

# HATS Battery Electric Vehicle Transportation Facility Electrification Transition Plan

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HATS Electrification Transition Plan

Prepared by the Center for Transportation and the Environment  
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# Executive Summary

North Carolina Department of Transportation (NCDOT) engaged the Center for Transportation and the Environment (CTE) to perform a zero-emission vehicle (ZEV) transition study for two of their agencies – AppalCART and Hoke Area Transit Service (HATS). This report will focus on the HATS agency. NCDOT Integrated Mobility Division (IMD)’s goal is to gradually transition 100% of their state-funded public transit fleet to zero emission by 2050. The results of this study will inform NCDOT and HATS staff of the estimated costs, benefits, constraints, and risks of the transition to a zero-emission fleet and will guide future planning and decision-making.

## Transition Plan Overview

**ZEV Fleet Transition Milestone Goals:** The milestone goals in **Table ES 1** were set in accordance with North Carolina Governor’s [Executive Order 246 \(EO 246\)](#), which outlines expectations for ZEV adoption. NCDOT included these goals in a Zero-Emission Fleet Transition Plan that the Institution for Transportation Research and Education (ITRE) developed for NCDOT to meet an FTA requirement under the Bipartisan Infrastructure Law. This schedule is based on a 250,000 mileage or 10-year replacement parameter for a light duty transit vehicle, also known as a chassis cab or cutaway.

*Table ES 1. IMD Goal: ZEB Purchase Percentage Requirements*

Starting January 1	ZEV Percentage of Total New Bus Purchases for Small Transit Agencies
2025	5%
2030	50%
2040	75%
2050	100%

**HATS’ Fleet Composition:** HATS operates an all-ICE fleet comprised of two (2) minivans, four (4) full size vans, and fifteen (15) 20-28’ cutaways, all fueled by gasoline. All vehicles are housed at a single facility, located at 316 S Magnolia St, Raeford, North Carolina. This transition plan only considers HATS’ fifteen (15) cutaways.

**Services Provided:** HATS mainly provides inter-county service trips scheduled through Dial-A-Ride for the residents of Hoke County, North Carolina.

**ZEV Fleet Transition by 2050:** Based on this study, in order for HATS to successfully transition to a fully zero-emission fleet by 2050, it will be necessary for the agency to expand their current fleet of 15 ICE vehicles to a fleet of 23 depot-charged battery electric cutaways. Current battery electric cutaway technology does not have the capacity to complete HATS’ current fixed-route services and midday charging is not feasible for HATS to incorporate given the nature of the inter-county service trips they provide; therefore, fleet expansion will be necessary. In the initial deployment of zero-emission vehicles, it may be possible for HATS to allocate battery electric cutaways on its AM/PM

service that would allow a limited amount of mid-day charging although, as noted in the Fuel Assessment, this may lead to higher utility rate charges in the short-term.

**ZEV Propulsion Type:** Although HATS' current fleet is comprised of cutaways, minivans and full-size vans, this plan only expounds on the transition to battery electric cutaways due to the limited technology available today for battery electric minivans and full-size vans. In addition, this study was limited to battery-electric vehicles because hydrogen fuel cell cutaways are currently not available in the market and would be less financially feasible considering the high costs of hydrogen fuel today.

### Battery Electric Vehicle Investment and Total Cost of Ownership

As a result of the analysis described in this report, HATS can feasibly convert their current ICE fleet to a 100% BEV fleet by 2050. To achieve this goal, it will be necessary to invest an additional \$18.4 million in capital for BEVs and subsequent charging infrastructure as compared to what HATS may have invested in ICE vehicles over the same time period. The breakdown of this investment is shown in **Table ES 2**.

*Table ES 2. HATS Capital Investment to transition to a 100% BEV fleet by 2050*

	Transition	Baseline	Total Cost Difference
<b>Fleet</b>	\$24,690,000	\$5,900,000	\$18,780,000
<b>Infrastructure</b>	\$2,230,000	N/A	\$2,230,000
<b>Fuel</b>	\$5,260,000	\$7,470,000	-\$2,210,000
<b>Maintenance</b>	\$2,210,000	\$2,600,000	-\$390,000
<b>Total Cost of Ownership</b>	\$34,380,000	\$15,970,000	\$18,410,000

**Total Cost of Ownership:** The total capital investment over the entire transition period will be approximately \$34.4 million as compared to the baseline cost of roughly \$16 million that would have been incurred by a fully ICE fleet over that same period. These cost estimates include an inflationary rate of 3% per year.

### Challenges and Mitigation Strategies

In an effort to decarbonize the transportation sector and provide direct air quality benefits to communities, transit agencies in the United States are increasingly deploying ZEVs that would include BEVs and fuel cell electric vehicles (FCEVs). ZEVs are an attractive alternative to ICE vehicles because they are cleaner, quieter, and more efficient. However, there is not a one-size-fits all solution for ZEV deployment and agencies should plan accordingly to overcome challenges that may arise over the transition period. The following items are highlighted for HATS' consideration as they work to mitigate issues that may arise due to transitioning to ZEVs:

**Understanding Factors that Impact BEV Range:** BEV energy efficiency and range are impacted by ambient air temperatures, driving style, route conditions, vehicle weight, and battery age. HATS should ensure they are well versed in how range is affected to ensure they are scheduling ZEVs on the most effective routes.

**Vehicle Operators:** By expanding their fleet from 15 ICE vehicles to 23 BEVs, it will be necessary for HATS to hire additional drivers in order to successfully operate their entire fleet.

**Workforce Training:** As HATS introduces its first battery electric vehicles in its fleet, it will need to implement workforce training to ensure their employees have the knowledge required to operate and maintain zero emission assets and infrastructure, including vehicles, chargers, and electrical subcomponents as technology evolves.

HATS is currently developing an FTA Low or No Emission Vehicle Program grant application for the purchase of two EVT vehicles (one to replace an ICE vehicle and one for expansion as outlined in their transition plan needs), as well as two (2) depot chargers for their facility. If awarded, HATS will provide frontline workforce training on the operations and maintenance of the vehicles and related infrastructure. The training program is aimed at retention of existing staff and recruitment of new staff, while supporting professional development opportunities of the agency.

**Utility Partnerships:** As part of HATS' Transition Plan development, CTE worked with Duke Energy Progress, HATS' local utility provider, to obtain rate schedules, prior utility bills, and critical peak, peak, and off-peak demand periods that would allow HATS to determine when to charge electric vehicles most efficiently. As noted in the Fuel Assessment section of this Plan, the facility has service capacity to meet the transition needs, but the most cost effective rate is evening charges. HATS will continue coordination with the local utility in an effort to optimize charge schedules and plan for any necessary changes as they approach charging loads that may impact operating costs.

#### Recommendations

**Initial Costs, Upgrades, and More:** To successfully transition to a fully ZEV fleet by 2050, this plan projects that HATS will purchase their first BEV in 2023, and add more to their fleet each year after. Starting the planning process early for their first BEV purchases, including costs for vehicles and supporting equipment, infrastructure upgrades, and utility coordination will allow for an easier transition overall.

**Consistent Updates to ZEV Transition Plan:** CTE recommends revisiting assumptions, requirements, and goals documented in this plan every two years or as needed when changes occur.

# Introduction

## Project Overview

### HATS Goals and Alignment with Electrification

Widespread adoption of zero-emission vehicle technology has the potential to significantly reduce greenhouse gas (GHG) emissions resulting from the transportation sector. The North Carolina Department of Transportation (NCDOT) is committed to implementing environmentally-friendly policies and reducing its carbon footprint; therefore, NCDOT has set the goal of reaching full fleet electrification by the year 2050.

### Funding

The Federal Transit Administration (FTA) administers a grant program known as HOPE (Helping Obtain Prosperity for Everyone) to develop plans that improve transit services or facilities in areas of persistent poverty. On October 7th, 2020, the [FTA awarded](#) the North Carolina Department of Transportation \$122,048 in funding to work with two transit systems, one near Boone, NC and one in rural eastern NC, to plan to deploy zero-emission buses. The plans will provide the basis for other rural agencies in the state to draft transition plans for new-technology buses, allowing them to benefit from economic benefits, such as lower fuel and maintenance costs. This project will help NCDOT enter the BEV market and begin to evaluate the technology and the operation of an electric vehicle within an agency's service areas. Furthermore, this final project report will determine the impact on operations and capital programs as an agency transitions to an all-electric fleet by 2050.

The initial cost of zero-emission vehicles, as well as deploying charging infrastructure and providing workforce training to effectively operate and maintain them, will require increased funding beyond what is typically programmed for ICE fleet replacement programs. HATS realizes that alternative funding sources will be necessary to implement zero emission deployments and meet the transition milestone goals established herein. Programs such as the FTA's Low or No Emission Vehicle and Buses and Bus Facilities discretionary grant programs provide opportunities to close these funding gaps. HATS is currently developing a FY2023 discretionary grant application to replace one (1) ICE vehicle with an electric LTV, purchase an expansion electric LTV, and install two (2) depot chargers at its facility.

As their transition continues, the agency will look to additional federal sources such as the USDOT Rebuilding American Infrastructure with Sustainability and Equity (RAISE) program, the USDOT Rural Surface Transportation program, and/or the USEPA Diesel Emission Reduction Act (DERA) program for eligible projects to support investment in zero emission fleets and infrastructure. In conjunction, the agency will plan for potential local match needs and assess availability of any potential state revenue sources to leverage federal discretionary grant programs.

## Project Partners

### *North Carolina Department of Transportation (NCDOT)*

The North Carolina Department of Transportation (NCDOT) executed a contract with CTE to prepare a ZEV Transition Plan for two transit agencies in the state. NCDOT is one of the largest state agencies in North Carolina and is responsible for all means of transportation in the state, including highways, aviation, public transit, and more. NCDOT's mission is "Connecting people, products and places safely and efficiently with customer focus, accountability and environmental sensitivity to enhance the economy and vitality of North Carolina."<sup>1</sup>

Joining NCDOT in this project are two North Carolina transit agencies, AppalCART, which operates in Boone, Watauga County, and Hoke Area Transit Service (HATS), which operates in Raeford, Hoke County.

### *AppalCART*

AppalCART is Watauga County's Public Transportation Authority. They are "committed to keeping the High Country moving." Services began as Appalachian Campus Area Rapid Transit, and thus, it became AppalCART. Initial services began in 1980, but AppalCART became the official and first bus transit system for Boone, North Carolina in 1981. AppalCART's mission is to provide sustainable, high-quality transportation services.<sup>2</sup>

### *Hoke Area Transit Service (HATS)*

Hoke Area Transit Service (HATS) is a county-operated public transportation system designed and operated to provide door-to-door transportation to the portion of the population for which transportation or mobility is a problem. The fleet is comprised of many vehicles, from standard minivans to 28' buses, and most are equipped with wheelchair lifts. HATS regularly transports passengers to and from doctor's offices, dialysis, pharmacies, work, school, senior citizen nutrition sites, day cares, grocery stores, department stores and much more by appointment only. HATS' mission is to provide safe and dependable transportation to the Hoke County Community and the agency is committed to ensuring that no person is excluded from participating in the benefits of the transit services they offer.<sup>3</sup>

### *Center for Transportation and the Environment (CTE)*

The [Center for Transportation and the Environment \(CTE\)](https://www.cte.org/) is a nonprofit, 501(c)(3) organization that develops technologies and implements solutions to achieve energy and environmental sustainability. CTE is a national leader in providing technical assistance for ZEV deployments, guiding transit agencies through battery electric and fuel cell electric vehicle deployment projects while minimizing project risks.

This report serves as the zero emission fleet transition plan for HATS, but will be revised as technologies, funding sources, and progress on meeting the milestones outlined herein are achieved.

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<sup>1</sup> <https://www.ncdot.gov/about-us/our-mission/Pages/default.aspx>.

<sup>2</sup> Background information taken from AppalCART's website at <https://www.appalcart.com/who-we-are>.

<sup>3</sup> Background information taken from HATS' website at <https://www.hokecounty.net/158/Hoke-Area-Transit-Service-HATS>.

## Project Management

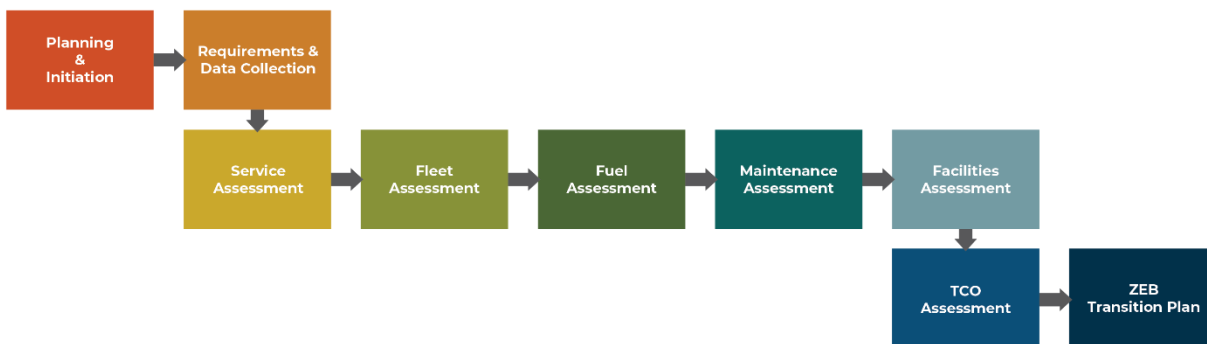
CTE provided project management services in conjunction with the NCDOT Integrated Mobility Division (IMD). Project management by IMD was led by the Deputy Director for Innovations and Data, Sarah Searcy. See Methodology Section and **Figure 1** below for further details.

