ZEB Strategy and Rollout Plan

Ventura County Transportation Commission
ZEB Rollout and Implementation Plan

Final Report

May 2023

Stantec

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ZEB Rollout Plan and Implementation Strategy

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EXECUTIVE SUMMARY

Ventura County Transportation Commission (VCTC) oversees regional commuter bus services as well as public transit fixed-route and demand response services in the Santa Clara River Valley. VCTC carried over 252,000 unlinked passenger trips in 2021[1]. VCTC's services are organized under two umbrellas:

- **Intercity service**, which provides regional commuter services throughout Ventura County and to Santa Barbara and Los Angeles Counties, and
- **Valley Express service**, which provides local fixed route, ADA paratransit, and general-purpose dial-a-ride to the Ventura County communities of Santa Paula, Fillmore, and Piru.

With a service area population of 209,877[2] and a fleet of 51 vehicles – 36 motorcoaches for Intercity service and 15 cutaways for Valley Express service – VCTC is classified as a small transit agency under the Innovative Clean Transit (ICT) regulation. This regulation by the California Air Resources Board (CARB) mandates that all transit agencies have a goal of gradually transitioning to a zero-emission bus (ZEB) fleet by 2040. Small transit agencies are required to submit a plan to CARB by June 30, 2023 and begin ZEB purchases in 2026. VCTC has chosen two approaches to its fleet transition: Intercity diesel motorcoaches will be transitioned to hydrogen fuel cell electric (FCEBs) motorcoaches, while Valley Express gasoline cutaways will transition to battery-electric (BEBs) cutaways. This report provides a strategic transition plan for all revenue vehicles in VCTC's fleet.

This document also serves as the source for VCTC's rollout plan submission to CARB and provides a detailed plan of the technology, needs, and strategies that will help VCTC's transition to a ZEB fleet. The previous phases of this project (summarized in this report) laid the foundation for this plan by assessing VCTC's existing conditions and modeling the power and fuel requirements needed to meet VCTC's service through a ZEB fleet. For the Valley Express fleet, due to its small size, a BEB fleet is a better fit for the fleet requirements, but VCTC will need to work with partners throughout the Heritage Valley to deploy charging infrastructure. For the Intercity fleet, the operating profile requires vehicles with substantial range, and we recommend that while BEBs will be used initially, that VCTC should deploy FCEB motorcoaches when they become available and collaborate with Gold Coast Transit for hydrogen fueling.

A financial ZEB model for each fleet was developed for comparative purposes against a base case (or business as usual with fossil fuel buses) and developing a phasing or implementation plan. For the Intercity fleet, implementing a FCEB fleet will cost $76.4 million (cumulative capital and operating costs, in 2023 dollars) compared to $62.8 million for business-as-usual through 2040. In other words, the transition to ZEBs for the Intercity fleet adds incremental capital and operating costs of $13.6 million to VCTC over the horizon of the transition. For the Valley Express fleet, implementing a BEB fleet will cost $11.2 million (cumulative capital and operating costs, in 2023 dollars) compared to $10.4 million for business-as-usual

[1] 2021 NTD agency profile.
[2] 2021 NTD service profile.

through 2040. In other words, the transition to ZEBs for the Valley Express fleet adds incremental capital and operating costs of $813,000 to VCTC over the horizon of the transition. Note that these costs do not include capital costs for fueling infrastructure since VCTC does not own any facilities in which to install necessary equipment; a rough capital cost estimate of the charging equipment for the BEBs for Valley Express service is just under $1.5 million. VCTC is exploring different partnership opportunities to deploy charging infrastructure for BEBs to operate the Valley Express fleet and plans to collaborate with Gold Coast Transit District for hydrogen fueling of the Intercity fLeet.

Based on VCTC's existing fleet replacement schedule and the required ZEB regulations outlined by CARB, this plan recommends that the ZEB procurement begins in 2027 and gradually continues through 2040 as fossil fuel vehicles reach the end of their useful lives and are retired. This phased approach allows for VCTC to implement a smaller number of ZEBs over time and learn from the process by slowly scaling up to reach a 100% ZEB revenue vehicle fleet by 2040 while adhering to ICT guidelines and goals. For the Valley Express fleet, as VCTC plans a fossil fuel vehicle purchase in 2025, the Valley Express electrification will occur gradually starting in 2034.

The full phasing and implementation plan is outlined in Table 1, along with infrastructure considerations. With a full transition to ZEBs, VCTC can reduce its fleet-related greenhouse gas emissions by approximately 15% (over 9,000 tons for both Intercity and Valley Express fleets) compared to current fleet emissions, due to the residual carbon footprint of hydrogen fuel production and transportation.

Throughout this document, information is provided that corresponds to the required sections of the ICT ZEB Rollout Plan. Taken together, this plan is a living document that is intended to provide a practical framework for VCTC to deploy and transition to ZEBs in response to CARB's mandate. Like with any other strategic plan, VCTC intends to periodically revisit and in its discretion adjust this Plan in response to funding realities, changes in service delivery, optimal vehicle types and lengths, and based on the needs of VCTC and its ridership, particularly given the long-term (20 years) outlook.

Table 1: ZEB implementation phasing plan, FY2023-2040

Year	Intercity ZEB Fleet Procurements	Intercity Capital Costs (2023$)	Intercity O&M Costs (2023$)	Intercity Total (2023$)	Valley Express ZE Fleet Procurements	VE Capital Costs (2023$)	VE O&M Costs (2023$)	VE Total (2023$)	VCTC Grand Total (2023$)	Infrastructure Notes
FY2023	N/A	$0	$2,410,000	$2,410,000	N/A	$0	$536,000	$536,000	$2,946,000	Intercity – Potential deployment of BEB motorcoach chargers and related equipment in Camarillo
FY2024	N/A	$0	$2,352,000	$2,352,000	N/A	$0	$518,000	$518,000	$2,870,000	
FY2025	N/A	$1,968,000	$2,265,000	$4,233,000	N/A	0	$498,000	$2,674,000	$6,907,000	
FY2026	N/A	$1,255,000	$2,183,000	$3,438,000	N/A	$0	$480,000	$480,000	$3,918,000	Intercity – Potential facility modifications for gas leak detection and other precautions for hydrogen technologies
FY2027	3 FCEB motorcoaches	$7,063,000	$2,079,000	$9,142,000	N/A	$0	$463,000	$463,000	$9,605,000	
FY2028	3 FCEB motorcoaches	$7,288,000	$1,972,000	$9,260,000	N/A	$0	$447,000	$447,000	$9,707,000	
FY2029	9 FCEB motorcoaches	$9,266,000	$1,803,000	$11,069,000	N/A	$0	$431,000	$431,000	$11,500,000	
FY2030	N/A	$0	$1,724,000	$1,724,000	N/A	$0	$417,000	$417,000	$2,141,000	
FY2031	3 FCEB motorcoaches	$2,776,000	$1,675,000	$4,451,000	N/A	$0	$420,000	$420,000	$4,871,000	
FY2032	N/A	$0	$1,604,000	$1,604,000	N/A	$0	$404,000	$404,000	$2,008,000	
FY2033	NA	$46,000	$1,541,000	$1,587,000	N/A	$0	$390,000	$390,000	$1,977,000	Valley Express – Deployment of BEB cutaway chargers and related equipment
FY2034	NA	$43,000	$1,475,000	$1,518,000	5 BEB cutaways	$1,048,000	$327,000	$1,375,000	$2,891,000	
FY2035	5 FCEB motorcoaches	$3,899,000	$1,433,000	$5,332,000	5 BEB cutaways	$999,000	$268,000	$1,267,000	$6,596,000	
FY2036	NA	$0	$1,371,000	$1,371,000	5 BEB cutaways	$953,000	$212,000	$1,165,000	$2,532,000	
FY2037	3 FCEB motorcoaches	$2,086,000	$1,277,000	$3,363,000	N/A	$0	$203,000	$203,000	$3,563,000	
FY2038	2 FCEB motorcoaches	$1,301,000	$1,199,000	$2,500,000	N/A	$0	$196,000	$196,000	$2,692,000	
FY2039	9 FCEB motorcoaches	$5,569,000	$1,078,000	$6,647,000	N/A	$0	$188,000	$188,000	$6,832,000	
FY2040	10 FCEB motorcoaches	$5,888,000	$953,000	$6,841,000	N/A	$0	$181,000	$181,000	$7,019,000	

Abbreviations

AHJ	Authorities having jurisdiction
AHSC	Affordable Housing and Sustainable Communities Program
APCD	Ventura County Air Pollution Control District
APTA	American Public Transportation Association
BEB	Battery electric bus
BESS	Battery electric storage system
BEV	Battery electric vehicle
BUILD	Better Utilizing Investments to Leverage Development
CAF	Clean Air Fund
CARB	California Air Resources Board
CCS	Carbon capture and storage
CMAQ	Congestion Mitigation and Air Quality Improvement Program
CRT	Charge Ready Transport
CTTC	California Transit Training Consortium
DGE	Diesel gallon equivalent
FCEB	Hydrogen fuel cell electric bus
FHWA	Federal Highway Administration
FTA	Federal Transportation Administration
GCTD	Gold Coast Transit District
GHG	Greenhouse gas
HVIP	Hybrid and Zero-Emission Truck and Bus Voucher Incentive Program
ICE	Internal combustion engine
ICT	Innovative Clean Transit
LCFS	Low Carbon Fuel Standard
LCTOP	Low Carbon Transit Operations Program
LPP	Local Partnership Program

MPO	Metropolitan Planning Organization
NFPA	National Fire Protection Association
NPV	Net present value
NREL	National Renewable Energy Laboratory
NTI	National Transit Institute
O&M	Operations and maintenance
OEHHA	Office of Environmental Health Hazard Assessment
OCPP	Open Charge Point Protocol
PPE	Personal protective equipment
PV	Photovoltaic
RAISE	Rebuilding American Infrastructure with Sustainability and Equity
SBCAG	Santa Barbara County Association of Governments
SCAG	Southern California Association of Governments
SCCAB	South Central Coast Air Basin
SCCP	Solutions for Congested Corridors Program
SCE	Southern California Edison
SMR	Steam methane reformation
SOC	State of charge
STEP	Sustainable Transportation Equity Project
STIP	State Transportation Improvement Program
TDA	Transportation Development Act
TIRCP	Transit and Intercity Rail Capital Program
TOU	Time of use
USDOT	United States Department of Transportation
VCTC	Ventura County Transportation Commission
VCREA	Ventura County Regional Energy Alliance
ZE	Zero emission
ZEB	Zero-emission bus

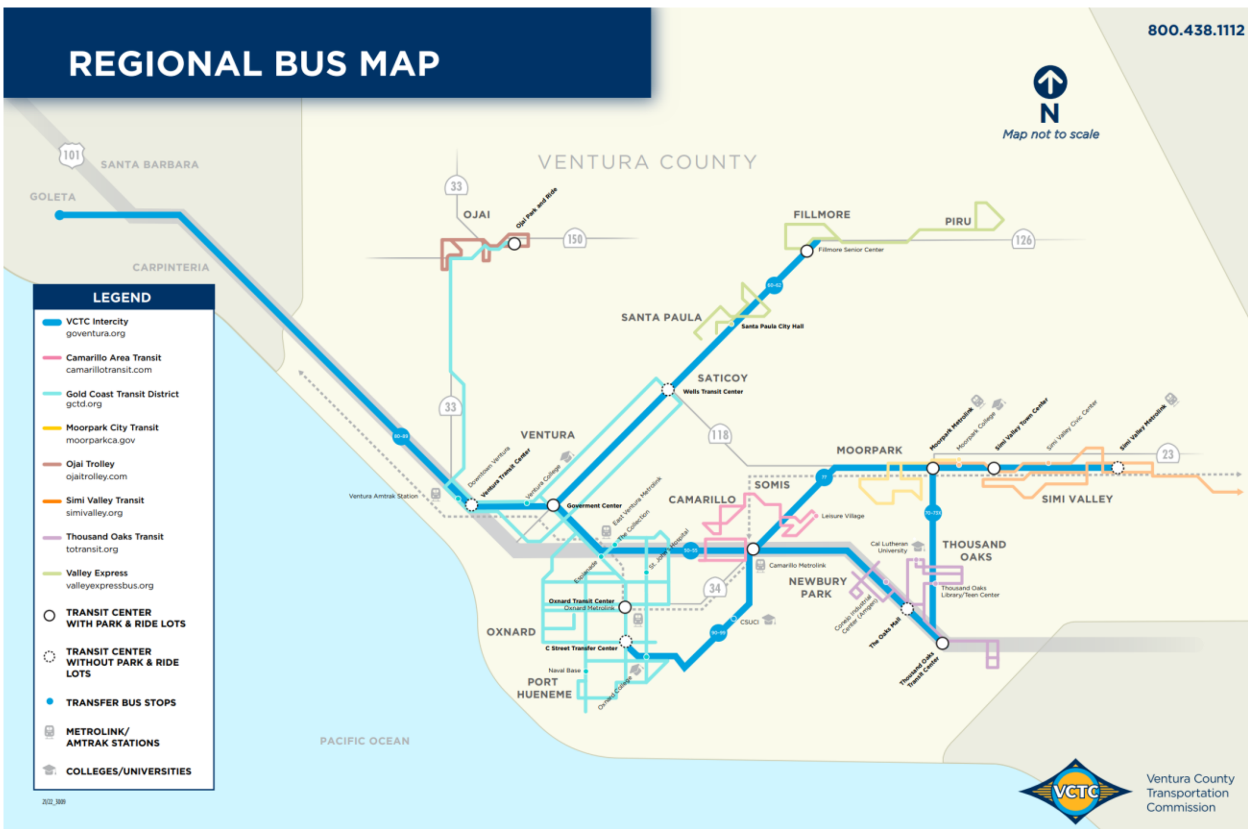
1.0 INTRODUCTION AND BACKGROUND

Ventura County Transportation Commission (VCTC) provides public fixed-route and demand response transportation services in eastern Ventura County as well as regional commuter services. VCTC provided over 252,000 unliked passenger trips in 2021[3].

VCTC's services are organized under two umbrellas (Figure 1):

- **Intercity service**, which provides regional commuter services throughout Ventura County and to Santa Barbara and Los Angeles Counties, and
- **Valley Express service**, which provides local fixed-route, ADA paratransit, and general-purpose dial-a-ride transportation to the eastern Ventura County communities of Santa Paula, Fillmore, and Piru.

Figure 1: Current transit services in Ventura County. Intercity routes are blue, and Valley Express routes are light green (Source: VCTC)



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3 2021 NTD agency profile.

VCTC will soon own a fleet of 56 vehicles—41[4] motorcoaches for Intercity service and 15 cutaways for Valley Express service. VCTC owns both fleets, and each is housed at separate operations and maintenance facilities leased by VCTC's third-party operators. VCTC is a part of the Ventura County Air Pollution Control District (APCD), South Central Coast Air Basin (SCCAB), and Southern California Edison (SCE) utility territory.

With a service area population of 209,877 and fewer than 100 vehicles in maximum service, VCTC is classified as a small transit agency under the Innovative Clean Transit (ICT) mandate[5] and is required to submit a zero-emission (ZE) rollout plan to the California Air Resources Board (CARB) by June 30, 2023.

This document serves as the source for VCTC's rollout plan submission to CARB and provides a detailed plan of the technology, needs, and strategies that will help VCTC transition to a ZEB fleet. To develop this rollout plan, several steps have been taken to determine the best ZEB strategy for VCTC. These steps included:

- A review of existing conditions to understand characteristics and constraints for VCTC's operations and service area. This included a primer on different ZEB technologies to provide a scan of the market and technologies, including battery-electric buses (BEBs) and hydrogen fuel cell-electric buses (FCEBs).
- Energy and power modeling to understand performance under different ZE technology options, their feasibility, and suitability for VCTC's needs. A quantitative and qualitative assessment of modeling results was completed to determine the preferred ZE fleet composition for VCTC.

This report is intended to act as a roadmap to guide VCTC through the ZEB transition to 100% ZEB deployment and implementation by 2040, as well as to fulfill the CARB guidelines as outlined in the ICT mandate. As CARB has reminded transit agencies, the **ICT-regulated rollout plan is intended to be a living document that can and should be regularly revisited and updated over time as ZE technologies continue to evolve.**

[4] Including the 5 BYD BEBs to be delivered later in 2023.
[5] CARB ICT defined large transit agencies as operating in "an urbanized area with a population of at least 200,000 as last published by the Bureau of Census before December 31, 2017 *and* has at least 100 buses in annual maximum service." Agencies that do not meet this definition are categorized as small transit agencies.

2.0 REGULATORY CONTEXT

This section provides a review of the ICT regulation to provide a basis for why the ZEB transition is taking place and to provide VCTC staff and Commission members with information on how ICT and ZEB implementation fits within and impacts VCTC operations and future plans.

2.1 INNOVATIVE CLEAN TRANSIT

CARB adopted the ICT regulation in December 2018, which requires all public bus transit agencies in the state to gradually transition to a completely ZEB fleet by 2040. This regulation is in accordance with preceding state legislation SB 375 and SB 350. SB 375, the Sustainable Communities and Climate Protection Program, creates initiatives for increased development of transit-oriented communities, better-connected transportation, and active transportation. Relatedly, SB 350 supports widespread transportation electrification through collaboration between CARB and the California Public Utilities Commission.

The ICT regulation also states that transit agencies are required to produce a ZEB rollout plan that describes how the agency is planning to achieve a full transition to a ZE fleet by 2040 as well as outlining reporting and record-keeping requirements. Specific elements required in the rollout plan include:

- A full explanation of how the agency will transition to ZEBs by 2040 without early retirement of conventional internal combustion engine buses;
- Identification of the ZEB technology the agency intends to deploy;
- How the agency will deploy ZEBs in disadvantaged communities;
- Identification of potential funding sources;
- A training plan and schedule for ZEB operators and maintenance staff;
- Schedules for bus purchase and lease options (including fuel type, number of buses, and bus type); and
- Information on the construction of associated facilities and infrastructure (including location, type of infrastructure, and timeline).

