BCAG
BUTTE COUNTY ASSOCIATION OF GOVERNMENTS

Zero-Emission Bus Rollout Plan

Prepared by Center for Transportation and the Environment

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List of Abbreviations

3R: Redundancy, Resilience, and Emergency Response

ADA: Americans with Disabilities Act

A&E: Architecture and Engineering

ACTC: Alameda County Transportation Commission

BCAG: Butte County Association of Governments

BEB: Battery Electric Bus

CA: California

CARB: California Air Resources Board

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

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

B-Line provides regional and local public transit services in Butte County and covers roughly 700 square miles of service area. The current bus fleet consists of 29 fixed-route buses: 29 diesel buses (11 35-foot diesel and 18 40-foot diesel buses). B-Line also operates 2 types of paratransit services—ADA Paratransit and Dial-A-Ride. Their paratransit fleet consists of 22 gasoline-powered cutaway vehicles (28-feet). Butte County Association of Governments (BCAG) engaged the Center for Transportation and the Environment (CTE) to perform a zero-emission bus (ZEB) transition study to create a plan for a 100% zero-emission fleet by 2040 to comply with the Innovative Clean Transit (ICT) regulation enacted by the California Air Resources Board (CARB).

BCAG's Rollout Plan achieves a zero-emission bus fleet in line with the 2040 target of the ICT Regulation. To achieve this goal, B-Line will replace all 35' and larger ICE buses with ZEBs when the vehicles reach the end of their 12-year useful life. By 2040, 24 of the agency's buses are expected to be BEBs and 8 will be FCEBs. The last of the agency's ICE buses will reach end of life in 2039. Four of B-Line's cutaways will also be transitioned to fuel cell electric cutaways. The remaining cutaways will remain gasoline vehicles as there is not currently a zero-emission vehicle on the market that has received a Bus Resting Report that can meet the service requirements of B-Line's paratransit service based on CTE's analysis.[1]

All of B-Line's services operate out of a single operations, maintenance, and administrative facility at 326 Huss Dr. Chico, CA 95928. BCAG plans to install both charging and hydrogen fueling infrastructure at this location to support their mixed fleet. BCAG also explored redundancy, resilience and emergency response options related to fueling in the event that B-Line would be expected to provide service during an emergency or power outage.

B-Line's bus service provides transportation opportunities to numerous Disadvantaged Communities (DACs) and moving toward zero-emission buses will help improve the health of DACs and non-DACs alike. The agency will build upon an existing training structure for bus maintenance and operators to provide the necessary battery-electric bus (BEB) and fuel cell electric bus (FCEB) specific training that will be required for the agency to own and operate BEBs and FCEBs. The agency estimates that pursuing a ZEB fleet in place of an internal combustion engine (ICE) fleet will cost an additional $27M in bus costs and infrastructure alone between 2021 and 2040, which will require significantly more funding opportunities. BCAG plans to pursue funding opportunities at the federal, state, and local levels to help fill this funding gap.

[1] This is allowable under the ICT regulation which states that "Purchases of cutaway, over-the-road, double- decker, or articulated buses are subject to the zero-emission bus purchase requirements as specified in section 2023.1(a) on or after January 1, 2026, if the cutaway, over-the-road, double-decker, or articulated bus type has a model that has passed the bus testing procedure and obtained a Bus Testing Report as described in section 2023(b)(8) for a given weight class."

A

Transit Agency Information

BCAG Profile

History

In June 2005, B-Line was formed in order to consolidate transit systems previously operated by the County of Butte (Butte County Transit), the City of Chico (Chico Area Transit), the City of Oroville (Oroville Area Transit) and the Town of Paradise. B-Line service is delivered by a contract transit operator, Transdev, Inc., which also performs dispatching and maintenance duties at the Butte Regional Operations Center (BROC) in the City of Chico.

BCAG is the Regional Transportation Planning Agency (RTPA) and Metropolitan Planning Organization (MPO) for Butte County, as designated by the Secretary of the Business Transportation & Housing Agency for the State of California. Through the BCAG Joint Powers Agreement, the BCAG Board also serves as the administrative and policymaking agency for B-Line allowing for better routes, a uniform fare structure, improved service with timed transfers, consistent headways for ease of use, and comprehensive customer service.[2]

Service Area and Bus Service

B-Line provides regional and local public transit services in Butte County and covers roughly 700 square miles. The current bus fleet consists of 29 fixed-route buses: 29 diesel buses (11 35-foot diesel and 18 40-foot diesel buses).

B-Line operates 21 fixed routes, which includes 5 regional routes, 15 local routes, and an express route to Chico Airport. Regional routes connect the towns and cities of Chico, Oroville, Paradise, Magalia, Gridley, and Biggs. Local routes serve the Chico urban area and the city of Oroville. The average speed of the regional routes is 28.9 mph. For local routes, the average speed is 15 mph. The average speed for the express route is 17.3 mph.

B-Line also operates 2 types of paratransit services—ADA Paratransit and Dial-A-Ride. Their paratransit fleet consists of 22 gasoline-powered cutaway vehicles (28-feet).

[2] BCAG Unmet Transit Needs Assessment – 2021/2022 http://www.blinetransit.com/documents/UTN/2122-Transit-Needs-Assessment-Final.pdf

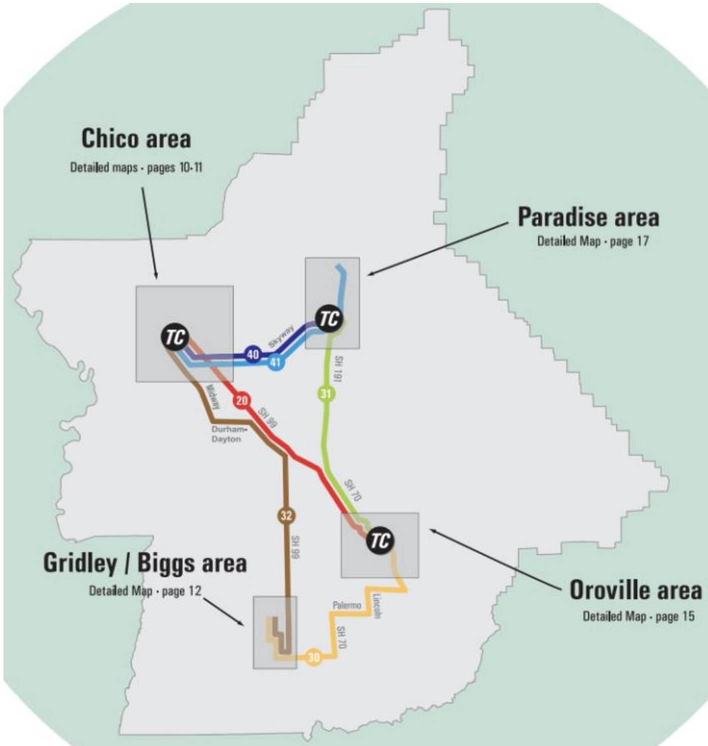

Figure 1 - BCAG Service Area

Ridership

B-Line serves a diverse community, with a large portion of its daily passengers being individuals without cars (by choice or because of financial limitation), university students, and paratransit riders. Although ridership on transit in general has been decreasing over the past few years due in part to lower gas prices and more affordable automobiles, which has allowed more people the opportunity to own personal cars, the ridership reductions seen by B-Line in recent years are more directly tied to reduced population in its service area following the Camp Fire.[3] In 2018, the Camp Fire burned through Butte County and destroyed homes and businesses in the town of Paradise, which is served by B-Line. In 2020, B-Line's service was further reduced by the Coronavirus Disease 2019 SARS-CoV-2 (COVID/COVID-19) pandemic.

B-Line's service experienced significant reduction after the 2018 Camp Fire and has not returned to its original service levels and is not expected to. Since the beginning of the COVID-19 pandemic, the services have stayed the same with the exception of Route 40 and 41, which runs through areas affected by the Camp Fire—demand for bus service in Paradise has remained low. Based on BCAG's data of available ridership and total fares received from July 2018 through the month of June 2019 (pre-COVID levels), there were 949,871 fixed-route passengers and 141,277 paratransit passengers.[4] BCAG anticipates annual ridership to be less than this over the next 5 years. In response to the changing ridership needs, due in part to the Camp Fire and COVID, BCAG is conducting a Route Optimization Study, which will be completed in the Summer of 2023 in order to re-assess how to most efficiently serve individual routes as well as the whole system.

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

[4] Page 21 of BCAG's Unmet Transit Needs Assessment – 2021/2022 http://www.blinetransit.com/documents/UTN/2122-Transit-Needs-Assessment-Final.pdf

BCAG Basic Information

Transit Agency's Name:

Butte Regional Transit

Mailing Address:

Butte County Association of Governments

326 Huss Dr. Suite 150

Chico, CA 95928

Transit Agency's Air Districts:

BCAG is part of the Butte County Air Quality Management District.

