



Zero-Emission Vehicle Transition Plan

April 2024



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Executive Summary

ARRIVE provides public transit services in Wilson County, North Carolina. ARRIVE owns and operates a fleet of 15 vehicles for demand-response transit services. To support local air quality improvement goals, modernize its fleet, prepare for the future, and plan for new transit facilities, ARRIVE is pursuing a transition to zero-emission vehicles (ZEVs) for its services.

While developing this plan, ARRIVE determined that battery electric vehicles (BEVs) are the most suitable zero-emission technology to transition its current fleet. Additionally, ARRIVE is in the process of securing county-owned land that will have sufficient electrical capacity to support the needed infrastructure of BEV chargers. ARRIVE's current fleet is made up of transit vans and cutaways. ARRIVE plans to procure vehicles that are similar in size and seating capacity to the existing fleet. ARRIVE will follow a dedicated phasing strategy to implement the transition to BEVs, shown below in **Figure 1**.

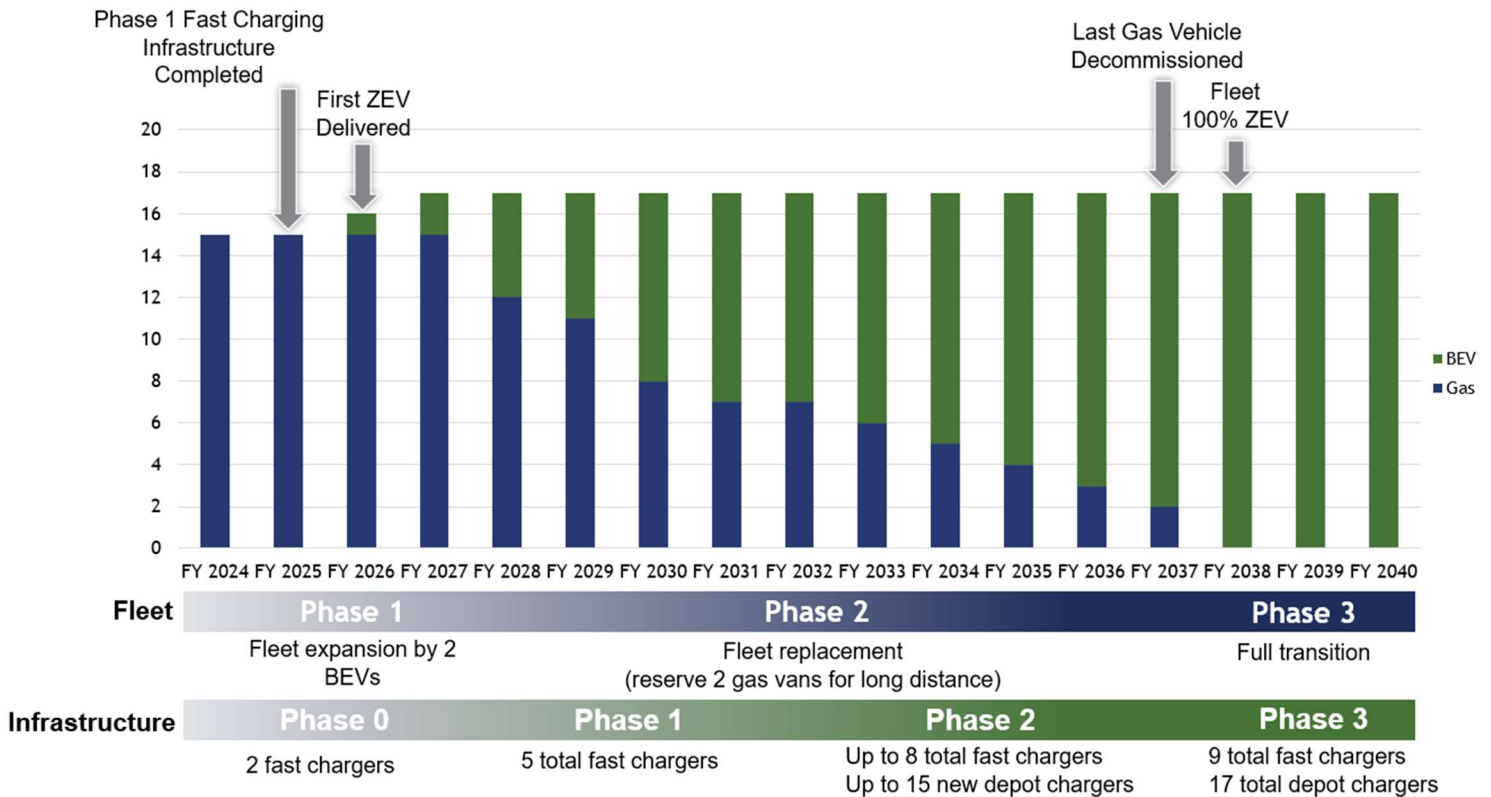


Figure 1: Fleet Composition Based on Phased Transition Plan

The composition shown in **Figure 1** is a result of a three-phased ZEV approach:

- Phase One: An initial zero-emission implementation of two BEVs between 2024 and 2027, preceded by necessary infrastructure
- Phase Two: Fleet replacement and infrastructure expansion while reserving two gas powered vehicles for long distance trips between 2028 and 2037
- Phase Three: Full transition to a zero-emission fleet by 2038

Introduction

ARRIVE is a public transportation service operated by Wilson County, North Carolina. ARRIVE provides scheduled, demand-response employment transportation, non-emergency medical, and paratransit services in Wilson County Monday through Saturday from 5 AM to 6 PM. ARRIVE also provides trips outside of Wilson County to Durham, Rocky Mount, and Greenville on select days during the week. Wilson County contracts with Hendrickson Transportation Group (HTG), who provides dispatching and scheduling, vehicle maintenance, and daily operations for ARRIVE.

With the exception of the weekly trips made to Durham, Rocky Mount, and Greenville, ARRIVE's service territory is the entirety of Wilson County. Within Wilson County, 15 of the 19 census tracts are classified as disadvantaged by the Council on Environmental Quality using the Climate and Economic Justice Screening Tool.¹

Many of the disadvantaged census tracts within Wilson County meet the burden thresholds for climate change, health, and transportation, indicating that these are areas with high susceptibility to natural disasters, have high rates of asthma and diabetes, and that residents spend a disproportionate amount of their income on transportation. Further, many of the census tracts in Wilson County are above the 65th percentile for the number of households below the federal poverty line. A map of Wilson County, with these census tracts highlighted, is shown in **Figure 2: Justice 40 Census Tracts**.

ARRIVE is pursuing the acquisition of zero-emission vehicles (ZEVs) to reduce operational emissions. While this plan identifies an aspirational goal of 100 percent ZEVs in 2038, this target will be continually evaluated and revised based upon changing markets, emergent technologies, and battery-electric technology's ability to meet service and operations requirements.

The Bipartisan Infrastructure Law (BIL) has introduced a requirement that any federal grant application for projects related to ZEVs must include a zero-emission transition plan. Therefore, the Federal Transit Administration (FTA) requires a Zero-Emission Fleet Transition Plan from each transit agency that applies for the FTA Low- or No-Emission Grant Program—5339 (c) for ZEV projects.

Per FTA requirements, this Zero-Emission Fleet Transition Plan includes the following six elements:

1. **Policy and Legislative Impacts:** Considers policy and legislation impacting relevant technologies
2. **Fleet Plan:** Demonstrates a long-term fleet management plan with a strategy for how the applicant intends to use the current request for resources and future acquisitions
3. **Facility and Infrastructure Plan:** Evaluates existing and future facilities and their relationship to the technology transition
4. **Fuel Plan:** Describes the partnership of the applicant with the utility or alternative fuel provider
5. **Funding Plan:** Addresses the availability of current and future resources to meet costs for the transition and implementation
6. **Workforce Transition Plan:** Examines the impact of the transition on the applicant's current workforce by identifying skill gaps, training needs, and retraining needs of the existing workers. This

¹Council on Environmental Quality. 2022. Climate and Economic Justice Screening Tool. Retrieved from: <https://screeningtool.geoplatform.gov>

focuses on support ARRIVE's short-term and long-term needs to operate and maintain ZEVs while avoiding displacement of the existing workforce.

ARRIVE's Zero-Emission Fleet Transition Plan includes each of these required elements, which will guide the agency's investments and strategy in the coming years. In addition to these required elements, this plan includes a Transition Strategy section that details the phasing of vehicle procurement and facility improvements necessary to a successful ZEV transition for ARRIVE.

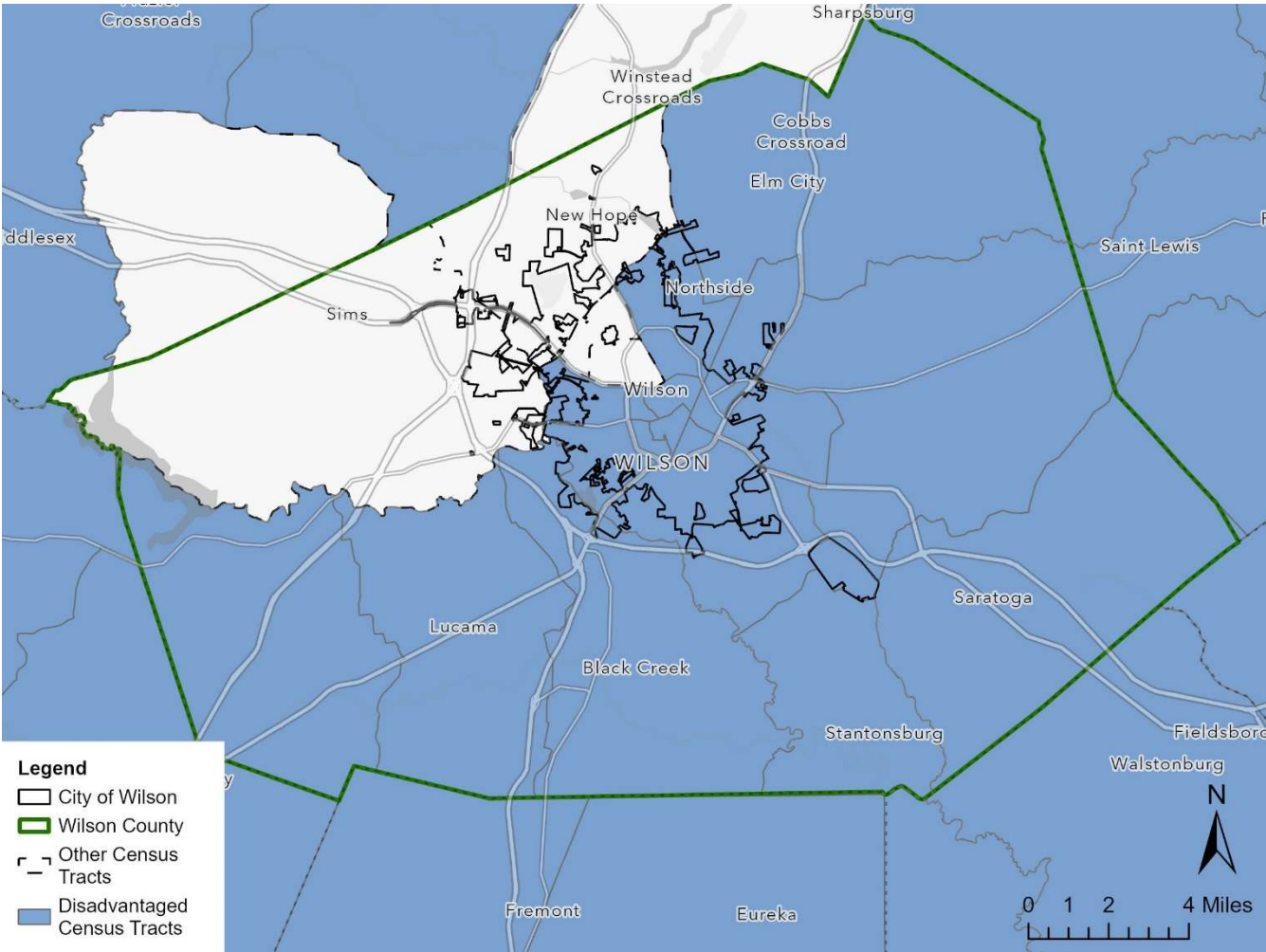


Figure 2: Justice 40 Census Tracts

Policy and Legislative Impacts

ARRIVE's ZEV Transition Plan supports various transportation electrification and decarbonization policies and initiatives at the state and local level. Most notably, this plan will support the various commitments that North Carolina has made to reduce greenhouse gas emissions and increase the use of ZEVs statewide.

Statewide Initiatives

Legislation

In 2021, North Carolina ratified a bill (House Bill 951) that requires the Utility Commission to “take all reasonable steps to achieve a 70 percent reduction in emission of carbon dioxide from electric public utilities from 2005 levels by 2030 and carbon neutrality by the year 2050.”² North Carolina’s long-term plans to improve upstream emissions in energy generation will support ARRIVE’s transition to ZEV technology from “wheel to well.”³

Executive Orders

Between 2018 and 2022, Governor Roy Cooper issued three executive orders related to ZEVs and transportation decarbonization that are relevant to ARRIVE’s Zero-Emission Vehicle (ZEV) Transition Plan.

Executive Order 80: North Carolina’s Commitment to Address Climate Change and Transition to a Clean Energy Economy

Governor Cooper issued Executive Order 80 in October 2018. This order included a commitment to reduce statewide greenhouse gas emissions to 40 percent below 2005 levels and to increase the number of registered ZEV to at least 80,000 by 2025. Executive Order 80 also called for the development of multiple statewide ZEV plans and the creation of the North Carolina Climate Change Interagency Council to oversee progress toward the state’s climate goals.⁴

Executive Order 246: North Carolina’s Transformation to a Clean, Equitable Economy

Executive Order 246 builds on the commitments made in Executive Order 80 to update the energy reduction and ZEV adoption goals for 2030. This order states that greenhouse gas emissions must be 50 percent below 2005 levels by 2030 and aims to have least 1.25 million ZEVs registered in the state by 2030. This order also calls for the development of the North Carolina Clean Transportation Plan, which is detailed below.⁵

Executive Order 271: Growing North Carolina’s Zero-Emission Vehicle Market

Governor Cooper issued this order in October 2022 to address the global market transition to zero-emission medium duty vehicles (MDV) and heavy-duty vehicles (HDV), including vans, buses, and trucks. This order requires the North Carolina Department of Environmental Quality (NCDEQ) to establish a North Carolina Advanced Clean Trucks program requiring MDV manufacturers to sell an increasing percentage of MDV ZEV over time in the state. Under this order, NCDOT was directed to develop a ZEV infrastructure needs assessment that includes the needs of larger vehicles like trucks and buses.⁶

Statewide Zero Emission Vehicle Plans and Reports

The North Carolina Department of Transportation (NCDOT), NCDEQ, and Department of Administration (NCDOA) have adopted many ZEV plans that are relevant to ARRIVE’s ZEV Transition Plan. Many of these

² North Carolina General Assembly. 2021. House Bill 951 Ratified Bill. Retrieved from:

<https://www.ncleg.gov/Sessions/2021/Bills/House/PDF/H951v5.pdf>

³ “Wheel to well” is a method to evaluate efficiency and emissions of a vehicle by considering the emissions of all upstream energy production methods.

⁴ State of North Carolina. 2018. Executive Order No. 80. Retrieved from: governor.nc.gov/documents/files/executive-order-no-80-north-carolinas-commitment-address-climate-change-and-transition-clean-energy

⁵ State of North Carolina. 2022. Executive Order No. 246. Retrieved from: governor.nc.gov/executive-order-no-246/open

⁶ State of North Carolina. 2022. Executive Order No. 271. Retrieved from: governor.nc.gov/executive-order-no-271/open

plans were mandated by Executive Orders 80, 246, and 271, summarized above. These plans define the state's commitments and initiatives to transportation decarbonization and electrification.

North Carolina ZEV Plan (2019, 2022)

In 2019, NCDOT published the North Carolina ZEV Plan in partnership with NCDEQ to achieve the goals set forth in Executive Order 80. This plan identified 20 recommendations to support ZEV adoption. Relevant to ARRIVE's plan, this statewide plan included a medium-term recommendation (2020-2023) for NCDOT to establish a task force to issue a report recommending goals and strategies for electrifying transit fleets statewide. The 2022 update states that North Carolina State University's Institute for Transportation Research and Education will be developing a Zero Emission Transit Fleet Transition Plan for NCDOT. As of March 2024, it does not appear that this task force has been convened but ARRIVE should track the progress of this effort.⁷

NCDOT published an update to this plan in 2022, reflecting progress made on the 2019 plan and updated requirements for ZEV from Executive Order 246. This update reflected that NCDOT was in the process of developing a Zero Emission Transit Fleet transition plan and that this plan would be incorporated into the North Carolina Clean Transportation Plan. This update also noted that a task force for transit fleet electrification had not yet been convened but that many transit agencies statewide were starting to transition to electric and alternative fuel fleets.⁸

North Carolina Clean Transportation Plan (2022)

The Clean Transportation Plan identified 12 strategies, two of which address clean transportation infrastructure. This includes a strategy to evaluate and deploy clean transportation infrastructure to support all types of fleet vehicles and applications, including transit.⁹

Climate Strategy Reports

The state's Cabinet agencies are obligated to provide an annual Climate Strategy Report to the Climate Change Interagency Council. According to the state's 2023 Climate Strategy Report, which reports on progress towards these orders, NCDOT was expected to publish this needs assessment in late 2023.

The 2023 report also states that NCDOT's Integrated Mobility Division is supporting four transit agencies in developing ZEB strategies. This includes Wilson County ARRIVE's ZEB Transition Plan. It is notable that this Transition Plan supports one of NCDOT's strategies to work towards the state goal established in Executive Order 246 to have least 1.25 million ZEVs registered in the state by 2030.¹⁰

⁷ North Carolina Department of Transportation. 2019. ZEV Plan. Retrieved from: www.ncdot.gov/initiatives-policies/environmental/climate-change/Documents/nc-zev-plan.pdf

⁸ North Carolina Department of Transportation. 2022. ZEV Plan Progress Update. Retrieved from: www.ncdot.gov/initiatives-policies/environmental/climate-change/Documents/zev-plan-progress-update-2022.pdf

⁹ North Carolina Department of Transportation. 2023. Clean Transportation Plan. Retrieved from: www.ncdot.gov/initiatives-policies/environmental/climate-change/Documents/nc-clean-transportation-plan-final-report.pdf

¹⁰ North Carolina Department of Transportation. 2023. Climate Strategy Report. Retrieved from: www.deq.nc.gov/media/41846/download?attachment

Local Initiatives

City of Wilson

The City of Wilson's 2030 Comprehensive Plan identified the following goal for the city to develop a multimodal transportation system. The accompanying policy 14.4 affirms the City's commitment to reducing vehicle emissions.¹¹

- **Goal 14. A Multimodal Transportation System:** Provide an efficient, safe, and accessible multi-modal transportation system that protects the natural environment and community character.
 - **Policy 14.4:** The transportation system should promote vehicles that are more fuel-efficient and reduce carbon emissions and the use of fossil fuels while promoting the use of local renewable and sustainable fuels. Needed improvements include installing charging stations for electric vehicles (EVs) and upgrading City vehicle fleets to more energy-efficient vehicles.