Small California transit agencies, such as VCTC, are mandated to submit ZEB rollout plans to CARB by June 30, 2023. ICT also requires the ZEB purchase schedules for both large and small agencies. Beginning in 2021 and continuing annually through 2050, each transit agency is required to provide a compliance report[6]. The initial report outlines the number of and information on active buses in the agency's fleet as of December 31, 2017. Subsequent reports must include transit agency information, details on each bus purchased, owned, operated, leased, or rented (including make, model, curb weight,

[6] https://ww2.arb.ca.gov/sites/default/files/2019-10/ictfro-Clean-Final_0.pdf

engine and propulsion system, bus purchases, and any information on converted buses), ZE mobility option information (if applicable), and information on renewable fuel usage (including date purchased, fuel contract number, and effective date, as applicable).

Table 2 below outlines the ZEB purchase schedule for small transit agencies for heavy-duty transit vehicles. **Specific vehicle types, such as motor coaches, cutaways, double decker, and 60-ft. vehicles, are exempt from this purchase schedule until 2026 or later (dependent on Altoona testing[7] being completed). This exemption is particularly relevant to VCTC since VCTC operates cutaways and motorcoaches exclusively, meaning VCTC is exempt from ZEB adoption until 2026 or later.** Whereas large agencies are required to start purchasing ZEBs in 2023, small agencies are exempt until 2026. In that year a minimum of 25% of new bus purchases must be ZE.

Table 2: CARB Standard Bus ZEB Purchase Schedule (As a Percentage of Total New Bus Purchases for Small Transit Agencies)[8]

Year	Percentage
2023	-
2024	-
2025	-
2026	25%
2027	25%
2028	25%
2029 and after	100%

Specifically, the ZEB rollout plan required to be submitted to CARB by mid-2023 must include the following components, broken down by CARB into nine sections:

- Section A: Transit agency information
- Section B: Rollout plan general information
- Section C: Technology portfolio
- Section D: Current bus fleet composition and future bus purchases
- Section E: Facilities and infrastructure modifications
- Section F: Providing service in disadvantaged communities
- Section G: Workforce training
- Section H: Potential funding sources

[7] Altoona testing is a federally mandated series of tests to certify the safety and compliance of buses and vehicles for transit authorities. Buses must be Altoona tested for agencies to use federal monies for purchase.
[8] In this report, standard buses refer to 35-ft. or 40-ft. unless otherwise stated

- Section I: Start-up and scale-up challenges

To account for circumstances beyond a transit agency's control that may impact their ability to comply with ICT regulations, the mandate laid out specific provisions for exemptions. Exemptions will be permitted for the following circumstances:

- If the required ZEB type is unavailable;
- If daily mileage needs cannot be met;
- If gradeability needs cannot be met;
- If there are delays in infrastructure construction;
- If a financial emergency is declared by the transit agency; and
- In circumstances where incremental capital or electricity costs for charging cannot be offset after applying for all available funding and incentive opportunities.

Finally, CARB acknowledges the continuous evolution of ZEB technologies as well as the service design and delivery of transit services.

2.2 ICT EXEMPTIONS

As discussed above, the ICT regulation has specific provisions for exemptions if at least one the following criteria are met. If the exemption is granted, transit agencies may purchase conventional internal combustion engine (ICE) bus(es) instead of ZEB(s).[9]

1. Delay in bus delivery is caused by ZEB infrastructure construction setbacks beyond the transit agency's control. ZEB infrastructure includes charging stations, hydrogen stations, and maintenance facilities. The following circumstances would qualify a transit agency for exemption:

    a. Change of a general contractor
    b. Delays obtaining power from a utility
    c. Delays obtaining construction permits
    d. Discovery of archeological, historical, or tribal cultural resources
    e. Natural disaster

    A transit agency may also request an exemption if they can provide documentation that demonstrates the needed infrastructure cannot be completed within the two-year extension period or in time to operate the purchased buses after delivery, whichever is later.

2. When available ZEBs cannot meet a transit agency's daily mileage needs (due to operating conditions and the operating range of a ZEB).

[9] https://ww2.arb.ca.gov/sites/default/files/2019-10/ictfro-Clean-Final_0.pdf

3. If available ZEBs do not have adequate gradeability performance to meet the transit agency's daily needs for any bus in its fleet. For service areas with lots of grade changes, operating ranges may be impacted so that a ZEB may be unable to provide suitable service.

4. When the selected ZEB type (either an FCEB or BEB) for the applicable weight class based on gross vehicle weight rating (GVWR) (like a cutaway, motorcoach, etc.) is unavailable for purchase. A ZEB bus type is considered unavailable for purchase for any of the following reasons:

    a. The ZEB has not passed the complete Altoona Bus Testing and not obtained a Altoona Bus Testing Report
    b. The ZEB cannot be configured to meet applicable requirements of the Americans with Disabilities Act
    c. The physical characteristics of the ZEB would result in a transit agency violating any federal, state, or local laws, regulations, or ordinances

5. When a ZEB cannot be purchased by a transit agency due to financial hardship. Financial hardship would be granted for the following reasons:

    a. If a fiscal emergency is declared under a resolution by a transit agency's governing body following a public hearing
    b. A transit agency can demonstrate that it cannot offset the incremental cost of purchasing all available ZEBs compared to the cost of the same type of conventional bus
    c. A transit agency can demonstrate that it cannot offset the managed, net electricity cost for depot charging BEBs when compared to the fuel cost of the same type of conventional ICE buses

If a transit agency wishes to request an exemption, they must provide documentation demonstrating the criteria are met. Required documentation for each exemption is summarized in Table 3. In addition, a request for exemption for a particular calendar year's compliance obligation must be submitted by November 30th of that year.[10]

Table 3: Required documentation for ZEB purchase exemptions

Criteria	Required Documentation
1. Delay in bus delivery and infrastructure construction	• A letter from the agency's governing body • A letter from the contractor, utility, building department, or other involved organizations explaining the reasons for delay and estimating the project completion date
2. Available ZEBs cannot meet transit agency's daily mileage needs	• An explanation of why the exemption is needed • A current monthly mileage report for each bus type

[10] https://ww2.arb.ca.gov/sites/default/files/2019-10/ictfro-Clean-Final_0.pdf

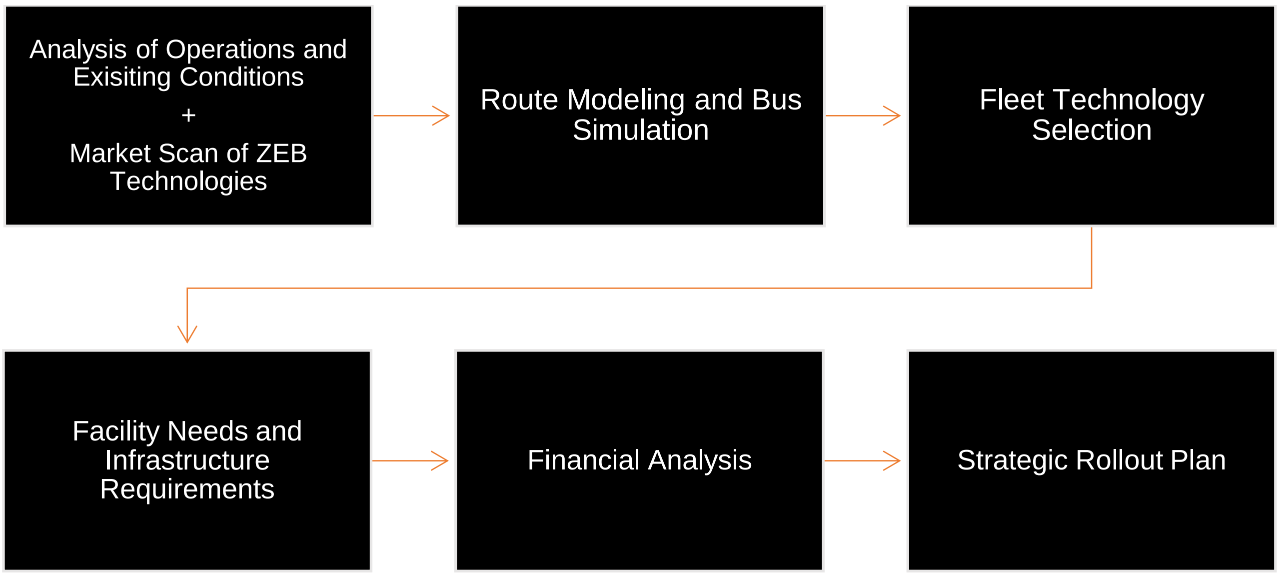
Criteria	Required Documentation
	• A copy of the ZEB RFP and resulting bids showing rated battery capacity • If available, measured energy use data from ZEBs operated on daily assignments in the transit agency's service
3. Available ZEBs do not have adequate gradeability performance to meet the transit agency's daily needs	• Documentation showing no other buses in the fleet can meet the gradeability requirements and the ZEBS of that bus type cannot be placed into service anywhere else in the fleet • Topography information including measurement of the grade(s) where the ZEBS would be placed in service • A description of the bus types that currently serve the route(s) • An explanation of why the gradeability of all available ZEBs are insufficient to meet the transit agency's service needs • A copy of the ZEB RFP, specifying the transit agency's required gradeability and the resulting bids • If available, empirical data including grades, passenger loading, and speed data from available ZEBs operated on the same grade
4. When a required ZEB for the applicable weight class based on GVWR is unavailable for purchase	• A summary of all bus body-types, vehicle weight classes being purchased, chassis, reasons why ZEBs are unavailable for purchase • Current fleet information showing how many ZEBs of that bus type are already in service and how many are on order • If applicable, documentation showing that ADA requirements cannot be met • If applicable, a letter from its governing body that details how the physical characteristics of the ZEB would violate federal, state, or local law
5. When a ZEB cannot be purchased by a transit agency due to financial hardship	• A resolution by the transit agency's governing body declaring a fiscal emergency • Documentation showing the transit agency cannot offset the initial capital cost of purchasing ZEBs

Taken together, CARB recognizes the challenges that transit agencies will face when adopting ZEBs and wants to avoid hardships around finances and service delivery. As such, if VCTC faces certain challenges for a particular year, for example, the vehicle type needed is not available as a ZEB or if the charging infrastructure is not ready, then VCTC can apply for an exemption to CARB by documenting that VCTC cannot offset the incremental cost of a ZEB compared to a conventional fossil fuel vehicle. Nonetheless, the ZEB rollout and transition plan in this document is built upon assumptions that VCTC will have sufficient funding to carry out the transition. **As such, the CARB ICT plan is a living document that is flexible and can be amended to account for circumstances that require exemptions or shifting of ZEB procurement or other implementation steps.**

3.0 APPROACH TO ZEB PLANNING

The graphic in Figure 2 provides a high-level schematic of the major steps in this project to derive a recommended fleet mix and implementation plan.

Figure 2: Schematic representation of the steps in the ZEB planning process



The first step involved a review of existing conditions of VCTC to provide a foundation and understanding of VCTC's operations, service, and business processes that would be impacted by a transition to a ZEB fleet. A summary of these findings is provided in Section 4.0. Site visits of the operating base and maintenance facilities in Camarillo and Santa Paula provided insights into the constraints and opportunities for implementing ZEBs, as well as the condition of the facilities, buildings, and existing service cycles. A market scan was also conducted to analyze the current ZEB technologies, their limitations, and in-development technologies that can help shape VCTC's future ZEB fleet.

Next, we modeled block-level and vehicle-level fuel economies to understand the predicted performance of different ZEB technologies under VCTC's operating parameters for both fixed-route and demand response services. Together with a multicriteria trade-off analysis and in consultation with VCTC staff, Stantec and VCTC determined that the best path forward to a ZE future is with a hydrogen fleet for Intercity and a BE fleet for Valley Express services (Section 5.0). The fleet procurement schedule and outlook were designed to account for the ICT Regulation's requirement of annual apportionment of ZEB purchases, accounting for the 5 BE motorcoaches in the Intercity fleet that VCTC can use to offset ZEB requirements to future dates (Section 6.0).

One major challenge for VCTC is that it does not own the operations and maintenance facilities for either service, making the infrastructure planning for the ZEB-related fueling equipment particularly challenging. In Sections 7.0 and 8.0, we outline the strategies for VCTC's two fleets with regard to fueling infrastructure.

Stantec then developed a financial analysis for the ZEB rollout through 2040 for the Valley Express and Intercity fleets that focuses on propulsion-dependent costs, like fleet acquisition, fueling, and vehicle maintenance (Section 9.0). Operating and planning considerations (Section 10.0), workforce training (Section 12.0), and potential funding sources (Section 13.0) are also reviewed and discussed.

All steps described here provide VCTC with a comprehensive ZEB rollout plan and strategy. Throughout this document, reference is made to specific sections that are found in the ICT mandated ZEB Rollout Plan document.

4.0 SUMMARY OF KEY EXISTING CONDITIONS

The Existing Conditions report provided a comprehensive review of VCTC's existing conditions, encompassing operations, facilities, and finances to lay the groundwork for the modeling and understand current operating conditions.

Major findings from the existing conditions report that will affect the ZEB transition include:

- VCTC operates in a vast and diverse service area. Intercity operates in more urban areas, providing long-distance commuter service to major trip generators throughout Ventura, Santa Barbara and Los Angeles counties with routes traveling largely along highways to connect different destinations. Valley Express provides service to the smaller, less dense communities in the Santa Clara River Valley of Ventura County. Overall, VCTC's vehicles operate across long distances.

- **VCTC's current fleet is made up of motorcoaches for Intercity service and cutaways for Valley Express service** (Table 4). Motorcoaches and cutaways have fewer ZE alternatives when compared to options available for standard buses. Current Intercity buses are all diesel-powered with an average fleet age of 6.6 years. Valley Express cutaways are gasoline-powered and are 7 years old on average. Valley Express vehicles are fueled offsite at local gas stations, while motorcoaches are fueled with diesel fuel onsite in Camarillo at the operations and maintenance (O&M) contractor's facility.

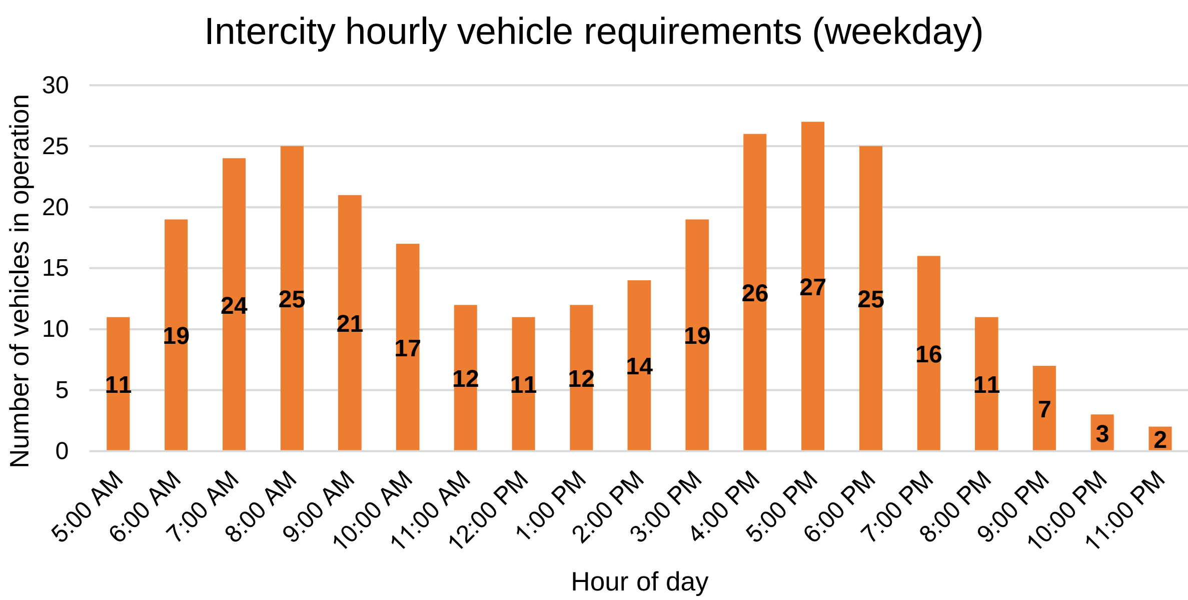
Table 4: Current revenue fleet composition

Model Year	In-Service Year	Quantity	Make	Vehicle Type	Seating Capacity	Fuel type	FTA minimum useful life[11]	Current age[12]	Service type
2015	2015	25	MCI	Motorcoach	57	Diesel	14 years	7 years	Intercity
2016/2017	2019	3	MCI	Motorcoach	57	Diesel	14 years	6 years	Intercity
2019	2019	3	MCI	Motorcoach	57	Diesel	14 years	3 years	Intercity
2014	2014	1	Volvo	Motorcoach	53	Diesel	14 years	9 years	Intercity
2013/2014	2019	4	Volvo	Motorcoach	53	Diesel	14 years	3 years	Intercity
2015	2015	5	Glaval	Cutaway	12	Gasoline	10 years	7 years	Valley Express
2015	2015	5	Glaval	Cutaway	16	Gasoline	10 years	7 years	Valley Express
2015	2015	5	Arboc	Cutaway	23	Gasoline	10 years	7 years	Valley Express

[11] https://olga.drpt.virginia.gov/Documents/forms/DRPT%20Asset%20Useful%20Life%20Chart.pdf
[12] Current age determined from in-service year.

- For Intercity services, a typical service day sees more vehicles in service during the morning and afternoon peaks, reflective of typical commuter services[13]. Hourly vehicle requirements are the highest at 5-6 pm with 27 vehicles required for service (Figure 3).

