CALIFORNIA
AIR RESOURCES BOARD

Gavin Newsom, Governor
Yana Garcia, CalEPA Secretary
Liane M. Randolph, Chair

September 11, 2023

Mr. Ron Profeta
Transit Manager
City of Riverside
3900 Main Street
Riverside, California 92522
RProfeta@riversideca.gov

Dear Mr. Profeta:

Thank you for submitting the City of Riverside's Zero-Emission Bus Rollout Plan (Rollout Plan) as required by the Innovative Clean Transit regulation (California Code Regulations (CCR) Title 13 § 2023.1(d)) on June 28, 2023. Staff reviewed the Rollout Plan and concluded that:

(1) The Rollout Plan is complete and meets the requirements of CCR Title 13 § 2023.1(d)(1)(A)-(H)

(2) A copy of Resolution 24002 is provided to show the Rollout Plan is approved and adopted by your Board

I am pleased to inform you that the Rollout Plan has met the regulation's requirements. On behalf of my team, I wish you successful implementation of this plan and appreciate your leadership in protecting local community health through adoption of zero-emissions technologies.

If you have any questions regarding the Innovative Clean Transit regulation, please contact Dr. Yachun Chow, Manager of the Zero Emission Truck and Bus Section, at *Yachun.Chow@arb.ca.gov*.

Sincerely,

Annmarie Rodgers

Annmarie Rodgers, Branch Chief, Compliance Assistance and Outreach Branch

cc: Yachun Chow, Ph.D., Manager, Zero Emission Truck and Bus Section

Zero-Emission Bus Rollout Plan

Prepared by Riverside Connect with support from the Center for Transportation and the Environment, Arcadis IBI Group, and the Riverside County Transportation Commission

Adopted by the Riverside City Council on June 20, 2023

Table of Contents

List of Tables **4**

List of Figures **4**

List of Abbreviations **5**

Executive Summary **6**

A Transit Agency Information **7**

Riverside Connect Profile *7*
History 7
Service Area and Bus Service 7
Ridership 8

Riverside Connect Basic Information *9*

Fleet Facility *10*

Riverside Connect Sustainability Goals *12*

B Rollout Plan General Information **13**

Overview of the Innovative Clean Transit Regulation *13*

Riverside Connect Rollout Plan General Information *13*

Additional Agency Resources *14*

C Technology Portfolio **15**

Zero Emission Transition Technology Selection *15*
Local Developments and Regional Market 15

ZEB Transition Planning Methodology *15*
Requirements Analysis & Data Collection 17
Service Assessment 17
Modeling & Procurement Assumptions 18
Results 18
Description of Zero Emission Technology Solutions Considered 19

D Current Fleet Composition and Future Vehicle Purchases **21**

Fleet Assessment Methodology *21*

Zero Emission Vehicle Cost Assumptions *21*

Description of Riverside Connect's Current Fleet *21*
Fleet 22
Routes and Blocks 22
Current Mileage and Fuel Consumption 22
Maintenance Costs 22

Zero-Emission Bus Procurement Plan and Schedule *23*

Additional Considerations *24*

E Facilities and Infrastructure Modifications **26**

Riverside Connect Facility Configuration and Depot Layout *26*

Facilities Assessment Methodology *26*

Infrastructure Upgrade Requirements to Support Zero-Emission Buses *26*

Description of Depot-Charging Infrastructure Considered *26*
Battery Electric Charging Infrastructure Summary 27
FCEB Fueling Infrastructure Summary 27

F Providing Service in Disadvantaged Communities **30**

Providing Zero-Emission Service to DACs *30*

Map of Disadvantaged Communities served by Riverside Connect *31*

Emissions Reductions for DACs *31*

Estimated Ridership in DACs *32*

G Workforce Training **33**

Riverside Current Training Program *33*
Riverside Connect's Current Training Program 33
Operator Training 33
Mechanics Training 33
Dispatchers and Supervisors Training 33

Riverside Connect Zero Emission Vehicle Training Plan *34*
OEM Training 34
Bus and Fueling Operations and Maintenance 34
ZEB Training Programs 34

H Potential Funding Sources **36**

Available Funding Opportunities *36*
Federal 36
State 36
Local 37

I Start-up and Scale-up Challenges **38**

Financial Challenges *38*

Limitations of Current Technology *38*

Appendix A – Approved Board Resolution **40**

Appendix B – Glossary **41**

List of Tables

Table 1- Fleet Assessment Cost Assumption *21*
Table 2 – Labor and Materials Cost Assumptions *22*
Table 3 – Midlife Overhaul Cost Assumptions *23*
Table 4 – Riverside Connect Vehicle Capital Investment to Transition to a 100% Zero Emission Fleet by 2040 ..... *24*
Table 5 – Annual Vehicle Operation Pollutants by Fuel Type *32*
Table 6 – Incremental Cost of Zero Emission Transition *38*

List of Figures

Figure 1 – Riverside Connect Service area *8*
Figure 2 – City of Riverside Urbanized Rural Map *10*
Figure 3 – Fueling, Administrative, and Storage Facility Overview *11*
Figure 4 – Dial-A-Ride Feasibility *19*
Figure 5 – Projected Fleet Procurements for Zero Emission Transition *23*
Figure 6 – Annual Fleet Composition, Zero Emission Transition *24*
Figure 7 – Infrastructure Projects & Costs, Zero Emission Transition with Hydrogen and Electric Infrastructure *28*
Figure 8 – Riverside Connect Disadvantaged Communities Service Map *31*

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

Riverside Connect operates a paratransit service for seniors over the age of 60 and disabled residents within the City of Riverside. It is a program within the Special Transportation division of the City Riverside's Parks, Recreation and Community Services Department. Riverside Connect's service area is within the 81 square mile area within the city limits of the City of Riverside. As of July 2022, Riverside Connect's fleet included thirty-four (34) 26-ft Compressed Natural Gas (CNG) cutaways, (2) NOR CAL VAN, TYPE V Ford Transit 350EL, all of which are allocated for paratransit service. 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 Riverside Connect's transition to zero-emission technology.

Riverside Connect's Rollout Plan achieves a zero-emission fleet in line with the 2040 target of the ICT Regulation. To achieve this goal, Riverside Connect will replace all CNG cutaways with zero emission cutaways when the vehicles reach the end of their 7-year useful life. By 2040, 17 of the agency's cutaways are expected to be battery electric cutaways that will recharge midday and 17 will be fuel cell electric cutaways. The last of the agency's CNG cutaways will reach end of life in 2033.

Riverside Connect's entire on demand or "Dial-A-Ride" (DAR) paratransit fleet operates out of 8095 Lincoln Avenue, within the City of Riverside's Corporation Yard. The administrative facility includes administrative offices, a dispatch area, restrooms, and a break room. The facility also includes a parking lot for the agency's fleet, a CNG slow fill station, and a CNG Maintenance Bay. The Maintenance Bay facility has four maintenance bays for CNG vehicles, an administrative office, and multiple storage compartments for vehicle parts and equipment. Riverside Connect plans to install both charging and hydrogen fueling infrastructure at this location to support their mixed fleet.

Riverside Connect's DAR service provides transportation opportunities to Disadvantaged Communities (DACs) and moving toward zero-emission vehicles will help improve the health of DACs and non-DACs alike. The agency will build upon an existing training structure for vehicle maintenance and operators to provide the necessary battery-electric cutaway and fuel cell electric cutaway specific training that will be required for the agency to own and operate battery electric and fuel cell electric cutaways. The agency estimates that pursuing a zero-emission fleet in place of a compressed natural gas (CNG) fleet will cost an additional $23M in vehicle costs and infrastructure alone between 2021 and 2040, which will require significantly more funding opportunities. Riverside Connect plans to pursue funding opportunities at the federal, state, and local levels to help fill this funding gap.

A

Transit Agency Information

Riverside Connect Profile

History

Owned and operated by the City of Riverside, Riverside Connect is an origin-to-destination shared ride service available to senior citizens (60 years of age and older) and persons with disabilities. Documentation from a physician is required for individuals with a disability.

