Zero-Emission Bus Rollout Plan

Prepared by City of Corona Transit Service with support from the Center for Transportation and the Environment, Arcadis IBI Group, and the Riverside County Transportation Commission

Table of Contents

List of Tables

List of Figures

List of Abbreviations

ADA: Americans with Disabilities Act

A&E: Architecture and Engineering

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

MW: Megawatt

OEM: Original Equipment Manufacturer

PM: Particulate Matter

PPI: Producer Price Index

CPI: Consumer Price Index

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 B - Glossary

Executive Summary

City of Corona Transit Service (CCTS) provides public transit services for the community in and around the city of Corona in Riverside County, operating two fixed routes in the city, as well as Dial-A-Ride (DAR) service. CCTS transit fleet as of 2022 consists of seven (7) Compressed Natural Gas (CNG) low-floor buses and thirteen (13) CNG cutaways. Riverside County Transportation Commission (RCTC) awarded a contract to 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 on behalf of transit agencies and municipal transportation services in the cities of Banning, Beaumont, Corona and Riverside and the Palo Verde Valley Transit Agency to comply with the Innovative Clean Transit (ICT) regulation enacted by the California Air Resources Board (CARB). This report will focus on CCTS transition plan to zero-emission technology.

CCTS's Rollout Plan achieves a zero-emission bus fleet in line with the 2040 target of the ICT Regulation. To achieve this goal, CCTS will replace all CNG buses with ZEBs when the vehicles reach the end of their useful life. By 2040, 13 of the agency's buses are expected to be BEBs and 7 will be FCEBs. The last of the agency's CNG buses will reach end of life in 2039.

CCTS entire transit fleet operates out of 735 Public Safety Way, termed the Corporation Yard, and is operated and dispatched by a transit operator contractor, MV Transportation. Maintenance is also performed independently by the contractor at an offsite facility located at 1930 S. Rochester Ave., in Ontario, CA, approximately 13 miles from the administrative building and bus garage. The City of Corona owns and operates a public CNG fueling station at 430 Cota Street; however, the transit fleet primarily fuels overnight at the slow-fill CNG fueling station located within the Corporation Yard at 740 Public Safety Way. CCTS plans to install both charging and hydrogen fueling infrastructure at this location to support their proposed mixed fleet.

CCTS bus service provides transportation opportunities to 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 a compressed natural gas (CNG) fleet will cost an additional $14M in bus costs and infrastructure alone between 2021 and 2040, which will require significantly more funding sources. CCTS plans to pursue funding opportunities at the federal, state, and local levels to help fill this funding gap.

A

Transit Agency Information

CCTS Profile

On January 19, 1977, Corona City Council approved the name for the Corona Dial-A-Ride (demand response public transportation) and approved an Agreement with DAVE Systems to operate the Corona Dial-A-Ride. The Corona Dial-A-Ride began service in 1977 serving the general public, seniors, and people with disabilities within its service area that includes Corona and neighboring Riverside County area, like Coronita, El Cerrito, Home Gardens, including some satellite locations located within the City of Norco.

On February 2001 Corona launched the Corona Cruiser (deviated fixed route shuttle service) with two routes (Route 1 (A, Blue, bisecting Corona from east to west) and Route 2 (B, Red), serving the southwest quadrant of Corona) and in July 2001 Corona implemented Route 3 (C, Green, traveling along Hidden Valley Parkway/Norco/northwest part of Corona).

In 2004 the Corona Cruiser evolved to operate with two (2) fixed routes dubbed the Blue and Red Line, these route alignments have been slightly modified overtime but continue to serve Corona in current times; in addition to serving Corona the Corona Cruiser serves portions of El Cerrito, Home Gardens, and Norco.

On January 2, 2018, the Corona Dial-A-Ride was restructured to serve seniors (age 60 and over), persons with disabilities, and persons certified under the Americans With Disability Act of 1990 (ADA), the Corona Dial-A-Ride Service Area remained the same.

Currently, the Blue Line serves the McKinley Street retail area, travels onto Magnolia Avenue and Main Street to the River Road Area. The Red Line connects the residential areas of central Corona with commercial areas along Sixth Street, Ontario Avenue/California Avenue, and the Cajalco Rd. and Temescal Canyon Rd. retail area.

Service Area and Bus Service

City of Corona Transit Service (CCTS) public transit services in and around the city of Corona, a suburban community located southeast of Los Angeles in Riverside County. The City of Corona operates a system that provides services on two fixed routes in the city, Red Line, and Blue Line. The current bus fleet consists of seven (7) 32-ft. El Dorado National EZ Rider Compressed Natural Gas (CNG) low-floor buses. Corona's bus routes connect with Riverside Transit Agency regional bus routes, North Main Metrolink Station, and Park and Ride Lots. The Red Line also provides extended service to the Dos Lagos shopping center on Saturdays. Both the Red Line and the Blue Line have a service frequency of 60-70 minutes. The transit system transports passengers to Corona City Hall, Corona Public Library, major shopping centers and hospitals, the Senior Center, and more.

In addition to fixed-route service, Corona Transit provides dial-a-ride (DAR) service. This service is provided for Seniors 60 and older; persons with disabilities; and persons certified under the Americans with Disability Act (ADA). Service is provided within the City of Corona and adjacent unincorporated communities of Coronita, El Cerrito, and Home Gardens, as well as several satellite locations. This includes ADA services within three-quarters of a mile of fixed-route service. Unlike fixed-route service, the DAR service does not run a set route, and so a single vehicle may provide trips both within and outside of a DAC during a single day. The paratransit fleet consists of eleven (11) 25-ft. Glaval Universal E450 CNG cutaways and two (2) 26-ft. El Dorado Aerotech 240 CNG cutaways. CCTS service map is illustrated in **Figure 1.**

