Kimley»Horn

# MEMORANDUM

To: City Council, Charlottesville Area Transit

*City of Charlottesville*

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Date: July 12, 2023

Subject: CAT Feasibility of Alternative-Fuel Buses Study
Executive Summary of Analysis

## Introduction

This memo documents the background and preliminary findings of the Charlottesville Area Transit (CAT) Alternative-Fuel Buses Study. This study, initiated in mid-2022, is intended to support the adopted climate goals of the City of Charlottesville, which seeks to reduce carbon emissions 45% by 2030 and achieve carbon neutrality by 2050.

The complete report discusses the short and long-term goal of transitioning the CAT's fleet to alternative fueled vehicles with the goal to reach zero carbon emissions by 2050 without sacrificing quality of service. This is discussed in the context of current and future technology advancements with a focus on technical viability and risk related to continuity of operations. Factors that were considered are range and current/planned system needs, size and ridership capacity, emissions reduction (both greenhouse and other health-related emissions), capital and life cycle costs, fuel costs per mile, infrastructure costs associated with depot and on-route chagrining, and maintenance costs per mile and over the life of the vehicle.

A complimenting memorandum describing the climate and health impacts of the alternative fuel scenarios was completed concurrently with the feasibility study and its findings are summarized below and incorporated by reference.

## Alternative Scenarios

Six fleet transition scenarios were developed for this study:

0. Diesel ("business as usual" as a comparative baseline)
1. Battery Electric Buses (BEB)
2. Battery Electric Buses with Fast Charging Locations On-Route
3. Battery Electric Buses with Low Vehicle Replacement Ratio Estimate
4. Fuel Cell Electric Buses (FCEB, also known as Hydrogen or Hydrogen Fuel Cell)
5. Natural Gas (Compressed Natural Gas, CNG, and Renewable Natural Gas, RNG)

All transition scenarios were based on the range requirements from CAT's system optimization plan and CAT's planned expansion of its fleet. All scenarios consider some baseline assumptions regarding feasibility such as fuel availability and ability to purchase sufficient quantities of vehicles in needed replacement years. These are considered in the comparison of findings.

## Findings

This section summarizes potential applications and considerations for the alternatives described in this study. Long-term considerations/opportunities for further study are described in the full report.

### Compressed Natural Gas

A transition to natural gas vehicles (either compressed natural gas, CNG or renewable natural gas, RNG) would be the simplest scenario for CAT in terms of feasibility. Natural gas buses are a mature technology for transit applications; natural gas buses are highly reliable, fuel sourcing is abundant and dependable, and natural gas buses have been used by multiple transit agencies such as Greater Richmond Transit Company (142 buses, planned to be 85% natural gas), Arlington County Transit (78 busses, currently 100% natural gas), and Metrobus (1,578 buses, 28% natural gas). A full-scale deployment of natural gas buses would also be the cheapest option among the alternative fuel scenarios.

While a switch to natural gas would provide a reduction in CAT's carbon emissions and emittance of other harmful pollutants (except for carbon monoxide which would increase significantly), switching purely to natural gas would not be congruent with the City of Charlottesville's carbon emissions reduction goal of becoming carbon neutral by 2050. The purchase of renewable natural gas provides a further reduction in carbon emissions, though is establishing a reliable and direct RNG source is likely to be challenging. There is a potential to purchase carbon offset credits through Charlottesville Gas utility, however any combustion-based technology will continue to emit greenhouse gases and particulate matter into the community.

### Battery Electric

The operational analysis results show that the commercially available Battery Electric Buses (BEBs) are capable of reliably serving only 38% of CAT's operational blocks under the system optimization plan. On-route charging could help to mitigate range challenges, but on-route chagrining can occur high expenses due to peak rate electrical costs and maintenance. Additionally, operations may suffer considering additional layover time required for the vehicle to recharge. Alternatively, a 100% BEB system could require CAT to increase the size of its fleet by deploying more than one BEB per block to meet range requirements (therefore requiring additional storage/facility space) or require changes to CAT scheduling and operations.

### Hydrogen Fuel Cell

Hydrogen fueling infrastructure is similar to natural gas infrastructure and the range of fuel cell vehicles are greater than BEBs. Additionally, refueling a fuel cell vehicle takes only six to ten minutes meaning fleet operations can be performed similarly to existing operations with diesel buses. Hydrogen deployment also becomes more cost effective with larger fleets since fueling infrastructure remains nearly the same with an increase in fleet size. If CAT were to adopt hydrogen fuel as the preferred fuel type, CAT would not be required to change their service structure and could perform a 1:1 fleet transition.

Challenges to hydrogen fuel include the cost and availability of Fuel Cell Electric Buses (FCEBs) less than 40'. Hydrogen fuel is still maturing and not widely used for municipal purposes outside of California, thus few manufacturers currently produce FCEBs. CAT would likely have hydrogen fuel delivered by truck or construct a hydrogen production facility. Further funding and research through initiatives including the Department of Energy's "Hydrogen Energy Earthshot" will help to reduce the cost of hydrogen in the future, targeting a cost of $1 per 1 kg hydrogen compared to approximately $9 per 1 kg of hydrogen in today's market.