Riverside Connect operates 362 days per year, only suspending service on Thanksgiving Day, Christmas Day and New Year's Day. Hours of operation are 8:00 a.m. – 5:30 p.m. Monday through Friday and 9:00 a.m. – 4:00 p.m. on weekends and holidays. To schedule a ride, passengers must call Riverside Connects' reservation telephone number, during the business hours of 8:00 a.m. – 5:00 p.m., Monday through Friday, and 9:00 a.m. – 3:00 p.m. on weekends and holidays. An answering machine is available before and after business hours for cancellations.

Service Area and Bus Service

Riverside Connect offers service within an 81 square mile area within the city limits of the City of Riverside. The city of Riverside is served by both Riverside Transit Agency (RTA) and Riverside Connect. Riverside Connect is operated by the City of Riverside, separately from the transit agency, under a Memorandum of Understanding (MOU) in order to provide solely paratransit, demand response services within the City limits. RTA provides fixed route service to the area and paratransit service outside the City limits. The current paratransit fleet consists of thirty-four (34) Glaval Bus Type C Ford E-450 CNG cutaways, and (2) NOR CAL VAN, TYPE V Ford Transit 350EL. Riverside Connect's DAR service is reserved for seniors of age 60 and older and people with disabilities, including those covered by the Americans with Disabilities Act (ADA). The DAR service may be primarily used for rides to grocery stores and medical facilities currently, however, as COVID-19 infection rates decrease, Riverside Connect anticipates that workshops, senior centers, and other programs will reopen and service will eventually return to pre-COVID levels.

Riverside Connect's service map is illustrated in **Figure 1.**

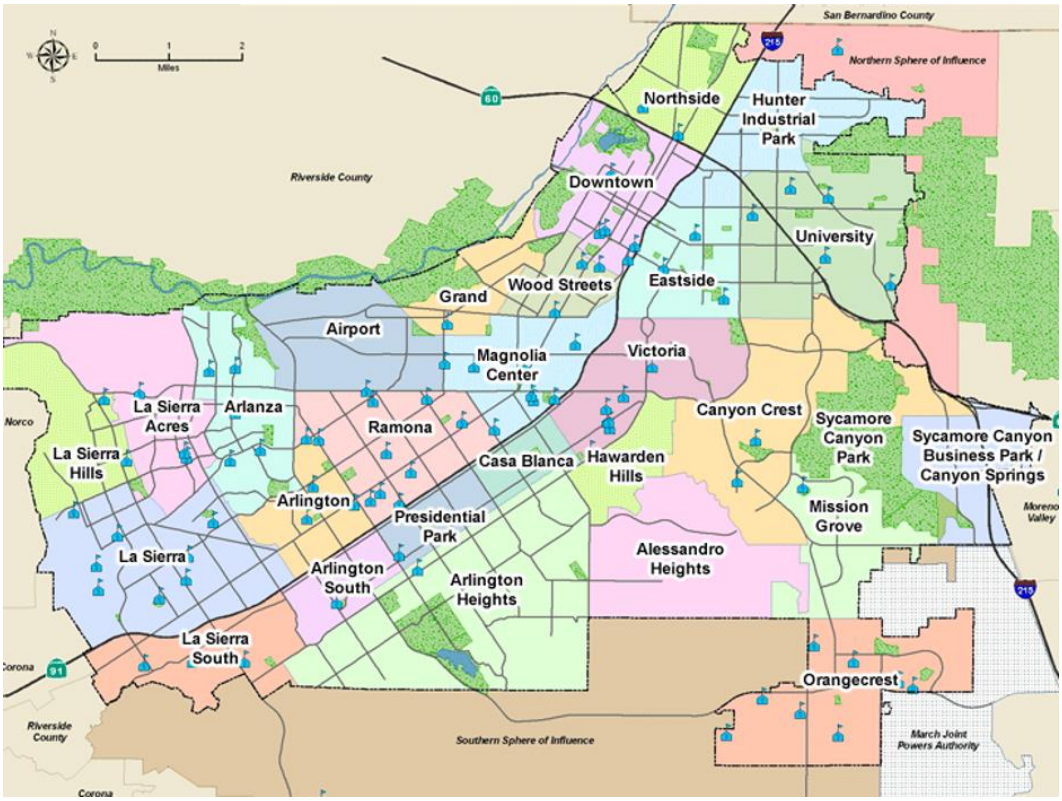

Figure 1 – Riverside Connect Service area

Ridership

Based on Riverside Connect data of total ridership from fiscal year 2021/2022, staff estimated that there were a total of 38,900 passengers throughout the year. In the 2020/2021 Fiscal Year, there were a total of 26,518 passengers. Riverside Connect anticipates that annual ridership in the 2022/2023 Fiscal Year will be 80,000 passengers, an increase of 106% over the 2021/2022 ridership.

Riverside Connect Basic Information

Transit Agency's Name:

Riverside Connect

Mailing Address: Riverside Connect

6927 Magnolia Ave,

Riverside, CA 92506

Transit Agency's Air Districts:

Riverside Connect 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 demand response services out of the Corporation Yard is thirty-four (34). The fleet is composed of 34 26' CNG cutaways.

Urbanized Area:

Riverside, CA. Riverside is 81.23 square miles of land area with 3,878 people per square mile living within that area.[2]

Population of Urbanized Area:

317,261 residents.[2]

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

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

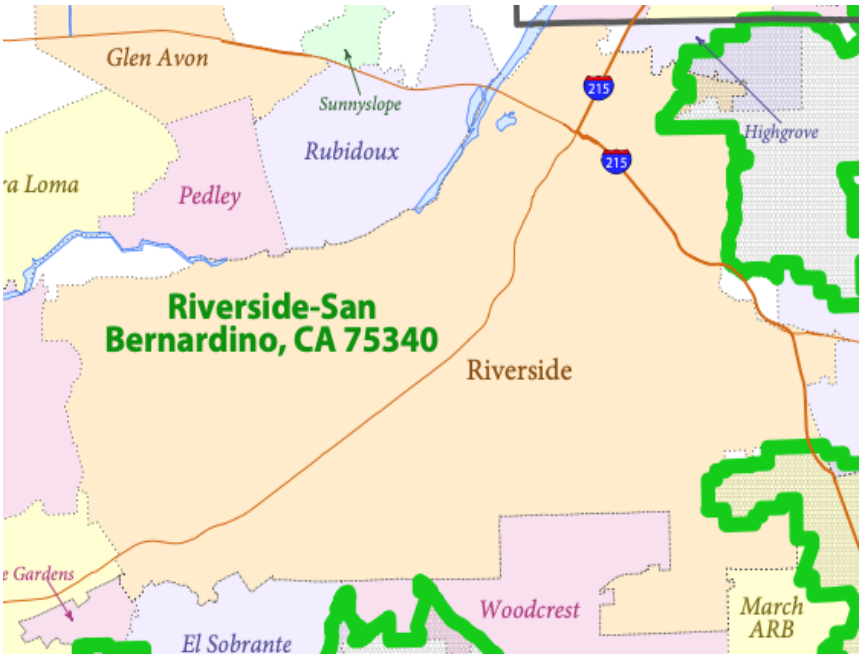

Figure 2 – City of Riverside Urbanized Rural Map[3][4]

Contact Information for Inquiries on the Riverside Connect ICT Rollout Plan:

Ron Profeta, Transit Manager, City of Riverside

3900 Main St,

Riverside, CA 92522

Tel: (951)-826-2000

RProfeta@riversideca.gov

Is your transit agency part of a Joint Group? No

Fleet Facility

Riverside Connect's entire DAR paratransit fleet operates out of 8095 Lincoln Avenue, within the City of Riverside's Corporation Yard. The administrative facility includes administrative offices, a dispatch area, restrooms, and a break room. The facility also includes a parking lot for the agency's fleet, a CNG slow fill station, and a CNG Maintenance Bay. The Maintenance Bay facility has four maintenance bays for CNG vehicles, an administrative office, and multiple storage compartments for vehicle parts and equipment. A map of the Corporation Yard is shown in **Figure 3**. These facilities offer a starting point for the consideration of viable locations for zero-emission fueling infrastructure, chargers and/or a **hydrogen fueling station**.