ARRIVE's ZEV Transition Plan will advance this City goal and corresponding policy by reducing carbon emissions and the use of fossil fuels. This policy also notes that the City will expand its network of charging stations for electric vehicles; there are currently ten charging stations in downtown Wilson and the City plans to add more stations downtown and around the city.¹² While Policy 14.4 notes that the City's vehicle fleets will be upgraded to more fuel-efficient vehicles, they do not currently have electric vehicles in their fleet.¹³

Wilson County

Wilson County is currently updating its 2045 Comprehensive Land Use Plan. The plan will build on the goals from the 2025 Comprehensive Plan to create an updated list of recommendations and policies for the management and growth of Wilson County.¹⁴

Surrounding Jurisdictions

ARRIVE provides weekly service to Raleigh, Greenville, and Rocky Mount. Since these surrounding jurisdictions are far from Wilson County, the agency will need to identify charging strategies to allow for service to these areas as the ZEV transition progresses.

All three of these jurisdictions have started installing public charging stations. The City of Rocky Mount installed the City's first two city-owned EV charging stations in December 2023, with plans to install a city-owned Direct Current Fast Chargers (DCFC) charger at the Rocky Mount Event Center in June 2024.¹⁵ There are two public EV charging stations in Greenville, both of which are on the East Carolina University Campus.¹⁶

¹¹ North Carolina Department of Transportation. 2023. Climate Strategy Report. Retrieved from: www.wilsonnc.org/home/showpublisheddocument/574/636707374173130000

¹² City of Wilson. 2024. Charging Stations. Retrieved from: www.wilsonnc.org/residents/all-departments/planning-community-revitalization/downtown-parking/charging-stations

¹³ City of Wilson. 2024. Fleet Maintenance. Retrieved from: www.wilsonnc.org/residents/city-services/all-departments/public-works/fleet-maintenance

¹⁴ Wilson County Government. 2024. 2045 Comprehensive Plan. Retrieved from: <https://www.wilsoncountync.gov/departments/development-services/planning/2045-comprehensive-plan>

¹⁵ WRAL. 2023. Rocky Mount Installs First City-Owned EV Chargers. Retrieved from: www.wral.com/story/rocky-mount-installs-first-city-owned-ev-chargers/21183709/

¹⁶ Greenville Utilities. 2024. Electric Charging Stations. Retrieved from: www.guc.com/clean-future/electric-charging-stations

The City of Raleigh has made extensive investments in installing public charging stations and has committed to fully electrifying its own city fleet of over 2,000 vehicles within the next 10 years. In February 2024, the City received a \$450,000 grant from the U.S. Department of Energy which will fund three zero-emission transportation projects in the city, including electric vehicle chargers for the city's fleet vehicles. The City plans to install 30 EV chargers for its fleet vehicles.¹⁷

Fleet Plan

The Fleet Plan is a long-term fleet management plan that outlines how ARRIVE intends to transition its current fleet to ZEV. This section describes ARRIVE's existing fleet and daily operations and assesses zero-emission technology for suitability for ARRIVE's operations.

As detailed in **Appendix A: Market Overview Technical Memorandum**, the most comparable ZEV to ARRIVE's current fleet is a battery electric passenger van. Specifically, the Ford E-transit has been identified as being the vehicle most similar to the vehicles in ARRIVE's fleet that is readily available on the market. For the purposes of the analysis and transition strategy presented below, it is assumed that ARRIVE will replace its gas-powered vehicles with Ford E-transit vans.



Figure 3: Example of ARRIVE's Current Transit Van

Fleet Operations

Current fleet

ARRIVE's existing fleet consists of 15 vehicles: 10 passenger vans, four cutaways, and one Americans with Disabilities Act (ADA) van. All 15 vehicles are gasoline powered. At present, ARRIVE plans to decommission

¹⁷ City of Raleigh. 2024. Zero-emission Transportation Projects. Retrieved from: raleighnc.gov/climate-action-and-sustainability/news/raleigh-awarded-450k-zero-emission-transportation-projects



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vehicles once they reach 100,000 miles in line with state requirements. This is a recent change, and the mileage of some of the vehicles in ARRIVE’s present fleet will exceed this benchmark.

For the purposes of zero-emission planning and the **Transition Strategy** detailed later in this document, a five-year vehicle life cycle was used as a reasonable proxy for the 100,000-mile benchmark. **Table 1** below highlights ARRIVE’s existing fleet, vehicle type, model year, mileage, and planned decommission year.

Vehicle ID	Model	Vehicle Type	Model Year	Mileage ¹⁸	Planned Decommission year
31346	Ford Transit	Passenger Van	2017	221,756	FY 2023
35126	Ford Transit	Passenger Van	2017	127,878	FY 2025
77500	Ford Transit	Passenger Van	2017	68,468	FY 2023
31345	Ford Transit	Passenger Van	2017	185,063	FY 2023
37794	Ford Transit	Passenger Van	2018	149,206	FY 2024
37795	Ford Transit	Passenger Van	2018	223,396	FY 2023
31431	Ford Transit	Passenger Van	2019	164,353	FY 2024
31432	Ford Transit	Passenger Van	2019	134,400	FY 2025
69371	Ford Transit	Passenger Van	2022	7,024	FY 2028
57407	High-top Transit Van	Passenger Van	2023		FY 2028
68834	Ford E 350 Ltv	Cutaway	2020	60,644	FY 2025
68835	Ford E 350 Ltv	Cutaway	2020	49,235	FY 2025
14389	Ford E 350 Ltv	Cutaway	2021	52,144	FY 2026
15017	Ford E 350 Ltv	Cutaway	2022	30,191	FY 2027
58338	Braun Voyager Van	ADA Van	2023		FY 2028

Table 1: ARRIVE's Current Fleet

Current Operations

ARRIVE provides scheduled, demand-response employment transportation, non-emergency medical, and paratransit services in Wilson County Monday through Saturday from 5 a.m. to 6 p.m. ARRIVE also provides trips outside of Wilson County to Durham, Rocky Mount, and Greenville on select days during the week. To request a ride, passengers must contact ARRIVE by 4 p.m. the day before. ARRIVE then dispatches drivers based on the scheduled rides and their locations.

Because ARRIVE only offers demand-response services, the revenue hours and mileage of a vehicle can vary day to day. **Figure 4** shows the 25th percentile, 85th percentile, and average mileage of each of ARRIVE’s vehicles from July 2023 to December 2023. During this time, the average daily mileage of vehicles in ARRIVE’s fleet was about 115 miles, and vehicles were in service for an average of eight hours per day.

¹⁸ Vehicle mileage as of November 2023. Vehicles without a listed mileage have been put into service after November 2023.

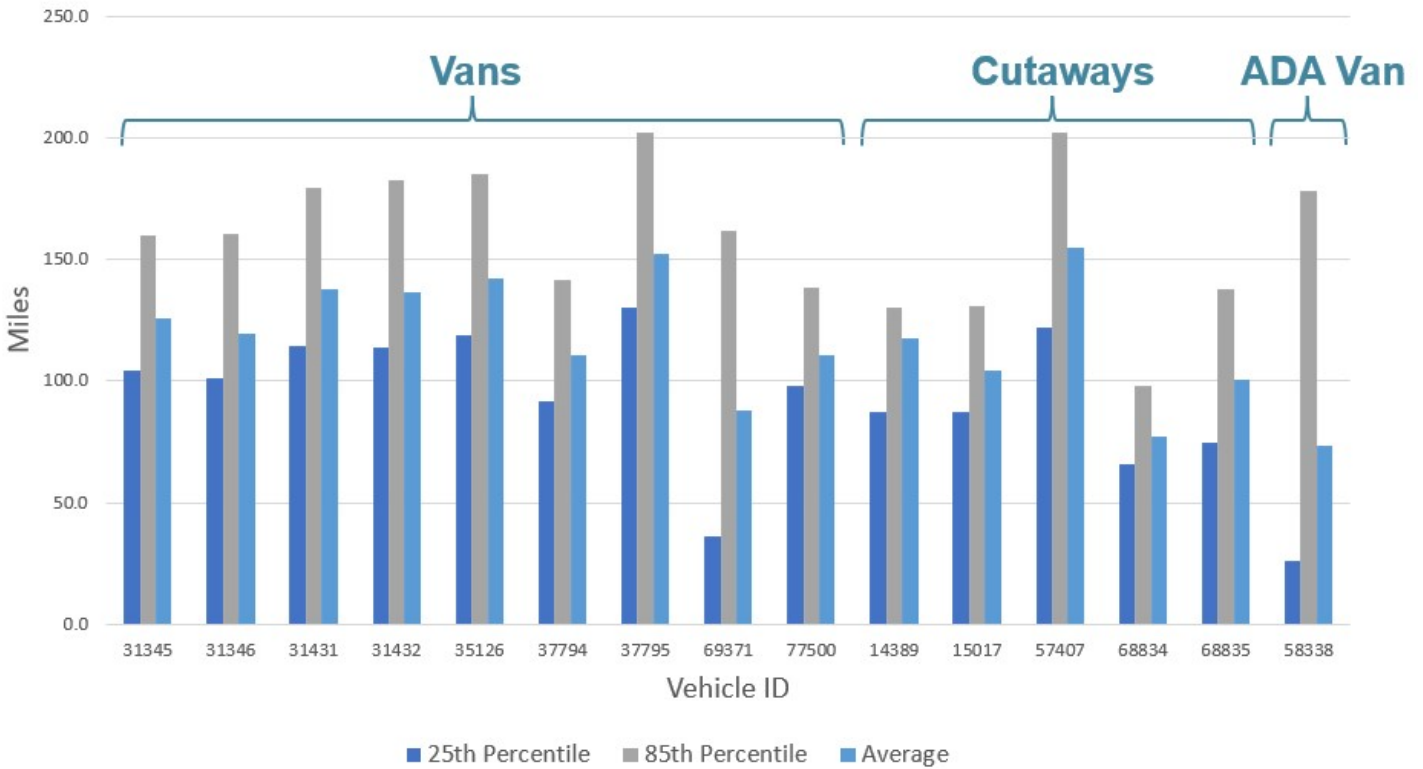


Figure 4: ARRIVE Vehicle Utilization (July 2023 to December 2023)

Future Operations

To meet the growing demands of ridership, ARRIVE is pursuing an initial expansion fleet in the early stages of its ZEB transition. Expanding ARRIVE’s fleet will ensure shorter wait times for passengers and greater flexibility to serve more riders, especially on days where ARRIVE is serving trips outside of Wilson County to destinations in Durham, Rocky Mount and Greenville.

ARRIVE is also studying expanding its existing services beyond on-demand services to include a geofenced microtransit service. This study will include an analysis of existing travel patterns within the county and determine potential microtransit zones based on existing transit demand. ARRIVE recognizes that electric vehicles could be a relevant and applicable vehicle type to be used for this service. Given the range limitations of existing zero-emission technology (see **Technology Assessment**), electric transit vans may be better suited for implementation in a smaller service area. ARRIVE expects to complete its microtransit study by the end of 2024.

Technology Assessment

Based on the market research that informed the **Appendix A: Market Overview Technical Memorandum**, the existing market for zero-emission vehicles that are comparable to the vehicles being used by ARRIVE currently is limited.

While propane conversion options do exist, ARRIVE is not currently pursuing propane powered vehicles as part of its zero-emission transition. Many of these propane conversions occur aftermarket, which presents potential danger of voiding vehicle warranties.

Similar to other fueling alternatives explored in **Appendix A: Market Overview Technical Memorandum**, propane refueling infrastructure requires a significant level of investment that is beyond what ARRIVE can support at its existing operations and maintenance (O&M) facility. Because ARRIVE leases its current facility, ARRIVE may not be able to install propane storage tanks and fueling infrastructure (given necessary safety setbacks) and may not have room to do so.

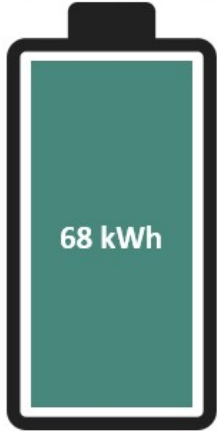
Because of the limitations posed by a potential propane fueling option for transit operations, ARRIVE is focusing zero-emission transition on BEVs and battery electric charging infrastructure. Of the battery electric transit options that are available, the Ford E-Transit presents the most direct substitute for the vehicles in ARRIVE's fleet. The following section assesses the suitability of the Ford E-Transit for ARRIVE's existing operations, using the range and other specifications provided by Ford.

Battery Capacity

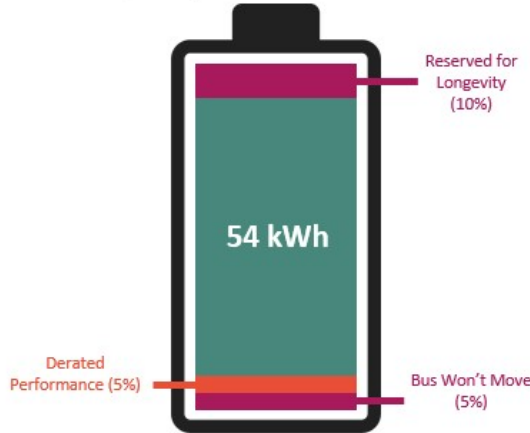
ARRIVE has completed an assessment of BEV technology for the purposes of conservatively estimating vehicle range, based on the understanding that the capacity and range advertised by the manufacturer is not fully usable in actual operations. Electric batteries degrade, which occurs over time as the battery loses its ability to hold a charge. **Figure 5** highlights the effects of battery degradation. When the battery is new, the first 10% of the battery should be reserved for longevity. The remaining 90%, referred to as service energy, is the portion of battery capacity that is useable. The service energy is designed to protect the battery life.¹⁹ The last 10% will hold the vehicle to a derated performance, and the BEV will not experience the same range per kilowatt hour (kWh) as it would with the rest of the battery. Below 5%, the energy supplied by the battery will be insufficient to move the vehicle.

¹⁹ Mountain Line Transit. 2020. Zero-Emission Bus Implementation Plan. Retrieved from: <https://mountainline.az.gov/wp-content/uploads/2021/03/Phase-2-Implementation-FINAL.pdf>

The battery capacity you think you're getting:



A realistic view of your battery capacity:



Your battery capacity with 30% battery degradation:

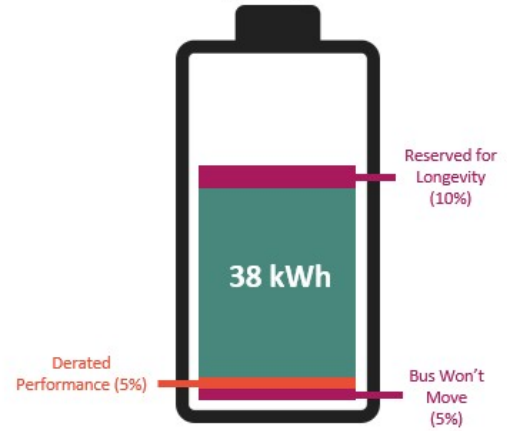


Figure 5: BEV Battery Degradation

For fixed-route transit vehicles, manufacturers (original equipment manufacturers [OEMs]) typically provide an initial warranty on the battery, which often guarantees between 70 to 80% of the kWh of a new battery. This warranted amount of battery life is typically calculated against the stated range of the battery, rather than the actual range of the battery, not including a reserve. For example, if the battery is advertised at 68 kWh nameplate capacity, the actual benchmark amount covered and replaced by the warranty could be anywhere between 46 kWh and 55 kWh.

While ARRIVE will be replacing its fleet with electric vans (and not fixed route-transit vehicles), this highlights the need to plan for lifetime and warrantable battery degradation to account for a vehicle's ability to complete its required tasks. The amount of battery degradation covered by the warranty is dependent on negotiation with the OEM and can influence the purchase price of the BEV.

Local Climate and Impacts on Resilience

Because operating an HVAC system in hot or cold temperatures can draw power away from the propulsion system in a BEV, the weather can have a significant impact on the range of an electric transit vehicle. The constant summertime air-conditioning demand present in warm climates like Wilson County cause the battery to deplete more quickly than it might in more moderate climates. Based on data available from the National Weather Service (**Figure 6**), Wilson County's hottest month is July, with the average high temperatures reaching around 90°F. The coldest month is January, where the average low dips to around 32°F.

Monthly Climate Normals (1991–2020) – WILSON 3 SW, NC

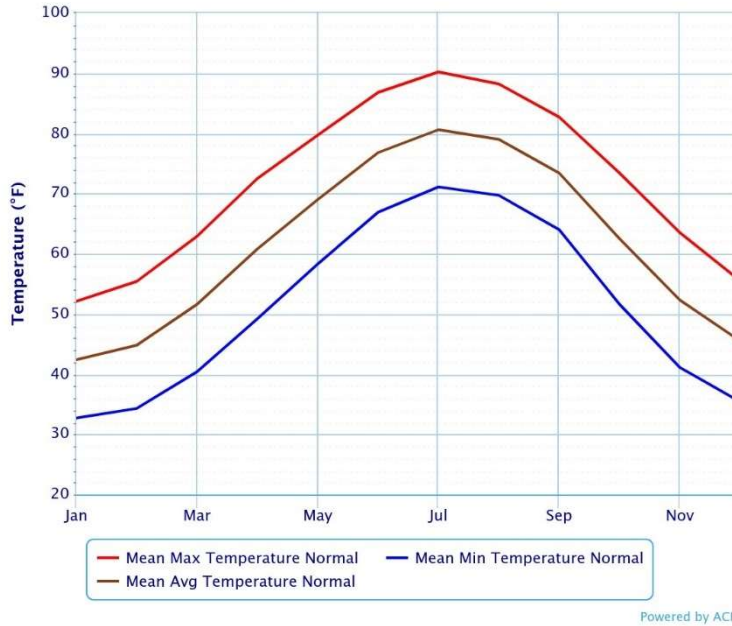


Figure 6: Wilson County's Average Monthly Temperatures

To compare the yearly temperatures of Wilson County to the experiences of other transit agencies deploying electric transit vehicles, **Figure 7** shows observed battery performance for a battery electric bus (BEB) in a range of temperatures. The agencies included in this analysis represent a variety of climates (District Department of Transportation [DDOT] in Washington, DC; Seneca Transit in Seneca, SC; Duluth Transit Authority [DTA] in Duluth, MN; and Worcester Regional Transit Authority [WRTA] in Worcester, MA). While each of these agencies operate only fixed-route services with their electric fleet of buses, the relative battery performance is still a useful metric for estimating impacts to weather on the performance of medium-duty electric transit vehicles. In general, these agencies saw battery performance peaking around 60°F, with efficiency declining at higher and lower temperatures. Because Wilson County experiences temperatures on both ends of this spectrum throughout the year, ARRIVE will need to be prepared for fluctuations in the actual ranges of BEVs.