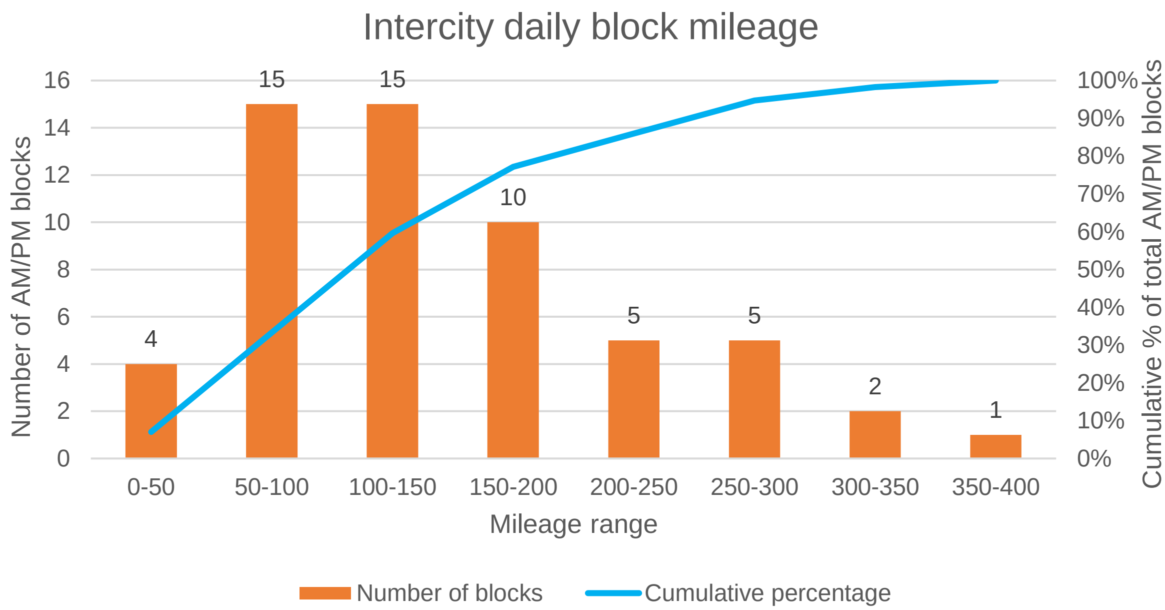
Figure 3: Hourly vehicles in operation (fixed route)



- Assessing scheduling and operating practices is crucial for understanding VCTC's blocking practices, how long blocks are, and how blocks are assigned to vehicles. This translates to how long vehicles are out in revenue operation and, from a modeling perspective, helps us understand if current blocks can be completed with ZE equivalents. Figure 4 shows that 60% of all Intercity blocks have mileages under 150 miles. The maximum block length is approximately 385 miles.

[13] Representative data from summer/fall 2022 were analyzed.

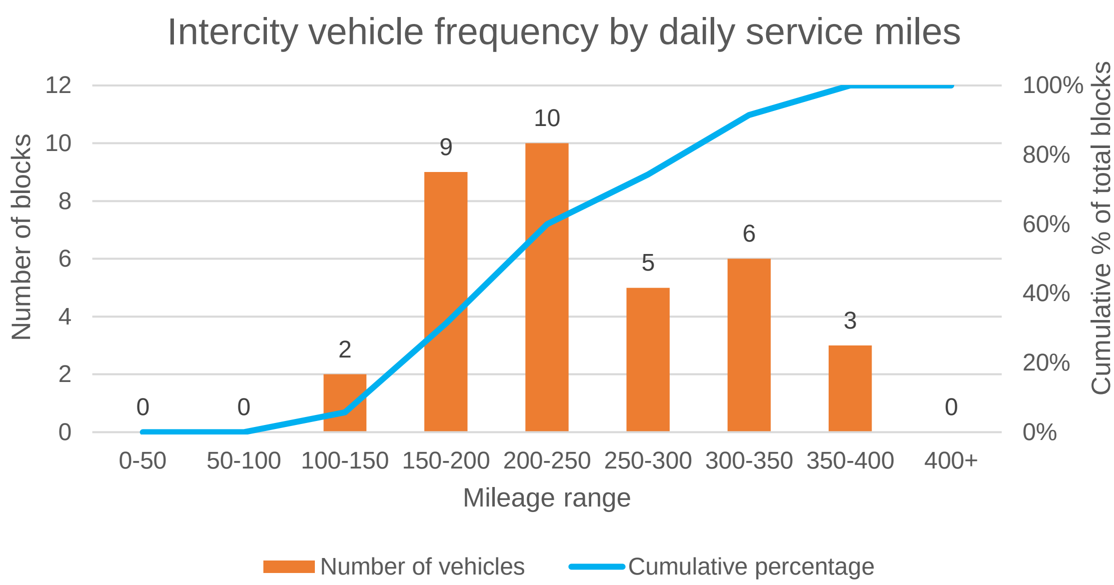
Figure 4: Block frequency by daily service miles



- Twenty-two out of 35 vehicles (or 63% of vehicles in operation) complete two blocks on an average day. When considering vehicle assignments, the total mileage increases significantly (Figure 5) compared to block-only mileage. This shows that 40% of vehicles travel more than 250 miles in a day, which would pose a challenge for BEB implementation if vehicles were to charge solely overnight, as the current range of BEB motorcoaches vary between 170 and 230 miles per charge[14].

[14] Based on quotes from MCI: Features - MCI (mcicoach.com)

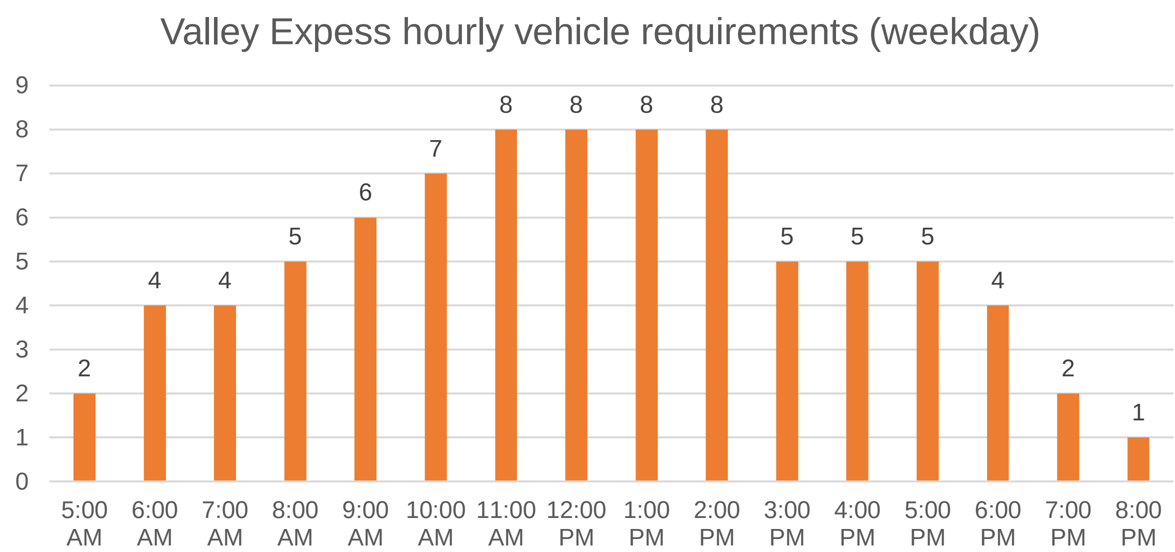
Figure 5: Vehicle frequency by daily service miles



- Valley Express service operates using a fleet of cutaways that are used for both fixed route and demand response services. Daily service is scheduled such that an operator can operate both fixed route and demand response in the same day and vacillate. Due to the variable nature of demand response services, where there is no fixed schedule and service varies based on demand, it is important to capture this variation in the modeling. For the purposes of the existing conditions report, one representative service day was chosen to show an example of how Valley Express vehicles operate on an average day[15]. Figure 6 shows that service peaks from 11 am-2 pm, with eight vehicles in operation, and total hourly vehicle requirements fluctuate from one vehicle at 8 pm to eight vehicles during the midday. The bulk of service is during the midday period, and these vehicles are completing both fixed route and demand response services during this time.

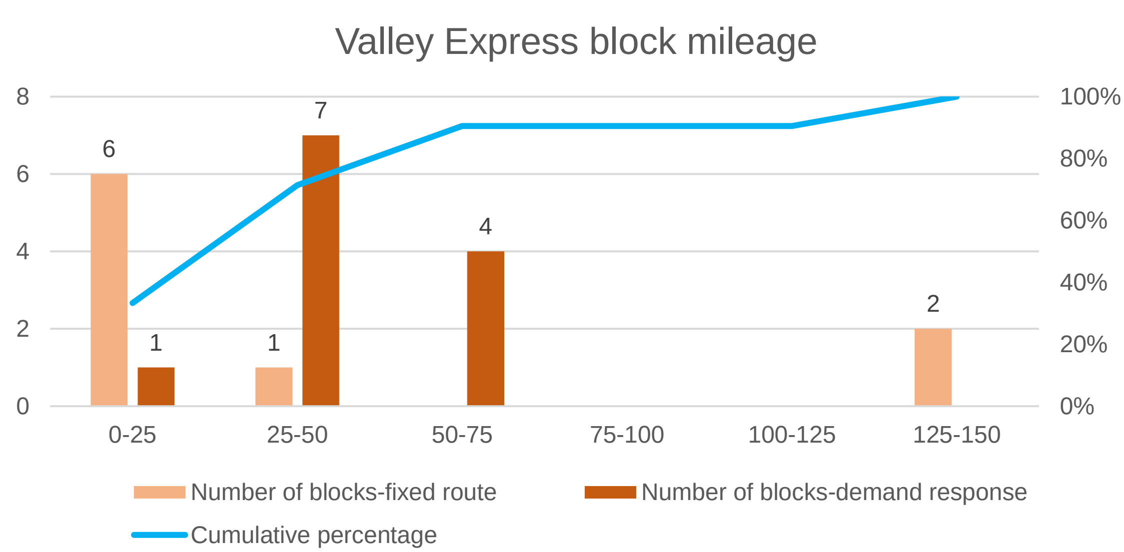
[15] Monday, August 22, 2022 was chosen as the representative service day.

Figure 6: Hourly weekday vehicle requirements for Valley Express services



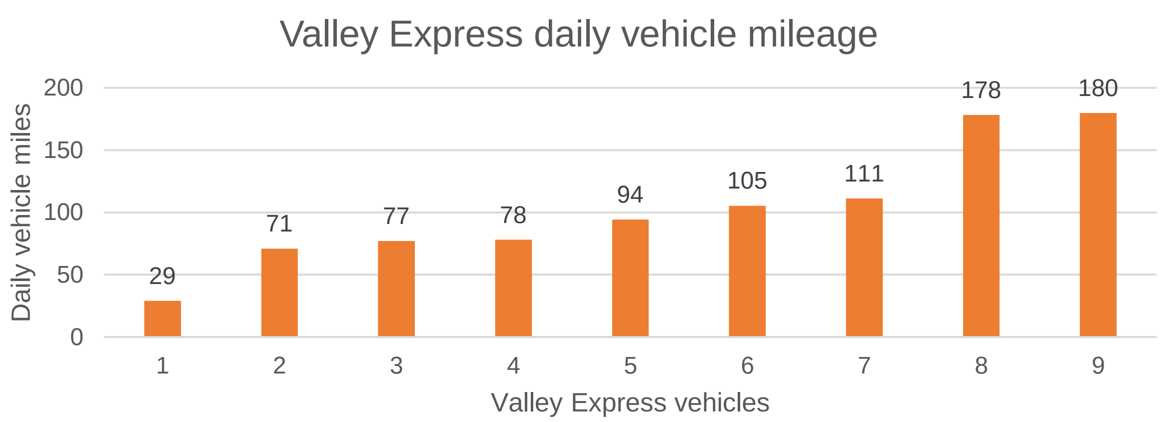
- Figure 7 shows Valley Express service broken out by block mileage, which is further broken down into fixed route and demand response block mileage. There is a close-to-even split between the number of daily blocks assigned to fixed routes (nine blocks) and demand response (12 blocks). Fixed route block mileage shows a wider variation, with six blocks operating between zero and 25 miles, but two blocks operating over 125 miles. Demand response block mileage shows less variation, with all 12 blocks operating between 16 and 71 miles.

Figure 7: Daily service for demand response vehicles (2019)



- Figure 8 shows the daily mileage per vehicle when blocks are combined at the vehicle assignment level. When combined at the vehicle assignment level, the average Valley Express vehicle is in service for 103 miles, compared to an average block length of 44 miles. As range is more of an issue with smaller ZEBs, such as cutaways, these daily distances may be difficult to complete with ZEB equivalents.

Figure 8: Valley Express daily vehicle mileage



- **VCTC does not own the operations and maintenance facilities for the Intercity service nor for the Valley Express service.** Both the Camarillo and Santa Paula facilities (for Intercity and Valley Express, respectively) largely appear in good working condition.
- Because VCTC does not own these facilities and because VCTC's contractors may change from time to time depending on contract award, **VCTC is unable to invest in the facility modifications that would be needed to accommodate ZEBs (chargers, electrical upgrades, hydrogen fueling, gas leak detection, etc.). Moreover, space is limited so hydrogen fueling infrastructure would be unlikely to fit at the current site.**
  - To circumvent this challenge, VCTC and Gold Coast Transit District (GCTD) are exploring a potential partnership to allow VCTC access to GCTD's eventual hydrogen fueling infrastructure at its facility in Oxnard.
  - For Valley Express vehicles, developing a charging or fueling strategy is more complicated given the isolated nature of these services and the inability of VCTC to invest in the Santa Paula facility. VCTC is the managing agency working on behalf of the member agencies, so VCTC needs to work with the member agencies to partner with them to strategize on charging solutions.

Overall, VCTC is unique in several aspects compared to other transit agencies—long routes and mileages, VCTC doesn't own its facilities, and the vehicle types VCTC operates have few ZE options—making ZEB transition planning uniquely challenging.

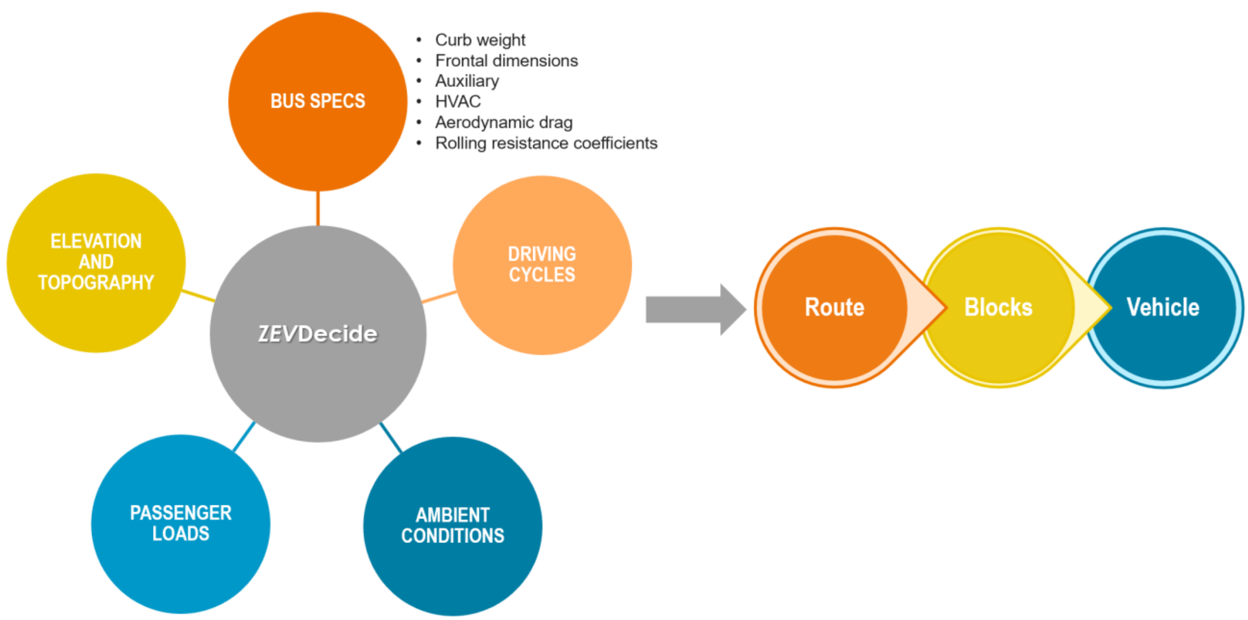
5.0 PREFERRED/RECOMMENDED FLEET COMPOSITION

This section provides an overview of the power and energy modeling methodology and presents the results of the modeling to understand the feasibility of transitioning VCTC's operations to different ZE alternatives. Based on the modeling outcomes, we present a discussion of the different ZE fleet solutions and the pros and cons of different fleet compositions which were used to determine the preferred ZEB fleet composition for VCTC's Intercity and Valley Express fleets.

5.1 FLEET AND POWER MODELING OVERVIEW

ZEVDecide, Stantec's fleet modeling tool, was used to determine the feasible ZEB composition for VCTC's fleet. The predictive ZEB performance modeling (schematic overview shown in Figure 9) depends on several inputs, such as passenger loads, driving cycles (or duty cycles), topography, vehicle specifications, and ambient conditions subject to the environment in which the agency operates.

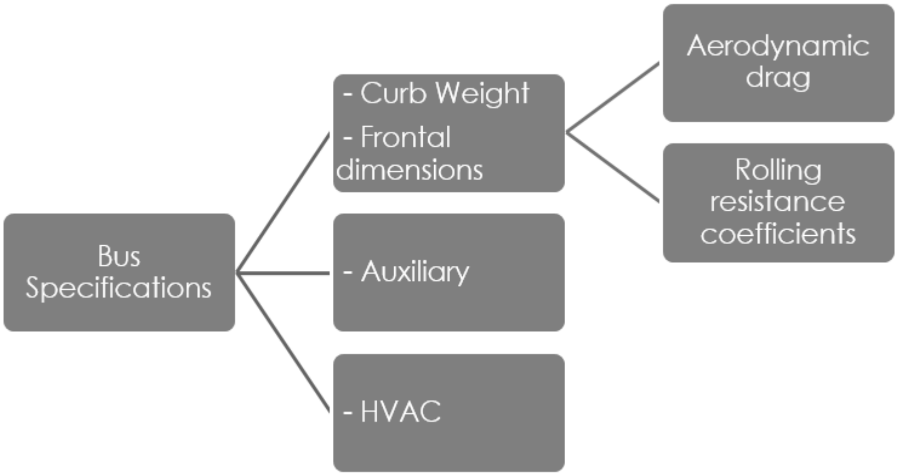
Figure 9: ZEVDecide modeling overview



Modeling Inputs

ZEVDecide's energy modeling process predicts ZEB drivetrain power requirements specific to given acceleration profiles. One key component to the modeling is the bus design or bus specifications that include curb weight and frontal dimensions (factors needed to account for aerodynamic drag and rolling resistance coefficients), auxiliary, and HVAC (Figure 10).