Transit Agency's Air Basin:

Butte County Air Quality Management District is part of the Sacramento Valley Air Basin District.[5]

Total number of buses in Annual Maximum Service:

The maximum number of active buses operating fixed-route service out of the Butte Regional Operations Center is 32. B-Line also operates 22 gas cutaway vehicles in support of dial-a ride and paratransit service.

Urbanized Area:

Chico, CA. Chico is 28 square miles of land area with 2,161 people per square mile living within that area.

Population of Urbanized Area:

101,475 people

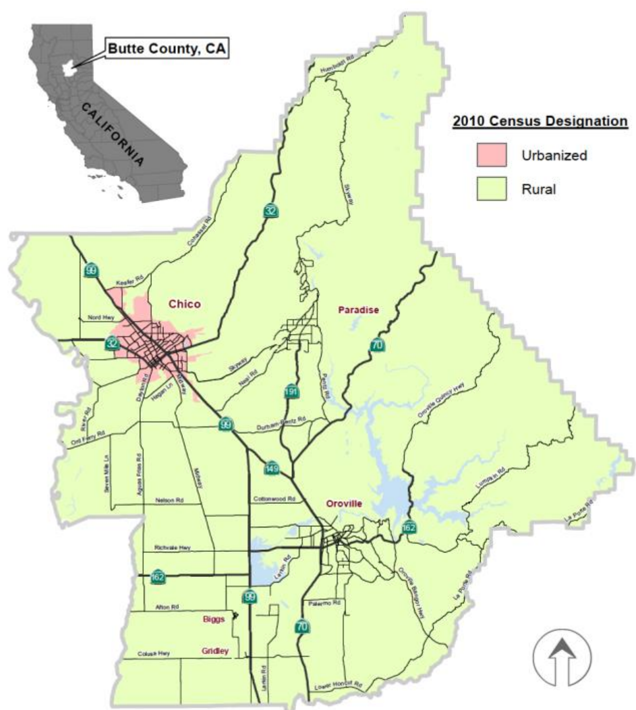

Figure 2 - Butte County Urbanized and Rural Map

Contact Information for Inquiries on the BCAG ICT Rollout Plan:

Andy Newsum, Deputy Director, Butte County Association of Governments

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[5] https://www.airquality.org/Meetings/Sacramento-Valley-Basinwide-Air-Pollution-Control-Council

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Is your transit agency part of a Joint Group? No

Fleet Facility

BCAG currently has one maintenance facility, located at 326 Huss Ln, Chico, CA 95928 as shown in **Figure 3.**

Figure 3 - Butte Regional Operations Center

BCAG's Sustainability Goals

Butte County Association of Governments (BCAG) has developed a plan to transition to a fully zero emission bus (ZEB) fleet composed of battery electric and fuel cell electric buses by 2040, in accordance with the Innovative Clean Transit (ICT) regulation, requiring all California transit agencies to follow zero-emission procurement guidelines with the goal of achieving 100% zero-emission fleets by 2040. BCAG has committed to purchasing zero emission buses, demonstrating the agency's commitment to reducing emissions. BCAG has worked with CTE to select a plan that prioritizes B-Line's local needs and conditions, namely considering resilience, redundancy, and emergency response adaptation options. B-Line's transition to a fully ZEB fleet will ultimately benefit communities through cleaner air, greater independence from fossil fuels, and more environmental sustainability.

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.

BCAG's Rollout Plan General Information

Rollout Plan's Approval Date: August 25, 2022

Resolution No: See **Appendix A – Approved Board Resolution.**

Is a copy of the approved resolution attached to the Rollout Plan?
Yes, please see **Appendix A – Approved Board Resolution.**

Contact for Rollout Plan follow-up questions:
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Who created the Rollout Plan?
This Rollout Plan was created by BCAG, with assistance from the Center for Transportation and the Environment (CTE).

BCAG created their ICT Rollout Plan in combination with a Zero-Emission Bus Transition Master Plan, which explains BCAG's plans for transition in greater detail. The Master Plan will be maintained and updated annually. As a result of CTE's fleet transition planning methodology described herein and in greater detail in the Master Plan, BCAG decided to pursue a zero-emission fleet comprised of 75% BEBs and 25% fuel cell electric buses (FCEB). BCAG's fleet transition strategy is to replace each ICE bus with a BEB as they reach the end of their useful life. In 2030, however, rather than replacing all 13 buses that have reached the end of their useful life with BEBs, BCAG plans to procure 8 FCEBs in addition to 5 BEBs, thus resulting in a mixed fleet.

This document, the ICT Rollout Plan, contains the information for BCAG'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. BCAG may update the Rollout Plan as needed as the industry continues to develop and as the Master Plan is updated.

Additional Agency Resources

BCAG agency website: http://www.bcag.org/index.html

C

Technology Portfolio

ZEB Transition Technology Selection

BCAG has elected to pursue a BEB Majority Mixed Fleet comprised of 75% BEBs and 25% FCEBs for their 35' and 40' buses and a 20% FCEV cutaway fleet. The bus fleet is projected to be 100% zero-emission in 2040 with a cutaway fleet that is 20% zero-emission, which results in a 66.7% zero-emission fleet overall. As detailed below, BCAG explored four possible ZEB transition scenarios: BEB Only, two Mixed Fleet scenarios (one 75% BEB & one 75% FCEB), and FCEB Only. BCAG decided against a BEB Only or FCEB Only fleet to avoid being tied to a single fuel technology. BCAG's chosen BEB Majority Mixed Fleet scenario allows the agency to rely primarily on the more mature and relatively less expensive BEB technology for a majority of their fleet, while benefiting from the resilience and redundancy that is provided by having a portion of the fleet transition to FCEBs.

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 home to four bus OEMs that manufacture zero-emission buses. Although three of these OEMs do not currently build FCEBs, growing demand for this vehicle technology may encourage these manufacturers to enter the market.

The 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 than traditional combustion fuels and through funding opportunities offered by CARB and CEC. The state's electrical utility companies have also supported the transition to ZEB technology by offering incentive programs for heavy duty EV charging infrastructure and service upgrades. California BEB deployments represent 37% of the nation's BEB deployments. [6]

California also has one of the most mature hydrogen fueling networks in the nation. The state's hydrogen market has developed to support the growing number of fuel cell electric vehicles on the roads in the state. California has four medium-and-heavy-duty 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. California FCEB deployments represent 75% of the nation's FCEB deployments.[7]

ZEB Transition Planning Methodology

BCAG's ICT Rollout Plan was created in combination with BCAG's ZEB Transition Master Plan, utilizing 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 BCAG's Rollout Plan are outlined below:

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[6] CALSTART. 2021. THE ADVANCED TECHNOLOGY TRANSIT BUS INDEX: A NORTH AMERICAN ZEB INVENTORY REPORT. https://calstart.org/wp-content/uploads/2022/01/2021-ZIO-ZEB-Final-Report_1.3.21.pdf

[7] CALSTART. 2021. THE ADVANCED TECHNOLOGY TRANSIT BUS INDEX: A NORTH AMERICAN ZEB INVENTORY REPORT. https://calstart.org/wp-content/uploads/2022/01/2021-ZIO-ZEB-Final-Report_1.3.21.pdf

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 BCAG'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 costs 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 ICE 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 begins by compiling operational data from BCAG 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 B-Line to use as the basis for analyses. CTE also collected GPS data from a representative sample of B-Line's routes, which was used as the basis for modelling energy efficiencies for BEBs operating in B-Line's service area. The calculated efficiencies were then used in the Service Assessment to determine the energy requirements of B-Line 's service.

CTE evaluated BEBs and FCEBs in B-Line 's service to support BCAG's technology selection. The range of FCEBs, however, does not have the same level of sensitivity to environmental and operating conditions as BEBs. After collecting route and operational data, CTE determined that B-Line 's longest block is 225 miles long. Based on observed performance, CTE estimates FCEBs are able to complete any block under 350 total miles, which means that FCEB technology already has the capability to meet B-Line 's service requirements. Although FCEBs were determined to have the capability of serving all of B-Line's routes, BCAG was interested in exploring BEB Only and Mixed Fleet scenarios as well, so it was necessary to determine how much of B-Line's service could feasibly be served by depot-only charged BEBs in order to develop a set of ZEB transition scenarios that would allow the agency to make an informed decision on what technology or technologies would be most suitable to the agency's needs.

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 BCAG to determine efficiency and range estimates based on an accurate representation of its operating conditions.

To understand BEB performance on B-Line'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.

In addition to loading conditions, CTE modeled the impact of battery degradation on a BEB's ability to complete a block. The range of a battery electric bus is reduced over time due to battery degradation. 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

Given the conclusion that FCEBs could meet the range requirements for B-Line's service, the Service Assessment focused on evaluating the feasibility of BEBs in B-Line's service area. The efficiencies calculated in the Requirements Analysis & Data Collection stage were used to estimate the energy requirements of B-Line's service. The main focus of the Service Assessment is called 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".[8] A block 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 BEB can successfully operate on that block.