### Comparison of Scenarios

Based on the information above, **Table 1** summarizes the numerical comparison of each alternative scenario for greenhouse gas emissions, capital costs, and operational costs.

*Table 1: Summary Comparison of Scenarios*

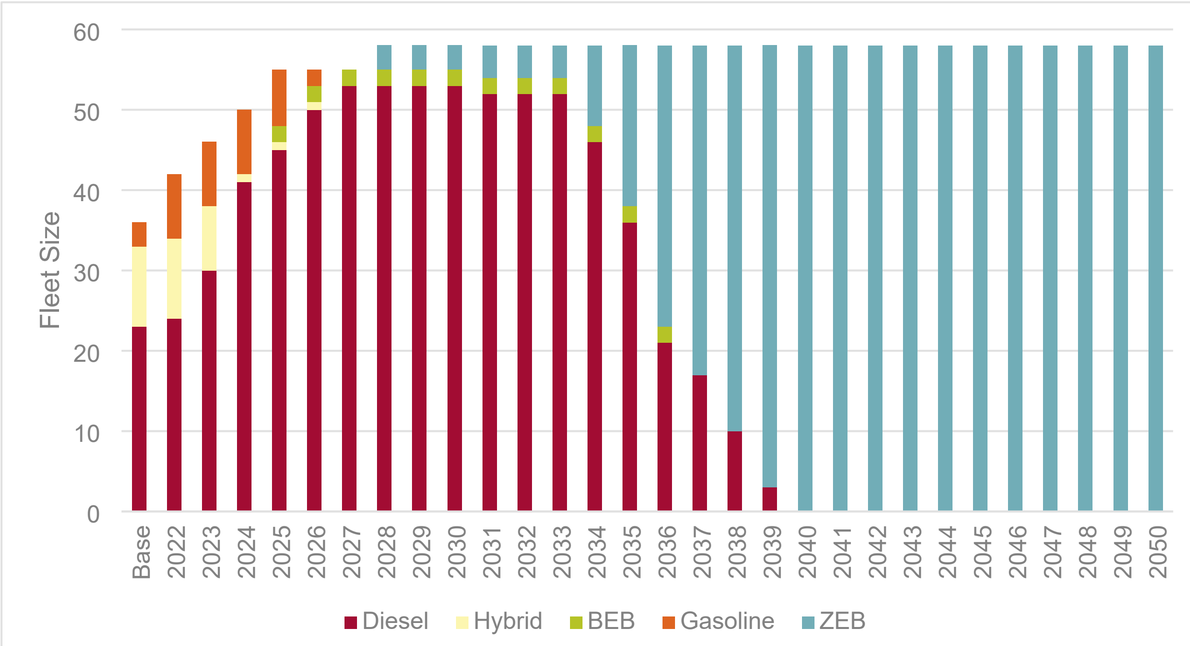
| Scenario | Number of Vehicles | Emissions Reduction | | Vehicle Costs | Facility Costs | Operational Costs (Fuel + Maintenance) |
|---|---|---|---|---|---|---|
| | | Long-Term | Near-Term | | | |
| Diesel | 58 | - | - | $29 M | - | $2.2 M |
| Battery Electric | 94 | 99.4% | 6.8% | $102 M | $7.6 M | $1.4 M |
| Battery Electric (Fast Charging) | 63 | 99.6% | 6.8% | $68.5 M | $6.0 M | $1.45 M |
| Battery Electric (Low Estimate) | 58 | 99.6% | 6.8% | $60 M | $4.7 M | $1.3 M |
| Hydrogen | 58 | 99.0% | 5.1% | $78.5 M | $5.7 M | $1.8 M |
| CNG/RNG | 58 | 7.3% | 3.1% | $39 M | $2.3 M | $1.7 M |

## Transition Timeline

The following three charts indicate potential fleet transition scenarios based on the above technical analysis and the planned replacement of CAT buses considering federal useful life requirements.

**Figure 1** shows alternatives that assume 1 alternative-fuel bus replaces each diesel bus that reaches useful life balance. **Figure 2** accounts for a higher replacement ratio for BEBs due to range limitations (1:1.62 based on modeling results). **Figure 3** accounts for the installation of fast chargers at the downtown transit station and minor expansion to accommodate longer routes with midday vehicle swap-out for routes which do not access the downtown transit station.

*Figure 1: 1:1 Fleet Transition Scenario*




*Note "ZEB" refers to Low OR Zero-Emissions fuels as a generic term, BEB, FCEB, CNG, or RNG.*