# Transition Planning

## Methodology

This study uses CTE's ZEB Transition Planning Methodology, which is a complete set of analyses used to inform agencies converting their fleets to zero-emission technology. The methodology consists of data collection and analysis, and assessment stages; these stages are sequential and build upon findings in previous steps. The work steps specific to this study are outlined below:

1. Planning & Initiation
2. Requirements & Data Collection
3. Service Assessment
4. Fleet Assessment
5. Fuel Assessment
6. Maintenance Assessment
7. Facilities Assessment
8. Total Cost of Ownership Assessment



*Figure 1. CTE's ZEB Transition Study Methodology*

The **Planning & Initiation** phase builds the administrative framework for the transition study. During this phase, the project team drafted the scope, approach, tasks, assignments, and timeline for the project. CTE worked with NCDOT staff to plan the overall project scope and all deliverables throughout study timeline.

For the **Requirements Analysis & Data Collection**, CTE collects data on the agency's fleet, routes and blocks, operational data, like mileage and fuel consumption, and maintenance costs. Using this data, CTE establishes requirements for the planned zero-emission fleet to drive analyses in the later assessments.

The **Service Assessment** phase initiates the technical analysis of the study. Using information collected in the Data Collection phase, CTE evaluates the feasibility of a zero-emission fleet over the study timeframe. Results from the Service Assessment are used to guide ZEV procurements in the Fleet Assessment and to determine energy requirements in the Fuel Assessment.

The **Fleet Assessment** develops a projected timeline for replacement of current vehicles with ZEVs that is consistent with the agency's fleet replacement plan. This assessment also includes a projection of fleet capital cost over the transition timeframe and is optimized with regard to state mandates or agency goals, such as minimizing cost or maximizing service levels.

The **Fuel Assessment** merges the results of the Service Assessment and Fleet Assessment to determine annual fuel requirements and associated costs. The Fuel Assessment calculates energy costs through the transition timeframe, including the agency's current fossil fuel vehicles. To more accurately estimate BEV charging costs, a focused Charging Analysis is performed to simulate daily system-wide charging use. As current technologies are phased out in later years of the transition, the Fuel Assessment calculates the increasing energy requirements for ZEVs. The Fuel Assessment also provides a total energy cost over the transition lifetime.

The **Facilities Assessment** determines the necessary infrastructure to support the projected zero-emission fleet based on results from the Fleet Assessment and Fuel Assessment. This assessment provides quantities of charging infrastructure and calculates associated costs sequenced over the transition timeframe.

The **Maintenance Assessment** calculates all projected fleet maintenance costs over the transition timeframe. This includes costs related to existing fossil fuel vehicles remaining in the fleet, as well as new BEVs.

The **Total Cost of Ownership Assessment** compiles results from the previous assessments and provides a comprehensive view of all associated costs over the transition timeframe.

# Planning and Initiation

## Project Kickoff

The project kickoff between CTE and NCDOT took place on March 15<sup>th</sup>, 2022. CTE and NCDOT discussed the scope, timeline, budget, and risks of the project. The Transit Teams kickoff took place on March 29<sup>th</sup>, 2022. CTE met with AppalCART and HATS stakeholders to discuss ZEV basics, challenges to ZEVs, transition planning methodology, data requirements, transition plan assessment goals, and the project schedule.

## Scope

**Table 1** below provides a summary of the scope agreed upon between stakeholders in the Project Charter.

*Table 1. Project Scope*

<b>Milestone</b>	<b>Initial Timeline</b>	<b>Deliverables</b>
<b>Phase 1: Planning and Initiation</b>	March 1, 2022-May 23, 2022	<i>Two (2) kickoff meetings and project plan outlining the project goals, tasks, and timeline.</i>
<b>Phase 2: Service Assessment</b>	April 1, 2022-August 4, 2022	<i>Presentation to review the vehicle feasibility and strategies for scenarios where a vehicle cannot be replaced on a 1:1 basis.</i>
<b>Phase 3: Fleet Assessment</b>	June 15, 2022-August 4, 2022	<i>Presentation to review the vehicle replacement schedule for AppalCART's and HATS' fleets.</i>
<b>Phase 4: Fuel Assessment</b>	August 15, 2022-October 28, 2022	<i>Presentation to review the charging requirements and charging equipment needs for AppalCART's and HATS' fleets.</i>
<b>Phase 5: Maintenance Assessment</b>	August 31, 2022-September 14, 2022	<i>Presentation to review the maintenance requirements and costs for AppalCART's and HATS' fleets throughout the transition to zero-emission vehicles.</i>
<b>Phase 6: Facility Assessment</b>	October 31, 2022-November 3, 2022	<i>Workshop reviewing the facility requirements to transition AppalCART's and HATS' fleets to zero-emission vehicles.</i>
<b>Phase 7: Total Cost of Ownership Assessment</b>	November 15, 2022-November 21, 2022	<i>Workshop reviewing the total cost of ownership for the fleet transitions and a workshop reviewing the training requirements for the fleet transitions.</i>

<p><b>Phase 8:</b> <b>Zero-Emission Vehicle Transition Plan</b></p>	<p>December 1, 2022-January 4, 2023</p>	<p><i>Prepare draft and final versions of AppalCART's and HATS' fleet transition plans. The final report will include an appendix that will meet the Federal Transit Administration's requirements for a Zero-Emission Transition Plan.</i></p>
<p><b>Phase 9:</b> <b>Zero-Emission Vehicle Transition Workshop</b></p>	<p>January 2023</p>	<p><i>One webinar to present the full plans created for both AppalCART and HATS that will demonstrate planning for fixed route and on-demand service.</i></p>

## Requirements Analysis

It is essential to understand the key elements of HATS' current service to evaluate the costs of a full zero-emission transition. HATS staff provided key data elements of the current service as inputs to the analysis, which included the following:

- Fleet composition
- Odometer readings
- Inter-county service data
- Mileage and fuel consumption
- Maintenance costs

### Fleet

HATS' fleet is comprised of two (2) minivans, four (4) full size vans, and fifteen (15) 20-28' cutaways. All vehicles are housed at a single facility, located at 316 S Magnolia St, Raeford, North Carolina. The facility contains an open lot where all vehicles are parked. Vehicles range in age from model year 2014 to 2022; the average age is 7.8 years and average total mileage is 1,265,126 miles as of June 2021. CTE's projections for battery capacities based on the capacities of battery electric cutaways and full-size vans available in the market today are not sufficient for meeting NCDOT's 2050 ZEV goals with only depot charging and would need to consider either mid-day charging or fleet size expansion to support an earlier transition timeline. There are currently no battery electric minivans for sale in the United States.

After evaluating HATS' dial-a-ride inter-county service trips, CTE chose to base this transition plan on fleet expansion rather than mid-day charging. Mid-day charging would not be sufficient for HATS' inter-county trips because there is not an opportunity that would benefit HATS for the vehicles to return to the depot to charge considering the far distances traveled on these trips. If mid-day charging were to be used, it would need to be on-route to avoid the need to return to the depot then back out to complete services after charging, but because these trips are dial-a-ride and unpredictable, there is no ideal location for on-route chargers to be placed. Fleet expansion is the most logical decision for this transition plan and will allow HATS to utilize more than one BEV for a trip and preserve each vehicle's mileage to successfully meet their service needs.

It will be important for HATS to plan for additional drivers ahead of the transition period. Planning will include determining exactly how many additional drivers will be needed to operate a fleet of 23 vehicles as well as how much funding will be required to hire these new employees. Creating a financial plan ahead of the transition period that accounts for additional vehicle operators will be beneficial for HATS in the long run. Workforce training should also be a factor when planning as all HATS' drivers will need to well versed in the operations of battery electric vehicles.

Although battery electric cutaways face limitations in the market today regarding their battery capacity and range, they are significantly more technologically advanced than the current battery electric full-size vans and minivans in the market. For this reason, CTE only evaluated the transition to battery electric cutaways in this ZEV transition plan. **HATS' replacement timeline of 250,000 miles or 10 years, depending on which parameter came first, was used as the basis for developing the fleet replacement schedule.**

## Inter-County Services

In addition to transporting Hoke County residents to areas in the county, HATS provides more strenuous mileage services, inter-county service trips, on set days during each week, using their ICE cutaways to transport Hoke County residents to six (6) surrounding counties/regions: the City of Fayetteville, Moore County, Scotland County, Robeson County, Chapel Hill-Duke, and Durham County. Hoke County residents most commonly use these services to travel to and from medical appointments. **Table 2** shows the main hospital destination, roundtrip mileage, and roundtrip time of each inter-county trip.

To determine an accurate mileage requirement for each inter-county trip, CTE calculated the mileage needed to travel to the main medical facility in each county/region provided by HATS. Using the odometer readings provided by HATS, CTE then evaluated which cutaways services each inter-county trip based on their average daily mileage and analyzed the feasibility of these services for BEVs.

*Table 2. HATS' Inter-County Service Data*

<b>Region</b>	<b>Medical Facility (Destination)</b>	<b>Roundtrip Mileage</b>	<b>Roundtrip Time</b>
<b>Moore County</b>	First Health Moore Regional Hospital	48.4 mi	1.2 hr
<b>Chapel-Hill Duke</b>	UNC Hospitals	176.2 mi	3.5 hr
<b>Fayetteville</b>	Cape Fear Valley Medical Center	60.0 mi	1.5 hr
<b>Fayetteville</b>	VA Medical Center	68.0 mi	1.5 hr
<b>Fayetteville</b>	VA Health Care Center	27.2 mi	0.8 hr
<b>Durham County</b>	Durham VA	193.2 mi	3.9 hr
<b>Scotland County</b>	Scotland Memorial Hospital	50.6 mi	1.1 hr
<b>Robeson County</b>	UNC Health Southeastern	58.2 mi	1.3 hr

HATS' inter-county roundtrip distances range from approximately 27 to 193 miles and durations range from about 1 to 4 hours long, with the shortest trip being to Fayetteville and the longest to Durham County.

## Mileage and Fuel Consumption

HATS operates an all-ICE fleet. The annual fleet mileage of all 15 cutaways is 425,602 miles. Fleet average efficiency is 2.9 mpg. It costs HATS an estimated \$199,676.40 in 2021 to fuel its fleet at an average cost of \$0.47 per mile. This assumes that the amount of service miles will remain the same throughout the entire transition period.

## Maintenance Costs

In 2021, HATS spent approximately \$51,456 on scheduled and unscheduled maintenance, including both parts and labor, for its entire fleet. This results in an average maintenance cost of \$0.13 per mile.

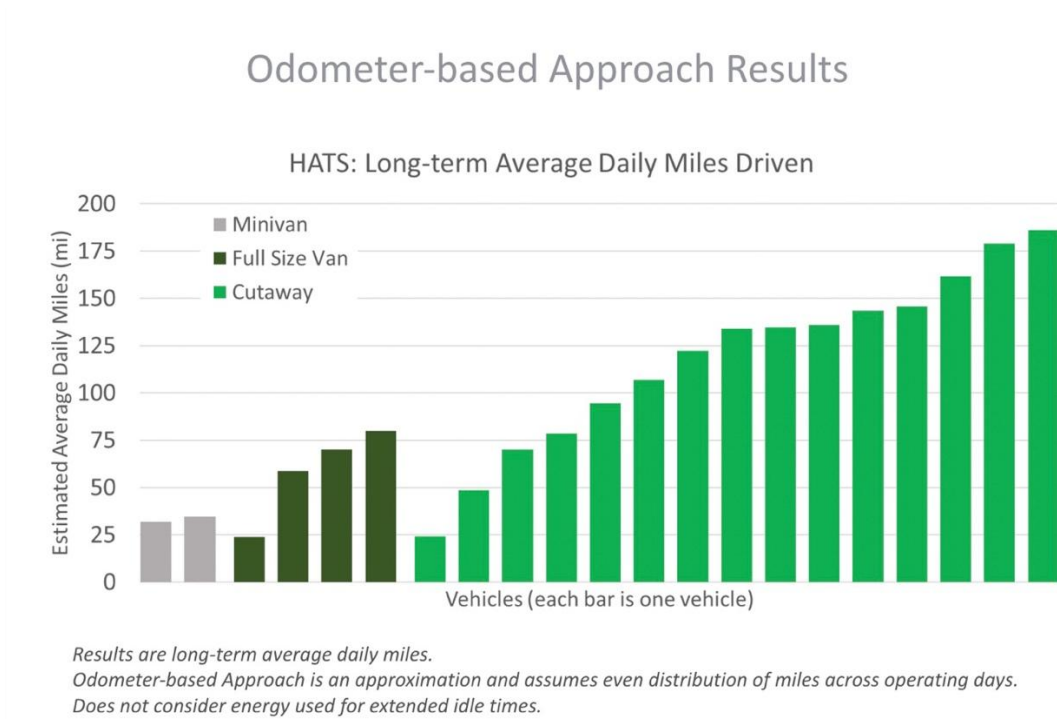
# Service Assessment

## Assessment Overview

The Service Assessment phase initiates the data collection and technical analysis of the study. CTE met with HATS to define assumptions and requirements used throughout the study and to collect operational data. The results from the Service Assessment are used to guide ZEV procurement projections in the Fleet Assessment and to determine energy requirements in the Fuel Assessment.