The Service Assessment projects the performance of a BEB that is charged overnight at the depot and operates on BCAG's service schedule at the time of the plan's writing. The results are used to determine when along the transition timeline a fleet of overnight depot-charged BEBs can feasibly serve B-Line 's territory or if another zero-emission technology is required to maintain service. This information can then be used to inform the scale and timing of BEB procurements in the Fleet Assessment.

Modeling & Procurement Assumptions

CTE and BCAG defined the following assumptions and requirements used throughout the study:

The Service Assessment energy profile assumed a 5% improvement in battery capacity every year with a starting battery capacity of 440 kWh for 35' and 40' buses, which was the average battery capacity seen in commercially-available buses in 2021. Electric cutaways are modeled to have a battery capacity of 110 kWh and were assumed to have the same 5% rate of improvement in battery capacity every year.

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[8] 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

This analysis also assumed B-Line will maintain blocks in a similar distribution of distance, relative speeds, and elevation changes to pre-COVID-19 service because buses will continue to serve similar locations within the service area and general topography remains constant even if specific routes and schedules change.

Fleet size and vehicle length distribution do not change over time. The analysis assumed that buses reaching the end of their useful life would be replaced with vehicles of the same size. Total fleet size remains the same over the transition period.

Buses are assumed to operate for a 12-year service life. Cutaways are assumed to operate for a 7-year service life.

Usable on-board energy is assumed to be that of a mid-life battery (10% degraded) with a reserve at both the high and low end of the battery's charge potential. As previously discussed, battery age affects range, so a mid-life battery was assumed as the average capacity of the battery's service life. Charging batteries to 100% or dropping the charge below 10% also degrades the batteries over time, which is why the analysis assumes that the top and bottom portions of the battery are unusable.

CTE accounts for battery degradation over the transition period with the assumption that B-Line can rotate the ZEBs to battery capacity to block energy requirements. As the zero-emission fleet transition progresses, older buses can be moved to shorter, less demanding blocks and newer buses can be assigned to longer, more demanding blocks to account for battery degradation in BEBs over time. B-Line can rotate the fleet to meet demand, assuming there is a steady procurement of BEBs each year to match service requirements. CTE accounts for this variability in battery age by using a mid-life usable battery capacity to determine block feasibility.

Results

The Service Assessment determines the timeline for when B-Line 's service may become achievable by BEBs on a single depot charge. Coupled with the FCEB range-to-block length comparison, the block analysis determines when, or if, a full transition to BEBs or FCEBs may be feasible. BCAG and CTE can then use these 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 then used in the Fuel Assessment to estimate the 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 B-Line will continue to serve similar destinations within the city. This core assumption affects energy use estimates and block achievability in each year.

The results of B-Line's Service Assessment can be seen below in **Figure 4**. Based on CTE's analysis, 72% of B-Line's blocks could be served by a single charge of a depot-only BEB with a 440-kWh battery and, with the assumed 5% improvement every year, 100% of BCAG's blocks could be served by this technology by 2035, which means that all of B-Line's service is feasible with depot-only charged BEBs within the transition period.

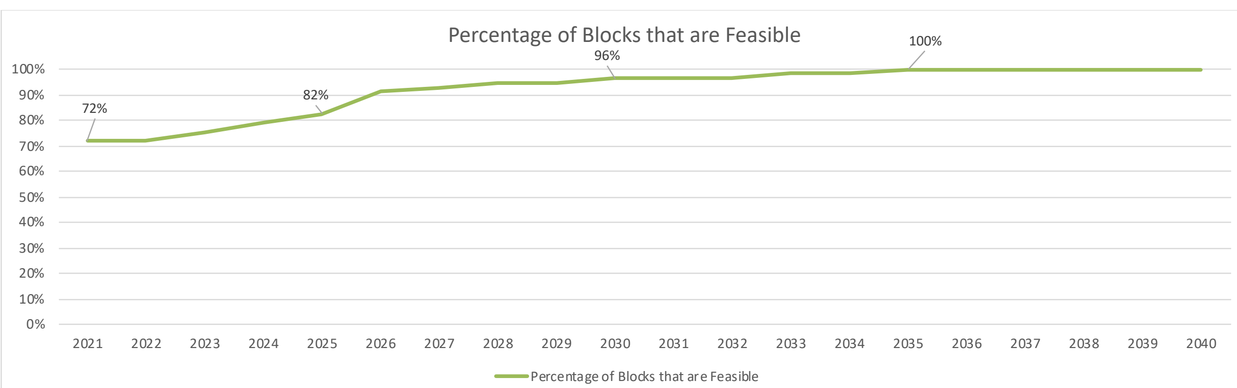

Figure 4 - BEB Block Achievability Percentage by Year

As noted previously, FCEBs are assumed to be able to complete any block under 350 total miles and BCAG's longest block is 225 miles long, which means that FCEB technology already has the capability to meet B-Line's service requirements.

Cutaway Modeling

CTE's modeling also included an analysis for battery electric cutaway vehicles using B-Line's paratransit drive cycles. CTE found that the power limitations of the battery electric cutaway motor may limit the possible service to 8 to 9% of B-Line's paratransit annual service. By 2025, 16.4% of B-Line's paratransit annual service would be considered feasible and by 2030, an electric cutaway vehicle is projected to be able to complete about half of their annual service.

Since the paratransit fleet also expends significant amount of energy idling, CTE conducted an Endurance Analysis, which brought the energy requirements of the HVAC while idling into consideration for determining the range of these vehicles. Endurance may be more representative of the paratransit duty cycle as it accounts for idling energy during breaks, loading, or pauses in service along with miles traveled. Taking into account endurance, by 2025, only 4.4% of B-Line's paratransit annual service would be considered feasible. The results found that idling would have a significant detrimental impact on cutaway range.

Based on these results, BCAG opted to refrain from applying a full zero-emission transition plan to their paratransit cutaway fleet in this current scope. BCAG, however, requested CTE to introduce fuel cell electric cutaways in future procurement cycles with the goal of transitioning up to 20% of their paratransit fleet composition from gasoline to fuel cell starting in 2030. BCAG may need to submit a request for exemption from the zero-emission bus purchase requirements in section 2023.1(c).

Description of ZEB Technology Solutions Considered

For this study, CTE developed 4 scenarios to compare to a baseline scenario and analyze the feasibility and cost effectiveness of implementing each bus technology as well as the co-implementation of both technologies. The scenarios are referred to by the following titles and described, in detail, below. A baseline scenario was developed to represent the typical "business-as-usual" case with retention of ICE buses for cost comparison purposes.

0. Baseline (current technology)
1. BEB Only

2a. Mixed Fleet - BEB Majority

2b. Mixed Fleet - FCEB Majority

3. FCEB Only

In the **BEB with Depot-Only Charging 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 an exception in the ICT regulation that will allow the agency to request an exemption to retain ICE buses in their fleet. Based on CTE's modeling, all of B-Line's blocks are fully achievable using BEB technology by 2035.

In the **Mixed Fleet – BEB Majority – (75% BEB) scenario**, FCEBs supplement a primarily BEB fleet to make up a fully ZEB fleet. The costs for infrastructure and installation of two different charging and fueling infrastructures are taken into account. FCEBs and hydrogen fuel, however, are more expensive than BEBs and electricity, so this scenario allows B-Line to assign the less expensive BEB technology where possible and supplement service with FCEBs as needed in support of resilience and redundancy adaption measures.

A **Mixed Fleet – FCEB Majority (75% FCEB) scenario** BEBs supplement a primarily FCEB fleet to make up a fully ZEB fleet. The costs for infrastructure and installation of two different charging and fueling infrastructures are taken into account. Based on CTE's modeling, all of B-Line's blocks are fully achievable using BEB technology by 2035, however, the range of FCEBs already currently exceed that of BEBs. This assessment therefore considers FCEBs capable of replacing diesel buses at a 1:1 ratio and allows B-Line the flexibility to operate the FCEBs in any of its blocks. In turn, blocking assignments are a key consideration for BEBs, particularly for those that are purchased prior to 2035. Overall, a mixed fleet is more resilient as it would allow service to continue if either fuel became temporarily unavailable for any reason.

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 avoids the need to install two types of fueling infrastructure by eliminating the need for depot 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.

When considering the various scenarios, this study can be used to develop an understanding of the range of costs that may be expected for BCAG's ZEB transition, but ultimately, can only provide an estimate. Furthermore, this study aims to provide an overview of the myriad considerations the agency must take into account in selecting a transition scenario that go beyond cost, such as space requirements, safety implications, and operational changes that may differ between scenarios.

