Zero-Emission Bus Rollout Plan

Prepared by Center for Transportation and the Environment

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List of Abbreviations

ADA: Americans with Disabilities Act
A&E: Architecture and Engineering
ACTC: Alameda County Transportation Commission
BEB: Battery Electric Bus
CA: California
CARB: California Air Resources Board
CCCTA: County Connection
CI: Carbon Intensity
CNG: Compressed Natural Gas
COVID/COVID-19: Coronavirus Disease 2019 (SARS-CoV-2)
CTE: Center for Transportation and the Environment
DAC: Disadvantaged Community
FCEB: Fuel Cell Electric Bus
HVAC: Heating, Ventilation, and Air Conditioning
ICE: Internal Combustion Engine
ICT: Innovative Clean Transit
kW: Kilowatt
kWh: Kilowatt-Hour
MTC: Metropolitan Transportation Commission
MV: MV Transportation
MW: Megawatt
OEM: Original Equipment Manufacturer
OET: Operator Excellence Training
PM: Particulate Matter
PPI: Producer Price Index
RCNG: Renewable Compressed Natural Gas
RFP: Request for Proposals
SCE: Southern California Edison (SoCal Edison)
TDA: Transportation Development Act
VTT: Verification of Transit Training
ZEB: Zero-Emission Bus

A glossary of useful terms can also be found in **Appendix C – Glossary**

Executive Summary

County Connection (CCCTA) provides transportation services to communities in Contra Costa County and serves 10 cities and towns plus one county, for a total of 11 jurisdictions. Communities served reside in Concord, Pleasant Hill, Martinez, Walnut Creek, Clayton, Lafayette, Orinda, Moraga, Danville, San Ramon, as well as unincorporated communities in Central Contra Costa County.

County Connection currently operates 125 transit buses which are a combination of renewable diesel and battery electric buses of varying sizes: 30-ft., 35-ft., and 40-ft. buses. County Connection LINK, the paratransit service is provided in and around the Central Costa County area using a fleet of 63 cutaway vehicles.

Based on outcomes of the zero-emission fleet transition planning study completed by the Center for Transportation and the Environment (CTE), County Connection plans to transition its fleet to a mix of battery electric buses (BEB) and fuel cell electric buses (FCEB). While the analysis described within this report focuses on depot-only fueling for both BEBs and FCEBs, County Connection has existing depot and on-route charging infrastructure and is committed to maintaining both. By 2040, County Connection expects to operate a zero-emission fleet of 125 transit buses, including a mix of 30-ft., 35-ft., and 40-ft. vehicles.

A mixed technology zero-emission fleet scenario provides a better range of options than a BEB-only fleet while mitigating the higher fuel cost of a FECB-only fleet. A mixed technology zero-emission fleet also offers resilience by allowing service to continue should either fuel (electricity or hydrogen) should become temporarily unavailable. This plan summarizes the charging and hydrogen infrastructure costs needed to support a fleet of 77 BEBs and 48 FCEBs.

Paratransit service was excluded from County Connection's ZEB Transition Plan and ICT Rollout Plan because at the time of completion, CARB had not revised its regulation regarding cutaway vehicles. The current policy allows agencies to defer cutaways until either January 1, 2026 or until a model has passed the Altoona bus testing procured and obtained a Bus Testing Report.

All of County Connection's services, including operations, maintenance, and administration, operate out of a single facility at 2477 Arnold Industrial Way in Concord, CA. The agency estimates a transition cost of additional $119 million in bus and infrastructure costs between 2021 and 2040, which is the incremental cost of first-time zero-emission-fleet purchases plus infrastructure capital. The transition cost differs from the total cost of ownership which adds in annual operating expenses over the transition period.

To support this fleet transition process, County Connection will build upon an existing training protocols to provide the necessary ZEB-specific training. County Connection also plans to pursue funding opportunities at the federal, state, and local levels.

A

Transit Agency Information

County Connection Profile

Central Contra-Costa Transit Authority (CCCTA) was established in 1980 and is now popularly referred to as County Connection. The agency provides fixed-route and paratransit bus service for Contra Costa County and serves 10 cities and towns plus one county, for a total of 11 jurisdictions, in the East Bay. Communities served reside in Concord, Pleasant Hill, Martinez, Walnut Creek, Clayton, Lafayette, Orinda, Moraga, Danville, San Ramon, as well as unincorporated communities in Central Contra Costa County, California[1]. The service area covers approximately 200 square miles and contains more than 482,000 residents[2]. County Connection's fleet includes 125 transit buses that operate daily, including twenty-nine 30-ft., thirteen 35-ft., and eighty-three 40-ft. buses, and 63 cutaway vehicles that provide paratransit services. County Connection currently has one maintenance facility, located at 2477 Arnold Industrial Way, Concord, CA 94520 as shown in **Figure 1.**

As a transit agency in California, County Connection is subject to the Innovative Clean Transit (ICT) regulation, requiring all California transit agencies to develop a plan to achieve a zero-emission fleet by 2040.

[1] County Connection. (2021, December 5). About webpage. https://countyconnection.com/about/

[2] National Renewable Energy Laboratory (NREL). (2018, December). Zero-Emission Bus Evaluation Results: County Connection Battery Electric Buses (NREL/TP-5400-72864). https://www.nrel.gov/docs/fy19osti/72864.pdf

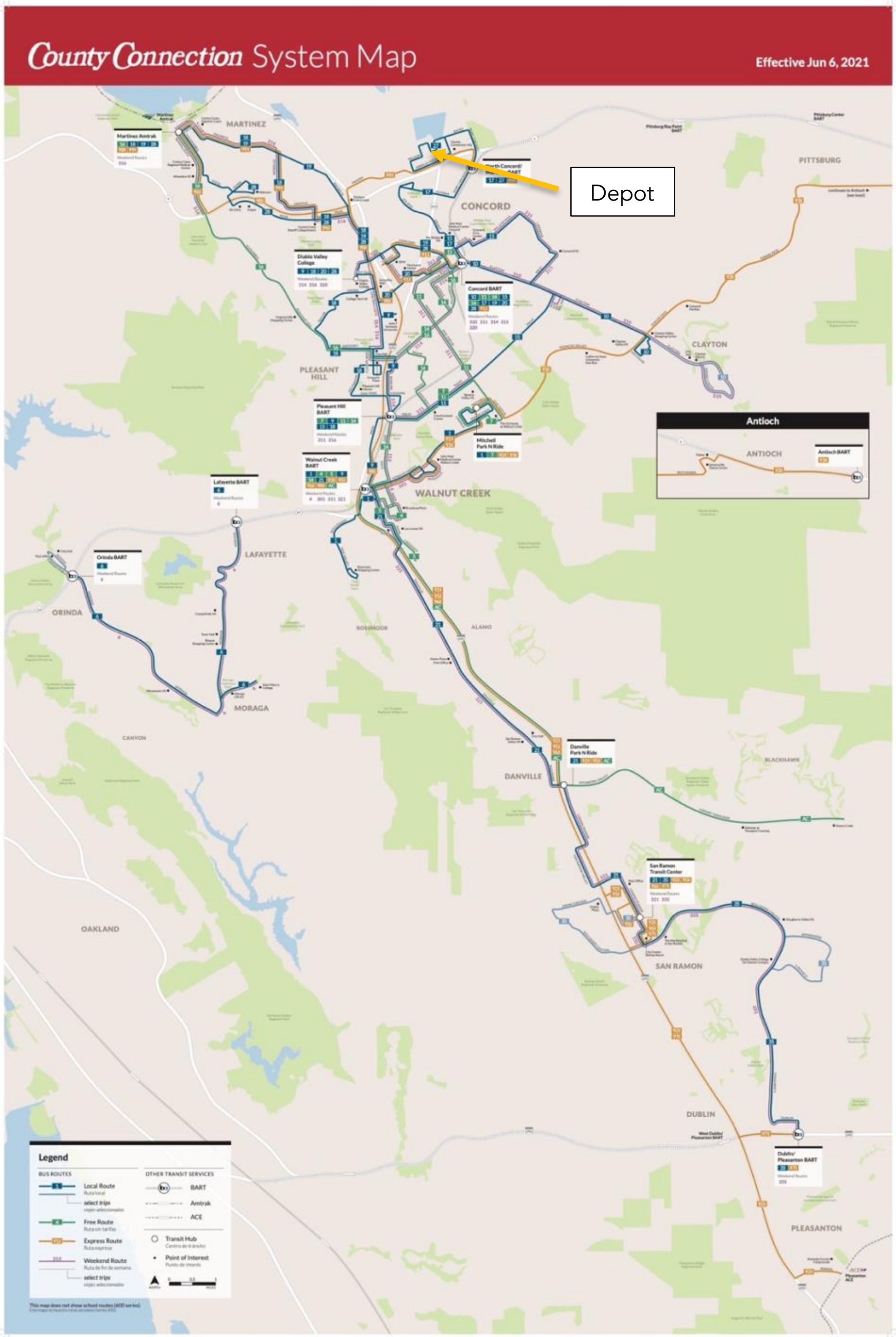

Figure 1 – County Connection System Map Highlighting Facility Location

County Connection Basic Information

Transit Agency's Name:
County Connection

Mailing Address:
County Connection Administrative Offices
2477 Arnold Industrial Way
Concord, CA 94520

Transit Agency's Air Districts:
County Connection is part of the Bay Area Air Quality Management District. California's 35 local Air Districts are responsible for regional air quality planning, monitoring, and stationary source and facility permitting. The districts administer air quality improvement grant programs and are CARB's primary partners in efforts to ensure that all Californians breathe clean air.[3]

Transit Agency's Air Basin:
County Connection is part of the San Francisco Bay Area Air Basin (SFBAAB), which comprises all of Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, and Santa Clara counties, the southern portion of Sonoma, and the southwestern portion of Solano County.

Total Number of Buses in Annual Maximum Service:
County Connection 87 fixed route vehicles in revenue service as of Fall 2022. The agency's total bus fleet is made up of 125 renewable diesel and battery electric buses. County Connection LINK, the paratransit service is provided in and around the Central Costa County area using a fleet of 63 cutaway vehicles.

Urbanized Area:
203.75 square miles

Population of Urbanized Area:
615,968 people in Concord, CA UZA[4]

Contact Information for Inquiries on the County Connection ICT Rollout Plan:
Bill Churchill, General Manager
Phone: 925-676-1976
Email: churchill@countyconnection.com

Is your transit agency part of a Joint Group?
No

[3] California Air Resources Board. (2022, February 24). California Air Districts webpage. https://ww2.arb.ca.gov/california-air-districts

[4] Federal Transit Administration. (2022, September 17). Urbanized Areas in Region 9. https://www.transit.dot.gov/region9/uza

County Connection's ZEB Mission

Agency Mission

"The Central Contra Costa Transit Authority (CCCTA) is committed to provide transportation services within the constraints of our suburban and financial environment. The Authority will also aggressively promote the expanded use of transit through creative implementation of programs and services to the communities we serve in order to improve air quality, reduce traffic congestion, and energy consumption."[5]

As part of the Central Contra Costa Transit Authority's Short Range Transit Plan, County Connection is committed to ensuring the transit fleet remains in a state of good repair while maneuvering itself to meet the growing needs of a diversifying population. Efforts to maintain state of good repair include the 2016 project funded by the FTA Low or No Emission program to replace the existing diesel trolley fleet that runs in Walnut Creek with electric trolleys and its necessary infrastructure with the aim of reducing long term fuel cost and reduce local emissions in a dense business district.