HATS provides mostly dial-a-ride services, meaning they do not have set routes and blocks implemented into their services. This makes it difficult to collect vehicle energy requirements for the fleet. The exception is daily trips to serve regional medical centers (two on Mondays, Thursdays, and Fridays; one on Tuesdays and Wednesdays). To accurately project service feasibility for zero-emission technologies, CTE used HATS' provided odometer readings of each cutaway to estimate the average daily mileage of each vehicle by assessing the average daily mileage based on the provided odometer reading and vehicle age, including assumptions for time not in operation and reduced service during weekends and holidays, and estimated miles required for out of service operations such as maintenance.

The average daily mileage estimates for each vehicle are shown below in **Figure 2**. CTE then estimated the energy requirements for HATS' most strenuous duty cycles based on the agency's historic travel data to determine whether or not the mileage requirements would be feasible under the operation of zero-emission vehicles. This study was conducted before HATS implemented routes and blocks into their services in late 2022/early 2023.



*Figure 2. Average Daily Miles per Vehicle*

This assessment analyzes the feasibility of maintaining HATS' current level of service with BEVs. The recommended fleet expansion only goes to support HATS' operations data received in early 2022. The main focus of the HATS Service Assessment is the inter-county trip analysis, which determines if BEVs can meet trip mileage requirements throughout the transition period based on vehicle endurance, range limitations, weather conditions, levels of battery degradation, and other route specific requirements. CTE determined BEV feasibility by comparing the energy required to complete a trip to the available energy from the vehicle types that service the respective trip. This assessment also determines a timeline for when trips with higher mileage requirements or more strenuous conditions become eligible for zero-emission vehicles as technology improves. This information is then used to inform BEV procurements in the Fleet Assessment.

**The analysis assumes a 5% improvement in battery capacity every other year and a starting battery capacity of 149 kWh for a 28' cutaway,<sup>4</sup> which is used to determine the timeline for when BEVs will be able to replace ICE vehicles on inter-county trips.** The results from the analysis are used to determine when, or if, a full transition to BEVs may be feasible. Results from this analysis are also used to determine the specific energy requirements for the agency and develop the estimated costs to operate the BEVs in the Fuel Assessment. **This modeling analysis also assumes service trips will maintain a daily average distribution of distance, relative speeds, and elevation changes to match current dial-a-ride service.** This core assumption affects energy use estimates and mileage achievability in each year.

CTE's service modeling considers the impact of varying passenger load, accessory load, and battery degradation on real-world bus performance, fuel efficiency, and range. CTE considered results of cutaways models and real-world deployments to represent "strenuous" loading conditions, as opposed to "nominal" loading conditions. Nominal loading conditions assume average passenger loads and moderate temperature over the course of the day, which places marginal demands on the motor and heating, ventilation, and air conditioning (HVAC) system. Strenuous loading conditions assume high or maximum passenger loading and near maximum output of the HVAC system. Modeling strenuous conditions allows agencies to plan for demanding conditions. Service modeling ultimately provides an average energy use per mile (kilowatt-hour/mile [kWh/mi]) associated with each duty cycle, bus size, and load case. System-wide energy use is estimated in subsequent assessments.

As noted previously, CTE models the impact of battery degradation. BEV range is negatively impacted by battery degradation over time. With 2022's lithium-ion battery technology, all batteries experience degradation over time due to the effects of cell aging (regardless of how it is used) and mechanisms associated with heavy use cases. A BEV may be placed in service on a given trip with beginning-of-life batteries; however, it may not be able to complete the entire trip at some point in the future before the batteries reach end-of-life (typically considered 70-80% of available service energy). **HATS can rotate the fleet to meet demand, assuming there is a steady procurement of BEVs each year to match service requirements so that older vehicles with reduced range are continually moved to shorter trips, while new vehicles are placed on longer trips.**

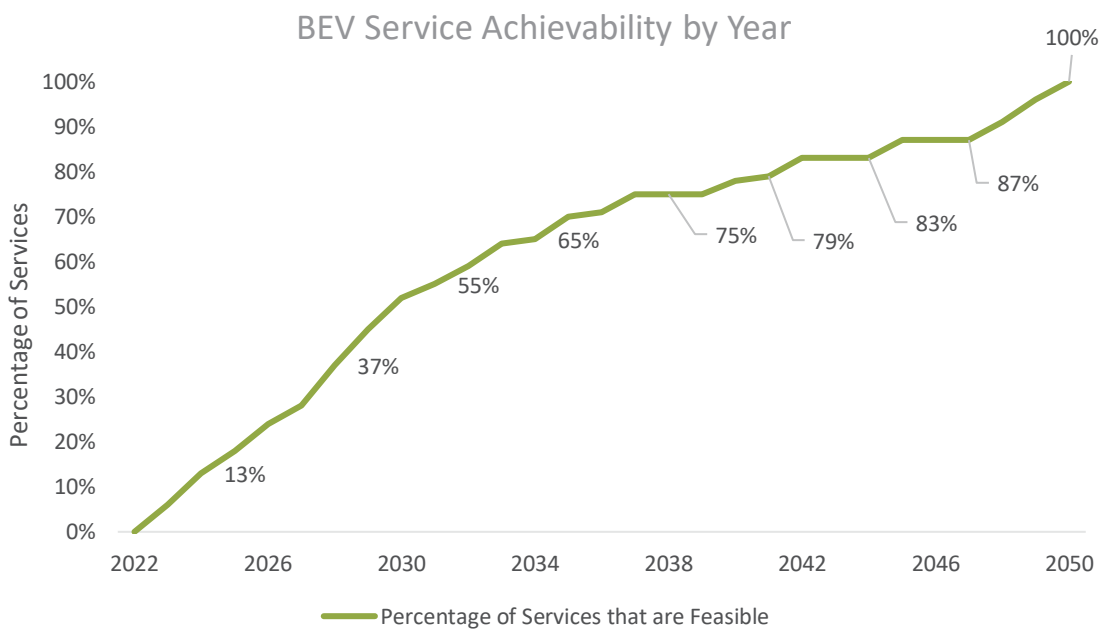
As mentioned, current charge technology for battery electric cutaways only allows for charging speeds of 50-80 kW, making it difficult for a BEV to extend range appreciably without major service interruptions of one or more hours. For this reason, the charging option for this analysis was limited to depot charging.

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<sup>4</sup> <https://californiahvip.org/vehicles/alpha-mobility-model-g-shuttle-bus>.

## Key Results

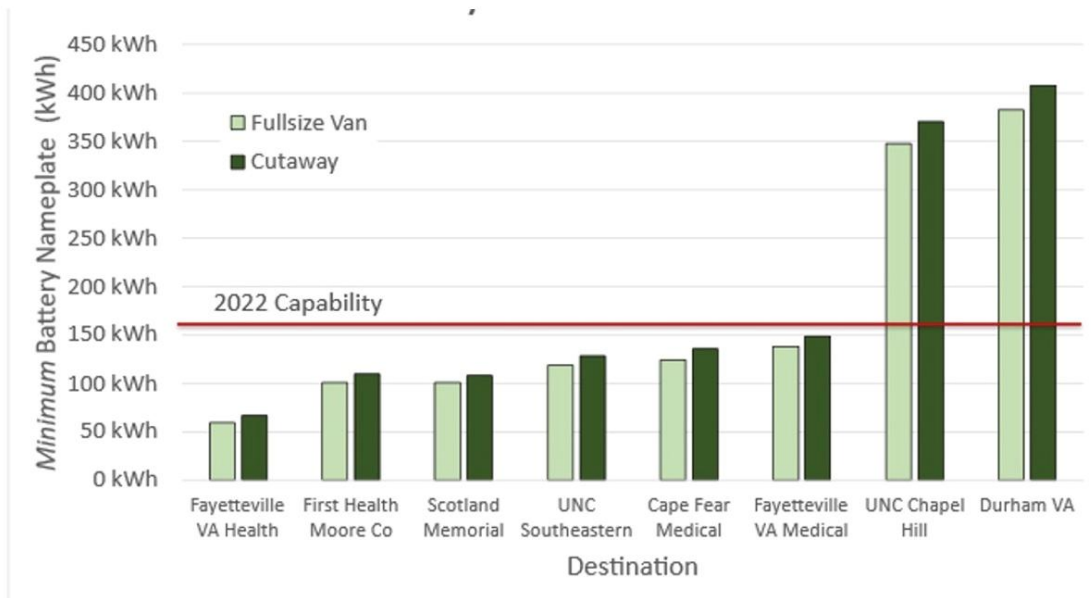
**Figure 3** shows the percentage of services that are BEV feasible between 2022 and 2050. The analysis assumed battery capacity will improve by 5% every two years. **If batteries do not improve at the modeled pace, the number of vehicles needed will increase to meet service demands. Conversely, if energy storage exceeds the projection, a smaller number of additional vehicles will be needed.** Due to the low projected battery capacities for battery-electric cutaways, HATS' services will not be achievable by a 1:1 BEV replacement for each inter-county trip in the transition timeline. Therefore, fleet expansion and operations changes are necessary for a successful transition to a zero-emission fleet. Dial-a-ride service varies day to day. HATS may face logistical challenges when providing daily dial-a-ride service with vehicles that do not have enough range to cover an entire day of operations. Working with schedulers and bus operators is the key to developing a process to switch vehicles mid-day as needed, and to have procedures in place for how and when the swap should occur. **Due to the predictability of inter-county trips, at least one trip per day is achievable with 2022 BEV cutaway technology. CTE recommends that HATS schedules their first BEV deployment on one inter-county trip per day.**



*Figure 3. BEV Service Achievability Percentage by Year (based on average daily mile needs for dial-a-ride service)*

**Figure 4** shows how the HATS inter-county service trips analyzed compare to the 2022 BEV technology capabilities. All service trips with exception of UNC Chapel Hill and Durham VA are achievable under strenuous conditions with 2022 BEV technology.

## HATS Inter-County 2022 Service Assessment



Results for Strenuous Condition: 20°F, Highway Driving

Figure 4. HATS Inter-County 2022 Service Assessment

## Conclusion

Assuming a 5% improvement in battery capacity every other year and considering that the current market's largest available battery is 149 kWh, CTE concludes that HATS will need to expand their fleet size from 15 to 23 vehicles to achieve a full battery electric fleet by 2050, which is in line with the NCDOT's zero-emission goals. These results will be used to inform the following Fleet, Fuel, Maintenance, and Facilities Assessments, which will produce an estimated total cost to transition to depot-charged BEVs. No other ZEV transition scenarios were explored for this assessment. HATS will continue to evaluate federal, state, and local revenue sources and seek grant funding as competitive opportunities arise in preparation for these transition-related expenses

# Fleet Assessment

## Assessment Overview

The Fleet Assessment develops a projected timeline for the replacement of existing vehicles with BEVs that is consistent with HATS’ fleet replacement plan. This assessment also includes a projection of fleet procurement capital costs over the transition timeline. The assessment can be optimized with regard to any state mandates or agency goals such as minimizing cost or maximizing service levels.

## Cost Assumptions

CTE and HATS developed cost assumptions for future vehicle purchases. Key assumptions for bus costs for the HATS Transition Study are as follows:

- Bus costs are based on HATS’ most recent procurement prices for 20-28’ ICE cutaways.
- Future bus costs are estimated using an annual inflation rate of 3%.
- For the purpose of this analysis, HATS’ full-size van and minivan procurements and cost assessment were not considered.
- The battery capacity will continue to increase, but the cost will not increase or decrease; the technology will improve, but the cost will remain stable due to economies of scale.
- Increase fleet size to accommodate BEV range deficiency; fleet size will grow from 15 to 23 vehicles; BEV purchases will be delayed to the minimum pace to meet fleet composition goals while spreading purchases out over multiple years.
- HATS will continue to purchase ICE vehicles until 2047; only one ICE vehicle will become eligible for replacement after 2041 and uncertainties in market conditions may allow the delay of the replacement until EV capacities are sufficient.

**Table 3** provides estimated bus costs used in the analysis. Considering HATS’ fleet will be increasing from 15 vehicles to 23, the fleet procurement schedule is expected to increase the overall transition costs.