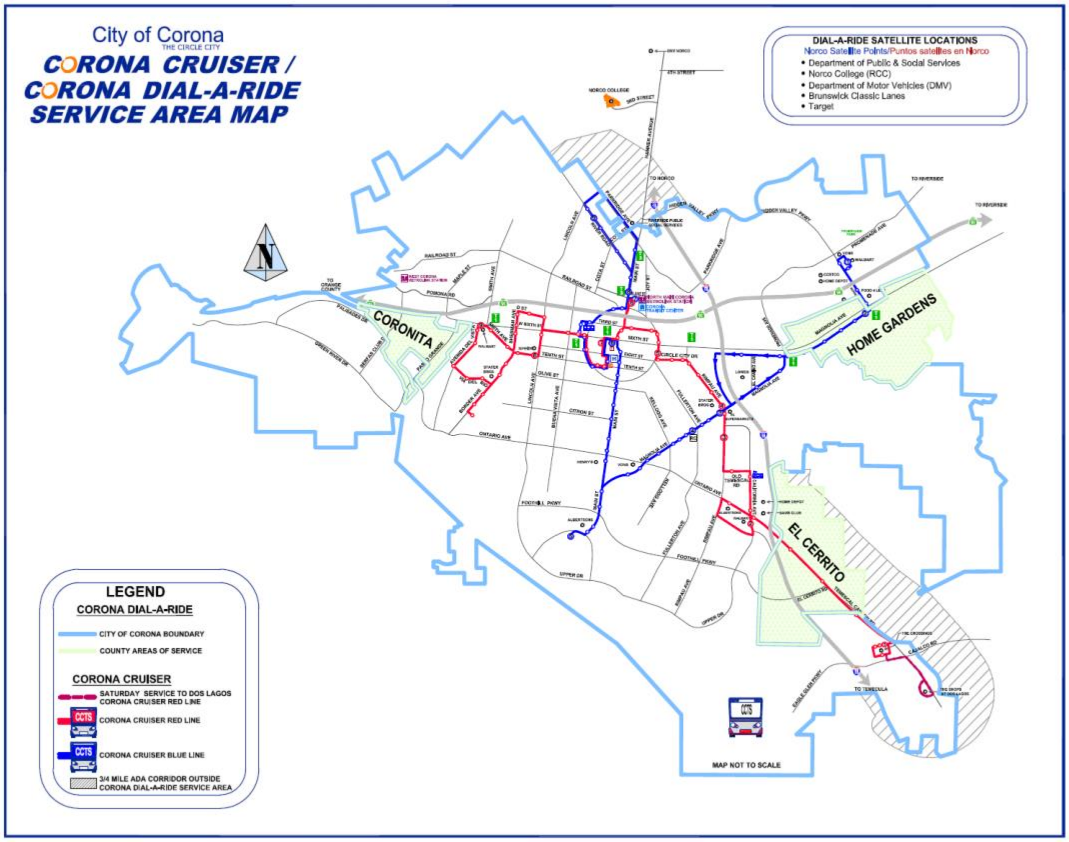

Figure 1 – CCTS Service Area

Ridership

Based on CCTS data of total ridership from July 2021 through the month of March 2022, staff estimated that there were a total of 111,257 unlinked passenger trips (UPT) throughout the year, with DAR services having 20,684 UPT and fixed route services having 90,573 UPT. In the 2020/2021 Fiscal Year, there were a total of 90,031 UPT, with DAR services having 13,386 UPT and fixed route services having 76,645. CCTS anticipates that annual ridership in the 2022/2023 Fiscal Year will be 153,283 passengers, with DAR passenger trips increasing by 62% and fixed routes by 22%. Per the CCTS Comprehensive Operations Analysis (COA), the agency is pursuing several service changes including extending fixed route services to areas in and surrounding Corona that are not currently being served, adding an additional bus to service the fixed routes, and opening DAR services to the general public.

CCTS Basic Information

Transit Agency's Name:

City of Corona Transit Service

Mailing Address: City of Corona Transit Service

735 Public Safety Way,

Corona, CA 92880

Transit Agency's Air Districts:

CCTS is part of the South Coast Air Quality Management District (SCAQMD).

Transit Agency's Air Basin:

Mojave Desert Air Quality Management District is part of the South Coast Air Basin.[1]

Total number of buses in Annual Maximum Service:

The maximum number of active buses operating fixed route and DAR services out of the Corporation Yard is ten (10). The fleet is composed of seven (7) low floor transit buses and thirteen (13) cutaways.

Urbanized Area:

Corona, CA. Corona is 39.2 square miles of land area with 3,934 people per square mile living within that area.[2]

Population of Urbanized Area:

Over 160,000 residents[3]

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[1] https://www.rcrcd.org/south-coast-air-quality-management-district-scaqmd

[2] https://www.census.gov/quickfacts/fact/table/coronacitycalifornia/RHI525221#RHI525221

[3] https://www.coronaca.gov/about-us

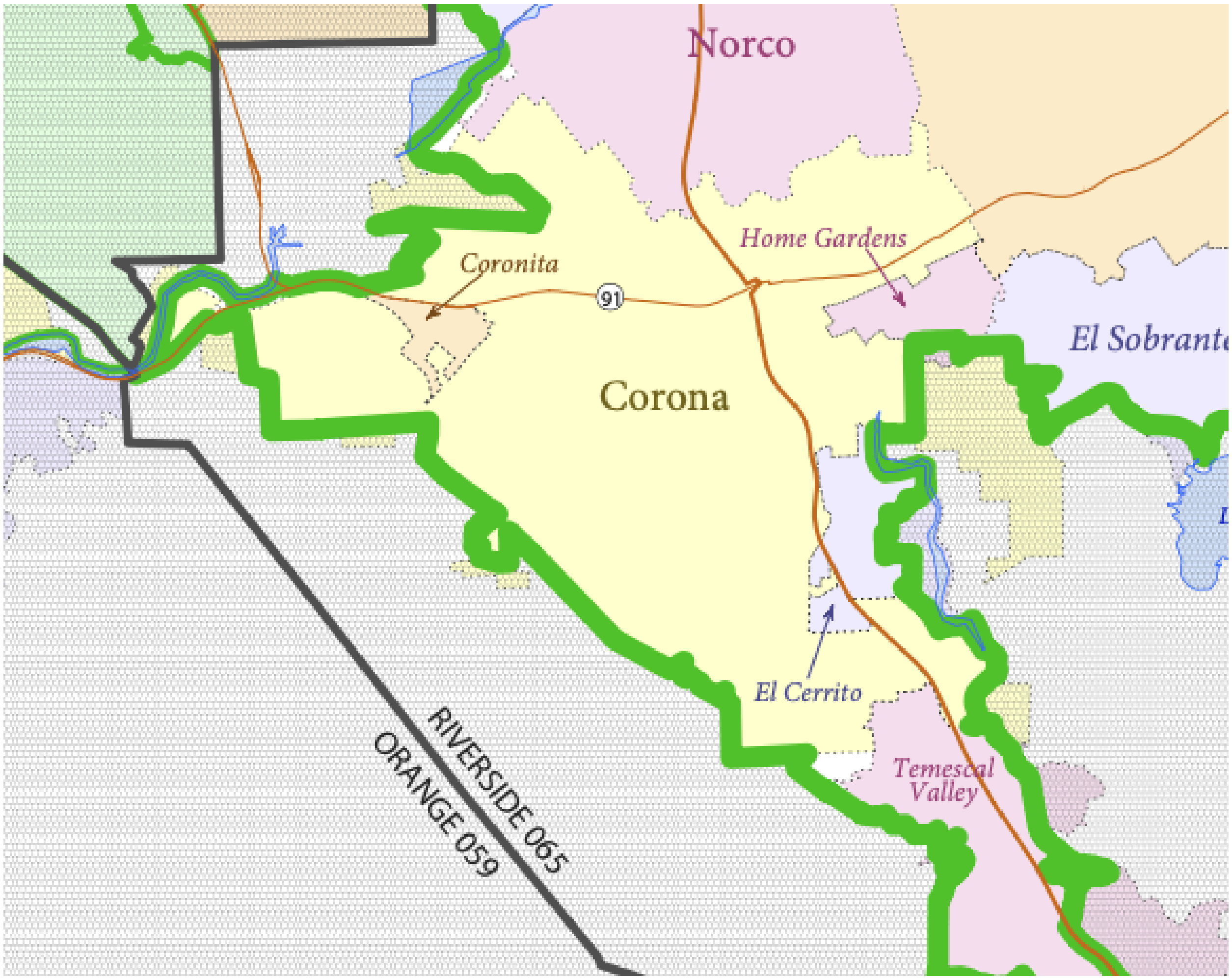

Figure 2 – City of Corona Urbanized and Rural Map[4][5]

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Is your transit agency part of a Joint Group? No

[4] https://www2.census.gov/geo/maps/dc10map/UAUC_RefMap/ua/ua75340_riverside--san_bernardino_ca/DC10UA75340_000.pdf

[5] Solid Green lines represent the boundaries of the urbanized area

Fleet Facility

CCTS's entire transit fleet operates out of 735 Public Safety Way, termed the Corporation Yard, and is operated and dispatched by a transit operator contractor, MV Transportation. Maintenance is also performed independently by the contractor at an offsite facility located at 1930 S. Rochester Ave., in Ontario, CA, approximately 13 miles from the administrative building and bus garage. The City owns and operates a public CNG fueling station at 430 Cota Street; however, the transit fleet primarily fuels overnight at the slow-fill CNG fueling station located within the Corporation Yard at 740 Public Safety Way. A map of the facilities and fueling locations are provided below, in **Figure 3** and **Figure 4** to understand the locations of CCTS properties in relation to one another, as well as to routes and service areas.

