Johnston County Area Transit System

Zero-Emission Transition Plan

April 2024

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List of Acronyms and Abbreviations

ASE	Automotive Service Excellence
BEB	battery electric bus
CRP	Carbon Reduction Program
CMU	concrete masonry unit
FCEB	fuel cell electric bus
FTA	Federal Transit Administration
GHG	greenhouse gas
IIJA	Infrastructure Investment and Jobs Act
JCATS	Johnston County Area Transit System
kW	kilowatt(s)
kWh	kilowatt-hour(s)
NCDOT	North Carolina Department of Transportation
NRV	non-revenue vehicle
OEM	original equipment manufacturer
Plan	Zero-Emission Transition Plan
PPE	personal protective equipment
RGP	rural general public
SAE	Society of Automotive Engineers
SOC	state of charge
ULB	useful life benchmark
v	volt(s)
VOMS	Vehicles Operated in Maximum Service
ZEB	zero-emission bus

Executive Summary

The transportation sector is a significant driver of greenhouse gas (GHG) emissions in North Carolina (North Carolina Greenhouse Gas Inventory, 2024). Public transit plays an important role in reducing GHG emissions by reducing vehicle miles traveled by the general population. Transitioning the vehicle fleet of transit agencies to electric vehicles further reduces GHG emissions, improving local air quality and public health. The Zero-Emission Transition Plan (the Plan) is the Johnston County Area Transit System's (JCATS) guide as the agency strives to reduce its dependence on fossil fuels.

The Plan begins with an overview of its context and purpose that identifies relevant policies, initiatives, and studies (see "Transition Plan Context and Purpose"). The Plan then provides an overview of the various technologies and associated considerations for each vehicle type (see "Overview of Electric Bus Technology"), including each vehicle type's battery and charging infrastructure.

In the next section ("Electrification Analysis and Evaluation"), the Plan evaluates existing facilities and their relationship to the technology transition. This evaluation provides an in-depth description of the service and fleet, including the current fleet composition, early transition opportunities, and a facility analysis.

The Plan also addresses current and future resource availability to meet the costs associated with the vehicle fleet transition and its implementation (see "Resource Availability"). Resources, including power from utility providers, funding availability, and the agency's workforce, are described in this section. The utility coordination discussion outlines the partnership between Johnston County Area Transit System (JCATS) and the utility provider, Duke Energy, which the Town of Selma, North Carolina, administers. JCATS plans to maintain open communication and work with the utility company to provide sufficient lead time to ensure continuous service availability when deploying its electric fleet. The workforce section examines the impact of the transition on the workforce and identifies strategies to avoid displacing existing workers.
After summarizing the conclusions (see "Conclusions"), the Plan identifies the next steps for JCATS to continue its transition to a zero-emission fleet (see "Next Steps"). The Plan's responsiveness to the six elements required for a Federal Transit Administration (FTA)-compliant Zero Emission Fleet Transition Plan as required by the IIJA in order to obtain zero-emission related FTA funding can be found at the following headings and pages:

1. Demonstrate a long-term fleet management plan (see "Fleet Transition Projection," on page 26)
2. Availability of current and future resources to meet costs for the transition and implementation (see "Funding Availability" on page 36)
3. Policy and legislation impacting relevant technologies (see "Existing Policies, Initiatives, and Studies," on page 3)
4. Evaluation of existing and future facilities (see "
5. Facility Analysis" on page 26)
6. Partnership of the applicant with the utility or alternative fuel provider (see "Coordination With the Utility" on page 34)
7. Impact of the transition on the applicant's current workforce (see "Workforce Development and Training," page 38)

1. Transition Plan Context and Purpose

Reducing transportation-related emissions helps not only to improve local air quality but also to reduce greenhouse gas (GHG) pollution, which contributes to negative global impacts. The Johnston County Area Transit System (JCATS) is committed to minimizing the environmental impact of its transit operations while maintaining a quality, equitable service to its riders. JCATS will achieve this by evaluating low- and no-emission vehicles and implementing a Zero Emission Fleet Transition Plan. This strategic plan will guide JCATS in decision-making processes and appropriate phasing to transition from a conventional fossil fuel-powered fleet to zero-emission alternatives.

Johnston County Area System Services and Facilities

JCATS, a division of Community & Senior Services of Johnston County, Inc. (CSS), is located in Selma, North Carolina, just southeast of the Raleigh Urbanized Area. Due to its status as a private non-profit and its operation of publicly accessible transit services, JCATS receives funding via grants from local, state, and federal agencies. Along with receiving payment from county agencies on a shared per-mile basis, JCATS also receives fares from public transit. The transit system also benefits from peer support from other county transportation systems as well as direct consulting support from NCDOT.

Figure 1. *JCATS Service Area Map*

Figure 1 illustrates the JCATS service area. JCATS will pick up riders anywhere inside of Johnston County and will take them anywhere inside of the County or within the following surrounding areas: Chapel Hill, Dunn, Durham, Fuquay Varina, Goldsboro, Greenville, Kinston, Newton Grove, Wilson, and Raleigh. JCATS provides on-demand service for Johnston County residents throughout and around the County. The service is categorized into two categories: Human Services Transportation and Rural General Public (RGP) Transportation.

Services such as transportation for medical trips, workplace job training, senior centers, childcare centers, social services, public hearing, and others fall under Human Services Transportation. In order to use this component of JCATS service, partner agencies are contacted directly to determine eligibility. While JCATS primarily provides non-emergency medical transportation and other contracted services, it also offers RGP Transportation from 6:00 a.m. to 5:00 p.m., Monday through Friday (some limited transportation is provided on weekends, evenings, and holidays). This service accommodates transportation to schools, work destinations, appointments, and more, all at a reduced cost for riders. Seating availability is secondary to riders served by its contracting agencies due to the limited number of vehicles in the fleet and the extremely limited RGP financing support for this service.

In addition to JCATS' Human Services Transportation and RGP Transportation services, the agency deployed a microtransit service called QuickRide in early 2023. Rides are provided throughout Selma and Smithfield, two of the fastest-growing population zones within the JCATS service area, as well as the unincorporated areas. The service also makes connections for multi-modal trips and connections to Raleigh, NC, at the Selma Amtrak station and the Johnston Regional Airport in Springfield, NC. Service is offered Monday through Saturday from 6 a.m. to 8 p.m. Riders may schedule curb-to-curb rides in advance through a mobile app or by phone. Rides cost $6 each way and may be paid with cash or with a credit card. The QuickRide service complements ridership demand where density and roadway networks would make more traditional fixed-route or deviated services inefficient to operate. It has experienced substantial ridership growth in its first year of operation. It is anticipated that JCATS will continue to operate this service and look for ways to expand service to meet rider demands in the current and neighboring areas in the future.

JCATS operates a fleet of over 30 buses and vans that are ADA-compliant to assist those with specialized needs. The agency currently has a year-old facility with six Level 2 chargers and is installing five Level 3 chargers. The agency is also in the process of installing solar panels in its vehicle parking area.

Environmental Impacts of Transit

Transit plays a crucial role in reducing a region's overall greenhouse gas (GHG) emissions. When passengers opt for transit instead of driving their own vehicles, it reduces the total vehicle mileage traveled, leading to lower net emissions. Investing in efficient and sustainable transit systems is essential for mitigating environmental impacts and promoting cleaner, healthier communities. Benefits can be further enhanced by reducing emissions from transit vehicle operations.

Trend Toward Zero-Emission Buses

Transit agencies across the country and internationally are implementing strategies to reduce emissions from their fleets by integrating more low- and no-emissions technologies. Zero-emission bus (ZEB) adoption in the United States is anticipated to accelerate due to increased funding availability to support ZEB purchases and increased adoption of emissions-reducing policies by local governments and municipalities.

As of September 2023, 6,147 full-size transit ZEBs are in the United States, which is a 12 percent increase from the previous count.[1] California continues its lead with the most ZEBs adopted in the United States at 1,946 ZEBs. However, New York experienced the most significant growth in full-size transit ZEBs during 2023, with a 66 percent increase compared to 2022.

Existing Policies, Initiatives, and Studies

Reducing emissions has been of increasing concern nationally and locally as research continues to demonstrate the wide range of environmental and health benefits associated with such reductions. This section discusses policy and legislation with implications for the zero-emission transition for JCATS.

Nationwide Initiatives

Infrastructure Investment and Jobs Act

Signed into law by President Biden on November 15, 2021, the Infrastructure Investment and Jobs Act (IIJA), also known as the "Bipartisan Infrastructure Law," invests "$89.9 billion in guaranteed funding for public transit over the next 5 years—the largest federal investment in public transit history.[2] As part of these transit investments, the IIJA includes provisions to support and increase investment in zero-emission vehicles through grant programs, studies, fleet funding, and other measures.[3] In particular, the IIJA includes provisions to continue the grants for the Buses and Bus Facilities program with increased funding levels compared to that of previous authorizations. The IIJA also includes funding appropriation for the Low-No Grant program at around $1.1 billion annually from 2022 through 2026 (The Low-No Grant program is a program within the Federal Transit Administration's [FTA] Buses and Bus Facilities program.). This discretionary grant program requires agencies to have a zero-emission fleet transition plan. The program also requires that 5 percent of Low-No Grants related to zero-emission vehicles and related infrastructure be used for workforce development activities unless the applicant certifies that less is needed to carry out their zero-emission fleet transition plan. However, it should be noted that federal transit funding focuses on capital needs, not the costs associated with the operation and maintenance of ZEBs or other transit services.[4]

Statewide Initiatives

There are several clean transportation initiatives happening within the state, including Executive Orders (E.O.) 80 and 246, as well as NCDOT plans aimed at reducing emissions. These initiatives are summarized below.

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[1] CALSTART, *Zeroing in on ZEBs* (February 2024).

[2] The White House, *Fact Sheet: The Bipartisan Infrastructure Deal* (November 6, 2021).

[3] Alternative Fuels Data Center, *Bipartisan Infrastructure Law (Infrastructure Investment and Jobs Act of 2021).* Accessed June 2023.

[4] Federal Transit Administration, *Fact Sheet: Buses and Bus Facilities Program* (last updated December 9, 2021).

Executive Order 80

E.O. 80, signed by Governor Roy Cooper in 2018, called for the state to reduce greenhouse gas emissions to 40 percent below 2005 levels and have 80,000 registered zero emission vehicles by 2025.

Executive Order 246

E.O. 246, issued in January 2022, focused on milestones for years 2023 and 2050 with increased metrics tied to emissions and the number of ZEVs traveling along roadways within the state. The following are strategies from E.O. 246:

- Reduce economy-wide emissions by 50% below 2005 levels by 2030 and achieve net-zero emissions no later than 2050
- Increase the total number of registered ZEVs to at least 1.25 million by 2030
- Increase the sale of passenger ZEVs so that 50% of in-state sales are zero-emission by 2030

JCATS will advance state goals to reduce harmful emissions by transitioning heavy pollutant transit vehicles to zero-emission BEBs. In addition to yielding immediate environmental benefits through vehicle replacements, the transition will set the foundation for additional future improvements through training to ensure frontline employees are skilled in BEB maintenance, particularly as JCATS works towards a fully electric fleet.

Consistency with NCDOT Priorities

According to the 2018 NCDOT Public Transportation Strategic Plan, the state’s transportation system is called to “Embrace new transportation innovations such as on-demand transit, autonomous vehicles, electric buses, and alternative fueled vehicles.” In response to E.O. 80, in 2019, NCDOT released the North Carolina Zero Emission Vehicle (ZEV) Plan to outline actions to support state ZEV adoption. This plan outlined the importance of converting North Carolina’s transit systems to electric fleets and identified the FTA’s Low-No program as a key funding source.

In 2022, E.O. 246 tasked NCDOT with developing a Clean Transportation Plan. The plan outlines strategies to further decarbonize the transportation sector, including fleet transitions to zero- or low-emission vehicles. By switching from diesel to zero-emission vehicles and providing clean, safe, and dependable public transportation, JCATS' transition contributes to NCDOT and IMD's goals of decarbonizing transportation and improving quality of life.