The transition to ZEB 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 transportation sector. Widespread adoption of zero-emission bus technology has the potential to significantly reduce greenhouse gas (GHG) emissions resulting from the transportation sector. With its 100% transition to ZEBs by 2040, County Connection is committed to improving air quality and reducing traffic congestion and energy consumption.

[5] Central Contra Costa Transit Authority. (2022, February 24). Short Range Transit Plan FY2011-12 through FY2020-21. http://countyconnection.com/wp-content/uploads/2010/06/Attachment-1-FY12-SRTP-Final-Draft.pdf

B

Rollout Plan General Information

Overview of the Innovative Clean Transit Regulation

On December 14, 2018, CARB enacted the Innovative Clean Transit (ICT) regulation, setting a goal for California public transit agencies to have zero-emission bus fleets by 2040. The regulation specifies the percentage of new bus procurements that must be zero-emission buses for each year of the transition period (2023–2040). The annual percentages for Small Transit agencies are as follows:

ICT Zero-Emission Bus Purchase Requirements for Small Agencies:

January 1, 2026 - 25% of all new bus purchases must be zero-emission

January 1, 2027 - 25% of all new bus purchases must be zero-emission

January 1, 2028 - 25% of all new bus purchases must be zero-emission

January 1, 2029+ - 100% of all new bus purchases must be zero-emission

March 2021-March 2050 – Annual compliance report due to CARB

This purchasing schedule guides agency procurements to realize the goal of zero-emission fleets in 2040 while avoiding any early retirement of vehicles that have not reached the end of their 12-year useful life. Agencies have the opportunity to request waivers that allow purchase deferrals in the event of economic hardship or if zero-emission technology cannot meet the service requirements of a given route. These concessions recognize that zero-emission technologies may cost more than current internal combustion engine (ICE) technologies on a vehicle lifecycle basis and that zero-emission technology may not currently be able to meet all service requirements.

County Connection's Rollout Plan General Information

County Connection's Rollout Plan achieves a zero-emission fleet in accordance with ICT's 2040 target. The agency's last internal combustion engine (ICE) buses will reach end of life in 2040.

Rollout Plan's Board Approval Date: October 20, 2022 (anticipated)

Resolution: No. 2023-XXX

Is a copy of the Board-approved resolution attached to the Rollout Plan? Yes, a copy of the Board-approved resolution in included as **Appendix A** – Approved Board Resolution

Contact for Rollout Plan follow-up questions:

Bill Churchill, General Manager
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Email: churchill@countyconnection.com

County Connection Administrative Offices
2477 Arnold Industrial Way
Concord, CA 94520

Who created the Rollout Plan?

County Connection authored this plan with assistance from the Center for Transportation and the Environment (CTE).

County Connection created their ICT Rollout Plan in combination with its Zero-Emission Bus Fleet Transition Study (February 2022), which describes County Connection's plans for transition in greater detail. The Transition Study will be maintained and updated regularly. As a result of CTE's fleet transition planning methodology described herein and in greater detail in the Transition Study, County Connection decided to pursue a mixed technology fleet of zero-emission buses. County Connection's fleet transition strategy is to replace each ICE bus with a battery-electric bus (BEB) or fuel cell electric bus (FCEB) as they reach the end of their useful life, thus avoiding the early retirement of ICE buses.

This document, the Zero-Emission Bus Rollout Plan, contains the information for County Connection's zero-emission fleet transition trajectory as requested by the ICT regulation. It is intended to outline the high-level plan for implementing of the transition. The Rollout Plan provides estimated timelines based on information on bus purchases, infrastructure upgrades, workforce training, and other developments and expenses that were available at the time of writing. County Connection may update the Rollout Plan as needed as the industry continues to develop.

C

Technology Portfolio

ZEB Transition Technology Selection

County Connection has elected to pursue a Mixed Fleet (BEB & FCEB). The fleet is projected to be zero-emission by 2040 when it will be comprised of 125 BEBs and FCEBs, including 30-ft., 35-ft., and 40-ft. transit buses. This Zero-Emission Bus Rollout Plan summarizes the charging and hydrogen infrastructure costs needed to support a fleet of 77 BEBs and 48 FCEBs. As detailed below, County Connection explored five possible ZEB transition scenarios:

- BEB Depot-Only with Diesel
- BEB Depot-Only with Fleet Expansion
- BEB Depot and On-Route
- Mixed Fleet (BEB & FCEB)
- FCEB-Only

County Connection decided not to pursue the three BEB-only scenarios for a number of reasons. All three BEB-only scenarios required alternative solutions such as maintaining a partial diesel fleet, fleet expansion, and/or on-route charging in order to meet County Connection's service needs. While these solutions could be helpful, they introduce challenges that include not being in compliance. The BEB depot-only with diesel scenario requires exemptions and is not in compliance with ICT regulation; the BEB depot-only with fleet expansion results in additional costs and does not fit within County Connection's existing depot footprint; and the BEB depot and on-route scenario requires additional costs, more infrastructure, and increased service time to cover on-route charging.

County Connection also decided against FCEB-only in order to provide greater flexibility in transitioning to ZEBs. Additionally, while there are benefits to a FCEB-only fleet, it has higher capital and operational costs and may not provide the resilience offered by a fleet consisting of multiple propulsion technologies.

County Connection is committed to pursuing a mixed fleet of zero-emission vehicles to offer reliance and flexibility. For example, if fueling for either the FCEBs or BEBs become temporarily unavailable, County Connection expects to be able to minimize service interruptions by relying on the available propulsion technology. While it may be a challenge to host both infrastructure types in the single depot that County Connection operates, FCEBs can replace diesel buses at a 1:1 ratio due to the similarities of hydrogen fueling to traditional fueling operations and longer demonstrated ranges than BEBs allowing them to complete blocks that BEBs cannot. Another advantage of a mixed fleet scenario is that it allows flexibility to use less expensive depot-charged BEB technology and infrastructure where possible and cover service needs with FCEBs as needed.

County Connection also plans to participate in the LCFS credit program, which will help offset the agency's fuel costs. The California state legislature has fostered growth in zero-emission fuels through the state's Low-Carbon Fuel Standard (LCFS) program, which incentivizes the consumption of fuels with a lower carbon intensity (CI) than traditional combustion fuels. The LCFS program aims to reduce carbon emissions by setting annual CI standards for the transportation sector. All transportation fuels have CI scores that are predetermined by CARB by taking into account all steps of fuel production, transportation, and consumption, also known as a complete lifecycle. Low carbon fuels below the CI benchmark generate credits while fuels above the CI benchmark generate deficits. In the LCFS program, one credit is equivalent to one metric ton of carbon dioxide reduction. The current program extends through 2030 but is expected to be renewed within the next few years.

Local Developments and Regional Market

California has become a global leader for zero-emission buses, as well as the zero-emission fuel and fueling infrastructure required to support these vehicles. California is leading the industry in the number of BEBs deployed, largely due to state support and CARB requirements to transition to clean transportation technologies.

California is home to four bus OEMs that manufacture zero-emission buses. Three of the four OEMs do not currently manufacture FCEBs; however, growing demand for this vehicle technology may encourage these manufacturers to enter the market. California also has one of the most mature hydrogen fueling network in the nation. California's hydrogen market has developed to support the growing number of fuel cell electric vehicles on the roads in the state. California has five medium-and-heavy-duty hydrogen fueling stations in operation and four more in development. Additionally, the number of hydrogen production and distribution centers is growing to meet increased hydrogen demand as it gains popularity as a transportation fuel. One of these distribution centers, operated by First Element Fuel, is located in nearby Livermore, CA.

ZEB Transition Planning Methodology

County Connection's Zero-Emission Bus Rollout Plan was created in combination with County Connection's ZEB Fleet Transition Study, using CTE's ZEB Transition Planning Methodology. CTE's methodology consists of a series of assessments that enable transit agencies to understand what resources and decisions are necessary to convert their fleets to zero-emission technologies. The results of the assessments help the agency decide on a step-by-step process to achieve its transition goals. These assessments consist of data collection, analysis, and modeling outcome reporting stages. These stages are sequential and build upon findings in previous steps. The assessment steps specific to County Connection's Rollout Plan are outlined below:

1. Planning and Initiation
2. Requirements Analysis & Data Collection
3. Service Assessment
4. Fleet Assessment

5. Fuel Assessment
6. Facilities Assessment
7. Maintenance Assessment
8. Total Cost of Ownership Assessment

For **Requirements Analysis & Data Collection,** CTE collects data on the agency's fleet, routes and blocks, operational data (e.g., mileage and fuel consumption), and maintenance costs. Using this data, CTE establishes service requirements to constrain the analyses in later assessments and produce agency-specific outputs for the zero-emission fleet transition plan.

The **Service Assessment** phase initiates the technical analysis phase of the study. Using information collected in the Data Collection phase, CTE evaluates the feasibility of using zero-emission buses to provide service to the agency's routes and blocks over the transition plan timeframe from 2021 to 2040. Results from the Service Assessment are used to guide ZEB procurement plans in the Fleet Assessment and to determine energy requirements in the Fuel Assessment.

The **Fleet Assessment** projects a timeline for the replacement of existing buses with ZEBs that is consistent with County Connection's existing fleet replacement plan and known procurements. This assessment also includes a projection of fleet capital costs over the transition timeline and is optimized to meet 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 full transition timeline for each fleet scenario, including the agency's existing fossil-fuel buses. To more accurately estimate battery electric bus (BEB) charging costs, a focused Charging Analysis is performed to simulate daily system-wide energy use. As older technologies are phased out in later years of the transition, the Fuel Assessment calculates the changing fuel requirements as the fleet transitions to ZEBs. The Fuel Assessment also provides a total fuel cost over the transition timeline.

The **Facilities Assessment** determines the infrastructure necessary to support the projected zero-emission fleet composition over the transition period based on results from the Fleet Assessment and Fuel Assessment. This assessment evaluates the required quantities of charging infrastructure and/or hydrogen fueling station projects and calculates the costs of infrastructure procurement and installation sequenced over the transition timeline.

The **Maintenance Assessment** calculates all projected fleet maintenance costs over the transition timeline. Maintenance costs are calculated for each fleet scenario and include costs of maintaining existing fossil-fuel buses that remain in the fleet and maintenance costs of new BEBs and FCEBs.

The **Total Cost of Ownership Assessment** compiles results from the previous assessment stages to provide a comprehensive view of all fleet transition costs, organized by scenario, over the transition timeline.

Requirements Analysis & Data Collection

The Requirements Analysis and Data Collection stage began by compiling operational data from County Connection regarding its current fleet and operations and establishing service requirements to constrain the analyses in later assessments. CTE requested data such as fleet composition, fuel consumption and cost, maintenance costs, and annual mileage from County Connection to use as the basis for analyses. CTE also collected GPS data from a representative sample of County Connection's routes, which was used as the basis for modelling energy efficiencies for BEBs operating in County Connection's service area. The calculated efficiencies were then used in the Service Assessment to determine the energy requirements of County Connection's service.