Figure 3 – CCTS Administrative and Maintenance Facility

Figure 4 – Fueling Facility Overview

CCTS Sustainability Goals

The City of Corona Transit Service desires to maintain a sustainable public transportation program that offers multiple transit options that are essential to ensuring uninterrupted mobility services to the community. CCTS is dedicated to sustainability and defines sustainability as the ability of the current generation to meet its needs without compromising the ability of future generations to meet their needs. California's plan to address public health, air quality and climate protection goals includes the Innovative Clean Transit (ICT) regulation, which aims to reduce greenhouse gas (GHG), nitrogen oxide (NOx), and diesel particulate emissions, with which, CCTS will be compliant at the conclusion of this project. To accomplish its sustainability goals, CCTS is working to replace its CNG fleet with 100% zero-emission vehicles by 2040 in accordance with ICT regulations.

CCTS 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. CCTS has committed to purchasing zero emission buses, demonstrating the agency's commitment to reducing emissions. CCTS 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 useful life (12 years for buses providing Fixed Route service and 5 years for the DAR cutaways). 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.

CCTS Rollout Plan General Information

Rollout Plan's Approval Date:

Resolution No:

Is a copy of the approved resolution attached to the Rollout Plan?

Contact for Rollout Plan follow-up questions:
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Who created the Rollout Plan?
This Rollout Plan was created by the City of Corona, with assistance from the Center for Transportation and the Environment (CTE) and the Riverside County Transportation Commission (RCTC).

This document, the ICT Rollout Plan, contains the information for CCTS zero-emission fleet transition trajectory as requested by the ICT Regulation. It is intended to outline the high-level plan for implementing 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.

Additional Agency Resources

CCTS agency website: https://www.coronaca.gov/transit

C

Technology Portfolio

ZEB Transition Technology Selection

Based on outcomes of the zero-emission fleet transition planning study completed by CTE, CCTS plans to transition its fleet to a mix of battery electric cutaways and fuel cell electric buses. By 2040, CCTS expects to operate a fully zero-emission fleet of 20 transit vehicles.

A mixed zero-emission technology 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) become temporarily unavailable. This plan summarizes the charging and hydrogen infrastructure costs needed to support a fleet of 20 buses.

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.[6]

ZEB Transition Planning Methodology

CCTS's ICT Rollout Plan was created in combination with CCTS Existing Conditions Report and the Riverside County ZEB Financial Strategy 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

[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

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 CCTS'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. Maintenance Assessment
7. Facilities Assessment
8. Total Cost of Ownership Assessment
9. Policy Assessment
10. Partnership 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 2022 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 CCTS 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 **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 **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 **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.

The **Policy Assessment** considers the policies and legislation that impact the relevant technologies.

The **Partnership Assessment** describes the partnership of the agency with the utility or alternative fuel provider.

Requirements Analysis & Data Collection

The Requirements Analysis and Data Collection stage begins by compiling operational data from CCTS 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 to use as the basis for analyses. CTE conducted a screening-level analysis of CCTS routes by determining their average speed and grades, and classified them as fast or slow and flat or hilly. CTE used these classifications to model the energy efficiencies for each of CCTS routes. The calculated efficiencies were then used in the Service Assessment to determine the energy requirements of CCTS service.

CTE evaluated BEBs and FCEBs to support CCTS technology selection. After collecting route and operational data, CTE determined that CCTS longest block is 183 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 service requirements. Although FCEBs were determined to have the capability of serving all of CCTS routes, CCTS was interested in exploring BEB and FCEB service scenarios, so it was necessary to determine how much of CCTS 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's bus operational behavior, and vehicle 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 CCTS to determine efficiency and range estimates based on an accurate representation of its operating conditions.

To understand BEB performance on CCTS 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 CCTS service, the Service Assessment focused on evaluating the feasibility of BEBs in CCTS service area. The efficiencies calculated in the Requirements Analysis & Data Collection stage were used to estimate the energy requirements of CCTS 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".[7] A block is usually

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[7] 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

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 CCTS 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 CCTS 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 CCTS 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 450 kWh for a 35' bus which represents an analogous ZEB suitable for CCTS transit vehicles and is an average of battery capacities seen in commercially-available buses of the same size and passenger capacity in 2022. Electric cutaways are modeled to have a battery capacity of 120 kWh and were assumed to have the same 5% rate of improvement in battery capacity every year.

This analysis also assumed CCTS 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 twelve-year service life. Cutaways are assumed to operate for a five or seven-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 CCTS 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. CCTS 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 CCTS 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. CCTS 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 CCTS 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 CCTS Service Assessment for fixed route service can be seen below in **Figure 5**. Based on CTE's analysis, 0% of CCTS blocks could be served by a single charge of a depot-only BEB with a 450-kWh battery and, with the assumed 5% improvement every year, 50% of CCTS blocks could be served by this technology by 2034, which means that CCTS service is not feasible with depot-only charged BEBs within the transition period. However, service can be conducted with the addition of on-route charging.

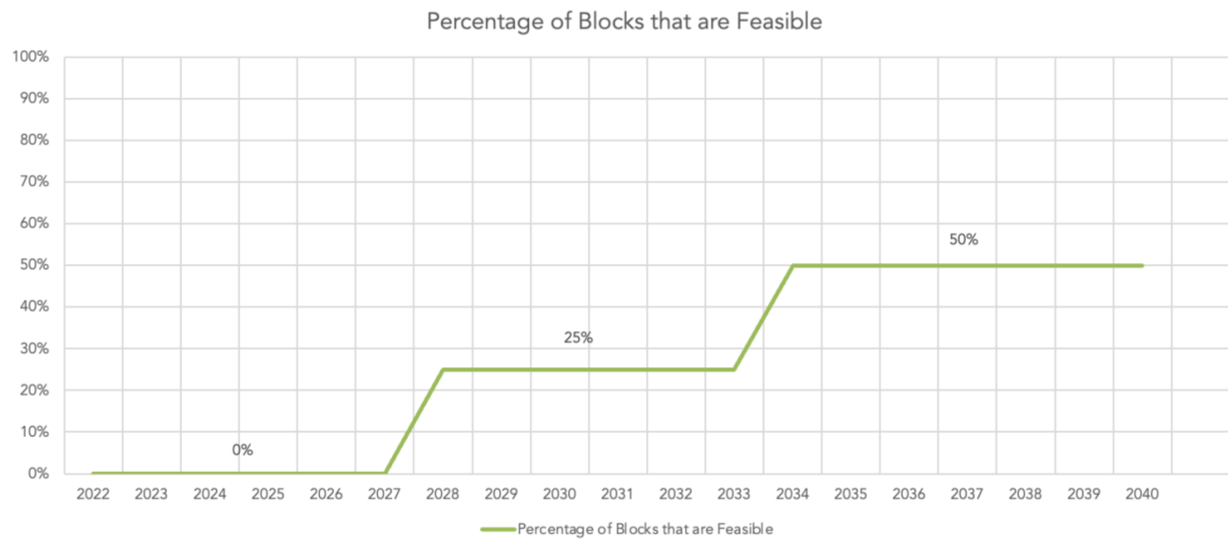

Figure 5 – BEB Block Achievability Percentage by Year

As noted previously, FCEBs are assumed to be able to complete any block under 350 total miles and CCTS longest block is 183 miles long, which means that FCEB technology already has the capability to meet CCTS service requirements.

Cutaway Modeling

CTE's modeling also included an analysis for battery electric cutaway vehicles using CCTS paratransit operational data. CCTS paratransit service operates between 16 and 159 miles per vehicle per day, with an average daily distance of 78 miles. CTE modeled the electric cutaway performance and found that approximately 49% of CCTS service is feasible with overnight depot-only charged cutaways in 2022. By 2040, CTE's modeling estimates that 91% of CCTS daily service will be feasible, which means that CCTS service is not feasible with overnight depot-only charged cutaways within the transition period.