2. Overview of Electric Bus Technology

Currently, three ZEB technologies are commercially available: electric trolleybuses, fuel-cell electric buses (FCEBs), and battery electric buses (BEBs). Although electric trolleybuses have been in use for nearly a century, only five transit agencies across the country currently operate this type of ZEB as a part of their regular service offerings.[5] Power to these buses is provided via two trolley poles connecting the top rear of the bus to overhead catenary wires. This technology is not available to demand-response vehicles.

FCEBs—buses that use an onboard electrochemical hydrogen fuel cell for propulsion—are becoming more prevalent across the U.S., with the adoption of these buses increasing by 64 percent since 2021. Two agencies in the U.S. are currently piloting demand-response vehicles with fuel cell electric propulsion, but these vehicles are not in commercial production and are still an unproven technology. As such, the JCATS is not currently considering this technology.

BEBs use onboard battery packs for bus propulsion and power rather than conventional fuels such as diesel or gasoline. When BEB acceptance in the United States is discussed, the figures presented typically reflect full-size transit buses that are over 30 feet in length. The SMTD operates small transit buses (defined as under 30 feet). Such buses make up a significant portion of transit vehicles in the country. The transition to BEB technology for these smaller vehicles has not been as prevalent as with full-size buses, but this transition is increasing for small buses. There was a 111 percent growth in the deployment of smaller public transit vehicles from 2021 to 2022, and these vehicles were significantly adopted in private-sector industries. As such, BEB technology is the most advantageous for JCATS to use as it implements its zero-emission transition plan.

BEB Vehicle Considerations

The batteries onboard a BEB provide both the energy required to drive the bus and the energy necessary to operate all vehicle auxiliary functions, including the heating and cooling of the passenger cabin. The amount of energy the battery provides is described by its energy capacity measured in kilowatt-hours (kWh). Unlike conventional buses, which typically have enough diesel or gasoline to power the vehicle for an entire day, BEBs typically have a reliable range in transit service of 100 miles or less on a single charge.[6] A BEB range is a function of two primary characteristics: (1) battery capacity and (2) energy usage.

Larger **battery capacity** translates to increased energy (fuel) storage and thus increased range. Smaller transit buses are limited in their battery capacities, as the size and strength of the vehicle limit its ability to carry heavy batteries. In addition, just as operators avoid driving a conventional bus until the fuel tank is empty, a portion of a BEB's battery capacity is typically preserved for operational flexibility. By preserving this capacity, transit agencies can ensure that BEBs will have sufficient range to return to the garage in case of an unforeseen delay or other unexpected event requiring a BEB to remain in service longer than initially planned.

The amount of **energy usage** by the bus (kWh/mile) also impacts a BEB's range. When the energy used to heat and cool the bus cabin is the same energy used for the bus propulsion, its range can be substantially reduced in cold or hot weather as increased energy must be devoted to maintaining a comfortable temperature in the passenger cabin. The speed at which a BEB

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[5] Federal Transit Administration, *The National Transit Database (NTD)* (last updated November 2, 2022).

[6] National Academies of Sciences, Engineering, and Medicine, *Guidebook for Deploying Zero-Emission Transit Buses* (Washington, DC: National Academies Press. https://doi.org/10.17226/25842.2021, 1921).

operates also influences energy usage and, therefore, the BEB range. Typically, slower speeds are a result of either busy or congested environments. In busy environments, buses often see greater energy usage, owing to bus doors being open more often and for longer periods of time. When the doors are open, the heating and cooling of the bus cabin is more difficult, as extra energy needs to be drawn from the battery. Also, when buses are stuck in congested environments, they spend an increased amount of time idling and accelerating from rest, thereby also requiring greater energy usage. Efficient operation of the vehicle through gentle accelerations and decelerations can reduce energy usage by not only requiring less energy to accelerate from rest but also maximizing the ability of the bus to regenerate energy. When the bus is rolling forward, BEBs are capable of recapturing some of that energy and improving their overall energy usage. From this combination of factors, energy usage on the same bus can vary widely within a single transit agency's operation and, therefore, lead to different functional ranges.

Charging Infrastructure

In the North American BEB industry, there are currently three primary types of BEB chargers: (1) plug-in chargers, (2) overhead conductive chargers with inverted overhead pantograph dispensers, and (3) in-ground wireless inductive chargers (Figure 2). Plug-in chargers are typically used at garages and in bus service/maintenance bays, whereas overhead and inductive chargers can be used for either garage or on-route (opportunity) charging. BEB charging infrastructure typically includes transformers, switchgear, chargers (charger "bases/cabinets," where the majority of charging equipment is housed, including alternating current (AC)–direct current (DC) rectifiers, charge controls, and communication), and dispensers (e.g., pantographs or plugs).

Plug-In

Source: Lightning eMotors

Overhead Conductive

Source: TriMet, March 2021

Wireless Inductive

Source: Link Transit & eVehicle Technology

Figure 2: BEB Charging Infrastructure

Plug-in chargers can be either an all-in-one unit with dispensing plug-in cords attached directly to the charger cabinet or a charging cabinet connected to remote plug-in dispensers (Figure 3).

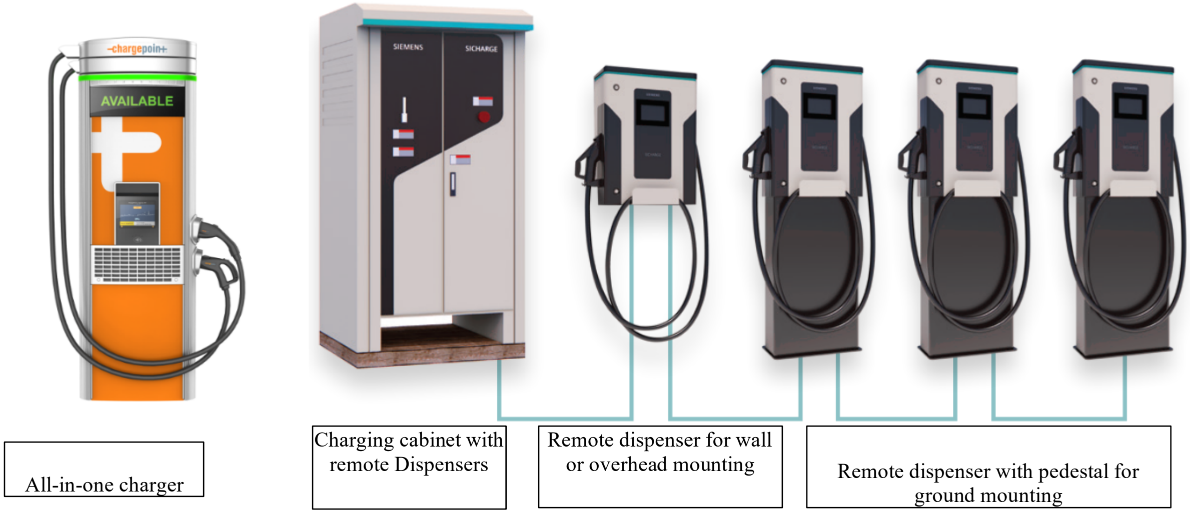


Figure 3: Plug-In Charger Detail

The smaller size of a remote dispenser allows multiple vehicles to be charged away from the large charging cabinet, which is practical when powering multiple larger vehicles. Typically, an all-in-one charger has one or two cords, while a charging cabinet can energize between one to four remote dispensers, allowing for scheduled charging of multiple buses. Charge power for plug-in chargers ranges from 8 to 115 kilowatts (kW) for small transit buses. There is specialized equipment that can charge these vehicles at 220 kW or higher, but it is expensive and not compatible with all BEBs. Due to the relatively low power of typical equipment, plug-in chargers typically take several hours to charge a bus fully and are often used for overnight charging. A factor to be considered with shared charging (one charging cabinet energizing multiple dispensers) is that, depending on the charger manufacturer and model, the nameplate rating of the charger (120 kW, for example) might only output a maximum of 60 kW if the one charger cabinet is energizing two dispensers (expressed as a 1:2 charging ratio). There is no industry standard yet for a shared charging configuration, so any shared plug-in charging assumed-performance operations (e.g., ability to provide 80 kW to any dispenser at a time) are recommended to balance the planned incoming charging equipment with the anticipated charging operational time. BEBs, by default, have charging ports in locations similar to conventional internal combustion engine fuel ports (e.g., curbside, rear quarter of bus). Buses can be specified to have plug-in ports on a specific vehicle area, but most plug-in locations are manufacturer-determined. Per unit capital costs for plug-in chargers are lower than for other types of charging infrastructure. The J1772 standard, published by the Society of Automotive Engineers, allows for the interoperability of plug-in chargers with different types of buses from multiple manufacturers, analogous to the standardized pump size for gasoline vehicles across manufacturers, which allows you to fill your gas tank at any gas station. Retrofitting ground-mounted charger cabinets (2 feet [ft] to 3 feet 6 inches) in depth adjacent to existing parked buses and dense bus parking arrangements can lead to blocking staff circulation or create a bus-to-charger impact danger. On large retrofit deployments at dense, closely parked depots, it is not uncommon to eliminate some bus parking spaces to allow for ground-mounted chargers. Overhead suspended dispenser plug-in cords mounted over parked buses energized by charging cabinets located remotely away from bus parking can be used where ground-mounted plug-in cord equipment is impractical or not desired. Overhead plug-in cords over buses, if not left always dangling protected by bollards or other structures, would require some means to retract and extend the cords. Currently, the original equipment manufacturers (OEMs) do not offer a remote overhead reel or retraction system and rely on third-party vendors or site-specific custom solutions that range from the simple, suspended rope tagline connected to a manual pull charging cord to powered retraction systems that use reels or winches.

Overhead conductive chargers typically use an extending arm pantograph or piston-mounted charging bars that lower down from the charger to connect to the roof-mounted charge rails on the bus. This technology does not currently exist for demand-response vehicles.

Inductive chargers use a wireless power pad as the charging dispenser embedded in a garage floor or roadway surface in conjunction with a power receiver installed under the bus. This technology is relatively new, with full-size BEBs, and it is gaining popularity as it matures. Currently, inductive charging is not being used to charge small transit BEBs; however, companies are beginning to provide trial inductive charging options for battery electric cars and small fleet vehicles, which may also benefit smaller BEBs.

3. Electrification Analysis and Evaluation

Service and Fleet Analysis

This section of the Plan analyzes JCATS' fleet and service to identify the estimated number of miles each run could perform before needing to be charged. This analysis looks at three vehicle types (Mobility Van, E350, and E450) due to the passenger capacity abilities of each vehicle. The data set used in this analysis was for the two weeks of 1/8/2024 – 1/19/24.

Current Fleet Composition

JCATS's operating fleet consists of 19 Ford E350 cutaways and 16 Ford Mobility vans with lifts. The oldest vehicle in the fleet is eight years old, and the average age is four. No vehicles are beyond their useful life benchmark (ULB). All vehicles are housed at the new JCATS facility building.

Due to gross vehicle weight capacity constraints with electric vehicles (the batteries add weight, which reduces the potential passenger load capacity), it is assumed that all vehicles will be replaced with vehicles of similar seating capacity. This may change the type of vehicle needed for a run. An analysis of peak passenger loads was used to determine the vehicle capacity needed. Vehicles carrying a max of four passengers or less were assigned a Mobility Van (Van) for a replacement, 5 to 9 passengers an e350, and ten or more an e450.

Service Analysis Assumptions

JCATS operates Monday through Friday from 4:30 AM to 9:00 PM and on Saturdays from 4:30 AM to 5:00 PM. Service is to and from anywhere within Johnston County and to select areas outside of the county.

Table 1 lists each type of service operated. The Rural General Public (RGP) service, microtransit service called Johnston Quick Ride (Quick Ride), and out-of-county services are open to the general public. JCI is a regional non-profit that provides employment and training to those with disabilities. JCATS' JCI services pick up individuals in areas of the county and bring them to the JCI headquarters or Unity House in Selma for 8:00 AM service, with a return pick-up between 3:00 PM and 4:00 PM. The Senior Clayton service provides trips to and from the Clayton Senior Center for residents at set times.

