION IN UNDERSERVED COMMUNITIES

Using ZEBs improves air quality and reduces greenhouse gas emissions and noise pollution. Underserved and under resourced communities have traditionally been exposed to pollutants often due to high density areas with vehicle emissions as well as locations of polluting manufacturing companies. The Climate and Economic Justice Screening Tool supported by the Council on Environmental Quality identifies disadvantaged census tracts if one or more criteria are at or below defined thresholds. Census tracts throughout WRTA's service area are considered disadvantaged. This tool shows the City of Youngstown and the City of Warren and surrounding areas are disadvantaged and the common categories that these areas do not meet the threshold are Clean Energy and Energy Efficiency and Health Burdens.

The gray area on Map 7 illustrates the disadvantaged communities in WRTA's service area. Mahoning County's hub, Federal Station, and Trumbull County's hub are considered disadvantaged. Federal Station area is considered disadvantaged in five of the eight categories: clean energy and energy efficiency; sustainable housing; legacy pollution; health burdens and workforce development. Trumbull County's hub is considered disadvantaged in four of the eight categories: clean energy and energy efficiency; sustainable housing; health burdens and workforce development.

MAP 7: DISADVANTAGED COMMUNITIES IN WRTA'S SERVICE AREA



Source: *https://screeningtool.geoplatform.gov/en/#3/33.47/-97.5*

ZEBs deployed in underserved or disadvantaged communities can provide focused environmental benefits due to the lack of harmful GHG emissions. In WRTA's case, according to the Climate and Economic Justice Screening Tool supported by the Council on Environmental Quality, the City of Youngstown is severely disadvantaged. There are only two census tracts on the northern side of the city that are not considered disadvantaged. Regarding the City of Warren, it too is surrounded by disadvantaged census tracts. Under the current formula, a census tract is identified as disadvantaged if one or more categories of criteria are at or below the defined thresholds. A common category for both Youngstown and Warren are Clean Energy and Energy Efficiency and Health Burdens. Particularly relevant with ZEBs are these two cities alarming asthma rates. Within the Health Burdens category, the weighted percent of people who have been told they have asthma is well above the 90th percentile, thus being flagged as disadvantaged.

BASELINE EMISSIONS

WRTA's baseline emission rates *(assuming a fleet that is 100% diesel)* were determined utilizing the Bureau of Transportation Statistics estimated Average Vehicle Emission Rates per Vehicle-by-Vehicle Type using diesel, shown in Table 34. These estimates are provided by calendar year. Vehicle types are defined as follows: light-duty vehicles (passenger cars); light-duty trucks *(two axle, four tire);* heavy-duty vehicles (trucks with more than two axles or four tires); motorcycle *(highway only).* Based on these classifications, it was determined that WRTA's heavy duty bus, LTV, and modified minivan fleet would be categorized as "light-duty."

TABLE 34: VEHICLE EMISSIONS RATES PER VEHICLE-BY-VEHICLE TYPE (GRAMS PER MILE)

EMISSIONS (GRAM PER MILE)	LIGHT-DUTY TRUCKS
Total Hydrocarbons (HC)	0.308
Exhaust carbon monoxide (CO)	2.458
Exhaust NOx (nitrogen oxides)	1.804
Exhaust particulate matter (PM2.5)	0.078

SOURCE: *U.S. Environmental Protection Agency, Office of Transportation and Air Quality, personal communication, Apr. 30, 2021.*

Table 35 shows what WRTA's emissions would be if the Authority kept its fleet entirely diesel. These emissions were determined by multiplying the total service miles by the aforementioned emission rates.

TABLE 35: WRTA'S BASELINE EMISSIONS (GRAMS PER MILE)

	2022 ANNUAL EMISSIONS
Total Hydrocarbons (HC)	695,460
Exhaust carbon monoxide (CO)	5,550,129
Exhaust NOx (nitrogen oxides)	4,073,406
Exhaust particulate matter (PM2.5)	176,123

EMISSION REDUCTIONS

To determine WRTA's emissions during their transition to 100% electric, the per-vehicle annual mileage for diesel vehicles, shown in Table 24 *(EV vs Diesel Fleet Deployment Annual mileage) was* multiplied by the Bureau of Transportation Statistics estimated Average Vehicle Emission Rates per Vehicle-by-Vehicle Type, shown in Table 34.

Table 36 breaks out the annual diesel mileage *(decreasing as EVs are deployed)* that was used for this analysis.

TABLE 36: ZESP ANNUAL DIESEL MILEAGE

YEAR	HEAVY DUTY BUS	MODIFIED MINIS	LTV	TOTAL DIESEL MILEAGE
2022	961,735	20,907	334,516	1,317,158
2023	961,735	20,907	167,258	1,149,900
2024	961,735	41,815	167,258	1,170,807
2025	961,735	41,815	167,258	1,170,807
2026	794,476	41,815	62,722	899,013
2027	689,940	20,907	0	710,847
2028	459,960	20,907	0	480,867
2029	271,795	0	0	271,795
2030	83,629	0	0	83,629
2031	0	0	0	0
TOTAL:	**6,146,739**	**209,073**	**899,013**	**7,254,825**

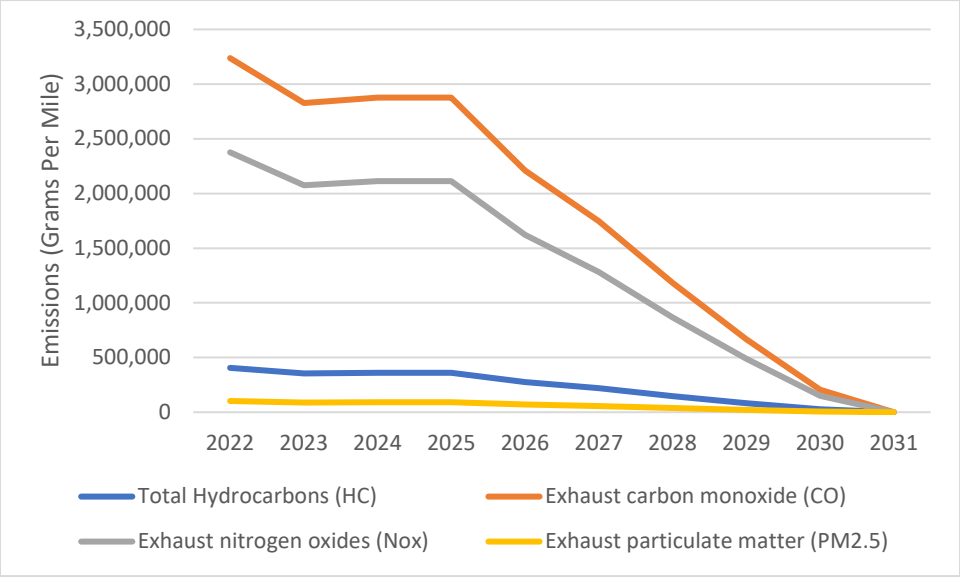
Table 37 shows the annual reduction in emissions as WRTA gradually integrates into an EV fleet, with emissions reaching zero in 2031. The decline in emissions can also be seen in Figure 10.