Figure 10: Schematic of the inputs for bus specifications



For Intercity service, the key motorcoach specifications used in the modeling process are detailed in Table 5. Given that hydrogen fuel cell motorcoaches are not commercially available in the US, certain assumptions were made in order to model this vehicle type. Available models of 40-ft low floor buses in the US are equipped with 37.5 kg of hydrogen tanks, therefore, this was the assumed tank size for a potential hydrogen coach. Additionally, the curb weight of the motorcoach was assumed to be similar to the weight of an electric coach since the chassis and the frame would be similar in size and the weight of the batteries is assumed to be equivalent to the weight of the fuel cell power plant. Lastly, while hydrogen fuel cell motorcoaches are not available in the US, these vehicles will likely be available in the future. Currently, the only available model that appears to market ready (yet not in revenue service) is the Hyzon 35-ft high-floor hydrogen fuel cell motor coach, equipped with at 35-kg tank and a stated range of 250 miles[16]; 40% of Intercity vehicles travel more than 250 miles per day. Note that fossil fuel motorcoaches are able to travel over 500 miles on a single tank.

Table 5: ZE motorcoach specifications for Intercity energy modeling

Technology Type	BEB	FCEB
Battery/Tank	544 kWh	37.5 kg
Vehicle Length (ft.)	45	35
Curb Weight (lbs.)	47,000	47,000
Example Image		

[16] https://www.hyzonmotors.com/vehicles/hyzon-high-floor-coach

Currently, few ZE cutaways have been tested and deployed to operate paratransit/demand response services. We modeled Valley Express service delivery with a BE cutaway that has a 127-kWh battery. Valley Express operations were also modeled with FCE cutaways (13.5-kg tanks), though these vehicles are not currently commercially available. For modeling purposes, we assumed the hydrogen cutaways would be equipped with 13.5-kg tanks, similar to those on hydrogen passenger vans. Additionally, the curb weight for a hypothetical hydrogen cutaway was based on the incremental weight between a hydrogen and an electric van, given that the frame and chassis would be equivalent, the weight difference would relate to the extra weight from the propulsion system, like the fuel cell. Assumed vehicle specifications for Valley Express modeling are detailed in Table 6. Note for fossil fuel cutaways, typical operating ranges exceed 200 miles on a single tank.

Table 6: ZE cutaway specifications for Valley Express energy modeling

Technology Type	BEB	FCEB
Battery/Tank	127 kWh	13.5 kg
Curb Weight (lbs.)	14,500	16,500
Example image		

Representative driving cycles: Assigning representative driving cycles, also called acceleration profiles or duty cycles, is the other major step in the energy modeling. A driving cycle is a speed versus time profile that is used to simulate the vehicle performance, and consequently, the energy use. Representative diving cycles were assigned to all routes based on Intercity and Valley Express operations and observed driving condition.[17] The driving cycles have been created from data collection of real-world operations or from chassis dynamometer tests and have been convened by the National Renewable Energy Laboratory (NREL) in a drive cycle database called DriveCAT.

Passenger loads: As the total weight of a ZEB impacts its performance, it is important to understand and capture passenger loads in the modeling process. To examine the impacts of passenger loads and its associated weight[18], VCTC provided data for each route detailing the passenger load to be modeled. Based on this data, and to capture the variation of passengers onboard throughout the course of the day,

[17] Due to the lack of data, the Conejo Connection route to Woodland Hills/Warner Center was not modeled. However, the results presented here look at the aggregate of all service and assume worst case conditions and as such, hydrogen fuel predictions will likely cover the required amount to provide services to the Conejo route.
[18] Estimated average passenger weight—170 lbs.

all routes were modeled with a high passenger load, reflecting conditions when the bus is full to 75% of its seated capacity, and a low passenger load when the bus reaches 25% of its seated capacity.

Ambient temperature: Stantec developed a correlation between ambient temperature and power requirements from the HVAC system. The power requirement for modeling purposes was set based on an annual low temperature average of 46°F[19].

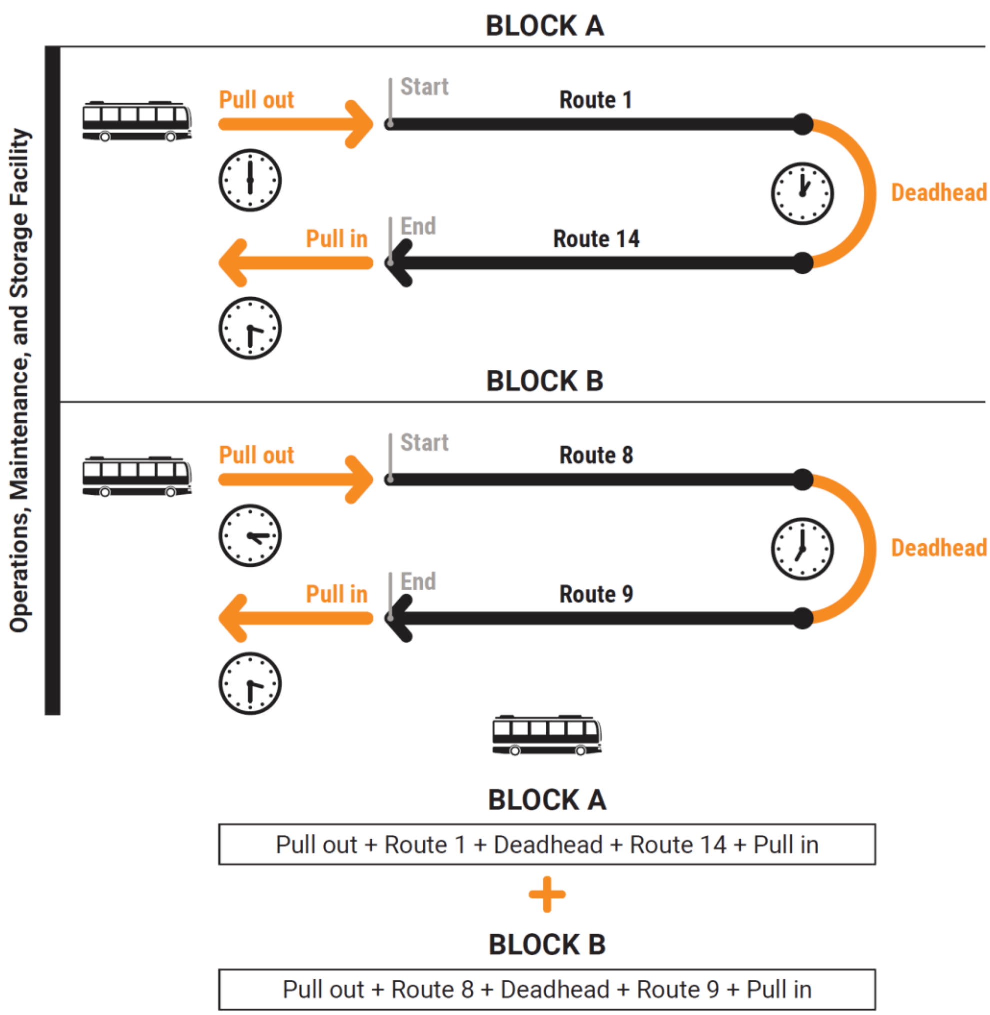
Topography and elevation: Given that portions of VCTC's service area are highly influenced by elevation and topography, it is important to account for the impacts of terrain and elevation on the energy efficiency of ZEBs. While the topography of western Ventura County is largely flat, varied topography can be seen elsewhere, and these elevation changes influence energy efficiency and subsequently expected ZEB performance.

Modeling Process

Using the inputs above, the first step in modeling Intercity and Valley Express services is obtaining route-level fuel economy and energy use for the BEBs and FCEBs using the driving cycles assigned to each route. However, we cannot stop at route-level modeling as this does not represent what a vehicle does in a day due to interlining, deadheading, etc. The graphic in Figure 11 demonstrates a hypothetical relationship between routes, deadheading, blocks, and vehicle assignments.

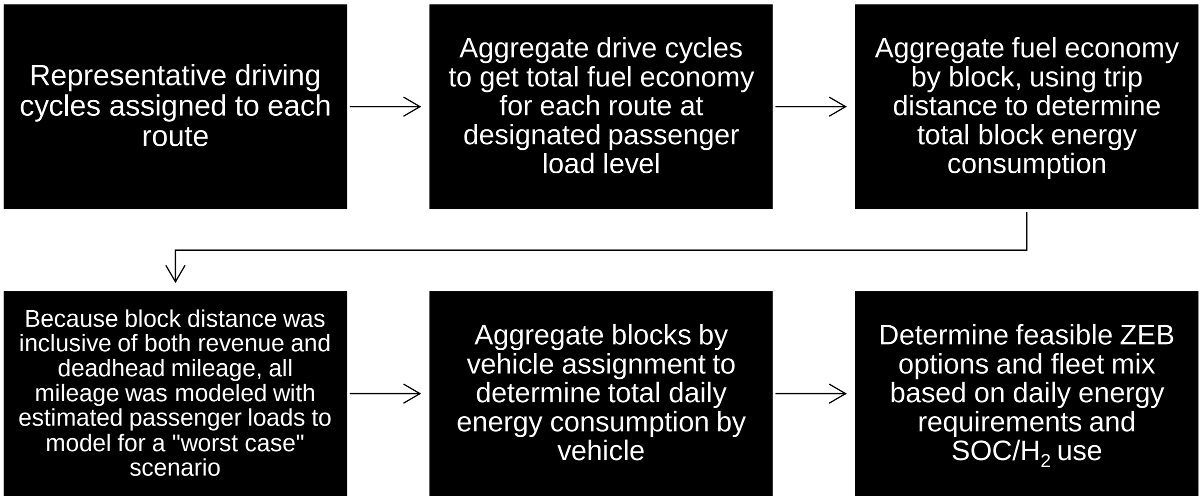
[19] US Climate Data https://www.usclimatedata.com/climate/oxnard/california/united-states/usca0819 and https://www.usclimatedata.com/climate/santa-barbara/california/united-states/usca1017

Figure 11: Relationship between routes, blocks, and vehicle assignments



The process of modeling a route and then assigning fuel economies to blocks and vehicle-level assignments is outlined in Figure 12.

Figure 12: ZEVDecide energy modeling process



After the route-level modeling is completed, fuel economies are then aggregated by block using the trip distance to determine total energy consumption for each block. Finally, to understand the fuel economy and total daily energy consumption of each vehicle operated on a representative service day, blocks are aggregated at the vehicle level, so that vehicles that are assigned multiple blocks throughout a day are modeled appropriately.

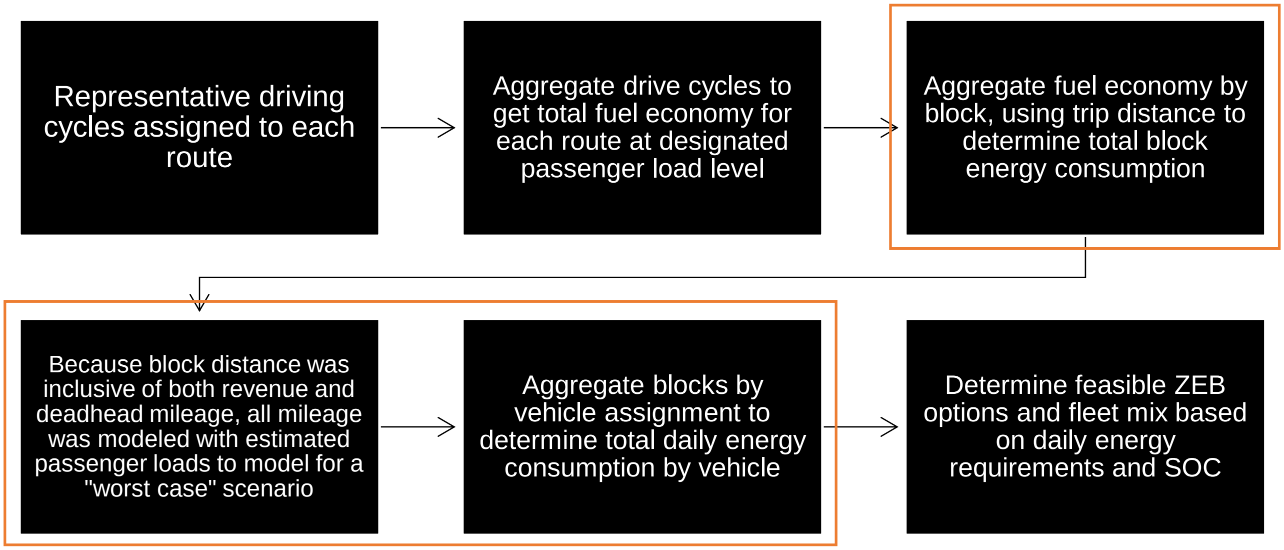
The results of the modeling provide insight into:

- Fuel economy and energy requirements
- Operating range
- The feasibility of different ZEB technologies
  - For BEBs, this is determined through state of charge (SOC); the vehicle assignment can be successfully completed with a BEB if it can complete its scheduled service with at least 20% battery SOC.
  - For FCEBs, if a bus consumes less than 90% of its tank capacity, the vehicle assignment is counted as successful.

Modeling Results

Following the assignment of driving cycles to routes and aggregating these to determine the total fuel economy for each route at different passenger loads, the modeling moves to the next stages which are highlighted in orange in Figure 13.

Figure 13: ZEVDecide block- and vehicle-level modeling steps



These steps define 1) the energy consumption at the block level, and 2) the energy consumption for each vehicle assignment. The modeling results for these two steps of the process are presented in the sections below, and they are categorized per service type, vehicle type, and technology type.

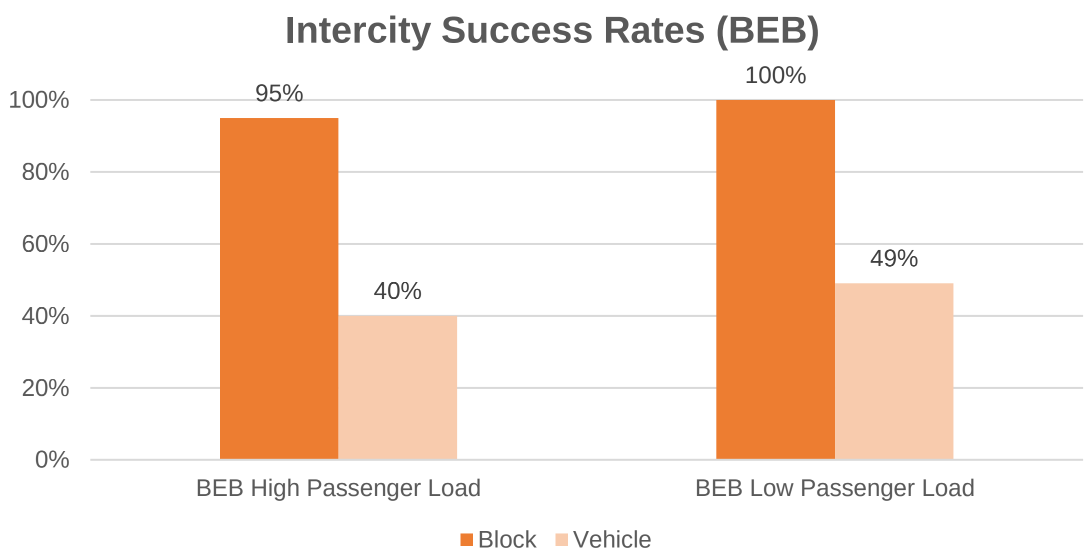
5.1.3.1 Intercity

The overall energy or fuel demand per block was obtained by aggregating the fuel consumption from each trip according to the route-level results. Note that this analysis considers the entire Intercity fleet and service beyond the 5 BEBs on order.

BEB Motorcoaches

Block- and vehicle-level modeling results are shown for 525-kWh BEB motorcoaches (Figure 14). High passenger loads represent 75% seated capacity, while low passenger loads represent 25% seated capacity.

Figure 14: Intercity BEB block and vehicle success rate



These results in Figure 14 indicate that while almost all blocks are successfully modeled as BEBs even when assuming high passenger loads, fewer than half of vehicles can successfully complete their daily assignments on a single charge. In other words, since vehicles are assigned multiple blocks, the totality of the vehicle mileage exceeds the operating limit of the BEBs modeled. These results don't directly translate to a doubling of the fleet size, but in order to make BEB work for Intrecity services it is very likely tha the fleet would need to increase in size. Furthermore, a detailed reblocking analysis would be required to estimate the exact number of additional buses that would result in a direct increase to capital expenses and additional operational changes due to mid-day vehicle swapping as well as added deadhead mileage.

Table 7 summarizes the average fuel efficiency and range for the BE motorcoach under the Intercity operating conditions.

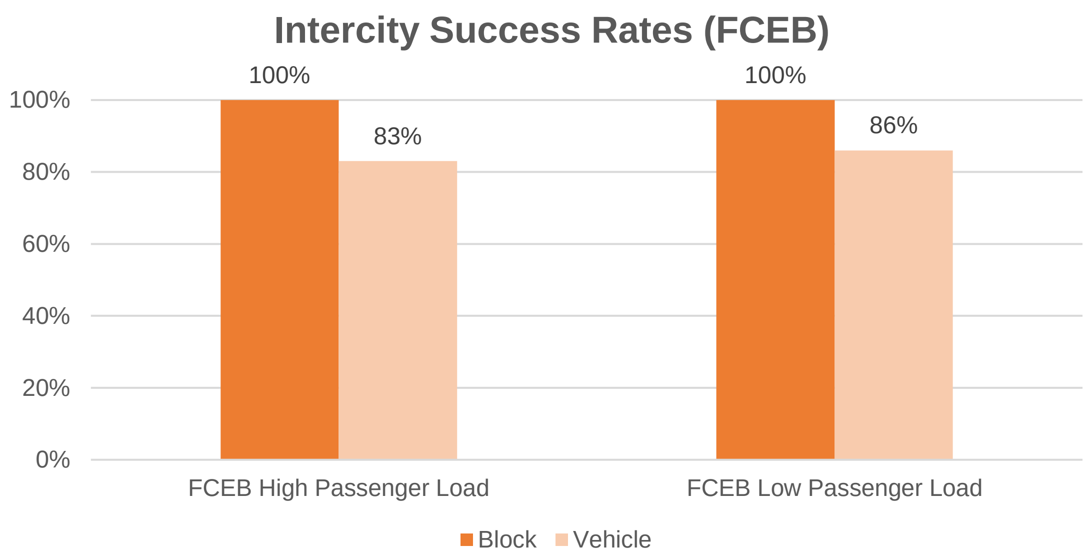
Table 7: Average fuel efficiency for Intercity BEB modeling results

Vehicle type	Average fuel efficiency (kWh/mi)	Est. max range (mi)
45-ft BE motorcoach	2.11 – 2.23	190 – 200

FCEB Motorcoaches

Next, Intercity service was modeled with hypothetical hydrogen FCEB motorcoaches equipped with 37.5-kg tanks. Figure 15 shows both the block-level and vehicle assignment-level results for FCEBs.