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

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

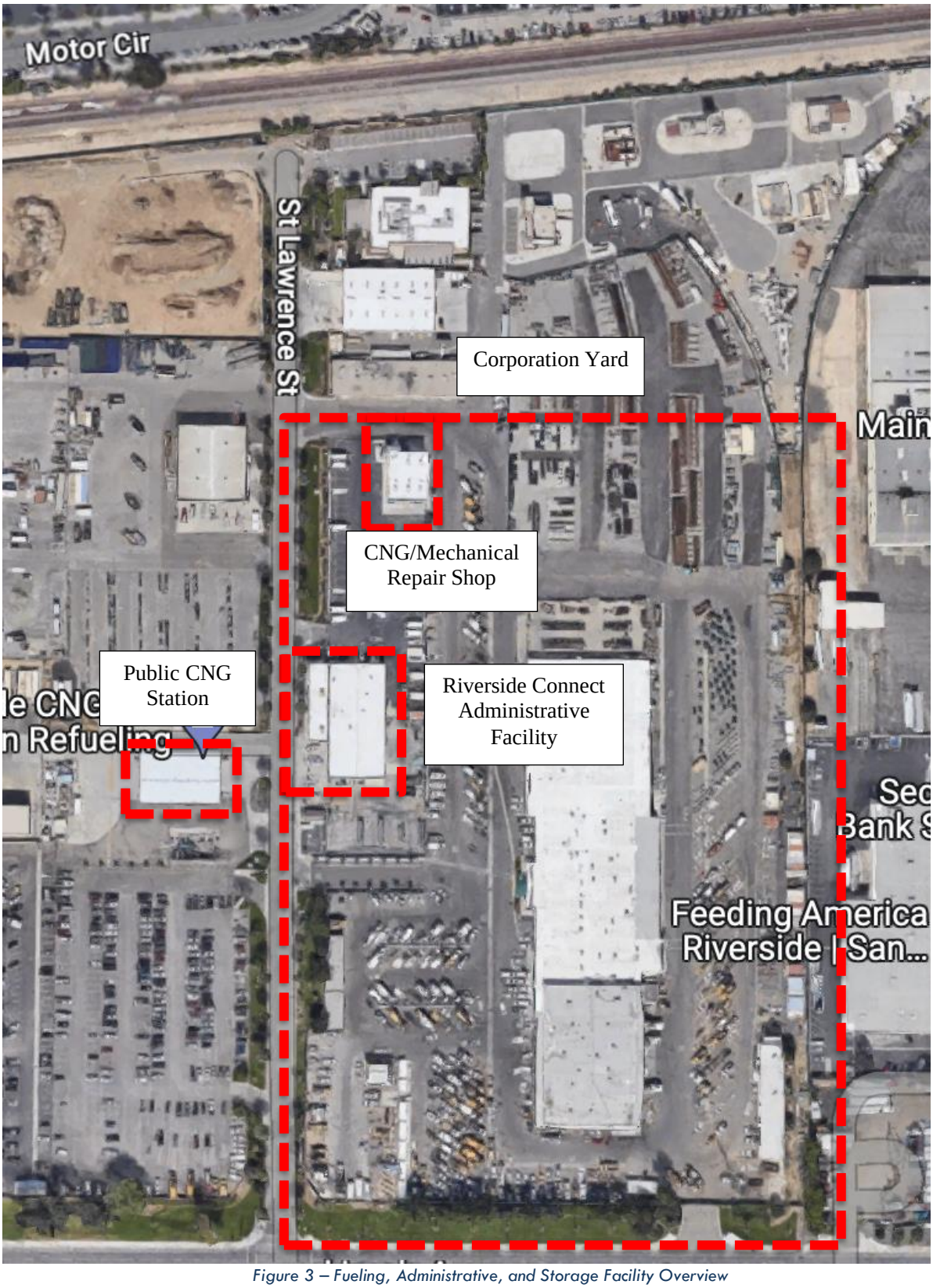

Figure 3 – Fueling, Administrative, and Storage Facility Overview

Riverside Connect Sustainability Goals

Per their City Strategic Plan, Envision Riverside 2025[5] The City of Riverside has dedicated themselves to the strategic priorities of "Environmental Stewardship" and "Infrastructure, Mobility & Connectivity." The City of Riverside defines Environmental Stewardship as "Champion[ing] proactive and equitable climate solutions based in science to ensure clean air, safe water, a vibrant natural world, and a resilient green new economy for current and future generations." To this end, relevant goals that they are working to fulfill are "rapidly decrease[ing] Riverside's carbon footprint by acting urgently to reach a zero carbon electric grid with the goal of reaching 100% renewable energy production by 2040 while continuing to ensure safe, reliable and affordable energy for all residents," "implement[ing] proactive policies and inclusive decision-making processes to deliver environmental justice and ensure that all residents breath healthy and clean air with the goal of having zero days of unhealthy air quality per the CalEnviroScreen by 2030," and "implement[ing] the requisite measures to achieve citywide carbon neutrality no later than 2040." The City's goals within their Strategic Priority of Infrastructure, Mobility & Connectivity are to "provide, expand and ensure equitable access to sustainable modes of transportation that connect people to opportunities such as employment, education, healthcare, and community amenities," "maintain, protect and improve assets and infrastructure within the City's built environment to ensure and enhance reliability, resiliency, sustainability, and facilitate connectivity," "Identify and pursue new and unique funding opportunities to develop, operate, maintain, and renew infrastructure and programs that meet the community's needs," and "Incorporate Smart City strategies into the planning and development of local infrastructure projects."

Riverside Connect has developed a plan to transition to a fully zero emission vehicle (ZEV) fleet composed of battery electric and fuel cell electric cutaways 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. Riverside Connect has committed to purchasing zero emission cutaways, demonstrating the agency's commitment to reducing emissions. Riverside Connect's transition to a fully zero emission fleet will ultimately benefit communities through cleaner air, greater independence from fossil fuels, and more environmental sustainability.

[5] https://www.riversideca.gov/sites/default/files/City%20Strategic%20Plan_Digital_2021_Spreads.pdf

B

Rollout Plan General Information

Overview of the Innovative Clean Transit Regulation

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

ICT Zero-Emission Bus Purchase Requirements for Small Agencies:

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

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

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

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

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

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

Riverside Connect Rollout Plan General Information

Rollout Plan's Approval Date: June 20, 2023

Resolution No: 24002

Contact for Rollout Plan follow-up questions:
Ron Profeta, Transit Manager, City of Riverside

3900 Main St,

Riverside, CA 92522

Tel: (951)-826-2000

RProfeta@riversideca.gov

Who created the Rollout Plan?
This Rollout Plan was created by Riverside Connect, 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 Riverside Connect's 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

Riverside Connect agency website: https://riversideca.gov/park_rec/programs-sports/seniors/special-transportation-division

C

Technology Portfolio

Zero Emission Transition Technology Selection

Based on outcomes of the zero-emission fleet transition planning study completed by CTE, Riverside Connect plans to transition its fleet to a mix of battery electric and fuel cell electric cutaways. By 2040, Riverside Connect expects to operate a fully zero-emission fleet of 34 cutaways.

A mixed technology zero-emission fleet scenario provides more service energy while avoiding as much opportunity charging and mitigating the higher fuel cost of a fuel cell electric-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 17 battery electric cutaways and 17 fuel cell electric cutaways.

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 fuel cell electric bus (FCEB) deployments represent 75% of the nation's FCEB deployments.[6]

ZEB Transition Planning Methodology

Riverside Connect's ICT Rollout Plan was created in combination with Riverside Connect's 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

[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

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 Riverside Connect'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 zero emissions vehicle 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 zero emission vehicles that is consistent with Riverside Connect'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 vehicles. To more accurately estimate battery electric cutaway 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 zero emission vehicles. 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 cutaways that remain in the fleet and maintenance costs of new battery electric cutaways and fuel cell electric cutaways.