TABLE 37: ZESP EMISSION REDUCTIONS

	TOTAL HYDROCARBONS (HC)	EXHAUST CARBON MONOXIDE (CO)	EXHAUST NITROGEN OXIDES (NOX)	EXHAUST PARTICULATE MATTER (PM2.5)
2022	405,685	3,237,575	2,376,154	102,738
2023	354,169	2,826,455	2,074,420	89,692
2024	360,609	2,877,845	2,112,137	91,323
2025	360,609	2,877,845	2,112,137	91,323
2026	276,896	2,209,774	1,621,819	70,123
2027	218,941	1,747,263	1,282,369	55,446
2028	148,107	1,181,972	867,485	37,508
2029	83,713	668,071	490,317	21,200
2030	25,758	205,560	150,867	6,523
2031	0	0	0	0

The environmental benefits of these efforts can fortify the economic benefits, where each fleet transition can substantially reduce carbon into the atmosphere.

FIGURE 10: GRADUAL EMISSION REDUCTIONS



OPERATIONAL BENEFITS

Primary operational benefits are realized from a reduction in maintenance costs because ZEBs have fewer moving parts and higher fuel savings. Advanced Energy, a non-profit energy firm in North Carolina, (*https://www.advancedenergy.org/2020/02/24/beneficial-buses-electric-buses-bring-benefits-to-businesses-communities-and-utilities/#:~:text=1%20Operational%20Benefits*) provided an example of savings in the City of Greensboro, North Carolina "switching from a diesel to an electric bus would save nearly $160,000 in fuel and $185,000 in maintenance over the bus's lifetime."

An October 26, 2018 article by Richard Nunno for the Environmental and Energy Study Institute (*https://www.eesi.org/papers/view/fact-sheet-electric-buses-benefits-outweigh-costs*) provided the following:

- "BEBs are more economical in the long run than internal combustion engine buses".
- "It is about 2.5 times cheaper to power vehicles with electricity rather than diesel".
- "Electricity prices are generally much more stable than gasoline or diesel prices".
- "Fuel economy of BEBs is five times higher than that of diesel buses operated on equivalent routes".
- Maintenance costs for electric motors is much lower because they have far fewer moving parts than conventional motors and are far more efficient".

Maintenance costs are projected to decrease for a variety of reasons including regenerative braking resulting in longer lasting brake pads, elimination of oil changes, air filters, spark plugs and coils, and transmission maintenance. Regenerative braking also has a positive impact on fuel efficiency – the gradual braking allows the recovery of kinetic energy.

POLICY AND LEGISLATION

The ever-evolving policy and legislation regarding zero-emissions vehicles and infrastructure must be considered as part of a zero-emissions transition plan. These policies and legislation will have real-world implications on WRTA's acquisition, build-out, maintenance, and operation of zero-emissions vehicles and equipment. Below are examples of recent policy and legislative impacts to monitor, within the State of Ohio, as WRTA commences on its transition to zero-emissions vehicles:

- Electric Vehicle Commission: The State of Ohio is advancing the creation of an Electric Vehicle Commission through its legislative process. The intent of the Electric Vehicle Commission would be to "…study existing EV policy and write annual reports with recommendations for developing the market". *(https://ohiocapitaljournal.com/2021/11/29/house-passes-bill-creating-electric-vehicle-commission/)*
- Utility-Owned EV Charging Stations: The Ohio General Assembly is currently debating legislation that would "…subsidize big utility companies' plans to building a network of company-owned electric-vehicle charging stations *(https://www.cleveland.com/news/2022/05/proposed-ohio-law-would-let-power-companies-bill-customers-for-utility-owned-charging-stations.html#:~:text=COLUMBUS%2C%20Ohio%20%2D%2D%20State%20lawmakers,307%2C%20sponsored%20by%20Republican%20Sen)*. Users of power from energy companies serving Ohio *(including AEP, FirstEnergy, Duke Energy, etc.)* would be charged a "rider", or an additional fee for using power that would fund the build-out of EV chargers. The Public Utility Commission of Ohio would provide oversight of electric vehicle transition plans developed by energy companies and whether increased fees meet criteria laid out in the legislation.

FUNDING

Given the nature of WRTA's proposed transition, there are numerous public funding opportunities *(in the form of grants, low-interest loans, and loan guarantees)* available to facilitate WRTA's transition to a zero-emissions fleet. Funding opportunities for capital improvements, vehicles, equipment, and service exist at both the state and federal level. Recent legislation, including the 2021 *Bipartisan Infrastructure Law*, will continue to provide financial incentive and opportunities for a zero-emissions transition. Below is a summary of resources currently available to WRTA for its proposed transition.

STATE

PROGRAM NAME: CONGESTION MITIGATION AND AIR QUALITY (CMAQ)

STATE AGENCY: Ohio Department of Transportation

FUNDING TYPE: Grant

PROGRAM DESCRIPTION: Funding for projects that have documented ozone emissions and particulate matter reductions. These projects may include signalization and operation highway improvements including roundabouts, transit (new system service or expansion), replacement or retrofit of diesel buses, alternative fuel programs and projects *(including vehicle refueling infrastructure),* fare/fee subsidy programs, truck-stop electrification, rideshare projects, and park-and-ride projects.

ELIGIBLE APPLICANTS: Qualified government entities that are members of a large MPO within the metropolitan planning area; projects may also be considered through Public-Private-Partnerships with an appropriate written agreement in place.

APPLICATION TIMELINE: Rolling deadline; application and loan process takes approximately 30-60 days.