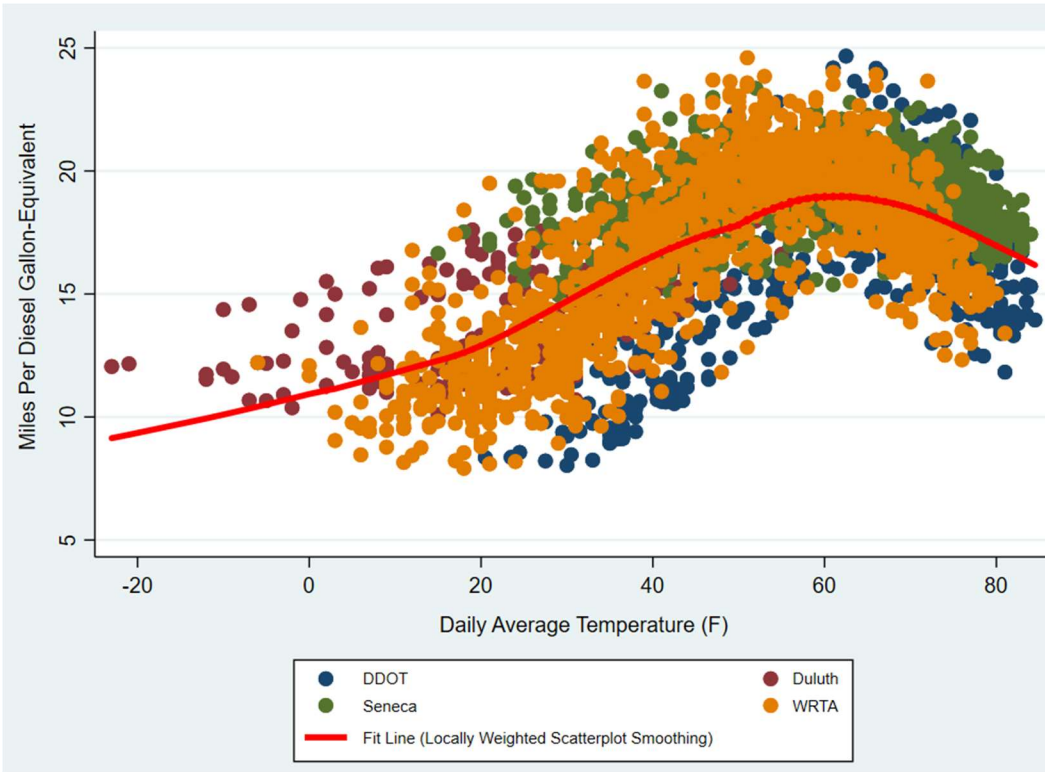


Figure 7: Miles Per Diesel Gallon-equivalent Fuel Economy for BEVs²⁰

BEV Range Assessment

Considering the battery degradation and climate impacts described above, ARRIVE has modeled BEV performance based on battery capacity estimates and estimated range.

To account for battery degradation, the feasibility model developed by ARRIVE for this analysis accounts for battery degradation of up to 30% of the original battery capacity, representing a vehicle operating with 70% of the battery’s original capacity. Although batteries can degrade well beyond 70% of their original capacity, this threshold was chosen based on warranty practices observed in the current market. To account for weather impacts on BEV range, the feasibility model estimated the range of a BEV in particularly cold or warm conditions – representing a strenuous day for the BEV.

The analysis is based on the range estimates shown in **Table 2**, modeling the range of a 68 kWh Ford E-Transit in various conditions to create conservative estimates of the maximum daily range for ARRIVE’s fleet. Analyzing BEV feasibility using conservative battery capacity estimates is intended to represent a difficult day for the battery capacity of the vehicle, estimating intensive HVAC usage. The assumed impacts of these strenuous conditions are detailed in **Appendix B: Modeled Battery Range Thresholds**.

²⁰ Mark Henning, Andrew R. Thomas, Alison Smyth. 2019. An Analysis of the Association between Changes in Ambient Temperature, Fuel Economy, and Vehicle Range for Battery Electric and Fuel Cell Electric Buses. Retrieved from: https://engagedscholarship.csuohio.edu/cgi/viewcontent.cgi?article=2634&context=urban_facpub

Battery Condition	Battery Capacity (kWh)		Range (miles)	
	New	70% Battery Capacity	New	70% Battery Capacity
Advertised Capacity	68 kWh	48 kWh	N/A	N/A
Usable Capacity	54 kWh	38 kWh	116 miles	81 miles
Perceived Capacity in Strenuous Conditions	38 kWh	27 kWh	81 miles	57 miles

Table 2: Battery Capacity for 68kWh Ford E-Transit Van

When analyzing ARRIVE’s current operations under these conditions, the average day for seven vehicles is infeasible on one charge. Comparing 85th percentile days, only one of ARRIVE’s vehicles would be able to complete its operations on one charge. These findings are summarized in **Figure 8**, where the blue and black dashed lines represent the usable range of a new Ford E-Transit and a Ford E-Transit in strenuous conditions, respectively. Strategies to mitigate the effects of strenuous conditions and battery degradation for demand-response vehicles are explored in the **Strategies to Account for Strenuous Days** section below.

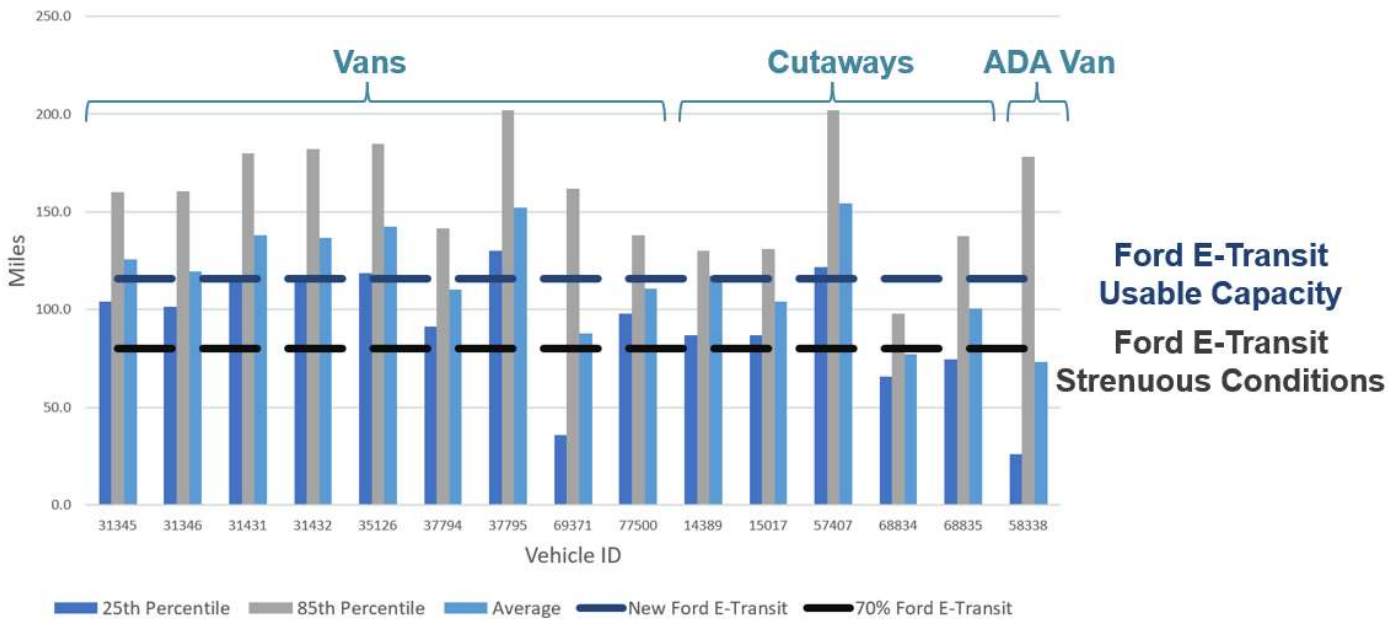


Figure 8: ARRIVE Vehicle Utilization with Estimated BEV Ranges

Strategies to Account for Strenuous Days

There are a few strategies that ARRIVE can deploy to ensure that BEVs can complete their daily operations on strenuous days. These strategies include midday vehicle charging, increasing the number of BEVs in ARRIVE’s fleet, and adjusting dispatching strategies to optimize BEV efficiency. These strategies, which are described below, can be implemented on their own or implemented together to increase the resiliency of a BEV fleet.

Midday Charging

Implementing midday charging at fast chargers within Wilson County will allow BEVs to regain charge during the service day. This strategy would require vehicles to have approximately 10 to 45 minutes at a fast charger several times throughout a day of service to gain sufficient state-of-charge to complete daily operations. These charging windows could be timed with preplanned driver breaks to maximize efficiency.

Increased Fleet Size

Increasing the size of ARRIVE's fleet would allow for swapping out an in-service vehicle with a fully charged replacement. This would minimize the downtime needed to charge vehicles midday and provide ample time for vehicles to be fully recharged during the day. However, relying solely on this strategy would drastically increase ARRIVE's fleet size and cost of ARRIVE's zero-emission transition.

Adjusting Dispatching Strategies

To maximize the revenue service of a fully charged electric transit vehicle, ARRIVE may update their dispatching procedures to better match trips with drives. This may be done by assigning drivers trips in a smaller region within the county and better matching trips that end in one location with a trip that begins in a nearby location. This can improve the performance of a BEV by limiting the non-revenue miles between trips with no passengers. This strategy, however, limits ARRIVE's overall demand-response flexibility and capacity to accommodate various passenger needs.

The procurement plan to support the future fleet associated with ARRIVE's ZEV transition will be covered in the **Transition Strategy** section.

Facility and Infrastructure Plan

The Facility and Infrastructure Plan incorporates an analysis of ARRIVE's existing facility, plans for a new facility, and recommendations for short- and long-term plans to accommodate and support a zero-emission fleet.

Current Facilities

At present, all ARRIVE vehicles are stored at a facility leased by its contractor, HTG. The building and the parking lot at the current ARRIVE facility, which is located at 1901 Tarboro Street, is shared with other tenants, and has limited office space for staff and operators. ARRIVE's parking area is constrained to the right portion of the parking lot. The vehicles are parked every other spot to allow room for wheelchair lifts to be deployed. Based on this existing parking configuration, the maximum number of vehicles that can be stored at the lot is 17 vehicles. An aerial of the facility is shown below in **Figure 9**, with the area reserved for ARRIVE vehicles outlined in black.



Figure 9: ARRIVE's Current Facility

ARRIVE's contract with HTG, which is in place through 2028, covers light maintenance (including oil changes, tire replacement and some body work), which occurs on-site at the leased facility. Heavy maintenance is outsourced to local vendors.

The current facility, due to its size and the fact that it is leased, limits what ARRIVE can do at the facility in terms of expansion and increased maintenance. Because of this, ARRIVE has interest in moving to a dedicated facility that would be owned by the County, which may allow for greater flexibility in installing EV charging infrastructure. A new facility remains a long-term desire, however, and neither ARRIVE nor Wilson County has taken steps to begin planning for a location for a new O&M facility.

Future Facility Candidates

While a permanent O&M facility is unlikely to be in place by the time ARRIVE begins its transition to ZEVs, ARRIVE will need to have some BEV chargers installed in a central, convenient location to begin the transition to electric transit vehicles.

To facilitate this and ensure that ARRIVE is ready to receive its battery-electric vehicles by Phase 1 of its zero-emission transition, ARRIVE has Wilson County's support to install two fast chargers on a county-owned site (**see Appendix D**). ARRIVE and Wilson County are currently working through the site selection process and have narrowed down a list of county-owned properties to three high-potential sites for further consideration:

- Wilson County Health Department
- Wilson County Government Center
- Wilson County Botanical Garden

Of these three sites, the Wilson County Health Department site is the top priority for charger implementation in the early phases of ARRIVE’s zero-emission transition (see below). However, all three sites do represent opportunities for future charger placement in later phases of ARRIVE’s zero-emission transition.

All three sites are in the City of Wilson, central to the fleet’s daily operations, and close to the current ARRIVE facility (see **Figure 10**). After site selection, ARRIVE and the county will work on the design phase for the planned high-capacity electrical infrastructure. As the ZEV transition progresses, ARRIVE will continuously reevaluate the most suitable charging infrastructure for the fleet.



Figure 10: Potential Sites for ZEV Charging Infrastructure

Priority Site for Initial Charger Implementation: County Health Department

The Wilson County Health Department is located at 1801 Glendale Drive, approximately .5 miles from ARRIVE’s current O&M facility. Currently, Wilson County parks county-owned fleet vehicles at this site. During the day, the parking lot can fill up, but the employee parking area behind the building (on the west side of the site) typically has excess capacity for parking ARRIVE vehicles. While vehicles are charging at this site, drivers would have access to a bathroom and other facilities inside of the Health Department building.

In the Summer of 2024, the County Health Department parking lot will be repaved. As part of this project, the county is exploring a reconfiguration of the southeast corner to support the installation of BEV chargers. These improvements will include planning for wider turning radii for transit vans, ensuring the necessary utility connections to support EV charging, and pouring a concrete pad for chargers. Because of this construction, and the County’s support for installing ZEV chargers on site, the County Health Department is the top candidate for installing fast chargers in Phase 1 of ARRIVE’s zero-emission transition. A high-level site concept for fast-charger placement at the Wilson County Health Department is shown in **Figure 11**.

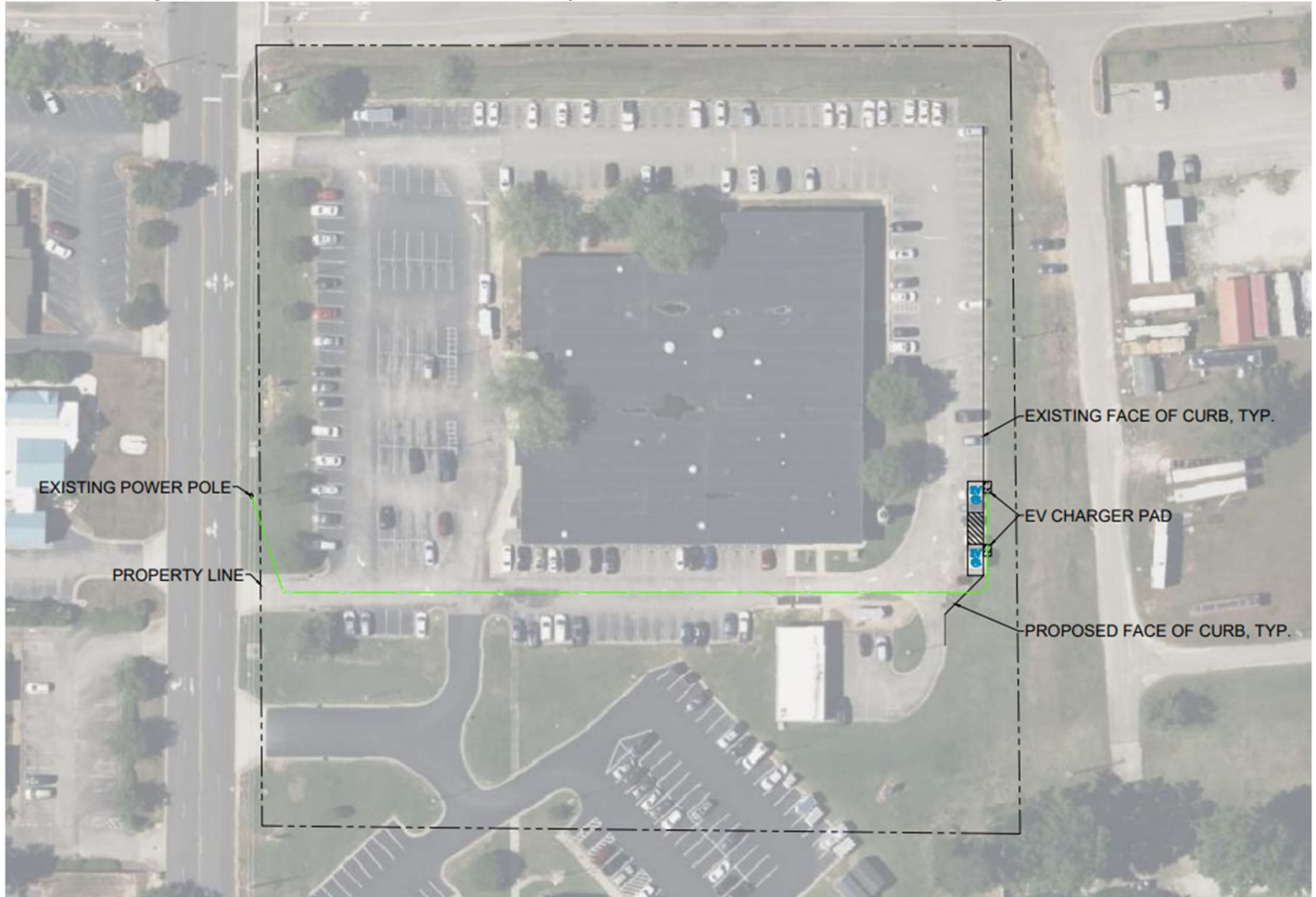


Figure 11: Wilson County Health Department Fast-Charging Concept

Additional Site for Future Phases: Government Center

The Wilson County Government Center is located at 2201 Miller Road South, about three miles from the current ARRIVE O&M site. While the parking lot is typically full and the turning radii in the parking lot may present operational challenges for transit vans, the site has room for parking lot expansion and the installation of ZEV chargers.