Based on the results of the analysis, battery-electric cutaways would require some form of opportunity charging throughout the day to complete their service. Pantograph and inductive charging have not yet been demonstrated to be feasible for electric cutaways, so this option was not considered. Demand response service is run sporadically throughout the day, with vehicles typically returning to the depot after completing their assignments. Based on this service pattern, it was assumed that battery-electric cutaways could be charged throughout the day when they return to the depot which would allow them to complete all of CCTS service.

Description of ZEB Technology Solutions Considered

For this study, CTE developed three 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
2. Mixed Fleet – FCEB & BEBs
3. FCEB Only

In the **BEB Fleet Transition**, 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, on-route charging is utilized on fixed-routes and returning to the depot for midday opportunity charging is used on DAR service to sustain energy on-board. Based on CTE's modeling, all of CCTS blocks are fully achievable using BEB technology by 2040.

In the **Mixed Fleet Transition,** FCEBs supplement a primarily BEB fleet to make up a fully ZEB fleet. Although there may be some exceptions, due to the higher range capacity of FCEBs, BEBs will be used for DAR service and FCEBs will be used for fixed route service. 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 CCTS to assign the less expensive BEB technology where possible and supplement service with FCEBs as needed in support of resilience and redundancy adaptation measures.

Finally, the **FCEB Fleet Transition** 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 CCTS 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 ZEBs. The timeline is consistent with CCTS fleet replacement plan that is based on the twelve-year service life of transit buses and larger cutaways and five-year service life of van-style cutaways. This assessment also includes a projection of fleet capital costs over the transition timeline.

ZEB Cost Assumptions

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

- CNG vehicle prices were provided by CCTS and are inclusive of costs for configurable options and taxes.
- Capital vehicle costs are derived from the 2022 California, Washington and New Mexico State Contracts plus the annual PPI (2%) and tax (8.75%). Fuel Cell Cutaway pricing is a price estimation due to lack of market information.
- Costs for retrofits or bus conversions are not included. Procurements assume new vehicle costs.

Table 1- Fleet Assessment Cost Assumption

	Fuel Type		
Length	CNG	Electric	Fuel Cell
Cutaway	$172,766	$300,955	$376,153*
35'	$658,037	$994,678	$1,327,513*

*Bus size not currently available for this technology

Description of CCTS Current Fleet

CCTS current service and fleet composition provide the baseline for evaluating the costs of transitioning to a zero-emission fleet. CCTS 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

As of 2022, the CCTS bus fleet includes thirteen (13) CNG cutaways used for DAR paratransit service and seven (7) CNG low-floor buses used for fixed-route service. Bus services operate out of one depot in Corona, CA. Operations, maintenance, and fueling functions are performed at an offsite facility in Ontario, CA.

Routes and Blocks

CCTS 2022 service consists of four fixed routes run on four blocks, two run on weekends and two run on weekdays. Blocks range in distance from 101 miles to 183 miles. Buses pull out as early as 6:25 AM and return as late as 7:20 PM. CCTS service runs within the boundaries of the City of Corona, as well as the unincorporated communities of Coronita, El Cerrito, and Home Gardens.

Current Mileage and Fuel Consumption

Annual mileage of the fleet:
318,150 miles

CCTS ZEB Transition Plan assumes that the amount of service miles will remain the same.

Annual fuel consumption:

74,126 GGE of CNG

Fleet average efficiency:

6.8 miles per GGE for Cutaways

3.2 miles per GGE for Low-floor Buses

CCTS current fuel expense:
$132,630 per year

Average fuel costs:
$1.79 per GGE of CNG

Maintenance Costs

Average maintenance costs per mile by vehicle type are estimated in **Table 2** Buses also undergo one overhaul at midlife summarized in **Table 3**. These costs were utilized to project transition maintenance costs.

Table 2 – Labor and Materials Cost Assumptions

Vehicle Type (Cutaways and Low-floor Buses)	Estimate (Per Mile)
Gas Cutaway	$ 0.35
CNG Cutaway	$ 0.35
30'/35'/40' CNG Bus	$ 0.38
Battery Electric Cutaway	$0.32
30'/35'/40' Battery Electric Bus	$0.34
Fuel Cell Electric Cutaway	$0.51
30'/35'/40' Fuel Cell Electric Bus	$0.56

Table 3 – Midlife Overhaul Cost Assumptions

Vehicle Type	Overhaul (FC/Transmission) Cost Per vehicle life	Battery Warranty Cost Per vehicle life
Gas Cutaway	$0	$0
CNG Cutaway	$0	$0
30'/35'/40' CNG Bus	$30,000	$0
Battery Electric Cutaway	$0	$24,000
30'/35' 40' Battery Electric Bus	$0	$75,000
30'/35'/40' Fuel Cell Electric Bus	$40,000	$17,000
Fuel Cell Electric Cutaway	$0	$10,000

Zero-Emission Bus Procurement Plan and Schedule

CCTS will provide demand response service with a fleet of thirteen (13) depot-charged and opportunity-charged battery electric cutaways. Fixed route service will be performed by seven (7) FCEBs. This technology combination will be sufficient for meeting the agency's service demands. CCTS fleet transition strategy is to replace each compressed natural gas (CNG) bus with battery electric cutaways and FCEBs as they reach the end of their minimum service life beginning in 2028. **Figure 6** below provides the number of each bus type that will be purchased each year through 2040 with this replacement strategy and the total cost of that procurement.

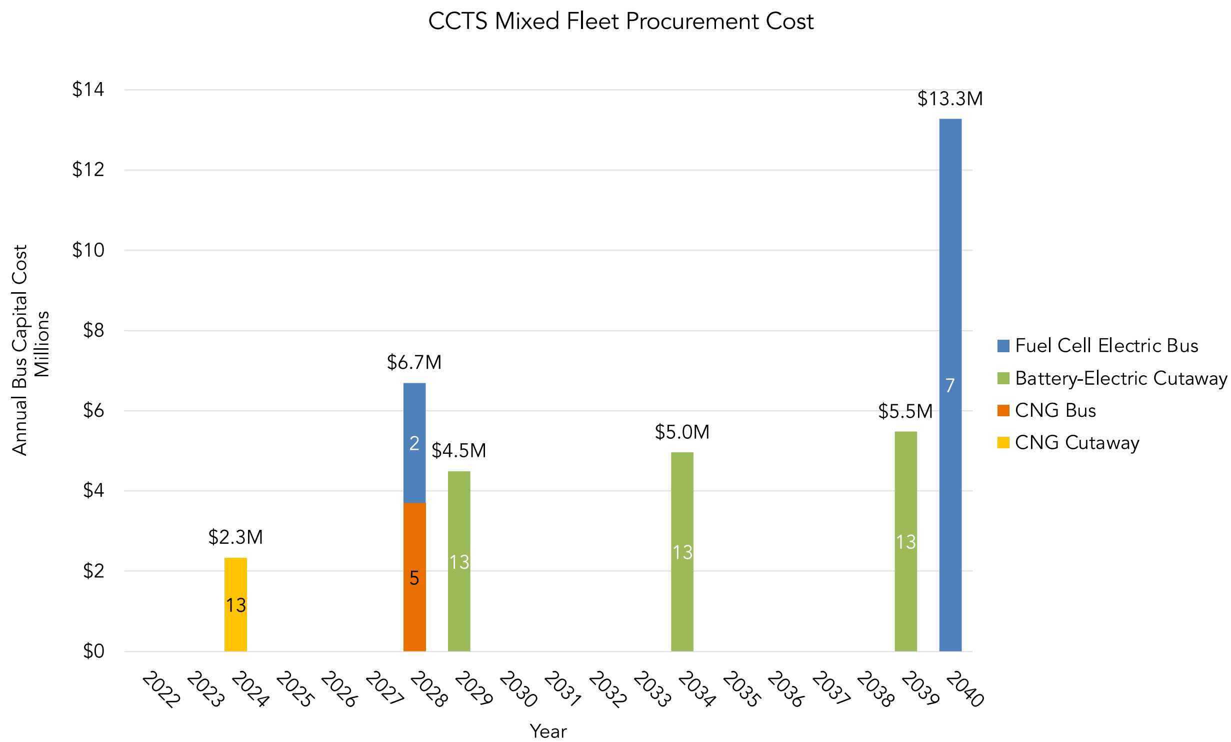

Figure 6 – Projected Bus Procurements for ZEB Transition

Figure 7 demonstrates the annual composition of CCTS fleet through 2040. By 2040, CCTS bus fleet will consist entirely of BEB and FCEBs. The fleet will remain the same size throughout the transition period.