WEBSITE: https://eastgatecog.org/programs/transportation/transportation-improvement-program

PROGRAM NAME: STATE INFRASTRUCTURE BANK (LOAN)

STATE AGENCY: Ohio Department of Transportation

FUNDING TYPE: Loan

PROGRAM DESCRIPTION: Revolving loans for any transportation related project eligible under Federal Title 23, including highway and transit, as well as aviation, rail, and intermodal facilities. Loan collateral is any secure revenue stream such as: gasoline tax revenues, non-tax revenues, Tax Increment Financing district revenues, and license plate and registration fees.

ELIGIBLE APPLICANTS: Applicants include any public entity, such as counties, cities, villages, townships, boards or commissions, regional transit, and port authorities.

PROGRAM TERMS/CONDITIONS: Loans can be secured for up to 30 years at 3% interest rate. Interest deferral is available for up to 12 months. Closing costs can be financed into the loan. Other terms and conditions may vary based upon the amount borrowed.

APPLICATION TIMELINE: Rolling deadline; application and loan process takes approximately 30-60 days.

WEBSITE: https://www.transportation.ohio.gov/programs/state-infrastructure-bank#page=1

PROGRAM NAME: STATE INFRASTRUCTURE BANK (BOND)

STATE AGENCY: Ohio Department of Transportation

FUNDING TYPE: Bond Issue

PROGRAM DESCRIPTION: A bond program create to generate additional State Infrastructure Bank proceeds to fund larger projects. The SIB program assists with all levels and modes of transportation projects within the state. Collateral is any secure revenue stream such as: gasoline tax revenues, non-tax revenues, Tax Increment Financing district revenues, and license plate and registration fees. Depending upon the credit quality of the borrower, these financing programs can frequently take a specific revenue pledge toward a project rather than requiring a full general obligation pledge which preserves debt capacity of the borrower.

ELIGIBLE APPLICANTS: Applicants include any public entity, such as counties, cities, villages, townships, boards or commissions, regional transit, and port authorities.

PROGRAM TERMS/CONDITIONS: Up to a 25-year term can be secured. Market interest rates apply. There is not an interest-free period, but it could potentially be capitalized for up to 3 years. Transaction costs range from 1% to 3%.

APPLICATION TIMELINE: Rolling deadline; application and loan process takes approximately 60-90 days.

WEBSITE: https://www.transportation.ohio.gov/programs/state-infrastructure-bank#page=1

TABLE 38: COMPARISON OF SIB LOAN AND BOND FUND PROGRAMS

COMPARISON OF SIB LOAN AND BOND FUND PROGRAMS		
	LOANS	BONDS
AMOUNTS	$15,000 – $35,000,000	$2,000,000 – $20,000,000
MAXIMUM TERM	30 years	25 years
INTEREST RATE	3%	Market
REPAYMENT	First year free, second year accrued interest	No free interest period, up to three years of capitalized interest
TRANSACTION FEES	$1,000 – $10,000 *(Financial advisor fee)*	1% - 3% of bond issuance amount
ELIGIBLE BORROWERS	Same	Same
ELIGIBLE PROJECTS	Same	Same
REPAYMENT PENALTY	Yes, first 36 months	N/A
PROCESS TIME *Application submittal to loan closing*	30 – 60 days	60 – 90 days
APPLICATIONS	Accepted year round	Accepted year round

SOURCE: ODOT

PROGRAM NAME: DIESEL EMISSION REDUCTION GRANTS

STATE AGENCY: Ohio Department of Environmental Protection

FUNDING TYPE: Competitive Grant

PROGRAM DESCRIPTION: The Diesel Emission Reduction Grant (DERG) program is supported with federal Congestion Mitigation and Air Quality (CMAQ) dollars awarded by the Federal Highway Administration to the Ohio Department of Transportation. The program provides support to public transit systems serving Ohio counties, for the early retirement and replacement of older diesel transit buses.

ELIGIBLE APPLICANTS: Public transit agencies within CMAQ-eligible counties.

PROGRAM TERMS/CONDITIONS: Vehicles must be operated in CMAQ-eligible areas of Ohio for at least sixty-five percent (65%) of the time. Grant applicants should show in the project narrative that the vehicles proposed for replacement have been registered *(if applicable)* and operating within Ohio for the most recent year. Written records must be maintained with the owner/operator of the approved project for a minimum 5 years.

MATCH REQUIREMENT: Applicants must provide at least 20% in matching funds.

APPLICATION TIMELINE: Opens Spring/Summer annually.

WEBSITE: https://epa.ohio.gov/static/Portals/42/documents/DERG/DERG-2021-RFP.pdf

PROGRAM NAME: DIESEL MITIGATION TRUST FUND (VW FUND)

STATE AGENCY: Ohio Department of Environmental Protection

FUNDING TYPE: Competitive Grant

PROGRAM DESCRIPTION: Grants to install DC fast chargers to expand the state's electric vehicle charging infrastructure network along designated corridors in 26 priority counties in Ohio. This program is supported with funds from Ohio's allocation under the Volkswagen Mitigation Trust Fund.

ELIGIBLE APPLICANTS: Eligible applicants include incorporated non-profits; local, state, and federal government entities and political subdivisions; Ohio-based MPOs; other air quality or transportation organizations located in Ohio; and private sector businesses.

PROGRAM TERMS/CONDITIONS: Eligible costs include new DC fast charging station units and associated equipment and construction required for the installation of the charger.

MATCH REQUIREMENT: Chargers on government-owned property require no matching funds; charger on privately-owned property require 20% in matching funds.

APPLICATION TIMELINE: TBD

WEBSITE: https://epa.ohio.gov/divisions-and-offices/environmental-education/grant-programs/vw-mitigation-grants

PROGRAM NAME: OHIO TRANSIT PARTNERSHIP PROGRAM (OTP2)

STATE AGENCY: Ohio Department of Transportation

FUNDING TYPE: Competitive Grant

PROGRAM DESCRIPTION: Grants to facilitate the most efficient and effective use of state funds in the provision of public transportation services while meeting transit system needs, improving economic conditions, and providing a quality-of-life environment for the State of Ohio. Applications are received annually from urban and rural transit agencies to the ODOT Office of Transit and competitively selected via committee of Office of Transit Staff. Applications are divided between Tier I for preservation projects such as vehicle replacements, preventative maintenance, and operating assistance. Tier II applications include expansion, new construction, regionalization, technology, and transportation for workforce development for healthcare initiatives.