Table 1. JCAT Service Type Descriptions

Service Type	Description	Run Numbers	Days Operated	Current Vehicle Types	Maximum Passengers on Board	Total Daily Miles
JCI Princeton	JCI trips in the Princeton, Smithfield Area going to Smithfield and Selma.	5,6	Tu/W/Th 6:00 AM-8:00 AM & 3:00 PM – 6:00 PM	E350	8	96
Senior Clayton	Senior Trips in the Clayton Area	11, 12	M-F 7:00 AM-9:00 AM & 12:00 PM – 2:00 PM	E350 (89%), Van (11%)	8	64
JCI Clayton	JCI tips in the Clayton area going to Smithfield and Selma area	17, 18	M-F 6:00 AM-8:00 AM & 3:00 PM – 6:00 PM	E350	13	123
JCI Zebulon	JCI trips in the Zebulon, Middlesex and Kenly area going to Smithfield and Selma area.	21, 22	M-F 6:00 AM-8:00 AM & 3:00 PM – 6:00 PM	E350	12	133
JCI Benson	JCI trips in the Four Oaks, Benson and Willow Spring	25, 26	M-F 6:00 AM-8:00 AM &	E350	10	140

Service Type	Description	Run Numbers	Days Operated	Current Vehicle Types	Maximum Passengers on Board	Total Daily Miles
	area going to Smithfield and Selma area.		3:00 PM – 6:00 PM			
Microtransit	Microtransit	135, 136, 137, 138, 139	M-S 6:30 AM – 9:00 PM	Van	5	556
Out of County	Out of County	600, 601	M-Th 4:30 AM – 5:00 PM	E350	6	393
Rural General Public (RGP)	All other trips	400-408, 410-421, 430, 431, 500-513, 515, 520-522	M-Sa 6:00 AM-5:00 PM	E350 (60%), Van (40%)	15	4,484

To provide the services, JCATS operates between 41 and 51 runs daily on weekdays, using 31 to 34 different vehicles (Figure 4); weekend service requires significantly fewer resources. To reduce vehicle needs, vehicles are reused on runs when possible (**Table 2**). Wednesdays have the highest demand, using 31 vehicles in the peak hour at 8:00 AM. Wednesdays also have the greatest mileage, operating 5,900 miles in the day (**Figure 5**). Of that, 15 percent is deadhead, and the average total deadhead per run is 20.3 miles.

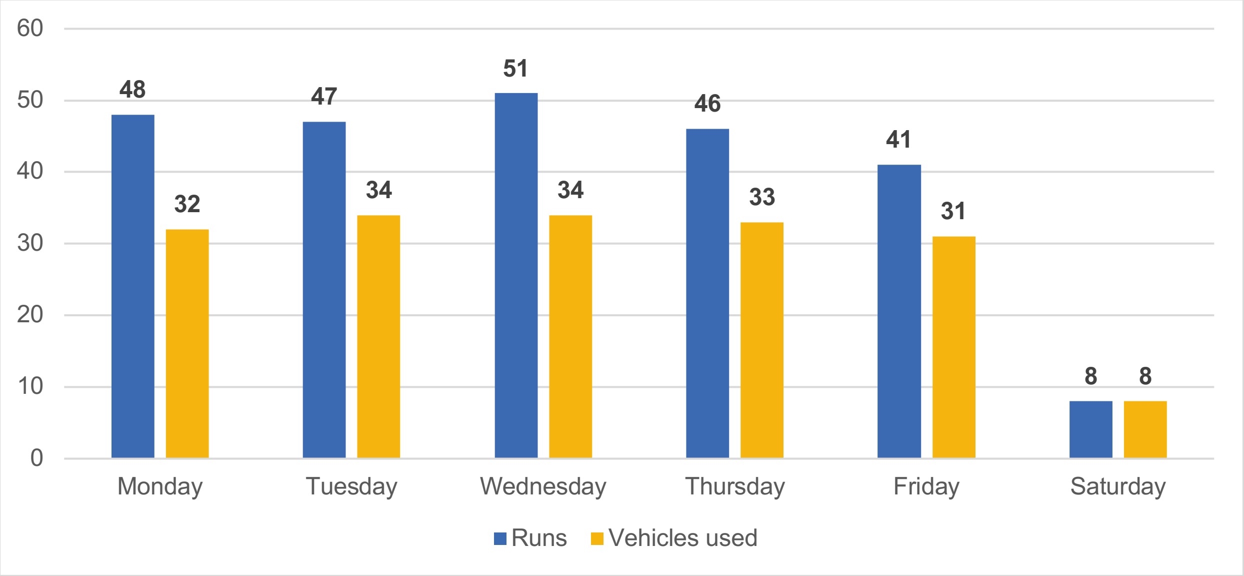
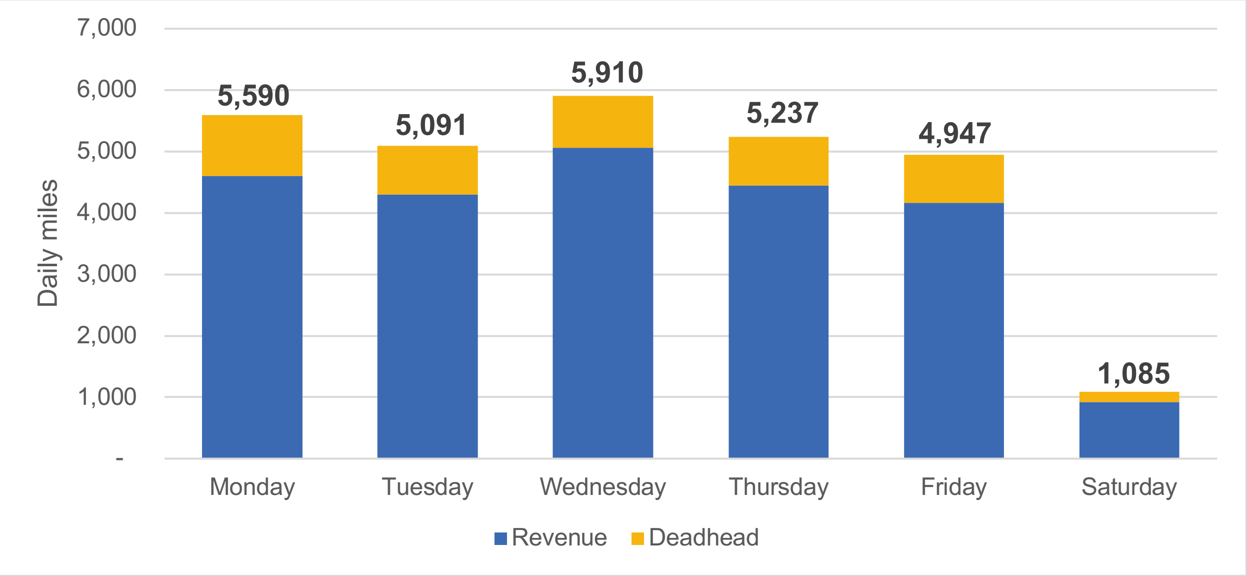


Figure 4. *JCAT Daily Runs and Vehicle Utilization*

Table 2. *Vehicle Reuse on Runs*

AM PEAK Run	Mid-Day run	PM Peak run
5 – JCI Princeton	• 401 – RGP	6 – JCI Princeton
11 – Senior Clayton	• At least one "RGP" run type	12 – Senior Clayton
17 – JCI Clayton	• 416 – RGP • Occasionally: 420 – RGP, 508 – RGP, 430- RGP, or 401- RGP	18 – JCI Clayton
21 – JCI Zebulon	• 417 – RGP • Either 420 – RGP, 508 – RGP, 520- RGP, 521- RGP, or 421 – RGP	22 – JCI Zebulon
25 - JCI Benson	• 408 – RGP & 430 – RGP (Tu/W/Th only) • 401 – RGP (M/F only)	26 – JCI Benson
505 – RGP	• 601 – Out of county	601 – Out of county

Figure 5. Daily Miles Breakdown



As previously discussed, battery/energy capacity and energy usage are the primary drivers influencing BEB range and, consequently, the viability for service to be operated with BEBs. The following section defines the assumptions for each factor in assessing BEB service viability. Battery capacity and energy usage assumptions are then summarized in Table 3 for each vehicle type. As mentioned, the vehicle replacement type is based on passenger capacity needs by run for JCAT and may result in a change in the vehicle type assigned.

Battery/Energy Capacity Impacts on BEB Range

To calculate and model a battery's energy capacity, three factors must be considered: (1) battery degradation, (2) battery life, and (3) operational flexibility:

Battery Degradation

Batteries become less efficient and wear down over time as they are constantly charged and discharged. For example, as smartphone and laptop users are aware, as these devices grow older, they require more frequent charging as a "full charge" no longer provides power for as long as when the device was new. Based on manufacturer warranties, it is estimated that a BEB's battery capacity degrades by approximately 2 percent per year, which equals a capacity loss of approximately 10 percent after 5 years (manufacture vehicle service life, and up to about 16 percent after 8 years (typical vehicle ULB)).

Battery Life Capacity Reservations

Beyond general battery degradation, charging a BEB to full capacity or charging it from a zero SOC increases battery degradation rates, as additional strain is placed on the battery's physical and chemical components. All battery manufacturers recommend reserving a portion of the battery's capacity to preserve battery life to prevent more rapid degradation of battery capacity than the annual 2 percent described above. The portion of a battery's capacity that is protected and unavailable for use varies by manufacturer and can range from between 5 percent to approximately 35 percent of the battery's capacity.[7]

Operational Flexibility Capacity Reservations

Just as operators avoid driving a conventional vehicle until the fuel tank is empty, a portion of a BEB's battery capacity is typically preserved for operational flexibility.[8] By preserving this capacity, transit agencies can increase the likelihood that BEBs will have sufficient range to return to the garage in the event of unseen delays or other unexpected events that might require a BEB to remain in service longer than originally planned.

Usable Battery Capacity Calculation Summary

Overall, JCATS's BEB service planning is based on a battery's usable, rather than nominal, capacity at ULB to account for battery degradation and capacity reservations. Based on an approximately 2 percent annual battery capacity degradation, 11 percent of the battery is protected and unusable[9], the reservation of 10 percent battery capacity for battery life and 5 percent for operational flexibility, the usable battery capacity at the vehicle ULB (8 years) is calculated as 61 percent of the nominal (advertised) battery capacity.

Energy Usage Impacts on BEB Range

Along with battery capacity, the amount of energy consumed by the bus (kWh/mile) also impacts the BEB range. When the energy used to heat/cool a bus's passenger cabin is the same energy used for the bus's propulsion, the bus range can be substantially reduced in cold and hot weather, as increased energy must be devoted to maintaining a comfortable passenger cabin temperature.

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[7] National Renewable Energy Laboratory, *Electrifying Transit: A Guidebook for Implementing Battery Electric Buses* (April 2021).

[8] National Renewable Energy Laboratory, *Electrifying Transit: A Guidebook for Implementing Battery Electric Buses* (April 2021).

[9] Altoona test report for the Lightning eMotors Inc ZEV3 https://www.altoonabustest.psu.edu/bus-details.aspx?BN=2023-03

Raleigh, North Carolina, experiences a temperature low of 32 degrees Fahrenheit and a high of 101 degrees, which can be detrimental to a BEB’s range because more energy will be required to heat or cool the interior. Therefore, even though many transit agencies across the country can largely plan BEB service assuming relatively average ambient temperatures, JCAT must plan BEB service around worst-case range estimates based on winter temperatures to ensure reliable service can be maintained year-round. Drawing on the experience of others and national research on EV temperature range curves, this JCAT transition plan utilizes a reduction factor of 22 percent for worst-case energy efficiency at 32 degrees. Just as with combustible engines, as the road grade increases, so does the amount of energy consumed per mile. The more varied the terrain, the greater the energy consumption.

Summary of BEB Service Analysis Assumptions

Table 3 summarizes the battery capacity and energy usage assumptions and criteria outlined above and used to assess the suitability of JCAT’s service for BEB operation[10].