The Government Center is currently undergoing renovations, and part of this construction will include an expansion and reconfiguration of the on-site parking lot. While the renovations and parking lot improvements

present an opportunity for installing fast chargers (like the County Health Department), the Government Center is less centrally located and has fewer driver amenities like convenience stores and food options nearby. With this in mind, the Government Center represents an opportunity for installing charger infrastructure in a future phase of ARRIVE’s zero-emission transition. A high-level site concept for fast-charger placement at the Wilson County Government Center is shown in **Figure 12**.



Figure 12: Wilson County Government Center Fast Charging Concept

Additional Site for Future Phases: Agriculture Center

The third site under consideration is the Wilson County Botanic Gardens and North Carolina State Cooperative Extension at 1806 Goldsboro Street. This site is approximately two miles from ARRIVE’s current O&M facility, and potentially has space to expand the existing parking lot to accommodate EV chargers.

The Botanic Gardens site, however, is not located centrally compared to where most of ARRIVE’s service occurs, and there are few driver amenities like convenience stores or food options nearby. Further, the Agricultural Center hosts events year-round at all times of day, and the parking lot can fill up rapidly as a result. Of the three sites, the Agricultural Center represents the least opportunity for charger placement but may still represent a future opportunity. A high-level site concept for fast-charger placement at the Agricultural Center is shown in **Figure 13**.



Figure 13: Wilson County Agricultural Center Fast Charging Concept

Fuel Plan

The Fuel Plan details the implementation considerations for ARRIVE to transition to a zero-emission fleet. As established in the Market Overview Memo (see **Appendix A: Market Overview Technical Memorandum**), battery electric alternatives are the only realistic zero-emission solution for ARRIVE’s existing fleet and operations. As a result, this section focuses on the charging infrastructure for BEVs.

Battery Electric Charging Infrastructure

The charging infrastructure for battery electric vehicles utilizes the existing electrical grid to charge vehicles. Typically, this involves leveraging existing power lines, transformers, and switchgears to install electric chargers. The existing electrical grid can sometimes serve as a limiting factor, and upgrades to electrical infrastructure may be necessary to support BEV charging.

For the battery electric vehicles that are comparable to the vehicles that ARRIVE currently operates, ground-mounted plug-in chargers are the only readily available options. These are the most common type of BEV chargers and utilize a plug-in connection to recharge a BEV.

Depending on the power output of a plug-in charger, which can range from 5 kW to 200 kW, plug-in chargers are classified as either a depot charger or a fast charger. ARRIVE plans to utilize both lower-output depot chargers and higher-powered fast chargers during its BEV transition. The implementation of these chargers will

be phased, with a reliance on fast chargers in the early stages of ARRIVE's BEV transition and the installation of depot chargers once ARRIVE has built a new, permanent O&M facility.

For ground-mounted plug-in chargers, the following are design considerations for the facilities where ARRIVE will install BEV chargers:

- Requires trenching to distribute power to cabinets
- Requires space dedicated to charging cabinets and dispensers, as well as cable management (to avoid risk of cable damage)
- May require placement of new curbs or bollards to protect power modules and other above-ground equipment
- Requires that operators plug-in vehicles to begin charging
- Charging cabinets are at ground level and are therefore easier to access and maintain when needed

Depot Charging

Depot charging typically takes place overnight at an O&M facility after a vehicle has finished service for the day or prior to beginning service. The typical output of a depot charger is between 5 kW and 20 kW. As a result of this lower electrical output, depot chargers are slower than methods of fueling traditional diesel and gas vehicles and can require four to ten hours to fully charge a vehicle. This is often a lower-cost way to charge BEVs since many electric utilities incentivize customers to charge slower and to charge during the grid's off-peak period at night.

To ensure that all vehicles are ready for service the following day, ARRIVE will plan to charge its entire BEV fleet overnight. This means that the number of depot chargers to support ARRIVE's fleet will follow a 1:1 ratio of vehicles to chargers. To utilize overnight depot chargers, ARRIVE will need to have a permanent facility to safely park vehicles overnight. Because ARRIVE will not have a permanent O&M facility in place at the start of its zero-emission transition, ARRIVE plans to begin implementing depot chargers after Phase 2 of its transition.

Fast Charging

Fast charging usually takes place midday at a layover location where the vehicle will be in a fixed location for a period. Fast chargers have a higher electrical output than depot chargers, ranging from 50kW to 350 kW.

Because ARRIVE does not own its O&M facility, ARRIVE will rely on fast chargers located on a county-owned site during Phase 1 of the transition while ARRIVE works to acquire dedicated land. To ensure that vehicles are fully charged before they begin service, operators will be required to use fast chargers at the beginning and/or end of service for the day. Throughout the day, operators will utilize the fast chargers to recharge the vehicles. To create scheduling efficiencies, drivers will be encouraged to charge their vehicle during preplanned operator breaks.

The number of fast chargers needed is also dependent on the number of BEVs in ARRIVE's fleet, but at a lower ratio of vehicles to chargers than depot chargers. Generally, ARRIVE will plan for a 2:1 ratio of vehicles to chargers during all phases of its zero-emission transition. Charging windows will need to be staggered throughout the day to ensure that there are enough chargers at any one time to support midday charging for all ARRIVE's BEVs.

Utility Partnership

ARRIVE has been coordinating with Wilson Energy, the municipal energy provider in the City of Wilson, to determine how the sites identified in the **Facility and Infrastructure Plan** can support depot and fast charging. This coordination is ongoing and will serve to inform the extent of the improvements needed to the electric grid at sites being identified for charging infrastructure. ARRIVE has Wilson Energy's support to install two fast chargers and will coordinate with Wilson County to ensure proper grid capacity at the sites identified (see **Appendix E**).

Transition Strategy

Combining the **Fleet Plan** and **Facility and Infrastructure Plan** above, ARRIVE has developed a comprehensive transition strategy to implement zero-emission technology. The overall transition strategy includes a Fleet Procurement Plan and a Facility and Infrastructure Phasing Plan.

Fleet Procurement Plan

The purpose of the Fleet Procurement Plan is to determine the number of ZEVs in ARRIVE's fleet at throughout the zero-emission transition, as well as plan for the cost of procuring ZEVs.

With the range limitations and other considerations described above in the **Technology Assessment** section, ARRIVE is planning for a gradual, phase approach to its zero-emission vehicle transition. The transition will begin with a small initial fleet expansion utilizing ZEVs and then slowly replacing its gas vehicle fleet. This approach allows ARRIVE to begin to adopt zero-emission technology while retaining some gas-powered vehicles for longer trips and days of heavier transit usage.

ARRIVE's fleet transition separates procurement generally into three phases:

- **Phase One:** Covers the years 2024 to 2027, characterized by a small fleet expansion with BEVs for ARRIVE's microtransit service
- **Phase Two:** Spans from years 2028 to 2037, highlighted by gas-powered vehicles being replaced with EVs – with the exception of two gas-powered vehicles reserved for long-distance trips
- **Phase Three:** From years 2038 and beyond, ARRIVE fully electrifies its fleet

While ARRIVE has recently updated its policies for decommissioning vehicles from a year-based standard to a mileage-based standard, the procurement plan, detailed in **Table 3** below, assumes that all vehicles (both gas-powered and electric) are on a five-year decommissioning schedule.

Year	Vehicles Delivered		Fleet Composition			Development Notes
	Gas	BEV	Gas	BEV	Total	
2024	2	0	15	0	15	Start of Phase 0: ARRIVE begins ZEV transition by preparing site for charger installment
2025	4	0	15	0	15	
2026	2	1	15	1	16	Start of Phase One: Fleet expansion begins, first ZEV put into service
2027	1	1	15	2	17	
2028	2	3	12	5	17	Start of Phase Two: First ZEV replacement vehicles arrive. Gas powered vehicles slowly replaced with ZEVs, except for long distance fleet
2029	1	1	11	6	17	
2030	1	3	8	9	17	
2031	1	2	7	10	17	
2032	1	1	7	10	17	
2033	2	3	6	11	17	
2034	0	2	5	12	17	
2035	0	4	4	13	17	
2036	0	3	3	14	17	
2037	0	2	2	15	17	Start of Phase Three: Full fleet transition, long distance fleet replaced with ZEVs
2038	0	5	0	17	17	
2039	0	2	0	17	17	
2040	0	2	0	17	17	

Table 3: ARRIVE Year-by-Year Vehicle Procurement and Fleet Composition

Phase One Transition

Phase One of ARRIVE’s zero-emission transition is planned to span from 2024 through 2027. Alongside a planned fleet expansion from 15 to 17 vehicles, ARRIVE will begin its zero-emission transition with the procurement of BEVs (**Figure 14**). During this time, ARRIVE will also:

- Prepare for zero-emission vans by installing fast chargers to be used for midday charging
- Continue to work on procuring a site for a permanent facility
- Continue to monitor the ZEV market for range improvements and ZEV technology investment

Prior to receipt of the first zero-emission vehicles, ARRIVE will have installed two fast-chargers at a county-owned site within the City of Wilson (see Facility and Infrastructure Plan).

During Phase One of the ZEV transition, ARRIVE would rely on fast-chargers installed at a county-owned facility within the City of Wilson for all charging needs (see **Facility and Infrastructure Plan**). Prior to starting a day of service, operators would take the vehicle to a fast-charging location and fully charging the vehicle. Throughout the service day, the operator of an electric vehicle would visit the charging location to recharge the vehicles as needed.

ARRIVE will continue to decommission gas powered vehicles as planned, with two planned decommissions in FY 2026 and one planned decommission in FY 2027. In Phase One, ARRIVE will replace these vehicles with gas powered vehicles.

Phase Two Transition

In Phase Two of ARRIVE’s ZEV transition, ARRIVE will begin to replace gas-powered vehicles with BEVs. Like previous decommissioning, vehicles will be replaced on a five-year schedule.

By the second half of Phase Two, ARRIVE will start replacing existing EVs with new ones, including those procured in Phase One of the zero-emission transition (**Figure 15**). ARRIVE will also reserve two gas-powered vehicles to be used for trips that are made outside of Wilson County on a regular basis.

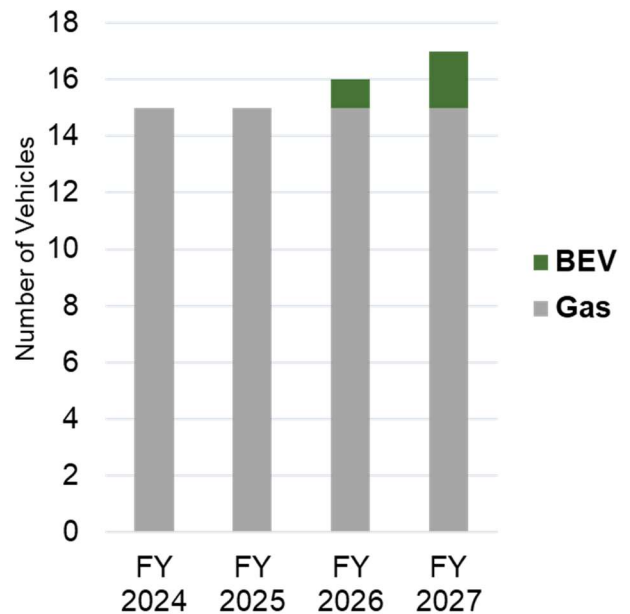


Figure 14: ARRIVEs Fleet Composition, Phase One

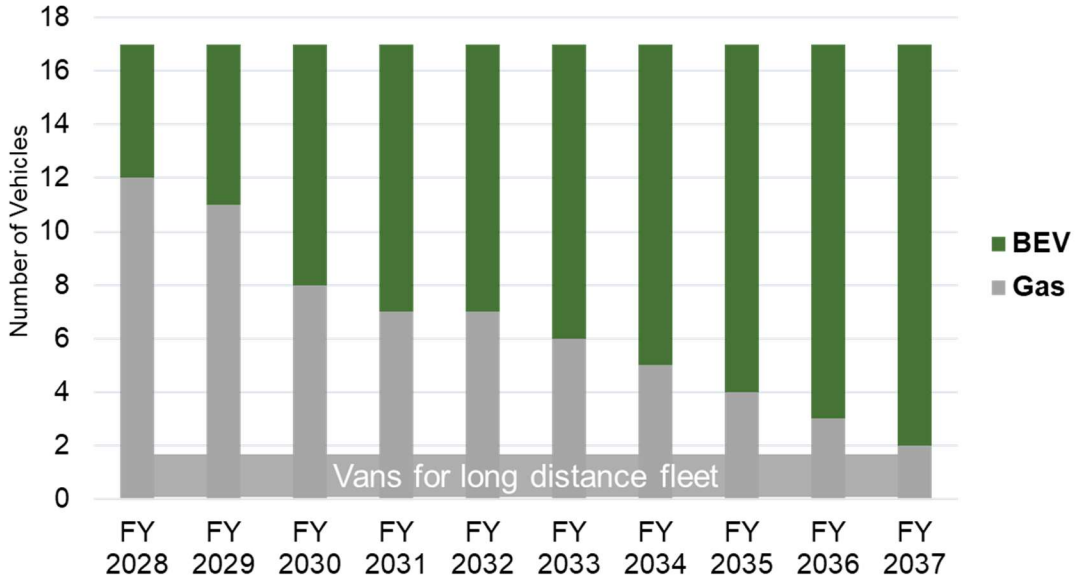


Figure 15: ARRIVE Fleet Composition, Phase Two

Phase Three Transition

By Phase Three of ARRIVE’s zero-emission transition, the ARRIVE fleet is fully electric. This is projected to happen in 2038, when the last of ARRIVE’s gas-powered vehicles is scheduled to be decommissioned (Figure 16). The decommissioning of the last gas-powered vehicles will be heavily dependent on the ability of BEVs to complete ARRIVE’s most operationally demanding days (especially the days that ARRIVE serves trips outside of Wilson County).

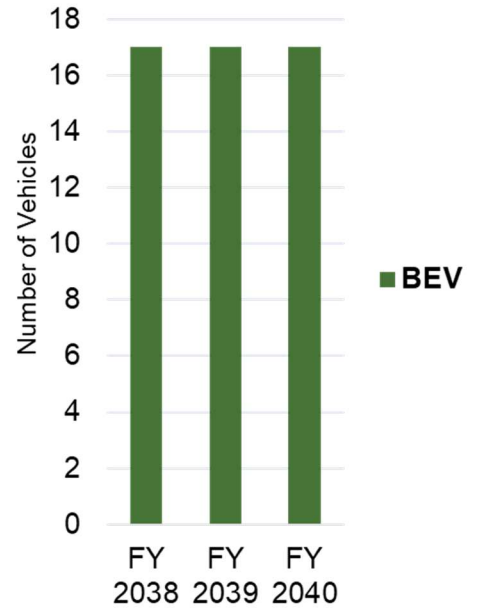


Figure 16: ARRIVE Fleet Composition, Phase Three

Annual Fleet Composition

As ARRIVE begins to procure ZEVs and replace gas-powered vehicles that have reached the end of their useful life, the overall composition of ARRIVE’s fleet will shift. The projected fleet composition from 2024 to 2040, after ARRIVE will reach a full zero-emission fleet, is shown below in **Figure 17**.

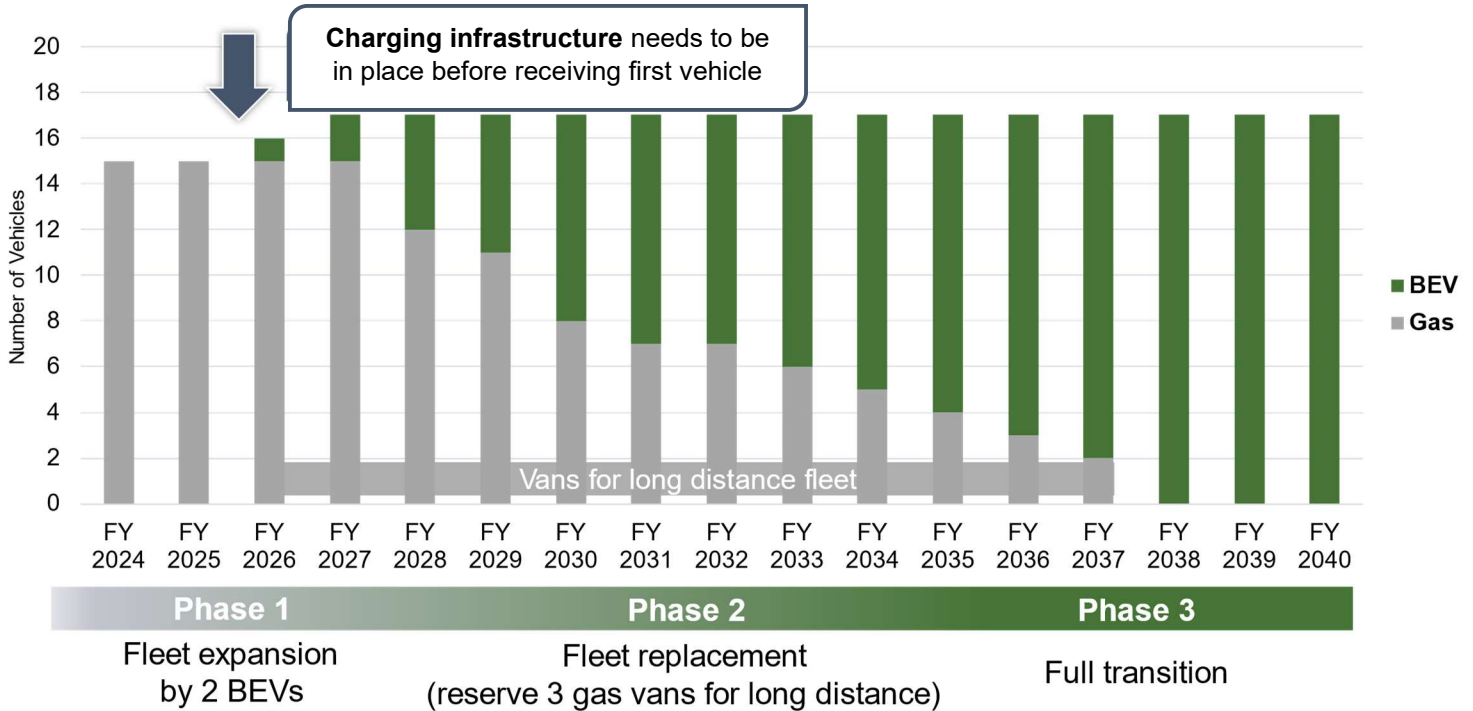


Figure 17: ARRIVE Fleet Composition Through Full Zero-Emission Transition

Facility and Infrastructure Phasing

Like the above Fleet Procurement Plan, ARRIVE is also taking a phased approach to BEV charging infrastructure and phasing. With the exception of Phase 0 (which will occur prior to the arrival of any ZEVs), each phase aligns with the timeline provided above for vehicle phasing.