ELIGIBLE APPLICANTS: Eligible applicants include regional transit authorities, county transit boards, municipalities, county boards of commissioners, local governmental authorities, non-profit organizations, and operators that provide public transportation in Ohio.

MATCH REQUIREMENT: Matching funds not required but strongly encouraged; applications that show a greater level of non-federal match receive higher scoring.

APPLICATION TIMELINE: Application rounds open annually; applications typically due in Spring.

WEBSITE: https://www.transportation.ohio.gov/programs/transit/transit-funding-resources/ohio-transit-partnership-program

FEDERAL

PROGRAM NAME: GRANTS FOR BUSES AND BUS FACILITIES PROGRAM (SECTION 5339)

STATE AGENCY: U.S. Department of Transportation

FUNDING TYPE: Grant

PROGRAM DESCRIPTION: The Grants for Buses and Bus Facilities Competitive Program *(49 U.S.C. 5339(b))* makes federal resources available to states and direct recipients to replace, rehabilitate and purchase buses and related equipment and to construct bus-related facilities, including technological changes or innovations to modify low or no emission vehicles or facilities.

ELIGIBLE APPLICANTS: Eligible applicants for the Buses and Bus Facilities Program include designated recipients that allocate funds to fixed-route bus operators, States *(including territories and Washington D.C.)* or local governmental entities that operate fixed route bus service, and Indian tribes. Eligible subrecipients include all otherwise eligible applicants and also private nonprofit organizations engaged in public transportation.

ELIGIBLE ACTIVITIES: Capital projects to replace, rehabilitate and purchase buses, vans, and related equipment, and to construct bus-related facilities, including technological changes or innovations to modify low or no emission vehicles or facilities. Additionally, 0.5% of a request may be for workforce development training, and an additional 0.5% may be for training at the National Transit Institute. Applicants for zero-emission vehicles must also spend 5% of their award on workforce development and training as outlined in their Zero-Emission Transition Plan, unless the applicant certifies that their financial need is less.

MATCHING FUNDS REQUIREMENT: The federal share of eligible capital costs is 80 percent of the net capital project cost, unless the grant recipient requests a lower percentage. The Federal share may exceed 80 percent for certain projects related to the ADA and the Clean Air Act. All low-no emission projects are attributable to compliance with the Clean Air Act and/or the Americans with Disabilities Act. Therefore, the Federal share of the cost of leasing or purchasing a low or no emission transit bus is not to exceed 85 percent of the total transit bus cost. The federal share in the cost of leasing or acquiring low- or no-emission bus-related equipment and facilities is 90 percent of the net project cost. Applicants must identify these specific activities in their application in order to receive this increased federal share.

APPLICATION TIMELINE: Rolling deadline; application and loan process takes approximately 30-60 days.

WEBSITE: https://www.transit.dot.gov/bus-program

PROGRAM NAME: LOW OR NO EMISSION VEHICLE PROGRAM (SECTION 5339C)

STATE AGENCY: U.S. Department of Transportation

FUNDING TYPE: Grant

PROGRAM DESCRIPTION: The Low or No Emission competitive program provides funding to state and local governmental authorities for the purchase or lease of zero-emission and low-emission transit buses as well as acquisition, construction, and leasing of required supporting facilities.

ELIGIBLE APPLICANTS: Eligible applicants include direct or designated recipients of FTA grants; states; local governmental authorities; and Indian Tribes. Except for projects proposed by Indian Tribes, proposals for funding eligible projects in rural (non-urbanized) areas must be submitted as part of a consolidated state proposal. States and other eligible applicants also may submit consolidated proposals for projects in urbanized areas.

ELIGIBLE ACTIVITIES: Eligible project activities include:

1. Purchasing or leasing low or no-emission buses.
2. Acquiring low or no-emission buses with a leased power source.
3. Constructing or leasing facilities and related equipment *(including intelligent technology and software)* for low or no-emission buses.
4. Constructing new public transportation facilities to accommodate low or no-emission buses.
5. Rehabilitating or improving existing public transportation facilities to accommodate low or no-emission buses.
6. A maximum of 0.5% of a request may be for workforce development training and an additional 0.5% may be for training at the National Transit Institute (NTI). Applicants may also spend 5% of their award on workforce development and training as outlined in their Zero-Emission Transition Plan, unless the applicant certifies that their financial need is less.

MATCHING FUNDS REQUIREMENT: The federal share of the cost of leasing or purchasing a transit bus is not to exceed 85 percent of the total transit bus cost. The federal share in the cost of leasing or acquiring low or no-emission bus-related equipment and facilities is 90 percent of the net project cost.

APPLICATION TIMELINE: May 31, 2022; program re-opened annually.

WEBSITE: https://www.transit.dot.gov/lowno

PROGRAM NAME: REBUILDING AMERICAN INFRASTRUCTURE WITH SUSTAINABILITY AND EQUITY (RAISE)

STATE AGENCY: U.S. Department of Transportation

FUNDING TYPE: Grant

PROGRAM DESCRIPTION: The RAISE program provides competitive grant funding to surface transportation infrastructure projects with a significant local or regional impact.

ELIGIBLE APPLICANTS: Eligible applicants include States and the District of Columbia; any territory or possession of the United States; a unit of local government; a public agency or publicly chartered authority established by one or more States; a special purpose district or public authority with a transportation function, including a port authority; a federally recognized Indian Tribe or a consortium of such Indian Tribes; a transit agency; and a multi-State or multi-jurisdictional group of entities that are separately eligible.

ELIGIBLE ACTIVITIES: Eligible ***construction*** project types include:

1. Highway, bridge, or other road projects eligible under title 23, United State Code.
2. Public transportation projects eligible under chapter 53 of title 49, United State Code.
3. Passenger and freight rail transportation projects.
4. Port infrastructure investments *(including inland port infrastructure and land ports of entry).*
5. The surface transportation components of an airport project eligible for assistance under Part B of subtitle VII of title 49, United States Code.
6. Intermodal projects.
7. Projects to replace or rehabilitate a culvert or prevent stormwater runoff for the purpose of improving habitat for aquatic species while advancing the goals of the RAISE program.
8. Projects investing in surface transportation facilities that are located on Tribal land and for which title or maintenance responsibility is vested in the Federal Government.
9. Any other transportation infrastructure project that the Secretary considers to be necessary to advance the goals of the program.