CTE evaluated BEBs and FCEBs in County Connection's service to support County Connection's technology selection. After collecting route and operational data for County Connection's current service of 60 routes operated on 167 blocks, CTE determined that County Connection's longest block is 363 miles. County Connection did not have a full picture of which technology or combination of technologies would be the best fit for the agency at this stage of the analysis, so it was necessary to determine how much of County Connection's service could feasibly be served by depot-only charged BEBs in order to develop a set of ZEB transition scenarios that allow the agency to make an informed decision on technologies deemed to be most suitable to the agency's needs. Based on observed performance, CTE estimates FCEBs are able to complete any block under 350 total miles, which means that future FCEB technology will likely have the ability to complete County Connection's longest block of 363 miles.

The energy efficiency and range of BEBs are primarily driven by bus specifications, such as on-board energy storage capacity and vehicle weight. Both metrics are affected by environmental and operating variables including the route profile (e.g., distance, dwell time, acceleration, sustained top speed over distance, average speed, and traffic conditions), topography (e.g., grades), climate (e.g., temperature), driver behavior, and operational conditions such as passenger loads and auxiliary loads. As such, BEB efficiency and range can vary dramatically from one agency to another or even from one service day to another. It was, therefore, critical for County Connection to determine efficiency and range estimates based on an accurate representation of its operating conditions.

To understand BEB performance on County Connection's routes, CTE modeled the impact of variations in passenger load, accessory load, and battery degradation on bus performance, fuel efficiency, and range. CTE ran models with different energy demands that represented nominal and strenuous conditions. Nominal loading conditions assume average passenger loads and moderate temperature over the course of the day, which places low 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. This nominal/strenuous approach offers a range of operating efficiencies to use for estimating average annual energy use (nominal) or planning minimum service demands (strenuous). Route modeling ultimately provides an average energy use per mile (kilowatt-hour/mile [kWh/mi]) for each route, bus size, and load case.

The range of a battery electric bus is reduced over time due to battery degradation. Thus, in combination with loading conditions, CTE modeled the impact of battery degradation on a BEB's ability to complete a block. A BEB may be able to service a given block with beginning-of-life batteries, while later it may be unable to complete the entire block at some point in the future as batteries near their end-of-life or derated capacity (typically considered 70-80% of available service energy).

Service Assessment Methodology

The Service Assessment analyzes the feasibility of maintaining County Connection's current level of service with battery-electric technology. In this stage, the efficiencies that were modeled in the

Requirements Analysis & Data Collection stage are used to estimate the energy requirements of County Connection's service.

The main focus of the Service Assessment is the block analysis, which determines if generic battery electric technology can meet the service requirements of a block based on range limitations, weather conditions, levels of battery degradation and route specific requirements. The Transit Research Board's Transit Cooperative Research Program defines a block as "the work assignment for only a single vehicle for a single service workday"[6] and is usually comprised of several trips on various routes. The energy needed to complete a block is compared to the available energy of the bus assigned to service the block. If the bus's usable onboard energy exceeds the energy required by the block, then the conclusion is that the battery electric bus can successfully operate on that block.

Results from this analysis are used to determine the specific energy requirements for the agency, which are used to determine when, or if, a full transition to BEBs may be feasible and can be used to inform BEB procurements in the Fleet Assessment.

Modeling & Procurement Assumptions

CTE and County Connection defined the following assumptions and requirements to use throughout the Transition Study:

- The Service Assessment applies assumptions to battery electric technology improvement over time. The analysis assumes a 5% improvement in battery capacity two years, with a cap at 733 kWh and a starting battery capacity of 450 kWh.
- The analysis also assumes blocks will maintain a similar distribution of distance, relative speeds, and elevation changes that existed at County Connection pre-COVID 19 since bus service will continue to serve similar locations within the city and use similar roads to reach these destinations even if specific routes and schedules change.
- County Connection's fleet composition remains constant. No buses are assumed to be added and current buses will be replaced with buses of the same length.
- Buses are assumed to operate for a 12-year service life.
- Usable on-board energy is assumed to be that of a mid-life battery with a reserve at both the high and low end of the battery's charge potential to give a conservative estimate of service performance. Charging batteries to 100% or dropping the charge below 10% also degrades the batteries over time, which is why it was assumed that the top and bottom portions of the battery are unusable. This 80% useable battery capacity is called the service energy or service capacity.. As previously discussed, battery age affects range, so a mid-life battery is assumed to have a 72% capacity.

[6] TRB's Transit Cooperative Research Program. 2014. TCRP Report 30: Transit Scheduling: Basic and Advanced Manuals (Part B). https://onlinepubs.trb.org/onlinepubs/tcrp/tcrp_rpt_30-b.pdf

Results

The Service Assessment determines the timeline for when County Connection's service may become achievable by BEBs on a single depot charge. County Connection has existing on-route infrastructure and intends to continue pursuing on-route charging as a supplement to depot charging; however, the mixed-fleet analysis described in this report includes depot-only charging.

County Connection and CTE can then use the Service Assessment results to inform ZEB procurement decisions in the Fleet Assessment. Results from this analysis are also used to determine the specific energy requirements and fuel consumption of the fleet over time. These values are later used in the Fuel Assessment to estimate the fueling costs to operate the transitioning fleet.

While routes and block schedules are unlikely to remain the same over the course of the transition period, these projections assume the blocks will maintain a similar distribution to current service because County Connection will continue to serve similar destinations within the city. This core assumption affects energy use estimates and block achievability in each year.

The results from County Connection's Service Assessment can be seen below in Figure 2. Based on CTE's analysis, by 2040, 67% of County Connection's 35-ft. and 40-ft. blocks can be completed under normal driving conditions when operating a 450-kWh usable battery capacity with 5% improvement every two years capped at a 733 kWh maximum capacity for 35-ft. and 40-ft. BEBs.

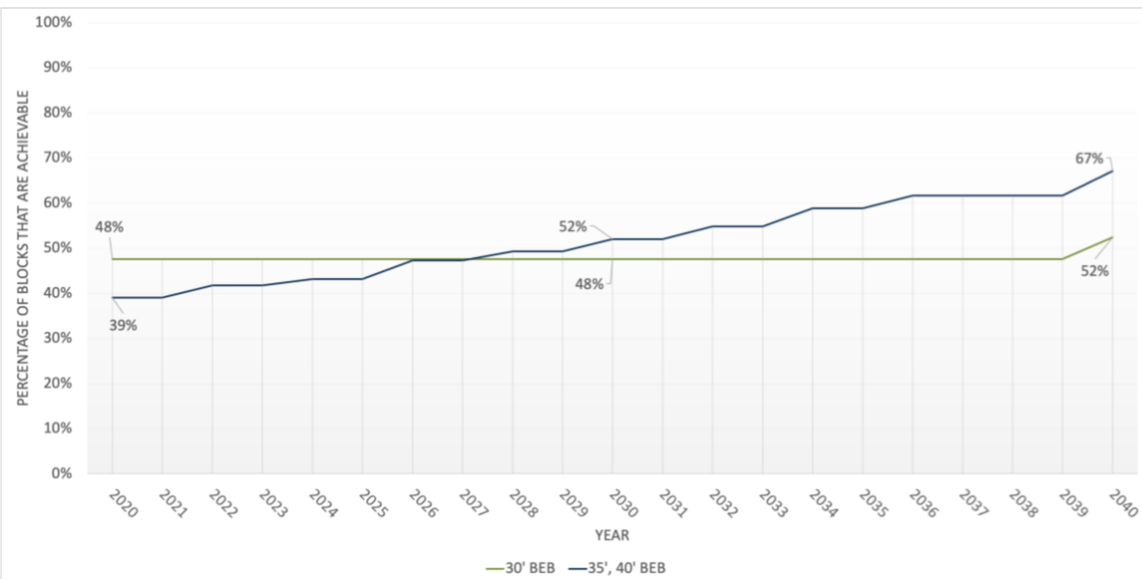

Figure 2 – 30', 35', 40' BEB Block Achievability Percentage by Year

Description of ZEB Technology Solutions Considered

With the Service Assessment results showing that all of County Connection's service would not be feasible with today's BEB technology on a single charge, CTE developed four transition scenarios that provide zero-emission solutions for serving the more energy-intensive blocks by supplementing the range of BEBs, as well as a fifth scenario that would entirely avoid the range limitations of BEBs.

The scenarios are:

- BEB with Depot-Only charging, with continuation of the use of diesel buses
- BEB Depot-Only charging which includes fleet expansion
- BEB with Depot and On-Route charging
- Mixed Fleet of BEB Depot-Only charging and FCEB, which assumed BEBs would be deployed on the blocks that could be served by with the onboard energy of an overnight depot-charged BEB and that FCEBs would be deployed on the longer blocks
- FCEB-only scenario, in which FCEBs would serve every route because they meet County Connection's range requirements for every route

In the BEB with Depot-Only charging and diesel buses scenario, BEBs are purchased and deployed only on blocks that are within a BEB's achievable range as determined by CTE's modeling. If depot-charged BEBs are not capable of meeting a transit agency's daily service requirements, there is component in the ICT regulation that allows the agency to request an exemption to retain ICE buses in their fleet. The analysis results showed County Connection would need to request an exemption to maintain 99 diesel buses in its fleet from 2030 to 2033; 59 diesel buses from 2034 to 2036; 55 diesel buses from 2037 to 2039; and 48 diesel buses in 2040 under this scenario.

Alternatively, in the BEB Depot-Only charging with fleet expansion scenario, blocks that exceed the modeled range for a single BEB may be achievable through vehicle swapping and serviced by two BEBs to replace the service of one ICE bus (i.e., 2:1 ratio). A second BEB enters service once the BEB that was deployed at the beginning of the service day reaches its energy capacity limit and cannot complete the block before charging. The objective of this scenario is to meet existing bus service requirements with an entirely BEB fleet without requiring on-route charging. A uniformly BEB fleet allows for the installation of a single fueling technology at the depot, which can be helpful for streamlining operations and depot configurations.

In the BEB with Depot and On-Route charging scenario, on-route charging supplements depot charging to support a fully BEB fleet. For blocks that cannot be completed on a single overnight charge, on-route charging allows an agency to add energy to buses while in- service and provide the additional energy necessary to complete a block without having to travel the extra distance and take the extra time to return to a depot for charging. The costs for infrastructure and installation of on-route charging as well as added operator labor expenses are estimated.

A Mixed Fleet (BEB and FCEB) scenario was developed to cover the range limitations and charging duration limitations of BEB technology. The range of FCEBs exceeds that of BEBs, so this assessment considers FCEBs capable of replacing diesel buses at a 1:1 ratio. FCEBs and hydrogen fuel, however, are more expensive than BEBs and electricity, so a mixed fleet allows an agency to use the less expensive BEB technology where possible and supplement service with FCEBs as needed. A mixed fleet is also more resilient as it would allow service to continue if either fuel became temporarily unavailable for any reason. The split of BEB and FCEBs was determined by the percentage of routes and service that could first be completed with BEB technology, with FCEB used to complete the remaining blocks.