D

Current Bus Fleet Composition and Future Bus Purchases

Fleet Assessment Methodology

The Fleet Assessment projects a timeline for the replacement of existing buses with BEBs and FCEBs. The timeline is consistent with BCAG's fleet replacement plan that is based on the 12-year service life of transit buses and 7-year service life of cutaways. This assessment also includes a projection of fleet capital costs over the transition timeline.

ZEB Cost Assumptions

CTE and BCAG developed cost assumptions for future bus purchases. Key assumptions for bus costs for the BCAG Transition Plan are as follows:

- ICE vehicle prices were provided by BCAG and are inclusive of costs for configurable options and taxes.
- Battery Electric 35'/40' and Fuel Cell Electric 35'/40' prices are from the 2019 CA State Contract Bus Pricing Report plus the annual PPI and tax (7.25%).
- Battery Electric 35'/40' prices include $50K for extended battery warranty & $120K for configurable options.
- Fuel Cell Electric 35'/40' prices include $11k for extended fuel cell battery warranty & for $120K configurable options.
- Electric Cutaway price is based on the CA State Contract and also includes $50K for extended battery warranty & $75K for configurable options and tax (7.25%).
- Fuel Cell Cutaway price is estimated from the battery-electric cutaway price + $100,000 for fuel cell components (based on comparable costs for fuel cell trucks) and also includes $11k for extended fuel cell battery warranty & $75K for configurable options and tax (7.25%). No such vehicle exists on the market today.
- BEB range will improve, but the cost will remain stable due to economies of scale.
- The battery capacity will continue to increase, but the cost will not increase or decrease.
- Annual costs were not adjusted for inflation.
- Costs for retrofits or bus conversions are not included because BCAG does not plan to convert any ICE buses to battery electric powertrains.

Table 1- Fleet Assessment Cost Assumption

	Fuel Type				
Length	CNG	Gas	Diesel	Electric	Fuel Cell
Cutaway	NA	$70,000	NA	NA	$446,000*

35'	NA	NA	$575,000	$967,000	$1,262,000*
40'	$399,000	NA	$600,000	$978,000	$1,262,000

*Bus size not currently available for this technology

Description of BCAG's Current Fleet

B-Line's current service and fleet composition provide the baseline for evaluating the costs of transitioning to a zero-emission fleet. BCAG 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

In 2021, the B-Line bus fleet included 29 diesel buses used for fixed route service, and 22 gasoline powered cutaways used for paratransit service. Bus services operate out of one depot in Chico, CA. Operations, maintenance, and fueling functions are performed at the depot.

Routes and Blocks

B-Line's current service consists of 21 fixed routes run on 57 blocks. Routes range in length from 4.26 miles to 52.26 miles and blocks range in distance from 45.63 miles to 225.34 miles. Buses pull out as early as 4:25 and return as late as 22:20. BCAG's service runs through the County of Butte, the City of Chico, the City of Oroville, and the Town of Paradise.

Current Mileage and Fuel Consumption

Annual mileage of the fleet:
1,940,000 miles

B-Line's ZEB Transition Plan assumes that the amount of service miles will remain the same.

Annual fuel consumption:
59,000 therms of CNG

230,000 gallons of diesel

90,000 gallons of gasoline

Fleet average efficiency:
5.75 miles per DGE

BCAG current fuel expense:
$1,217,000 per year

Average fuel costs:
$3.80 per diesel gallon

$1.79 per therm of CNG

$3.60 per gasoline gallon

ICE Maintenance Costs

In 2019, BCAG spent approximately $729k on scheduled and unscheduled maintenance, including both parts and labor, for the entire fleet. This results in the average annual maintenance costs per mile by vehicle type in **Table 2**. Buses also undergo one engine overhaul at midlife summarized in **Table 3**.

Table 2 - Labor and Materials Cost Assumptions

Vehicle Type	Estimate (Per Mile)
30'/35' Diesel Bus	$ 0.32
40' Diesel Bus	$ 0.35
Gas Cutaway	$ 0.33

Table 3 - Midlife Overhaul Cost Assumptions

Type	Overhaul Scope	Estimate
Diesel	Engine/Transmission Overhaul	$56k per bus
Cutaway	Engine/Transmission Overhaul	$10k per cutaway

Zero-Emission Bus Procurement Plan and Schedule

As previously discussed, a fleet made up primarily of depot-charged BEBs (75% of the fleet) with 25% FCEBs will be sufficient to meet B-Line's service demands. BCAG's fleet transition strategy is to replace each diesel and compressed natural gas (CNG) bus with a BEB or FCEB as they reach the end of their 12-year useful life beginning in 2030. **Figure 5** below provides the number of each bus type that will be purchased each year through 2040 with this replacement strategy.

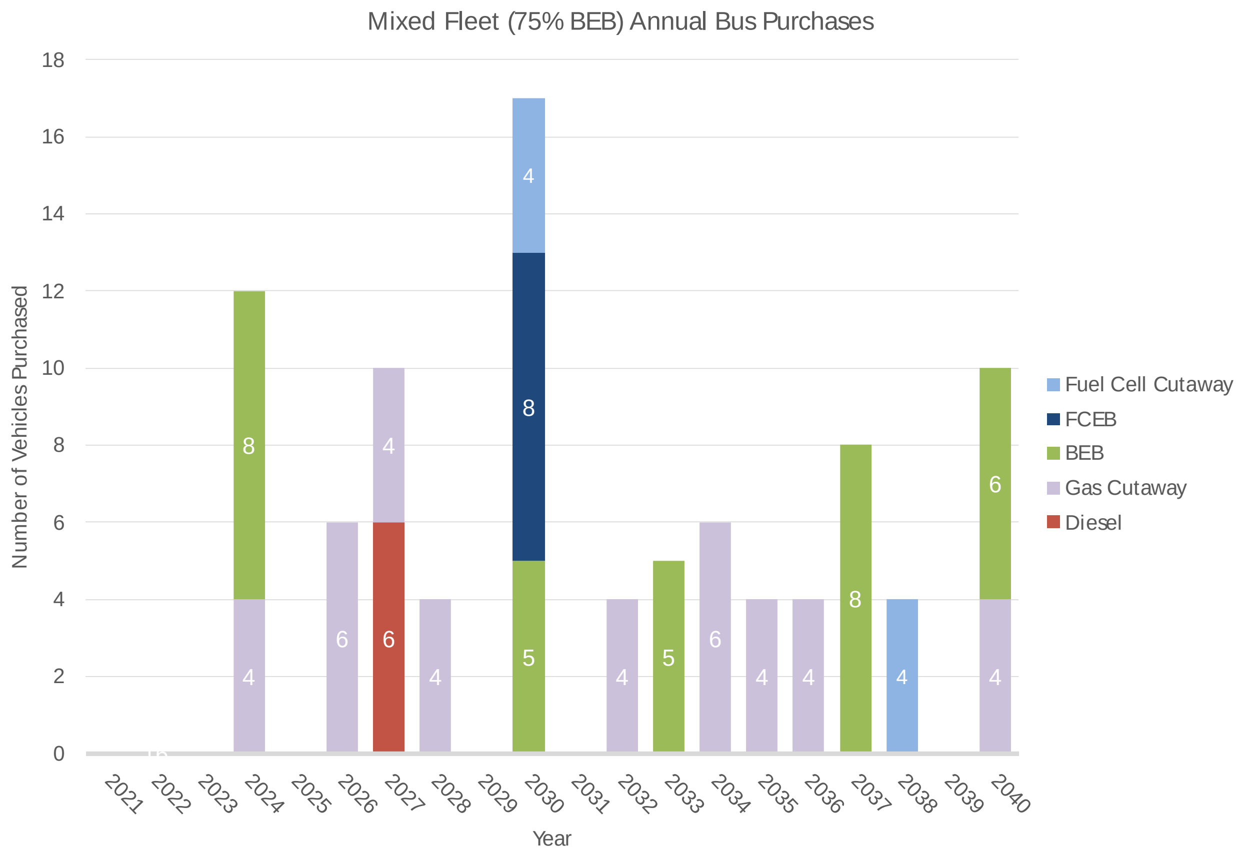

Figure 5 - Projected Bus Purchases, Mixed Fleet - BEB Majority

Figure 6 demonstrates the annual composition of B-Line's fleet through 2040. As previously discussed, B-Line does not plan to fully transition their paratransit cutaway fleet until a suitable zero-emission vehicle is available, but they do want to begin integrating zero-emission cutaways into their fleet by transitioning four cutaways to fuel cell vehicles in 2030. By 2040, B-Line's bus fleet will consist entirely of BEB and FCEBs. The fleet will remain the same size throughout the transition period.