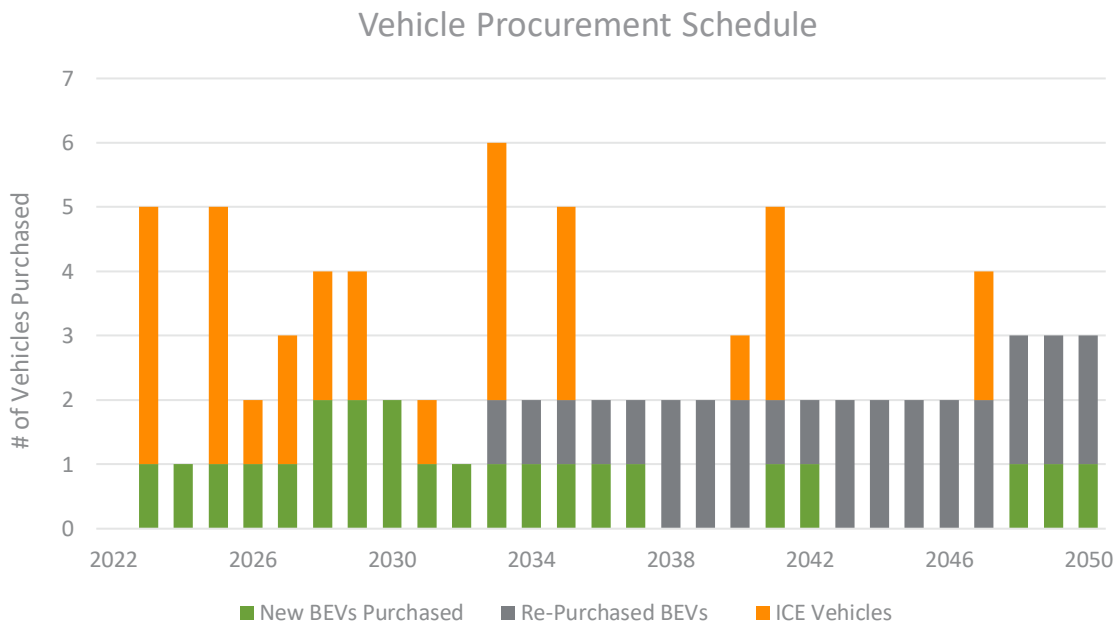
*Table 3. Fleet Assessment Cost Assumptions*

	ICE Vehicle Type: Gasoline Vehicle	Zero-Emissions Vehicle Type: BEB
<b>Bus Cost (HATS provided data)</b>	\$75,000	\$250,000
<b>Annual Inflation Rate</b>	3%	3%

## Key Results

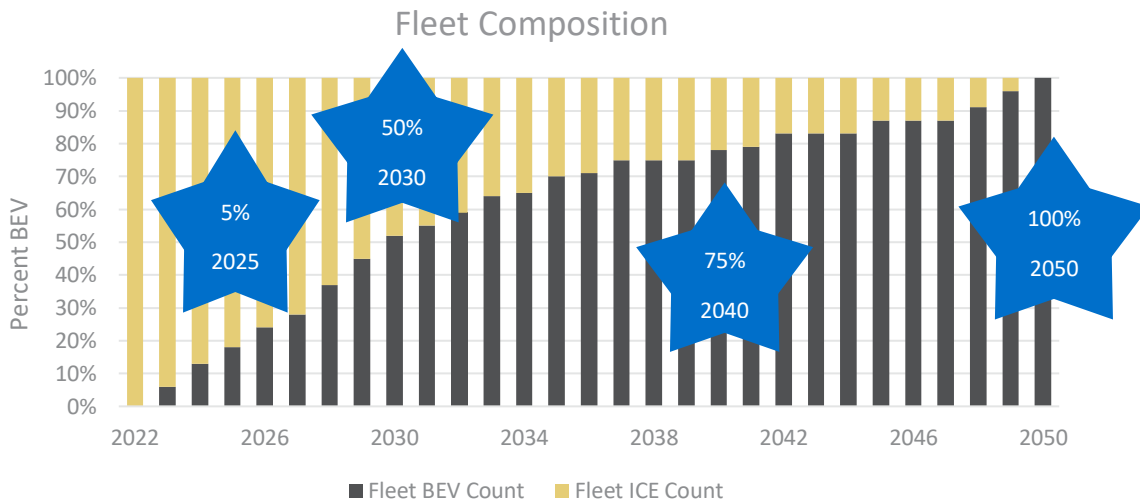
As previously discussed, in the Service Assessment, depot-charged BEVs are assumed because DC fast charging is not fast enough to add appreciable range in a short time window (less than 30 minutes). The fleet transition strategy is to replace each ICE vehicle series with BEVs as they reach the end of their useful life as well as add additional BEVs to the fleet, increasing the fleet size from 15 to 23 vehicles in total.

**Figure 5** provides the number of buses purchased each year through 2050 with this replacement strategy.



*Figure 5. Projected Bus Purchases, BEV with Depot Only Charging Scenario*

**Figure 6** depicts the annual fleet composition through 2050 compared to NCDOT’s transition goals. HATS phases out their ICE buses for BEVs throughout the transition timeline. By 2050, HATS’ fleet consists entirely of BEVs. The fleet is able to transition to 100% ZEV using depot-charged BEVs with the addition of 8 vehicles.



*Figure 6. Annual Fleet Composition, BEV with Depot Only Charging Scenario*

**Figure 7** shows the annual total vehicle capital costs for BEVs purchased in a given year through 2050. The expected total cost over the entire transition period is around \$34.4 million, compared to the roughly \$16 million that would have been incurred by a fully ICE fleet over that period. As noted in **Table 3** these cost estimates include an inflationary rate of 3% per year. An extended battery warranty will cover the cost of a mid-life battery replacement, and CTE assumed that warranty costs were included in HATS’ provided bus procurement costs. Costs are incurred as vehicles are ready for replacement, according to HATS’ 250,000-mile vehicle or 10-year lifespan. 2050 represents the last year that BEVs will be replacing ICE vehicles. That means that the costs to fully electrify the fleet are all incurred in 2022-2055. Therefore, future assessments will reflect costs in this transition timeline.

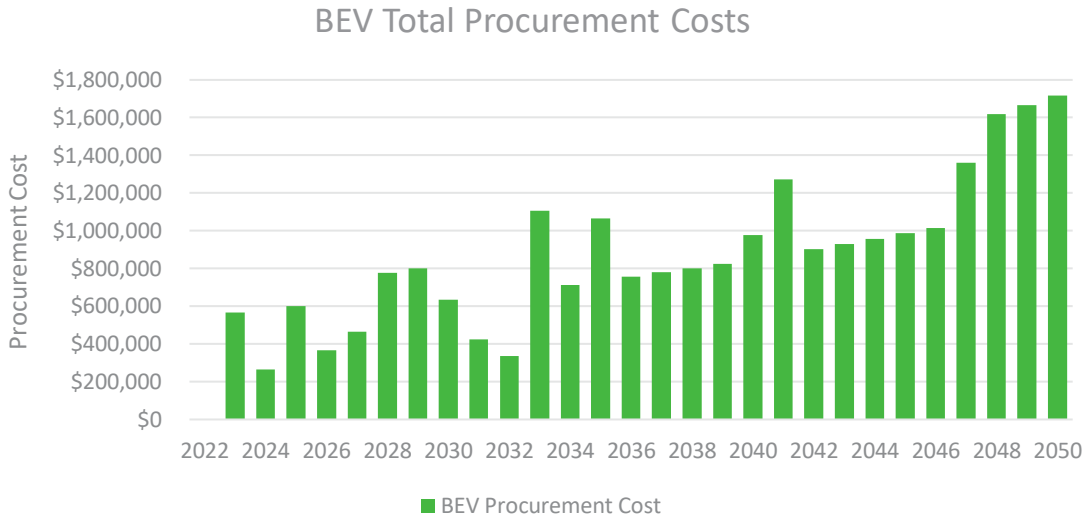


Figure 7. Annual Capital Costs, BEV with Depot Only Charging Scenario

Table 4. HATS Vehicle Capital Investment to transition to a 100% BEV fleet by 2050

	ICE Baseline	BEV Incremental Costs	Total Investment
<b>Initial Buses</b>	\$5,900,000	\$18,790,000	<b>\$24,690,000</b>

As seen in **Table 4**, the capital investment in purchasing BEVs is significantly higher than for ICE vehicles. **This highlights the importance of staying vigilant in the search for funding opportunities to help fill this gap.**

## Conclusion

The Service Assessment concludes that it will be possible for HATS to transition to an entirely BEV fleet without the need for on-route charging by increasing the fleet size from 15 to 23 vehicles. The expected total bus capital cost, including ICE replacements, of the transition to a BEV fleet is estimated at \$24.7 million. **The years with highest costs will be 2048 to 2050, which are years when the agency is projected to purchase 3 battery electric cutaways in each year, respectively.**

## Fuel Assessment

### Assessment Overview

The Fuel Assessment estimates fuel consumption and cost for each of the fuel technologies: ICE and electricity.

Using ZEB performance data from the Service Assessment, CTE analyzed expected vehicle performance on each vehicle duty cycle in HATS' service to calculate daily fuel required to complete respective trips. CTE completed this analysis for depot-charged BEVs on all of HATS' trips to estimate the fuel costs unique to the respective transition scenarios throughout the transition period.

Fuel cost estimates are based on the assumptions shown in **Table 5** below.

*Table 5. Fuel Cost Assumptions*

Fuel	Cost	Source
Gasoline	\$0.47/mile	Based on HATS' 2021 annual fuel cost over estimated annual mileage
Electricity	Demand: \$1.40/kW Energy: \$0.04/kWh Other charges: \$42.90/month	Based on Duke Energy Progress Small General Service 2022 (Time-of-Use) Schedule SGS-TOU-74

The primary source of energy for a BEV comes from the local electrical grid. Utility companies typically charge separate rates for total electrical energy used [kilowatt-hours (kWh) or megawatt-hours (MWh)] and for peak power demand [kilowatts (kW) or megawatts (MW)] on a monthly basis. Peak power demand is defined as the maximum amount of power that a customer pulls from the grid for any 15-minute window within a month. Demand charges are then applied on a per kW basis to that maximum demand in addition to per kWh costs for energy consumption. In addition to Energy and Demand charges, utilities typically have other standard monthly service fees.

As a transit agency adds more BEVs and chargers, the agency's energy consumption increases. With more BEVs in the fleet, more vehicles are being charged simultaneously, resulting in an increase in the peak power demand and related costs. Rates may vary with time of day, day of the week, and with the changes of seasons. As a result, the time to charge and the number of chargers operating concurrently must be effectively managed to keep energy costs to a minimum. Charge management strategies include limiting charging vehicles to times of day at which energy rates are lower and spreading out the number of vehicles charging concurrently to minimize peak power demand.

**Ideally, vehicles would charge exclusively in the least expensive off-peak times, currently between 10pm and 6am, to minimize overall cost.**

At the time of the analysis, HATS operated under the Duke Energy Progress Small General Service 2022 (Time-of-Use) Schedule SGS-TOU-74 rate schedule,<sup>5</sup> also referred to as the "current rate" in the analysis. CTE used this rate schedule's costs reflected on HATS' September 2022 Duke Energy Progress Utility Bill. The Small General Service 2022 (Time-of-Use) Schedule SGS-TOU-74 rate schedule used for this analysis can be found in the appendix of this transition plan.

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<sup>5</sup> <https://www.duke-energy.com/business/billing/rates>.

**These rates may change and HATS will reassess the expected cost of fuel on an annual basis to account for any changes in Duke Energy Progress rates, as well as coordinate with the utility to identify any potential cost savings as transition milestone progress in the coming years..** CTE escalated yearly electricity rates and gasoline prices in the Fuel Assessment from base rates from the U.S. Energy Information Administration (EIA) annual projections to 2050 to account for inflation.<sup>6</sup>

## Charging Analysis Methodology

To accurately estimate energy consumption, peak power demand, and resulting costs, CTE conducted simulations of charging at the depot for each year of the transition. The Fuel Assessment estimated energy consumption and peak power demand based on current trip schedules and projections of BEV utilization each year of the transition period. CTE then used Duke Energy Progress rate schedules to calculate the annual cost of charging. This annual cost is evaluated for each year of the study (2022–2050) to obtain a total charging cost of BEVs with depot charging for the transition period. CTE uses this estimate of total charging cost as the total fuel cost for this BEV transition scenario.

## Charge Management

Charging speeds for the electric cutaway vehicles are limited to 50-80kW, lagging that of the passenger vehicle market significantly, and cannot currently extend range appreciably without major service interruptions of one or more hours.

**As the fleet grows, charging will require additional planning to ensure all buses are charged to meet service requirements, to minimize utility costs, and to minimize required infrastructure.** Charge management software can automate fleet charging and is an important tool for managing charging schedules and costs. It minimizes electricity costs by limiting the number of chargers running simultaneously, thereby limiting the overall power demand. This software can turn individual dispensers on and off, limit the power of an individual charger, and also be used to schedule charging to avoid on-peak costs. Currently there is no standard charge management software available in the market.

**Figure 8** shows an example of how charge management can delay charging to avoid on-peak times and minimize the number of required chargers (maximum 18 required chargers using charge management versus 22 without). **Figure 9** shows an example of how charge management avoids on-peak periods and reduces the overall demand of the charging system by spreading charging over a longer period (maximum 2,250 kW peak demand with charge management versus 2,984 kW without).

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<sup>6</sup> U.S. Energy Information Administration Annual Projections to 2050 <https://www.eia.gov/analysis/projection-data.php#annualproj>.