- **Phase 0:** Prior to any vehicles, ARRIVE will prepare for an install and initial set of two fast chargers at a county-owned property to allow for midday charging of the initial ZEVs procured by ARRIVE.
- **Phase One:** ARRIVE will install three additional fast chargers, at either the same site or a new site, to support midday charging of additional ZEVs.
- **Phase Two:** ARRIVE will have a location for a dedicated O&M facility in place and will install fast chargers at this location. ARRIVE will also increase the number of fast chargers to support midday charging for a larger number of vehicles.
- **Phase Three:** ARRIVE’s fleet will be fully zero-emission, and will have fully built out its charging capacity to support a fully electrified fleet.

The number of chargers in service in each phase will be dictated by the number of BEVs that ARRIVE has in service at each time. For depot chargers, ARRIVE will have a 1:1 ratio of vehicles to chargers, as each vehicle will require a charger to recharge overnight. For fast chargers, to be used primarily for midday fast charging,

ARRIVE is generally planning for a 2:1 ratio of vehicles to chargers (for more detail on the planned ratio of chargers to vehicles, see **Appendix C: Charging Infrastructure Needs Analysis**). The number of each type of charger throughout ARRIVE’s ZEV transition is shown below in **Figure 18**.

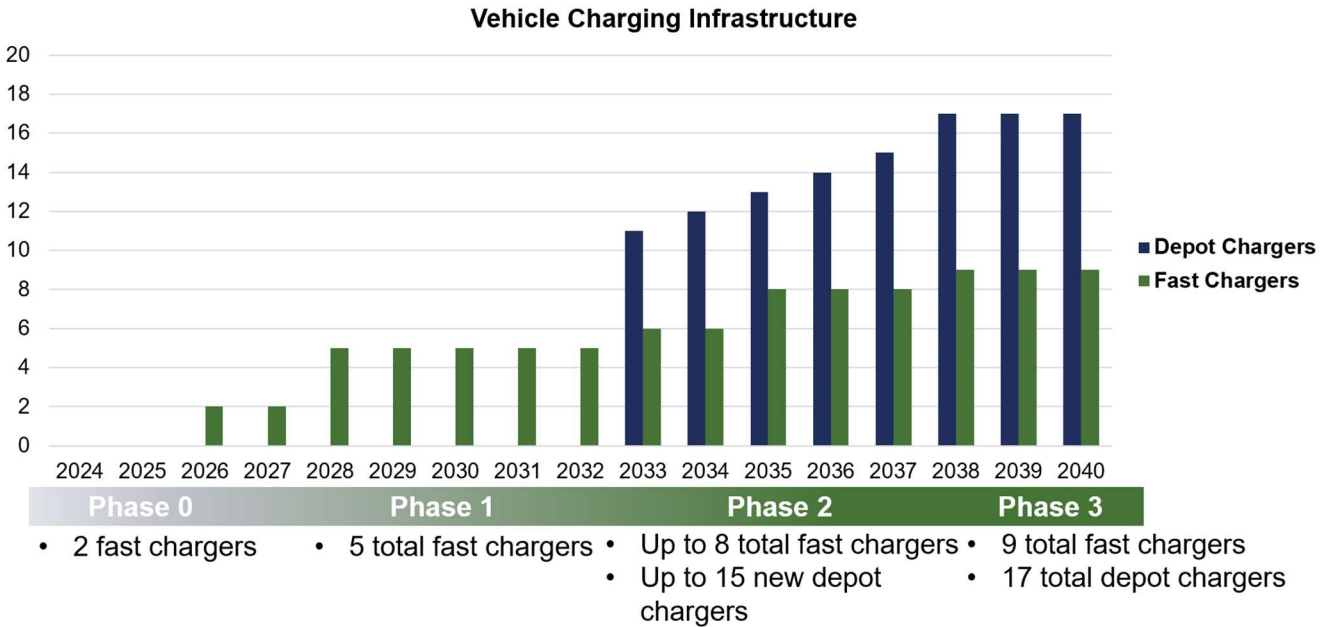


Figure 18: ARRIVE Vehicle Charging Infrastructure

Throughout Phases One and Two, ARRIVE will be studying locations inside or near the City of Wilson to build a new, dedicated O&M facility. This facility will require space to store and maintain ARRIVE’s entire fleet and will require electrical capacity to install and operate depot chargers that will support overnight charging of ARRIVE’s vehicle fleet. Depending on the location of the O&M facility, ARRIVE may install fast chargers to support some level of midday charging at this location.

Actions

While ARRIVE is moving through its zero-emission transition, ARRIVE will take the following actions in the short-term:

- Identity and finalize a location for the installation of fast chargers at a county-owned site and ensure that:
 - The site can accommodate an initial installment of two fast chargers to support midday charging
 - The site has sufficient driver facilities either nearby or on-site
- Continue to monitor ZEV transitions for other departments and agencies in the City of Wilson and County of Wilson to identify opportunities to share fueling infrastructure and benefit from procurements that serve multiple departments
- Continue to monitor the marketplace for low- and no-emission technology and performances, track promising state and regional initiatives and incentives for low- and no-emission technology and performance, and communicate regularly with surrounding counties to determine opportunities for infrastructure sharing

In the long-term, ARRIVE will continue to study potential locations for a permanent O&M facility. This facility can either be an ARRIVE-only facility or shared with another Wilson County department to spread the capital cost around. This site should have the physical space and electrical capacity to support full overnight charging for ARRIVE’s fleet and be able to support some level of midday fast charging.

Funding Plan

The replacement of ARRIVE’s existing gas-powered fleet with ZEV will have a significant capital cost impact. As such, ARRIVE will address the availability of current and future resources to meet the costs of the transition and implementation and has compiled the following assessment of anticipated O&M costs, vehicle procurement costs and infrastructure costs in alignment with the above **Transition Strategy**.

Operations and Maintenance Costs

Currently, ARRIVE’s operations and maintenance cost per mile is \$4.92. Applying this cost to the overall lifetime of a gas-powered vehicle, which is anticipated to be 100,000 miles, the total O&M cost of a gas-powered vehicle is anticipated to be around \$492,000.

Because the use of BEVs for on-demand and demand response transit is a recent development, very little peer data on the O&M costs for electric transit vehicles is available. However, despite being unable to quantify the lifetime O&M costs of electric vehicles, ARRIVE anticipates that transitioning from gas-powered vehicles to BEVs will result in a significant lifetime O&M cost savings. These expected savings are due in part to reduced fuel costs, as electricity costs are generally lower and more stable than costs for gasoline and diesel, as shown in **Figure 19**. Further, because electric vehicles generally have fewer moving parts that require maintenance than a vehicle that is powered by internal combustion engine, lifetime maintenance costs are anticipated to be less than ARRIVE is currently expecting for gas-powered vehicles.²¹

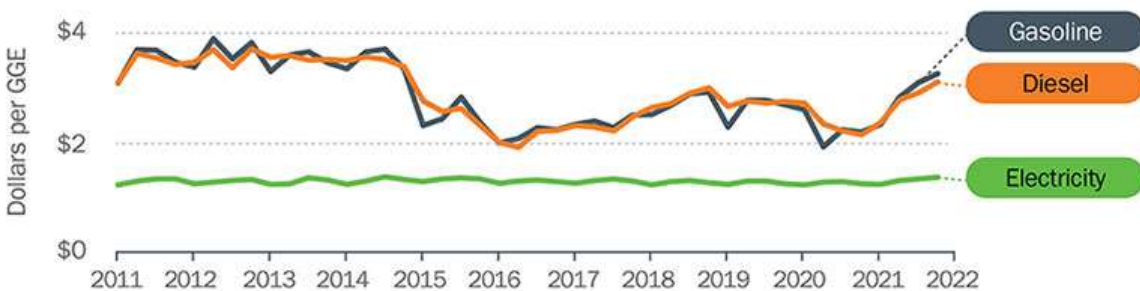


Figure 19: Electricity Prices Compared to Gasoline and Diesel²²

These findings are supported through research of transit agencies that have recently transitioned to ZEVs. Alameda-Contra Costa (AC) Transit, for example, experienced operational savings of approximately \$.70 per

²¹ United States Department of Energy Alternative Fuels Data Center. Electric Vehicles for Fleets. Retrieved from: <https://afdc.energy.gov/vehicles/electric-fleets>

²² United States Department of Energy Alternative Fuels Data Center. Electric Vehicles for Fleets. Retrieved from: <https://afdc.energy.gov/vehicles/electric-fleets>

mile from transitioning its diesel buses to BEBs.²³ While these costs are calculated from AC Transit's fixed-route services, and AC Transit likely benefits from the economies of scale experienced by a transit agency with a much larger vehicle fleet, ARRIVE anticipates similar costs savings.

Vehicle Procurement Costs

A detailed breakdown of the year-by-year vehicle procurement costs for ARRIVE's zero-emission transition is shown below in **Table 4**. The table shows the vehicles purchased per year, along with the total procurement costs for both gas-powered and electric vehicles. To calculate the yearly per-vehicle costs for gas-powered vehicles, ARRIVE's past procurements were used. The newest Ford Transit vehicles in ARRIVE's fleet were purchased for \$63,000. The costs of converted and accessible Ford E-transit vans were estimated based on the North Carolina state contract and assumed to be \$104,500 per vehicle.

²³ AC Transit. 2022. Zero Emission Transit Bus Technology Analysis. Retrieved from: https://www.actransit.org/sites/default/files/2023-01/0430-22%20Report-ZEBTA%20v4_FNL_012423.pdf

Year	Vehicles Purchased		Procurement Costs			Development Notes
	Gas	BEV	Gas	BEV	Total	
FY 2023	2		\$152,000 ²⁴		\$152,000	Start of Phase 0: ARRIVE begins ZEV transition by preparing site for charger installment
FY 2024	4		\$252,000		\$252,000	
FY 2025	2	1	\$126,000	\$104,500	\$230,500	Start of Phase One: Fleet expansion begins, first ZEV put into service
FY 2026	1	1	\$63,000	\$104,500	\$167,500	
FY 2027	2	3	\$126,000	\$313,500	\$439,500	Start of Phase Two: First ZEV replacement vehicles arrive. Gas powered vehicles slowly replaced with ZEVs, except for long distance fleet
FY 2028	1	1	\$63,000	\$104,500	\$167,500	
FY 2029	1	3	\$63,000	\$313,500	\$376,500	
FY 2030	1	2	\$63,000	\$209,000	\$272,000	
FY 2031	1	1	\$63,000	\$104,500	\$167,500	
FY 2032	2	3	\$126,000	\$313,500	\$439,500	
FY 2033		2		\$209,000	\$209,000	
FY 2034		4		\$418,000	\$418,000	
FY 2035		3		\$313,500	\$313,500	
FY 2036		2		\$209,000	\$209,000	Start of Phase Three: Full fleet transition, long distance fleet replaced with ZEVs
FY 2037		5		\$522,500	\$522,500	
FY 2038		2		\$209,000	\$209,000	
FY 2039		2		\$209,000	\$209,000	
FY 2040		2		\$209,000	\$209,000	

Table 4: ARRIVE Year-by-Year Zero-Emission Vehicle Transition Costs

Infrastructure Costs

Table 5 below summarizes the estimated infrastructure costs for each phase of ARRIVE's zero-emission transition. The table uses the charging infrastructure identified per phase as part of the **Fuel Plan** to project the

²⁴ The procurement costs shown for FY 2023 reflect ARRIVE's vehicle purchases during the fiscal year, which included two gas-powered replacement vehicles for their current fleet.

charging infrastructure costs throughout the transition. Costs were assumed to be \$150,000 per fast charger and \$6,000 per depot charger. All costs are shown in 2024 dollars.²⁵

Transition Phase	Number of New Chargers		Procurement Costs			Total
	Fast Chargers	Depot Chargers	Fast Chargers	Depot Chargers	Other Costs	
Phase 0	2		\$300,000		\$85,000	\$385,000
Phase 1	3		\$450,000		\$85,000	\$535,000
Phase 2	3	15	\$450,000	\$90,000	\$85,000	\$625,000
Phase 3	1	2	\$150,000	\$12,000	\$85,000	\$247,000

Table 5: Estimated Infrastructure Costs per Phase of ARRIVE's Zero-Emission Transition

Additional costs (listed in the table as “Other Costs”) include the costs needed to install supportive electrical infrastructure such as transformers and conduit extensions, as well as any other necessary site civil work. Based on coordination with Wilson Energy, the municipal energy provider for the City of Wilson, each location being studied for fast chargers in the initial phases of ARRIVE’s zero-emission transition would require a new transformer to provide the necessary electrical capacity. Wilson Energy recommends a 300 kVA transformer for Phase 0 and quoted ARRIVE \$75,000. To provide a conservative estimate of charging infrastructure costs, ARRIVE has assumed that one additional transformer would be needed for each phase of the zero-emission transition. This cost will increase if transformer upgrades, or more than one additional transformer are required in any of the transition phases.

Potential Funding Sources

To fund its transition to ZEVs, ARRIVE will continue to leverage existing state and local funding sources, and seek additional funds from federal sources summarized below in **Table 6**.²⁶ Many of these federal programs allow for funds to be used towards maintenance facilities and BEV charging infrastructure, and may be critical to ARRIVE building a new, dedicated O&M facility.

Federal Funding Program	Administering Agency	Eligibility			Funding Potential
		Maintenance Facility	Charging Infrastructure	BEV Purchase	
Rebuilding American Infrastructure with Sustainability and Equity (RAISE) Grants	USDOT	✓	✓	✓	Moderate to Low

²⁵ Chris Nelder and Emily Rogers. 2020. Reducing EV Charging Infrastructure Costs. Retrieved from: <https://rmi.org/wp-content/uploads/2020/01/RMI-EV-Charging-Infrastructure-Costs.pdf>

²⁶ PalmTran. 2022. Zero Emission Transition Plan. Retrieved from: <https://www.transit.dot.gov/sites/fta.dot.gov/files/2023-02/PalmTran-Zero-Emission-Transition-Plan.pdf>

Federal Funding Program	Administering Agency	Eligibility			Funding Potential
		Maintenance Facility	Charging Infrastructure	BEV Purchase	
Capital Investment Grants (CIG) Small Starts	FTA		✓	✓	Low
Section 5307: Urbanized Area Formula Grants	FTA	✓	✓	✓	High to Moderate
Section 5339: Bus and Bus Facilities Formula Funds Grant	FTA	✓	✓	✓	High
Section 5339 (C): Low or No Emission Vehicle Program	FTA	✓	✓	✓	Moderate
Advanced Transportation and Technologies and Innovative Mobility Deployment	FHWA	✓	✓	✓	Low
Discretionary Grant Program for Charging and Fueling Infrastructure	FHWA		✓	✓	Low
Surface Transportation Grant Block Program	FHWA		✓	✓	Moderate
National Electric Vehicle (NEVI) Formula Program	FHWA		✓	✓	Low
Carbon Reduction Program	FHWA		✓	✓	Moderate
Charging and Fueling Infrastructure Grant Program	FHWA		✓		Low
Alternative Fuel Tax Credit	USDOE		✓		Moderate to High
New Market Tax Credits	USDOT		✓		Moderate
Opportunity Zones	USDOT	✓	✓		Low to Moderate

Table 6: Overview of Potential Funding Sources

In addition to these sources, the BIL, as enacted in the Infrastructure Investment and Jobs Act, authorizes up to \$108 billion for public transportation—the largest federal investment in public transportation in the nation’s history. Part of the BIL funding will be used to increase the funds available through the FTA Low or No Emission Vehicle Grant Program and the FTA Bus and Bus Facilities Grant Program.

While there are many statewide initiatives in North Carolina promoting low and zero-emission vehicles, none of these initiatives have funding streams to directly support ARRIVE’s transition. Further, there is currently no funding available at the local level for transitioning to zero-emission vehicles. ARRIVE will continue to monitor policies and programs at the state and local that may provide a source of funding.

Workforce Transition Plan

The **Workforce Transition Plan** provides a framework to identify skill gaps, training needs, and retraining needs of existing workers to operate and maintain ZEVs and related infrastructure while undergoing a significant operational shift. This is done with the goal of not only of ensuring consistent passenger service while delivering environmental benefits, but also in recognition of the value and importance of the existing workforce. ARRIVE will partner with Kimley-Horn and Associates, OEMs, and other industry specialists to train trainers, operators, mechanics, and other staff to work with the new zero-emission vehicles with the goal of avoiding the displacement of the existing workforce.

ARRIVE’s Workforce

ARRIVE’s workforce consists of 24 employees, two Wilson County employees, and 22 contracted employees. In 2023, Wilson County selected HTG as the contract operator for ARRIVE service operations and maintenance. The roles and numbers of staff in each position are summarized in **Table 7: ARRIVE’s Workforce**.

Role	Employed by	Number of staff
General Manager	Contractor (HTG)	1
Operations Supervisor / Maintenance Manager	Contractor (HTG)	1
Administrative Assistant	Contractor (HTG)	1
Dispatcher	Contractor (HTG)	3
Scheduler	Contractor (HTG)	1
Operators (FTE)	Contractor (HTG)	15
Transportation Coordinator	Wilson County	1
Administrative Assistant	Wilson County	1

Table 7: ARRIVE’s Workforce

Vehicle Maintenance Practices

Currently, ARRIVE’s contractor HTG has one in-house maintenance position, the Maintenance Manager. HTG’s Maintenance Manager performs light maintenance in-house, with more intensive maintenance or repair projects outsourced to local vendors. HTG currently contracts with local vendors for body work.

As ARRIVE transitions to a ZEV fleet, the agency will need to ensure that their contract operator’s employees have adequate training on ZEV maintenance and safety. Future contracts with maintenance providers should ensure any work being completed is performed by technicians with training and experience in maintaining ZEV systems.

Training Needs and Approach

ARRIVE’s workforce transition plan accounts for the diverse training needs for frontline staff, including operators and the Maintenance Manager. Training will occur in various formats to support diverse learner needs, such as in-person, instructor-led sessions; hands-on exercises; computer-based training; knowledge checks; reference material; and operational manuals. Workforce training efforts will consider the human aspect of this shift in operations and acknowledge the challenges that come with introducing new skills, processes, and procedures. For this reason, the workforce transition will include resources to support affected employees directly and indirectly through the cultural and technological shift.