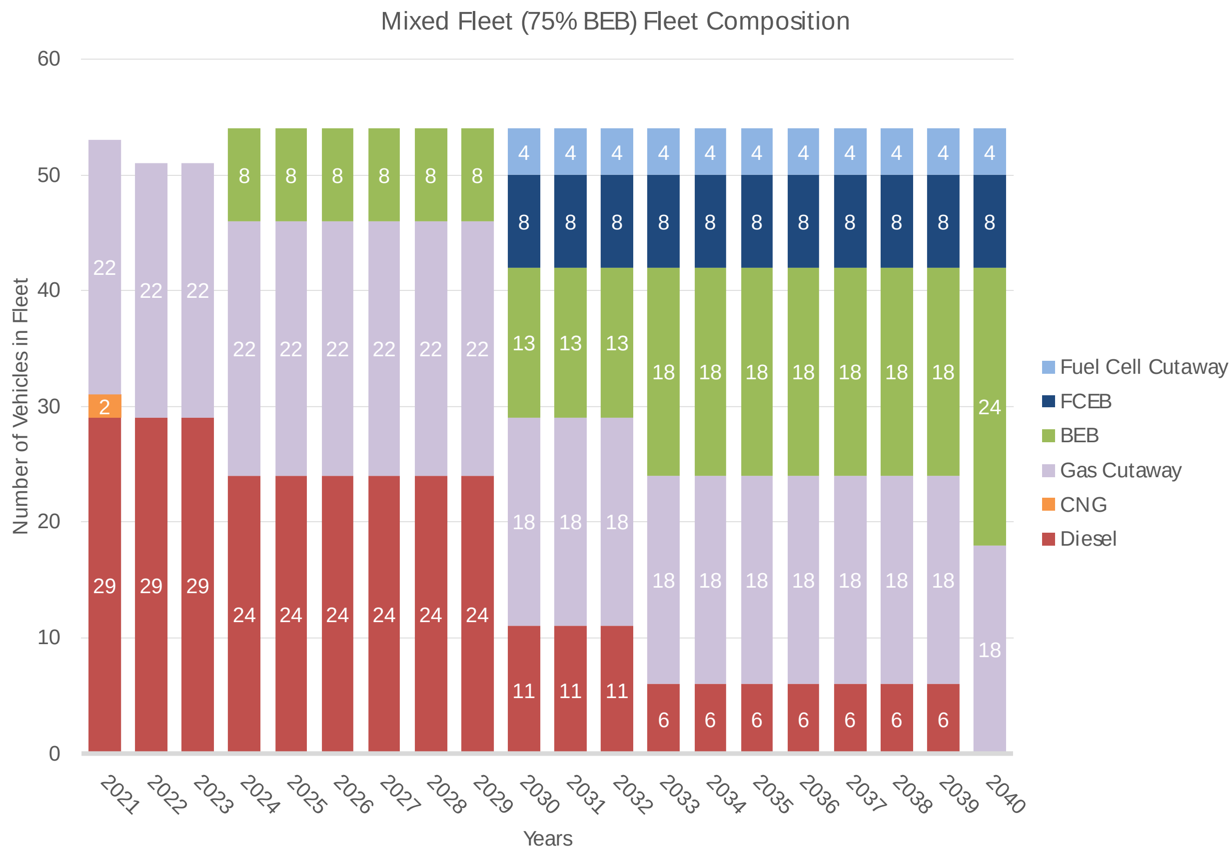

Figure 6 - Annual Fleet Composition, Mixed Fleet - BEB Majority

Figure 7 shows the annual total bus capital costs in the selected transition scenario. 2030 is a major purchase year when 13 diesel buses will reach the end of their 12-year useful service life and 16 gasoline powered cutaways will reach the end of their 7-year useful life.

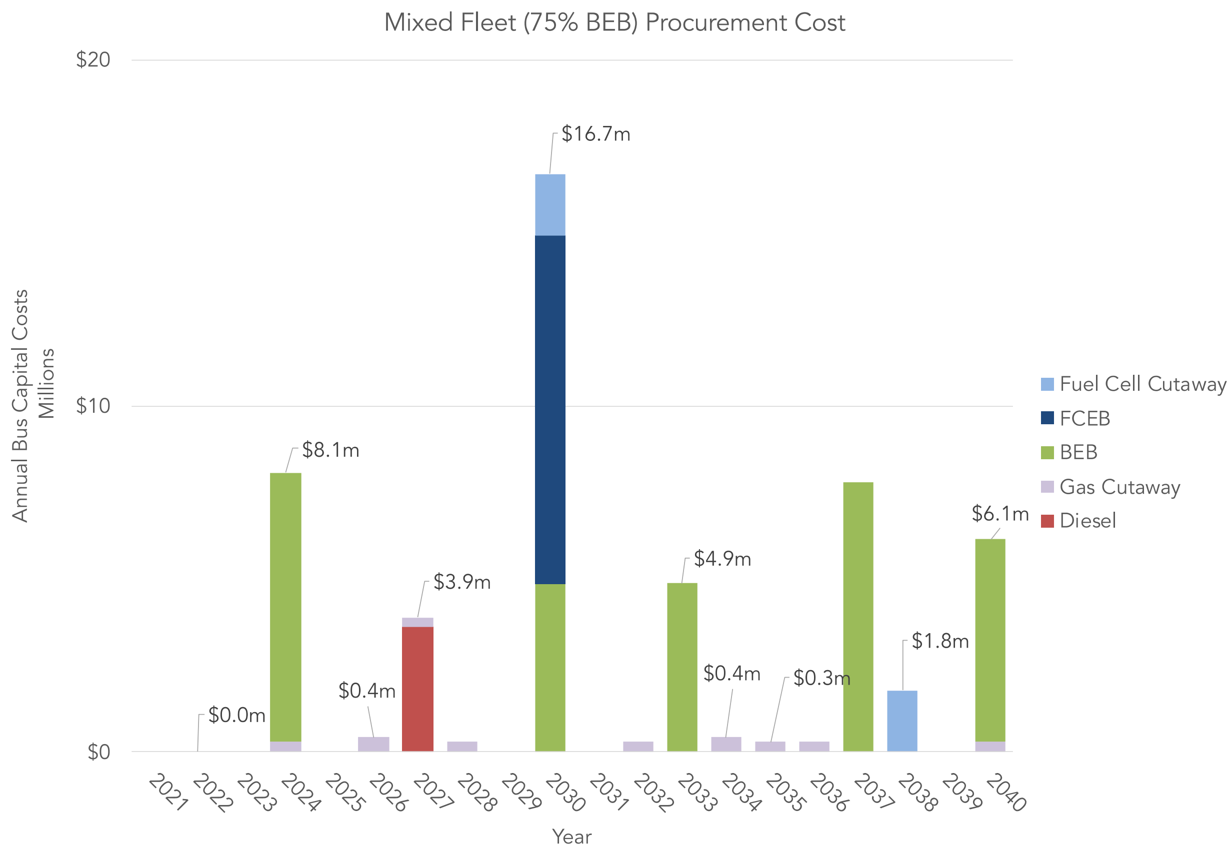

Figure 7 - Annual Capital Cost, Mixed Fleet - BEB Majority

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

Table 4 - BCAG Bus Capital Investment to transition to a 100% ZEB fleet by 2040

	ICE Baseline*	ZEB Incremental Costs	Total Investment
Bus Capital Costs	$35M	$16M	$51M

*Represents the capital costs that would have been incurred in the absence of the ICT Regulation

Additional Considerations

When purchasing FCEBs and BEBs, the process may differ slightly from the process BCAG currently uses to purchase vehicles. First, when contracting with FCEB and BEB manufacturers, BCAG should ensure expectations are clear between the bus OEM and the agency. As with a CNG and diesel purchases the agreement should be clear regarding the bus configurations, 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), BCAG 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 ZEBs may differ from ICE buses.

When developing RFPs and contracting for BEB and FCEB procurement, BCAG 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. BCAG 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 ZEBs will also differ slightly from their current diesel, CNG and gasoline vehicles since they will need to include requirements for hydrogen fuel cell and battery performance. It is also recommended that BCAG purchase an extended battery warranty for the vehicles, which should be specified in the RFP and contract.

FCEB procurement will also differ from ICE procurements since there are fewer OEMs presently manufacturing these vehicles, although this is expected to change with increasing demand. BCAG 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

BCAG Facility Configuration and Depot Layout

Depot Address:
326 Huss Lane, Chico CA, 95928

Electric Utility:
PG&E

Located in a NOx Exempt Area?
No

Bus Parking Capacity:
50+

Current Vehicle Types Supported:
BCAG's depot currently supports fueling and maintenance of diesel and CNG buses and gasoline cutaways.

Propulsion Types That Will be Supported at Completion of ZEB Transition:
Battery electric and hydrogen fuel cell electric propulsion

Facilities Assessment Methodology

Mixed fleet BEB and FCEB deployments such as BCAG's require installation of charging stations and improvements to existing electrical infrastructure as well as hydrogen fueling infrastructure. FCEB deployments require installation of a fueling station and may require improvements such as upgrades to the switchgear or utility 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.