Table 3. *Assumptions for Vehicle Ranges*

Item	Van	E350	E450
Battery size–nominal capacity	120 kWh	80 kWh	127 kWh
Battery size–usable capacity *	74 kWh	49 kWh	78 kWh
Average kWh per mile**	0.82	0.80	1.32
Average range in miles	90	62	59
Worst-case kWh per mile**	1.03	1.03	1.69
Worst-case (winter in Ashville) range in miles	72	48	46
Passenger capacity	4	9	13

Note(s):

* Usable battery capacity is defined as the ULB battery capacity calculated as 61% of nominal battery capacity. This definition assumes a 2 percent annual battery capacity degradation and a total of 26% capacity reserved for a combination of battery health and operational flexibility.

** Average and worst-case energy efficiency (kWh per mile) were calculated using assumptions and modeling efforts based on temperature range curves

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[10] Perger, T., Auer, H. Energy efficient route planning for electric vehicles with special consideration of the topography and battery lifetime. *Energy Efficiency* **13**, 1705–1726 (2020). https://doi.org/10.1007/s12053-020-09900-5

Demand Response Service Analysis Results

To estimate the ability of the JCATS service to be operated with battery electric vehicles, a representative sample of two weeks of trip data from January 2024 was used to model the ability of these vehicles to complete similar assignments. The analysis did not include trips that were canceled, no-shows, or on holiday. It's important to note that, unlike the fixed route service, demand response does not have a set number of miles or types of trips it operates. Mileage can vary greatly and depends on ridership, and the needs of customers who require a mobility device may change the vehicle that can be assigned to a route. As such, the analysis examines average daily and maximum daily mileage, ridership, and peak passenger loads. The following sections provide a breakdown of mileage, vehicle use, and passenger loads for each service type operated.

JCI Routes

Each JCI service uses one vehicle (**Table 4**). In the morning, the vehicles deadhead to their pickup communities, which range from 12 to 21 miles away, to bring passengers into Selma and Smithfield. In the afternoon, the passengers are returned home using the same vehicles, and the vehicle deadheads back to the garage. Deadhead miles make up 23 percent to 31 percent of the overall miles. The JCI Princeton route travels the shortest distance daily and carries the fewest passengers. The Clayton route carries the greatest number of passengers at any given time, and the Benson route has the greatest number of miles daily.

Table 4. *JCI Route Statistics*

Route	Vehicle Use	Max daily Revenue Miles	Daily DH miles	Total Miles	Peak Passengers
JCI Princeton	1	71	25	96	8
JCI Clayton	1	91	32	123	13
JCI Zebulon	1	102	31	133	12
JCI Benson	1	97	43	140	10

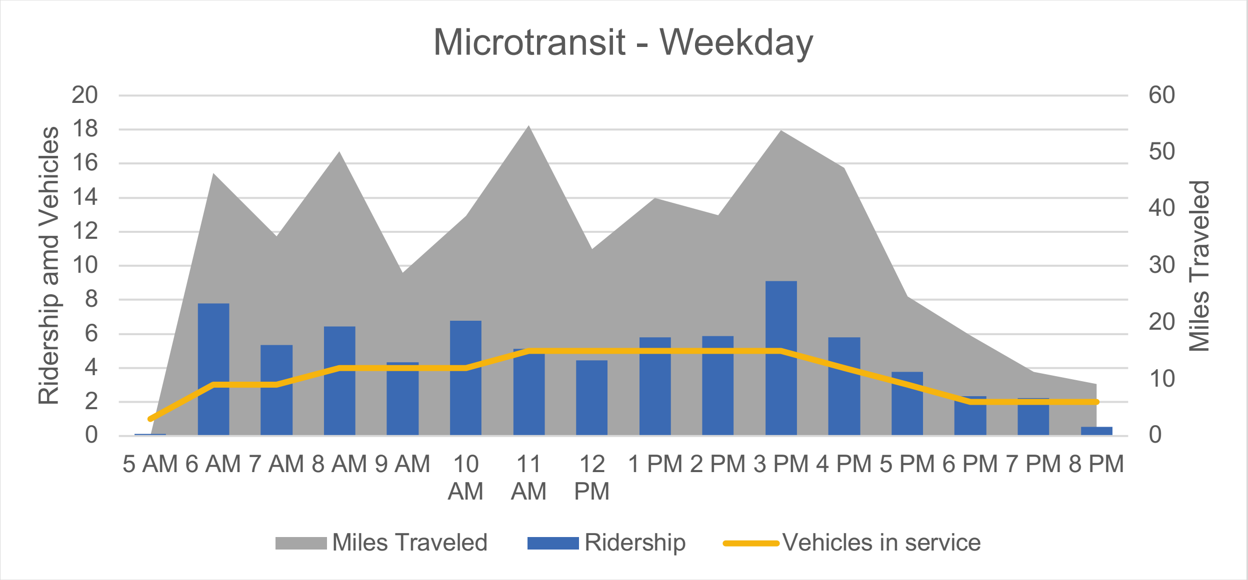
Senior Clayton

The Senior Clayton route uses one vehicle. In the morning the vehicle deadheads an average of 11 miles to Clayton to pick up 5 to 8 individuals to bring them to the senior center for 9:00 AM. The vehicle is then used on the RGP service mid-day before returning at noon to pick up the passengers and return them home. On Mondays and Fridays, when the vehicle is done with the return drop-offs, it is used again on the RGP service. Despite being reused mid-day and in the afternoon on select days, deadhead mileage accounts for 59 percent of the overall miles on this route.

Quick Ride

The microtransit uses five vehicles at peak times, which are from 11:00 AM to 3:00 PM (Figure 6). Weekday mileages range from 397 to 635, with an average of 532. Eight percent of miles is deadhead. Daily ridership is 63 to 87 on weekdays, averaging 72. Ridership is largely proportional to the miles traveled throughout the day, with 7.4 miles traveled for each unique passenger carried. The average trip length per passenger is 3.7 miles. When the average trip length is half the miles traveled per unique passenger, this suggests that there are significant miles without passengers on board. Seventy-two percent of trips are private trips. Ridership is highest in the morning at 6:00 AM and then again at 3:00 PM; this is not proportional to the number of vehicles in service, resulting in slack time in the schedules mid-day, primarily from 11:00 AM to 2:00 PM.

Figure 6. *Microtransit Service*



Out of County Routes

Out of County service operates on weekdays only. One leg of the trip is in Johnston County, and the other is to select cities outside of the county. Two vehicles are dedicated to this service and the RGP vehicles can be used to provide out of county trips. The 600 & 601 runs (dedicated to out of county) each travel an average of 192 miles daily with a max of 284. Deadhead accounts for 7 percent of the mileage and varies considerably based on where the first pick-up and last drop-off of the day are. Per run, the average deadhead is 13.2 miles. The vehicles deadhead to their first pick-up location, then continue to traverse the county, picking up to 4 additional passengers before heading primarily to Raleigh and Chapel Hill. These vehicles are amongst the earliest to start service at 4:00 AM in order to pick up all passengers and drop by 9:00 AM. The return trips are often not until 2:30 PM on the 600; the 601 varies depending on the trip. Generally, there is a mid-day gap where the vehicle is not performing pick-ups and drop-offs. RGP runs perform some out-of-country trips, typically to destinations just beyond the county lines. On average, 47 one-way out-of-county trips are performed daily on RGP runs. Just under half of these trips are shared trips. The average trip length is 14 miles.

Trips were analyzed to determine which city-to-city trips went out of county and would require mid-day off-site charging, which trips could deadhead back during the middle of the day to charge, and which trips were too long to complete on a single charge. Sixty-eight trips that went out of county were longer than 31 miles, which means that a BEB would have to charge before returning to the garage. It couldn’t do a round trip. Sixty-four percent were trips to or from Raleigh, and eighteen percent to Chapel Hill. Eleven trips were longer than 67 revenue miles, and I would not be able to make that one-way trip at all; all but one was to Chapel Hill or Raleigh. **Table 5** shows the city-to-city combinations that would require charging after one leg of the trip and the amount of charging time needed at a level 2 charger.

Table 6 shows the city-to-city combinations where, after dropping passengers off, the vehicle would need to deadhead to the garage to charge**. Table 7** lists the out of county trips that could not be completed due to the BEB's range.

***Table 5.** Out of County Trips Requiring Mid-Day off-site Charging*

Origin-Destination combination	Average miles per direction (including one way DH)	20% tolerance for exact P/U and Drop off location	Required Charging	Avg Number of One-way trips per day
Benson - Raleigh	50	60	5:02	2
Clayton - Raleigh	28	33.6	2:49	4
Selma - Raleigh	38	45.6	3:49	3.67
Clayton - Durham	52	62.4	5:14	1
Clayton - Holly Springs	43	51.6	4:19	0.17
Smithfield - Holly Springs	36	43.2	3:37	0.17
Clayton - Morrisville	43	51.6	4:19	0.33
Wilson - Zebulon	51	61.2	5:08	0.33
Knightdale - Garner	50	60	5:02	0.44
Willow Spring - Garner	38	45.6	3:49	1.44
Benson - Kenly	46	55.2	4:37	0.22
Micro - Wilson	56	67.2	5:38	0.22

***Table 6.** Out of County Trips the Must Deadhead to the Garage After Completing*

Origin-Destination combination	Average miles per Round-Trip (including DH)	20% tolerance for exact P/U and Drop off location	Avg Number of One-way trips per day
Benson - Angier	56	67.2	0.33
Selma - Garner	55	66	0.66
Smithfield - Garner	50	60	1

***Table 7.** Out Of County Trips That Cannot be Performed*

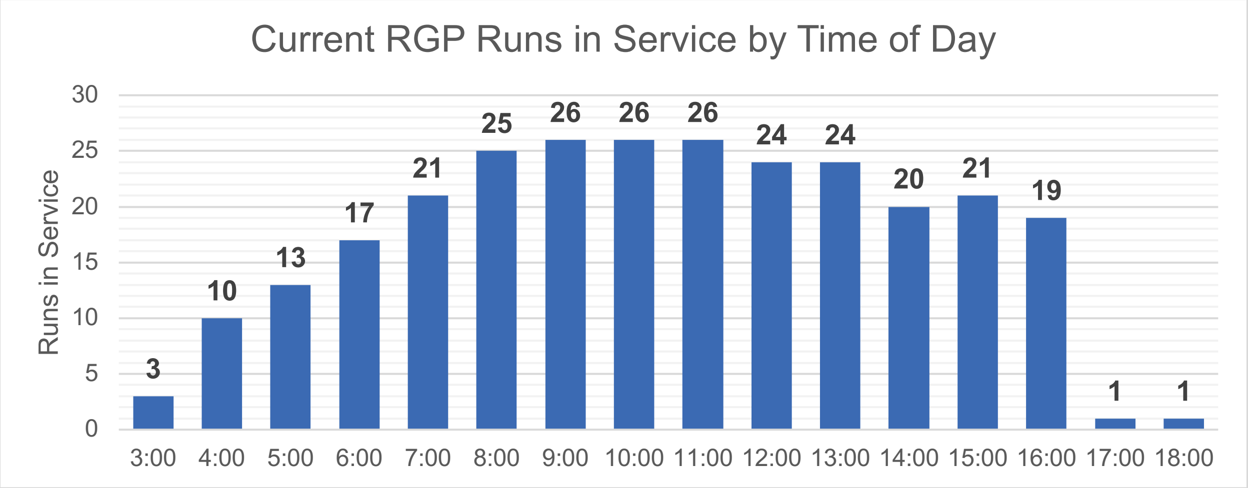
Trips they would be unable to perform
Trips to **Chapel Hill** – The one-way mileage with deadhead, is longer than what the vehicle would allow.
Trips to **Greenville** – The one-way mileage with deadhead, is longer than what the vehicle would allow.
Reverse commute trips from Raleigh into Johnston County – this would require staging a vehicle overnight in Raleigh at a location here it could charge.