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 Riverside Connect 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. Riverside Connect self-assigned topography and speed characteristics to each service day, which were utilized to better define efficiencies. The calculated efficiencies were then used in the Service Assessment to determine the energy requirements of Riverside Connect's service.

CTE evaluated battery electric and fuel cell electric vehicles to support Riverside Connect's technology selection. After collecting route and operational data, CTE determined that Riverside Connect's longest day in service is 122 miles and the average distance is 105 miles. Based on observed performance, CTE estimates FCEBs are able to complete any block under 350 total miles. Although there are currently no fuel cell electric cutaways on the market, CTE assumed that when fuel cell electric cutaways enter the market, they will perform similarly to FCEBs, and therefore Riverside Connect's service will likely be feasible with fuel cell cutaways. Although fuel cell cutaways were determined to have the capability of serving all of Riverside Connect's routes, Riverside Connect was interested in exploring battery electric and fuel cell electric cutaway service scenarios, so it was necessary to determine how much of Riverside Connect's service could feasibly be served by depot-only charged battery electric cutaways on a single charge and with midday charging in order to develop a set of zero emission 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 battery electric cutaways are primarily driven by vehicle 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 Riverside Connect to determine efficiency and range estimates based on an accurate representation of its operating conditions.

To understand battery electric cutaway performance on Riverside Connect routes, CTE modeled the impact of variations in passenger load, accessory load, and battery degradation on vehicle 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 ensuring that a vehicle will be able to meet service demands (strenuous). Route modeling ultimately provides an average energy use per mile (kilowatt-hour/mile [kWh/mi]) for each load case.

In addition to loading conditions, CTE modeled the impact of battery degradation on a battery electric cutaway's ability to complete a block. The range of a battery electric cutaway is reduced over time due to battery degradation. A battery electric cutaway may be able to complete a given trip with beginning-of-life batteries, while later it may be unable to complete the entire trip 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 fuel cell electric cutaways can meet the range requirements for Riverside Connect's service, the Service Assessment focused on evaluating the feasibility of battery electric cutaways in Riverside Connect's service area. The efficiencies calculated in the Requirements Analysis & Data Collection stage were used to estimate the energy requirements of Riverside Connect's service. The main focus of the Service Assessment is called the block analysis, which determines whether 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] In Riverside Connect's case, because they operate DAR paratransit service only, a block refers to the mileage performed by each vehicle across a series of unique trips throughout its service day. The energy needed to complete a block is compared to the available energy of the cutaway assigned to service the block. If the cutaway's usable onboard energy exceeds the energy required by the block, then the conclusion is that the battery electric cutaway can successfully complete that block on a single charge.

The Service Assessment projects the performance of a battery electric cutaway on a single overnight charge and operates on Riverside Connect'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 battery electric cutaways can feasibly serve Riverside Connect's territory or if another zero-emission technology or midday charging is required to maintain service. This information can then be used to inform the scale and timing of battery electric cutaway procurements in the Fleet Assessment.

Modeling & Procurement Assumptions

CTE and Riverside Connect 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 120 kWh for a 25' cutaway which represents an analogous zero emission cutaway suitable for Riverside Connect's transit vehicles and is an average of battery capacities seen in commercially-available cutaways of the same size and passenger capacity in 2022.

This analysis also assumed Riverside Connect will maintain their service in a similar distribution of distance, relative speeds, and elevation changes to pre-COVID-19 service because their cutaways 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 vehicles 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.

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 Riverside Connect can rotate the cutaways to match battery capacity to block energy requirements. As the zero-emission fleet transition progresses, older vehicles can be moved to shorter, less demanding blocks and newer vehicles can be assigned to longer, more demanding blocks to account for battery degradation in battery electric cutaways over time. Riverside Connect can rotate the fleet to meet demand, assuming there is a steady procurement of battery electric cutaways 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 Riverside Connect's service may become achievable by battery electric cutaways on a single depot charge. After determining what proportion of Riverside Connect's service could be completed by battery electric cutaways on a single charge, CTE was also able to determine the

[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

proportion of service that would require midday charged battery electric cutaways or longer range fuel cell electric cutaways in order to reach 100% ZEB service. Riverside Connect and CTE can then use these results to inform zero emission cutaway 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 cost to operate the transitioning fleet.

These projections assume the average service days will maintain a similar distribution to current service because Riverside Connect will continue to serve similar destinations within the city. This core assumption affects energy use estimates and service achievability in each year.

The results of Riverside Connect's Service Assessment for Dial-a-Ride service on a single charge can be found below in **Figure 4.** Based on CTE's analysis, Riverside Connect's average service day does not become feasible for a depot charged battery-electric cutaway on a single charge by 2040, which means that battery-electric cutaways would require some form of opportunity charging throughout the day to complete their service.

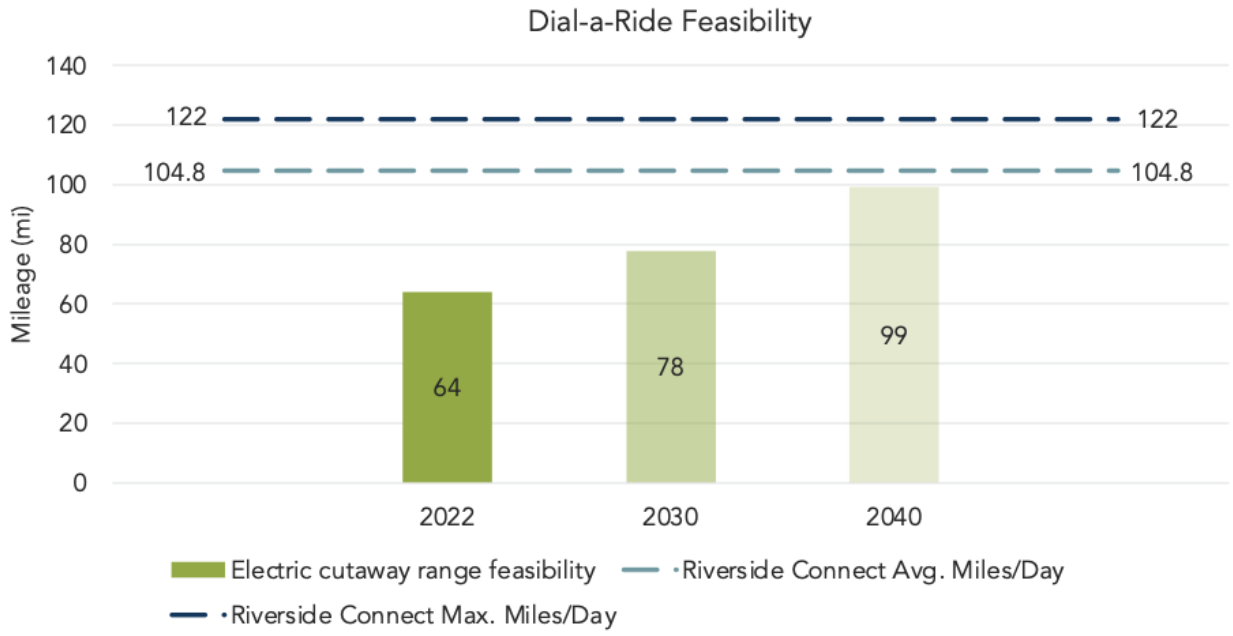

Figure 4 – Dial-A-Ride Feasibility

Pantograph and inductive charging have not yet been demonstrated on the market 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 Riverside Connect's service. Also, as noted previously, fuel cell cutaways are assumed to be able to complete any trip under 350 total miles and Riverside Connect's longest service day is 122 miles long, which means that fuel cell technology will have the capability to meet Riverside Connect's service requirements. Therefore, battery electric cutaways with opportunity charging at the depot and fuel cell electric cutaways are viable options for Riverside Connect.