Building off of the fleet procurement schedule that was outlaid in the Fleet Assessment, CTE then uses industry average pricing to develop infrastructure scenarios that estimate the cost of building out the infrastructure necessary to support a full fleet transition to ZEBs. This plan assumes that infrastructure projects will be completed prior to each bus delivery. To project the costs of fueling infrastructure, CTE used industry pricing provided by A&E subcontractors and an infrastructure build timeline based on the procurement timeline. 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

Description of Depot-Charging Infrastructure Considered

In the Mixed Fleet: BEB Majority scenario, charging infrastructure is required to service a total of 24 BEBs and additional hydrogen fueling infrastructure for eight FCEBs and four fuel cell electric cutaways to support a completely zero-emission bus fleet by 2040. Because there are separate costs associated with each type of ZEB technology, the facilities assessment for this scenario is broken down by each fuel type. The total cost of this scenario will be slightly more than $11.2M.

BEB Charging Infrastructure Summary

In order to support the BEB portion of the fleet, BCAG will need to work with a contractor to conduct detailed infrastructure planning, purchase chargers and dispensers, and add service capacity to their site. The estimated infrastructure costs for these technology & infrastructure expenses are as follows:

- **Infrastructure planning.** Building charging infrastructure requires planning at the depot. This assessment assumes that a planning project costs $200,000 and occurs only once per depot. The total cost of planning projects for BCAG's single depot is estimated at $200,000.
- **Dispensers and Chargers.** A total of 24 dispensers will be needed at BCAG's depot to accommodate 24 BEBs in the fleet. In total, this scenario will require 12 chargers under the assumption that there will be two dispensers per chargers. Charging projects include purchase and installation of 150 kW chargers and dispensers. This would come to $4.6 million for BCAG by 2040.
- **Electric Service Upgrade.** BCAG requires an estimated 2 MW of additional electricity capacity by 2040 to accommodate charging for 24 BEBs. To meet the growing demand for electricity, the BROC depot will need to upgrade its system to at least 1 MW of capacity by 2022 and up to 2 MW of capacity by 2033. This is estimated to cost around $1.9 million over the transition period.
- **General Conditions / General Requirements:** A 15% General Conditions and Requirements cost is applied to all projects to account for costs incurred by the contractor that are not directly construction costs, such as business operations.
- **Contingency.** A 20% contingency is added on all project costs.
- **Market Factor.** 7% is added on all project costs, conditions, and contingency.
- **Bonds and Insurance.** 2% is added on all project costs, conditions, contingency, and market factors.
- **Contractor's Fee.** 6.5% is added on all project costs, conditions, contingency, and market factors.

CTE recommends that BCAG complete the infrastructure over time as necessary to support their gradual BEB deployments. The estimated total BEB infrastructure costs for the Mixed Fleet scenario are approximately $6.7 million (see **Figure 8**) and costs are incrementally incurred with each BEB purchase.

FCEB Fueling Infrastructure Summary

In addition to BEB charging, hydrogen fueling is required to support the Mixed Fleet: BEB Majority Scenario. Like BEB infrastructure, a FCEB infrastructure deployment will also require hiring an infrastructure planning contractor. A storage capacity project, maintenance bay upgrades and fueling infrastructure costs will also be necessary to allow BCAG to fuel their hydrogen fuel cell vehicles on site. Infrastructure is assumed to be built out in one project that will conclude prior to the first FCEB deployment in 2030. The estimated infrastructure costs for these technology & infrastructure expenses are as follows:

- **Infrastructure planning.** Building hydrogen infrastructure requires planning at the depot. This assessment assumes that a planning project costs $200,000 and occurs only once per depot. The total cost of planning projects for BCAG's single depot will be approximately $200,000.
- **Storage Capacity Projects.** The total cost for storage capacity projects at BCAG will be approximately $500,000 over the transition period.
- **Maintenance bay upgrades.** Maintenance bay upgrades are required to make the bays compliant with hydrogen safety regulations. At BCAG, CTE integrated the A&E's estimated cost for each bay upgrade at $58,000. This cost estimate stems from the requirement of additional ventilation systems necessary for hydrogen detection. With six maintenance bay and gas detection upgrades, the total cost for hydrogen infrastructure in this scenario is estimated at $1.2 million.
- **H2 Fueling infrastructure.** The number of dispensers is a variable that can be scaled to fit the number of vehicles that need to be fueled. A single dispenser is capable of fueling a single bus every 15 minutes. Therefore, having two dispensers will allow vehicles to be fueled twice as fast as a single dispenser. Because this scenario requires fueling only 12 vehicles, which could be fueled in three hours with a single dispenser, and since this three-hour fueling window is acceptable to BCAG, a single dispenser and associated fueling elements is assumed, which is estimated to cost $1.9 million.

- **General Conditions / General Requirements:** A 15% General Conditions and Requirements cost is applied to all projects to account for costs incurred by the contractor that are not directly construction costs, such as business operations.
- **Contingency.** A 20% contingency is added on all project costs.
- **Market Factor.** 7% is added on all project costs, conditions, and contingency.
- **Bonds and Insurance.** 2% is added on all project costs, conditions, contingency, and market factors.
- **Contractor's Fee.** 6.5% is added on all project costs, conditions, contingency, and market factors.

Figure 8 shows the estimated infrastructure costs for the FCEB technology, which includes the following costs and reaches a sum of $4.6 million.

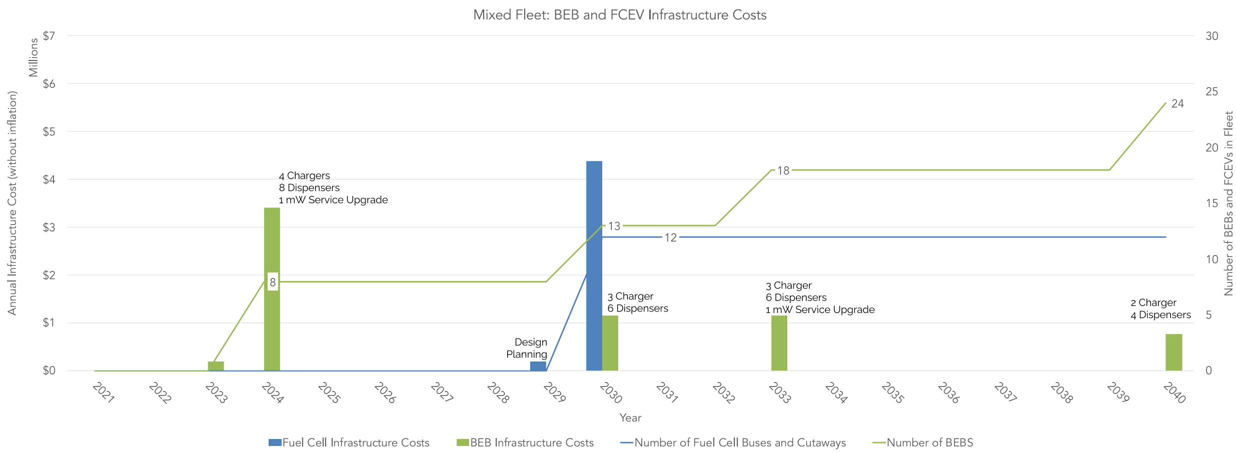

Figure 8 - Infrastructure Costs, Mixed Fleet - BEB Majority Charging Scenario

In addition to assessing the fueling and maintenance infrastructure requirements for BCAG's ZEB transition, CTE also conducted a Redundancy, Resilience, and Emergency Response (3R) Assessment, which investigates the new risks to an agency's ability to provide service during power outages or fuel disruptions and the ability to support required emergency response activities, such as community evacuation with a full ZEB fleet. The project team applied a risk assessment methodology to evaluate various adaptation measures that reduce risks from identified threats. The effectiveness of adaptation measures is informed by factors such as cost, risk reduction capabilities, a transit agency's risk tolerances, facility constraints, and environmental impacts.

BCAG's primary concerns are addressing ZEB fleet operation in the event of a fuel interruption (i.e., power outage or hydrogen fuel delivery disruption) and planning for evacuation support. BCAG has previously been impacted by severe wildfires, which required community evacuation, and may also put BCAG at risk from planned power outages. It is expected that severe wildfires and flooding events will become more likely and more extreme in the future due to climate change impacts.

CTE worked with BCAG to determine what the agency's minimum service requirements would be under several scenarios that would affect the agency's ability to fuel ZEBs, such as a wildfire, flood, or power outage and then created adaptation measures to meet the determined service demands. Adaptation measures explored include backup power options, such as a generator or maintaining additional hydrogen storage on-site, maintaining backup buses or creating an alternative fueling site. Adaptation measures were assessed to cost between $400,000 to $3,189,000 with varying effectiveness. Although BCAG has not chosen an adaptation package at this time, the knowledge that these options are available gives the agency confidence in their ability to provide necessary evaluation services with a fully ZEB fleet although implementing such a strategy will add to the capital costs of their transition.