Rural General Public (RGP) Routes

RGP routes transport individuals throughout Johnston County and to destinations just over the county line. Twenty-six vehicles are needed to operate this service during the peak day (Wednesday) and time (

Figure 7). Total daily mileage on a weekday ranges from 3,861 to 4,484, with an average of 3,959. Fifteen percent of the mileage is deadhead, and each run averages 21 miles of deadhead each day.

Figure 7. *Current RGP Runs in Service by Time of Day*



Daily ridership is 199 to 353 passengers per weekday, with an average of 285. Ridership is mainly proportional to the miles traveled throughout the day (Figure 8), with 11.8 miles traveled for each unique passenger carried. The average trip length per passenger is 13.6 miles. Seventy-two percent of trips are single-rider trips. Ridership is highest at 2:00 PM. Ridership is not proportional to the number of vehicles in service. Ridership declines from 11:00 AM to 2:00 PM, but the number of vehicles in service remains steady (Figure 9).

Figure 8. *RGP Hourly Ridership Compared to Mileage*

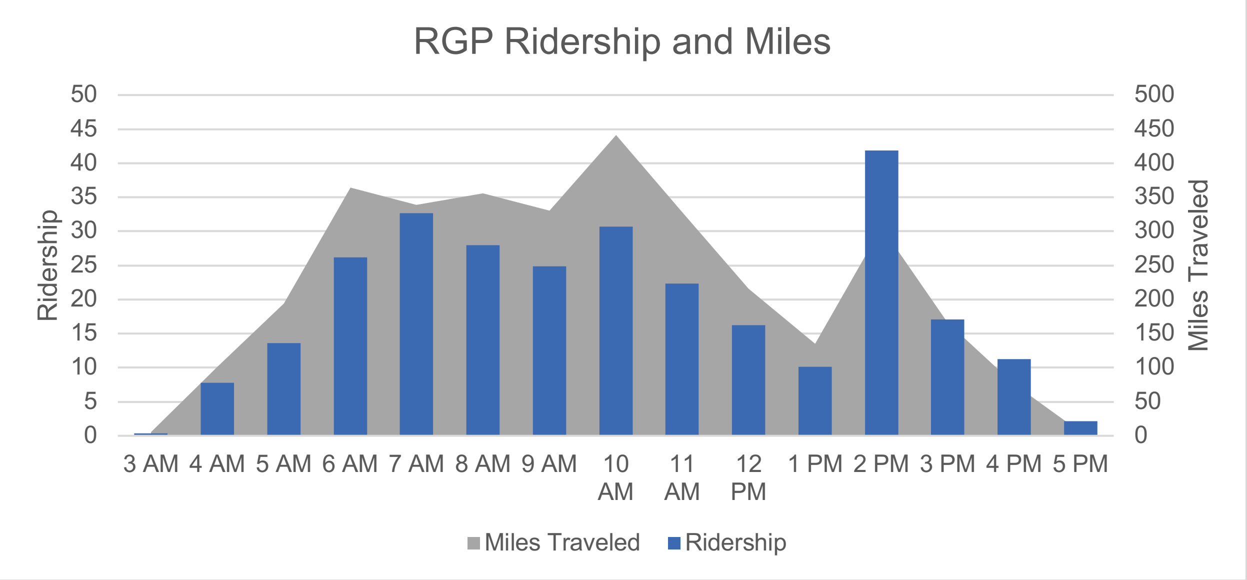
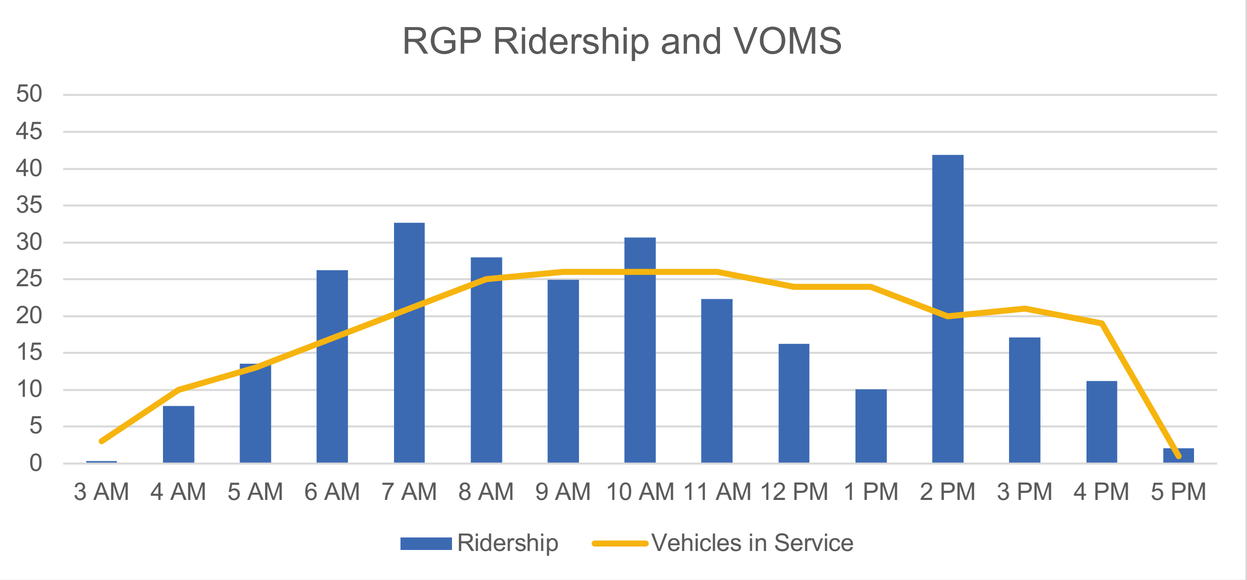


Figure 9. *RGP Hourly Ridership compared to VOMS*



Trips were analyzed to determine which city-to-city trips that stayed in Johnston County would require off-site charging, which trips could deadhead back during the middle of the day to charge, and which trips were too long to complete on a single charge. 220 trips had a passenger on board for longer than 31 miles, meaning a BEB would have to charge before returning and couldn't do a round trip.

Table 8 shows the city-to-city combinations that would require charging after one leg of the trip.

Table 9 shows the city-to-city combinations where, after dropping off its passengers, the vehicle would need to deadhead to the garage for a midday charge. Most of these trips were to or from Clayton.

Table 8. *RGP Trips Requiring Mid-Day Off-site Charging*

Origin-Destination combination	Average miles per direction (including one way DH)	20% tolerance for exact P/U and Drop off location	Required Charging
Benson - Kenly	46	55.2	4:37

Table 9. *RGP Trips the Must Deadhead to the Garage After Completing*

Origin-Destination combination	Average miles per Round-Trip (including DH)	20% tolerance for exact P/U and Drop off location	Required Charging	Avg Number of One-way trips per day
Benson - Clayton	53	63.6	5:20	10.66
Four Oaks - Clayton	40	48	4:01	13.22
Princeton - Clayton	51	61.2	5:08	5.78
Selma - Clayton	48	57.6	4:49	14.44
Smithfield - Clayton	32	38.4	3:13	28.11

BEB Vehicle and Energy Requirements

In modeling the vehicle and energy requirements that would be needed, the following assumptions were used:

- The worst-case energy consumption and mileage range were used.
- Calculations were based on the peak mileage day from the data set provided
- For those that had a maximum number of passengers on board greater than 4, it was first determined whether the vehicle had the range to do this, and if not, then it was split into two smaller capacity vehicles.

- Vehicles would only charge mid-day if they were being reused on another run later in the day. Otherwise, it was assigned to charge in the evening.
- Where possible, Level 2 mid-day charging was used. If the potential time duration for charging was insufficient with a Level 2 charger, a Level 3 charger was assigned.
- Level 2 charging assumed 204 V with a current of 60 amps, which equates to 12.24 kWh of charge gained per hour of charging.
- Level 3 charging assumed 1,000 V with a current of 60 amps, which equates to 60 kWh of charge gained per hour of charging.
- Assumes that vehicles are charged overnight and are at 100% SOC in the morning.

The following sections summarize vehicle needs, energy usage, and charging requirements. Whenever a singular charger is denoted below, this is in reference to one plug-in dispenser. Chargers may have one dispenser or multiple, as referenced in the Facilities Analysis.

JCI and Senior Clayton Routes

The JCI and senior services would require 14 vans (Table 10) across 28 runs. This is an increase of 9 vehicles from the 5 currently in use. The increase is associated with the passenger volumes, as the e450 and e350 with larger passenger capacities needed more range, resulting in the need to use multiple vans that have sufficient range but lower passenger capacities. After returning to the garage to charge for five hours, vehicles used on the morning runs would be reused in the afternoon runs. The JCI routes could use Level 2 chargers, but the Senior Clayton would require two Level 3 charges due to the shorter mid-day gap.

***Table 10.** JCI and Senior Clayton Runs Vehicle and Energy Needs*

Route	Vehicle Needs	Daily Miles	kWh Consumption
JCI Princeton	2	122	125
JCI Clayton	4	226	232
JCI Zebulon	3	215	221
JCI Benson	3	262	274
Senior Clayton	2	158	162
TOTAL	**14**	**983**	**1,014**

The mileage would increase by 63 percent, mostly due to an increase in deadhead miles from the additional vehicles. Overall energy consumption would be 1,014 kWh per day. Mid-day charging would require 486 kW of energy, and the remaining would be evening charging.

Out of County

The out-of-county runs would require 6 vans[11]. Three vans would provide service from Johnston County to Raleigh, and they would be required to charge for five hours at a Level 2 charger before returning (the time can be reduced by using a Level 3 charger). One van would provide service from Clayton to other destinations outside of the county that are not Raleigh. It would need to be charged before performing the return trip. The remaining two vehicles would provide trips from all other areas within Johnston County to destinations outside of the county. The need for mid-day, offsite charging would depend on the origin-destination combination. For analysis, it is assumed that mid-day charging would be required off-site.

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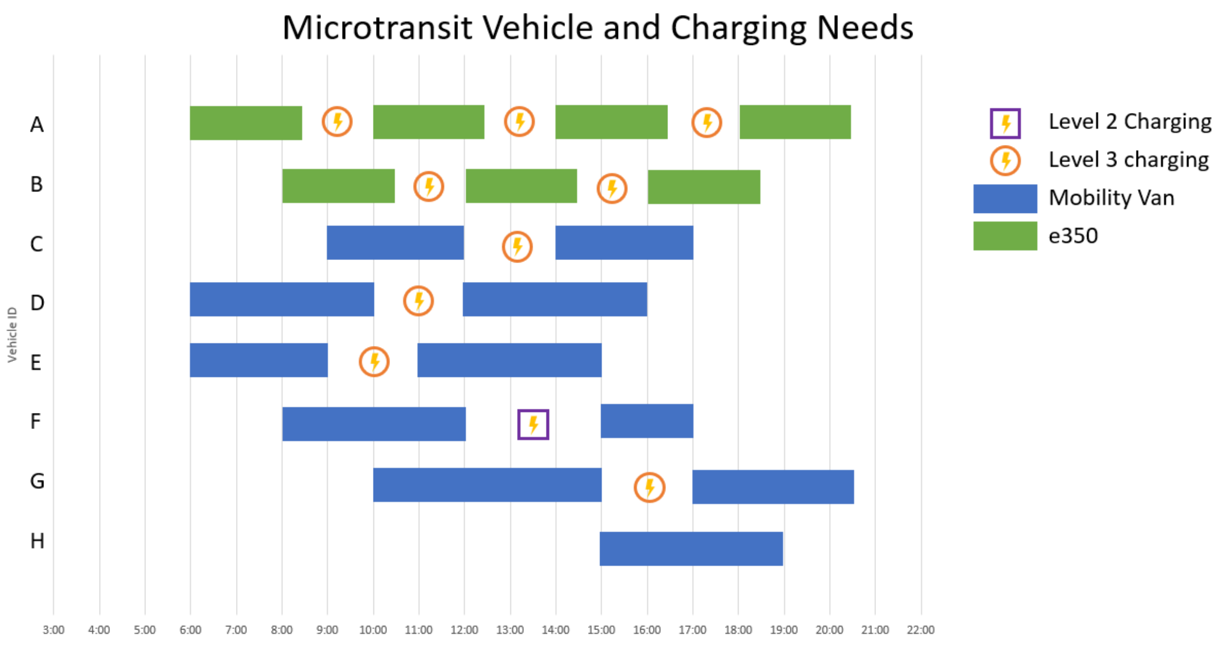
[11] It was assumed that trips which could not be completed on a single charge would no longer be performed.