Finally, the FCEB-only scenario was developed to examine the costs for hydrogen fueling and transitioning to a 100% FCEB fleet. A fully FCEB fleet enables all ICE buses to be replaced at a 1:1 ratio. It also avoids the need to install two types of fueling infrastructure by eliminating the need for depot and on-route charging equipment. Fleets comprised entirely of fuel cell electric buses also offer the benefit of scalability compared to battery electric technologies. Adding FCEBs to a fleet does not necessitate large complementary infrastructure upgrades. Despite this benefit, the cost of FCEBs and hydrogen fuel are still more expensive than BEBs and electricity at current market prices.

CTE expects improvements in technology beyond the current state, but there is no indication of when the ZEB technology may improve to the point where BEBs can replace diesel buses one-for-one or when the cost of FCEBs or hydrogen fuel will decrease to cost- competitive levels. As a result, when considering the various scenarios, this study can be used to develop an understanding of the range of costs that may be expected for County Connection's ZEB transition, but ultimately, can only provide an estimate.

As noted in the introductory paragraph of this section, County Connection plans to transition its fleet to a mix of BEBs and FCEBs. The mixed technology fleet approach allows the agency to use the less expensive BEB technology where possible and minimizes range and charging duration limitations that are typically experienced with BEB technologies because FCEBs are available for routes with greater service energy demands. A mixed technology fleet also offers resilience by allowing service to continue should either fuel should become temporarily unavailable. The remainder of this ZEB Rollout Plan describes compliance with the ICT regulation based on the mixed fleet scenario selection.

D

Current Bus Fleet Composition and Future Bus Purchases

Description of County Connection's Current Fleet

County Connection's current service and fleet composition provide the baseline for evaluating the costs of transitioning to a zero-emission fleet. County Connection staff provided the following key data on current service:

- Fleet composition by powertrain and fuel
- Routes and blocks
- Mileage and fuel consumption
- Maintenance costs

Fleet

County Connection's fleet is currently comprised of a combination of 125 renewable diesel and BEBs. Presently, as shown in **Table 1**Error! Reference source not found., 29 of these buses are 30-ft., 13 are 35-ft., and 83 are 40-ft. All buses are housed at a 2477 Arnold Industrial Way, Concord, California. Buses range in age from model year 2010 to 2018. County Connection plans on maintaining the same number and sizes of their current buses as they transition to 100% ZEBs.

Table 1 – County Connection Fleet Composition

Depot	Bus Length	Fuel Type			
		Diesel Hybrid (dHEB)	Diesel	BEB	Total
Concord	30'	--	21	8	29
	35'	--	13	--	13
	40'	9	74	--	83
	Total	9	108	8	125

Routes and Blocks

County Connection's 2021 service operated 60 fixed-service routes within 167 blocks. Blocks range in distance from 27.4 miles to 363.4 miles. Buses pull out as early as 03:31 and return as late as 23:16. County Connection's routes service Concord, Pleasant Hill, Martinez, Walnut Creek, Clayton, Lafayette, Orinda, Moraga, Danville, San Ramon, as well as unincorporated communities in Central Contra Costa County, California. A few routes also extend into Dublin, Pleasanton, Pittsburg, and Antioch.

Current Mileage and Fuel Consumption

County Connection currently operates a diesel and BEB fixed-route fleet. County Connection's ZEB Fleet Transition Plan assumes that the amount of service miles will remain the same.

Annual mileage of the fleet:
201,300 miles

Annual fuel consumption:
111,882 DGE for the existing fleet of 125 renewable diesel, diesel-hybrid, and battery-electric transit buses

Fleet average efficiency:
5.04 mpg

County Connection current fuel expense:
$1.3 million per year for the existing fleet of 125 transit buses

Average diesel cost:
$2.06 per gallon

Diesel Maintenance Costs

The maintenance assessment includes labor, materials, and midlife overhaul costs. Estimates were determined by applying a unit maintenance cost per mile by vehicle type with total costs based on average annual vehicle mileage as reported by County Connection. In non-midlife and replacement years, the baseline average annual maintenance cost is approximately $1.3 million.

Total costs for County Connection's transition planning are based on the following assumptions:

- Maintenance costs for diesel, diesel hybrid buses, BEBs based on data from County Connection's current fleet. It is important to keep in mind that maintenance costs are hard to predict. Compared to conventional diesel and gasoline fueled vehicles, BEBs have different maintenance needs that vary based on manufacturer and operating environment. In addition, some equipment for BEBs is covered by warranty so costs in the first few years for maintenance are significantly lower than in the latter half of their service lives. County Connection provided current cost data on maintaining early model BEBs to inform this assessment. Long-term maintenance costs are still to be determined and should be carefully considered as County Connection implements their transition plan.
- Hydrogen maintenance costs based on OCTA's reported labor and maintenance costs as a local, peer agency. The FCEB maintenance per mile value is based on the costs for the first year of

service at OCTA. Therefore, this cost is likely high and will eventually trend downward since this is a first-generation vehicle. Long-term FCEB maintenance costs for US manufactured buses are still to be determined and should be carefully considered as County Connection implements their transition plan.

Fleet Assessment Methodology

To satisfy this component of the ICT Rollout Plan, the Fleet Assessment is performed to project a timeline for the replacement of existing buses with BEBs and FCEBs. The timeline is consistent with County Connection's fleet replacement plan that is based on the FTA 12-year service life of transit buses. This assessment also includes a projection of fleet capital costs over the transition timeline.

ZEB Cost Assumptions

CTE and County Connection developed cost assumptions for future bus purchases, in

Table 2. Key assumptions for bus costs for the County Connection Transition Plan are as follows:

- The base price for each type of bus is based on the 2022 Metropolitan Transit Commission (MTC) Pricelist. This includes estimates for configurable options.
- The local sales tax (9.25%) is applied to the base price.
- The standard labor inflation rate is assumed at 3% per year.
- Inflation rate for the bus and charger equipment is assumed at 1.5% based on the PPI index.
- The nominal cost difference between diesel buses and ZEBs remains level over the ZEB transition period.

For bus lengths that are not currently available in the market for a specific technology, the pertinent cost assumptions to note are as follows:

- The price for a 40' bus was used as an estimate for a 35' FCEB as there is currently no market available 35' FCEB on the MTC Pricelist.
- Since the 2022 MTC Pricelist did not include a 30' FCEB option as there is not currently one available on the market, $200,000, which is the incremental cost difference between 40' BEBs and 40' FCEBs, was added to the 30' BEB MTC Price to generate an estimate for 30' FCEBs.

Table 2 – Fleet Assessment Cost Assumption based on Fiscal Year 2022 MTC Pricelist

Base Price Assumptions by Length and Fuel Type			
Length	**Diesel**	**Electric**	**Fuel Cell**
30’	$543,000	$934,000	$1,134,000*
35’	$600,000	$947,000	$1,264,000*
40’	$575,000	$1,130,000	$1, 264,000

**Bus size not currently available for this technology.*

Zero-Emission Bus Procurement Plan and Schedule

Deploying both battery electric and hydrogen fuel cell technologies makes it possible for County Connection to achieve an entirely zero-emission fleet and leverage the strengths of each technology. Battery electric buses can perform the shorter blocks while FCEBs, given their longer range, can be deployed on longer blocks. In this case, County Connection only incurs the higher costs of FCEBs where necessary to maintain full block achievability. The figures below show projected purchases, annual fleet composition, and annual total capital costs for the Mixed Fleet (BEB and FCEB). By 2040, County Connection will replace 100% of its fleet with BEB and FCEBs.

Figure 3 provides the number of buses scheduled for purchase per year through 2040 based on this replacement strategy.

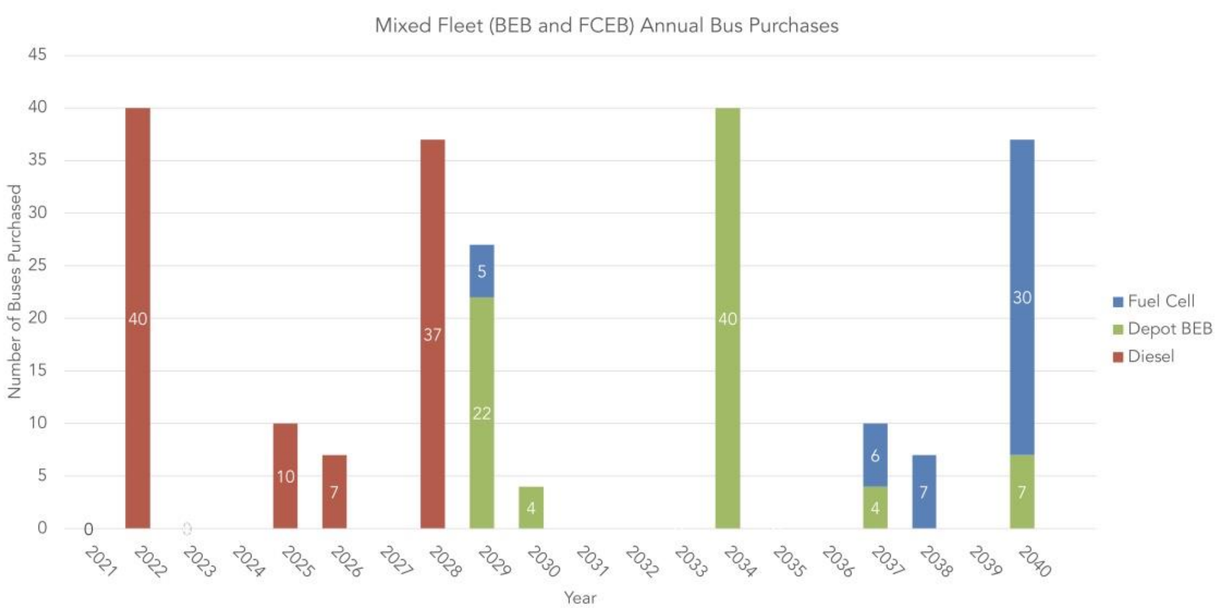

Figure 3 – Projected Bus Purchases, Mixed Fleet Scenario

Figure 4 depicts the annual composition of County Connection's fleet through 2040. FCEBs are slowly introduced with a total of 5 FCEB buses in the fleet by 2029, 11 by 2037, 18 by 2038, and 48 by 2040.