*Figure 2: 100% BEB Transition Scenario*

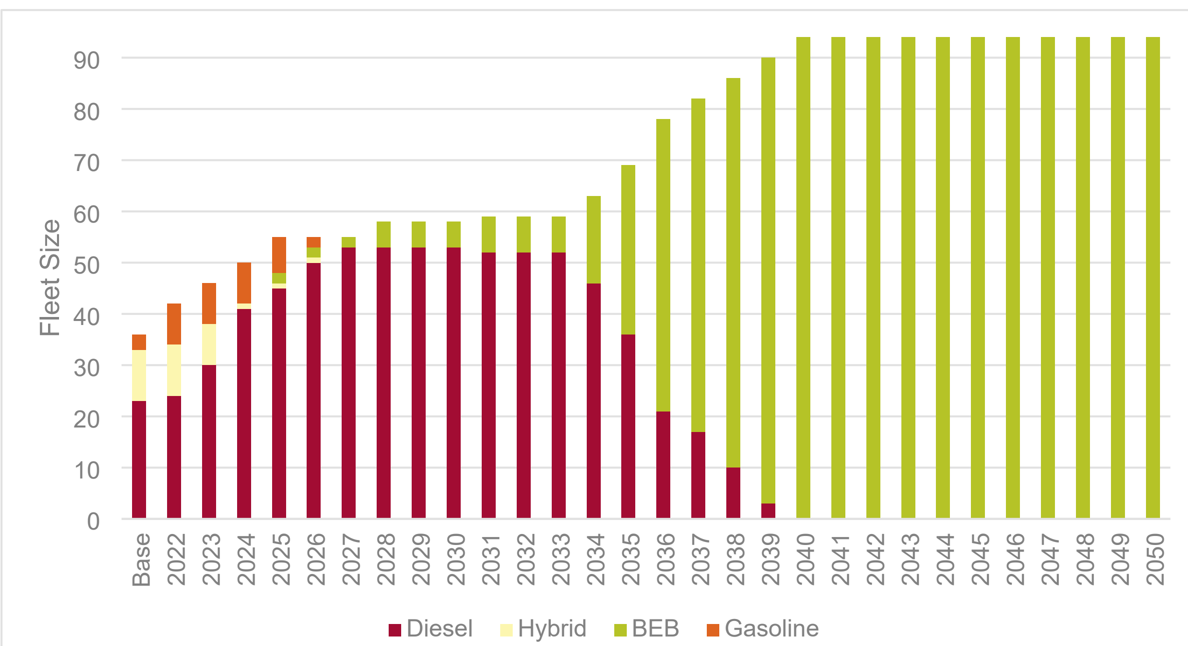
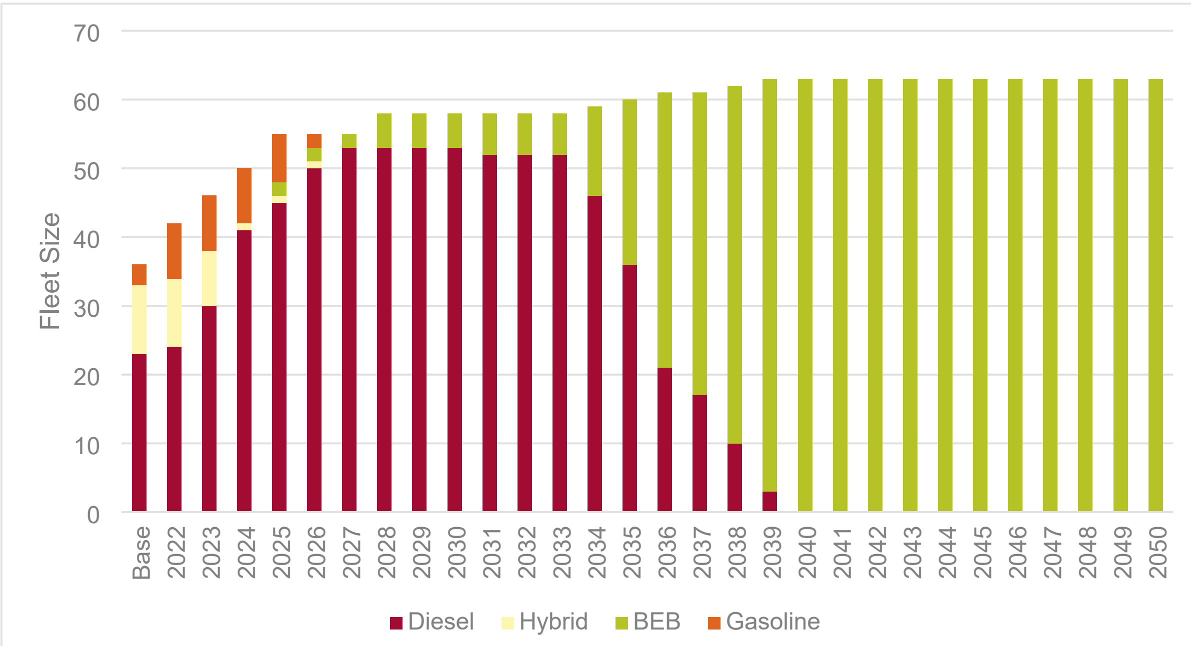


*Figure 3: BEB with Fast Charger Fleet Transition Scenario*




## Recommendations

Prior to the development of study recommendations, the project team will work with City Council and public representatives to prepare a priority order for the aforementioned alternative fuel scenarios. The scenario(s) determined viable following public engagement will be advanced to the next phase of study to move from theoretical assessment into conceptual design of facilities and implementation. This study will culminate in a alternative fuel transition plan for CAT in Fall 2023 for use in grant applications 2024 and beyond.