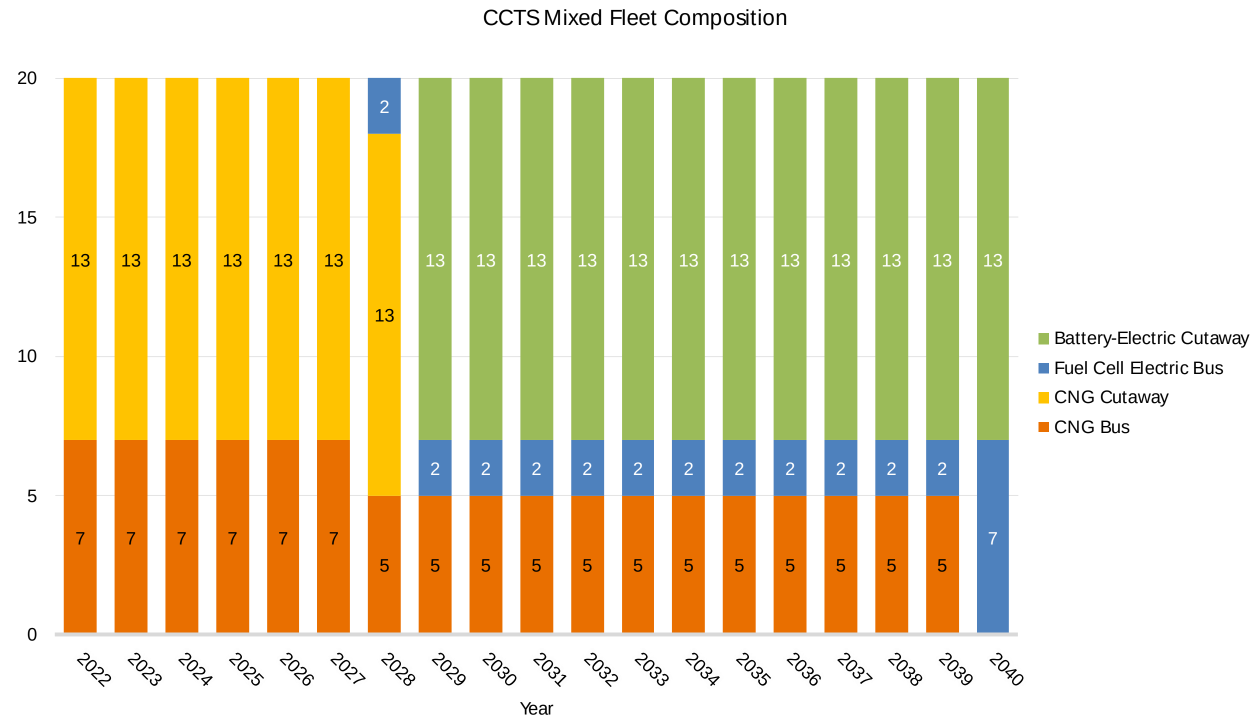

Figure 7 – Annual Fleet Composition, ZEB Transition

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

Table 4 – CCTS Bus Capital Investment to Transition to a 100% ZEB fleet by 2040

	CNG Baseline*	ZEB Incremental Costs	Total Investment
Bus Capital Costs	$23M	$14M	$37M

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

Additional Considerations

When purchasing ZEBs, the process may differ slightly from the process CCTS currently uses to purchase vehicles. First, when contracting with ZEB manufacturers, CCTS should ensure expectations are clear between the bus OEM and the agency. As with CNG 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), CCTS 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 ZEB procurements, CCTS 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. CCTS 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 CNG vehicles since they will need to include requirements for hydrogen fuel cell and battery performance. It is also recommended that CCTS 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. CCTS 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

CCTS Facility Configuration and Depot Layout

Depot Address:
735 Public Safety Way, Corona, CA 92880

Electric Utility:
Southern California Edison (SCE)

Located in a NOx Exempt Area?
No

Bus Parking Capacity:
20+

Current Vehicle Types Supported:
CCTS depot currently supports fueling and maintenance of CNG buses and 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 CCTS 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 outlined 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

With Corona's mixed technology fleet, charging infrastructure is required to service a total of 13 battery electric cutaways along with hydrogen fueling infrastructure for seven (7) FCEBs 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. In addition, CCTS has the opportunity to share hydrogen infrastructure with a neighboring transit operator in the City of Riverside, Riverside Connect, to decrease overall costs, but can implement independent hydrogen infrastructure if more desirable. The total cost for mixed fleet fueling infrastructure with shared hydrogen infrastructure is approximately $9.8 M and the scenario with independent hydrogen infrastructure is approximately $13.2 M.

BEB Charging Infrastructure Summary

In order to support the BEB portion of the fleet, CCTS 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 CCTS single depot is estimated at $200,000.
- **Dispensers and Chargers.** CCTS BEB charging depot will consist of seven chargers with two dispensers per charger. Prices are estimated at $170,00 for a 150kW charger with two dispensers.
- **Electric Service Upgrade.** CCTS requires an estimated 1 MW of additional electricity capacity by 2040 to accommodate charging for 13 BEBs. To meet the growing demand for electricity, the depot will need to upgrade its system to at least 1 MW of capacity by 2027. This is estimated to cost around $200,000 over the transition period.
- **Inflation Factor.** 5.4% inflation is added on all planning, procurement, and construction costs per the CPI. 3% inflation is added on all maintenance costs per Riverside's maintenance cost assumptions. All costs listed above are in 2022 dollars, projects occurring after 2022 are inflated per the inflation factor.

The estimated total BEB infrastructure costs for the Mixed Fleet scenario with shared hydrogen infrastructure is shown below in **Figure 8** and with independent hydrogen in **Figure 9**. The costs for charging equipment will stay the same whether CCTS shares hydrogen fueling infrastructure with Riverside Connect or not and totals approximately $2M over the transition period.

FCEB Fueling Infrastructure Summary

In addition to BEB charging, hydrogen fueling is required to support the Mixed Fleet. Like BEB infrastructure, a FCEB infrastructure deployment will also require hiring an infrastructure planning contractor. A storage capacity project, a fueling infrastructure capital project will also be necessary to allow CCTS to fuel their hydrogen fuel cell vehicles on site. Because CCTS contracts some maintenance services out, maintenance bay upgrades are not included as a cost to CCTS but are required for the contractor to safely maintain the new FCEB fleet. Infrastructure is assumed to be built out in one project that will conclude prior to the first FCEB deployment in 2028. 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 CCTS single depot will be approximately $200,000.
- **Maintenance bay upgrades.** Maintenance bay upgrades are not included in CCTS costs.
- **Hydrogen Fueling infrastructure.** CCTS fueling solutions were decided based on fuel consumption needs and approximately right-sized. Hydrogen infrastructure maintenance and operations are covered in the price of fuel in the fuel assessment. CCTS has the option of implementing an independent hydrogen fueling station or utilizing a shared hydrogen station with Riverside Connect.
- **Inflation Factor.** 5.4% inflation is added on all project costs per the CPI. All costs listed above are in 2022 dollars, projects occurring after 2022 are inflated per the inflation factor.

Figure 8 shows the estimated infrastructure costs for the FCEB technology with shared hydrogen infrastructure, totaling to approximately $6.5 M and **Figure 9** shows the estimated infrastructure costs for the FCEB technology with independent hydrogen infrastructure, totaling to approximately $10 M.