Description of Zero Emission Technology Solutions Considered

For this study, CTE developed 3 scenarios to compare to a baseline scenario and analyze the feasibility and cost effectiveness of implementing each technology as well as the co-implementation of both technologies. A baseline scenario was also developed to represent the typical "business-as-usual" case with retention of ICE cutaways for cost comparison purposes.

The scenarios are referred to by the following titles and described, in detail, below:

0. Baseline (current technology)
1. Battery Electric Cutaways Only
2. Mixed Fleet – Fuel Cell and Battery Electric Cutaways
3. Fuel Cell Cutaways Only

In the **Battery Electric Fleet Transition**, battery electric cutaways are to replace CNG vehicles as they reach end of life according to the purchasing requirements in the ICT Regulation. As previously noted, battery electric cutaways are not capable of meeting Riverside Connect's daily service requirements on a single charge, so midday opportunity charging is utilized on DAR service to sustain energy on-board. Based on CTE's modeling, all of Riverside Connect's service is fully achievable using opportunity-charged battery electric technology by 2040.

In the **Mixed Fleet Transition,** fuel cell cutaways and battery electric cutaways are purchased in equal numbers to make up a fully zero emission fleet. The costs for infrastructure and installation of two different charging and fueling infrastructures are taken into account. Fuel cell vehicles and hydrogen fuel, however, are more expensive than battery electric vehicles and electricity, so this scenario allows Riverside Connect to use the less expensive battery technology where possible and supplement service with fuel cell vehicles as needed, particularly in cases where the vehicle may not be able to return to the depot to charge midday, and support resilience and redundancy adaptation measures.

Finally, the **Fuel Cell Fleet Transition** was developed to examine the costs for hydrogen fueling and transitioning to a 100% fuel cell cutaway fleet. A fully fuel cell fleet avoids the need to install two types of fueling infrastructure by eliminating the need for depot charging equipment. Fleets composed entirely of fuel cell electric cutaways also offer the benefit of scalability compared to battery electric technologies. Adding fuel cell vehicles to a fleet after the initial facility build out does not necessitate large complementary infrastructure upgrades as long as the fueling station was appropriately sized for the fleet. Despite this benefit, the cost of fuel cell cutaways and hydrogen fuel are still more expensive than battery electric cutaways 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 Riverside Connect's zero emission 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 Fleet Composition and Future Vehicle Purchases

Fleet Assessment Methodology

The Fleet Assessment projects a timeline for the replacement of existing cutaways with zero emission cutaways. The timeline is consistent with Riverside Connect's fleet replacement plan that is based on the 7-year service life of truck-style cutaways. This assessment also includes a projection of fleet capital costs over the transition timeline.

Zero Emission Vehicle Cost Assumptions

CTE and Riverside Connect developed cost assumptions for future cutaway purchases. Key assumptions for cutaway costs for the Riverside Connect Transition Plan are as follows:

- CNG vehicle prices were provided by Riverside Connect 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	$157,537	$300,955	$376,153*

*Bus size not currently available for this technology

Description of Riverside Connect's Current Fleet

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

- Fleet composition by powertrain and fuel
- Daily paratransit service
- Mileage and fuel consumption
- Maintenance costs

Fleet

As of 2022, the Riverside Connect fleet includes 34 CNG 26' cutaways used for DAR paratransit service. Transit services, including operations, maintenance, and fueling, operate out of one depot in Riverside, CA.

Routes and Blocks

Riverside Connect's 2022 service exclusively consists of Dial-a-Ride paratransit service. Daily distances range from 82 miles to 122 miles. Vehicles pull out as early as 6:35 AM and return as late as 5:25 PM. Riverside Connect service runs within the boundaries of the City of Riverside.

Current Mileage and Fuel Consumption

Annual mileage of the fleet:
887,698 miles

Riverside Connect's ZEB Transition Plan assumes that the amount of service miles will remain the same.

Annual fuel consumption:
130,544 GGE of CNG

Fleet average efficiency:
6.8 miles per GGE

Riverside Connect current fuel expense:
$205,000 per year

Average fuel costs:
$1.57 per GGE of CNG

Maintenance Costs

Average maintenance costs per mile by vehicle type are estimated in **Table 2**. Vehicles also do not undergo any midlife overhauls due to their short usable life period as summarized in **Table 3.** These costs were utilized to project transition maintenance costs.

Table 2 – Labor and Materials Cost Assumptions

Vehicle Type	Estimate (Per Mile)
CNG Cutaway	$ 0.35
Battery Electric Cutaway	$0.32
Fuel Cell Electric Cutaway	$0.51

Table 3 – Midlife Overhaul Cost Assumptions

Vehicle Type	Overhaul (FC/Transmission) Cost Per vehicle life	Battery Warranty Cost Per vehicle life
CNG Cutaway	$0	$0
Battery Electric Cutaway	$0	$24,000
Fuel Cell Electric Cutaway	$0	$10,000

Zero-Emission Bus Procurement Plan and Schedule

Riverside Connect will provide demand response service with a fleet of seventeen (17) depot-charged and opportunity-charged battery electric cutaways and seventeen (17) fuel cell cutaways. This technology combination will be sufficient for meeting the agency's service demands. Riverside Connect's fleet transition strategy is to replace each compressed natural gas (CNG) cutaway as they reach the ends of their service lives with battery electric cutaways until 2029, and a mix of battery electric and fuel cell cutaways beginning in 2030. **Figure 5** below provides the number of each vehicle type that will be purchased each year through 2040 with this replacement strategy and the total cost of that procurement.

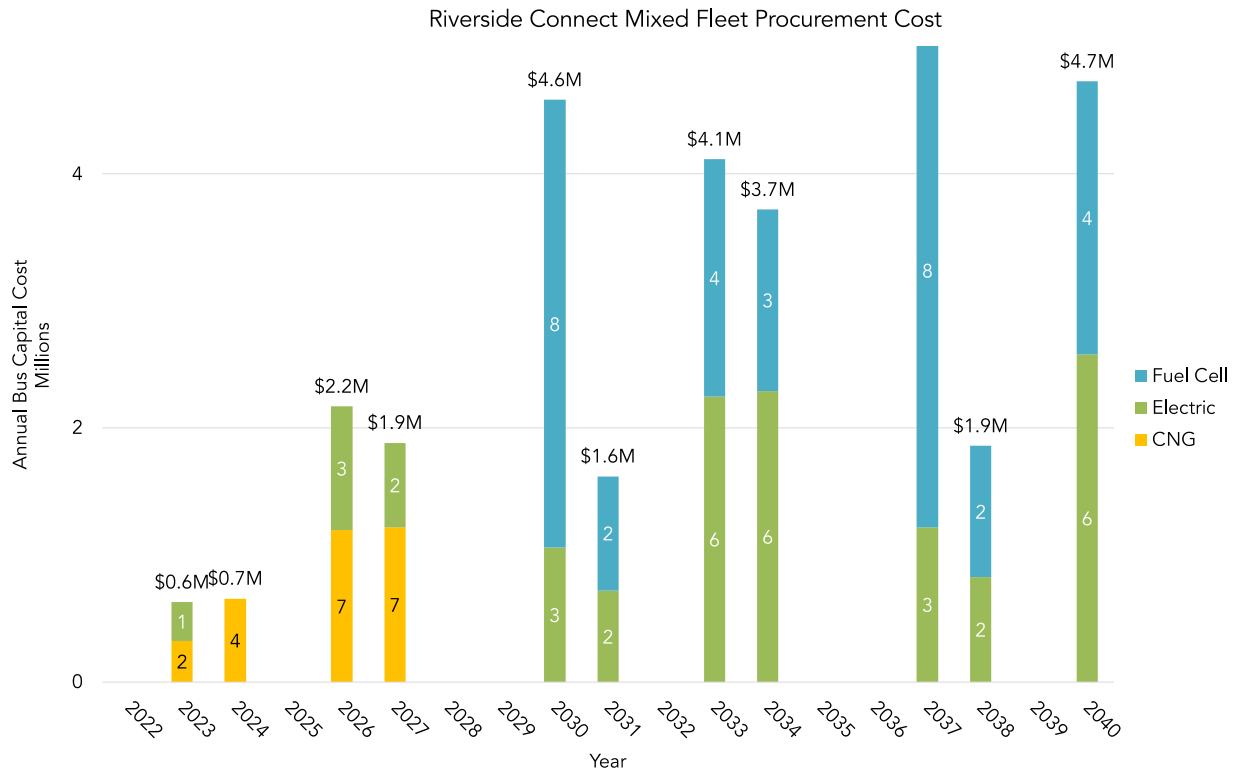

Figure 5 – Projected Fleet Procurements for Zero Emission Transition

Prepared by Riverside Connect with support from CTE, Arcadis IBI Group, and RCTC

Figure 6 demonstrates the annual composition of Riverside Connect's fleet through 2040. By 2034, Riverside Connect's fleet will consist entirely of battery electric and fuel cell cutaways. The fleet will remain the same size throughout the transition period.