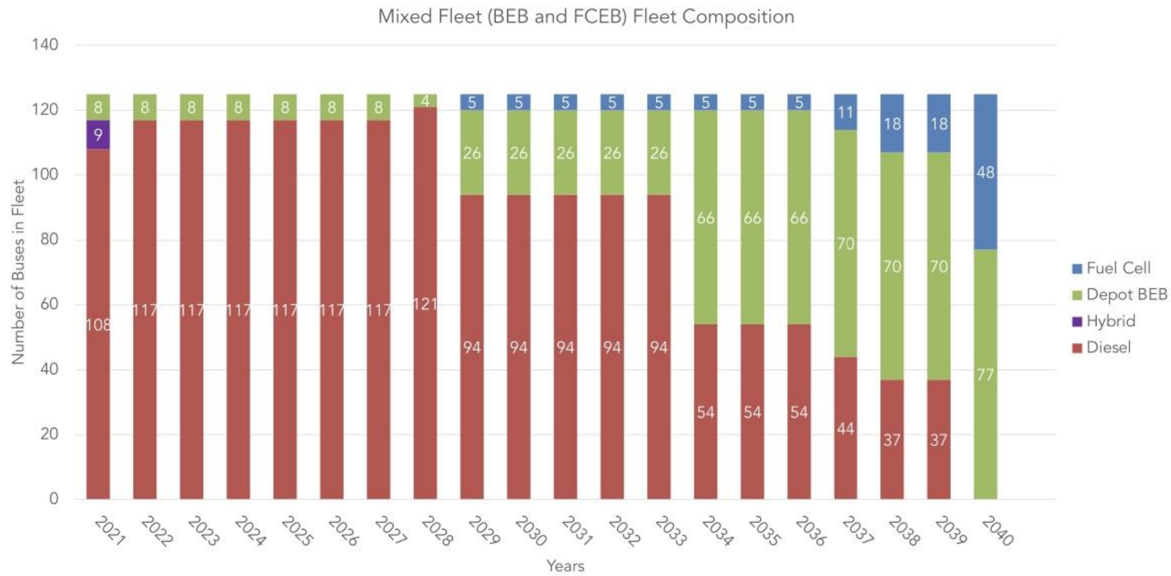

Figure 4 – Annual Fleet Composition, Mixed Fleet Scenario

Projected Annual Capital Costs for ZEB Purchases

The total capital cost for vehicles over the entire transition period is estimated at $253 million, compared to the $165 million that would have been incurred by continuing to purchase diesel and battery electric replacement buses for the baseline fleet over that period. Costs are incurred cyclically, according to the 12-year replacement cycle of transit buses. **Figure 5** below shows the annual capital costs for all ZEBs purchased in a given year through 2040. The years 2034 and 2040 are major purchase years with annual expenditures of $60 million and $66 million respectively.

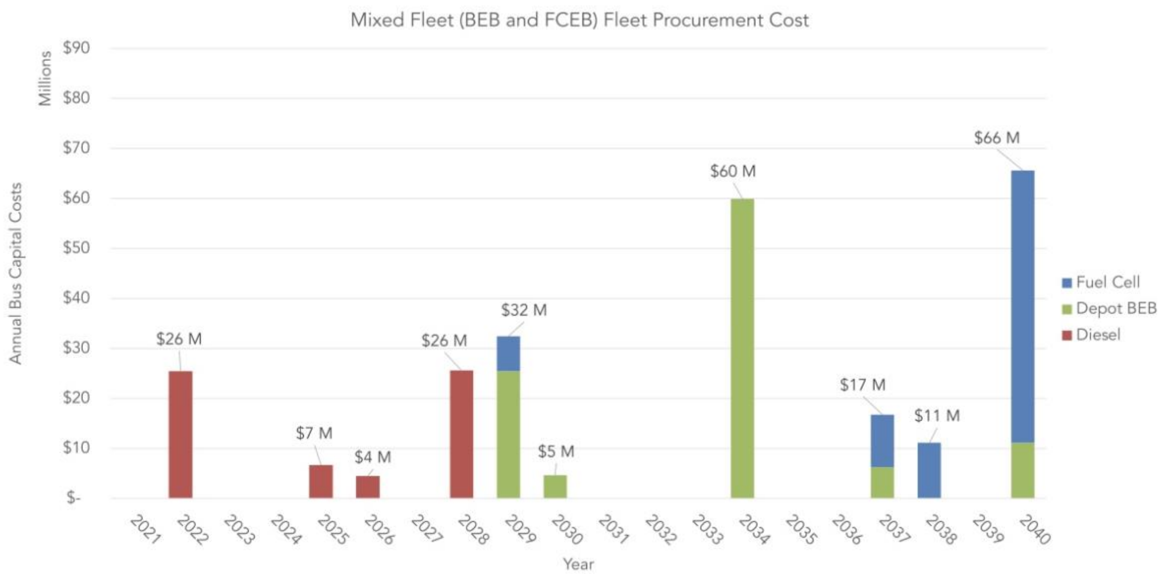

Figure 5 – Annual Capital Costs, Mixed Fleet Scenario

As seen in **Table 3**, the capital investment for purchasing ZEBs exclusively is $88 million higher than the 'business-as-usual' replacement plan for diesel and battery electric buses over the transition period. This highlights the importance of vigilance in the search for funding opportunities to help fill this gap.

Table 3 – County Connection Bus Capital Investment to Transition to a 100% ZEB Fleet by 2040

	Baseline	ZEB Incremental Costs	Total Investment
Bus Capital Costs	$165M	$88M	$253M

Additional Considerations

County Connection currently purchases diesel-hybrid, renewable diesel, and BEB buses through MTC and plans to do the same for FCEBs. Although the procurement process may be similar in this respect, the agency will need to consider several factors that should be given more attention in FCEB procurements than may be needed in diesel and BEB purchasing given that fuel cell is a newer technology.

First, when contracting with a BEB or FCEB manufacturer, County Connection should ensure expectations are clear between the bus OEM and the agency. As with a diesel purchase the agreement should be clear regarding bus configuration, technical capabilities, build and acceptance process, production timing with infrastructure, warranties, training, and other contract requirements. Additionally, by developing and negotiating specification language collaboratively with the bus vendor(s), County Connection can work with the vendor(s) to customize the bus to their needs as much as is appropriate, help advance the industry based on agency requirements and recommended advancements, ensure the acceptance and payment process is fully clarified ahead of time, fully document the planned capabilities of the bus to ensure accountability, and generally preempt any unmet expectations. Special attention should be given in defining the technical capabilities of the vehicle, since defining these for FCEBs may differ from diesel and BEB buses.

When developing RFPs and contracting for BEB or FCEB procurement, County Connection should specify the source of funding for the vehicle purchases to ensure grant compliance, outline data access requirements, define the price and payment terms, establish a delivery timeline, and outline acceptance and performance requirements. County Connection should test the buses upon delivery for expected performance in range, acceleration, gradeability, highway performance, and maneuverability. Any such performance requirements must be included in the technical specification portion of the RFP and contract to be binding for the OEM. Defining technical specifications for FCEBs will also differ slightly from diesel and BEBs since they will need to include requirements for hydrogen fuel cell and battery performance. It is also recommended that County Connection purchase an extended battery warranty for the vehicle, which should be specified in the RFP and contract.

ZEB procurement will also differ from diesel procurements since there are fewer OEMs presently manufacturing these vehicles, although this is expected to change with increasing demand. FCEBs are included in the MTC Pricelist. County Connection will also be able to apply for additional funding for these vehicles through zero-emission vehicle specific funding opportunities, which are discussed further in which are discussed further in Section H: Potential Funding Sources.

E

Facilities and Infrastructure Modifications

County Connection Facility Configuration and Depot Layout

Current Depot Address:

2477 Arnold Industrial Way, Concord, CA 94520

Electric Utility:
PG&E

Located in a NOx Exempt Area?
No

Bus Parking Capacity:
125

Current Vehicle Types Supported:
County Connection's depot in Concord, CA currently supports diesel-hybrid, renewable diesel, and BEB fueling and maintenance

Propulsion Types That Will be Supported at Completion of ZEB Transition:
Fuel cell electric propulsion, Battery electric propulsion

Facilities Assessment Methodology

BEB and FCEB deployments require installation of charging and fueling stations, respectively, and may require improvements to existing electrical infrastructure, such as upgrades to the switchgear or utility service connections. Planning and design work, including the detailed electrical and construction drawings required for permitting, is also necessary for both type of fueling equipment. By 2040, County Connection's depot will be designed to support a full zero-emission bus (ZEB) fleet of BEBs and FCEBs.

To project the costs of hydrogen fueling and charging infrastructure, CTE used industry pricing provided by A&E firms and an infrastructure build timeline based on the procurement timeline. For example, each bus procurement drives an infrastructure project to support those vehicles. This plan assumes that infrastructure projects will be completed prior to each bus delivery. These projects are described in detail below.

Infrastructure Upgrade Requirements to Support Zero-Emission Buses

The Mixed Fleet (BEB and FCEB) scenario states that County Connection deploys only BEBs and FCEBs to service all of its routes by 2040. This plan summarizes the charging and hydrogen infrastructure costs needed to support a fleet of 77 BEBs and 48 FCEBs. The project timeline assumes Phase 1 of the depot modifications are completed to serve the agency's first FCEB deployment in 2029. Because there are separate costs associated with each type of ZEB technology, the facilities assessment is broken down by each bus type beginning with BEB.

The phased transition of County Connection's infrastructure to support a mixed fleet consists of three phases. The three phase site plan for the mixed fleet ZEB transition can be seen in **Appendix B – ZEB Transition Site Plans**. For reference, a summary of the three phases is described immediately below.

- **Phase 1** (2029-2030): Installation of 5 gantries, 11 BEB chargers, 2 MW power upgrade, FCEB upgrades to the maintenance bays, and leasing of a mobile hydrogen fueler until the FCEB fleet reaches 11 buses
- **Phase 2** (2034): Installation of 8 additional gantries, 20 BEB chargers, and a 3 MW power upgrade
- **Phase 3** (2037, 2040): Installation of 6 additional BEB chargers and 1 FCEB hydrogen station

The total cost of project planning is estimated to cost $200,000 per ZEB technology. The following sections summarize the total BEB and FCEB infrastructure improvements, with **Figure 6** showing the cumulative summary of both BEB and FCEB costs by year.

BEB Charging Infrastructure Summary

The estimated total BEB infrastructure costs for the mixed fleet scenario are approximately $20 million, including the required infrastructure to fuel, operate and maintain BEBs.

The BEB infrastructure improvements consist of:

- 13 gantries to support BEB charging during the transition period. Each gantry can serve up to eight buses.
- 39 chargers (78 dispensers). Charging projects include purchase and installation of 120 kW chargers and dispensers. Every two buses (30-ft. and larger) will require one charger with two dispensers. Dispensers are expected to be either overhead reel or pantograph style.
- Additional estimated 5 MW of power to its system by 2040 to accommodate charging for 77 BEBs. Each entry in the figure below indicates the minimum amount of power that must be added in a given year to meet the growing demand at a given facility as more BEBs are purchased.

FCEB Hydrogen Fueling Infrastructure Summary

In addition to BEB charging, hydrogen fueling is required to support the mixed fleet scenario. Infrastructure is built out over time as necessary to support FCEB deployment, with an estimated cost of $10 million.

The hydrogen fueling infrastructure improvement consist of:

- Incremental addition of one or more 15,000 gallon liquid hydrogen storage tank.
- Maintenance upgrades to 14 bay make them compliant with hydrogen safety regulations. At County Connection, CTE integrated Fiedler Group's estimated cost for each bay upgrade at $200,000. This cost estimate stems from the requirement of additional ventilation systems and sensors necessary for hydrogen detection. These costs are estimates of the anticipated expenditure required to retrofit and upgrade a diesel maintenance bay for hydrogen gas detection. Retrofitting is more expensive than the incremental cost of adding hydrogen detection to a new facility.
- Permanent station for 50-buses.
- Mobile fueler. Fiedler Group recommends leasing a mobile fueler until the number of FCEBs meets or exceeds 11 buses.