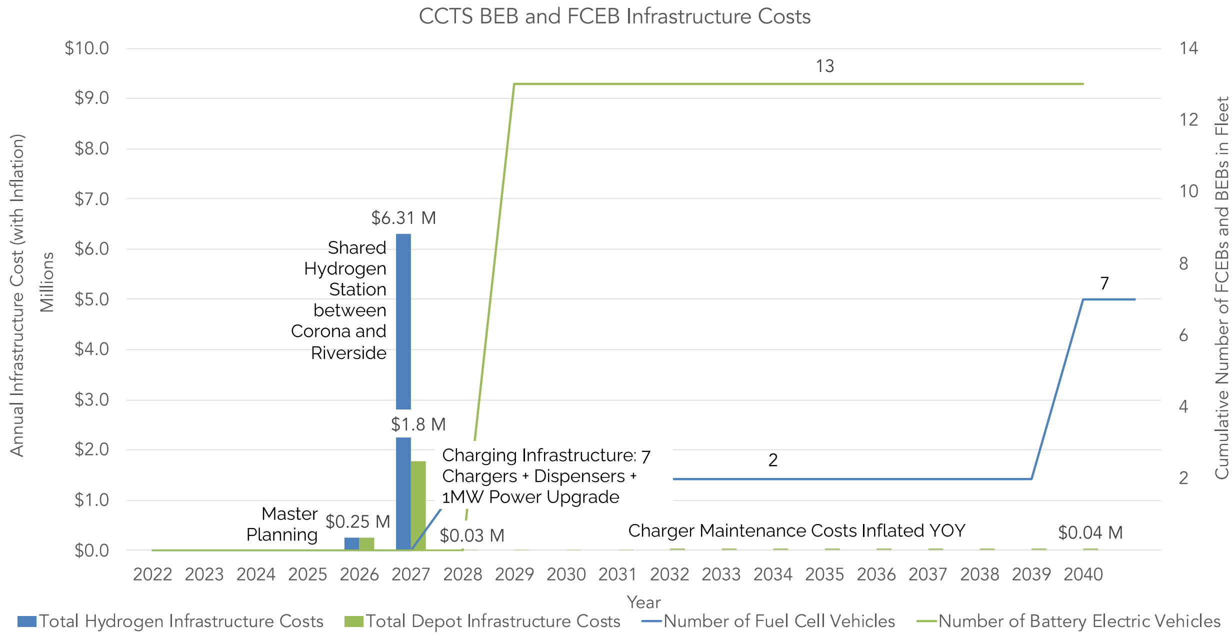

Figure 8 – Infrastructure Projects & Costs, ZEB Transition with Shared Hydrogen Infrastructure

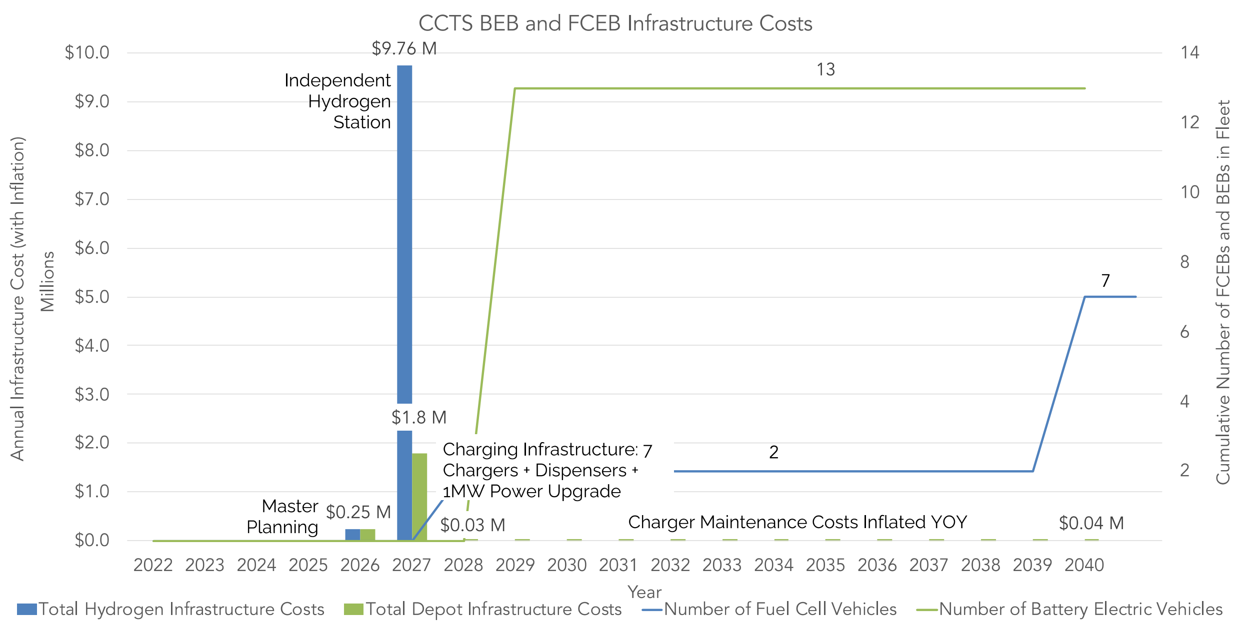

Figure 9 – Infrastructure Projects & Costs, ZEB Transition with Independent Hydrogen Infrastructure

Utility Partnership Review

The City of Corona is working with the Utility provider, Southern California Edison (SCE) who currently serves the Corporation yard where the buses are stored and charged. SCE has been active in sharing information related to its EV rates and incentives offered and the City is aware that taking advantage of these benefits and ensuring a successful battery electric bus deployment requires close, ongoing coordination with SCE.

SCE offers the Charge Ready Transport [8](CRT) program that supports both California's greenhouse gas (GHG)-reduction goal and local air-quality requirements. The Program assists customers with transitioning to cleaner fuels by reducing their cost for the purchase and installation of required battery-electric vehicle (EV) charging infrastructure, as well as providing rebates to offset the cost of charging stations for certain eligible customers[9].

Primarily, the CRT program offers low- to no-cost electrical system upgrades to support the installation of EV charging equipment for qualifying vehicles – heavy-duty vehicles weighing 6000+ lbs. In addition, participants that will be acquiring school buses or transit buses within SCE territory are also eligible for a rebate against the purchase of charging equipment. Programs like this will benefit CCTS significantly in the financial sector of their transition to zero-emission technology.

The City is sharing proposed planning documents to help SCE understand future loads so that any required grid infrastructure improvements can be addressed prior to implementation. The City's discussion of short- and long-term fleet goals with SCE will ensure that SCE can properly plan grid-side electrical infrastructure upgrades to the City's Corporation Yard, and that the City can adequately upgrade equipment to support battery electric buses. Once the infrastructure upgrade needs are established, the City will incorporate the design and construction timelines into the overall transition plan timeline. The City recognizes SCE as a critical partner in electrification and will continue to partner with SCE after the planning stages so that charge management strategies and fleet expansion efforts can be coordinated effectively. The City's current relationship with SCE is excellent and cooperative, the City of Corona serves a small portion of the City with electric service and meets regularly with SCE to discuss and address issues of concern.

Further, the City understands establishing and maintaining a partnership with the alternative fuel provider is critical to successfully deploying zero-emission vehicles and maintaining operations. Hydrogen fueling requires a plan for infrastructure installation, delivery, storage, dispensing, and upgrades to maintenance facilities. While fueling operations for hydrogen may require fewer operational changes than electric bus charging, understanding the local hydrogen supply market can be its own challenge. To overcome this challenge, the City may consider a competitive bid process for a design/build project as a reasonable approach to determining the appropriately sized station and selecting the most appropriate fueling technology at the best price.