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. Lower income neighborhoods are often exposed to greater vehicle pollution levels due to proximity to freeways and the ports, which puts these communities at greater risk of health issues associated with tailpipe emissions.[9] ZEBs will reduce energy consumption, harmful emissions, and direct carbon emissions in six opportunity zones and disadvantaged communities in rural Northern California as shown in in the service map below. B-Line serves the following census communities identified as DACs: 6007003700 and 6007001300, which have a pollution burden of 85-90% according to CalEnviroScreen. They are shown in **Figure 9** below.

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 car-less households as they are five times more likely to use public transit than households with at least one vehicle.[10] 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 people therefore rely solely on public transportation for their mobility needs.[11] B-Line's current fleet of fixed route diesel buses consume an annual average of 247,000 gallons of diesel. The combustion of this fuel exposes those who are reliant on public transportation to diesel exhaust, which has been classified as a probable human carcinogen with links to asthma and other lung related health issues.[12] Portions of B-Line's service area are in the 90th-100th percentile for diesel particulate matter (PM) according to CalEnviroScreen 4.0. Moving B-Line'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 Sacramento Valley 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. By purchasing new vehicles and decreasing the overall age of its fleet, B-Line is also able to improve service reliability and therefore maintain the capacity to serve low-income and disadvantaged populations. Replacing diesel vehicles with zero-emission vehicles, will also benefit these populations by improving local air quality and reducing exposure to harmful emissions from diesel exhaust.

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[9] 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

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

[11] 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=CABB49E7FF438A88A19D1137A2B1851806514EF576E9A2D9462D3FAF1F628357490756251970 9F8AD53DEC3CF95ACF27&originRegion=us-east-1&originCreation=20220216190930

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

Map of Disadvantaged Communities served by B-Line

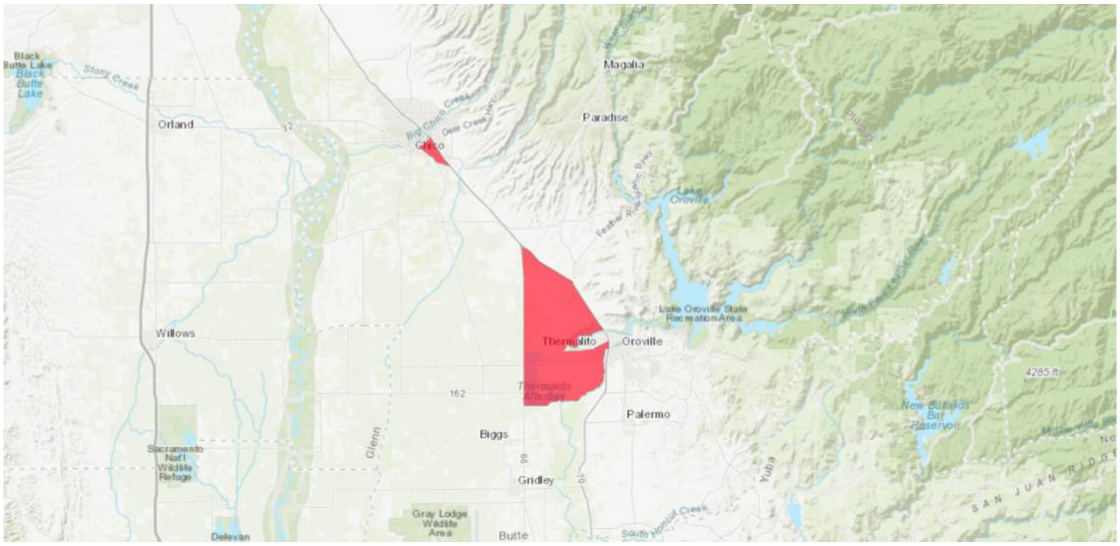

Figure 9 - B-Line Disadvantaged Communities Service Map

Emissions Reductions for DACs

Greenhouse gases (GHG) are the compounds primarily responsible for atmospheric warming and include carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). 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 (NO_x), particulate matter under 10 and 2.5 microns (PM_{10} and $PM_{2.5}$), volatile organic compounds (VOC), and sulfur oxides (SO_X). These pollutants are considered harmful to human health because they are linked to cardiovascular issues, respiratory complications, or other adverse health effects.[13] These compounds are also commonly 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 have often been cited 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, B-Line's zero-emission fleet will produce fewer carbon emissions and fewer harmful pollutants from the vehicle tailpipes. Communities disadvantaged by pollution served by B-Line's fleet will therefore directly benefit from the reduced tailpipe emissions of ZEBs compared to ICE buses.

Estimated Ridership in DACs

B-Line serves a diverse community, with a large portion of their daily passengers being individuals without cars (by choice or because of financial limitation), university students, and paratransit riders. Although ridership on transit in general has been decreasing over the past few years due, at least in part, to lower gas prices, combined with more affordable low-cost automobiles, which has allowed more people the opportunity to own and operate personal cars, the ridership reductions seen by B-Line in recent years are more directly tied to reduced population in their service

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13 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.

area following the Camp Fire.[14] In 2018, the Camp Fire burned through Butte County and destroyed homes and businesses in the town of Paradise, which is served by BCAG's transit services. In 2020, B-Line's service was further reduced by the Coronavirus Disease 2019 SARS-CoV-2 (COVID/COVID-19) outbreak.

B-Line's service experienced significant reduction after the 2018 Camp Fire and has not returned to its original service levels and is not expected to. Since the beginning of the COVID-19 pandemic , the services have stayed the same with the exception of Route 40 and 41, which runs through areas affected by the Camp Fire—demand for bus service in Paradise has remained low. Based on BCAG's data of available ridership and total fares received from July 2018 through the month of June 2019 (pre-COVID levels), there were 949,871 fixed-route passengers and 141,277 paratransit passengers[15]. BCAG anticipates annual ridership to be less than this over the next five years. In response to the changing ridership needs, due in part to the Camp Fire and COVID, BCAG is conducting a Route Optimization Study, which will be completed in the Summer of 2022 in order to re-assess how to most efficiently serve individual routes as well as the whole system.

[14] 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

[15] Page 21 of BCAG's Unmet Transit Needs Assessment – 2021/2022 http://www.blinetransit.com/documents/UTN/2122-Transit-Needs-Assessment-Final.pdf

G

Workforce Training

BCAG's Current Training Program

BCAG is experienced in recruiting, hiring, training, and integrating new staff to ensure that BCAG's employees are qualified to provide quality services to their riders. The level of training that BCAG drivers and maintenance staff engage in is dependent upon their level of experience at time of hiring. BCAG's training is conducted by Transdev, which specializes in operator and maintenance training.

Operator Development Program (ODP)

The Operator Development Program is designed to teach all the essential skills to enable Operators to do their job at the highest level of safety and competence. It integrates classroom courses, closed-course, and behind the wheel training modules. New hire training is 120 hours, and follow up training is required annually. Training includes:

- Technical Training
- Safe Driving
- Behind-the-Wheel (BTW) Training
- Cadetting In-service Training
- Ongoing Safety Monitoring
- Disability Awareness, Passenger Sensitivity, and Customer Service Training
- Training Documentation/Evaluation
- Operator Retraining

Operators must meet 33 Performance Standards and Skills.

Mechanics Training

Transdev has developed a maintenance training program that ensures that technicians are equipped to diagnose and address every eventuality with precision, thereby ensuring the necessary order or repair is competed correctly the first time and that a safe fleet of vehicles is available for operations. Technicians also receive annual refresher trainings, and any new systems and equipment that are added to BCAG's operations are immediately incorporated into the program.

Dispatchers and Supervisors Training

All Dispatchers and Road Supervisors complete all modules of Operator training, with 40 hours of additional training and on the job training. This includes job shadowing and ongoing training completed at least quarterly.

BCAG's ZEB Training Plan

OEM Training

BCAG 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 BCAG's workforce. Meaningful investment is required to upskill maintenance staff and bus operators trained in ICE vehicle maintenance and ICE fueling infrastructure.

BCAG 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. BCAG 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 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. BCAG plans to take advantage of these trainings offered by experienced agencies.

H

Potential Funding Sources

Sources of Funding for ZEB Transition

BCAG is prepared to pursue funding opportunities at the federal, state, and local level, as necessary and as available.

Federal

BCAG 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.

Annual Reliable Funding

- Federal Transportation Administration (FTA)
  - Urbanized Area Formula program
  - State of Good Repair Grants

Future Funding Opportunities

- United States Department of Transportation (USDOT)
  - Better Utilizing Investments to Leverage Development (BUILD) Grants
- Federal Transportation Administration (FTA)
  - Bus and Bus Facilities Discretionary Grant
  - Urbanized Area Formula program
  - State of Good Repair Grants
  - Capital Investment Grants – New Starts
  - Capital Investment Grants – Small Starts
  - Low-or No-Emission Vehicle Grant
  - Metropolitan & Statewide Planning and Non-Metropolitan Transportation Planning
  - 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

State

BCAG 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 Department of Transportation (Caltrans)
  - State Transit Assistance (STA) + STA SB1

Future Funding Opportunities

- 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)
    - Transportation Development Act
    - Transit and Intercity Rail Capital Program
    - Transportation Development Credits
    - New Employment Credit
- California Energy Commission

Local

Additionally, BCAG will pursue local funding opportunities to support zero-emission bus deployment. While the aforementioned funding opportunities are mentioned by name, BCAG will not be limited to these sources and will regularly assess opportunities for fiscal support for the ZEB program.