Eligible ***planning*** project types include:

1. Development of master plans, comprehensive plans, integrated land use and transportation plans, or corridor plans.
2. Planning activities related to the development of a multimodal freight corridor, including those that seek to reduce conflicts with residential areas and with passenger and non-motorized traffic.
3. Development of port and regional port planning grants, including statewide or multi-port planning within a single jurisdiction or region.
4. Risk assessments and planning to identify vulnerabilities and address the transportation system's ability to withstand probable occurrence or recurrence of an emergency or major disaster.

MATCHING FUNDS REQUIREMENT: The federal share of a project may not exceed 80% unless the project is located in a rural area, a historically disadvantaged community, or an area of persistent poverty.

APPLICATION TIMELINE: April 14, 2022; program re-opened annually

WEBSITE: https://www.transportation.gov/RAISEgrants

PROGRAM NAME: URBANIZED AREA FORMULA GRANTS (SECTION 5307)

STATE AGENCY: U.S. Department of Transportation

FUNDING TYPE: Formula Grant

PROGRAM DESCRIPTION: Formula funding for public transit operators located within eligible Urbanized Areas (UZAs).

ELIGIBLE APPLICANTS:: Public transit operators

ELIGIBLE ACTIVITIES:: Eligible activities include: planning, engineering, design and evaluation of transit projects and other technical transportation-related studies; capital investments in bus and bus-related activities such as replacement, overhaul and rebuilding of buses, crime prevention and security equipment and construction of maintenance and passenger facilities; and capital investments in new and existing fixed guideway systems including rolling stock, overhaul and rebuilding of vehicles, track, signals, communications, and computer hardware and software. In addition, associated transit improvements and certain expenses associated with mobility management programs are eligible under the program. All preventive maintenance and some Americans with Disabilities Act complementary paratransit service costs are considered capital costs.

MATCHING FUNDS REQUIREMENT: The federal share is not to exceed 80 percent of the net project cost for capital expenditures. The federal share may be 90 percent for the cost of vehicle-related equipment attributable to compliance with the Americans with Disabilities Act and the Clean Air Act. The federal share may not exceed 50 percent of the net project cost of operating assistance.

APPLICATION TIMELINE: Allocation distributed on an annual basis.

WEBSITE: https://www.transit.dot.gov/funding/grants/urbanized-area-formula-grants-5307

ELECTRIC STRATEGY

WRTA will continue to work with its energy provider, Ohio Edison, to ensure the electric grid can handle the increased demand and optimize the cost of electricity for successful deployment of ZEBs. TCRP Synthesis 130 provided "insights for how to manage and reduce electricity costs," related specifically to BEBs, which were extracted directly from this report and provided below.

- **INCREASE BEB EFFICIENCY.** A more efficient BEB requires less energy to go the same distance, which means transit agencies pay less for electricity. Aside from bus manufacturers' technological advancement, measures to increase BEB efficiency include adding a diesel heater to reduce electricity needs during the winter or training drivers to operate the BEB more efficiently.
- **OPTIMIZE BEB FAST CHARGING.** Scheduling fast-charging usage to maximize the number of BEBs served while avoiding demand charge increases can decrease the cost of charging per bus.
- **CHARGE MANAGEMENT.** Electricity costs may also be decreased by strategically planning the timing and duration of BEB charging. If a transit agency can accommodate slightly longer layovers or stops in their schedule, the BEBs may charge at a lower power level, thus decreasing demand charges. Transit agencies may also choose to have buses stop for smaller, more frequent top-offs to reduce demand charges. If time-of-use charges are in place, creating a charging schedule that minimizes peak hour charging and maximizes off-peak charging will reduce electricity costs as well. Software and data platforms can help avoid high peak demand by monitoring charging status and preventing charging during peak times. This type of demand management may also be of value to utilities.
- **COLLABORATION AND SUPPORT FROM UTILITY COMPANIES.** BEB charging is an unfamiliar technology for many utilities. The demand charges and time-of-use charges in traditional rate structures were not designed with BEB charging infrastructure in mind. For these reasons, it can be highly beneficial for transit agencies and fleet managers to establish channels of communication with their utility before the BEB deployment process. For transit agencies relying on fast-charging infrastructure, desirable rates will include higher energy usage rates, lower demand charges, and low time-of-use charges. Demand charges are especially detrimental for agencies just beginning to deploy BEBs, with only one or two buses, and may discourage the transition from diesel to electric buses. Often transit agencies find it beneficial to work with an energy consultant who can be supportive during the negotiation process with utility and energy providers.

Ohio Edison is in the process of doing upgrades on the south side of Youngstown in the next two years as well as substation upgrades. "Lincoln Park-Riverbend 138-kV Transmission Line Project (Case No. 19-1871-EL-BTX) American Transmission Systems, Incorporated (ATSI), a transmission subsidiary of FirstEnergy, is proposing to construct a new 138-Kilovolt (kV) Transmission Line and upgrade two existing substations in the Youngstown, Ohio, area. The project is expected to enhance service reliability and performance for approximately 15,000 customers and support residential and business expansion plans in the area. Project Overview ATSI will build a new approximately 5-mile, 138-kV transmission line between the existing Lincoln Park and Riverbend Substations, both located in Youngstown. In addition, the Riverbend Substation will be upgraded to an advanced design that will help reduce the frequency and duration of power outages, and the Lincoln Park Substation will be upgraded to accommodate the new transmission line. Specifically, the project will reduce the risk of a regional outage, improve voltage stability in the area, and allow for future load growth as new businesses and homes are built."

VEHICLE TO GRID TECHNOLOGY

Charging station infrastructure, coupled with BEB battery capacity, can benefit WRTA and the community. With Vehicle to Grid (V2G) technology, charging stations and BEBs can serve as power sources to the entire electrical grid during peak hours and power outages by increasing the overall load of the grid. V2G technology can therefore provide redundancy, stability, capacity, and emergency power to the grid when needed.

By incorporating V2G technology, WRTA can expect to see direct benefits to their agency. Every month WRTA can circulate energy back into the grid and receive credits from their utility company, which can be used to offset the agency's electric bill. For the community, every household, building, factory, and other facilities connected to the grid would be offered a much higher load, which translates to a more stable electrical grid. Utility companies, such as Ohio Edison, benefit from V2G technology by saving costs of purchasing more energy from providers during heavy demand times. In other words, instead of Ohio Edison purchasing more power, they can turn to WRTA and draw the already purchased energy from their infrastructure thereby achieving a cost savings.