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[8] https://crt.sce.com/program-details

[9] Charge Ready Transport, Quick Reference Guide

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.[10] ZEBs will reduce energy consumption, harmful emissions, and direct carbon emissions within the disadvantaged communities CCTS serves. The City of Corona includes 10 different census tracts designated as DACs. Corona's fixed routes that are in and pass through DACs, along with their stops are shown in **Figure 10** 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.[11] 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.[12] CCTS current fleet of fixed route and DAR CNG buses consume 74,126 Gasoline Gallons Equivalent (GGE) of fuel per year, operating for approximately 318,150 miles per year. Moving CCTS fleet to zero-emission technology will help alleviate the pollution from tailpipe emissions, which will improve the health of communities impacted by NOx and particulate matter emissions and all local 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, CCTS 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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[10] 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

[11] 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

[12] 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

Map of Disadvantaged Communities served by CCTS

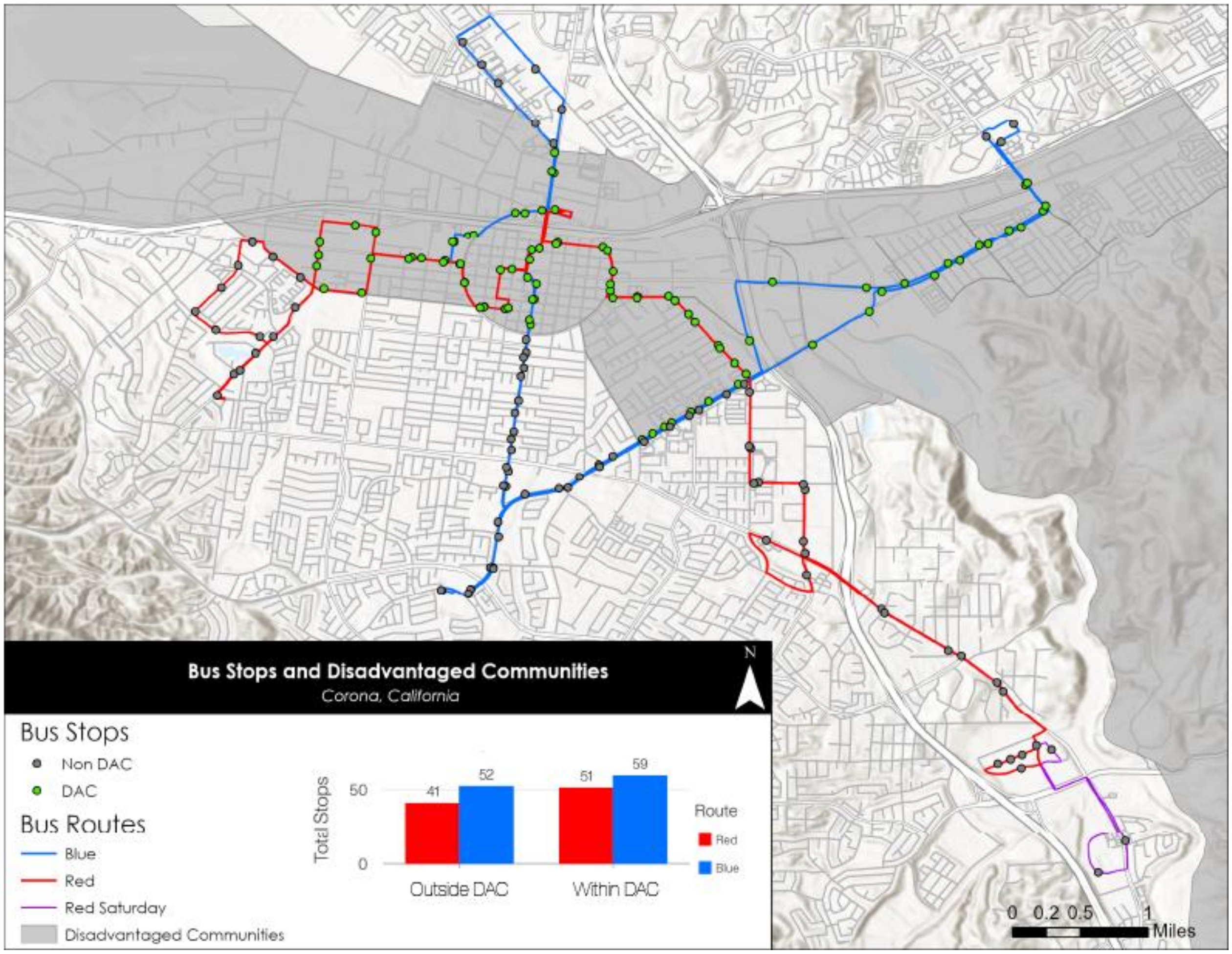

Figure 10 – CCTS Disadvantaged Communities Service Map

Emissions Reductions for DACs

Greenhouse gasses (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 gasses are not localized to the immediate area where the emissions are produced. Regardless of their point of origin, greenhouse gasses 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 (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

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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.

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. CCTS operational Well-to-Wheel criteria emissions are summarized in **Table 5.**

Table 5 – Annual Vehicle Operation Pollutants by Fuel Type

Overall Annual Vehicle Operation Pollutants (lbs.)								
Bus Group	**CO**	**NOx**	**PM10**	**PM2.5**	**VOC**	**SOx**	**PM10 TBW**	**PM2.5 TBW**
CNG	13,477.13	80.56	2.49	2.49	28.69	4.92	71.54	9.12

The transportation sector is the largest contributor to greenhouse gas emissions in the United States, accounting for more than 30% of total emissions, and within this sector, 25% of these emissions come from the medium- and heavy-duty markets, yet these markets account for less than 5% of the total number of vehicles. Electrifying these vehicles can have an outsized impact on pollution, fossil-fuel dependency, and climate change. ZEBs are four times more fuel efficient than comparable new diesel buses. Better fuel efficiency means less waste when converting the potential energy in the fuel to motive power. Less waste not only means less pollution, it results in more efficient use of natural resources. By transitioning to ZEBs from diesel buses, CCTS zero-emission fleet will produce fewer carbon emissions and fewer harmful pollutants from the vehicle tailpipes. Considering DACs experience significantly more pollution from harmful emissions, communities disadvantaged by pollution served by CCTS fleet will therefore directly benefit from the reduced tailpipe emissions of ZEBs compared to ICE buses.

Estimated Ridership in DACs

As shown in Figure 10, 110 (54%) of the fixed-route stops are located within DACs. By line, 55% of the Red Line stops and 53% of the Blue Line stops fall within DACs. In terms of route length, 9 miles (40%) of the Red Line and 14 miles (59%) of the Blue Line lie within DACs.

In addition, much of the DAR service area provided for Seniors 60 and older; persons with disabilities; and persons certified under the Americans with Disability Act (ADA) falls within DAC zones, but specific trips may start and/or end outside of DAC-designated areas. These areas include many sites within the City of Corona and adjacent unincorporated communities of Coronita, El Cerrito, and Home Gardens, as well as several satellite locations. This includes ADA services within three-quarters of a mile of fixed-route service. Unlike fixed-route service, the DAR service does not run a set route, and so a single vehicle may provide trips both within and outside of a DAC during a single day.

G

Workforce Training

CCTS Current Training Program

City of Corona's transit services (CCTS) are contracted out which includes dispatching, operations, and maintenance of the vehicles and bus stops. The transit contractor is responsible for all training pertaining to the operations of CCTS. While the city may coordinate/arrange the training necessary for the operation of the service, the contractor is ultimately responsible for ensuring their staff is up-to-date based on their core responsibilities. Contractor staff includes administration (general managers and safety managers), dispatchers, drivers, and maintenance staff (maintenance manager, mechanics, and utility workers). The contractor must adapt to changes in service levels, policies and procedures, and introduction to new technologies and adopt any and all changes into its' driver training program.