Training Approach

The Transit Cooperative Research Program's (TCRP) Research Report 219: Guidebook for Deploying Zero-Emission Transit Buses identifies three key best practices related to training and development:

- Ensure adequate safety training related to high voltage hazards and hydrogen fuel (as applicable)
- Require OEMs to conduct first responder training and specify training materials, needs, and responsibilities in the procurement contract
- Careful coordination of training prior to or in conjunction with bus delivery

The 2023 APTA publication *Zero-Emission Bus Maintenance Training* sets forth three modules of training informed by industry best-practice. ARRIVE will coordinate workforce training approaches internally and externally to cover the following three distinct modules:

- Level 100: ZEB Familiarization
- Level 200: Details of ZEB Safety, components
- Level 300: ZEB Maintenance, troubleshooting, and repairs

Operator Training Needs

Current training and development programs for operators include the agency's standard orientation and driver training, first aid, automated external defibrillators (AEDs), customer service, and de-escalation training. To operate ZEV, operators will need to know best practices for extending ZEV range, how and where to plug in the vehicles, how to identify system notification and alerts, field troubleshooting, and basic ZEV safety principles. ARRIVE will ensure that all current operators receive this training and will integrate this training into the training protocol for new employees.

Maintenance Manager Training Needs

To safely perform light maintenance of ARRIVE's ZEVs, the Maintenance Manager will need to develop a strong knowledge base in the realm of Foundational Electrical/Electronic Principles; high voltage safety protocol; ZEB system and ZEV-specific PPE; and may need to complete OEM-specific training. ARRIVE will coordinate closely with HTG to ensure the Maintenance Manager is sufficiently trained with a skillset to lead the maintenance of a fleet of ZEVs.

Engagement of Workforce in Development of Transition Plan

Ongoing engagement with the frontline workforce in all decision-making processes accounts for a critical piece of the transition plan and the implementation of ZEV technology. Involvement of all members of the workforce, especially operators and the agency's maintenance technician, will be integrated throughout the workforce transition process, from the initial planning phases through each consecutive step.

ARRIVE will identify strategic approaches to integrate and engage the current workforce in the development of the transition plan, including regular communications regarding progress updates and developing engagement mechanisms and tools between ARRIVE leadership and the frontline workforce. Another key component to prioritize engagement of the current workforce is to encourage and empower the frontline workforce to lend their voices to the decision-making processes, rather than keeping these processes in the hands of management.

Staff Engagement with OEM/Vendor for Training Resources

ARRIVE intends to carefully develop bus procurement documents to require the OEM/vendor to provide training aligned with closing the existing skill gaps and developing staff to work on ZEVs safely and confidently. Staff with local agency subject-matter expertise should be included in meetings with the OEM/vendor to ask questions and review training specifications in the Request for Proposals (RFPs). This would ensure that the staff who will be directly affected by the introduction of the ZEV technologies can influence discussions that affect how they will adapt to and develop skills for the successful deployment and maintenance of ZEBs.

Training Plan

ARRIVE's ZEV training plan will be informed by frontline worker engagement and national best practices. It will include a baseline skills assessment that will allow ARRIVE to identify specific training strategies, resources, and partners, and to select the most effective path forward for long-term maintenance of the ZEV fleet.

Skill Assessment of Existing Maintenance Workers

The baseline assessment of skills of ARRIVE's Maintenance Manager will establish proficiency at diagnosing and repairing electrical and electronic faults on ARRIVE's fleet of vans and cutaway buses. Without these foundational skills, staff cannot be trained on ZEV-specific skills, including working on systems with upwards of 800 volts and using specialized tools and instruments to diagnose electrical faults.

ARRIVE will evaluate the relevant skills that its Maintenance Manager has, including Automotive Service Excellence (ASE) Transit Bus certifications for Electrical/Electronic Systems (H6), or similar certifications from the automobile and heavy-truck sectors. ARRIVE also plans to recognize and account for training provided internally, as well as from technical schools, previous employment, and third-party training providers. The findings of this baseline assessment will inform more detailed assessments of skills gaps and next steps, explored further in the next section.

Skills Required for External ZEV Maintenance Vendors

ARRIVE's contractor HTG contracts out vehicle body work and some light maintenance to local vendors. ARRIVE and its contractor will work with these existing maintenance vendors to understand their technicians' experience and skill levels with maintaining ZEV, using the same skill standards expected for internal maintenance staff. ARRIVE will also explore opportunities to coordinate with local OEM/vendor facilities to perform repairs or maintenance for the battery-electric systems.

Strategies, Resources, and Partners

ARRIVE recognizes the significant value of the existing experience of the nationwide transit workforce and intends on working collaboratively throughout the process to support workers during the transition. ARRIVE's training plan will leverage training from the OEM and national best practices. ARRIVE will structure its RFP for ZEV procurement to include workforce training requirements and responsibilities of the OEM using the language and best practices outlined in the report from the International Teaching Learning Cooperative (ITLC) Network and Jobs to Move America (JMA) titled "Providing Training for Zero-Emission Buses: Recommended Expanded RFP Language." This will include training resources for both operators and maintenance staff.

Additionally, ARRIVE will use national best practice resources such as the American Public Transportation Association (APTA) "Zero-Emission Bus Maintenance Training" Recommended Practice. APTA partnered with transit agencies, labor unions, ZEB manufacturers, and the Transit Workforce Center (TWC) in the development of these standard learning objectives that represent the knowledge and skills that technicians



Zero-Emission Vehicle Transition Plan

should acquire through the training provided to them. ARRIVE will ensure that the training materials for its staff align with these standards.

TWC's ZEV training course, TWC Battery Electric Bus Familiarization, is another resource that ARRIVE will explore providing to relevant staff in coordination with HTG. This two-day course provides materials to build a foundation in battery electric vehicle systems.

Appendix A: Market Overview Technical Memorandum

This Market Overview memo was submitted to ARRIVE on 2/29/2024 to document ARRIVE’s existing conditions and current market availability. This memo provides a summary of the current state of zero-emission technology. The findings summarized in this memo were compiled through review of peer transit agencies, original equipment manufacturers (OEM), available industry research, and general market trends. This memo includes the following sections:

- Zero-Emission Vehicle (ZEV) Technology Overview
- Fueling Equipment and Infrastructure Overview

Zero Emission Vehicle Technology Overview

ARRIVE’s current fleet is comprised of gas-powered vans and cutaways. The ZEVs that are comparable to ARRIVE’s existing fleet is limited and relatively new. This section will discuss battery electric, fuel cell electric, and hybrid vehicles.

Battery Electric Vehicles

Battery electric vehicles (BEVs) operate using electricity as fuel stored in an onboard battery pack which powers an electric motor. BEVs are available with a range of battery capacities, measured in kilowatt-hours (kWh). This measurement of power storage correlates to vehicle range and is influenced by factors described in this section.

Table 7 highlights the available vehicles, battery capacities, and advertised ranges of five different original equipment manufacturers (OEMs) who produce zero-emission vehicles comparable to those currently used by ARRIVE.

Vehicle	Seating Capacity	Battery Size (kWh)	OEM-Stated Range (miles)	Starting Price
Ford E-Transit Van (medium roof)	12	68 kWh	116	~\$50,000
Ford E-Transit Cutaway		69 kWh	116	~\$50,000
Mercedes-Benz eSprinter	12	113 kWh	245	~\$70,000
Ram Promaster EV (coming 2025)		47 kWh/79 kWh	125/200	~\$70,000
GreenPower Motor Company EV Star Passenger Van ²⁷	19	118 kWh	150	No data available

Table 7: Current Comparable Battery Electric Vehicles on the Market

The Ford, Mercedes, and the Ram vehicles will require additional cost to convert the van from a cargo van to a passenger van, whereas GreenPower Motor Company sells vehicles ready to serve as a passenger van. Like the prices, the ranges in **Table 7** are dependent on a variety of factors. These ranges represent a new vehicle, the batteries of which are not entirely usable for vehicle propulsion and degrade over time (described in detail

²⁷ More research would need to be conducted by Wilson County to determine if Greenpower Motors is a viable option.

below). Additionally, the advertised range typically exceeds what operators experience during daily operations, primarily due to optimal testing conditions. The factors that limit the range of BEVs will be detailed below in the Usable Battery Capacity and Degradation section.

As for the options currently available in North America, the Ford E-Transit Van is the most popular electric cargo van in the North American demand response market, and is currently being used for the Utah Transit Authority's (UTA's) On-Demand Service in Tooele County, UT (**Figure 20**). In addition, CalVans, a public transit agency offering vanpooling, has a fleet of over 400 Ford E-Transit vans.

The other options identified have a more limited deployment and adoption. The Mercedes-Benz eSprinter was released in the beginning of 2024. No known American transit agencies are currently using the Mercedes-Benz eSprinter to electrify their fleet. As for the GreenPower EV Star vans, the Antelope Valley Transit Authority (AVTA) runs a microtransit program in rural Los Angeles County with these vehicles (**Figure 21**).



Figure 20: UTA Tooele County On-Demand Ford E Transit Fleet²⁸

²⁸ Utah Transportation Authority. (2023). UTA On Demand Service Make Switch to All-Electric in Tooele. Retrieved from: <https://www.rideuta.com/Rider-Info/Digital-Newsroom/UTA-On-Demand-Service-Makes-Switch-to-All-Electric-in-Tooele>



Figure 21: AVTA EV Star Passenger Van for Microtransit Pilot Program in Rural Los Angeles County²⁹

Usable Battery Capacity and Degradation

Electric batteries degrade over time as the battery loses its ability to hold a charge. **Figure 22** highlights the effects of battery degradation. When the battery is new, the first 10% of the battery should be reserved for longevity. The remaining 90%, referred to as “service energy,” is the portion of battery capacity that is useable. The service energy is designed to protect the battery life while ³⁰ the last 10% will hold the vehicle to a derated performance, and the BEV will not experience the same range per kWh. Below 5%, the energy supplied by the battery will be insufficient to move the vehicle. For that reason, it is recommended that a test to determine if a BEV can complete a given route be performed with only 80% of the battery capacity.

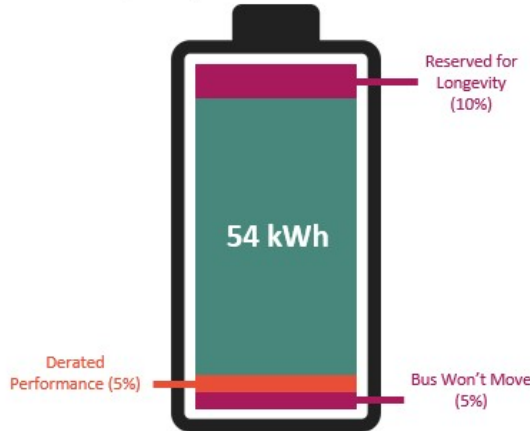
²⁹ Antelope Valley Transit Authority. (2022). AVTA Becomes the First All-Electric Zero-Emission Transit Agency in North America. Retrieved from: <https://www.avta.com/avta-becomes-first-all-electric-zero-emission-transit-agency>

³⁰ Mountain Line Transit. (2020). Zero-Emission Bus Implementation Plan. Retrieved from: <https://mountainline.az.gov/wp-content/uploads/2021/03/Phase-2-Implementation-FINAL.pdf>

The battery capacity you think you're getting:



A realistic view of your battery capacity:



Your battery capacity with 30% battery degradation:

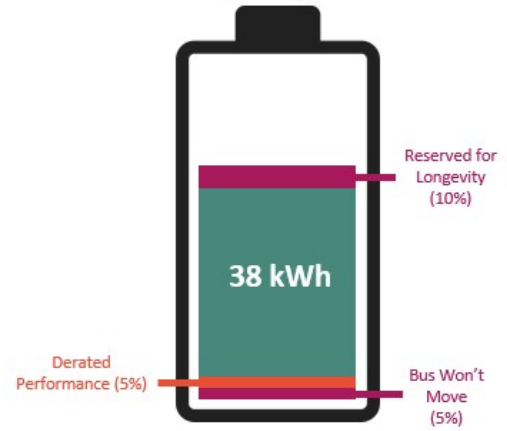


Figure 22: BEV Battery Degradation

Depending on the OEM and details outlined in the vehicle procurement contract, there is often an initial warranty offered on the battery, which usually guarantees between 70-80% of the kilowatts-hour (kWh) of a new battery. This warranted amount of battery life is calculated against the stated range of the battery, rather than the actual range of the battery (not including a reserve). For example, if the battery is advertised at 68 kWh nameplate capacity, the actual benchmark amount covered and replaced by the warranty could be anywhere between 46 kWh and 55 kWh. This highlights the need to plan for lifetime battery degradation to account for a vehicle's ability to complete its required tasks. As noted above, the amount of battery degradation covered by the warranty is dependent on negotiation with the OEM and can influence the purchase price of the BEV.

Impacts of HVAC Usage on Battery Capacity

BEVs use the battery to operate all aspects of the vehicle including running the heating, ventilating, and air conditioning (HVAC) system. Any heating or cooling demand will use battery power, which has the potential to significantly shorten the range of the BEV. On particularly hot or cold days, this will mean that the range of the vehicle will be significantly less that it would be in ideal operating conditions.

A 2019 study collected operations and performance data from eight transit agencies in climates ranging from Northern Minnesota to Southern California found that when temperatures dropped from 50-60° to 22-32°F, Battery Electric Buses (BEBs) lost around 32.1% efficiency.³¹ The degree of impact on the battery range is highly dependent on the degree to which the ambient temperature outside differs from the internal temperature set of the cabin. The exact energy consumption of the HVAC system can also depend on other factors, including the number of passengers onboard the vehicle, the average speed of the route, and how often the vehicle opens its doors. While this study was conducted using BEB's, it can be assumed that the batteries of the five vehicles identified in **Table 7** would experience similar proportional impacts to range. Wilson County

³¹ Mark Henning, Andrew R. Thomas, Alison Smyth. (2019). An Analysis of the Association between Changes in Ambient Temperature, Fuel Economy, and Vehicle Range for Battery Electric and Fuel Cell Electric Buses. Retrieved from: https://engagedscholarship.csuohio.edu/cqi/viewcontent.cgi?article=2634&context=urban_facpub

generally experiences milder weather than what was experienced in the study and would likely have a slightly reduced impact on battery capacity.

Local Climate

Since climate and extreme temperatures can impact the ability of a battery to maintain a charge, it is important to understand to what degree this may impact ARRIVE’s operations. Based on data available from the National Weather Service (**Figure 23**), Wilson County’s hottest month is July, with the average high temperatures reaching around 90°F. The coldest month is January, where the average low dips to around 32°F. For the purposes of planning a gradual transition to zero-emission transit vehicles, these temperatures will inform the analysis on potential impacts to vehicle range and performance.

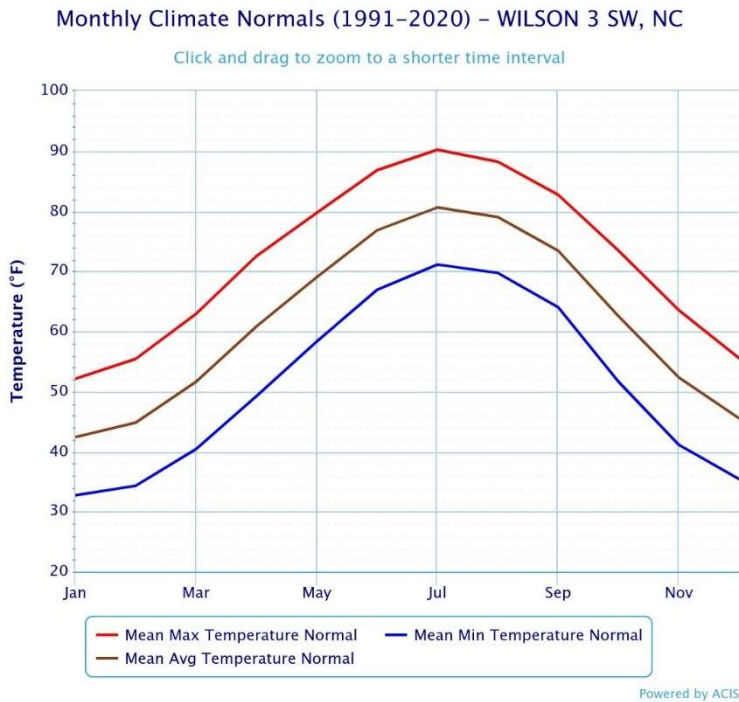


Figure 23: Average Monthly Temperatures in Wilson County

Energy Generation Mix

When planning for a potential transition to electric vehicles, it should be noted that while BEVs have great impacts in reducing and eventually eliminating tailpipe emissions from transit vehicles, there are upstream impacts based on the resources used to produce the energy that charges the electric vehicles.

Wilson Energy, which services the City of Wilson, purchases its power through the North Carolina Eastern Municipal Power Agency (NCEMPA), which buys all energy from Duke Energy Progress (DEP). The energy generation mix is shown in **Figure 24**.

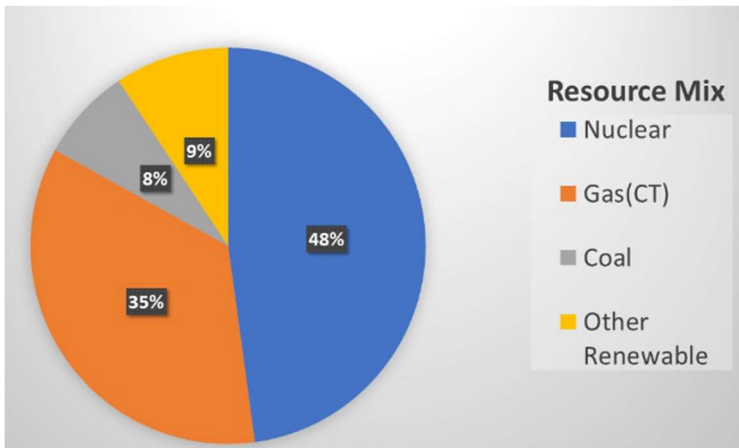


Figure 24: Energy Generation Mix³²

Fuel Cell Electric Vehicles (FCEV)

Instead of using combustion to produce mechanical motion, FCEVs operate using hydrogen fuel to produce electricity. The onboard fuel cell uses an electrochemical reaction to combine the onboard hydrogen fuel with atmospheric oxygen, producing an electrical reaction which powers the battery, electric motor, and other systems. This reaction also produces heat as a byproduct which can be used as auxiliary heating for cabin climate control. Like a traditional gas vehicle, the size of the fuel tank directly corresponds to the overall range performance of the vehicle. With a larger hydrogen tank, buses can operate over farther distances. The company Stellantis is beginning to produce Fuel Cell Mid-size and Large Vans in Europe but has not entered the US market. At present, there are no market-ready hydrogen fuel cell electric vehicles that are suitable to replace ARRIVE’s current fleet.