Daily mileage would increase from a maximum of 449 to 688 miles, which is associated with an increase in deadhead miles from the additional vehicles and a reduction in trip sharing. Overall energy consumption would be 707 kWh per day. The peak energy demand at the facility for charging is in the evening, as the vehicles would charge off-site during the day. Six Level 2 chargers would be needed in the evening.

Quick Trip

The mircotransit service would require 6 mobility vans and two e350 cutaways. This is an increase of three vehicles from the five currently in use. The increase is associated with removing vehicles from service to charge mid-day, breaking down the schedule into eighteen runs (Figure 10). Most vehicles would require mid-day charging. The duration of each run was calculated based on exiting peak loads, miles traveled per hour, and the assigned vehicle range. It assumed that a larger e350 would always be in service to accommodate larger groups.

Figure 10. *Microtransit Blocking*

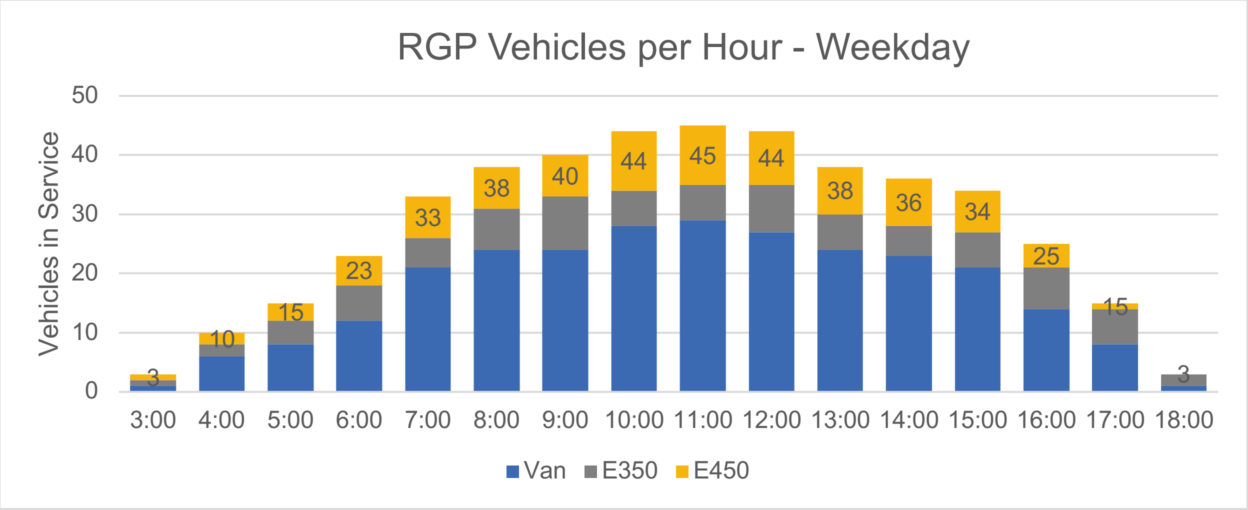


Daily mileage would increase from a maximum of 635 to 865 miles, associated with an increase in deadhead miles from the additional vehicles and runs. Overall energy consumption would be 888 kWh per day. Mid-day charging would require 448 kW of demand power; the remaining would be evening charging. The peak energy demand at the facility for charging is at 1:00 PM. Two Level 3 and six Level 2 chargers would be needed.

RGP Routes

The RGP runs would require 62 vehicles (39 mobility vans, 10 e350, 13 e450). While 62 vehicles would be needed, only 45 would be in operation at any given time (**Figure 11**). Those not in operation would be charged. Service would be broken down into 110 runs daily, with the average run lasting three hours and covering 54 miles. The duration of each run was calculated based on exiting peak loads, miles traveled per hour, and the assigned vehicle range.

Figure 11. *RGP Service Vehicles Operated per Hour of Service*



Daily mileage would increase from a max of 4,484 to 5907 miles. The 32 percent increase in miles is due to the increase in deadhead mileage to and from the garage as the number of runs increases and the duration of each decreases. Overall energy consumption would be 6,648 kWh per weekday. Ten Level 3 and 52 Level 2 chargers would be needed. The peak energy demand at the facility for charging is at 11:00 AM. This is due to Level 3 charging at the time, which would draw 383 kW.

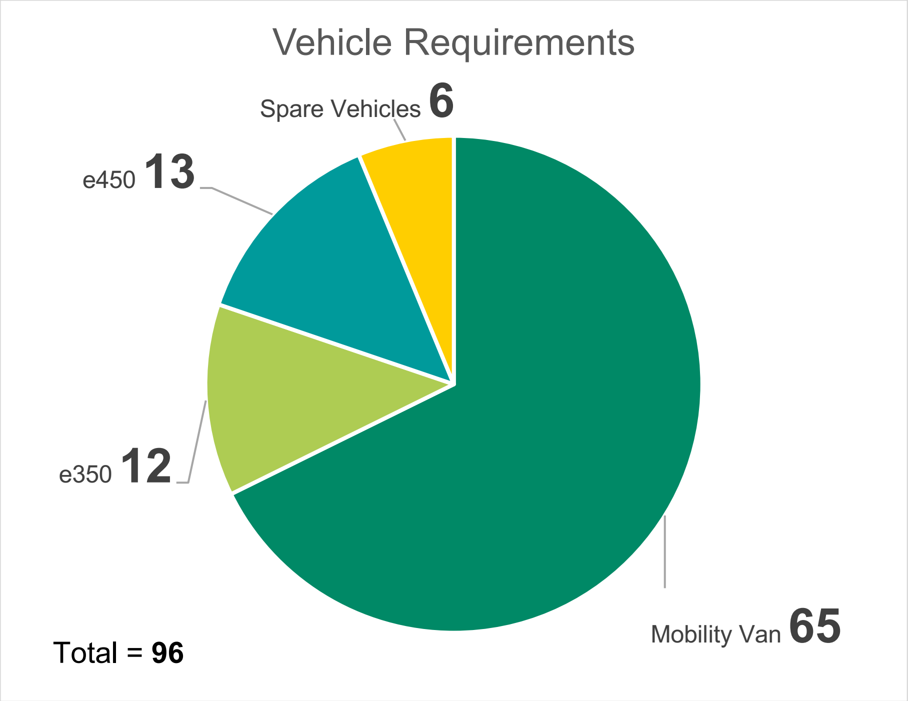
Summary Results

Systemwide, the daily miles would increase by 37 percent; this is associated with an increase in deadhead because the number of runs increases (from 51 to 162) as the average duration of a run decreases from 7:30 to 3:23. To operate the service 90 vehicles (not including spares) would be needed, without mid-day charging 162 would be needed (one per run). Currently, JCAT has a 6 percent spare ratio; using the ratio, 96 total vehicles in the fleet would be needed. Figure 12 shows the vehicle breakdown. While 90 vehicles would be needed, only 63 would operate at the peak (8:00 AM).

Table 11. *Vehicle, Mileage, and kWh Consumption Summary by Route/Service*

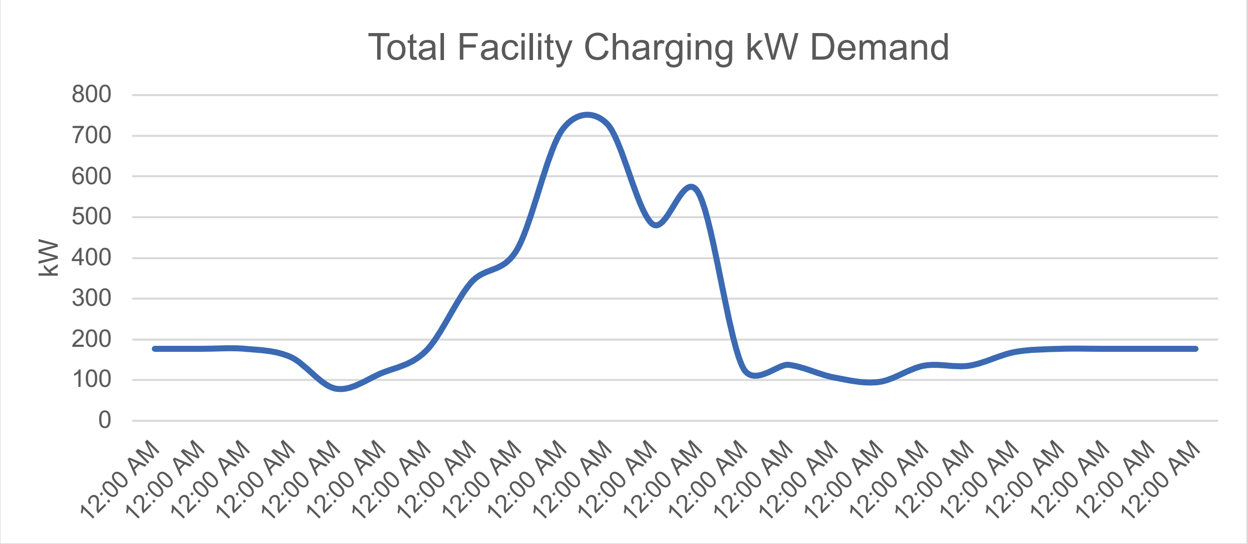
Route/Service	Vehicle Needs	Total Miles	kWh consumption	Mid-day kWh charge off-site	Mid-Day kWh Charge on-site	Evening kWh charging
JCI Princeton	2	122	126	0	63	63
JCI Clayton	4	226	233	0	115	118
JCI Zebulon	3	215	220	0	108	112
JCI Benson	3	262	275	0	130	145
Senior Clayton	2	158	162	0	70	92
Microtransit	8	865	232	0	166	66
Out of County	6	463	706	353	0	353
All Others	62	5907	6648	0	2708	3940
TOTAL	**90**	**8218**	**8476**	**353**	**3297**	**4826**

Figure 12. *Vehicle Requirements*



Daily mileage would increase from a max of 5,910 to 8,218 miles, primarily associated with an increase in deadhead miles from the additional vehicles and runs. Overall energy consumption would be 8,476 kWh per day. Mid-day facility charging would require 3,297 kWh, off-site charging 353 kWh, and the remaining 4,826 kWh would be evening charging. The peak energy demand at the facility for charging is at 11:00 AM for 729 kW (**Figure 13**). Seventy-seven percent (77%) of the mid-day charging is from fast charging on the RGP runs. Since service primarily ends by 5:30 PM and vehicles are off the road and available to charge for 10-12 hours overnight, evening charging can be spread out, reducing the peak evening demand.

Figure 13. *Total Facility kW Demands by Hour*



Fleet Transition Projection

At present, JCATS does not have any electric buses. However, it was recently awarded five Ford E-Transit Vans, a similar model to the mobility vans described in the previous section, through a Carbon Reduction Program (CRP) grant. The agency is also applying for two additional Ford E-Transit Vans through the FY24 Low-No Emission grant program. All these vehicles would be additions to their existing fleet.

One requirement of an FTA transition plan is to demonstrate how the agency will reach a 100 percent zero-emission fleet. Figure 10 shows JCAT's potential fleet transition through 2035 when all buses are anticipated to be electric. It is worth noting that this chart shows one potential scenario, and the plan implementation will likely be different in the future. We anticipate that the anticipated number of vehicles required to provide service will decrease as BEB technology improves. As such, we scheduled the replacement of the larger vehicle until later in the transition.