Operator Training

The transit contractor is responsible for all training of drivers including City's service policies, passenger fares and overview of the City's fleet. The contractor is responsible for the provision of qualified training staff to conduct behind-the-wheel driver training and other training determined by the contractor or the City. Hands-on training on the bus and bus-related equipment are required to ensure safe vehicle operations. The contractor is required to provide ongoing training and prepare all drivers assigned to the City's contract in a manner that conforms to all local, state, and federal laws.

Mechanics Training

The mechanics assigned to the City's contract must meet the requirements for vehicle maintenance as outlined in the scope of work. They must have knowledge of the city's fleet in order to perform complete, reliable, and safe inspections and repairs. They must be able to diagnose, repair, and maintain the vehicles listed in the City's revenue vehicle fleet. The contractor must comply with regulations pertaining to licensing and operations and maintenance of vehicles as contained in the California Vehicle Code, California Administrative Code, Title 13, and The Federal Motor Carrier Safety Regulations.

Dispatchers and Supervisors Training

Dispatchers are required to schedule and assign drivers and vehicles in accordance with the service hours schedule and scheduled trips for each day. The dispatchers are trained to assist drivers while they are in service and monitor the performance of the scheduled trips. They are trained to handle unanticipated service demands, passenger and/or vehicle accidents, and road calls in accordance with the City's policies and procedures which are outlined in detail in the scope of work. Further, the contract requires the transit contractor to provide a Safety and Training Supervisor who is licensed and certified to conduct classroom training of all drivers as well as behind-the-wheel driver training and other trainings determined necessary by the Contractor or the City

CCTS ZEB Training Plan

OEM Training

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

CCTS 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. CCTS 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

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

There are several transit agencies within and around Riverside County that have successfully begun their transition to zero-emission technology. California has at least seven heavy-duty and transit-operated fueling stations in operation and at least four more in development[14]. Additionally, the number of hydrogen production and distribution centers is growing to meet increased hydrogen demand as it gains popularity as a transportation fuel. At present, there are two heavy-duty, transit-operated hydrogen fueling stations in the neighboring San Bernadino and Orange counties within 40 miles of CCTS, and two planned transit-operated hydrogen fueling stations in Los Angeles County and Pomona within 30 miles of CCTS. In addition, private hydrogen fueling stations by First Element Fuels and Stratosfuel within 80 miles of Corona, CA are in development and should be commissioned before the end of the fleet transition timeline.

In the region, Omintrans, a public transit agency serving the San Bernadino Valley recently received $9.3 million from the Federal Transit Administration (FTA) under the FY2022 Low-No Emission Vehicle Program to develop hydrogen refueling infrastructure and launch a workforce development program. Similarly, Sunline Transit Agency has received $7.8 million to upgrade their liquid hydrogen refueling infrastructure. Riverside Transit Agency has also received $5.2 million to procure hydrogen fuel cell buses. The presence of hydrogen fueling infrastructure projects, especially in the counties of Riverside and San Bernadino, demonstrates the feasibility of fuel cell electric

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[14] Hydrogen Refueling Stations in California, California Energy Commission: https://www.energy.ca.gov/data-reports/energy-almanac/zero-emission-vehicle-and-infrastructure-statistics/hydrogen-refueling

technology for transit in the region. These agencies can serve as a resource for CCTS to use when implementing zero-emission technology and supporting programs into their services.

H

Potential Funding Sources

Available Funding Opportunities

Federal

CCTS 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
  - Bus and Bus Facilities Formula 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
  - 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
- Federal Highway Administration (FHWA)
  - Congestion Mitigation and Air Quality Improvement Program through SCAG
  - Surface Transportation Block Grant Program through SCAG
  - Carbon Reduction Program
- Environmental Protection Agency (EPA)
  - Environmental Justice Collaborative Program-Solving Cooperative Agreement Program

State

CCTS 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.

Annual Reliable Funding

- Administered by California Department of Transportation (Caltrans)
  - Transportation Development Act Funds
    - Local Transportation Funds

        - State Transit Assistance (STA)
    - State of Good Repair (SB 1 funds)
    - Low Carbon Transit Operations Program (LCTOP)

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)
    - State Transportation Improvement Program (STIP)
    - Solution for Congested Corridor Programs (SCCP)
    - Local Partnership Program (LPP)
- California Department of Transportation (Caltrans)
    - Transit and Intercity Rail Capital Program
    - Transportation Development Credits
    - New Employment Credit
- California Energy Commission

Local

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

Legislation Supporting the Zero-Emission Transition

Policies and regulations supporting the transition to zero-emission are proliferating as the efforts to decarbonize the transportation sector expand. CCTS is monitoring the implementation of relevant policies and legislation. With the passage of the *Bipartisan Infrastructure Law* and issuance of *Executive Order 14008: Tackling the Climate Crisis at Home and Abroad*, the federal government has set a renewed focus on zero-emission transit. Riverside County’s goal to deploy zero-emission vehicles supports the federal administration's priorities of renewing transit systems, reducing Greenhouse Gas emissions from public transportation, equity, creation of good paying jobs, and connecting communities. State legislation such as the Innovative Clean Transit Regulation further supports the replacement of fossil-fuel vehicles on the roads of California. Moreover, on August 25, 2022, the CARB approved the Advanced Clean Cars II Rule, requiring all new vehicles sold in California to be zero-emission vehicles (ZEVs) by 2035.

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 $980,000 and $1,310,000, which is about $320,000 to $650,000 more costly than traditional CNG buses. The predicted costs of zero-emission cutaways are between $300,000 and $370,000, which is about $120,000 and $200,000 more costly than traditional ICE cutaways.

Additionally, the necessary infrastructure to support these buses adds to the financial burden of transitioning to a ZEB fleet, as outlined below in **Table 6**, showing the cost of the transition. CCTS will seek financial support to cover the cost of their FCEBs from the resources discussed in Section H.

Table 6 – Incremental Cost of ZEB Transition

Incremental cost of ZEB Transition			
	CNG Baseline*	ZEB Incremental Costs	ZEB Transition Scenario Costs
Bus Capital Expense	$23M	$14M	$37M
Fueling Infrastructure	$0	$10-13M	$10-13M
Total	$23M	$24-27M	$47-50M

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

As seen in **Table 6,** the 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 CCTS 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.

Agency Specific Challenges

In March 2021, the City had undergone a restructuring and the transit division was moved from the Public Works Department to the Community Services Department under the newly created Community Assistance Division. During the reorganization, transit staffing was reduced in half, whereas the transit services are now being managed by one individual. Staff shortages create challenges in balancing increased day-to-day operations including, transit contractor oversight, budgeting, grant administration, regulatory compliance, etc.   Further, staffing constraints and competing priorities will make it difficult to pursue grant opportunities, initiate capital improvement projects, and project management. Should this trend continue, staffing shortages will play a big role in the timeliness of this project and the ability of the City to meet the purchasing mandate and the ICT regulation of achieving a 100% zero-emission fleet by 2040.

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.

In addition to the uncertainty of technology improvements, there are other risks to consider in trying to estimate costs over the 18-year transition period. Although current BEB range limitations may be improved over time as a result of advancements in 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. While this can be mitigated by on-route charging, there may be emergency scenarios where the buses are expected to perform off-route or atypical service. In these emergency scenarios that require use of BEBs, agencies may face challenges performing emergency response roles expected of them in support of fire and police operations. Furthermore, fleetwide energy service requirements, power redundancy, and resilience may be difficult to achieve at any given depot in an all-BEB scenario. Although FCEBs may not be subject to these same limitations, higher capital equipment costs and availability of hydrogen may constrain FCEB solutions. RCTC, CCTS, CTE and IBI Group will expand upon challenge mitigation and adaptation in the Riverside County ZEB Implementation & Financial Strategy Plan.

Appendix A – Approved Board Resolution

Appendix B – 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 (CO_2), carbon monoxide (CO), nitrous oxides (NO_x), 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