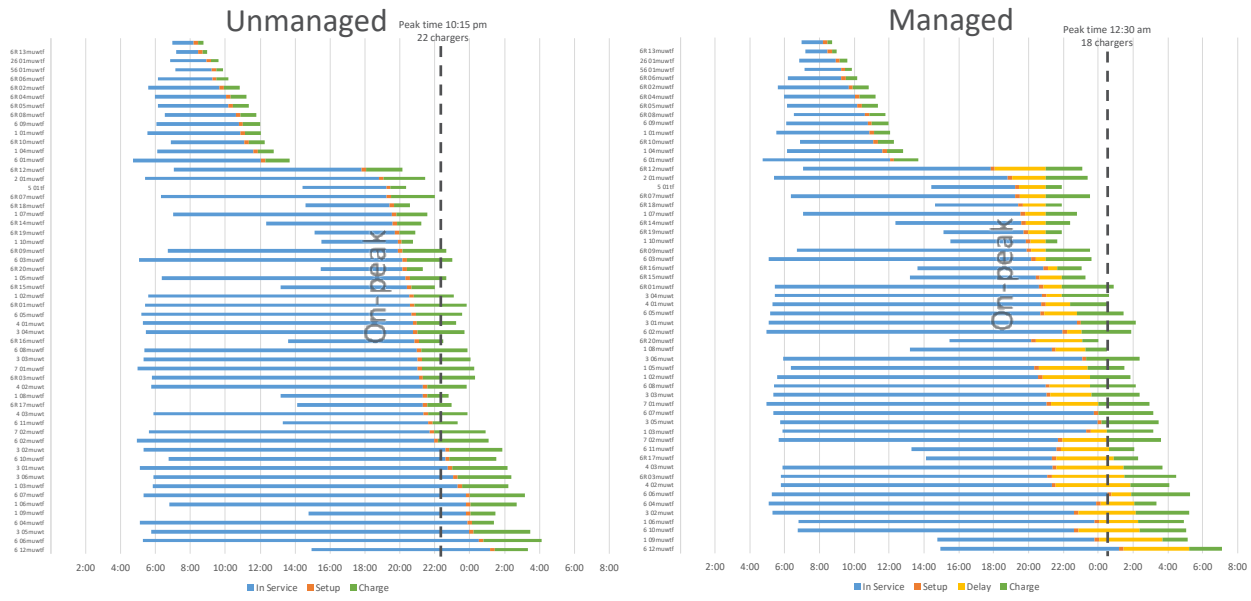


Figure 8. Example of Bus blocks without (left) and with (right) charge management

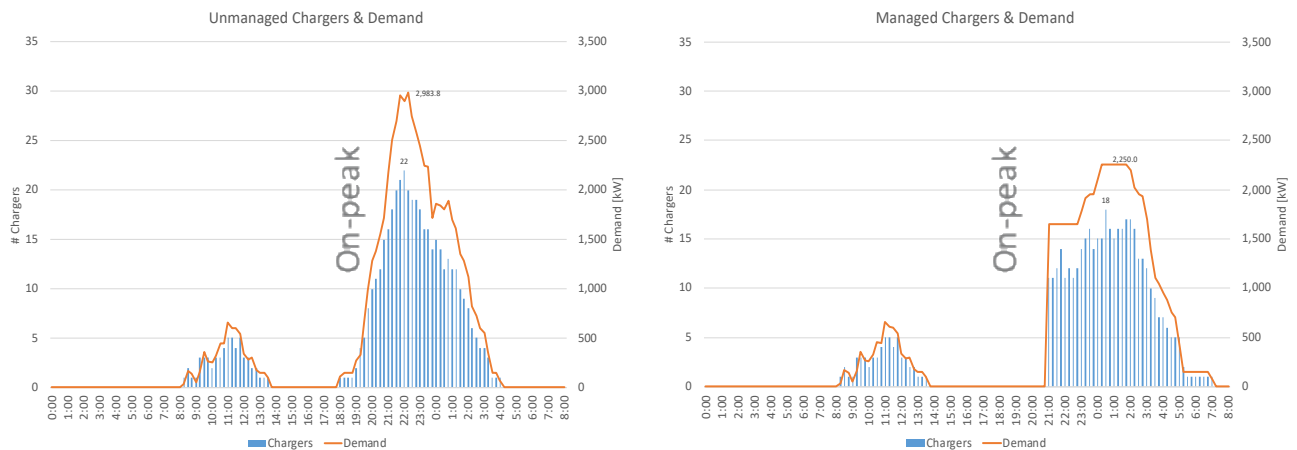


Figure 9. Peak demand example without (left) and with (right) charge management

## Fuel Assessment Results

The BEV Only scenario models a transition to an all-BEB fleet that employs depot charging only. The fuel costs for the BEV Only scenario is based on the assumption that the fleet will grow in size from 15 to 23 vehicles, but not change in service level.

**The price of fuel for ICE vehicles is expected to increase by approximately 27 percent from 2025 to 2050 and the price for electricity for BEVs is expected to increase by approximately 5 percent over that same time period.**

**Figure 10** shows the annual costs for each fuel type based on the Duke Energy Progress electric rate structure as well as the annual savings. The 2050 annual fuel cost would be \$75,118 under the

current rate. If the fleet remained entirely ICE, the 2050 annual costs would be \$282,012. These estimates include EIA inflation projections.

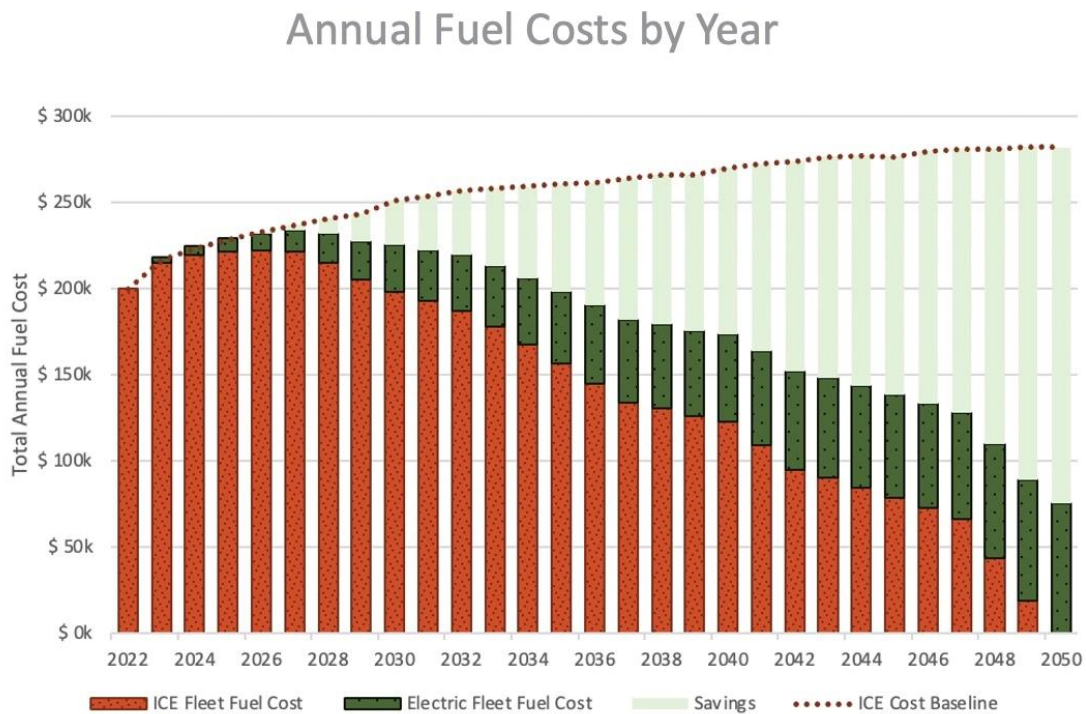


Figure 10. Annual Fuel Costs, Current Rate

**Figure 11** shows the cumulative fuel costs by each scenario throughout the transition period. The cumulative fuel cost is \$5,259,541 under the current rate. This compares to the baseline cumulative total of \$7,469,941 if HATS did not transition any of their fleet to electric. The potential cumulative fuel savings during the transition period is \$2,210,400.

## Cumulative Fuel Costs by Year

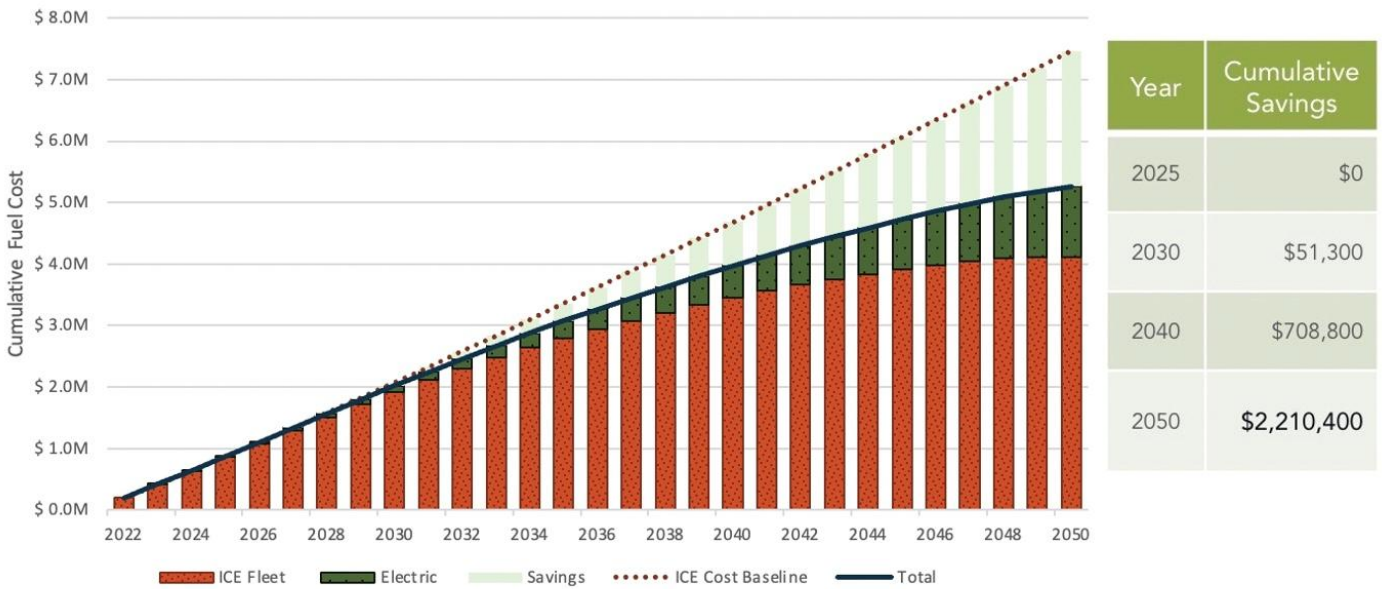


Figure 11. Cumulative Fuel Costs by Year

## Conclusion

Understanding how electricity costs are incurred and how to best structure charging to avoid unnecessary expense is essential for managing fuel costs. This analysis shows that current service capacity can accommodate the electric cutaway transition. However, ensuring charging occurs during off-peak times will allow HATS to capitalize on time-of-use rate incentives. Additionally, HATS should maintain an ongoing relationship with Duke Energy Progress in an effort to receive the best electric vehicle rates and incentives.

# Maintenance Assessment

## Assessment Overview

One of the anticipated benefits of operating a BEV fleet, compared to an internal combustion engine (ICE) fleet, is a reduction in maintenance costs. Early adopters of ZEV technologies have reported that a transit agency may save 30% to 50% in maintenance costs for a BEV compared to an ICE vehicle. Battery electric vehicles have fewer fluids to replace (no engine oil or transmission fluid), fewer brake changes due to regenerative braking, and far fewer moving parts than internal combustion engine vehicles. The savings in traditional maintenance costs may be offset by the cost of battery replacements over the life of the vehicles. Therefore, these costs will be covered by extended warranties.

HATS provided data on ICE vehicle labor and maintenance costs for their current fleet. CTE estimated that BEV labor and maintenance costs would be 30% lower than the ICE cost, which was based on industry expectations. **HATS should update this projection to reflect the BEV maintenance costs seen once these BEVs have been in service for a few years.** Table 6 shows the assumed costs of scheduled and unscheduled labor and maintenance used in this analysis.

Although these estimates are based on real-world data, the dataset is limited and based on early-stage BEV deployments. As a result, transit agencies may have a very different experience with lower maintenance costs. HATS will likely see lower BEV maintenance cost as compared to ICE since BEVs have fewer maintenance requirements due to fewer moving parts, fewer brake changes, no oil changes, etc.

At a minimum, BEVs will require a mid-life battery replacement. CTE assumes that HATS' vehicle maintenance costs include mid-life overhaul costs. There may be other BEV propulsion components that require mid-life replacements, but the scope of these replacements is not known at this time.

Table 6. Labor and Materials Cost Assumptions

Type	Estimate (Per Mile)	Source
ICE	\$ 0.13	HATS
BEV	\$ 0.09	U.S. DOE & NREL

For BEVs, the analysis uses an extended battery warranty cost in place of a midlife battery overhaul cost. Although incurring an additional ~\$30k for the extended battery warranty as part of the vehicle capital costs is a significant expense, paying for the extended warranty in place of incurring midlife battery replacement has been found to save agencies a significant amount. OEMs provided the \$30k extended warranty cost information. In the analysis, CTE assumes that this warranty cost was included in the HATS provided bus capital costs and is included in each purchase year.

## Maintenance Assessment for Battery Electric Bus Results

Figure 12 shows the maintenance costs for the BEV Only scenario for each year of the transition, including inflation at a rate of 3% per year. Comparing 2020 to 2050, inflation and BEV procurements are the cause of the higher annual BEV maintenance costs. The cost of maintenance in 2050 with a fully ICE fleet is \$92,019 compared to \$131,455 for a fully BEV fleet. This calculates to a potential yearly savings of \$39,346 for maintenance related expenses. Figure 13 displays the cumulative maintenance costs throughout the transition timeline of 2022-2050 comparing a fully

ICE fleet against a fully electric fleet at HATS. The cumulative maintenance cost between 2022-2050 is \$2,598,094 for a fully ICE fleet and \$907,246 for a fully BEV fleet. This works out to a potential cumulative savings of \$1,690,848 throughout the transition timeline.