Figure 14: BEB Fleet Transition Schedule

Year	Mobility Van	E350	E450	Cumulative Total
2024	7			5
2025	6			7
2026	6			14
2027	6			21
2028	6	1		29
2029	6	1	2	39
2030	6	3		49
2031	6		3	59
2032	7	3		69
2033	7		4	80
2034	7	4		91
2035	7		4	102

Facility Analysis

This section analyzes the suitability of the JCATS facility to support a transition to BEBs. JCATS operates and maintains its transit fleet from the agency-owned Administration Building, located at 1050 W Noble Street, Selma, NC 27576. The site was reviewed for existing configuration, current operational on-site vehicle flow, cutaway bus parking configuration, and existing electrical service. JCATS's goal of eventually replacing the existing carbon-based fleet with BEBs is anticipated to be implemented as incoming buses are replaced. In preparation for this transition, existing operational site flow and parking configurations must be identified and reviewed as compatible with the selected BEB charging technology. As introduced in "Overview of Electric Bus Technology" above, multiple BEB charging options/equipment configurations exist. Future charging technology should be compatible with the existing facility and the current daily service circulation of buses.

JCATS Site

The JCATs site is a standalone purpose-built transit operations and maintenance facility with dedicated parking outside the facility. The facility houses Administrative, operations, and bus maintenance. The vehicles are parked outside (Figure 15), and the vehicle wash area is a covered exterior bay adjacent to the bus parking. Current fueling operations are done offline with no existing ability to do so onsite. There is a capacity to park over 90 vehicles inside of the gate-protected vehicle parking area. The site currently hosts six level 2 electric vehicle charging stations with plans to add up to five more level 3 chargers.

The Administrative/operations building has concrete block walls and a pre-engineered steel structure supporting a corrugated metal deck roof, which is a shallow-sloped roof with a high point at the mid-span of the enclosure. There are six maintenance bays which are separated from the operations/administration offices and by CMU walls.

Figure 15. *Existing Bus Parking*


Figure 16. Maintenance area


Figure 17. Existing electrical level 2 chargers

Existing Bus Circulation

At the end of the daily shift, JCATS vehicles enter the site from W Noble Street, make their deposits at a “cash-out” alongside the North wall of the building, and then proceed to the washing bay. (Figure 18) After the exterior wash is completed, the bus operators leave the enclosed bus wash bay and circulate along the Northeastern edge of the site to park.

Figure 18. Vehicle Wash Area

The bus operators then make a 90 degree turn to enter the designated position within the parking area. In the morning, the buses pull out through the North wall of the building and exit to W Noble Street Road to begin daily transit service. (Figure 19) displays the bus circulation as it occurs at the site.

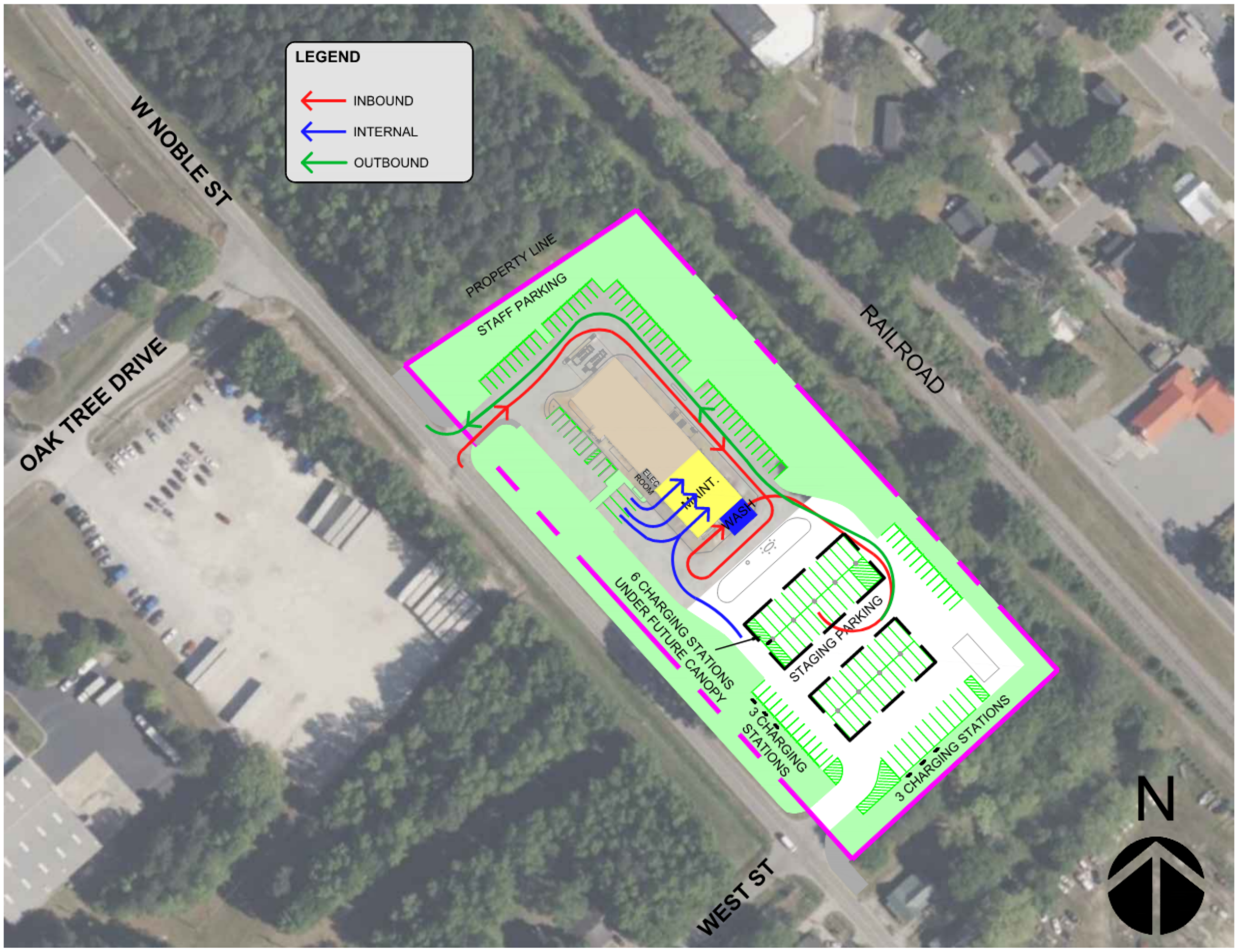


Figure 19. *Existing JCATS Site and Bus Circulation Plan*

Bus Charger Opportunities

The bus parking area has adequate parking distance from other vehicles, and a planned solar canopy over on row of parking should consider all the vehicle's heights to properly mount electrical feeds on the underside of the canopy structure to accommodate drop-down reel or retracted plug-in cord. The bus parking track widths are nominally 14 feet wide and would physically fit a remote ground-mounted, plug-in dispenser. It is recommended to avoid placing charging equipment and dispensers in the path of travel of the buses unless an overhead dispenser (plug-in cord) is not viable. As shown in Figure 20, the potential BEB parking plan allows JCATS to keep the exact site and vehicle flow that is utilized now with a drop-down plug-in cord. We prefer the drop-down overhead plugs because there are fewer opportunities for accidental contact from someone passing by the charging vehicle over ground-level cables, which can pose tripping hazards. A new 480-volt (v), three-phase transformer, and new 480 v, three-phase switchboard would be needed to energize a Level 3 charger in the 60 kW to 180 kW range. There is ample room in on-site grass areas to locate a new utility transformer. Because of the available space on-site, there are multiple viable options to install charging service and equipment. The approach shown on Figure 20 is for new feeder lines to be installed from a new utility-provided transformer that would likely be trenched or bored across the existing circulation pavement. Feeders on the canopy would be under-mounted and hang down. The new switchboard would have capacity to energize one to eight+, 150 kW nominal chargers. Each charger cabinet would be used to energize two dispensers each. Space can be consolidated by placing the charger cabinets on a new raised concrete pad both on grass areas and under the canopy. Basis of design for this proposed service is the ABB HVC-D4 which is a 200kW charger that can be subdivided to support 4 connected dispensers at 50kW's simultaneously (concurrent) or 200kW per individual dispenser one at a time (sequential).

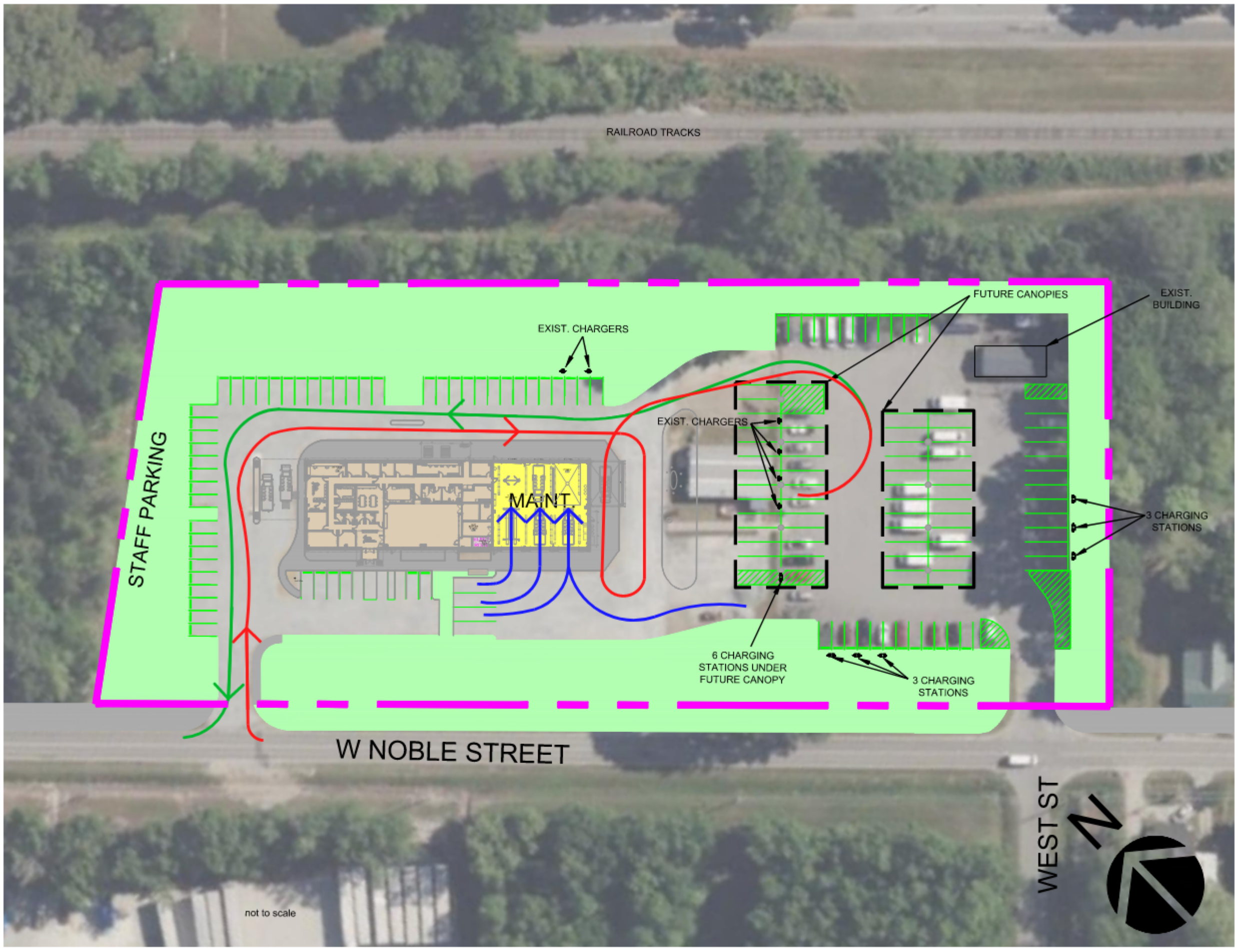


Figure 20. BEB Concept Master Plan

Due to the disruptive nature of construction at a transit facility, it is recommended that any facility modifications required for a full fleet transition, such as running conduit, laying concrete pads, upgrading switchboards, provisioning space for future chargers, etc., be designed and implemented during the initial deployment of the BEBs. This approach will allow the agency to quickly and easily add future BEBs and chargers to the fleet without modifying the overall site configuration multiple times.