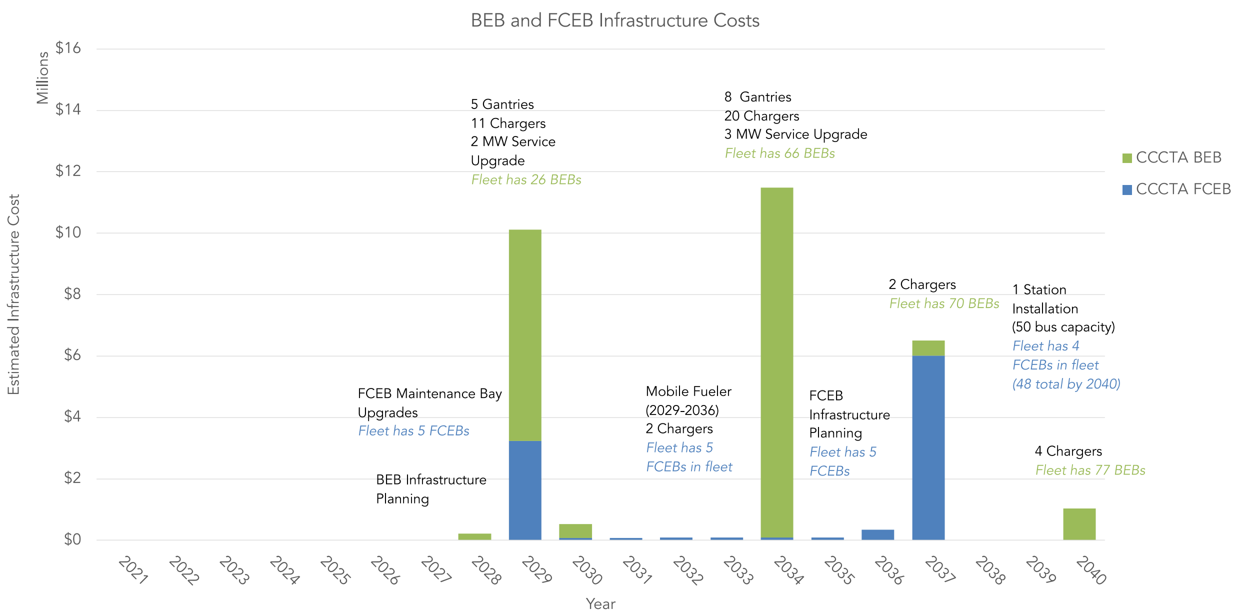

Figure 6 – Cumulative Infrastructure Costs, Mixed Fleet Scenario

Description of Changes to Depot

Given County Connection's plans to upgrade their depot support new BEB and FCEB deployments, it is expected that all necessary infrastructure will be present in time for each ZEB deployment and will meet the needs of the projected energy use for a full ZEB mixed fleet by 2040.

F

Providing Service in Disadvantaged Communities

Providing Zero-Emission Service to DACs

In California, CARB defines disadvantaged communities (DACs) as communities that are both socioeconomically disadvantaged and environmentally disadvantaged due to local air quality. In the Bay Area, lower income neighborhoods, such as West Oakland, are exposed to greater vehicle pollution levels due to proximity to freeways and the port of Oakland, which puts these communities at greater risk of health issues associated with tailpipe emissions.[7] Central Contra Costa County serves nearby disadvantaged communities in Martinez, Concord, and Antioch, California (**Figure 7**).

These disadvantaged communities are served by routes 9 Walnut Creek BART; 11 Concord BART/Peasant Hill BART; 17 Concord BART/North Concord; 18 Martinez Amtrak/Pleasant Hill BART; 19 Martinez Amtrak/Concord BART; 20 Concord BART; 27 North Concord/Martinez BART/Martinez Circle; 28 Concord BART/Amtrak; 91X Concord Commuter Express; 93X Kirker Pass Express; 98X Martinez Amtrak/Walnut Creek BART; 99X Martinez Amtrak/North Concord BART; 311 Concord BART/Pleasant Hill BART; 314 Concord BART/Monument Boulevard; 316 Martinez Amtrak/Pleasant Hill BART; 320 Concord BART; 608 VA Clinic; 611 Oak Grove Middle/Concord BART; 712 Bay Point BART; and, 715 North Concord Martinez BART to Pleasant Hill BART. Together, they had a total annual ridership of 839,524 people in FY2020. These routes will be targeted by County Connection's earliest ZEB deployments and fully zero-emission by 2040.

Environmental impacts, both from climate change and from local pollutants, disproportionately affect transit riders. For instance, poor air quality from tailpipe emissions and extreme heat harm riders waiting for buses at roadside stops. The transition to zero-emission technology will benefit the region by reducing fine particulate pollution and improving overall air quality. In turn, the fleet transition will support better public health outcomes for residents in DACs served by the selected routes.

Public transit has the potential to improve social equity by providing mobility options to low-income residents lacking access to a personal vehicle and helping to meet their daily needs. In California, transit use is closely correlated with carless households as they are five times more likely to use public transit

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[7] Reichmuth, David. 2019. Inequitable Exposure to Air Pollution from Vehicles in California. Cambridge, MA: Union of Concerned Scientists. https://www.ucsusa.org/resources/inequitable-exposure-air-pollution-vehicles-california-2019

than households with at least one vehicle.[8] Although 21% of Californians in a zero-vehicle household are vehicle free by choice, 79% do not have a vehicle due to financial limitations. Many low-income individuals, therefore, rely solely on public transportation for their mobility needs.[9] County Connection's current diesel fleet consumes an annual average of 605,600 gallons of diesel. The combustion of this fuel exposes those who are reliant on this transportation option to diesel exhaust, which has been classified as a probable human carcinogen with links to asthma and other lung related health issues.[10] Portions of County Connection's service area are generally around the 28th-33rd percentile for diesel particulate matter (PM) according to CalEnviroScreen 4.0. Moving County Connection's fleet to zero-emission technology will help alleviate this pollution, which will improve the health of communities impacted by high diesel PM and all Bay Area communities.

Access to quality transit services provides residents with a means of transportation to go to work, to attend school, to access health care services, and run errands among other activities. By purchasing new vehicles and decreasing the overall age of its fleet, County Connection is also able to improve service reliability and therefore maintain capacity to serve low-income and disadvantaged populations. Replacing diesel vehicles with zero-emission BEBs and FCEBs, will also benefit these populations by improving local air quality and reducing exposure to harmful emissions from diesel exhaust.

Census Tracts in Service Area Identified as DACs

County Connection Provides service through the following Census Tracts identified as SB 535 Disadvantaged Communities:

- Martinez, California, census tract 6013320001, which has a population of 3,671 people.
- Concord, California, census tract 6013315000, which has a population of 3,862 people.
- Concord, California, census tract 6013327000, which has a population of 7,430 people.
- Concord, California, census tract 6013336201, which has a population of 4,056 people.
- Pittsburg, California, census tract 6013313101, which has a population of 7,178 people.
- Pittsburg, California, census tract 6013313102, which has a population of 4,595 people.

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[8] Grengs, Joe, Jonathan Levine, and Qingyun Shen. (2013). Evaluating transportation equity: An inter-metropolitan comparison of regional accessibility and urban form. FTA Report No. 0066. For the Federal Transit Administration

[9] Paul, J & Taylor, BD. 2021. Who Lives in Transit Friendly Neighborhoods? An Analysis of California Neighborhoods Over Time. Transportation Research Interdisciplinary Perspectives. 10 (2001) 100341. https://reader.elsevier.com/reader/sd/pii/S2590198221000488?token=CABB49E7FF438A88A19D1137A2B1851806514EF576E9A2D9462D3FAF1F6283574907562519709F8AD53DEC3CF95ACF27&originRegion=us-east-1&originCreation=20220216190930

[10] National Resources Defense Council Coalition for Clean Air. No breathing in the aisles — diesel exhaust inside school buses. New York: The Council; January 2001. www.nrdc.org/air/transportation/schoolbus/sbusinx.asp

Map of County Connection Service Area

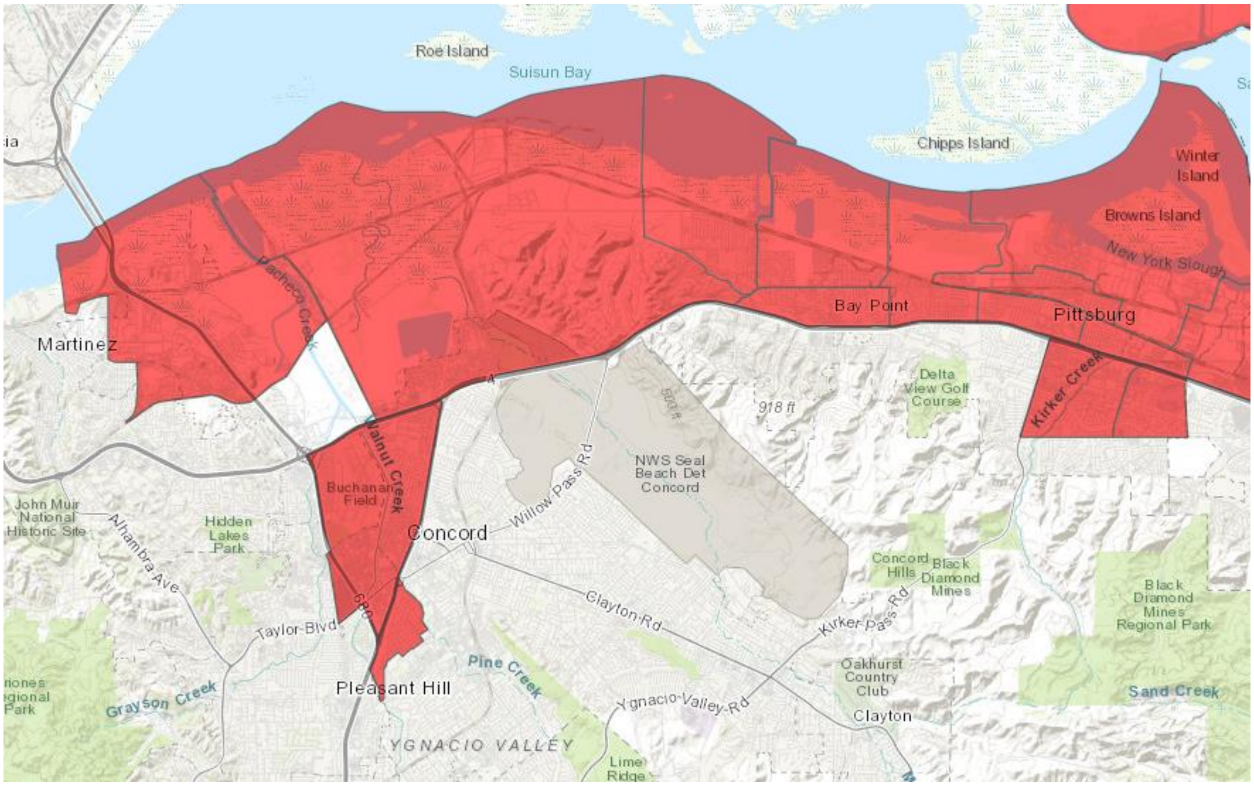


Figure 7 – Map of DAC Census Tracts in County Connection's Service Area (August 2022)

Emissions Reductions for DACs

Greenhouse gases (GHG) are the compounds primarily responsible for atmospheric warming and include carbon dioxide (CO2), methane (CH4), and nitrous oxide (N2O). The effects of greenhouse gases are not localized to the immediate area where the emissions are produced. Regardless of their point of origin, greenhouse gases contribute to overall global warming and climate change.