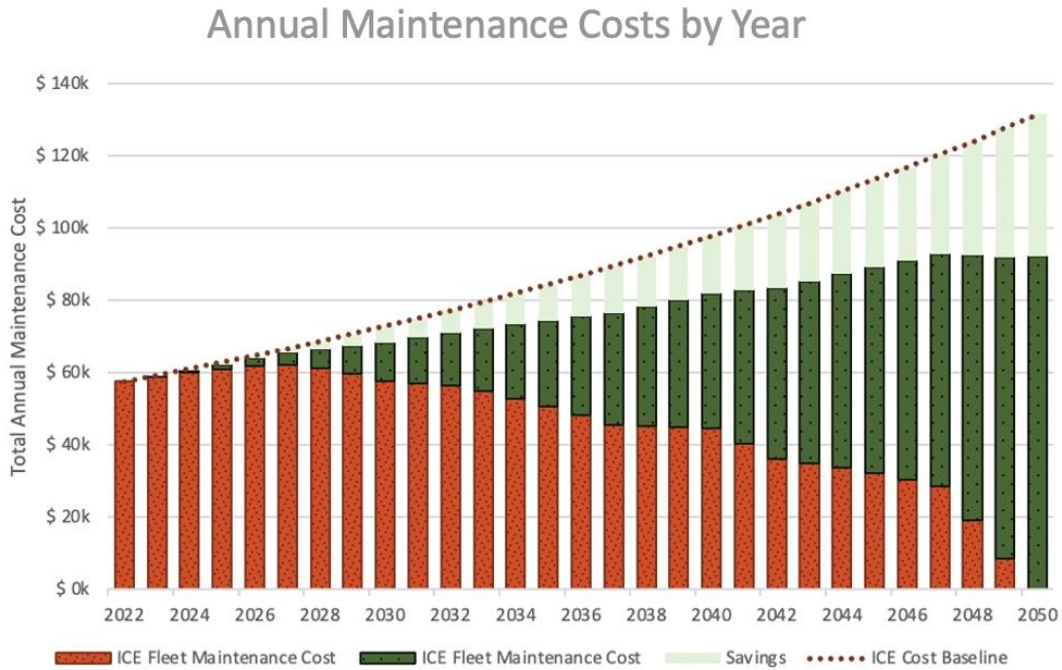


Figure 12. Annual Fleet Maintenance Costs

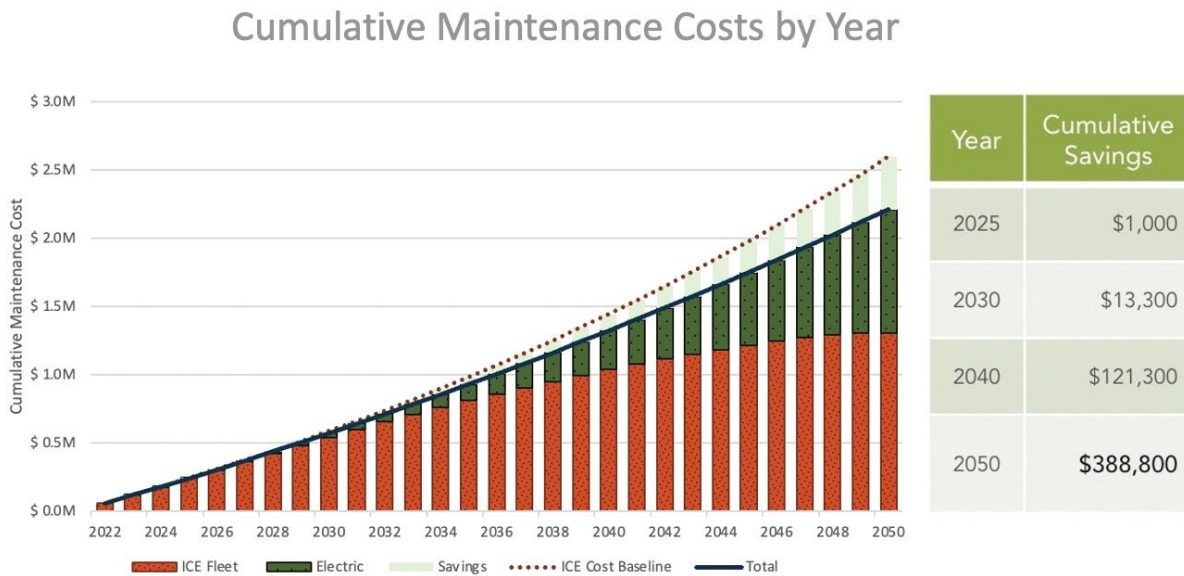


Figure 13. Cumulative Fleet Maintenance Costs

HATS should also consider the need for additional maintenance personnel as there may be a higher demand for maintenance, including an increase in the maintenance time required with the addition of eight vehicles into HATS' fleet. This will be necessary especially in instances where unexpected maintenance is needed. Creating a financial plan ahead of the transition period that accounts for additional maintenance needs will be beneficial for HATS in the long run.

## Conclusion

As HATS transitions to a fully electric fleet, per mile maintenance costs are expected to fall by 30% in the absence of inflation. This is assuming all maintenance is odometer based. Transitioning to fully electric could save HATS over \$300,000 in fleet maintenance costs by 2050. Additionally, annual fuel savings after the transition period may be up to \$40,000.

# Facilities Assessment

## Assessment Overview

Scaling to a fleetwide BEV deployment requires substantial infrastructure upgrades and a significantly different approach to charging compared to smaller pilot deployments. With pilot deployments, charging requirements are met relatively easily with a handful of plug-in pedestal chargers and minimal infrastructure investment.

Full fleet BEV deployments, however, require installation of charging stations and improvements to existing electrical infrastructure. These improvements may include upgrades to switchgear or service connections. Planning and design work, including development of detailed electrical and construction drawings required for permitting, is also necessary once specific charging equipment has been selected.

Through discussions with HATS, CTE broke the facility upgrades into four different phases, as shown in **Figure 15**.

**Table 7** shows the assumptions used for BEB infrastructure costs.

## Infrastructure Project Phasing

**The infrastructure deployment was broken into 4 phases. Although these phases are expected to occur in designated years, they are modular, which means that they can be adjusted as units are needed. The goal is to prepare the site for future BEB purchases while still allowing for flexibility as technology changes and agency operations evolve over time.**

HATS is planning to transition to a different facility in late 2023. While most of the facility planning that was conducted throughout this analysis will remain the same, HATS will need to ensure to apply the results to their future facility as it was not considered throughout this analysis.

Before moving into the new facility, it will be beneficial for HATS to start thinking about how an additional eight vehicles, as well as ZEV charging infrastructure will fit into their new parking layout. In addition, before the ZEV transition, HATS should update the facilities plan with important considerations such as and cost changes to consider that are specific to their new facility, especially for electrical upgrade requirements such as trenching and patchwork as this will look different for every facility.

## Site Designs and Upgrades

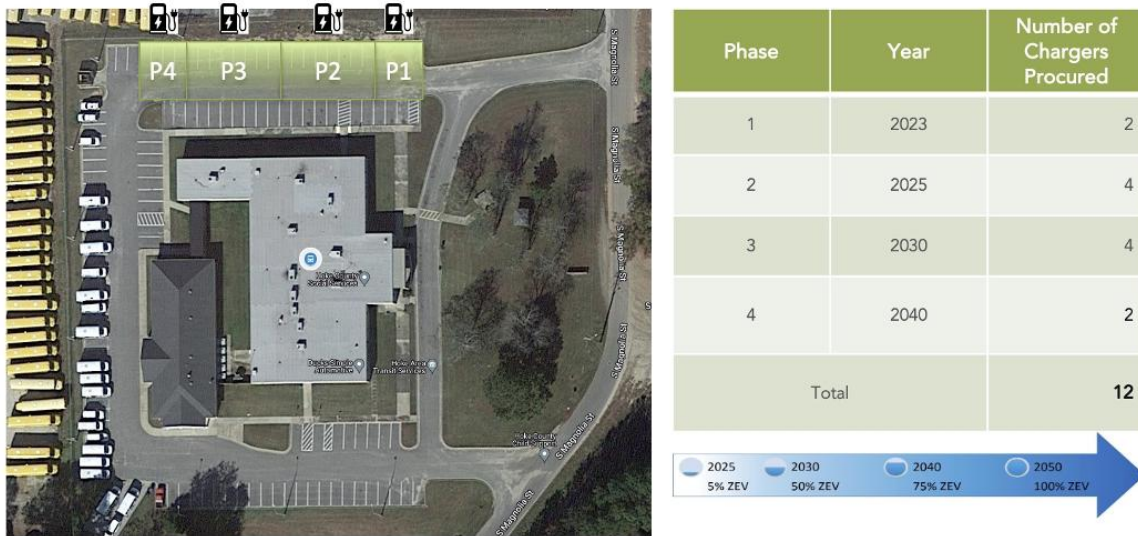


Figure 14. HATS Site Upgrade Phases

**Phase 1:** This phase is expected to occur between the years of 2023 and 2024 and includes initial site planning, trench/duct upgrades, and the procurement and installation of two 60 kW chargers and four dispensers to accommodate the first three BEV purchases. Each bus will require one dispenser so even if all buses are not charged simultaneously, they can all be physically plugged in overnight to allow a charge management system to provide a full charge by pull-out time the next morning. Every two buses will require one charger. Note that power levels are approximate and will vary based on individual BEV model voltage and current limitations. **All vehicles and charging technology will be stationed in the open parking lot of HATS away from the main building structure. This analysis was conducted in late 2022 for HATS' primary facility at the time. HATS has confirmed plans to move their facility since this analysis was conducted. The new facility is not considered in the analysis.**

**Phase 2:** This phase is expected to occur between the years of 2025 and 2029 and includes electrical and trench/duct upgrades, the purchase of eight BEVs, and the procurement and installation of four 60 kW chargers and eight dispensers.

**Phase 3:** This phase is expected to occur between the years of 2030 and 2040 and includes electrical and trench/duct upgrades, the purchase of seven BEVs, and the procurement and installation of four 60 kW chargers and eight dispensers.

**Phase 4:** This phase is expected to occur between the years of 2040 and 2050 and includes the final electrical and trench/duct upgrades, the purchase of five BEVs, and the procurement and installation of two 60kW chargers and four dispensers which will complete the ZEV transition.

HATS is planning to transition to a different facility in late 2023. While most of the facility planning that was conducted throughout this analysis will remain the same, HATS will need to ensure to apply the results to their future facility as it was not considered throughout this analysis.

Before moving into the new facility, it will be beneficial for HATS to think about how an additional eight vehicles, as well as ZEV charging infrastructure will fit into their new parking layout. In addition, before the ZEV transition, HATS should update the facilities plan with important considerations such as and cost changes related to their new facility, especially for electrical upgrade requirements such as trenching and patchwork as this will look different for every facility.

*Table 7. BEB Infrastructure Project Cost Assumptions*

<b>Plug-In Style Infrastructure</b>	<b>Cost</b>	<b>Description/Unit</b>
<b>Electrical Upgrades (Panel/switchgear, trenching/patchwork, etc.)</b>	\$300,000	For initial work (first installation)
	\$50,000	For additional work (per additional build)
<b>Contingency</b>	20%	on project costs
<b>Design Oversight</b>	7%	on project costs and contingency
<b>Dispenser and Cable Reel</b>	\$25,000	each
<b>Dispenser Installation</b>	\$5,000	each
<b>Infrastructure Planning</b>	\$200,000	For initial work
<b>60 kW Charger</b>	\$70,000	each
<b>Charger Installation</b>	\$5,000	each

**Figure 15** shows total required electrical demand, in kilowatts, for HATS’ facility over time. Each entry indicates the minimum amount of power that must be added in a given year to meet the growing demand at HATS’ facility as more BEVs are purchased.

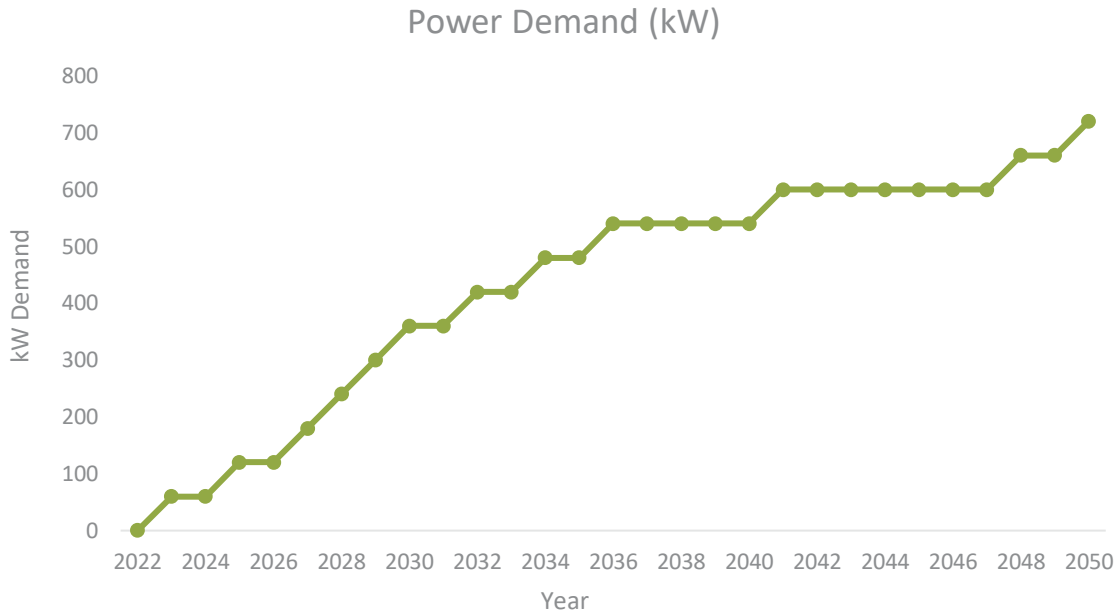


Figure 15. Incremental Depot Electrical Demand, BEV Only Scenario (MW)

Power upgrades are consolidated to occur in selected years, in accordance with the four phases and required demand in **Figure 15**. These recommended upgrades are expected to occur in the years outlined in **Table 8** below.