Figure 15: Intercity FCEB block and vehicle success rate



According to the modeling, all of VCTC's Intercity blocks assignments can be successfully transitioned to hydrogen FCEB motorcoaches. Eighty-three percent and 86% of vehicles can be successfully transitioned to FCE technology based on high and low passenger loads, respectively. Table 8 summarizes the average fuel efficiency and range for the FCEB motorcoach. However, it is important to recall that FCEB motorcoaches are not currently commercially available, and no actual real-world data exists regarding their performance.

Table 8: Average fuel efficiency for Intercity FCEB modeling results

Vehicle type	Average fuel efficiency (mi/kg)	Est. max range (mi)
34-ft FCE motorcoach	6.8 – 7.0	240 - 250

5.1.3.2 Valley Express

As with Intercity services, Valley Express services were first modeled at the block level and then aggregated at the vehicle level to represent all the trips that a vehicle completed on the sample day. The criteria for success for Valley Express services are the same as for Intercity services—completion of daily assignment with at least 20% SOC (BEB vehicles) or no more than 90% tank capacity consumed (FCEB vehicles).

BEB Cutaways

Figure 16 shows that 90% of Valley Express blocks can be successfully electrified, but after sorting the blocks into vehicles, it was determined that only 44% of vehicles could be electrified.

Figure 16: Valley Express BE block and vehicle success rate

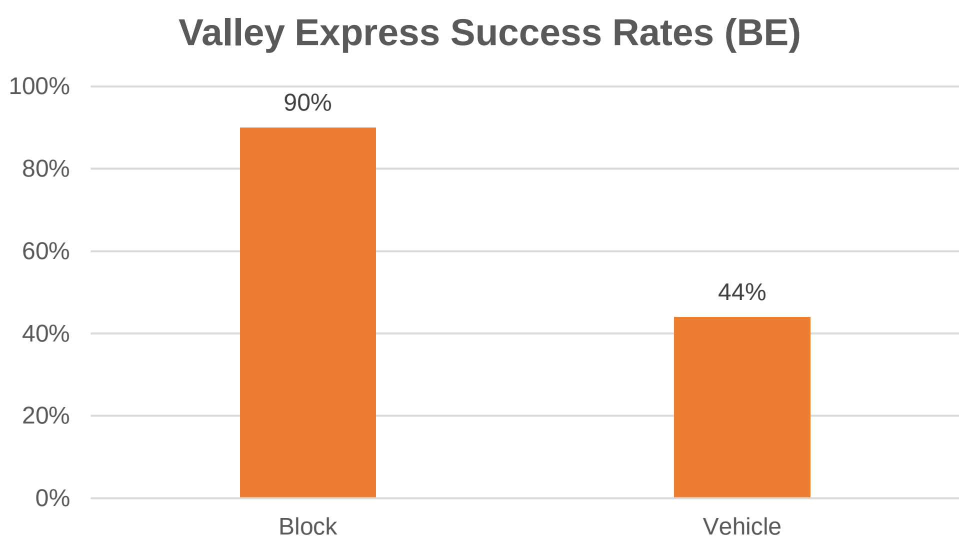


Table 9 summarizes the average fuel efficiency and expected maximum range for BE cutaways.

Table 9: Average fuel efficiency for Valley Express BE modeling results

Vehicle type	Average fuel efficiency (kWh/mi)	Est. max range (mi)
BE cutaway	1.19	90

FCEB Cutaways

Figure 17 shows that 100% of Valley Express blocks and 78% of vehicles can be successfully transitioned to hydrogen fuel with cutaways that have 13.5-kg tanks. Table 10 summarizes the average fuel efficiency and expected maximum range for FCEB cutaways.

Figure 17: Valley Express FCE block and vehicle success rate

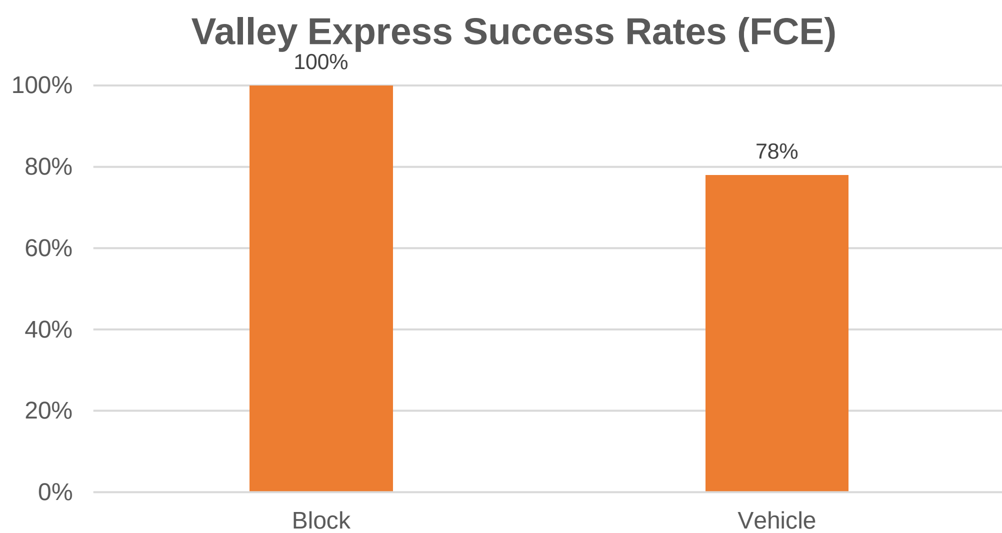


Table 10: Average fuel efficiency for Valley Express FCE modeling results

Vehicle type	Average fuel efficiency (mi/kg)	Est. max range (mi)
FCE cutaway	14	160

The daily maximum mileage for hydrogen cutaways operating Valley Express service is 160 miles with an average fuel efficiency of 14 mi/kg. However, FCEB cutaways are not commercially available.

5.2 SUMMARY AND FLEET RECOMMENDATIONS

In summary, the modeling results have the following major implications:

- Intercity service modeling results show that difficulties arise when modeling either BEB or FCEB options based on VCTC's operations. This is due to the fact that while block-level modeling demonstrates almost universal success (for either BE or FCE vehicles), vehicle-level results are less so. Forty percent to 49% of Intercity vehicles can be successfully transitioned to BE technology, while 83% to 86% of vehicles can be transitioned to FCE technology to run existing service.
- Valley Express results show similar disparities between technologies with 44% and 78% successfully modeled for BE and FCE cutaways, respectively.
- The results imply that VCTC cannot successfully transition their service to ZEBs (as the technologies currently exist) in a 1:1 manner and may need to explore other strategies such as

reblocking or growing the fleet size to comply with ICT guidelines. However, this will cost the agency by adding additional vehicles or decreasing operational efficiency.

- Notably, while modeling success rates for hydrogen vehicles were greater than BE vehicles, hydrogen motorcoaches (for Intercity) and cutaways (for Valley Express) are not yet commercially available.
- The hydrogen demand for a hypothetical fleet of FCEB cutaways would not justify the large (>$5 million) capital outlay required for a hydrogen fueling facility. Unlike Intercity, the Valley Express service is simply too isolated to feasibly leverage GCTD's eventual hydrogen fueling facility, and conversely, other Ventura County fleets are too far removed to use a potential hydrogen fueling facility in Santa Paula.

Based on these modeling results, potential fleet concepts were developed for each service type and are detailed below.

5.3 Fleet Recommendations

Due to the vehicle types that VCTC operates, the distance the vehicles travel daily and the fact that VCTC does not own either of their facilities, VCTC is in a unique predicament compared to other transit agencies subject to the ICT regulation. VCTC is actively exploring innovative options, such as regional partnerships for charging/fueling. If the technology of vehicles does not improve enough, or if vehicles required to reliably operate Intercity and Valley Express services are not available by the time VCTC needs to start acquiring them, VCTC could explore an exemption based on logistical/feasibility issues, based on subsection 2023.4 of ICT regulations[20]. The exemption would require detailed documentation and information for the review of CARB and would be required for the year that VCTC is requesting an exemption from purchasing its planned apportionment of ZEBs.

Based on the information presented throughout this section, the following ZE fleets are recommended for VCTC's services:

- **Intercity**: proceed with all-FCEB fleet (41 FCE motorcoaches by 2040). In this scenario, the five BEB motorcoaches on order would allow VCTC to offset the purchase of FCEBs until 2030. This also lets VCTC take advantage of current funding programs for ZEBs, both for vehicle purchases and through potential participation in the SCE Charge Ready Program.
- **Valley Express**: plan for an all-BEB fleet (15 BE cutaways by 2040), acknowledging that the technology and ranges will need to improve before VCTC can begin to reliably operate the service in a cost-effective manner that does not entail growing the fleet size. VCTC can explore opportunities with local municipalities for shared charging infrastructure.

[20] ICT Clean Final Reg. Order (ca.gov)

6.0 FLEET PROCUREMENT SCHEDULE/OUTLOOK

Based on the bus modeling, route simulations, and further analysis by the Stantec team, it was determined that a FCEB fleet is preferred for Intercity and a BEB fleet is preferred for Valley Express to maintain the current service levels. The phasing plan for VCTC to ZE vehicles considers the following:

- The same level of service will be provided as pre-pandemic conditions by using motorcoaches and cutaways for Intercity and Valley Express (respectively). As service levels are potentially increased in the future, the fleet will be expanded as well.
- CARB requires that 25% of new vehicle purchases from 2026 through 2029 be ZEB and that 100% of purchases starting in 2030 be ZEB
    - Even though VCTC will be operating 5 BEB motorcoaches as part of the Intercity fleet before 2026 (ahead of the CARB re25% purchase requirement), because VCTC doesn't hold ownership of these BEBs, the agency can't claim the five 5 CARB ICT credits that would help delay future ZEB purchases. Therefore, the fleet procurment schedule presented in this section doesn't consider any credits or delays in complying with the CARB requirements. Furthermore, an alternative fleet acquisition outlook is presented in Appendix C showing the procurement strategy if VCTC were to take ownership of the BEBs to claim the 5 credits.
- The same spare ratio will be maintained.

6.1 INTERCITY

Figure 18 displays a graph with the proportion of the Intercity fleet by vehicle type over time as the transition from carbon-emitting vehicles to ZEBs proceeds. The total fleet size, 41 with the inclusion of the 5 BEBs, is maintained through 2040. VCT will achieve 100% ZEBs for Intercity services by 2040, adhering to CARB's requirements. The proposed procurement schedule considers the 25% ZEB purchase regulation inforce from 2026 through 2028, but when accounting for rounding, 25% of vehicles purchased in each of these years is less than one bus. As such VCTC is able to purchase conventional buses in 2026 while remaining compliant with the ICT regulation, as per CARB's guidance.

Figure 18: VCTC Intercity fleet composition through 2040 by vehicle type and technology

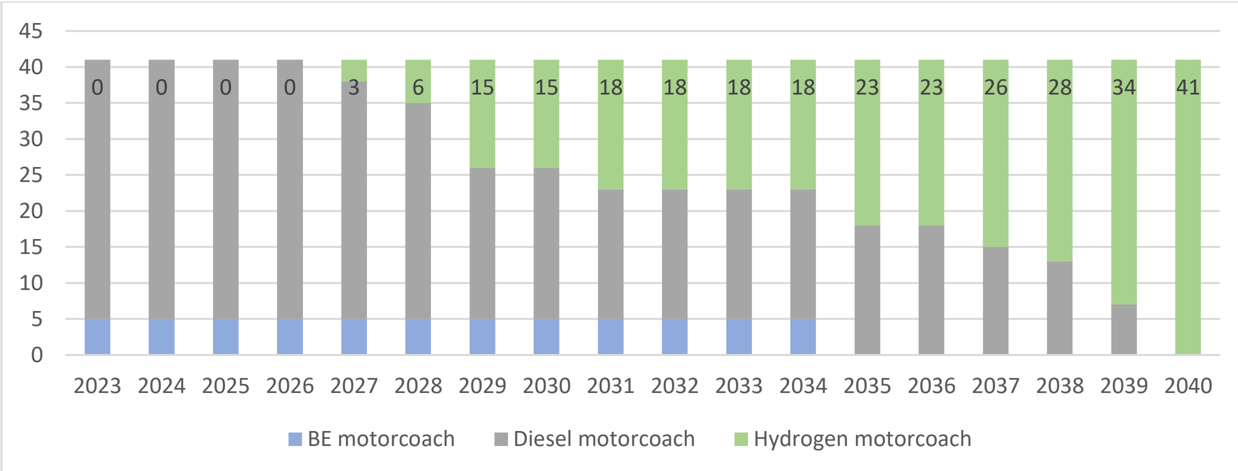


Table 11 displays the recommended fleet acquisition schedule for Intercity vehicles. This plan was developed by accounting for fossil fuel vehicle retirement and the ICT purchase requirement.

Table 11: 2023 – 2040 Fleet Forecast for Intercity Vehicles

		2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
BEB																			
	In fleet	5	5	5	5	5	5	5	5	5	5	5	5	0	0	0	0	0	0
	Retire	0	0	0	0	0	0	0	0	0	0	0	0	-5	0	0	0	0	0
	New	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Diesel																			
	In fleet	36	36	36	36	33	30	21	21	18	18	18	18	18	18	15	13	7	0
	Retire	0	0	-3	-2	-9	-10	-9	0	-3	0	0	0	0	0	-3	-2	-6	-7
	New	0	0	3	2	6	7	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen																			
	In fleet	0	0	0	0	3	6	15	15	18	18	18	18	23	23	26	28	34	41
	Retire	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-3	-3
	New	0	0	0	0	3	3	9	0	3	0	0	0	5	0	3	2	9	10
Total																			
	Total ZEB	5	5	5	5	8	11	20	20	23	23	23	23	23	23	26	28	34	41
	% ZEB Fleet	12%	12%	12%	12%	20%	27%	49%	49%	56%	56%	56%	56%	56%	56%	63%	68%	83%	100%
	% ZEB Procurement	NA	NA	0%	0%	33%	30%	100%	NA	100%	NA	NA	NA	100%	NA	100%	100%	100%	100%

6.2 VALLEY EXPRESS

Figure 19 displays a graph with the proportion of the Intercity fleet by vehicle type over time as the transition from carbon-emitting vehicles to ZEBs proceeds.

Figure 19: Valley Express fleet composition through 2040 by vehicle type and technology

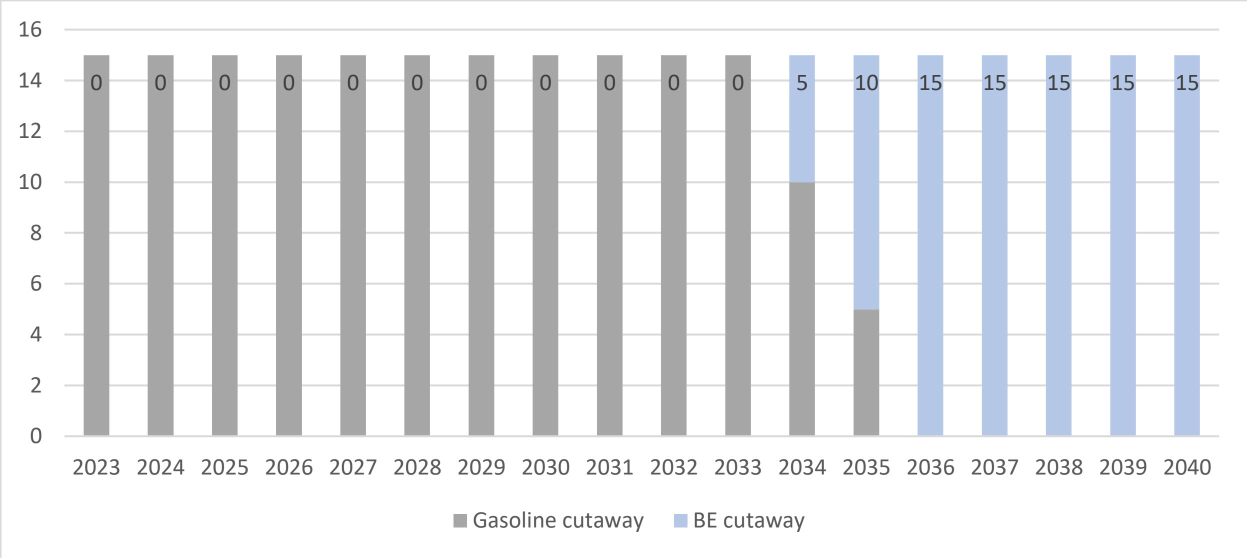


Table 12 displays the recommended fleet acquisition schedule for Valley Express vehicles. This plan was developed by accounting for fossil fuel vehicle retirement and the ICT purchase requirement. The acquisition schedule assumes the first purchase for BE vehicles in 2034.