Due to the potential for cold weather and precipitation, the project should plan for resiliency, raising and or covering the expensive equipment from potential weather damage. Given that the bus parking area is not enclosed, the location of the bus charging port (front of the bus for the pantograph and rear of the bus for the plug-in) would be fine as either charging setup could be accommodated. It is recommended that any DC charging and communication wiring from charger to dispenser be done in cable tray / wireway systems instead of being enclosed in conduit. Such an approach would allow easier reconfiguration of dispensers, if needed, and would also better accommodate the replacement or upgrading of the charging equipment multiple times in the remaining life of this site.

No charging is needed in the maintenance bays, as buses will typically complete their long-term charging in a parking position instead of taking up a maintenance bay. If desired and achievable during the detailed design of the chargers, a remote charging dispenser can be added to the maintenance bays. One drop-down plug between the two non-pit bays could supply both bays with charging power. Consider this would have to involve retrofitting power supplies through the existing building enclosure since the existing building panel possibly has no amperage headroom to provide such service.

4. Utility Coordination

Utility rates for electric fleet users are usually far more complex than for residential or small power users. Electricity will eventually replace diesel as the primary energy cost, so understanding how it is priced can help cut costs.

Energy, Demand, and Fixed Charges

Large utility tariffs usually have three major components and a variety of smaller riders or variables:

- The first is energy, (kWh) (power over time); this is the method for charging consumers for energy used.
- The second is demand (kW), which is the peak instantaneous power used, usually over a month. JCAT's power provider, the Town of Selma, automatically assigns any agency using 100kw or higher to a tariff plan that includes demand charges. JCATs will easily surpass this threshold with 2 vehicles simultaneously charging on level 3 chargers.
- Third, there is a fixed monthly rate for the connection. This fixed rate is typically small and covers the administrative overhead of reading the meter and invoicing.
- Additional smaller fees or adjustments are also applied, but demand and energy are the cost drivers so we will explore these in a little more detail.

Energy Charges (kWh)

The Town of Selma levies energy charges per kWh, which are the components of the bill people are familiar with paying privately at home. The best way to control these costs is operate the vehicles as efficiency as possible to keep the total energy needed to the run the vehicles as low as possible. Inefficient driving not only reduces the range of the vehicle but will cost will increase operating costs similar to fossil fuel vehicle.

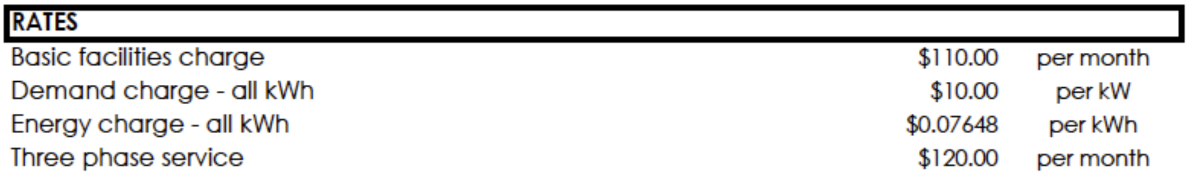
Demand Charges (kW)

Demand charges are based on the highest power in kW (kilowatts) drawn at any time over a given period. The utility meter measures and averages the maximum power "demanded" from the grid over a 15-minute window. The demand charge is then set to that maximum for the full billing period, even if it only occurs once! To prevent its large power customers from taxing the grid during times of peak use, utility companies often levy charges during "on-peak" times to incentivize energy users to only "demand" high power during times with lower overall power demand. The Town of Selma does not have published peak and off-peak times and levies a consistent demand rate for most of their tariffs across all times of day. However, they do have one rate structure that utilizes "coincident peak" in a similar manner.

Utility Rate Considerations

The Town of Selma currently has the following electrical rates for its Large General Service, which applies to users requiring more than 100 kW but less than 1000kW in demand:

Figure 21: Large General Service Rate Structure



RATES		
Basic facilities charge	$110.00	per month
Demand charge - all kWh	$10.00	per kW
Energy charge - all kWh	$0.07648	per kWh
Three phase service	$120.00	per month

Utilizing some of our assumptions from the BEB Vehicle and Energy Requirements section of this report on page 22, we can estimate potential electrical costs for charging vehicles at the JCATS facility. Our exercise below assumes 30 days of weekday service, but the actual number will be lower due to reduced weekend miles and increased energy efficiency of vehicles over the life of the transition. Table 12 illustrates a rough cost per mile across all vehicle types, which is lower than the average cost for demand response vehicle energy/fuel.

Table 12: Energy Cost per Mile for JCATS Chargers

Charge	Cost	Unit	Quantity	Costs	Monthly Miles	Cost per mile
Basic facilities charge	$110.00	per month	1	$110.00		
Three phase service	$120.00	per month	1	$120.00		
Demand charge	$10.00	per kW	729	$7,290.00		
Energy charge	$0.07648	per kWh	254,280	$19,447.33		
			Subtotal	$26,967.33		
			7% NC Tax	$1,887.71		
			Total	**$28,855.05**	239,610	**$0.12**

JCATs is currently in the process of installing solar panels at its facility. The Town offers a credit of $.066 per kWh for all generated power, which will help reduce the agency's energy charge some of these costs. However, the benefit of solar panels extends beyond this credit. This power generation will also reduce the amount of demand chargers place on the power grid. Considering that we have modeled high demand time in the late morning/early afternoon when solar panels are most productive, JCATS may also reduce its demand charges with this clean energy investment.

As previously mentioned, the Town of Selma has a rate structure incorporating "coincident peak" times to help control the town's overall energy demand from its large users. As the fleet size grows, it will be important to stay in communication with the energy department to understand when it may be beneficial to switch to this rate structure. Utility tariffs change biannually, so it is also crucial to keep in touch with the town energy representative throughout this process to ensure you understand how these changes would affect your electric bill.

Coordination With the Utility

The Town of Selma has been engaged and prepared to assist JCATS with the transition of its buses to zero-emission technology. The utility has been involved with the agency's installation of vehicle chargers and solar panels to provide clean power for these vehicles. They do not have concerns with supplying adequate power over the length of this transition. JCATS will work closely with the Town of Selma to coordinate future energy needs as its zero-emission fleet grows to ensure power is available to operate its electric fleet.

5. Resource Availability

Funding Availability

BEBs and their associated infrastructure would require additional funding beyond that which is usually available for transit vehicle acquisition due to the additional costs associated with the technology and the facility changes. The table below outlines cost estimates for the BEB, charging infrastructure, and design work.

Table 13. *Estimated Project Costs*

Project	Estimate Metrics	Cost Estimate	Source
Ford E-Sprinter (Mobility Van)	Base vehicle cost	$104,500	NCDOT Statewide Contract 54-SG-05062022
Electric Cutaway (E350)	Base vehicle cost	$310,002	State of Washington Transit Buses Contract
Electric Cutaway (E450)	Base vehicle cost	$310,002	State of Washington Transit Buses Contract
Infrastructure Design	Infrastructure planning and design	$200K per project	Engineer's estimate
Power upgrade projects	Design, construction & equipment	Variable ($200K–$400K) per project depending on capacity added	Engineer's estimate; includes 20% contingency.
Charging installation projects	Charging equipment & installation	$177K per 150 kW charger	State of Washington Transit Buses Contract, includes 20% contingency

Some of the programs that could provide such funding are described below.

2024 Low-No Grant

At present, JCATS is developing a Low-No Grant application for two E-Sprinters and two Level 3 chargers. As it continues the transition to a zero-emission fleet, JCATS will likely use this annual grant program as the primary funding source for both the vehicles and the infrastructure needed to reach its goals.

Buses and Bus Facilities Competitive Program

The Grants for Buses and Bus Facilities Competitive Program makes federal resources available to agencies like JCATS to replace, rehabilitate, and purchase buses and related equipment and to construct bus-related facilities, including technological changes or innovations to modify low- or no emission- vehicles or facilities. Funding is provided through formula allocations and competitive grants.

RAISE Grant

The Rebuilding American Infrastructure with Sustainability and Equity (RAISE) discretionary grant program helps project sponsors at the state and local levels, complete critical freight, and passenger transportation infrastructure projects. The eligibility requirements of RAISE allow project sponsors to obtain funding for projects that are harder to support through other U.S. DOT grant programs, however, many agencies have been successful in utilizing this program to advance their zero emission fleet programs.

Urbanized Area Formula Grants

JCATS receives an annual allocation of formulaic grant funds from the FTA known as 5307 funds for transit capital and operating assistance and transportation-related planning. Helping the agency transition to zero-emission vehicles is an eligible expense under this grant.

State and Local Funds

Almost all federal grants require non-federal, matching resources to receive funding. JCATS has historically split the non-federal funds requirement with local and state funds.

6. Workforce Development and Training

JCATs maintains its buses with a working Maintenance Supervisor with Automotive Service Excellence (ASE) A6 certifications, demonstrating proficiency with automotive electrical/electronic systems. The Maintenance Supervisor also has training in high-voltage electrical systems. His understanding of bus electric systems will continue to mature with the agency's delivery of its initial electric E-Sprinters. With its delivery, the supervisor will receive training on both the vehicles and associated chargers from their respective suppliers.

JCATS will utilize training materials from their electric vehicle purchases to train bus operators on the differences between a gas-powered vehicle and a BEB, including any driving changes needed to ensure that the battery is utilized efficiently, as well as other considerations needed to operate BEBs safely. Operators will also receive safety training on the plug-in chargers and their dispensers. These changes will be folded into the organization's training program to ensure that all new operators are sufficiently educated for the safe operation of BEBs.

Safety is of paramount importance. To support the safe operation and maintenance of BEBs, JCATS plans to purchase the additional personal protective equipment (PPE), tools, and equipment that the supervisor will need based on OEM recommendations. JCATS will also provide training to local first responders to help mitigate risks in case of a safety event affecting a BEB in the future.

JCATS will communicate with its frontline workers to determine if they need additional training as they attain experience with the equipment. By empowering the current workforce to maintain this new equipment, JCATS plans to retain its existing staff and does not expect to displace any of its employees because it is transitioning to zero-emission buses. Should vacancies arise in the future, JCATS will work with local trades and education centers to identify equitable workforce recruitment activities that will support the development of quality employment opportunities, particularly in disadvantaged communities in the area.

7. Conclusion

JCATS is well-positioned to begin incorporating battery electric buses into its fleet. Many of its existing runs can be accomplished with today's BEB technology and this will only increase with vehicle efficiency improvements throughout the transition. Its facility already has electric vehicle charges to support its initial deployments and has the space is to accommodate additional infrastructure to support a 100% BEB fleet.

Updates to the Transition Plan

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

Appendix 1: NCDOT ZEV Plan Glossary

Glossary

Zero Emission Vehicle ('ZEV')	Includes both fully electric plug-in as well as plug-in-hybrid electric vehicles (see definitions below); other forms of zero emissions vehicle will be considered as technology becomes more widespread and readily adopted
Electric Vehicle ('BEV')	A vehicle powered solely through a battery and electric powertrain that is capable of highway speeds (i.e., not golf carts or personal recreational vehicles)
Plug-in-Hybrid Vehicle ('PHEV')	A vehicle that combines a conventional gasoline powered engine with a battery that can be recharged allowing it to operate as an electric vehicle
Greenhouse Gas ('GHG')	A gas that contributes to the "greenhouse effect" through the absorption and emission of radiant energy in the thermal infrared range
Alternative Fuel Vehicle ('AFV')	Includes any vehicle fueled with an input other than gasoline or diesel
Original Equipment Manufacturer ('OEM')	A company that produces parts and equipment that may be marketed by another manufacturer (e.g., brake pads installed in a car)
Internal Combustion Engine ('ICE')	An engine that fuels a vehicle via combustion of a power source, using inputs such as gasoline, diesel, biofuels, propane or natural gas
DC Fast Charge ('DCFC')	Direct current fast charging stations offer significantly faster charging time compared to Level 1 or Level 2 charging stations. DC fast charging output is available at 50, 150 or 350 kilowatts