Hybrid Vehicles

Hybrid vehicles present an opportunity to significantly lower emissions without rapidly developing new fueling infrastructure. These vehicles have longer ranges than BEVs and function similarly to traditional diesel buses. There are currently no hybrid vehicles options that would be an adequate replacement to ARRIVE’s existing fleet of vans and cutaways, but there is a comparable Hybrid Vehicle to the ADA Van currently used by ARRIVE—BraunAbility’s Toyota Sienna Hybrid. **Table 8** highlights the available vehicle’s fuel efficiency and starting cost.

³² From Wilson, NC website: www.wilsonnc.org/residents/city-services/all-departments/wilson-energy/renewable-energy-program

Vehicle	OEM-Stated Fuel Efficiency (mpg)	Starting Cost
BruanAbility Toyota Sienna Hybrid	36	~\$90,000

Table 8: Current Comparable Hybrid Vehicle on the Market

CNG Vehicles

Compressed natural gas (CNG) vehicles could also be considered and would still meet ARRIVE’s goals of reducing its emission footprint while providing quality service. CNG vehicles qualify for the FTA’s Low/No emission program and there are CNG cutaways on the market that could be a comparable replacement vehicle for the current ARRIVE fleet. However, Wilson County does not have CNG infrastructure, which limits the cost effectivity of this as a path forward. The closest CNG fueling station is in Greenville, NC.

Propane Vehicles

Similarly to CNG vehicles, propane-fueled vehicles are a viable replacement of ARRIVE’s current fleet and would meet ARRIVE’s goals of reducing its emission footprint while provide quality service. Propane vehicles qualify for the FTA’s Low/No emission program and there are propane-conversion providers for cutaway and light-duty transit vehicles, one of which can even perform the conversion without violating the existing Ford vehicle warranty. However, Wilson County does not have existing propane vehicle fueling infrastructure, which challenges the viability of propane vehicles.

Fueling Equipment and Infrastructure Overview

Because BEVs, FCEVs, and CNG vehicles all rely on alternative forms of fuel, these technologies would require specialized refueling/recharging equipment and infrastructure beyond what is currently utilized by the ARRIVE fleet.

Battery-Electric Vehicles

The charging infrastructure for battery electric vehicles (BEV) utilizes the existing electrical grid to charge buses. Typically, this involves leveraging existing power lines, transformers, and switchgears to install electric chargers. The existing electrical grid can sometimes serve as a limiting factor, and upgrades to electrical infrastructure may be necessary to support BEV charging.

There are two primary charging methods for battery electric vehicle – depot charging and fast charging. Below is a description of both types of charging infrastructure. An in-depth analysis of the infrastructure, electrical capacity and spacing requirements needed to charge ARRIVE’s fleet will be conducted in the next stage of this planning effort.

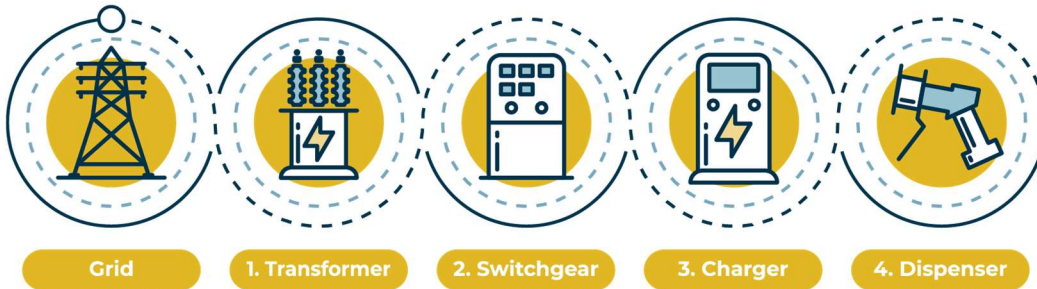


Figure 25: Generalized Battery Electric Vehicle Charging Schematic³³

Plug-in EV charging stations come in three types: Level 1, Level 2, and Level 3.³⁴

- **Level 1 chargers** are the slowest to charge a vehicle and can operate on standard 120-volt electrical outlet. Depending on the size of the battery, charging at a Level 1 charge can take up to 40-50 hours to charge a BEV from empty.
- **Level 2 chargers** are common for home and public charging. These chargers can charge a BEV from empty in 4-10 hours. These chargers can deliver 5 to 20 kW and are generally used for overnight charging.
- **Level 3 chargers**, also known as direct current fast charging (DCFC), are the fastest and can charge a BEV from empty in 30 minutes to an hour. The typical power output from these chargers is 50 to 350 kW.

As opposed to Level 1 and 2 chargers, which provide AC charging and rely on the vehicle to convert from AC to DC, Level 3 chargers convert from AC to DC within the charging station itself. A Level 3 charger is therefore able to deliver a higher power output and charge the vehicle more quickly.

Depot Charging

Depot charging typically takes place overnight at an O&M facility after a vehicle has finished service for the day or prior to beginning service. Depot chargers come in two primary styles: ground-level plug-in chargers (similar to a standard electric vehicle charger) and overhead chargers. Overhead chargers can be either plug-in style, where the charging cable drops down from an overhead structure, or pantograph, where an overhead structure on top of the vehicle comes in contact an overhead charging apparatus. Pantograph chargers are currently not available to be used with any of the vehicles listed in **Table 7**. The vehicles identified will require plug-in chargers. The advantages and disadvantages of each style of charger are detailed in **Table 9**. An example of a cabinet-style depot charger is shown in **Figure 26** and **Figure 27**.

Regardless of the style of charger, the typical output of a depot charger is between 5 kW and 20 kW. As a result of this lower electrical output, depot chargers are slower than methods of fueling traditional diesel and gas vehicles and can require four to ten hours to fully charge a vehicle. This is often a lower-cost way to charge BEVs since many electric utilities incentivize customers to charge slower and to charge during the

³³ National Academies of Science, Engineering, and Medicine. (2021). Transit Cooperative Research Program (TCRP) Research Report 219: Guidebook for Deploying Zero-Emission Buses. Retrieved from <https://nap.nationalacademies.org/catalog/25842/guidebook-for-deploying-zero-emission-transit-buses>

³⁴ U.S Department of Transportation. (2023). Electric Vehicle Charger Levels and Speeds. Retrieved from: <https://www.transportation.gov/urban-e-mobility-toolkit/e-mobility-basics/charging-speeds>

grid's off-peak period at night. ARRIVE would need to either acquire land for a facility where they can construct chargers, or partner with existing charging stations for overnight charging.



Figure 26: Depot charging cabinets at Antelope Valley³⁵

³⁵ National Renewable Energy Laboratory. (2021). Electrifying Transit: A Guidebook for Implementing Battery Electric Buses. Retrieved from: <https://www.nrel.gov/docs/fy21osti/76932.pdf>



Figure 27: UTA Tooele County On-Demand Fleet Charging

Fast Charging

Fast charging usually takes place on-route at a transfer center or layover location where the vehicle will be in a fixed location for a period of time. Fast chargers have a higher electrical output than depot chargers. Fast charging allows a BEV to stay in service longer by replenishing charge throughout the day while in service. If layover times are insufficient to provide the BEV with a meaningful charge, then it may be prudent to build time to charge mid-day into a vehicle's task assignments. ARRIVE would need to locate useful locations to place on route chargers that the vehicles can conveniently access during their daily operations.

The energy costs associated with fast charging tend to be higher due to the intensity of electrical consumption and often charging during the grid's peak period. Implementing on-route charging can be a stopgap measure to increase the range of BEVs.

Table 9 depicts the advantages and disadvantages of each type of charging and **Table 10** highlights observed costs of charging infrastructure. The costs of chargers can vary due to the type of equipment and necessary labor to install the infrastructure.

Configuration	Typical Use	Advantages	Disadvantages
Ground Mounted Plug-In	Depot, or fast charge	<ul style="list-style-type: none"> • Most universal charging solution with many implementations nationwide • Charging Cabinet is accessible at ground level for maintenance or replacement • Lowest-cost charging equipment • Open Charge Point Protocol (OCPP)-compliant chargers available (industry standardized) 	<ul style="list-style-type: none"> • Requires new curbs in existing parking areas to protect ground-mounted equipment • Requires operator to plug in charging cord • Charging cord must be managed for risk of damage from vehicles driving over • Requires trenching throughout the site to distribute power to cabinets and dispensers—likely operational impacts during install • Reconfiguration of charger layout based on fleet changes is difficult and requires trenching with extended operational downtime
Overhead Drop-Down Plug-In Cord	Depot (Overhead Drop-Down Plug-In Cord)	<ul style="list-style-type: none"> • Can be mounted to existing overhead structures • Minimal footprint in the parking areas allows for highest site capacity • Rapid reconfiguration of charging positions possible via remounting pantographs with no trenching required; capable of adjusting with fleet • Lowest amount of trenching to the site; distribution is carried via overhead conduit 	<ul style="list-style-type: none"> • If charging cabinets remain at ground level, there are no longer conduit runs to dispensers (if charging cabinets are mounted on the roof, as proposed, the conduit runs are minimized, thus minimizing cost) • Must confirm any existing structures are compatible; if not, an independent support frame is required

Table 9: Advantages and Disadvantages of Different Charger Configurations

Equipment Type	Power Rating	Estimated Cost Range (per Charger)
Plug-In Charger ³⁶	150 kW	\$150,000 (equipment, with garage buildout costs amortized on a per cost basis)
Depot Charger ³⁷ (AVTA)	80 kW	\$19,000 (equipment) \$55,000 (installation)
Depot Charger (King County) ³⁸	150 kW	\$60,000 (equipment and installation)
Depot Charger (City of Seneca) ³⁹	Unknown	\$60,000 (equipment) \$8,000 (installation)
Depot Charger Generic, no agency ⁴⁰	N/A	\$2,000-\$100,000 (equipment) \$2,000-\$64,000 (installation)
On-Route (fast Charger) Generic, no agency ⁴¹	N/A	\$330,000-\$600,000 (equipment) \$50,000-\$400,000 (installation)

Table 10: BEV Charging Infrastructure Costs

FCEV Infrastructure

At present, there are no market-ready hydrogen fuel cell electric demand-response vehicles available in the North American Market. However, if these vehicles became available, FCEVs require the following infrastructure to fuel: a hydrogen storage tank, a hydrogen pump and vaporizer, a compressed hydrogen storage tank, and a dispenser. Storing hydrogen in liquid form allows for a higher storage capacity. From the storage tank, the liquid hydrogen is processed by a pump and vaporizer which converts the liquid into a gas. The gas is then used to fuel buses via the dispenser, which operates similarly to a compressed-natural-gas (CNG) or diesel pump, which can refuel the bus in 10-20 minutes. A schematic of the components needed for hydrogen refueling system are shown in **Figure 28**.

³⁶ Sacramento Regional Transit District. (2021). Zero-Emission Bus Rollout Plan.

³⁷ National Academies of Sciences, Engineering, and Medicine. (2018). Battery Electric Buses State of the Practice

³⁸ Ibid.

³⁹ National Academies of Sciences, Engineering, and Medicine. (2018). Battery Electric Buses State of the Practice

⁴⁰ Ibid.

⁴¹ Ibid.

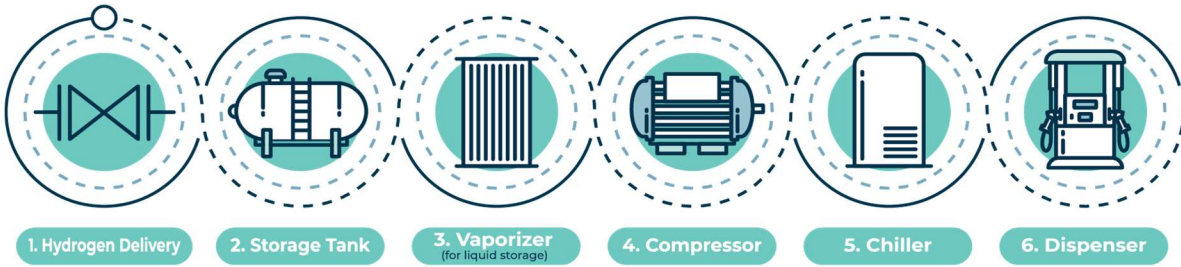


Figure 28: Generalized hydrogen fueling station schematic

Hydrogen is not as commonplace as other fuels (including diesel and electric), and there are currently no hydrogen fueling stations in North Carolina. A hydrogen deployment would likely require ARRIVE receiving regular shipments of hydrogen fuel to its facilities. This would involve a hydrogen tanker being parked on-site, from which FCEVs would be refueled. If these vehicles became available for ARRIVE’s fleet, ARRIVE would need to get approval from the owner of who they lease the land from or to find a new facility location that could accommodate this infrastructure, in addition to coordinating with local regulators to comply with spacing and building standards.

Because of the expense of installing the necessary infrastructure, storing the fuel, and receiving regular shipments of fuel, a hydrogen fuel implementation is more cost-effective at large scales. Ballard Power reports that in a study of public transit agencies that as fleet size increases, marginal costs for hydrogen infrastructure decrease, while the costs for electrical infrastructure increase. The point at which fuel cell infrastructure becomes more cost-effective per bus was found to be between 50-100 vehicles—well beyond ARRIVE’s fleet size.



Figure 29: Hydrogen storage infrastructure at AC Transit⁴²

Safety Considerations

Because liquid hydrogen is flammable and potentially dangerous if not stored properly, there are some safety considerations with an FCEV deployment. The installation of emergency shutoffs, gas detection systems, and

⁴² Photo taken by Kimley-Horn during site visit to AC Transit’s Oakland Facility

a rapid defueling system are standard for agencies operating FCEVs. Liquid hydrogen also vaporizes and expands to fill enclosed spaces, displacing oxygen and acting as an asphyxiant, which requires ample ventilation to prevent the accumulation of gas.⁴³

The National Fire Protection Agency also requires setbacks of at least 75 feet from property lines and combustible/flammable liquids. This spacing may not be feasible at ARRIVE's currently leased land but may be a possibility if new land is located for a facility. The setbacks required for the storage and dispensing of hydrogen fuel is highly variable based on the state of the fuel (liquid or gaseous hydrogen), the distance of conveyance, the diameter of tubing, adjacent land uses and exposures (lot lines, air intakes, parked cars, hazardous materials, flammable gas storage system, etc.), and the storage capacity of the equipment. The setbacks can often be significantly reduced using strategically placed fire barrier walls rated for no less than 2 hours, height dependent on specifications of the fueling infrastructure set-up.⁴⁴

CNG Infrastructure

ARRIVE does not currently have any CNG vehicles, and consequently has no CNG fueling infrastructure. Similar to the other technology types, this would necessitate the design and installation of CNG fueling infrastructure. Necessary components include:

- **Compressor Station:** This is the heart of the CNG fueling infrastructure, where natural gas is compressed and stored for later use. Compressor stations typically consist of multiple compressors that increase the pressure of the gas to the required level for fueling vehicles.
- **Storage Tanks:** CNG requires storage tanks to hold the compressed natural gas. These tanks are usually made of high-strength materials such as steel or composite materials to ensure safety and durability. The size and number of storage tanks depend on the expected demand and usage of the CNG fueling station.
- **Dispensers:** Dispensers are the interface between the CNG infrastructure and vehicles. They provide a controlled flow of compressed natural gas into the vehicle's storage tank. Dispensers are equipped with safety features such as breakaway valves and nozzle interlocks to prevent accidents and ensure proper fueling.
- **Fueling Island:** The fueling island is the area where vehicles are parked and refueled. It typically includes multiple dispensers and can accommodate different types of vehicles, including cars, trucks, and buses. The fueling island should be designed to provide easy access and maneuverability for vehicles.
- **Control System:** A control system is essential for managing the CNG fueling infrastructure. It monitors and controls the compressor station, storage tanks, and dispensers to ensure efficient operation and safety. The control system also tracks fueling transactions and monitors gas quality to maintain compliance with industry standards.
- **Safety Systems:** Safety is paramount in CNG fueling infrastructure. Various safety systems, such as gas detection sensors, emergency shutdown systems, and fire suppression systems, are necessary to

⁴³ Calstart. (2016). Best Practices in Hydrogen Fueling and Maintenance Facilities for Transit Agencies. Retrieved from: <https://calstart.org/wp-content/uploads/2018/10/Best-Practices-in-Hydrogen.pdf>

⁴⁴ National Fire Protection Agency. (2023). Hydrogen Technologies Code Section 7. Retrieved from: <https://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards/detail?code=2>

protect against potential hazards. These systems are designed to detect leaks, prevent over-pressurization, and respond to emergencies promptly.

Propane Infrastructure

As Propane is also a gaseous fuel type, the required fueling infrastructure is very similar to the CNG fuel type and would require all of the same components. **Figure 30** shows a propane fueling dispenser for a transit fleet in the US.



Figure 30: Propane Fueling Infrastructure⁴⁵

Conclusions and Next Steps

Based on the market research described above, the current options for zero-emission vehicles that are comparable to the vehicles currently being used by ARRIVE are limited. Of these options, the Ford E-Transit presents the most direct substitute for the vehicles in ARRIVE's fleet. However, additional research will need to be conducted to determine the level of effort required to add features such as a wheelchair lift to a Ford E-Transit vehicle.

At present, there are no hybrid or hydrogen fuel cell electric vehicles available in the United States that are suitable to replace most of the vehicles in ARRIVE's fleet. After-market conversion alternatives do exist, further research into the availability of these vehicles and their ability to complete daily transit operations, will need to be conducted before they can be recommended for procurement by ARRIVE.

⁴⁵ Energy for Everyone Propane. Retrieved from: <https://propane.com/for-my-business/paratransit/>

Appendix B: Modeled Battery Range Thresholds

To understand the potential for environmental and operational impacts on battery electric vehicle (BEV) range, ARRIVE performed a strenuous efficiency model. Strenuous efficiency modeling is intended to represent a hard day for the vehicle within reason of what it is likely to experience, including intensive HVAC usage. **Table 11** below outlines how intensive HVAC usage and battery degradation can impact the range of a battery electric bus. The estimates were calculated using a 68 kWh Ford E-Transit as the model vehicle.