Table 12: 2023 – 2040 Fleet Forecast for Valley Express Vehicles

		2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Gasoline																			
	In fleet	15	15	15	15	15	15	15	15	15	15	15	10	5	0	0	0	0	0
	Retire	0	0	-15	0	0	0	0	0	0	0	0	-5	-5	-5	0	0	0	0
	New	0	0	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BEB																			
	In fleet	0	0	0	0	0	0	0	0	0	0	0	5	10	15	15	15	15	15
	Retire	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	New	0	0	0	0	0	0	0	0	0	0	0	5	5	5	0	0	0	0
Total																			
	Total ZEB	0	0	0	0	0	0	0	0	0	0	0	5	10	15	15	15	15	15
	% ZEB Fleet	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	33%	67%	100%	100%	100%	100%	100%
	% ZEB Procurement	NA	NA	0%	NA	NA	NA	NA	NA	NA	NA	NA	100%	100%	100%	NA	NA	NA	NA

7.0 FUELING STRATEGIES

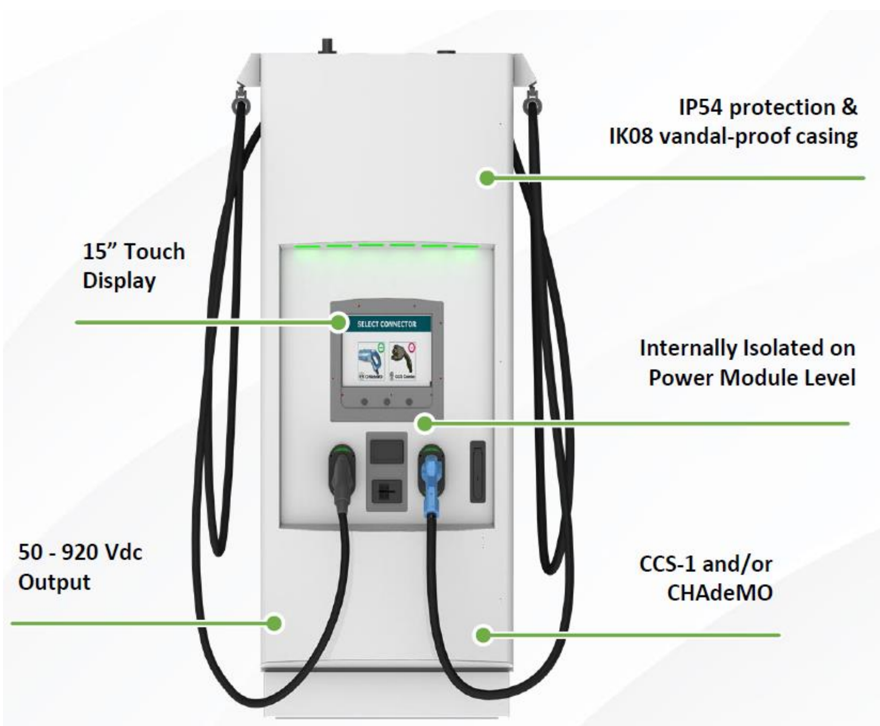
An overview of the fueling and charging strategies are presented in this section for Intercity and Valley Express services, while the infrastructure specifics for each site will be presented in Section 8.0.

7.1 INTERCITY FUELING NEEDS

BEB Coaches

While VCTC owns its fleet, operations and maintenance of the fleet and services is through a third-party contractor, who also provides an operations and maintenance facility, i.e., VCTC does not operate its fleet directly nor does it directly own an operations and maintenance facility. Therefore, for the 5 BYD BEB motorcoaches that VCTC is currently planning on deploying on the Coastal Express in 2023, they are planning on recharging them in Goleta at Santa Barbara County Association of Governments (SBCAG) Regional Transit Center at 6416 Hollister Ave. SBCAG is working with SCE to install 2 Level 2 chargers and 2 Level 3 fast chargers with dual dispensers at the SBCAG Regional Transit Center. The figure below is an example of the type of charger that will be installed at Goleta.

Figure 20: Example of charger at the SBCAG facility in Goleta – 100 kW (two with dual dispensers)



If all 5 electric coaches are laying over at the Goleta facility and they all charge simultaneously, then the facility would require a minimum of 300 kW and will only allow 5 vehicles charge simultaneously at 50 kW each, which would add around 20 miles for every hour charged. Alternatively, and also requiring 300-kW chargers, three vehicles could charge simultaneously each at 100 kW, adding close to 40 miles for every hour of charge. Therefore, an electric coach would need close to 2 hours charging at 100 kW to gain enough charge for an additional roundtrip from and to Goleta.

Given that the electric coaches will likely be laying overnight at VCTC's Intercity facility (not owned by VCTC) at 240 South Glenn Drive in Camarillo, it would also be required to have a charging location for the BEBs near Camarillo to ensure the vehicles have sufficient charge to return to Goleta if not enough time was allowed to charge during layovers. VCTC is currently collaborating with the City of Camarillo to explore charging infrastructure at a city-owned facility. Another potential strategy, at least on an interim basis, could involve portable chargers.

Lastly, VCTC is encouraged to consider other potential partnership options, like charging their buses at the Thousand Oaks Transit Center for 'on-route charging' for routes that pass through that location. Charging rates can be similar to the specifications in Goleta, i.e., ~100 kW chargers.

FCEB Coaches

After determining a hydrogen-fueled fleet as the best fit for the rest of the Intercity fleet, the next step was to determine the estimated daily hydrogen demand to fuel the future fleet as well as the best method of supplying hydrogen to the facility where the buses will be refueling. GCTD is currently starting the design and construction process for hydrogen refueling station that will have a total capacity of 2,400 kg per day and during its planning process, GCTD accounted for the refueling of VCTC's fleet. If all of VCTC's coaches refuel at GCTD's hydrogen station, it is anticipated they will have a demand close to 1,000 kg of hydrogen per day, as initially anticipated in the planning process. Table 13 summarizes estimated hydrogen demand needed at the GCTD facility. This includes demand from GCTD's fleet as well as the demand for VCTC.

Table 13: Daily hydrogen demand

Agency	Item Description	40-ft and 35-ft Buses	Cutaways and Vans
GCTD	Total vehicles in fleet	64	27
	No. of active vehicles	60 (4 contingency)	26
	Average H2 demand per vehicles (kg/day/vehicle)	15.5	8.5
	H2 demand for all active vehicles (kg/day/fleet)	885	180
	Total GCTD Fleet Hydrogen Demand (kg/day)	1,265	
VCTC	Total VCTC Fleet Hydrogen Demand (kg/day)	1,100	
Total Estimated Fleet Hydrogen Demand (kg/day)		**2,400**	
Monthly Estimated Hydrogen Demand (kg/month)		**72,000**	

Trucked-in liquified hydrogen is the most feasible and least costly option for the near-term implementation of FCEBs and is similar to the approach most other transit agencies in California are taking[21]. Additionally, GCTD is planning to have enough capacity to support public-access users, which is estimated at about an additional 60 kg per day.

Since VCTC is planning on refueling its hydrogen coaches at GCTD, additional operational strategies are required. VCTC coaches would need to travel from the VCTC facility to GCTD's refueling station which is around 7 miles one way. While vehicles that are already have routes assigned in that region can refuel during the day, the rest of the fleet would need to dedicate between 30 and 40 minutes to travel, refuel, and return to the VCTC facility. Beyond the added time and deadhead mileage, VCTC will have to dedicate staff to move the vehicles back and forth. Additional logistics to consider includes the fueling window and potential overlap with GCTD's fueling window (4-9 pm), whether VCTC or GCTD will fuel the Intercity fleet, and liability issues. Overall, GCTD and VCTC will have a number of items to sort out with regard to hydrogen fueling.

7.2 HYDROGEN SUPPLY

Not all hydrogen is created equal, in fact, hydrogen has several pathways to be generated and this includes different carbon intensity levels. Figure 21 provides an overview of the different hydrogen classifications based on the generation source. Gray, blue, and green hydrogen have different levels of carbon emissions, with green being the ultimate goal because it is carbon neutral.

[21] OCTA has recently commissioned hydrogen fueling facility based on trucked-in liquid, and other agencies including Foothill Transit, Santa Clarita Transit and Victor Valley Transit Authority are planning similar systems.

Figure 21: Types of hydrogen based on generation source[22]

Types of Hydrogen

Hydrogen is classified based on how it is produced.

Gray Hydrogen

- Gray hydrogen is produced from fossil fuel feedstocks **without carbon capture** at the point of production.
- Gray hydrogen accounts for **more than 95%** of global hydrogen production today.

Blue Hydrogen

- Blue hydrogen is produced from fossil fuel feedstocks **with carbon capture** at the point of production.
- Blue hydrogen **could reduce emissions in end-use segments** in the mid- to long- term.

Green Hydrogen

Green hydrogen includes multiple carbon-neutral production pathways:

- **Electrolytic hydrogen or power-to-gas (P2G)**, is the conversion of electrical power into a gaseous energy carrier, such as hydrogen or methane, using an electrolyzer. When powered with renewable electricity, **P2G is a green hydrogen source**.
- Other green hydrogen generation pathways exist, including **biogas reforming and artificial photosynthesis**.

Today, 37%-44% of hydrogen used in transportation is renewable, but 95% of all hydrogen produced in the United States is made by industrial-scale natural gas reformation (gray hydrogen). This process is called fossil fuel reforming or steam methane reforming (SMR). The process takes natural gas (NG) and steam to generate a product stream of carbon dioxide (CO_2) and hydrogen (H_2). Greenhouse gas emissions can be avoided completely if the CO_2 produced in SMR is captured and stored (blue hydrogen) in a process known as carbon capture and storage (CCS).

In the short-term, GCTD will likely receive its hydrogen from the Sacramento area that is currently produced via SMR with a mixed of biogas to account for 33% renewable green hydrogen. But as sustainable renewable energy generation advances in the United States, it is anticipated low to zero carbon hydrogen production will become more commonplace. For example, the City of Lancaster will host and co-own a green hydrogen production facility with SGH2, which will be able to produce up to 11,000 kilograms of green hydrogen per day[23]. Additionally, Plug Power recently announced it will build the largest green hydrogen production plant on the West Coast. The state-of-the-art production facility in Fresno County in the Central Valley of California will be powered by renewable energy. Once completed, it will produce 30 metric tons of green hydrogen daily and serve customers up and down the West Coast. The facility will use a new 300 MW zero-carbon solar farm to power 120 MW of Plug Power's state-of-the-art PEM electrolyzers, and the project includes construction of a new tertiary wastewater treatment plant

[22] https://www.energy.ca.gov/sites/default/files/2021-06/CEC_Hydrogen_Fact_Sheet_June_2021_ADA.pdf
[23] https://www.sgh2energy.com/worlds-largest-green-hydrogen-project-to-launch-in-california

in the city of Mendota that will provide recycled water for the people of Mendota and supply the full needs of the plant. The plant is expected to be complete by 2025[24].

7.3 VALLEY EXPRESS NEEDS

Similarly, to the constraints with the Intercity services, all vehicles from Valley Express are maintained and stored in a facility not owned by VCTC. Therefore, any charging infrastructure would require a permanent location that is unlikely to be secured in the near-term future. VCTC is only a managing agency and since the Valley Express partners are smaller cities, there are limited opportunities to devote space to store and charge the Valley Express fleet, which would require a secure, overnight storage/charging location. Nevertheless, in order to prepare for a future investment in charging infrastructure, the charging equipment required is further explored in Section 8.2

[24] https://www.plugpower.com/plugs-california-green-hydrogen-plant-saves-water-creates-new-energy-source/

8.0 MAINTENANCE FACILITY AND FUELING INFRASTRUCTURE CONSIDERATIONS

As discussed elsewhere, VCTC does not own the facilities where the fleet is stored, fueled, and maintained. This significant challenge means that facility modifications and investments in infrastructure at these locations are not financially desirable.

This section describes potential facility modifications and infrastructure needs in a site-agnostic way since, at this time, it is unclear where these modifications or needs are required.

8.1 INTERCITY FACILITY REQUIREMENTS

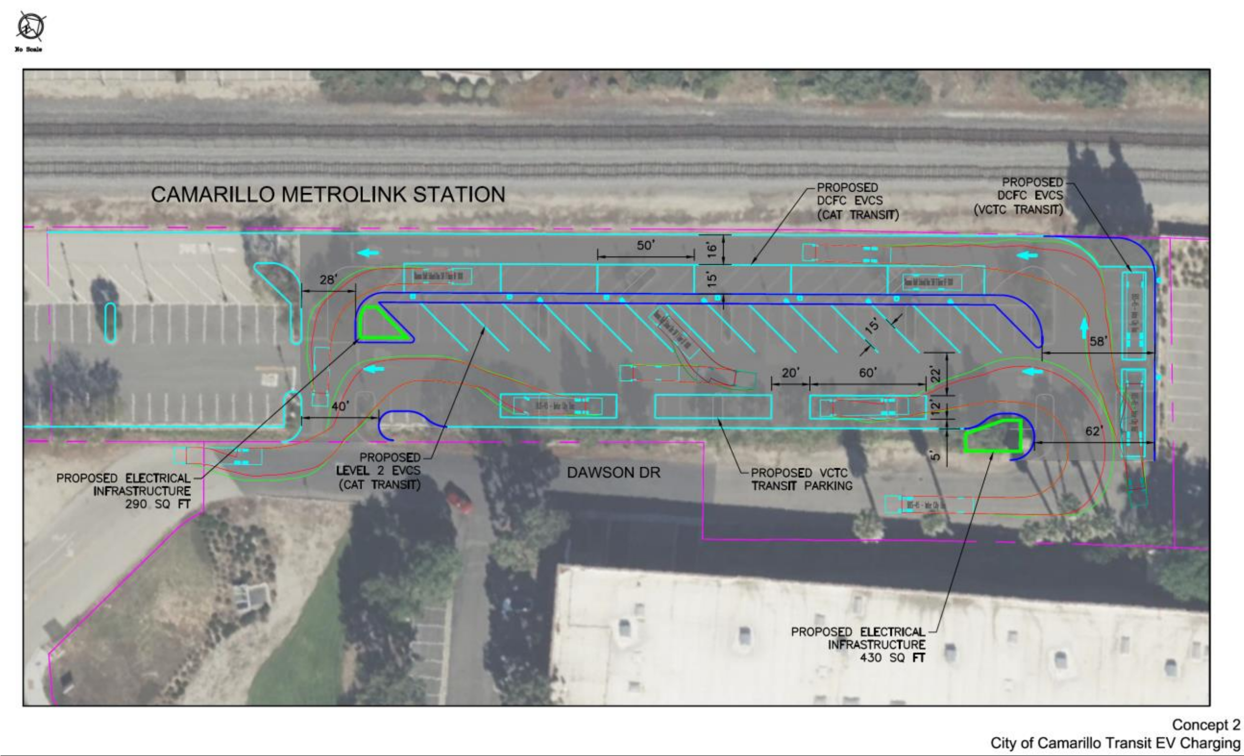
The FCEBs in the Intercity fleet will refuel at GCTD's bus operations and maintenance facility in Oxnard. Nonetheless, wherever VCTC intends to store and maintain the FCEBs in its fleet, VCTC will need to equip the buildings with safety systems such as appropriate gas leak detection sensors, building ventilation and exhaust systems, a fire sprinkler system, and other safety measures applicable to battery and hydrogen systems. The costs of these systems will vary significantly, depending on the current condition of the facility where they will be installed, as well as current ventilation systems and other infrastructure. VCTC can work with GCTD to understand GCTD's costs and approach to facility upgrades for safety concerns.

For the 5 BEB motorcoaches in the Intercity fleet, VCTC and SBCAG are collaborating for charging infrastructure in Goleta. Apart from the charging needs in Goleta, VCTC will also likely require charging equipment in Ventura County, preferably in Camarillo where the BEBs will likely be stored; VCTC is exploring two potential locations in Camarillo. However, without knowing exactly where these BEBs will be stored and charged, we have taken a site agnostic approach to the chargers and related infrastructure needed to support the charging of the 5 BEBs. The following lists the equipment to support 5 fast chargers, similar to the ones planned on at the Goleta facility:

- (5) 150 kW single connector chargers at an average distance of 75' from the switchgear
- A new 1000 kVa utility transformer will be provided, approx. 25' from the ROW (the utility will make final determination)
- A new 1600 A switchgear will be provided, located near the transformer
- A new 3' x 3' concrete equipment pad and (2) new bollards will be provided for each charger location
- New equipment pads and new bollards will be installed around the new switchgear and transformer

A concept level diagram of a potential layout for consideration at the Camarillo Metrolink station is shown in Figure 22. This design was developed by others as part of the City of Camarillo's ZEB transition, as both VCTC and the City of Camarillo can collaborate on the reconfiguration of the parking lot to accommodate transit vehicles and chargers.

Figure 22: Concept layout for the Camarillo Metrolink Station charging yard (Source: Willdan)



Accounting for the soft costs (like permitting, design fees) and hard costs, we estimate that the total cost for deploying the above equipment to be roughly $2.11 million (in current 2023 dollars; see Appendix A: Cost Estimates). These fees will vary depending on the conditions of the actual site and VCTC will need to conduct detailed cost estimates.

8.2 VALLEY EXPRESS REQUIREMENTS

Similar to the Intercity facility, the Valley Express facility is not owned by VCTC. However, as VCTC plans to transition the Valley Express fleet to BEBs, VCTC will need to work with the member agencies to identify a location/facility to install chargers that will be used to charge the Valley Express fleet. Regardless of the location, we have identified the following equipment to charge Valley Express BEBs:

- (7) 60 kW dual-dispenser chargers at an average distance of 75’ from the switchgear
- A new 500 kVa utility transformer will be provided, approx. 25’ from the ROW (the utility will make final determination)
- A new 800A switchgear will be provided, located near the transformer
- A new 3’ x 3’ concrete equipment pad and (2) new bollards will be provided for each charger location
- New equipment pads and new bollards will be installed around the new switchgear and transformer

Accounting for the soft costs (like permitting, design fees) and hard costs, we estimate that the total cost for deploying the above equipment to be roughly $1.58 million (in current 2023 dollars; see Appendix A: Cost Estimates). These fees will vary depending on the conditions of the actual site and VCTC will need to conduct detailed cost estimates.

8.3 BACKUP PLANNING AND RESILIENCY

Planning for resiliency and redundancy is necessary not only to support operations or evacuations during emergencies or other disruptions, but also to ensure if a bus facility loses power, ZEBs can still be operated. This is particularly important given the propensity of black outs in California, especially as the adoption of EVs increases along with the demand on the electrical grid throughout the state.

General Considerations

Solar Energy, Photovoltaics, and Battery Storage – A Microgrid

Building on the idea of resilience and sustainability, one approach that VCTC could explore with different partner agencies, depending where fueling infrastructure is implemented, is the concept of a microgrid.

Energy storage, in the form of containers of lithium-ion batteries or other technologies, can be charged during periods of low facility electricity demand or even from renewable energy resources like solar or wind, and then discharged during periods of high electricity demand when the buses also need to receive a charge. Such storage systems deployed “Behind the Meter” (BTM) can react to charge events quickly so that the utility does not see the entire impact of the charging event. In this way, the electricity demand (and associated cost) can be reduced.

Several transit agencies have already deployed solar photovoltaic (PV) assets to generate renewable energy to offset power needs for functions like administration and maintenance buildings and to charge vehicles. With the adoption of a BEB fleet, additional solar PV energy generation, together with storage of this power in stationary batteries in a Battery Energy Storage System (BESS), can be used to charge a portion of the fleet with energy that does not come ‘from the grid’. This microgrid strategy could be used to blunt some of the costs associated with charging, particularly during peak time-of-use periods.