Table 8. Depot Recommended Power Upgrade Projects, BEV Only Scenario

Year	Upgrade Required
2023	1
2025	1
2030	1
2040	1

**Total estimated power upgrade costs over the project life are approximately \$512,000 million. The initial upgrade is projected to be the most expensive, costing \$309,000 in the year 2023.**

### BEV Only Infrastructure Cost Summary

Figure 16 summarizes all costs for charging infrastructure for each of the phases as the HATS BEV count rises. **Figure 17** shows the cumulative infrastructure costs broken out by each phase. The estimated total infrastructure costs are approximately \$2.2 million. This total cost includes all electrical updates (costs required to support all panels/switchgears, trenching/patchwork upgrades), the added 20% contingency, 7% design oversight, and 3% annual inflation rate. This

cost also includes the cost of dispensers/cables reels, infrastructure planning costs, chargers, charging cabinets, and charger related installations.

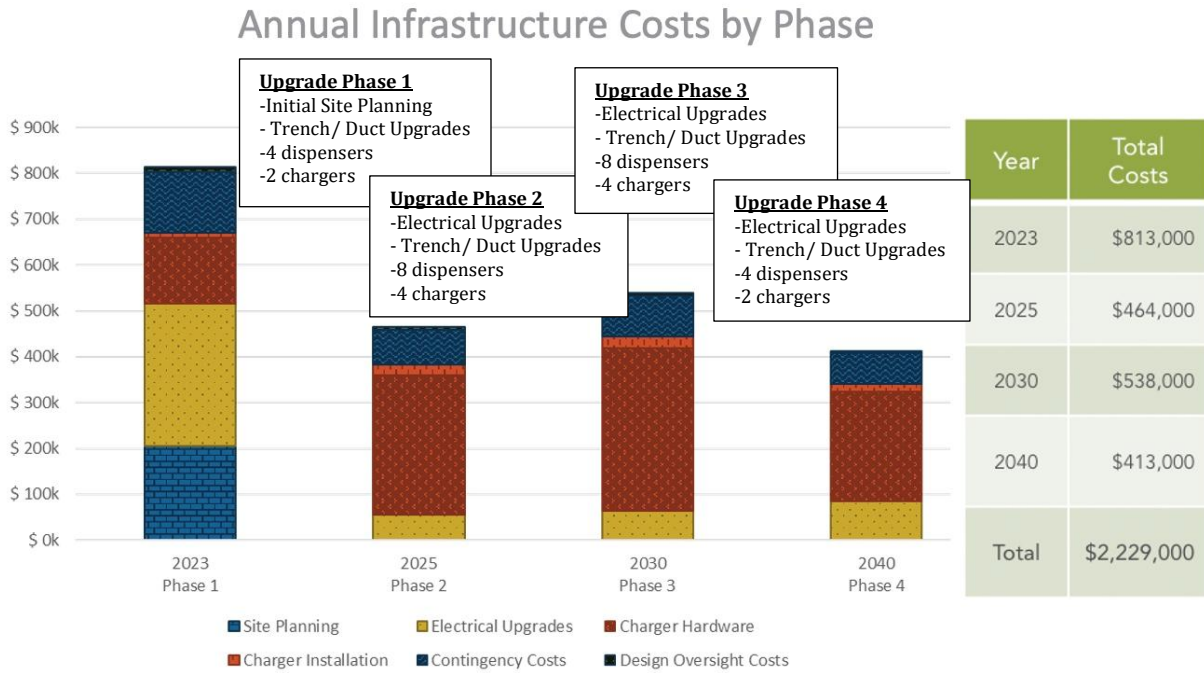


Figure 16. Annual Infrastructure Costs by Phase

## Cumulative Infrastructure Costs by Phase

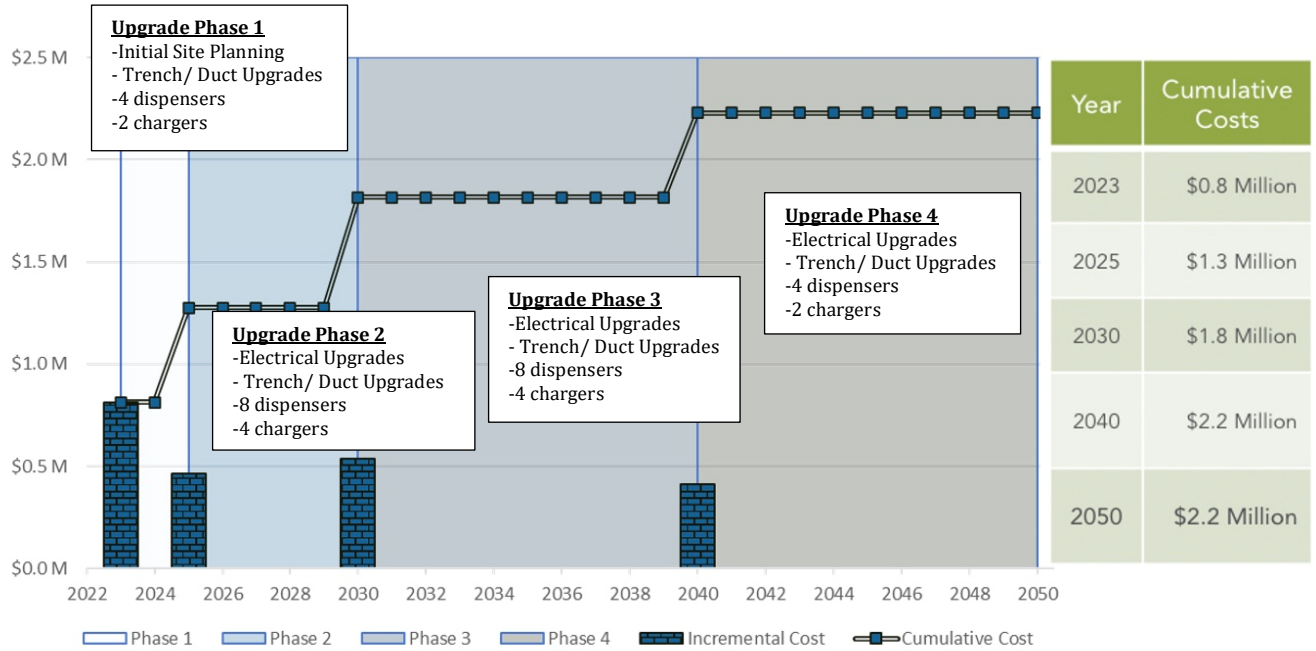


Figure 17. Cumulative Infrastructure Costs by Phase

The sum cost of all of these annual expenses can be seen in Table 9.

Table 9. HATS Infrastructure Capital Investment to transition to a 100% BEV fleet by 2050

	ICE Baseline	BEV Incremental Costs	Total Investment
<b>Fueling Infrastructure</b>	\$0	\$2,229,000	\$2,229,000

Looking at **Table 9**, the infrastructure required for this transition to a fully zero-emission fleet has a significant expense that would not be incurred by maintaining an ICE fleet. **However, there may be funding available to help fill this gap, and HATS should be able to meet the financial need through additional grant funding.**

## Other Considerations

In addition to the uncertainty of technology improvements, there are other risks in trying to estimate costs over the 28-year transition period to consider. Although current BEV range limitations may be improved over time as a result of advancements in battery energy density and more efficient components, battery degradation may re-introduce range limitations, which is a cost and performance risk to an all-BEV fleet over time.

Redundancy, Resilience, and Emergency Response are elements that require serious consideration with an all-electric fleet. In emergency scenarios that require use of BEVs, agencies may face challenges supporting long-range evacuations and providing temporary shelters in support of fire and police operations. Furthermore, fleetwide energy service requirements, power redundancy, and resilience may require additional infrastructure investment at any given depot in an all-BEV scenario.

## Resiliency and Redundancy

**With a growing BEV fleet, HATS will need to incorporate resiliency and redundancy to their fueling and infrastructure plans.** The loss of electrical power to HATS' facility could be the result of various causes including utility equipment or line faults, transformer failure, severe weather events, mandatory wildfire safety shutoffs, or high-demand load shedding (brown-outs).

HATS' emergency plan should be an ongoing discussion as the BEV fleet grows, as local policies change, and as new technologies emerge. To lay a solid foundation for an evolving energy resiliency plan, HATS should consider the following actions when creating an energy resiliency plan. These tasks are not an exhaustive list, and there may be other considerations that are specific to HATS.

1. Identify the frequency and duration of outages.
2. Determine a mitigation strategy proportional to the risk.
3. Obtain *essential service* designation to avoid being affected by rolling blackouts.
4. Create and assess infrastructure solutions to mitigate identified risks.

The strategies below are aimed at mitigating the impacts of utility outages and are all infrastructure-based solutions. Each strategy can be used as a standalone solution or in conjunction with one another. These are not one-size-fits-all solutions, and they have not yet been widely used in transit operations.

### DUAL UTILITY FEEDERS

HATS could work with Duke Energy Progress to install a second utility circuit at the depot. If this is determined to be feasible, this secondary circuit can continue to provide power to the site in the event the substation or distribution line becomes de-energized. Both feeders would meet at a main switchboard and be able to switch sources via automatic or manual means. This solution would provide redundancy should a problem occur upstream on one of the feeders, but it would not address the risk of wildfire safety shutoffs. To mitigate weather-related shutoffs, this would need to be coupled with one of the solutions below.

### BATTERY ENERGY STORAGE (BES) SYSTEMS

Battery energy storage (BES) systems can provide immediate backup power to a facility in the event of a complete utility outage. The size and rating of the BES along with the amount of backed-up load will determine how much time the BES will provide power without need for recharging. BES systems can be designed for both maximum power outputs and for power outputs for certain lengths of time, depending on the intended use of the system.

## STANDBY GENERATOR

A common option for backup power is providing one or more sockets at load centers for the connection of portable generators. Since it is unlikely that all chargers will be operating at the same time, a smaller generator could provide adequate backup power during an outage (assuming no substantial auxiliary loads are operating simultaneously). HATS already operates a stationary generator on-site that could be incorporated into any future on-site generation plans.

## MICROGRID

A microgrid is a small, on-site, independent power system that integrates generation, energy storage, and control devices at or near the bus depot.<sup>7</sup> Microgrids may also employ renewable generation from wind or solar, which can help meet net-zero emissions goals while saving on utility costs. In tandem with managed depot charging, a smart microgrid can manage the demands on the BES while utilizing on-site generation through multiple sources. In addition, a microgrid can supplement grid power to reduce peak-demand and energy costs from the utility.

# Total Cost of Ownership

## Assessment Overview

The Total Cost of Ownership Assessment compiles the results from the Fleet, Fuel, Facilities, and Maintenance Assessments to show cumulative and annual costs throughout the transition period for each scenario. It includes selected capital and operating costs of each fleet scenario over the transition timeline. Other costs may be incurred (e.g., incremental operator and maintenance training) during a fleet transition; however, these four assessment categories are the key drivers in ZEV transition decision-making.

Additional cost factors that are not included in the cost assessment include on-route charging options like gantries, resilience and redundancy add-ons like generators, and additional impacts to labor costs like charge management systems and increased maintenance labor.

Future changes to HATS' service level, depot locations, route alignments, block scheduling, or other operations are unknown. The analyses below provide best estimates using the information currently available and the assumptions detailed throughout this report.

## Total Cost of Ownership Assessment Results

**Figure 18** shows the combined fleet, fuel, facilities, and maintenance costs including inflation for infrastructure, which equals a total combined cost of \$34.4 million over the length of the transition (2022–2050). The TCO Assessment, consistent with the previous assessments, assumes a total of 23 total BEVs in service by 2050. Infrastructure costs are incurred in four phases of the project when the infrastructure is purchased to support the transition of each parking location. Maintenance and fueling costs remain relatively stable from year to year. Fleet costs are the main source of variability in costs from year to year.

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<sup>7</sup> Li, Fusheng, et al. *Microgrid Technology and Engineering Application*. 1st ed., Academic Press, 2015.

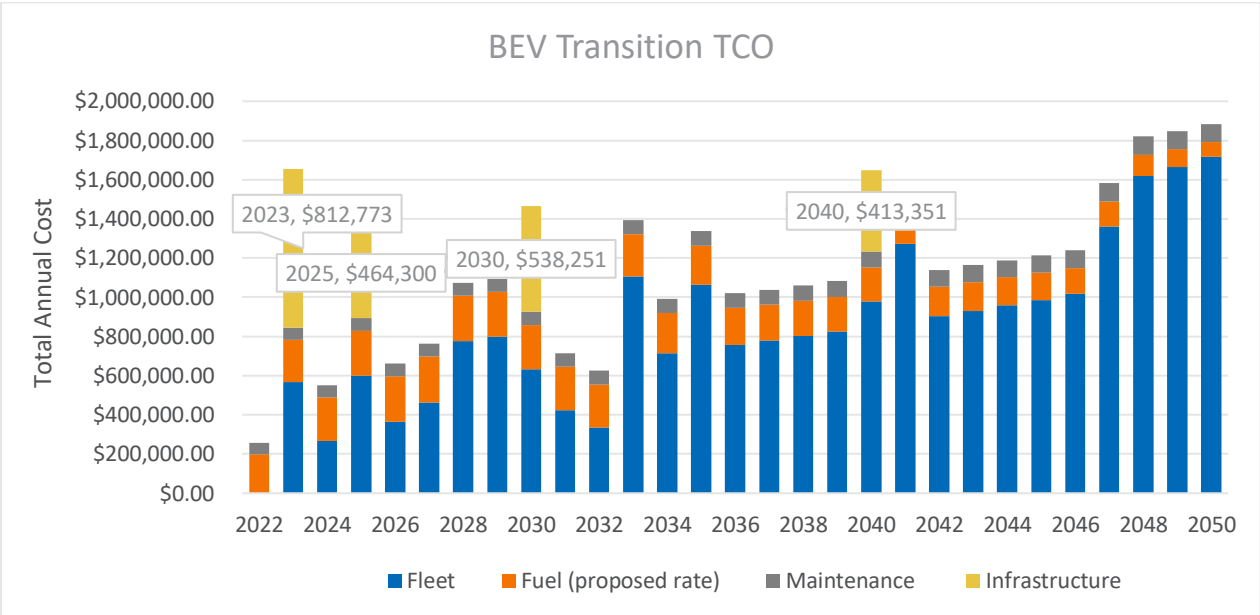


Figure 18. BEB Transition Annual Costs

**Table 10** compares the costs in each assessment between the transition scenario and the baseline, (all ICE) scenario. The total difference between transitioning and not transitioning to BEV from 2022-2050 is \$18,410,000.