Criteria pollutants include carbon monoxide (CO), nitrogen oxides (NOx), particulate matter under 10 and 2.5 microns (PM10 and PM2.5), volatile organic compounds (VOC), and sulfur oxides (SOx). These pollutants are considered harmful to human health because they are linked to cardiovascular issues, respiratory complications, or other adverse health effects.11 These compounds are also commonly

[11] Institute of Medicine. Toward Environmental Justice: Research, Education, and Health Policy Needs. Washington, DC: National Academy Press, 1999; O'Neill MS, et al. Health, wealth, and air pollution: Advancing theory and methods. Environ Health Perspect. 2003; 111: 1861-1870; Finkelstein et al. Relation between income, air pollution and mortality: A cohort study. CMAJ. 2003; 169: 397-402; Zeka A, Zanobetti A, Schwartz J. Short term effects of particulate matter on cause specific mortality: effects of lags and modification by city characteristics. Occup Environ Med. 2006; 62: 718-725.

responsible for acid rain and smog. Criteria pollutants cause economic, environmental, and health effects locally where they are emitted. CARB defines DACs in part as disadvantaged by poor air quality because polluting industries or freight routes are often situated in these communities. The resulting decrease in air quality has led to poorer health and quality of life outcomes for residents.

By transitioning to ZEBs from diesel buses, County Connection's fleet will produce fewer carbon emissions and fewer harmful pollutants from the vehicle tailpipes. CTE estimates that the fleet energy use cut in half by transitioning to a mixed fleet of ZEBs, with a reduction from about 0.6 million DGE in 2021 to under 0.3 million in 2040. Disadvantaged communities with pollution impacts that are served by County Connection's fleet will benefit greatly from the reduced tailpipe emissions of ZEBs compared to ICE buses.

G

Workforce Training

County Connection's Current Training Program

County Connection is experienced in recruiting, hiring, training, and integrating new staff to ensure that their employees are qualified to provide quality services to their riders. Once hired, staff undergo rigorous operator and maintenance training as well as education on other County Connection policies and procedures.

County Connection's ZEB Training Plan

OEM Training

County Connection plans to take advantage of trainings from the bus manufacturers and station suppliers, including maintenance and operations training, station operations and fueling safety, first responder training and other trainings that may be offered by the technology providers. OEM trainings provide critical information on operations and maintenance aspects specific to the equipment model procured. Additionally, many procurement contracts include train-the-trainer courses through which small numbers of agency staff are trained and subsequently train agency colleagues. This method provides a cost-efficient opportunity to provide widespread agency training on new equipment and technologies.

Bus and Fueling Operations and Maintenance

The transition to a zero-emission fleet will have significant effects on County Connection's workforce. Meaningful investment is required to upskill maintenance staff and bus operators trained in ICE vehicle maintenance and fossil fuel fueling infrastructure.

County Connection training staff will work closely with the OEM providing vehicles to ensure all mechanics, service employees, and bus operators complete necessary training prior to deploying ZEB technology and that these staff undergo refresher training annually and as needed. County Connection staff will also be able to bring up any issues or questions they may have about their training with their trainers. Additionally, trainers will observe classes periodically to determine if any staff would benefit from further training.

ZEB Training Programs Offered by Other Agencies

Several early ZEB adopters have created learning centers for other agencies embarking on their ZEB transition journeys. One such agency is SunLine Transit Agency, which provides service to the Coachella Valley of California and hosts the West Coast Center of Excellence in Zero Emission Technology (CoEZET). The Center of Excellence supports transit agency adoption, zero-emission commercialization and investment in workforce training. Similarly, AC Transit offers training courses covering hybrid and zero-emission technologies through their ZEB University program. County Connection plans to take advantage of trainings offered by experienced agencies.

H

Potential Funding Sources

Sources of Funding for ZEB Transition

County Connection is prepared to pursue funding opportunities at the federal, state, and local level, as necessary and as available. While there are several funding opportunities are mentioned by name, County Connection will not be limited to these sources and will regularly assess opportunities for fiscal support for the ZEB program.

Federal

County Connection is exploring federal grants through the following funding programs: Federal Transit Administration's (FTA) Urbanized Area Formula program; discretionary grant programs such as the Bus and Bus Facilities (B&BF) program, Low or No Emission Vehicle Deployment Program (Low-No), and Better Utilizing Investments to Leverage Development (BUILD) grant; and other available federal discretionary grant programs.

- United States Department of Transportation (USDOT)
  - Rebuilding American Infrastructure with Sustainability and Equity (RAISE) Grants
- Federal Transportation Administration (FTA)
  - Capital Investment Grants – New Starts
  - Capital Investment Grants – Small Starts
  - Bus and Bus Facilities Discretionary Grant
  - Low-or No-Emission Vehicle Grant
  - Metropolitan & Statewide Planning and Non-Metropolitan Transportation Planning
  - Urbanized Area Formula Grants
  - State of Good Repair Grants
  - Flexible Funding Program – Surface Transportation Block Grant Program
- Federal Highway Administration (FHWA)
  - Congestion Mitigation and Air Quality Improvement Program
- Environmental Protection Agency (EPA)
  - Environmental Justice Collaborative Program-Solving Cooperative Agreement Program

Additionally, County Connection purchases buses through the Metropolitan Transportation Commission (MTC), which allocates federal funds to help finance 80% of the vehicle's capital costs.

State

County Connection will also seek funding from state resources through grant opportunities including but not limited to Senate Bill 1 State of Good Repair (SGR), Transit and Intercity Rail Capital Program (TIRCP), Low Carbon Transit Operations Program (LCTOP) funding, the California Energy Commission's Clean Transportation Program as well as Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project (HVIP) for bus purchases when available.

Secured Funding

- California Air Resources Board (CARB)
    - Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project (HVIP)
    - State Volkswagen Settlement Mitigation
    - Carl Moyer Memorial Air Quality Standards Attainment Program
    - Cap-and-Trade Funding
    - Low Carbon Fuel Standard (LCFS)
- California Transportation Commission (CTC)
    - Solution for Congested Corridor Programs (SCCP)
- California Department of Transportation (Caltrans)
    - Low Carbon Transit Operations Program (LCTOP)
    - State Transit Assistance (STA) + STA SB1
    - Transportation Development Act
    - Transit and Intercity Rail Capital Program
    - Transportation Development Credits
    - New Employment Credit
- California Energy Commission

I

Start-up and Scale-up Challenges

Improvements in technology are expected. However, the timing of when, or if, BEB technology may improve to the point of one-for-one replacement of diesel buses or when the cost of FCEBs and hydrogen fuel will decrease to cost-competitive levels is impacted by numerous factors and unpredictable. Given these unknowns and the possible rapid changes in zero-emission technologies as the market develops, this section is intended to capture current challenges experienced in County Connection's ZEB fleet transition.

County Connection is an early adopter of ZEB technology, with BEBs in service since November 2016. Despite the success of the early vehicles in their fleet, County Connection has identified several start-up and scale-up challenges, including:

- Financial Challenges
- Performance Range & Reliability Challenges
- Workforce Training Challenges
- Facilities Constraints
- Utility Coordination
- Equipment Disposal

Financial Challenges

Challenges can arise with any new propulsion technology, its corresponding infrastructure, or in training operators and maintenance staff. Nearly all transit agencies must contend with the cost barriers posed by zero-emission technologies. The current market cost of ZEBs is between $750,000 and $1,200,000, which is about $250,000 to $700,000 more costly than traditional diesel buses. Additionally, the necessary infrastructure to support these buses adds to the financial burden of transitioning to a ZEB fleet, as outlined below in **Table 4**. County Connection will seek financial support to cover the transition cost of their BEBs and FCEBs from the resources discussed in **Section H**
Potential Funding Sources.

Table 4 – Incremental Cost of ZEB Transition

Incremental cost of ZEB Transition			
	Diesel Baseline	Mixed Fleet Incremental Costs	Transition Scenario Total Costs
Bus Capital Expense	$165M	$88M	$253M
Fueling Infrastructure Expense	$0	$31M	$31M
Total	$165M	$119M	$284M

As seen in **Table 4 ,** costs of required fueling infrastructure for ZEB technologies pose another hurdle for transit agencies transitioning to zero-emission service. Continued financial support at the local, state and federal level to offset the capital cost of this new infrastructure is imperative. For alternative fuels such as hydrogen, financial support from state and federal grant opportunities for green hydrogen supply chains and increasing production will ultimately benefit transit agencies deploying and planning for FCEBs. Additionally, engaging investor-owned or public electric utilities will be crucial BEB deployments, as subsidized or negotiated rate structures for electric vehicles aid the affordability of large-scale electrification.

CARB can support County Connection by ensuring continued funding for the incremental cost of zero-emission buses and fueling infrastructure. Funding opportunities should emphasize proper transition and deployment planning and should not preclude hiring consultants to ensure best practices and successful deployments. The price and availability of hydrogen, both renewable and not, continue to be challenges that can be allayed by legislation subsidizing and encouraging renewable fuel production.

Performance and Reliability Challenges

Transit agencies must ensure that available zero-emission technologies can meet the basic service requirements of the agency. Although current BEB range limitations may improve over time as a result of advancements in onboard battery energy capacity and more efficient components, battery degradation may re-introduce range limitations, which is a cost and performance risk to an all-BEB fleet over time. In emergency scenarios that require the use of BEBs, agencies may face challenges supporting long-range evacuations and providing temporary shelters in support of fire and police operations. Although FCEBs may not be subject to these same limitations, higher capital equipment costs and availability of hydrogen may constrain FCEB solutions.

Workforce Training Challenges

Developing and training the workforce required to operate and maintain zero-emission buses requires significant investment and planning. County Connection is facing the same industrywide challenges of finding technicians and implementing plans to ensure training on BEB and FCEB components. As the mixed fleet expands, County Connection has a identified the need to upskill current staff, upgrade training materials for the new technologies and new models, and review skills progression standards to ensure continued safety.

Facilities Constraints

A mixed fleet scenario adds complexity by requiring the installation of infrastructure for both BEB and FCEB fuel types. Since County Connection has only one depot, the space constraint of installing both infrastructure types may be a challenge. Additionally, while County Connection maintenance staff are familiar with scheduled and unscheduled repairs associated with past BEB deployments, maintenance costs will vary with the introduction of new models of BEBs and a new technology with FCEBs.

Utility Coordination

Coordination with PG&E will continue to require attention as County Connections ZEB fleet expands. The agency is especially concerned about the uncertainty of future electric rates and the potential cost implications for the BEB infrastructure. Charge management strategies may provide some relief by charging buses during times of day at which rates are lower and avoiding demand charges by spreading out the number of buses charging at once to minimize increases in peak power demand. However, proven charge management solutions are currently limited. Another potential solution is to explore the cost differences between working with PG&E in advance to identify existing/feasible locations for future BEB infrastructure compared to costs for bringing electricity to the depot or on-route chargers.