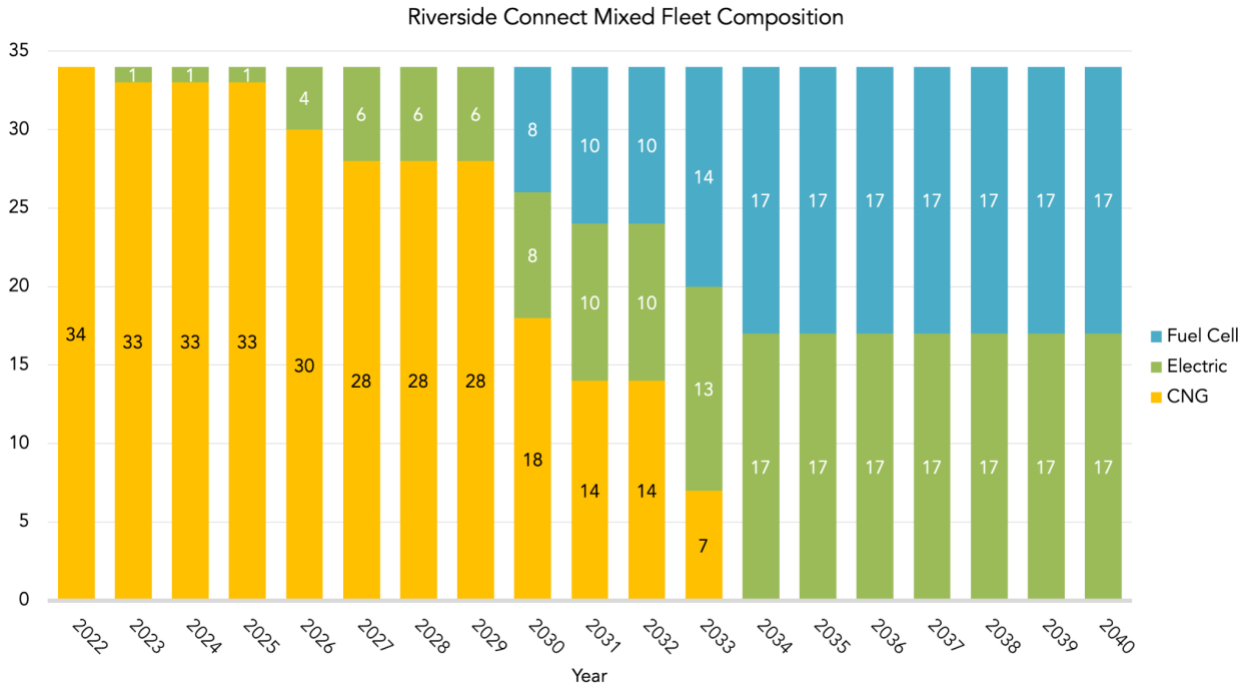

Figure 6 – Annual Fleet Composition, Zero Emission Transition

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

Table 4 – Riverside Connect Vehicle Capital Investment to Transition to a 100% Zero Emission Fleet by 2040

	CNG Baseline*	Zero Emission Incremental Costs	Total Investment
Vehicle Capital Costs	$19M	$12M	$31M

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

Additional Considerations

When purchasing zero emission vehicles, the process may differ slightly from the process Riverside Connect currently uses to purchase vehicles. First, when contracting with zero emission vehicle manufacturers, Riverside Connect should ensure expectations are clear between the OEM and the agency. As with CNG purchases the agreement should be clear regarding the vehicle's 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 vendor(s), Riverside Connect can work with the vendor(s) to customize the cutaway 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 cutaway 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 zero emission vehicles may differ from ICE vehicles.

When developing RFPs and contracting for zero emission vehicle procurements, Riverside Connect 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. Riverside Connect should test the vehicles 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 zero emission vehicles 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 Riverside Connect purchase an extended battery warranty for the vehicles, which should be specified in the RFP and contract.

Fuel cell procurement will also differ from ICE procurements since there are fewer OEMs presently manufacturing fuel cell buses and no OEMs presently manufacturing fuel cell cutaways, although this is expected to change with increasing demand. Riverside Connect 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

Riverside Connect Facility Configuration and Depot Layout

Depot Address:
8095 Lincoln Avenue, Riverside, CA 92504

Electric Utility:
Riverside Public Utilities

Located in a NOx Exempt Area?
No

Bus Parking Capacity:
34+

Current Vehicle Types Supported:
Riverside Connect's depot currently supports fueling and maintenance of CNG 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 battery electric and fuel cell deployments such as Riverside Connect's require installation of charging stations and improvements to existing electrical infrastructure as well as hydrogen fueling infrastructure. Fuel cell 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 zero emission vehicles. This plan assumes that infrastructure projects will be completed prior to each cutaway delivery. To project the costs of fueling infrastructure, CTE used industry pricing observed in active projects and an infrastructure build timeline based on the procurement timeline. This plan assumes that infrastructure projects will be completed prior to each vehicle delivery. These projects are described in detail below.

Infrastructure Upgrade Requirements to Support Zero-Emission Buses

Description of Depot-Charging Infrastructure Considered

With Riverside Connect's mixed technology fleet, charging infrastructure is required to service a total of 17 battery electric cutaways along with hydrogen fueling infrastructure for 17 fuel cell cutaways to support a completely zero-emission fleet by 2040. Because there are separate costs associated with each type of zero emission technology,

the facilities assessment for this scenario is broken down by each fuel type. The total cost for mixed fleet fueling infrastructure is approximately $7.5 M.

Battery Electric Charging Infrastructure Summary

In order to support the battery electric portion of the fleet, Riverside Connect 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 Riverside Connect's single depot is estimated at $200,000.
- **Dispensers and Chargers.** Riverside Connect's battery electric charging depot will consist of nine chargers with two dispensers per charger. Prices are estimated at $170,000 for a 150kW charger with two dispensers.
- **Electric Service Upgrade.** Riverside Connect requires an estimated 2 MW of additional electricity capacity by 2040 to accommodate charging for 17 battery electric cutaways. To meet the growing demand for electricity, the depot will need to upgrade its system to at least 2 MW of capacity by 2027. This is estimated to cost around $300,00 over the transition period.
- **Charger Maintenance.** Riverside Connect's chargers are estimated to require annual maintenance with an estimated cost of $3,000 per year.
- **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 industry standard inflation assumptions. All costs listed above are in 2022 dollars, projects occurring after 2022 are inflated per the inflation factor.

The cost of battery electric infrastructure is approximately $3M over the transition period.

FCEB Fueling Infrastructure Summary

In addition to battery electric charging, hydrogen fueling is required to support the Mixed Fleet. Like battery electric infrastructure, a fuel cell 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 Riverside Connect 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 fuel cell cutaway 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 Riverside Connect's single depot will be approximately $200,000.
- **Maintenance bay upgrades.** Riverside Connect requires four upgrades to their maintenance bays. Each maintenance bay upgrade from CNG to Hydrogen is expected to cost $14,000. The total cost for the four maintenance bays is estimated to be $56,000.
- **Hydrogen Fueling infrastructure.** Riverside Connect's 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. Cooperation with the adjacently located public hydrogen station located at 3044 St Lawrence St could decrease construction costs due to economies of scale. This project price is based on partnership and expansion of existing hydrogen infrastructure. A new build would increase the cost significantly.
- **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.