V2G will enable WRTA to establish a best practice with Ohio Edison and negotiate a Demand Response contract, which defines terms for the utility to draw energy from WRTA's BEB infrastructure and place it back into the grid during times of high demand. As the demand for energy rises during the day, WRTA's vehicles will continue to circulate energy back into the grid for Ohio Edison to use.

IMPLEMENTATION AND MONITORING PLAN

Critical elements to WRTA's Implementation and Monitoring Plan are:

1) Ongoing public input into the Plan.
2) Annual training employees and first responders.
3) At a minimum, annual review and update of the Plan taking into consideration advances in technologies as well as service changes to meet the needs on the communities.
4) Ongoing discussions with Ohio Edison to ensure electric grid can handle the increased demand and optimize the cost of electricity for successful deployment of EVs.
5) Energy strategies.
6) Key Performance Indicators.
    a. State of Charge
    b. kWh/mile overlayed with average temperature
    c. Emission reduction
    d. EV versus Diesel
        i. Road calls
        ii. Vehicle Not Available for Service
        iii. Maintenance Cost per Vehicle Mile
        iv. Maintenance Cost by Type *(preventative maintenance, propulsion related, cab/body/accessories)*
        v. Fuel Cost per Vehicle Mile

BUDGET SUMMARIES

Table 39 summarizes WRTA's Calendar Year 2022 Budget.

TABLE 39: WRTA CALENDAR YEAR 2022 BUDGET

Subsidies	$ 17,774,109
Other Revenue	$ 347,664
TOTAL REVENUE:	**$ 18,121,773**
GENERAL ADMINISTRATION	
Salaries & Wages	$ 503,390
Fringe Benefits	$ 329,918
Utilities	$ 199,002
Insurance	$ 355,610
Advertising	$ 278,500
Taxes	$ 434,882
Other	$ 315,440
TOTAL GENERAL ADMINISTRATION:	**$ 2,416,743**
MAINTENANCE	
Salaries & Wages	$ 958,563
Fringe Benefits	$ 690,471
Pro & Tech-Vehicle Maintenance	$ 5,200
Fuel & Lubricants	$ 1,220,519
Tires & Tubes	$ 25,139
Accident Repair	$ 35,250
Inspection & Maintenance	$ 461,689
Recovery	$ -27,500
Services-Non Vehicle Maintenance	$ 396,343
TOTAL MAINTENANCE:	**$ 3,765,675**
TRANSPORTATION	
Salaries & Wages	$ 6,352,892
Fringe Benefits	$ 3,624,337
TOTAL TRANSPORTATION:	**$ 9,977,229**
PROFESSIONAL AND TECHNICAL:	**$ 498,297**
TOTAL EXPENDITURES:	**$ 16,657,943**

TRANSITION COST SUMMARY

BASELINE COSTS, NO ELECTRIC VEHICLES

Table 40 outlines WRTA's total anticipated fleet procurement costs between 2022 and 2031, should they choose to not deploy EVs. The number of vehicles identified in this table and the accompanying costs does not include the increased vehicles needed for EV vehicles identified in the ZESP. The total vehicles replaced were obtained from the baseline replacement schedule that replaces a vehicle after it passes its useful life. Cost assumptions were obtained from WRTA's 2022 TAM.

TABLE 40. BASELINE DIESEL FLEET REPLACEMENT COSTS (2022 – 2031)

	PER-VEHICLE COST	TOTAL VEHICLES REPLACED	ANTICIPATED EXPENSES
Heavy Duty Bus	$430,000	46	$19,780,000
Modified Mini's	$50,000	8	$400,000
LTV	$90,000	42	$3,780,000
Support Vehicles	$51,000	19	$969,000
	TOTAL	**115**	**$24,929,000**

ZERO EMISSION SERVICE PLAN COSTS

Table 41 shows the total anticipated fleet procurement costs between 2022 and 2031 should WRTA deploy EVs. The cost assumptions for LTVs, modified mini-vans, and support vehicles are based on WRTA's preferred technology type (battery electric), bus length, and industry quotes from Lightning E-Motors. The purchase price of a heavy duty EVs is based on discussions with a Gillig sales representative.

TABLE 41. ZESP FLEET PROCUREMENT COSTS (2022-2031)

	PER-VEHICLE COST	TOTAL VEHICLES REPLACED	ANTICIPATED EXPENSES
Heavy Duty Bus	$925,000	62	$57,350,000
Modified Mini's	$150,000	8	$1,200,000
LTV	$285,000	57	$16,245,000
Support Vehicles	$70,000	19	$1,330,000
	TOTAL	**146**	**$76,125,000**

Table 42 provides a high-level summary of the total anticipated costs to transition WRTA's fleet to EV.

TABLE 42. EV TRANSITION COSTS (2022 – 2031)

COST CATEGORY	TOTAL
Fleet Procurement	$76,125,000
Chargers & Infrastructure	$4,086,700
Generators	$708,000
Maintenance	$13,208,380
New Employees Salary and Wages (Cumulative)	$9,536,024
New Employees Equipment	$163,988
Employee Training	$122,868
TOTAL:	**$103,950,960**

FLEET PROCUREMENT COST COMPARISONS

Deploying EVs is a significant financial investment. As shown in Table 43 the per-vehicle costs of EVs are considerably higher than the costs of procuring a diesel bus.