Beyond energy storage for use to charge during peak time-of-use periods, another use of microgrids is to store energy in case of power outages, such as during power shutdowns or natural disasters. With a stationary BESS, VCTC can use the energy stored in the batteries to power BEB chargers and provide BEBs with ‘fuel’.

There are, however, constraints and drawbacks to this approach. The first is that a solar-PV system will need a BESS in order to use energy captured at a later time. A solar-PV system without a BESS is helpful for some instantaneous charging, but since most charging will occur overnight when it is dark, a BESS is essential for energy storage to allow charging at different times.

Furthermore, a stationary BESS is quite large and costly at the moment, requiring substantial capital investment and real estate for installation. The amount of energy required to charge an entire fleet to 100% may be prohibitively expensive, as well as consume valuable and limited real estate at a bus garage. For these reasons, transit agencies typically will only have a portion of the charging via solar-PV with BESS while they explore other backup strategies, including fossil fuel-powered generators.

Fossil Fuel-Powered Backup Generators

Even though a PV system can provide very attractive economic and operational benefits, solar arrays and stationary batteries have limitations. The power generated with solar PV arrays will likely account for a small portion of the energy requirements of a BEB fleet, and in the case of stationary batteries, once they have been discharged to charge a BEB, they need to be recharged, which typically takes several hours.

A PV system of a sufficient size to fully charge a fleet of BEBs is also largely impractical because of the amount of space it would require. A rule of thumb based on experience with a number of bus fleets in California is that it requires approximately 1 acre of PV panels to generate the annual power consumed by a single heavy-duty transit bus. In the event of an emergency, relying solely on solar energy is impractical since, depending on time of day, weather, and other factors, the PV array may be able to generate only a fraction of the necessary energy to operate the emergency fleet.

As such, deploying fossil fuel-powered generators is typically necessary to provide the power required to charge a BEB fleet in the event of an emergency or power outage.

Most agencies deploying BEBs in California have implemented generator systems using fossil fuels, mostly diesel-fired generators. Natural gas and LPG-fueled generators have also been used depending on the specific site requirements. However, like with stationary batteries, considerable facility space will need to be allocated for such a backup generator in addition to emergency fuel storage (if desired). Additionally, a simple generator hook-up (external plug connected to the main electrical panel) can also be considered as an addition to the electrical service infrastructure so that a temporary, trailer-mounted generator could be deployed in the event of a power outage (Figure 23).

Figure 23: Backup mobile diesel generator at LA Metro Division 13

The level of service that is desired (e.g., percentage of all normal runs) sets the requirement for the size of the generator needed. If VCTC wishes to operate for several days during an emergency, the size of generator will stay the same, but the required quantity of fuel will scale linearly. The total amount of fuel required to be stored onsite will depend on the anticipated duration of the utility electrical outage and the amount of time required to get a fuel delivery of diesel or liquid petroleum gas (LPG), as well as environmental regulations and local policies.

Generators operating on natural gas have the option of having no onsite fuel storage. Historically, pipeline natural gas supplies have been shown to be quite resilient and dependable during electrical interruptions, although this depends on the locality, as well as the nature and intensity of a natural disaster. Some transit agencies that opt for pipeline gas for their generator will supplement it with a local moderately sized LPG storage system to provide an additional level of reliability should the natural gas supply be interrupted for a brief period after an external event such as an earthquake. The viability of pipeline gas at a given location is highly dependent on the capacity (pressure and flow) of the natural gas service in the region.

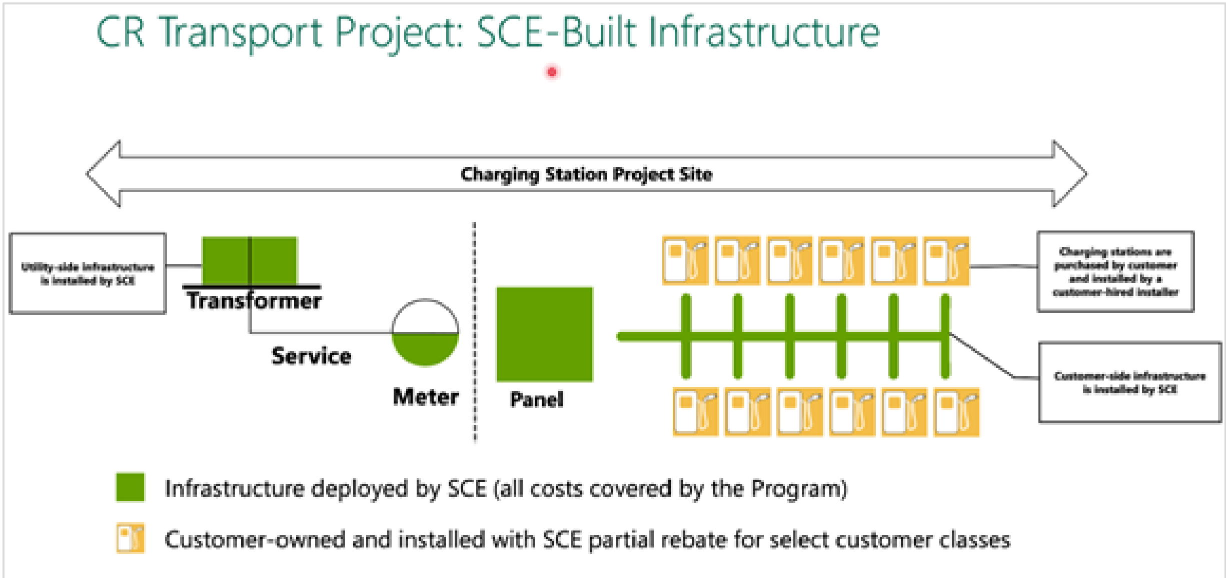
Intercity Considerations

For FCEB hydrogen fueling, GCTD plans on having diesel backup generators for the hydrogen fueling infrastructure, so this isn't a primary concern for VCTC. For the BEB motorcoach Intercity fleet, as SBCAG is the lead agency for the deployment of chargers and infrastructure in Goleta, VCTC will need to coordinate with SBCAG with regard to deploying backup equipment like generators. Similarly, for any charging equipment in Camarillo, like at the Metrolink station, VCTC should coordinate with SCE and other transit partners regarding backup equipment.

With regard to backup generators or stationary batteries or other similar equipment, VCTC will need to consult with SCE to understand the constraints and opportunities for backup equipment. SCE offers two different mechanisms for deploying charging infrastructure through its Charge Ready Transport (CRT) program. The SCE-Built Option (Figure 24) provides all the modifications from the utility side and the customer side (behind the meter), supplying all the needed grid upgrades and connections so that the customer only has to purchase the chargers and connect them. Additionally, the CRT program provides up to 50% rebates for the purchased chargers. However, this option requires the client to provide easements or entrance rights so that SCE can have direct and unrestrictive access to the property. The easement will be required for the duration of the owner's obligation to the CRT Program and could potentially be quit-claimed back to the owner after the term of the program expires. Such entrance rights may represent a risk from a legal standpoint to certain clients. Furthermore, another risk is the limited options of approved charger vendors on the SCE list, for example, there are only a couple of vendors that provide a 2-to-1 charger-to-dispenser connection; higher ratios of chargers-to-dispensers are not currently on the pre-approved list, and thus limits the configuration options and final design of the yard if using this approach.

Of significant importance and limitation, the SCE-Built approach is restrictive to adding additional distributed energy resource (DER) connections, such as a connection to on-site generators, solar PV, or battery (energy storage) systems to the SCE meter and switchgear. There are currently no exceptions to this in the SCE-Built option.

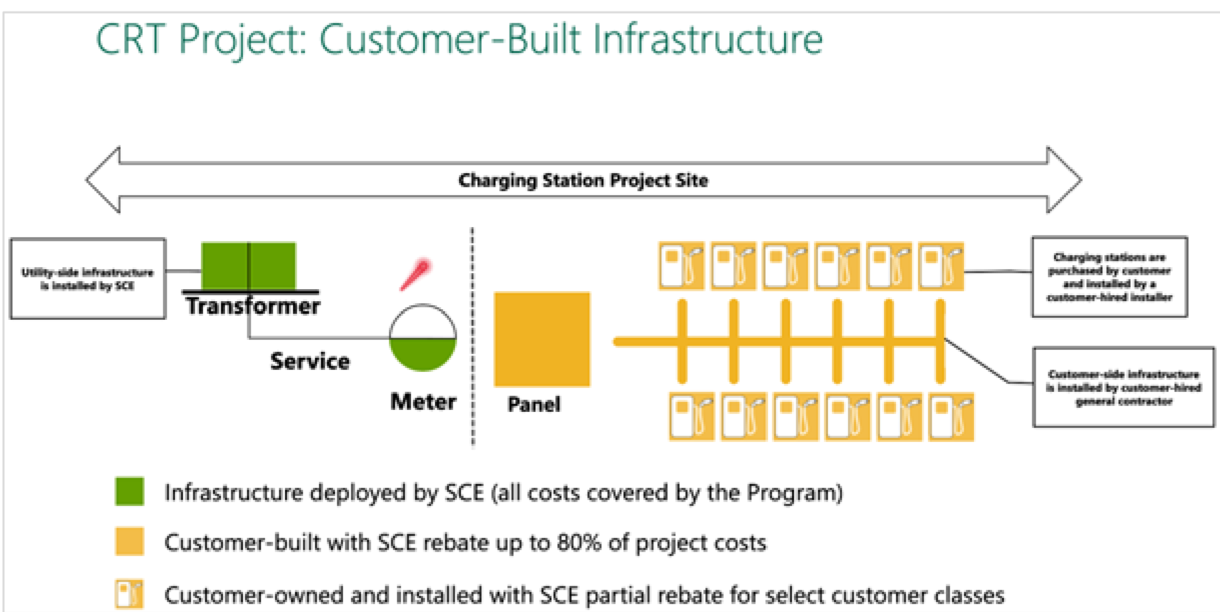
Figure 24: **SCE-Built Infrastructure option for the CRT program**



Property of SCE

In the Customer-Built Option (Figure 25), SCE covers the infrastructure on the utility side, but the customer is responsible for all the behind the meter infrastructure. While the CRT program offers a reimbursement of the cost of up to 80%, the actual cost of the rebate is completely up to SCE. While this option will actually allow for the installation of DER supplemental equipment, it will not be covered by the CRT program and will require separate trenching and conduit. The same equipment vendor limitations apply for the Costumer-Built Option as described above.

Figure 25: **Customer-Built option for the CRT program**



Property of SCE

The general customer requirements of the CRT program are:

- Lease or purchase at least two medium or heavy-duty battery powered EVs or convert at least two fossil-fuel vehicles to electric.
- Select, purchase, and install SCE-approved charging equipment in the quantity approved by SCE.
- Keep the charging equipment operational for at least ten years.
- Provide data related to charging equipment usage for a minimum of five years.
- Grant easement(s) depending on the built option, as described above.

As part of the program, SCE will:

- Perform on-site visits to evaluate site's electrical infrastructure needs.
- Develop utility-side and customer-side of the meter cost estimates.
- Design, secure permit, project manage and install the necessary infrastructure depending on the selected built option.
- Install a separate meter dedicated to the EV charging infrastructure and waive customer demand charges through 2024 with commercial EV rates.
- Make final inspections once the charging equipment is installed.

Overall, VCTC will need to work together with SCE and other potential agencies to plan for resiliency for charging for the BEB motorcoach Intercity fleet.

Valley Express Considerations

Similar to the situation above for the BEB Intercity fleet, backup considerations for chargers for the BEB cutaways for the Valley Express fleet requires an understanding of the location and facility where chargers will be located. Depending on the level of resiliency desired, and the collaborating agencies and total number of chargers, VCTC can consider deploying fossil fueled-generators and/or solar PV and stationary batteries. Further work, once an appropriate partner(s) and a charger location(s) are identified, will be required to design and implement a backup system.

8.4 FACILITY AND INFRASTRUCTURE MODIFICATIONS CONCLUSIONS

Table 14 summarizes the minimum facility and infrastructure requirements for ZEB implementation for VCTC's fleets.

Table 14: Infrastructure modification summary

Service Name	Service Type and Vehicle Type	Overall Strategy	Type(s) of Infrastructure	Service Capacity	Needs Upgrade? (Yes/No)	Estimated Construction Timeline
Intercity Service	Commuter Motorcoaches	BEB: Chargers in Goleta and Camarillo FCEB: Hydrogen fueling infrastructure at GCTD in Oxnard	BEB: DC fast chargers FCEB: Gas leak detection system	41	Yes	2023/2024
Valley Express Service	Fixed route and dial-a-ride Cutaways	Collaborate with local jurisdictions for EV charging infrastructure	DC fast chargers	15	Yes	2033-2036

Table 15 provides a rough order of magnitude breakdown by capital costs associated with potential chargers and infrastructure needed to support the charging of the BEBs for the Intercity and Valley Express fleets. Note that the cost estimates below are preliminary, subject to change, and in current 2023 dollars and excludes soft costs. The full cost estimate is found in Appendix A: Cost Estimates.

Table 15: Cost estimates for BEB infrastructure

Cost Category	Intercity Fleet Infrastructure (2023$)	Valley Express Infrastructure (2023$)
Site improvements	$8,050	$10,350
Main electrical equipment (chargers, transformers, switchgears, distribution, etc.)	$1,358,325	$940,107
Communications upgrades	$25,000	$35,000
Miscellaneous and testing	$94,340	$86,500
Prorates (General conditions-12%, design/estimate contingency-17%)	$469,486	$338,739
Contractor's mark-up (Bond-2%, contractor's fee-6%)	$156,416	$116,805
Grand total	**$2,111,617**	**$1,576,875**

9.0 FINANCIAL EVALUATION AND IMPACTS

The financial evaluation for VCTC's ZEB rollout plan consisted of the modeling of a Base Case (assuming continued use of diesel and the five BEB motorcoaches for Intercity and gasoline cutaways or 'business-as-usual' for Valley Express) and a ZEB Rollout scenario (assuming a transition to 100% ZEB operations and the phasing out of diesel and gasoline vehicles), and a comparison between the two scenarios to quantify the financial impacts of the transition and of ZEB operations. Because of the uncertainty around infrastructure costs, these costs are excluded from the analysis below. However, see Section 8.4 for cost estimates from Stantec's cost estimator, Jacobus & Yuang, Inc., regarding electric vehicle charging infrastructure. Detailed information can be found in Appendix A: Cost Estimates.

The main assumptions/inputs for the cost modeling are:

- Financial modeling was completed in real 2023 dollars (2023$).
- A 7% discount rate was applied for all calculations, as per USDOT guidance.
- The fleet replacement and procurement plan was based on VCTC's current Transit Asset Management Plan, and was vetted with VCTC staff with regard to useful life and fleet size.
- In both scenarios, we have specified that the fleet size will not grow and remain at 41 motorcoaches. This assumption is based on the fact that we expect technology to improve to meet the Intercity operating requirements, and that a certain amount of vehicle blocking adjustments would be required.
- In both scenarios, infrastructure costs related to hydrogen and/or BEBs are not included due to the uncertainty and lack of an identified location/facility.

The following sections present the financial evaluation for each of VCTC's fleets separately.

9.1 INTERCITY FINANCIAL ANALYSIS

This section describes the financial analysis for the Intercity motorcoach fleet. It is important to note that the analysis here focuses on the elements impacted by **propulsion** only, so elements like the cost of a vehicle, maintenance costs, and fuel costs are the focus, and labor costs for bus operators, administrative staff and any elements that would not be significantly impacted by a ZEB transition are not included here.

More details about the assumptions and inputs for both base case and ZEB case can be found in Appendix B: Financial Modeling Inputs and Assumptions.

Base Case – Intercity

Stantec developed the forecast for the Base Case (business-as-usual) scenario, assuming that the existing fleet of diesel motorcoaches would be maintained and renewed through to 20040. Moreover, the Base Case assumed that the 5 BYD BEBs would be in service in 2023 through 2034 and replaced with diesel motorcoaches. **It should be noted that this Base Case would be non-compliant with the ICT regulatory requirements as it deploys fossil fuel vehicles and is thus used only for comparative purposes to determine the financial impacts of a ZEB rollout.**

The Base Case fleet sees a total fleet size of 41 motorcoaches that remains constant over time. This model is inclusive of all scheduled fleet replacements required during the 2040 project horizon. Average mileage per vehicle per year is assumed to be 40,163 miles as per NTD information; similarly, fuel economy for the diesel motorcoaches was based on an NTD analysis showing a fuel economy of 5.44 miles per gallon. For BEBs, based on Stantec's modeling, an average fuel economy of 2.23 kWh/mi was used in the financial model.

- Capital expenses modeled consist of fleet acquisition based on VCTC's Transit Asset Management Plan, for inputs related to replacement quantities and estimated purchase costs. For the BYD BEBs, based on information from SBCAG, we assumed that any potential battery replacements would be covered in the original vehicle purchase price and warranty.
- Vehicle maintenance costs for diesel motorcoaches were derived from NTD 2021 data based largely on salaries, tires and other materials. For BEB motorcoaches, a conservative 10% reduction in maintenance cost per mile is assumed to account for potential savings since existing BEB experience reveals a range of potential cost savings.
- Diesel fuel costs are based on actual invoices from July to December 2022 provided by VCTC. Electricity costs were calculated based on the expected rates from SCE. Specifically, it is expected that VCTC will charge the buses at Goleta under the "electric schedule battery electric vehicle (BEV)" rate which eliminates demand chargers and has an attractive electricity price outside of peak hours (peak is from 4:00 PM to 9:00 PM). Stantec utilized the time-of-use (TOU) rate for the TOU-EV-8[25] option to estimate the total energy cost per day. The result was a projected cost of $0.1835 per kWh, which accounts for limited charging during peak hours and the subscription charges for the TOU rate.

ZEB Case – Intercity

The ZEB Case foresees a gradual transition to 100% ZE revenue vehicle operations by 2040 in alignment with ICT procurement regulations. The transition follows the fleet replacement schedule presented previously in Section 6.1, based on VCTC's Transit Asset Management Plan with its first purchase of FCEB motorcoaches in 2027. The assumed life cycle for the ZEB vehicles were the same as the current life cycles for non-ZEB vehicles—12 years for motorcoaches. As such, VCTC will continue purchasing diesel motorcoaches until 2029. Since the useful life of a motorcoach is assumed to be 12 years, the last diesel motorcoach would leave the revenue active fleet in 2040.