The cost of fuel cell infrastructure is approximately $4.5 M over the transition period. **Figure 7** shows the estimated total costs for the fuel cell and battery electric infrastructure over the transition period. The combined total cost is approximately $7.5 M.

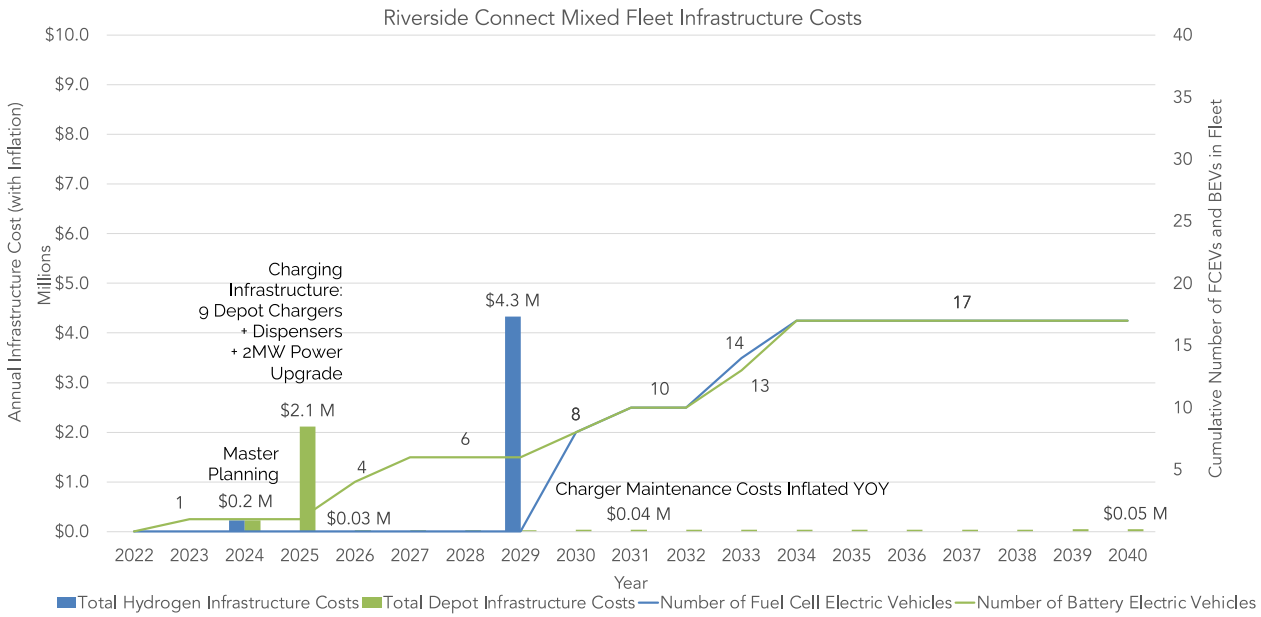

Figure 7 – Infrastructure Projects & Costs, Zero Emission Transition with Hydrogen and Electric Infrastructure

Utility Partnership Review

Riverside Public Utilities is a consumer-owned utility that provides both water and electricity to Riverside. Riverside Public Utilities is a founding member of the Southern California Public Power Authority (SCPPA), enjoying the benefits of joint action through cost-effective planning, construction, management, and operations of electrical energy resources. Riverside Public Utilities currently offers several EV incentives and rebates, although none of them are catered toward public transit applications8. Riverside Connect may be able to leverage their relationships with other agencies in the Commission to develop and maintain shared electric vehicle charging infrastructure by locating sites within Southern California Edison (SCE) territory.

Riverside Connect may also have access to local incentive programs aimed at reducing air pollution in Southern California; as the air pollution control agency for all of Orange County and the urban portions of Los Angeles, Riverside and San Bernardino counties, the South Coast Air Quality Management District (SCAQMD) provides a variety of financial incentives to encourage the immediate use of commercially available, low- or zero-emission technologies9. Of note is the Carl Moyer Program, that provides funding for alternative fueling infrastructure and heavy-duty vehicle replacement/conversion projects.

The City is sharing proposed planning documents to help the utility 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 their utility will ensure that the utility can properly plan grid-side electrical infrastructure

8 https://riversideca.gov/utilities/residents/rebates/electrify-riverside

9 http://www.aqmd.gov/home/programs/business

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 the utility as a critical partner in electrification and will continue to partner with the utility after the planning stages so that charge management strategies and fleet expansion efforts can be coordinated effectively. The City has its own utilities department, Riverside Public Utilities (RPU), that provides service to all of the City.

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.

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 ports, which puts these communities at greater risk of health issues associated with tailpipe emissions.[10] Zero emission vehicles will reduce energy consumption, harmful emissions, and direct carbon emissions within the disadvantaged communities Riverside Connect serves. The City of Riverside includes 38 distinct census tracts designated as DACs.

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] Riverside Connect's current fleet of CNG cutaways consume 130,550 Gasoline Gallons Equivalent (GGE) of fuel per year, operating for approximately 887,700 miles per year. Moving Riverside Connect's 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, Riverside Connect is also able to improve service reliability and therefore maintain the capacity to serve low-income and disadvantaged populations.

---

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

Map of Disadvantaged Communities served by Riverside Connect

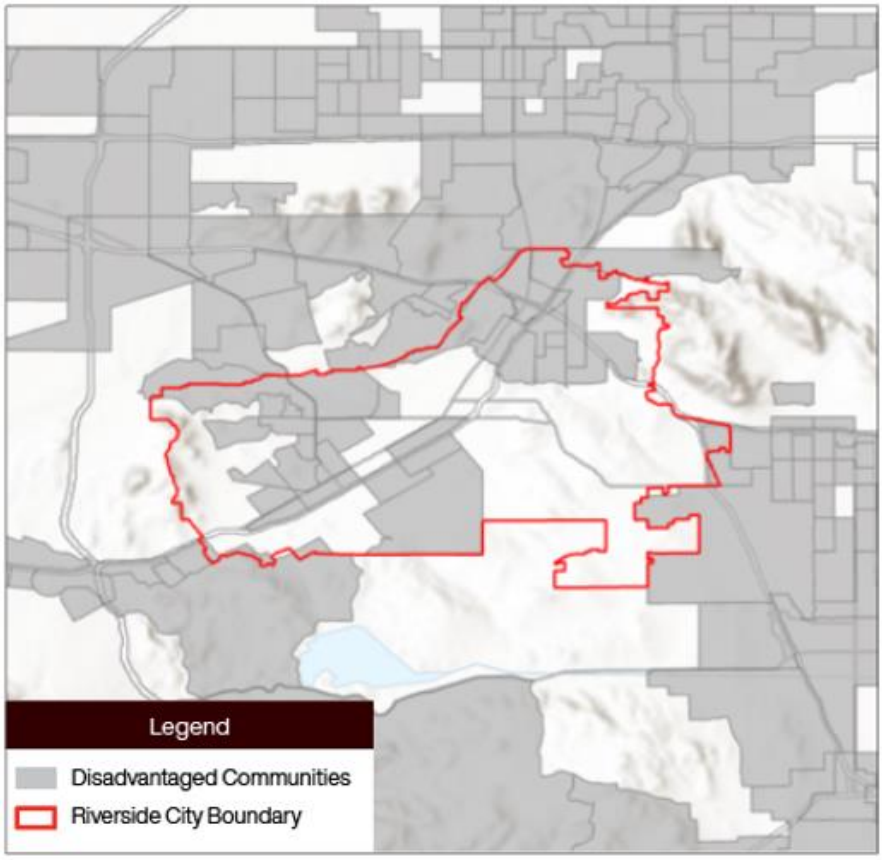

Figure 8 – Riverside Connect Disadvantaged Communities Service Map

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 in part as disadvantaged by poor air quality because polluting industries or freight routes have often been cited in

[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.

these communities. The resulting decrease in air quality has led to poorer health and quality of life outcomes for residents. Riverside Connect's 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.)								
	CO	NOx	PM10	PM2.5	VOC	SOx	PM10 TBW	PM2.5 TBW
CNG	39,541.72	1,352.97	48.60	44.40	132.32	8.67	189.09	23.48

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. Zero emission buses 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 zero emission cutaways from CNG cutaways, Riverside Connect's 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 Riverside Connect's fleet will therefore directly benefit from the reduced tailpipe emissions of zero emission vehicles compared to ICE vehicles.