Much of this additional cost is incurred during the fleet expansion to continue providing the same average daily miles of service. If BEV cutaway energy storage or DC fast charge capabilities experience a large jump, the number of vehicles needed will decrease from CTE’s estimations, reducing costs for additional vehicles.

Table 10. Transition Cost Summary by Scenario and Assessment

	Transition	Baseline	Total Cost Difference
<b>Fleet</b>	\$24,690,000	\$5,900,000	\$18,780,000
<b>Infrastructure</b>	\$2,230,000	N/A	\$2,230,000
<b>Fuel</b>	\$5,260,000	\$7,470,000	-\$2,210,000
<b>Maintenance</b>	\$2,210,000	\$2,600,000	-\$390,000
<b>Total Cost of Ownership</b>	\$34,380,000	\$15,970,000	\$18,410,000

This cost breakdown is also shown in **Table 11**, which includes the initial investment to transition to 100% BEBs by 2050, additional bus replacement capital, electricity to recharge the buses, and maintenance operating costs over the 28-year transition period.

Table 11. Total Cost of Ownership (2022-2050)

	ICE Baseline	BEV Incremental Costs	BEV Total Cost of Ownership
Initial Vehicles (2022-2050)	-	\$4,290,000	<b>\$4,290,000</b>
Vehicle Replacements (2022-2050)	\$ 5,900,000	\$14,500,000	<b>\$20,400,000</b>
Charging Equipment and Fueling Infrastructure (2022-2050)	-	\$2,230,000	<b>\$2,230,000</b>
Fuel (2022-2050)	\$7,470,000	(\$2,210,000)	<b>\$5,260,000</b>
Maintenance (2022-2050)	\$2,600,000	(\$390,000)	<b>\$2,210,000</b>
<b>Total</b>	<b>\$15,970,000</b>	<b>\$18,410,000</b>	<b>\$34,380,000</b>

It is also important to consider that there was already a significant amount of cost that would be incurred over that time even without switching to zero-emission technology.

In **Table 11**, all ICE related procurement and fuel costs were removed from the transition scenario to determine the incremental capital investment needed for a BEV transition. In addition, the prices of ICE related fuel and maintenance costs were removed from the transition scenario. The reflected costs are shown in **Table 11**, which shows that the incremental cost for HATS' BEV transition is roughly \$18.4 million.

## Conclusion

Current capabilities of the cutaway market make it challenging to meet daily operational needs. If longer range electric cutaway vehicles come to market, fewer vehicles will be needed to satisfy operational needs. Given HATS' operation at the time of this study, there were a number of challenges to consider in order to determine the most practical and cost-effective transition pathway to a fully battery electric vehicle fleet. The plan that HATS has set forth meets the expectations of NCDOT's transition goals and provides a blueprint for cutaway fleets with similar service to transition to zero emission vehicles by 2050. This study concludes that fuel and maintenance savings offset projected infrastructure costs incurred during the transition. CTE recommends revisiting this plan to ensure emerging technology is reviewed and implemented accordingly.

## Conclusions and Recommendations

ZEB technologies are in a period of rapid development and change. While the technologies have been proven in many pilot deployments, they are not yet matured to the point where they can easily replace current fossil-fuel technologies on a large scale. BEVs require significant investment in facilities and infrastructure and may require changes to service and operations to manage their constraints.

NCDOT's transition goals are an achievement toward addressing the challenges of climate change and improving local air quality with a goal of 100% zero-emission transit fleets by 2050. However, as demonstrated in this analysis, there will be substantial costs and technical challenges to overcome. Transit agencies may be challenged to meet this goal while maintaining the same level of passenger service. This analysis also showed that HATS has the feasibility to reach this goal, given that HATS has the resources needed to expand their fleet.

In an all-BEV strategy, total ZEV transitional costs are likely to be around \$34.4 million. The difference in cost between this scenario and the current fleet configuration is largely the result of the price difference between ICE vehicles and BEVs.

Given these considerations, the recommendations for HATS are as follows:

1. **Remain proactive with ZEB deployments:** For successful fleetwide deployment, BEVs will require charge management software, hardware, and standards to manage the fleetwide transition. HATS should move forward thoughtfully, taking advantage of various grant and incentive programs to offset the incremental cost for ZEV deployment. Incentive programs may be eliminated in future years as ZEV procurements are required instead of being optional.
2. **Target specific routes and blocks for early ZEV deployments:** HATS should consider the strengths of ZEB technologies and focus those technologies on routes and blocks that take advantage of their efficiencies and minimize the impact of the constraints related to the respective technologies. These technologies cannot follow a one-size-fits-all approach from either a performance or cost perspective. Matching the technology to the service will be a critical best practice.

The transition to ZEV technologies represents a paradigm shift in bus procurement, operation, maintenance, and infrastructure. It is only through a continual process of deployment with specific goals for advancement that the industry can achieve the goal of economically sustainable, zero-emission public transit.

Finally, this report is meant to serve as a living document that will be revisited every two to three years. As noted throughout, there were numerous assumptions made in creating this report and although these assumptions are made with the best available information, there is a level of unavoidable uncertainty when looking several years into the future. Although the projections for the next two years are fairly reliable, zero-emission technology is still advancing rapidly and it will be important for HATS to reassess this Transition Plan document fairly regularly.

# Appendix: Rate Schedules

The following Rate Schedule, Small General Service Schedule SGS-TOU-74, from Duke Energy Progress was used in the fuel assessment to estimate electrical costs for ZEVs.

Duke Energy Progress, LLC  
(North Carolina Only)

G-5

## SMALL GENERAL SERVICE (TIME-OF-USE) SCHEDULE SGS-TOU-74

### AVAILABILITY

This Schedule is available on a voluntary basis for electric service used by a nonresidential customer with an initial Contract Demand of 30 kW or greater but less than 1,000 kW. This Schedule is also available to an existing nonresidential customer with a Contract Demand below 30 kW (1) if service is also received under Net Metering for Renewable Energy Facilities Rider NM or (2) if served under the Small General Service (Time-of-Use) Schedule SGS-TOU before December 1, 2013, until such time as service is terminated or service is elected under another available schedule.

This Schedule is not available: (1) for residential service; (2) for breakdown, standby, or supplementary service, unless used in conjunction with the applicable standby or generation service rider for a continuous period of not less than one year; (3) for resale service; (4) for new applicants with a Contract Demand below 30 kW on and after December 1, 2013; or (5) whenever the registered or computed demand equals or exceeds 1,000 kW and an increase in the capacity of Company's facilities is required.

### APPLICABILITY

This Schedule is applicable to all electric service of the same available type supplied to Customer's premises at one point of delivery through one meter.

### TYPE OF SERVICE

The types of service to which this Schedule is applicable are alternating current, 60 hertz, single-phase 2 or 3 wires, or three-phase 3 or 4 wires, at Company's standard voltages. When Customer desires two or more types of service, which types can be supplied from a single-phase 3 wire type or a three-phase 4 wire type, without voltage transformation, only the one of these two types necessary for Customer's requirements will be supplied.

### CONTRACT DEMAND

The Contract Demand shall be the kW of demand specified in the Service Agreement.

### MONTHLY RATE

- I. Service used during the calendar months of June through September:
  - A. Basic Customer Charge:  
\$35.50
  - B. kW Demand Charge:
    - 1. \$ 13.51 per kW for all kW of on-peak Billing Demand
    - 2. \$ 1.40 per kW for all off-peak excess Billing Demand

SGS-TOU-74

Sheet 1 of 4

*Appendix Figure 1. Duke Energy Progress, LLC Small General Service (TIME-OF-USE) Schedule SGS-TOU-74 – Monthly Rate and Demand Charges*

- C. kWh Energy Charge:
    - 5.748¢ per on-peak kWh
    - 4.431¢ per off-peak kWh
  - II. Service used during the calendar months of October through May:
    - A. Basic Customer Charge:
      - \$35.50
    - B. kW Demand Charge:
      - 1. \$11.40 per kW for all kW of on-peak Billing Demand
      - 2. \$1.40 per kW for all off-peak excess Billing Demand
    - C. kWh Energy Charge:
      - 5.748¢ per on-peak kWh
      - 4.431¢ per off-peak kWh
  - III. Renewable Energy Portfolio Standard (REPS) Adjustment:
 

The monthly bill shall include a REPS Adjustment based upon the revenue classification:

    - Commercial/Governmental Classification - \$7.40/month
    - Industrial/Public Authority Classification - \$49.42/month

Upon written request, only one REPS Adjustment shall apply to premises serving the same customer for all accounts of the same revenue classification. If a customer has accounts which serve in an auxiliary role to a main account on the same premises, no REPS charge should apply to the auxiliary accounts regardless of their revenue classification (see Annual Billing Adjustments Rider BA).
  - IV. Minimum Bill:

The minimum monthly charge shall be the sum of (1) the Basic Customer Charge, (2) the REPS Adjustment, (3) 5.443¢ per kWh, and (4) \$1.40 per kW for the higher of: (a) the Contract Demand or (b) the maximum monthly 15-minute demand during the current and preceding 11 billing months.
  - V. Storm Securitization Charge:

A Storm Securitization charge will be added to the monthly bill based on the currently approved cents/kWh incremental rate as shown in the Storm Securitization Rider (STS).
- BILLING DEMANDS**
- I. The on-peak Billing Demand shall be the maximum demand registered or computed from Company's metering facilities used in the on-peak hours of the current month during any 15-minute interval.
  - II. The off-peak excess Billing Demand is the maximum demand registered or computed from Company's metering facilities used during any 15-minute interval in the off-peak hours of the current month less the on-peak Billing Demand.

*Appendix Figure 2. Duke Energy Progress, LLC Small General Service (TIME-OF-USE) Schedule SGS-TOU-74 – Monthly Rate and Demand Charges continued*

#### DETERMINATION OF ON-PEAK AND OFF-PEAK HOURS

##### I. On-Peak Hours:

- A. Service used beginning at 12:00 midnight March 31 and ending at 12:00 midnight September 30:

The on-peak hours are defined as the hours between 10:00 a.m. and 10:00 p.m., Monday through Friday, excluding holidays considered as off-peak.

- B. Service used beginning at 12:00 midnight September 30 and ending at 12:00 midnight March 31:

The on-peak hours are defined as those hours between 6:00 a.m. and 1:00 p.m., plus 4:00 p.m. through 9:00 p.m., Monday through Friday, excluding holidays considered as off-peak.

##### II. Off-Peak Hours:

The off-peak hours in any month are defined as all hours not specified above as on-peak hours. All hours for the following holidays will be considered as off-peak: New Year's Day, Good Friday, Memorial Day, Independence Day, Labor Day, Thanksgiving Day and the day after, and Christmas Day. When one of the above holidays falls on a Saturday, the Friday before the holiday will be considered off-peak; when the holiday falls on a Sunday, the following Monday will be considered off-peak.

#### SALES TAX

To the above charges will be added any applicable North Carolina Sales Tax.

#### PAYMENTS

Bills are due when rendered and are payable within 25 days from the date of the bill. If any bill is not so paid, Company has the right to suspend service in accordance with its Service Regulations. In addition, any bill not paid on or before the expiration of twenty-five (25) days from the date of the bill is subject to an additional charge of 1% per month as provided in Rule R12-9 of the Rules and Regulations of the North Carolina Utilities Commission.

#### CONTRACT PERIOD

The Contract Period shall not be less than one year, except where Customer fails to meet the availability requirements of this Schedule. For short-term, construction, or temporary service, the Contract Period may be for the period requested by the Customer and in such event Customer agrees:

- I. That the service supplied shall be for a continuous period until discontinued; and
- II. That where it is necessary for Company to extend lines, erect transformers, or do any work necessary to supply service, Customer shall pay for the line extension in accordance with Line Extension Plan E.

#### GENERAL

Service rendered under this Schedule is subject to the provisions of the Company's Service Regulations, and any changes therein, substitutions therefore, or additions thereto lawfully made.

*Appendix Figure 3. Duke Energy Progress, LLC Small General Service (TIME-OF-USE) Schedule SGS-TOU-74 – Off Peak Hours*

ADDITIONAL CHARGES

The MONTHLY RATE includes fuel, DSM and EE Billing Adjustment Factors set forth in Annual Billing Adjustments Rider BA, Excess Deferred Income Tax Riders EDIT-3 and EDIT-4, Storm Cost Recovery SCR, Joint Agency Asset Rider JAA, and Competitive Procurement of Renewable Energy Rider CPRE.

Supersedes Schedule SGS-TOU-72  
Effective for service rendered on and after June 1, 2022  
NCUC Docket No. E-2, Sub 1219

SGS-TOU-74

Sheet 4 of 4

*Appendix Figure 4. Duke Energy Progress, LLC Small General Service (TIME-OF-USE) Schedule SGS-TOU-74  
– Additional Charges*