I

Start-up and Scale-up Challenges

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 5.** BCAG will seek financial support to cover the cost of their FCEBs from the resources discussed in Section H.

Table 5 - Incremental Cost of ZEB Transition

Incremental cost of ZEB Transition			
	ICE Baseline*	ZEB Incremental Costs	ZEB Transition Scenario Costs
Bus Capital Expense	$35M	$16M	$51M
Fueling Infrastructure	$0	$11M	$11M
Total	$35M	$27M	$62M

*Represents the capital costs that would have been incurred in the absence of the ICT Regulation

As seen in **Table 5**, costs of required fueling infrastructure and fueling operations 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 economies of scale on the production side will ultimately benefit transit agencies deploying and planning for FCEBs and BEBs.

CARB can support BCAG 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.

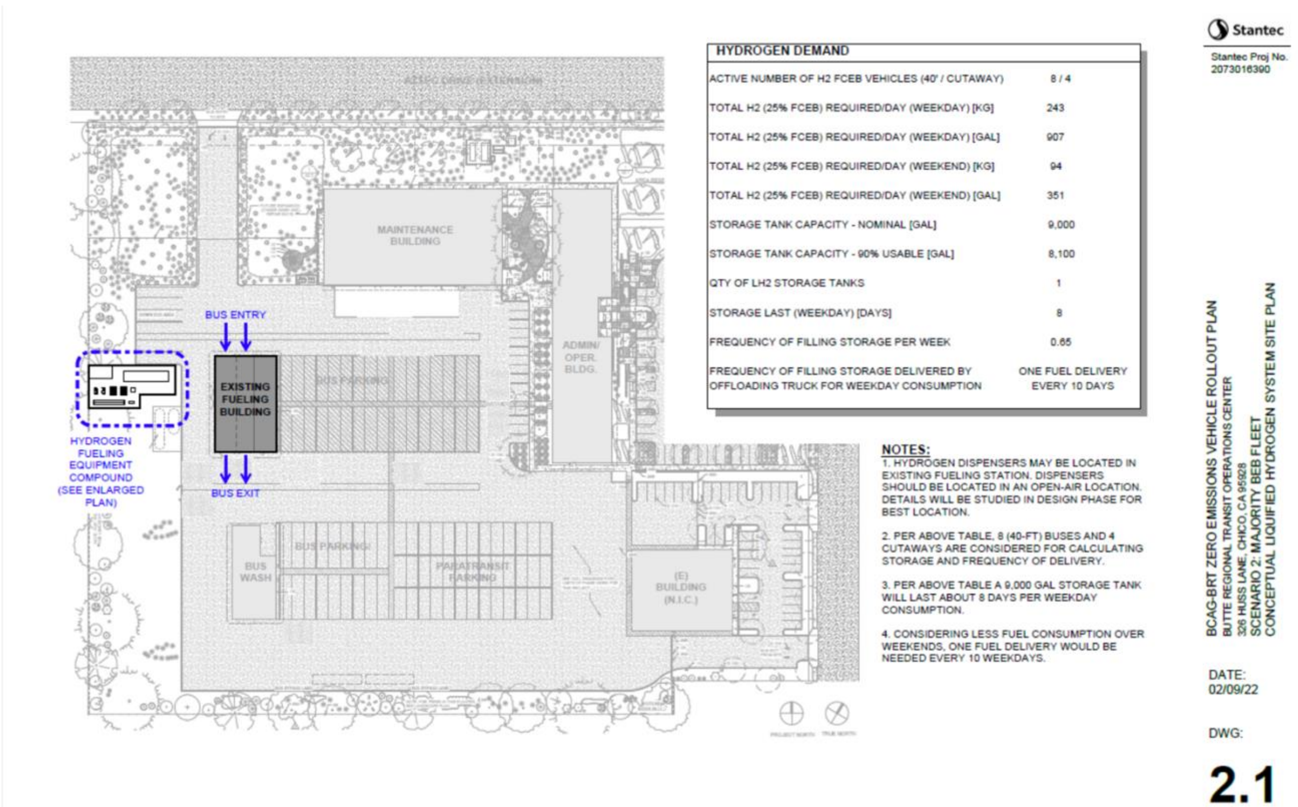
Limitations of Current Technology

Beyond cost barriers, transit agencies must also ensure that available zero-emission technologies can meet basic service requirements of the agency’s duty cycles. The applicability of specific zero-emission technologies will vary 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.

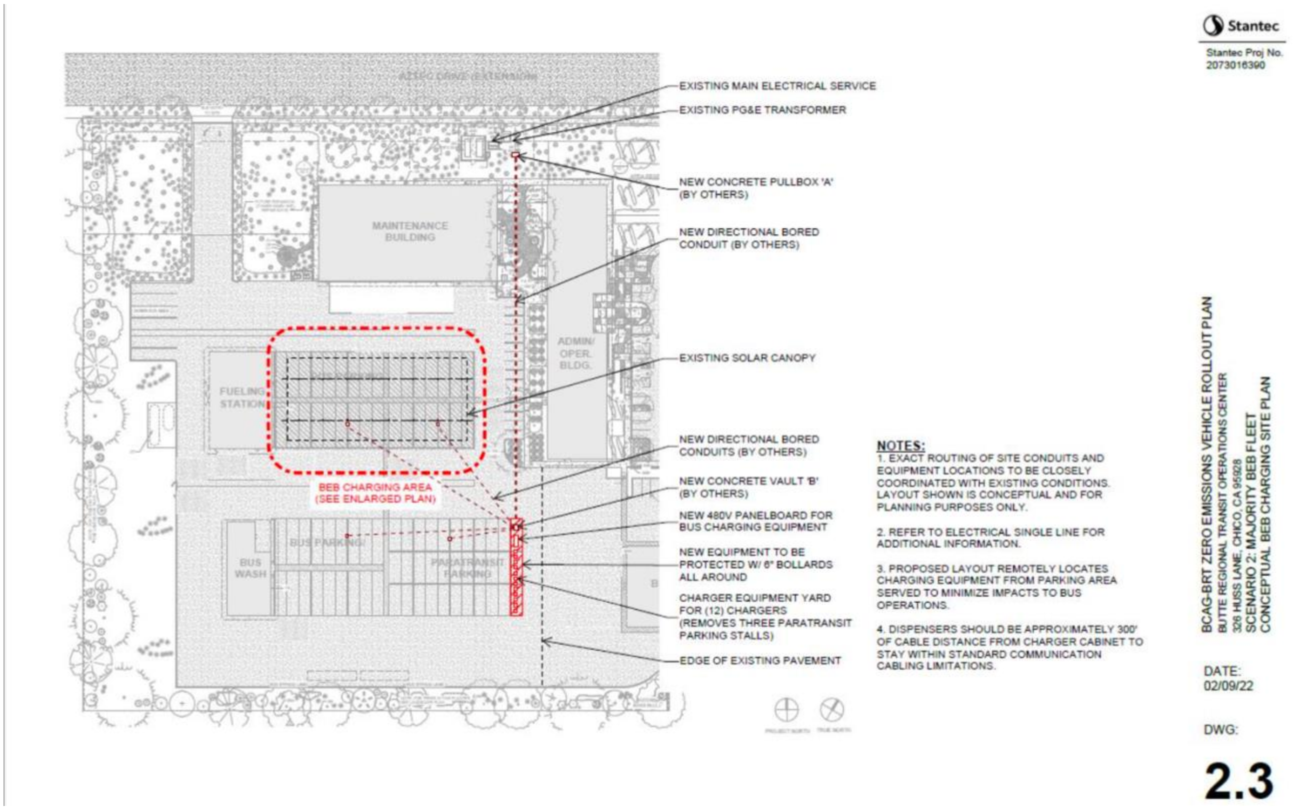
Appendix A – Approved Board Resolution

Appendix B – ZEB Transition Site Plans

Hydrogen infrastructure:



Battery-electric infrastructure:



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.

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, with the waste products of heat and water. The electricity powers the batteries, which powers the bus.

Greenhouse Gas Emissions: Zero-emission buses have no harmful emissions that result from diesel combustion. 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.

Hydrogen Fueling Station: The location that houses the hydrogen production (if produced onsite), storage, compression, and dispensing equipment to support fuel cell electric buses.

On-route Charging: BEB charging while on the route. 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 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: to confirm that the actual 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