Battery Condition	Battery Capacity (kWh)		Range (miles)	
	New	70% Battery Capacity	New	70% Battery Capacity
Advertised Capacity	68 kWh	48 kWh	N/A	N/A
Maximum Usable Capacity	54 kWh	38 kWh	116 miles	81 miles
Perceived Capacity in Strenuous Conditions	38 kWh	27 kWh	81 miles	57 miles

Table 11: 68 kWh Ford E-Transit Battery Capacity and Ranges

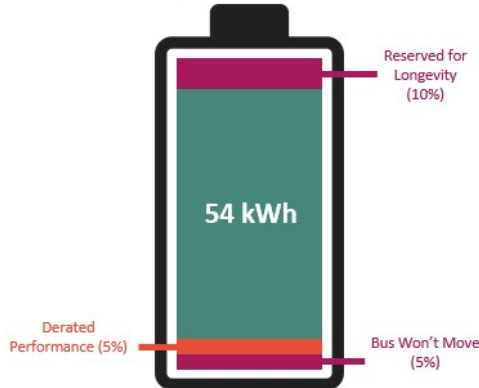
Maximum usable capacity is based upon the understanding that a battery’s advertised capacity is not necessarily representative of the energy available for propulsion, as represented in **Figure 31**. When the battery is new, the first 10% of the battery should be reserved for longevity. The remaining 90%, referred to as service energy, is the portion of battery capacity that is useable. The service energy is designed to protect the battery life.⁴⁶ The last 10% will hold the bus to a derated performance, and the BEV will not experience the same range per kWh as it would with the rest of the battery. Below 5%, the energy supplied by the battery will be insufficient to move the vehicle. For this reason, this analysis accounts for the energy useable to keep the vehicle in service, which is 90% of the advertised capacity.

⁴⁶ Mountain Line Transit. 2020. Zero-Emission Bus Implementation Plan. Retrieved from: <https://mountainline.az.gov/wp-content/uploads/2021/03/Phase-2-Implementation-FINAL.pdf>

The battery capacity you think you're getting:



A realistic view of your battery capacity:



Your battery capacity with 30% battery degradation:

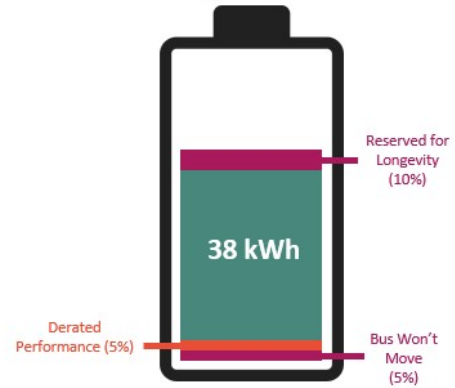


Figure 31: Battery Electric Degradation

This analysis also models the range when the vehicle has a degraded battery. To represent a vehicle that has been in service for a few years and has experienced degraded battery performance, 70% of the original battery capacity was used. This threshold is in line with industry standards for battery electric bus warranties.

The last condition that this analysis relies upon is the reduced efficiency of a BEV in strenuous conditions, represented by anticipated performance with high use of on-board HVAC system for both heating and cooling. A 2019 report published by the Center for Transportation and the Environment (CTE) along with the Midwest Hydrogen Center of Excellence (MHCoE), Cleveland State University (CSU), and the Stark Area Regional Transit Authority (SARTA) evaluated the relationship between ambient temperature and fuel economy of zero emission buses (BEBs)⁴⁷ The analysis found that when the ambient temperature fell from around 50-60°F to 22-32°F, BEBs lost about 37.8% of their range. While this study was conducted using battery electric buses, and not the types of vehicles that would be comparable to ARRIVE's existing fleet, ARRIVE assume that BEV batteries would experience similar impacts to range.

⁴⁷ Alison Smyth, Mark Henning, Andrew Thomas in partnership with Midwest Hydrogen Center of Excellence (MHCoE), Cleveland State University, and the Stark Area Regional Transit Authority (SARTA). 2019. Analysis of Cold Weather Impacts on ZEBs. Retrieved from: <https://cte.tv/cold-weather-study-2019/>

Appendix C: Charging Infrastructure Needs Analysis

BEV feasibility was studied for ARRIVE’s existing operations using the range and mileage outputs from the Modeled Battery Range Thresholds (**Appendix B**). The modeled ranges, assuming battery degradation and a battery reserve, were compared to ARRIVE’s operations from July 1st, 2023, to December 15th, 2023. The results of this analysis are shown in **Figure 32**, where the blue and black dashed lines represent the usable range of a new Ford E-Transit and a Ford E-Transit in strenuous conditions, respectively.

Using the modeled ranges of a Ford E-Transit, only seven of ARRIVE’s fifteen vehicles would be able to complete an average day of service on one charge. On an 85th percentile day, meant to represent a high usage day of service excluding outliers, only one of ARRIVE’s fifteen vehicles would be able to complete its day of service on one charge.

In strenuous conditions, none of ARRIVE’s vehicles would be able to complete a full day for service on an 85th percentile day. This analysis shows that midday charging will be required for ARRIVE to successfully implement battery electric vehicles.

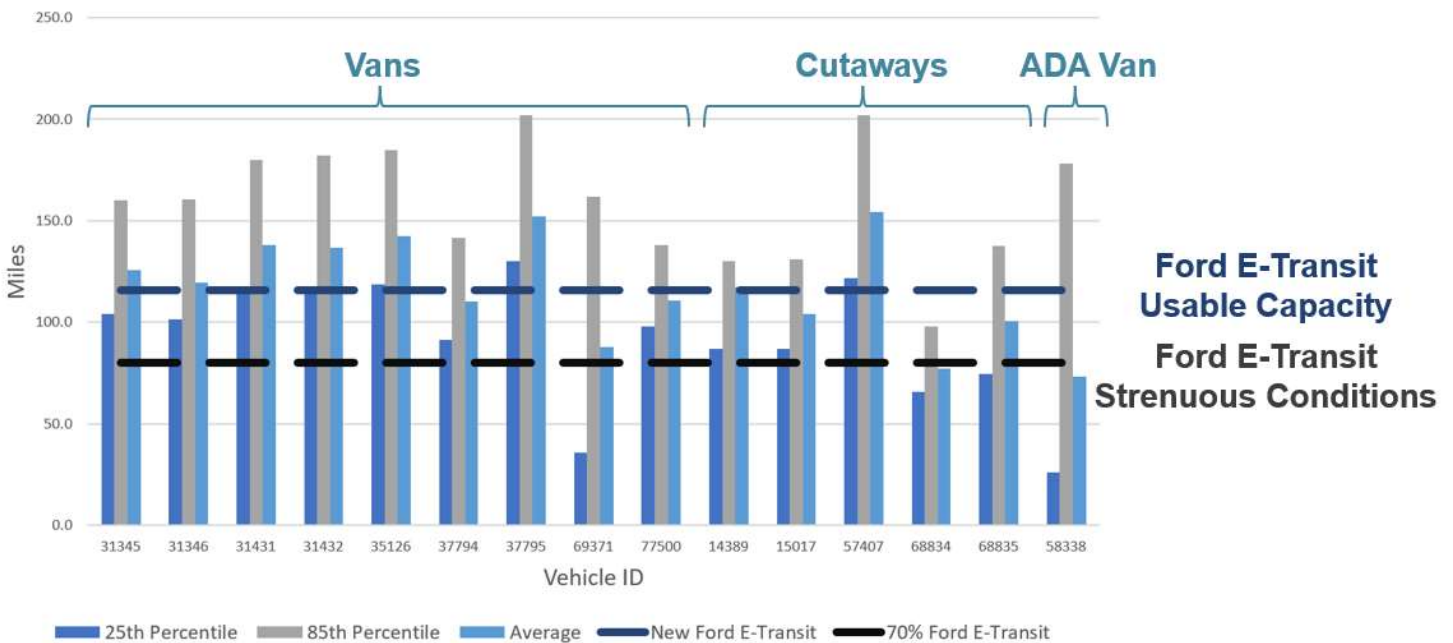


Figure 32: ARRIVE Vehicle Utilization with Estimated BEV Ranges

Midday Charging Infrastructure Needs

To analyze the level of infrastructure needed to support midday charging, ARRIVE performed a state of charge analysis using its existing operations and the modeled range of a Ford E-Transit.

Figure 33 represents the state of charge of two example vehicles throughout an 85th percentile day. The state of charge drawdown is assumed to be even throughout the day, and it is assumed that vehicles would be charged for 30 minutes once the battery has gotten below 40%. The vehicle start times are staggered, consistent with ARRIVE’s existing operations.

In this scenario, only one midday charger would be required to ensure that both vehicles can sustain enough charge throughout the day to complete its operations. ARRIVE and its operators would need to coordinate to ensure that a charger is available when the vehicles need to be charged, but one fast charger would support both vehicles.

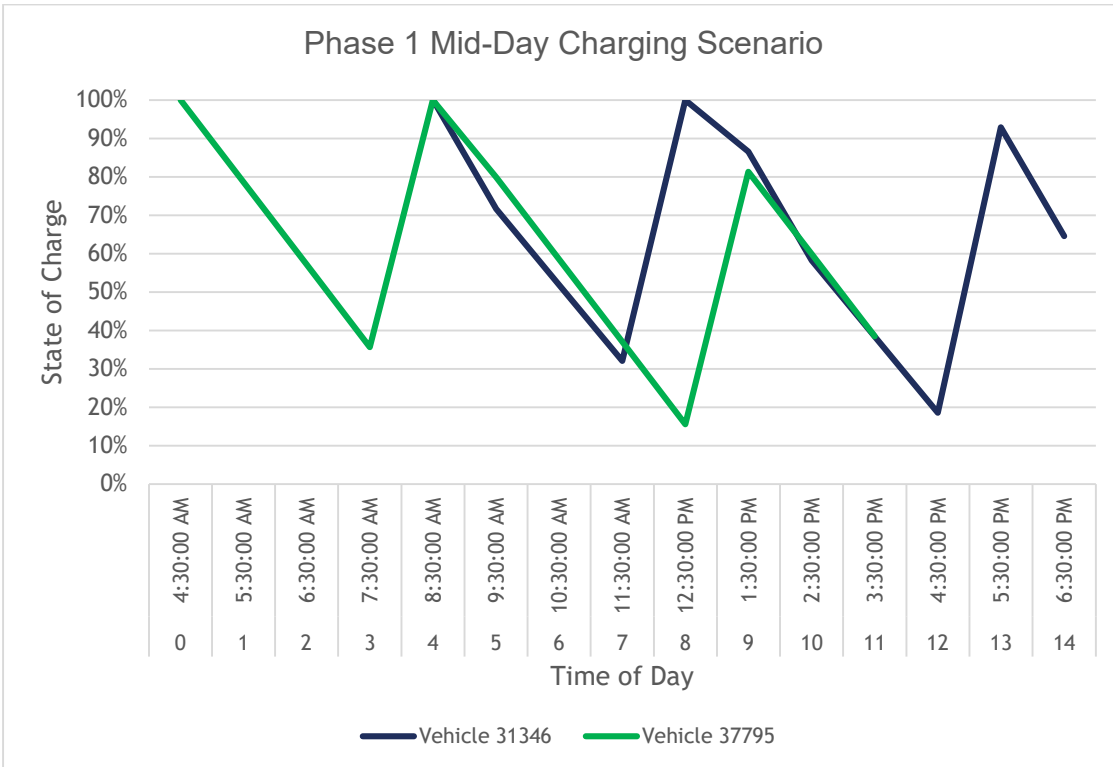


Figure 33: Phase 1 Charging Scenario

Figure 34 shows the same analysis as **Figure 33**, but with a greater number of vehicles. In this example, ARRIVE has six electric vehicles in service, and represents an 85th percentile day with staggered start times for the vehicles. As highlighted with the black box on the graph, the maximum number of vehicles that would need to be charged at one time is four vehicles – which would need to be supported by four total fast chargers. However, with more efficient dispatching, staggering of service start times and coordination of charging windows, ARRIVE could support midday charging for these six vehicles with three fast chargers. This is the same two vehicles to one fast charger as shown above.

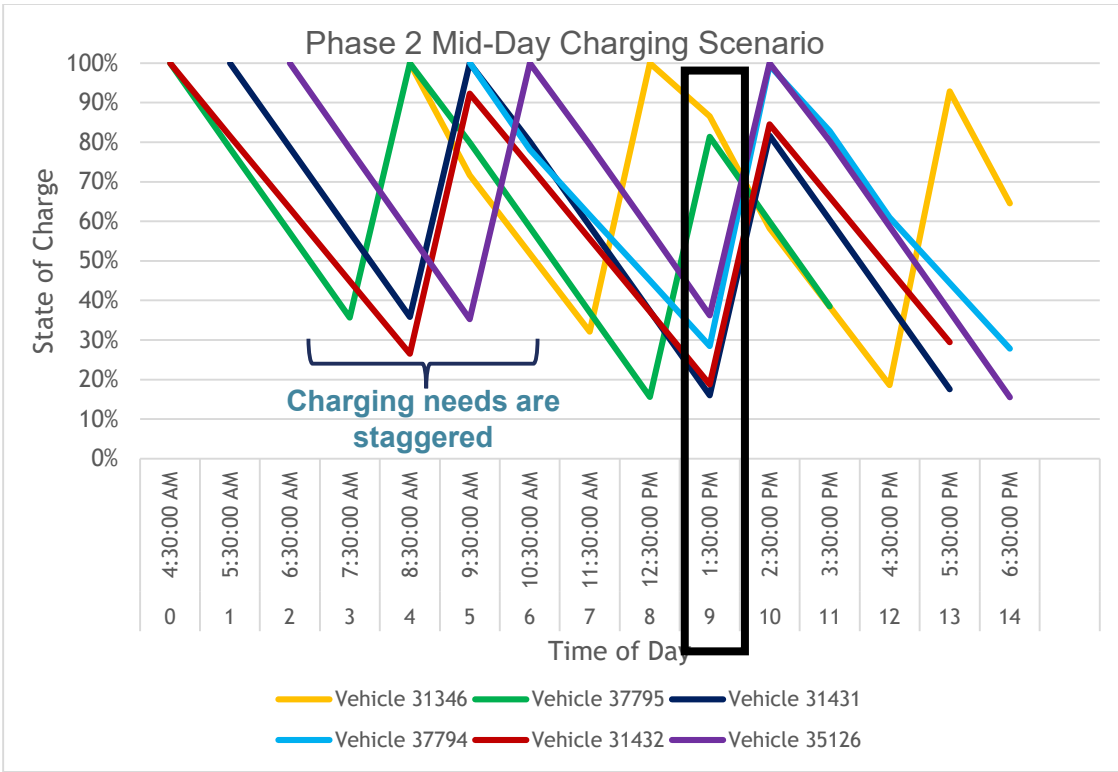


Figure 34: Later Phases Charging Scenario

As shown through these two examples, ARRIVE can support its midday charging need through a minimum of one fast charger for every two vehicles. Generally, ARRIVE will plan to maintain this ratio through all phases of its zero-emission transition to ensure that enough fast chargers are in place to support midday charging needs. Some level of coordination will need to occur to ensure that there are enough available chargers at any given time, especially as ARRIVE increases the number of ZEVs in service, but at minimum, this ratio should be effective.

However, when possible, ARRIVE will plan to have more fast chargers available than this minimum ratio to allow for greater operational flexibility, fleet expansion, and minimizing operational considerations.

Overnight Charging Infrastructure Needs

For overnight depot charging, best practice is that each vehicle has access to a charger to ensure that each vehicle can be fully charged prior to starting service in the morning. For this reason, ARRIVE is planning for a 1:1 ratio of depot chargers to vehicles once a permanent O&M facility is in place in the later phases of ARRIVE’s zero-emission transition.



Appendix D: Wilson County Government Letter of Support



Wilson
County

North Carolina

Wilson County Government
County Manager's Office

April 9, 2024

Margaretta Veltri, Office of Program Management
US Department of Transportation
1200 New Jersey Ave
SE Washington, DC 20590

Dear Ms. Veltri,

I am pleased to write to you in support of Wilson County's on demand service, ARRIVE, and the application for Low or No Emission and Bus and Bus Facilities competitive grant programs for FY2024.

This project includes expanding ARRIVE's fleet with two new electric transit vehicles and procuring two level three fast chargers to support midday, on-route charging of the vehicles. ARRIVE performed an analysis to identify ideal charging sites based on the most frequently requested stops of the demand response service. The central charging site locations, and the procurement of fast chargers, will allow electric vehicles to perform scheduled, midday charges without disrupting service operations, and minimizes the need for additional electric vehicles and chargers in this first phase of fleet transition.

The two sites identified as potential charging locations have ample space for vehicle staging, charging, and the installation of the chargers. Both sites are owned by Wilson County and administration are in support of hosting this portion of ARRIVE's operations at either site. We are coordinating with Wilson Energy to ensure the proper grid capacity is available at both sites, and the County will support ARRIVE's zero-emission vehicle goals within capacity of grid resources.

Wilson County fully supports this project and the efforts of ARRIVE to enhance equitable, sustainable transportation for our community. Wilson County is prepared to provide a local match \$96,223 in the form of an in-kind match of \$66,000 of salary and benefits for one full-time employee who will be dedicated to Zero Emission Transition implementation, alongside a cash match of \$30,223 from Wilson County's general fund.

Thank you for your full and fair consideration of Wilson County ARRIVE's application within all relevant rules and regulations.

Please do not hesitate to contact my office for any additional information about this project.

Sincerely,

A handwritten signature in black ink that reads "Lori Winstead".

Lori Winstead
Deputy County Manager



Appendix E: Wilson Energy Letter of Support



April 23, 2024

Margaretta Veltri, Office of Program Management
US Department of Transportation
1200 New Jersey Ave
SE Washington, DC 20590

Dear Ms. Veltri,

Wilson Energy supplies electric service to Wilson County and understands the benefits and impact an FTA Low No Emission and §5339 Bus and Bus Facilities grant would bring. Wilson Energy supports Wilson County's 2024 application to the Low No/Bus and Bus Facilities discretionary grant program for its Facility Development Project, a sustainable, modern approach to improve their on-demand transit service, ARRIVE.

This project includes expanding ARRIVE's fleet with two new electric transit vehicles and procuring two level three fast chargers to support midday, on-route charging. ARRIVE performed an analysis to identify ideal charging sites based on the most frequently requested stops of the demand response service. The central charging site locations coupled with fast chargers will allow electric vehicles to perform scheduled, midday charges without disrupting service.

The two prospective charging sites have room for vehicle staging, charging, and the chargers. Wilson Energy will coordinate with Wilson County to ensure the proper grid capacity is available at both sites, and the County will support ARRIVE's zero-emission vehicle goals with whatever utility improvements are required to facilitate the additional demand on the grid. Wilson Energy supports this project and the efforts of ARRIVE to enhance equitable, sustainable transportation for our community.

Thank you for your full and fair consideration of Wilson County ARRIVE's application.

Sincerely,

A handwritten signature in blue ink that reads "John M. Maclaga".

John M. Maclaga, PE
Director, Wilson Energy

PO Box 10, Wilson, NC 27894-0010
Telephone 252-399-2430
Facsimile 252-265-4874