Battery Disposal

The current battery disposal process needs improvement. BEB batteries have different chemical features and structural design which makes it difficult to make an efficient system for recycling and disposing of batteries once they reach the end-of-life.

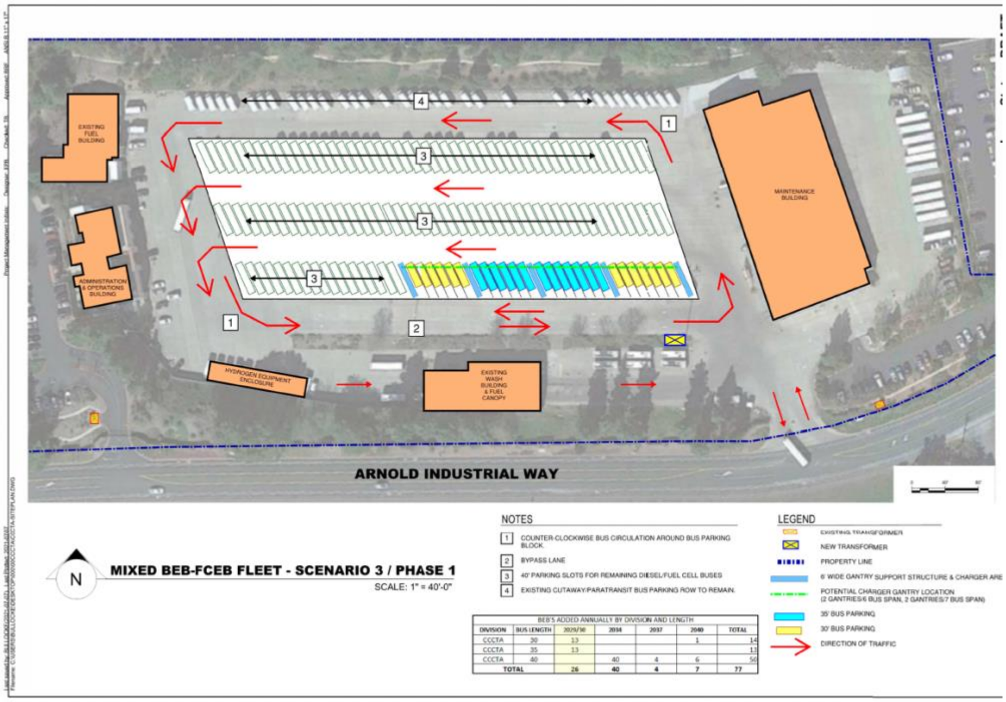
Limitations of Current Technology

The applicability of specific zero-emission technologies varies widely among service areas and agencies. As such, it is critical that transit agencies in need of technical and planning support have access to these resources to avoid failed deployment efforts. Support in the form of technical consultants and experienced zero-emission transit planners will be critical to turning Rollout Plans into successful deployments and tangible emissions reductions.

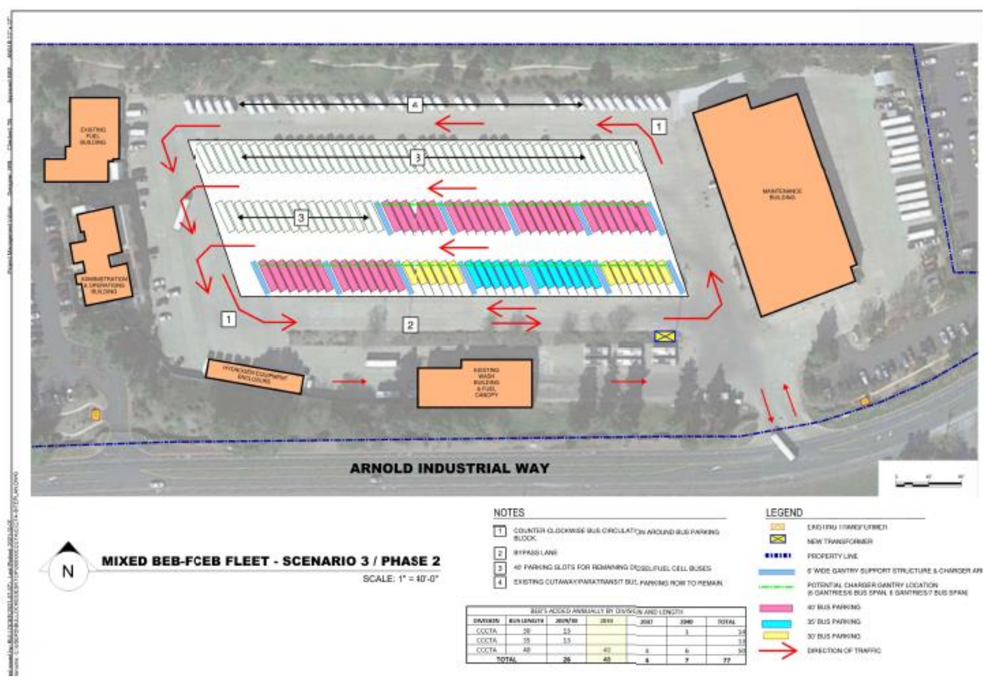
Appendix A – Approved Board Resolution

[Placeholder]

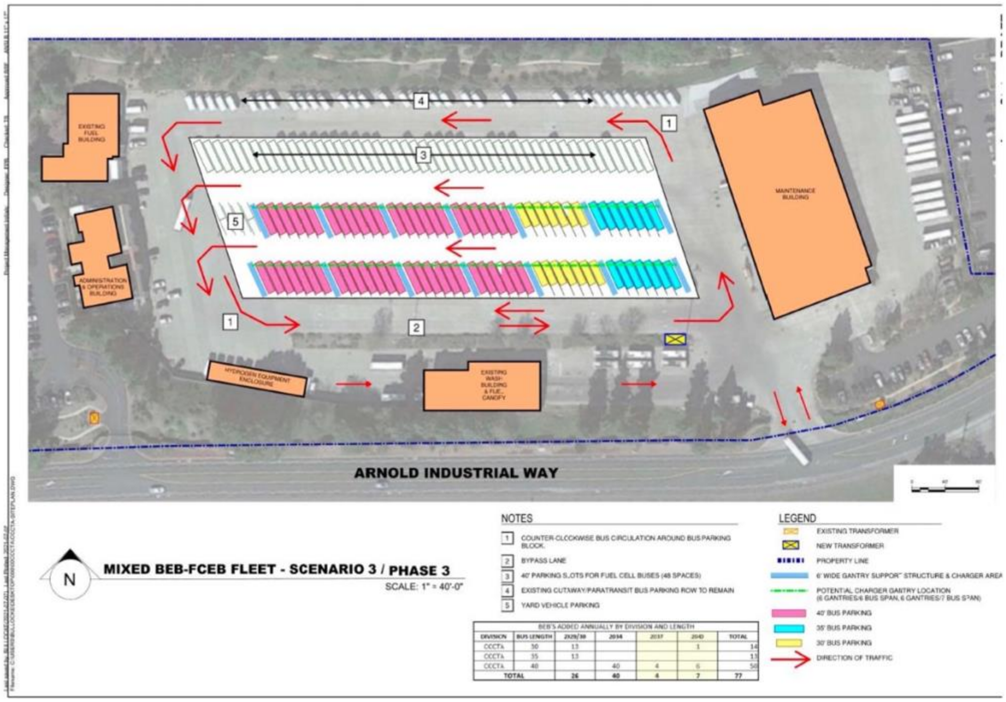
Appendix B – ZEB Transition Site Plans



Phase 1 – 2029-2030



Phase 2 – 2034



Phase 3 – 2037, 2040

Appendix C – Glossary

Auxiliary Energy: Energy consumed (usually as a by time measure, such as "x"kW/hour) to operate all support systems for non-drivetrain demands, such as HVAC and interior lighting.

Battery Electric Bus: Zero-emission bus that uses onboard battery packs to power all bus systems.

Battery Nameplate Capacity: The maximum rated output of a battery under specific conditions designated by the manufacturer. Battery nameplate capacity is commonly expressed in kWh and is usually indicated on a nameplate physically attached to the battery. It includes the unusable top and bottom portion of the battery's total energy.

Block: Refers to a vehicle schedule, the daily assignment for an individual bus. One or more runs can work a block. A driver schedule is known as a "run."

Charging Equipment: The equipment that encompasses all the components needed to convert, control and transfer electricity from the grid to the vehicle for the purpose of charging batteries. May include chargers, controllers, couplers, transformers, ventilation, etc.

Depot Charging: Centralized BEB charging at a transit agency's garage, maintenance facility, or transit center. With depot charging, BEBs are not limited to specific routes, but must be taken out of service to charge.

Energy: Quantity of work, measured in kWh for ZEBs.

Energy Efficiency: Metric to evaluate the performance of ZEBs. Defined in kWh/mi for BEBs, mi/kg of hydrogen for FCEBs, or miles per diesel gallon equivalent for any bus type.

Fuel Cell Electric Bus: Zero-emission bus that utilizes onboard hydrogen storage, a fuel cell system, and batteries. The fuel cell uses hydrogen to produce electricity. Its waste products are heat and water. The electricity powers the batteries, which powers the bus.

Greenhouse Gas Emissions: Common GHGs associated with diesel combustion include carbon dioxide (CO2), carbon monoxide (CO), nitrous oxides (NOx), volatile organic compounds (VOCs), and particulate matter (PM). These emissions negatively impact air quality and contribute to climate change impacts. Zero-emission buses have no harmful emissions that result from diesel combustion.

Hydrogen Fueling Station: The location and equipment that houses the hydrogen storage, compression, and dispensing equipment to support fuel cell electric buses. If hydrogen is produced onsite, it will also include this equipment.

On-route Charging: The behavior of using on-route located charging equipment to charge a BEB in-service. With proper planning, on-route charged BEBs can operate indefinitely, and one charger can charge multiple buses.

Operating Range: Driving range of a vehicle using only power from its electric battery pack or on-board hydrogen storage, fuel cell, and battery to travel a given driving cycle.

Route Modeling: A cost-effective method to assess the operational requirements of ZEBs by estimating the energy consumption on various routes using specific bus specifications and route features.

Useful Life: FTA definition of the amount of time a transit vehicle can be expected to operate based on vehicle size and seating capacity. The useful life defined for transit buses is 12-years. For cutaways, the useful life is 7 years.

Validation Procedure: Confirms that the demonstrated bus performance is in line with expected performance. Results of validation testing can be used to refine bus modeling parameters and to inform deployment plans. Results of validation testing are typically not grounds for acceptance or non-acceptance of a bus.

Zero-Emission Vehicle: A vehicle that emits no tailpipe emissions from the onboard source of power. This is used to reference battery-electric and fuel cell electric vehicles, exclusively, in this report.

Well-to-wheel Emissions: Quantity of greenhouse gas, criteria pollutants, and/or other harmful emissions that includes emissions from energy use and emissions from vehicle operation. For BEBs, well-to-wheel emissions would take into account the carbon intensity of the grid used to charge the buses. For FCEBs, well-to-wheel emissions would take into account the energy to produce, transport, and deliver the hydrogen to the vehicle.

Prepared by Center for Transportation and the Environment