TABLE 43. DIESEL VERSUS EV PER-VEHICLE PROCUREMENT COST COMPARISON

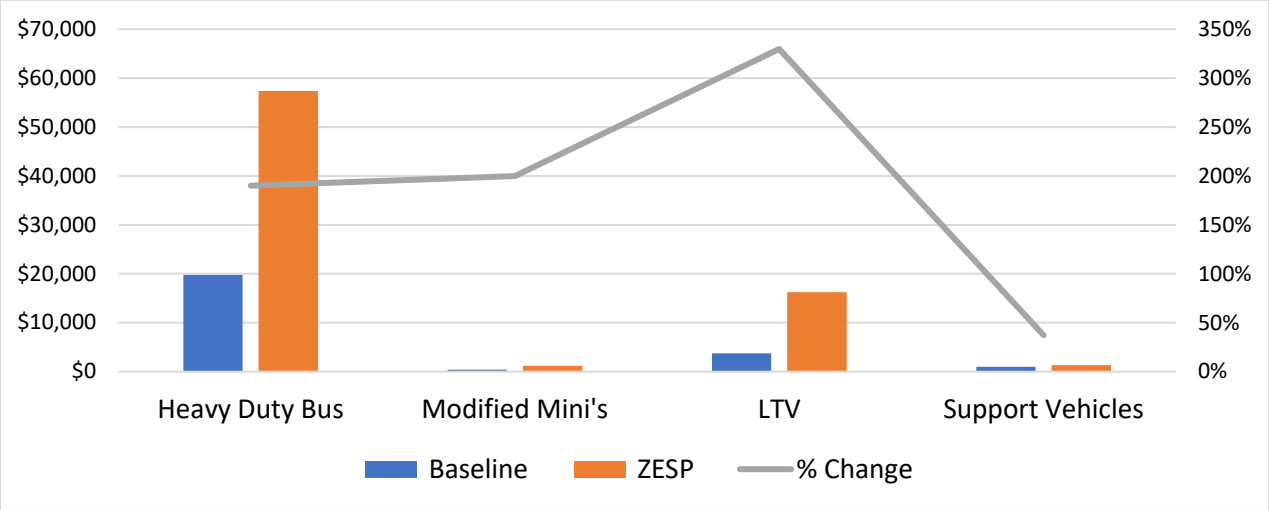
FLEET TYPE	ANTICIPATED COSTS: DIESEL VEHICLES	ANTICIPATED COSTS: EVS	PER-VEHICLE COST INCREASE
Heavy Duty Bus	$430,000	$925,000	115%
Modified Mini's	$50,000	$150,000	200%
LTV	$90,000	$285,000	217%
Support Vehicles	$51,000	$70,000	37%

As shown in Table 44 and Figure 11, deploying EVs under the ZESP would cost WRTA approximately $51 million more than if they kept their fleet diesel due to the higher per-vehicle costs shown in Table 43. The anticipated increase is also due to the assumption that WRTA will need to increase their fleet size by 27 percent.

TABLE 44. BASELINE VS ZESP PROCUREMENT COSTS (2022-2031)

FLEET TYPE	BASELINE SCENARIO (ALL DIESEL)		ZESP		SUMMARY	
	TOTAL PURCHASED	ANTICIPATED COST	TOTAL PURCHASED	ANTICIPATED COST	FLEET INCREASE	COST INCREASE
Heavy Duty Bus	46	$19,780,000	62	$57,350,000	**35%**	**$37,570,000**
Modified Mini's	8	$400,000	8	$1,200,000	**0%**	**$800,000**
LTV	42	$3,780,000	57	$16,245,000	**36%**	**$12,465,000**
Support Vehicles	19	$969,000	19	$1,330,000	**0%**	**$361,000**
TOTAL:	**115**	**$24,929,000**	**146**	**$76,125,000**	**27%**	**$51,196,000**

FIGURE 11. BASELINE VS ZESP PROCUREMENT COMPARISON (2022 – 2031)



COST SAVINGS

Deploying an EV fleet does cost more than comparable vehicles with internal combustion engines (ICEs). However, EVs superior efficiency, the moderate price of electricity, and high utilization of fleet vehicles will allow WRTA to quickly recoup the extra up-front costs and achieve a lower total cost of ownership (TCO). These higher costs for EVs can be offset with lower operating expenses including:

MAINTENANCE

Under the baseline scenario (all diesel), WRTA's total maintenance costs in 2031 would accrue to approximately $19,870,274. However, the proposed gradual deployment of EVs would result in a total maintenance expense of $13,208,380. Deploying EVs under the proposed ZESP would result in a 34 percent reduction in overall maintenance costs between 2022 to 2031, which equates to over $6.6 million in cost savings.

FUEL COSTS

AMPLY Power, a provider of charge management services and software for fleets, released a 2021 white paper, *Managed Charging Accelerates Cost and Health Benefits of EVs*, "assessing the cost saving potential of transitioning to an electric vehicle (EV) fleet and found that electric charging is 37% cheaper than diesel to fuel heavy-duty fleets. The white paper uses AMPLY's proprietary dollar per gallon-equivalent (DPGe) metric, which is the dollars needed to drive an EV the same number of miles compared to an internal combustion engine (ICE) vehicle, expressed in a per gallon basis. Findings of the DPGe calculation across the top 25 U.S. Metros reveal the following for different fleet vehicle types:

- Powering light-duty vehicles with electricity is 44% cheaper than fueling with gasoline.
- Electric power is 43% cheaper than gasoline for medium-duty vehicles.
- Electric charging is 37% cheaper than diesel to fuel heavy-duty fleets.
- Switching from diesel to electricity for city bus fleets reveals a cost savings of 63%.

To give a more complete picture of WRTA's potential fuel cost savings when considering the transition to electric, the aforementioned reduction in costs provided by Amply was applied to WRTA's annual diesel costs (37% reduction for heavy duty buses, 44% reduction for LTVs, and 43% reduction for modified minivans). Based on this analysis, it was determined that WRTA could reduce fuel expenses by approximately 38% which would accrue to approximately $3.9 million between 2022 and 2031.

OTHER COST SAVINGS

In addition to maintenance and fuel costs, there are other cost saving benefits associated with deploying EVs, including optimizing electricity usage and selling power back to the electric company.

- **OPTIMIZED ELECTRICITY USAGE.** Advanced end-to-end EV charging solutions such as ChargePoint's supported software can help WRTA optimize their electricity usage, further reducing costs. Smart Electric Vehicle Supply Equipment (EVSE) can also be programmed to avoid peak pricing and prioritize charging during low electricity rates, ensuring vehicles are fully charged at the right time to maximize cost savings.
- **SELLING POWER BACK TO ELECTRIC COMPANY.** A 2018 article titles "How Battery Storage Can Help Charge the Electric-Vehicle Market" by Stefan Knupfer *(How battery storage can help charge the electric-vehicle market | McKinsey)* indicated that "selling power stored in EV batteries back to the grid during periods of peak demand, which is a form of "vehicle to grid" (V2G) service, not only lessens maximum loads on the grid but also allows EV owners to capitalize on high electricity prices. Similarly, charging stations can be configured to refill EV batteries with grid power when prices dip. Doing this helps vehicle owners avoid demand charges *(additional fees, levied according to the maximum rate at which power is drawn),* which can make up about 90 percent of a charging station's electric bill."