Estimated Ridership in DACs

The City of Riverside includes 38 distinct census tracts designated as DACs. In addition, nearly 44% (35.64 square miles) of the city's land area is designated as a DAC. The City of Riverside's Special Transportation Division provides dial-a-ride (DAR) service within the city boundaries for seniors 60 and older, persons with disabilities, and other persons certified under the Americans with Disability Act (ADA). Some of the Riverside dial-a-ride service area falls within the DAC zones but specific trips may start and/or end outside of the DAC designated areas.

G

Workforce Training

Riverside Current Training Program

Riverside Connect's Current Training Program

Riverside Connect's transit services 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 Riverside Connect. 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

Riverside Connect Zero Emission Vehicle Training Plan

OEM Training

Riverside Connect plans to take advantage of trainings from the vehicle 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 Riverside Connect's workforce. Meaningful investment is required to upskill maintenance staff and bus operators trained in ICE vehicle maintenance and ICE fueling infrastructure.

Riverside Connect 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 zero emission technology and that these staff undergo refresher training annually and as needed. Riverside Connect 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 zero emission bus (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. Riverside Connect 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 Bernardino and Orange counties within 40 miles of Riverside Connect, and two planned transit-operated hydrogen fueling stations in Los Angeles County and Pomona within 30 miles of Riverside Connect. In addition, private hydrogen fueling stations by First Element Fuels and Stratosfuel within 80 miles of Riverside, 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 Bernardino 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 Bernardino, demonstrates the feasibility of fuel cell electric

[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 Riverside Connect to use when implementing zero-emission technology and supporting programs into their services.

H

Potential Funding Sources

Available Funding Opportunities

Federal

Riverside Connect 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

Riverside Connect 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, Riverside Connect will pursue local funding opportunities to support zero-emission bus deployment. While the aforementioned funding opportunities are mentioned by name, Riverside Connect will not be limited to these sources and will regularly assess opportunities for fiscal support for the zero-emission 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. Riverside Connect 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 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 CNG cutaways.

Additionally, the necessary infrastructure to support these vehicles adds to the financial burden of transitioning to a zero-emission fleet, as outlined below in **Table 6**, showing the cost of the transition. Riverside Connect will seek financial support to cover the cost of their fuel cell and battery electric cutaways from the resources discussed in Section H.

Table 6 – Incremental Cost of Zero Emission Transition

Incremental cost of Zero Emission Transition			
	CNG Baseline*	Zero Emission Incremental Costs	Zero Emission Transition Scenario Costs
Vehicle Capital Expense	$19M	$12M	$31M
Fueling Infrastructure	$0	$8M	$8M
Total	$19M	$20M	$39M

*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 zero emission 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 fuel cell and battery electric vehicles.

CARB can support Riverside Connect by ensuring continued funding for the incremental cost of zero-emission vehicles 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.

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 battery electric 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-battery electric fleet over time. While this can be mitigated by midday opportunity charging, there may be emergency scenarios where the cutaways are expected to perform off-route or atypical service. In these emergency scenarios that require use of battery electric vehicles, 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-battery electric scenario. Although fuel cell vehicles may not be subject to these same limitations, higher capital equipment costs and availability of hydrogen may constrain fuel cell solutions. RCTC, Riverside Connect, CTE and Arcadis IBI Group will expand upon challenge mitigation and adaptation in the Riverside County ZEB Implementation & Financial Strategy Plan.

Appendix A – Approved Board Resolution

RESOLUTION NO. 24002

A RESOLUTION OF THE CITY COUNCIL OF THE CITY OF RIVERSIDE, CALIFORNIA, AUTHORIZING THE SUBMISSION OF THE ZERO-EMISSION BUS (ZEB) ROLLOUT PLAN TO THE CALIFORNIA AIR RESOURCES BOARD (CARB) AS REQUIRED BY THE INNOVATIVE CLEAN TRANSIT (ICT) REGULATION.

WHEREAS, in 2018, CARB adopted the ICT Regulation, which requires public transit agencies to gradually transition to a 100 percent ZEB fleet with a goal of full transition by 2040;

WHEREAS, the ICT Regulation's requirements include, but are not limited, to the following:

1. Small Transit Agencies which operate fewer than 100 buses in annual maximum service shall submit to CARB a governing body-approved ZEB Rollout Plan by July 1, 2023.

2. Small Transit Agencies must purchase a minimum number of ZEBs during future procurements, according to the following schedule:

i) Starting in calendar year 2026, 25 percent of new bus purchases must be ZEBs.

ii) Starting in calendar year 2029, 100 percent of all new bus purchases must be ZEBs;

WHEREAS, the City of Riverside's ZEB Rollout Plan, currently being presented to the City Council for adoption, is a living document intended to guide Riverside Connects' conversion to a ZEB fleet and may be updated based on changes in vehicle technology, fleet size and operating requirements;

WHEREAS, the presented ZEB Rollout Plan must be approved by the City Council through the adoption of a resolution prior to submission to CARB; and

WHEREAS, the presented ZEB Rollout Plan includes, in the following sections, information required by the ICT Regulation:

1. Transit Agency Information
2. Rollout Plan General Information
3. Technology Portfolio
4. Current Bus Fleet Composition and Future Bus Purchases
5. Facilities and Infrastructure Modifications
6. Providing Service in Disadvantaged Communities

CITY ATTORNEY'S OFFICE
3750 UNIVERSITY AVE., STE. 250
RIVERSIDE, CA 92501
(951) 826-5567

7. Workforce Training

8. Potential Funding Sources.

NOW, THEREFORE, BE IT RESOLVED by the City Council of the City of Riverside, California, as follows: The City Council of the City of Riverside, California, hereby adopts the presented ZEB Rollout Plan as a guide for the City of Riverside's implementation of ZEB technology and approves it for submission to CARB.

Section 1: The above recitals set forth above are incorporated herein as findings by the City Council.

Section 2: That the City Council of the City of Riverside, California, hereby adopts the presented ZEB Rollout Plan as a guide for the implementation of ZEB technology and approves it for submission to CARB.

ADOPTED by the City Council this 20th day of June, 2023.

PATRICIA LOCK DAWSON
Mayor of the City of Riverside

Attest:

DONESIA GAUSE
City Clerk of the City of Riverside

//

//

//

//

//

//

//

//

CITY ATTORNEY'S OFFICE
3750 UNIVERSITY AVE., STE. 250
RIVERSIDE, CA 92501
(951) 826-5567

I, Donesia Gause, City Clerk of the City of Riverside, California, hereby certify that the foregoing resolution was duly and regularly adopted at a meeting of the City Council on the 20th day of June, 2023, by the following vote, to wit:

Ayes: Edwards, Cervantes, Fierro, Conder, Plascencia, Perry, and Hemenway

Noes:

Absent:

Abstain:

IN WITNESS WHEREOF, I have hereunto set my hand and affixed the official seal of the City of Riverside, California, this 21st day of June, 2023.

DONESIA GAUSE
City Clerk of the City of Riverside

23-0608 BGS 05/16/23

CITY ATTORNEY'S OFFICE
3750 UNIVERSITY AVE., STE. 250
RIVERSIDE, CA 92501
(951) 826-5567

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 (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