EMISSION DAMAGE COST SAVINGS

Economic damages caused by exposure to air pollution represent externalities because their impacts are borne by society rather than by the travelers and operators whose activities generate those emissions. The U.S. Department of Transportation's Benefit-Cost Analysis (BCA) Guidance, published in March 2022, provides a useful method to evaluate and compare potential transportation investments for their contribution to the economic vitality of the nation. This guidance describes an acceptable methodological framework for purposes of preparing BCAs for discretionary grant applications and provides sample calculations of some of the quantitative elements of a BCA including recommended economic values for reducing emissions. These standardized values are intended to ensure greater consistency in how various types of projects from across the country are evaluated.

The most common local air pollutants generated by transportation activities include nitrogen oxides (NOX) and fine particulate matter (PM2.5). Another important type of emissions from the combustion of transportation fuels is GHGs, specifically carbon dioxide (CO2). Table 45 summarizes USDOT's recommended monetized values for calculating damage costs for these emissions per metric ton.

TABLE 45. USDOT DAMAGE COSTS FOR EMISSIONS PER METRIC TON

EMISSION TYPE	CO_2	NO_X	$PM_{2.5}$
2022	$52	$15,600	$748,600
2023	$53	$15,800	$761,600
2024	$54	$16,000	$774,700
2025	$55	$16,200	$788,100
2026	$56	$16,500	$801,700
2027	$57	$16,800	$814,500
2028	$58	$17,100	$827,400
2029	$60	$17,400	$840,600
2030	$61	$17,700	$854,000
2031	$62	$18,100	$867,600

To determine economic damages under the baseline scenario (WRTA keeping their fleet entirely diesel), the 2022 Annual Emissions for CO_2, NO_x, and $PM_{2.5}$ shown in Table 35 were converted to metric tons and multiplied by the aforementioned USDOT damage costs. Based on this analysis, between 2022 and 2031, WRTA's operations will have contributed over $2 million in emission damages. However, should WRTA gradually integrate into an entirely EV fleet, these annual damages will reduce each year until reaching zero in 2031.

TABLE 46. BASELINE SCENARIO VS ZESP EMISSION COSTS (2022 – 2031)

SCENARIO	BASELINE (ALL DIESEL) EMISSION COSTS				ZESP EMISSION COSTS			
EMISSIONS	CO_2	NO_X	$PM_{2.5}$	TOTAL	CO_2	NO_X	$PM_{2.5}$	TOTAL
2022	$294	$64,360	$134,135	$198,789	$172	$37,543	$78,246	$115,960
2023	$300	$65,175	$136,442	$201,917	$153	$33,191	$69,485	$102,828
2024	$305	$65,989	$138,802	$205,097	$158	$34,217	$71,972	$106,347
2025	$311	$67,211	$141,198	$208,720	$161	$34,850	$73,214	$108,225
2026	$316	$68,433	$143,452	$212,202	$126	$27,247	$57,115	$84,488
2027	$322	$69,655	$145,724	$215,701	$101	$21,929	$45,876	$67,906
2028	$333	$70,877	$148,049	$219,259	$71	$15,094	$31,529	$46,694
2029	$339	$72,099	$150,409	$222,847	$41	$8,679	$18,105	$26,824
2030	$344	$73,729	$152,804	$226,877	$13	$2,731	$5,659	$8,403
2031	$350	$73,729	$152,804	$226,883	$0	$0	$0	$0
TOTAL:	**$3,214**	**$691,257**	**$1,443,820**	**$2,138,291**	**$995**	**$215,479**	**$451,200**	**$667,675**

Based on this analysis, WRTA's gradual deployment of EVs will result in a 68.8 percent reduction in CO_2, NO_X, and $PM_{2.5}$ which will have a total damage cost savings of $1,470,616 by 2031.

TABLE 47. SUMMARY OF EMISSION DAMAGE COST SAVINGS

YEAR	TOTAL BASELINE EMISSION DAMAGES	TOTAL ZESP EMISSION DAMAGES	DECREASE IN EMISSIONS	DAMAGE COST SAVINGS
2022	$198,789	$115,960	41.67%	$82,829
2023	$201,917	$102,828	49.07%	$99,089
2024	$205,097	$106,347	48.15%	$98,750
2025	$208,720	$108,225	48.15%	$100,495
2026	$212,202	$84,488	60.19%	$127,714
2027	$215,701	$67,906	68.52%	$147,795
2028	$219,259	$46,694	78.70%	$172,565
2029	$222,847	$26,824	87.96%	$196,023
2030	$226,877	$8,403	96.30%	$218,474
2031	$226,883	$0	100.00%	$226,883
TOTAL:	**$2,138,291**	**$667,675**	**68.78%**	**$1,470,616**

SUMMARY OF SAVINGS

It is anticipated that WRTA's deployment of EVs could result in over $10.5 million in cost savings over the 10-year period (2022 to 2031). However, it should be noted that the anticipated fuel savings does not account for inflation. Therefore, the identified fuel savings are rather conservative. Given the current economic climate, it is anticipated that transitioning to EVs would actually result in higher fuel cost savings.

TABLE 48. COST SAVINGS SUMMARY

COSTS	SAVINGS
Maintenance Costs	$6,661,894
Fuel Expenditure	$2,409,542
Emission Costs	$1,470,616
TOTAL:	**$10,542,052**

The transition to EV technologies represents a paradigm shift in bus procurement, operation, maintenance, and infrastructure. This technology requires significant development and investment before it is ready to fully support fleetwide transitions. However, it is only through a continual process of deployment with specific goals for advancement that the industry can achieve the goal of economically sustainable, zero-emission public transit.

While the short term costs of deployment are significant, the long-term total cost of an EV fleet is effectively proving to be less than a traditional ICE vehicle due to lower maintenance and fewer repairs. With innovations in electricity production expected to reduce the price of electricity and battery technologies extending the life and storage capacity of a charge, costs of transiting to electric are likely to keep decreasing. Furthermore, EV technologies are in a period of rapid development and change; which is anticipated to reduce the total costs for deploying these vehicles including procuring vehicles, accompanying software, and charger infrastructure.