- Capital expenses modeled consist of fleet acquisition and fuel cell replacements at a vehicle's mid-life for the FCEB motorcoaches.
- Vehicle maintenance costs for FCEB motorcoaches were generated based on VCTC's current costs for its fossil fuel fleet based on literature from comparative FCEB and fossil fuel bus operations for

[25] Based on SBCAG information.

two California transit agencies. The findings in these reports demonstrated that on a per mile basis, vehicle maintenance costs were comparable between fossil fuel buses and FCEBs.[26] The lack of data on maintenance costs, particularly for costs outside of any original equipment manufacturer (OEM) warranty, makes maintenance costs difficult to forecast.

- Fuel costs were based on industry reports that indicate that the price per kg of hydrogen will decrease in the future as the supply chain matures along with investments from private and public actors. The cost assumed here is the cost of the commodity as delivered liquid hydrogen. Since VCTC will refuel at the GCTD facility, we assumed that VCTC would be charged a non-marked-up rate for hydrogen on a per unit basis; however, GCTD and VCTC will need to work out an arrangement on cost sharing related to maintenance and wear-and-tear of the hydrogen fueling equipment. Without any information from VCTC or GCTD related to cost sharing, any additional fees related to hydrogen fuel costs were not considered here. However, we did factor into the model additional mileage from driving the FCEB motorcoaches between Camarillo and Oxnard to fuel at the GCTD yard. We assumed that each vehicle would need to be refueled 3 times per week and that each round trip is 15 miles, so each FCEB would accumulate an additional 2,340 miles each year to fuel at GCTD. This additional mileage will impact total maintenance costs and fuel costs. Additional labor costs associated with fueling at GCTD were assumed to be offset by the reduced need for diesel fueling as well as potentially less vehicle maintenance for ZEB propulsion technologies, and as such were not included in the modeling.

Comparison and Outcomes – Intercity

The cost comparison of net present value (NPV) between the Base Case and the ZEB Case transition scenario is presented in Table 16 incorporating both capital (orange) and operating (blue) expenses. The ZEB Case has a total NPV of $76,432,000 versus $63,813,000 for the Base Case, a difference of $13,619,000 or a 122% increase in NPV over the Base Case. The financial assessment below does not consider any rebates, grants, credits, or other alternative funding mechanisms. Therefore, there may be several opportunities to offset the difference in the price between the two scenarios. It does not include operator labor, administrative costs, and other costs not directly impacted by propulsion changes.

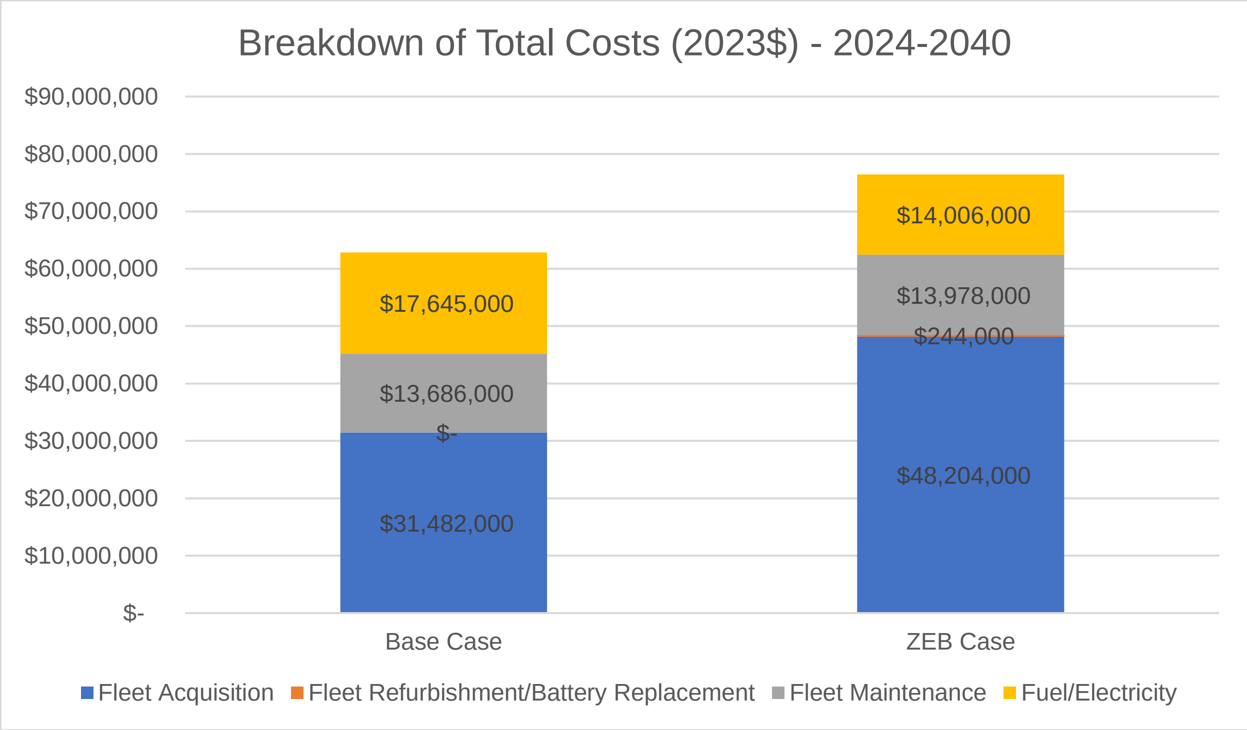
Table 16: Cost Comparison 2024-2040 – Intercity

	Base Case	ZEB Case	Cost difference (ZEB – Base)
Fleet Acquisition	$31,482,000	$48,204,000	$16,722,000
Fleet Refurbishment (fuel cell replacements)	$—	$244,000	$244,000
Fleet Maintenance	$13,686,000	$13,978,000	$292,000
Fuel/Electricity/Hydrogen	$17,645,000	$14,006,000	($3,639,000)
Total	$62,813,000	$76,432,000	$13,619,000

Figure 26 displays the breakdown of total costs by category—the largest difference between the two scenarios is the capital expenses related to fleet procurement and hydrogen fuel costs.

[26] https://www.nrel.gov/docs/fy21osti/78078.pdf, https://www.nrel.gov/docs/fy21osti/78250.pdf

Figure 26: Breakdown of Cost Categories for the Base Case and ZEB Case – Intercity



The procurement of ZEBs represents $13.6 million more in expenses due to the higher purchase price of FCEBs compared to fossil fuel vehicles. Capital costs associated with vehicle overhauls are related to fuel cell stack replacements or refurbishments at the midlife of an FCEB vehicle; for the Base Case, no heavy midlife refurbishments are conducted by VCTC. The fuel cell refurbishments amount to less than 1% of the total costs of ownership from 2024 through 2040.

Notably, we assumed comparable useful life spans for both fossil fuel and ZE vehicles. Given that no agency has yet to operate an FCEB motorcoach in the United States, it is unclear if an FCEB can operate longer than 12 years, but a recent report looking at the price parity of fossil fuel buses and FCEBs assumed a 14-year life span.[27]

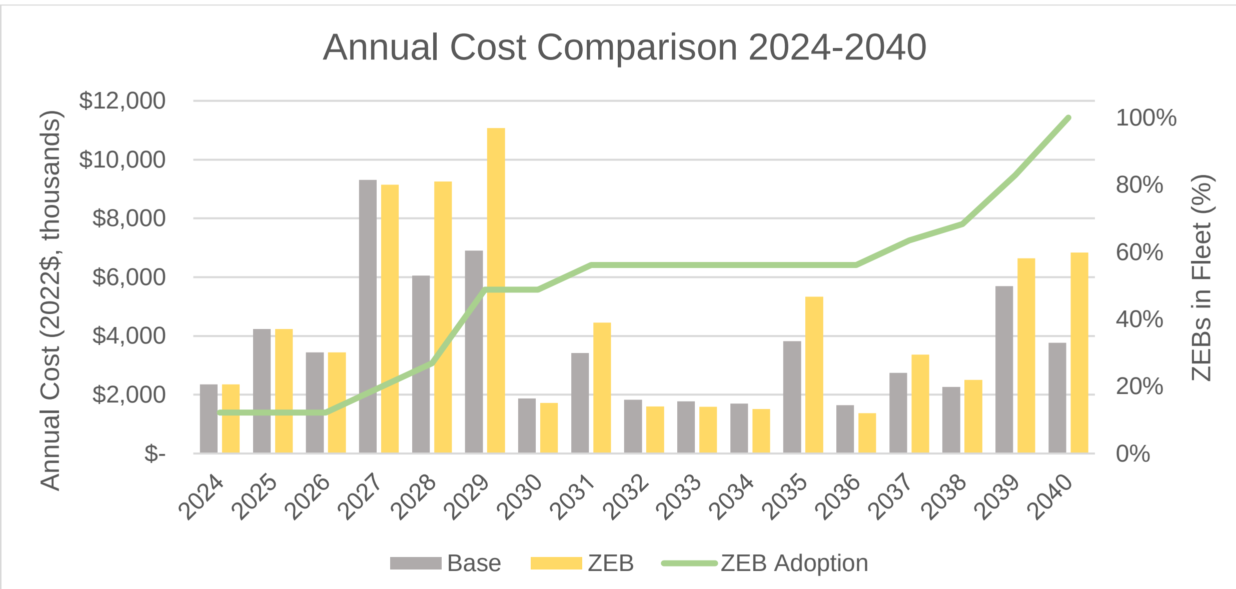
Related to operating costs, given the operating range parity of fossil vehicles and FCEBs, minimal changes to planning and scheduling is envisaged, and the servicing cycle will be similar too. Maintenance costs on a per mile basis of recent FCEBs at Sun Line and OCTA in Southern California have demonstrated relative cost parity with CNG buses. Initially, as maintenance technicians get trained to work on FCEBs, the learning curve will likely result in a greater maintenance cost for FCEBs over diesel vehicles; work under warranty can also help mitigate costs. Over time, as VCTC staff become more proficient with the FCEB technology, it is likely that maintenance costs will come down, particularly as FCEBs having fewer moving components than fossil fuel vehicles reducing the number of parts that can malfunction and that need to be periodically maintained.

[27] https://www2.deloitte.com/content/dam/Deloitte/fr/Documents/fusions-acquisitions/fueling-the-future-of-mobility-fuel-cell.pdf

Lastly, the use of hydrogen as an alternative fuel to diesel is expected to result in cost savings. This is due to the fact that diesel prices have recently been high and future fuel price projections from the US Energy Information Administration see continued price increases. Diesel prices are also very sensitive to fluctuating energy prices and externalities. The model assumed an eventual decrease of hydrogen fuel to $4 per kg based on market and industry forecasts. VCTC and GCTD will need to determine an agreement for cost sharing related to hydrogen fueling.

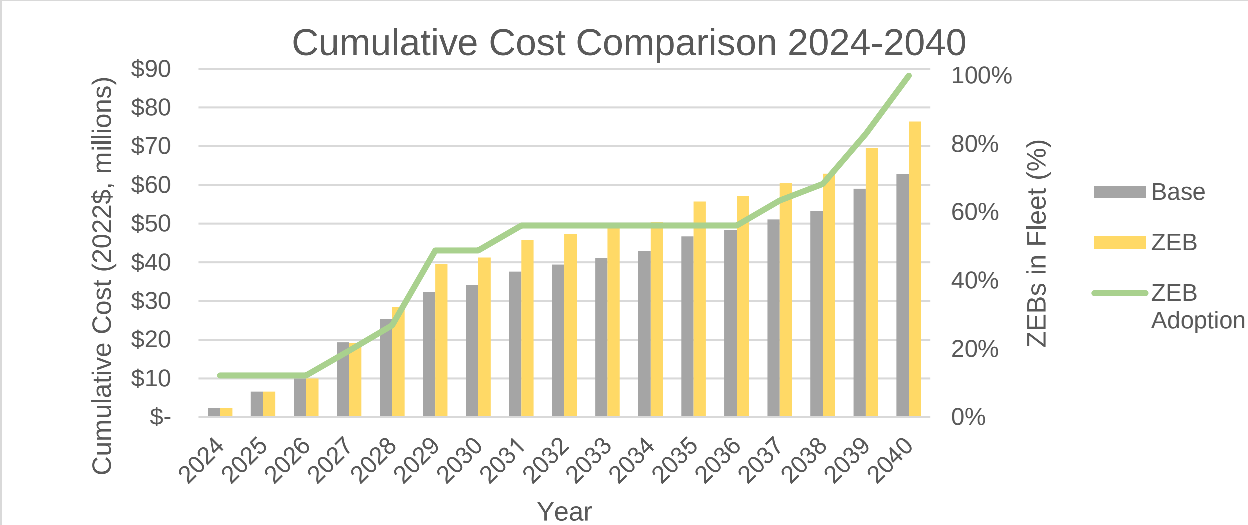
Figure 27 shows the year-to-year comparison between the Base Case and the ZEB Case. The higher costs for the FCEB scenario occur in the years when FCEB motorcoaches are procured, like 2030, 2031, and so on. In the years without vehicle procurements, the ZEB Case is expected to express cost savings largely due to the decreased dependence on diesel fuel.

Figure 27: Annual Total Cost Comparison – Intercity



- Figure 28 provides a different view of the financial analysis and shows the cumulative costs from 2024 and 2040. Overall, the ZEB Case will exceed the cost of the Base Case by over $13.6 million through 2040, largely due to the capital costs associated with ZEBs themselves.

Figure 28: Cumulative Cost Comparison – Intercity



9.2 VALLEY EXPRESS FINANCIAL ANALYSIS

Base Case – Valley Express

Stantec developed the forecast for the Base Case (business-as-usual) scenario, assuming that the existing fleet of gasoline cutaways would be maintained and renewed through to 2040. **It should be noted that this Base Case would be non-compliant with the ICT regulatory requirements as it deploys fossil fuel vehicles and is thus used only for comparative purposes to determine the financial impacts of a ZEB rollout.**

The Base Case fleet sees a total fleet size of 15 cutaways that remains constant over time. This model is inclusive of all scheduled fleet replacements required during the 2040 project horizon. VCTC is planning on purchasing 15 new gas cutaways in 2025. Average mileage per vehicle per year is assumed to be 15,528 miles as per NTD information; similarly, fuel economy for the gas cutaways was based on an NTD analysis showing a fuel economy of 6.72 miles per gallon.

- Capital expenses modeled consist of fleet acquisition based on VCTC's Transit Asset Management Plan for inputs related to replacement quantities and estimated purchase costs.

- Vehicle maintenance costs for gas cutaways were derived from NTD 2021 data based largely on salaries, tires and other materials; costs were developed as a cost per mile for both fixed-route services and demand responses services.

- Gasoline fuel costs were based on actual invoices from July 2022 provided by VCTC.

ZEB Case – Valley Express

The ZEB Case foresees a gradual transition to 100% ZE revenue vehicle operations by 2036 in alignment with ICT procurement regulations. The transition follows the fleet replacement schedule presented previously in Section 6.2 based on VCTC's Transit Asset Management Plan The assumed life cycle for the ZEB vehicles were the same as the current life cycles for non-ZEB vehicles—10 years for cutaways. Apart from the 15 new gas cutaways to be procured in 2025, the fleet plan here proposes spreading out the purchase of 15 BEB cutaways over 3 consecutive years to smooth out capital expenses. As such, the last gas cutaways will be operated in 2036 at an age of 12 years old. Depending on ZEB technology maturation and funding availability, VCTC may wish to accelerate conversion to ZEBs to avoid having a fossil fuel fleet that is that exceeds 10 years of age.[28] We note that no agency has operated these types of ZEBs for a full life cycle, so actual useful life is not currently known. However, given the overlap in components, such as chassis, doors, etc. between fossil fuel vehicles and ZEBs, it is not unreasonable to assume that ZEBs can have similar useful lives. Furthermore, the reduction in moving parts of an electric motor and other propulsion-related components compared to an internal combustion engine will likely translate into fewer breakdowns and thus a more reliable product. Given the assumed shorter vehicle life cycle and shorter service hours compared to typical urban fixed-route services, we assumed that batteries would not need replacing over the life cycle modeled here. VCTC should review contract and warranty terms to understand expected battery performance and replacement conditions.

Capital expenses modeled consist of fleet acquisition for BEB cutaways; we note that given the generally shorter lifespan of cutaways vs. heavy-duty buses, we have assumed that no battery replacements are needed over the 10-12 life span of BEB cutaways.

- Vehicle maintenance costs for BEB cutaways were generated based on VCTC's current costs for its fossil fuel fleet and assuming that, since the Valley Express O&M contractor has a lean staff complement for maintenance, further reductions in maintenance costs are unlikely. As such, we estimated that a ~10% cost savings could be experienced by BEB cutaways due to fewer moving parts compared to a combustion engine in gas cutaways. The lack of data on maintenance costs, particularly for costs outside of any OEM warranty, makes maintenance costs difficult to forecast.
- Electricity costs were calculated based on the expected rates from SCE. Specifically, it is expected that VCTC buses will charge under the "electric schedule BEV" rate which eliminates demand chargers and has an attractive electricity price outside of peak hours (peak is from 4:00 PM to 9:00 PM). Stantec utilized the Time of use (TOU) rate for the TOU-EV-8 option to estimate the total energy cost per day. The result was a projected cost of $0.1835 per kWh, which accounts for limited charging during peak hours and the subscription charges for the TOU rate.

Comparison and Outcomes – Valley Express

The cost comparison of NPV between the Base Case and the ZEB Case transition scenario is presented in Table 17 incorporating both capital (orange) and operating (blue) expenses. The ZEB Case has a total NPV of $11,197,000 versus $10,384,000 for the Base Case, a difference of $813,000 or an 8% increase in NPV over the Base Case. The financial assessment below does not consider any rebates, grants, credits, or other alternative funding mechanisms. Therefore, there may be several opportunities to offset

[28] We note that a benchmark for cutaway useful life mileage is 200,000 miles and VCTC's Valley Express fleet is lightly used—at about 15,500 miles per year, in theory, the Valley Express cutaways can operate for 10-12 years without exceeding 200,000 miles.

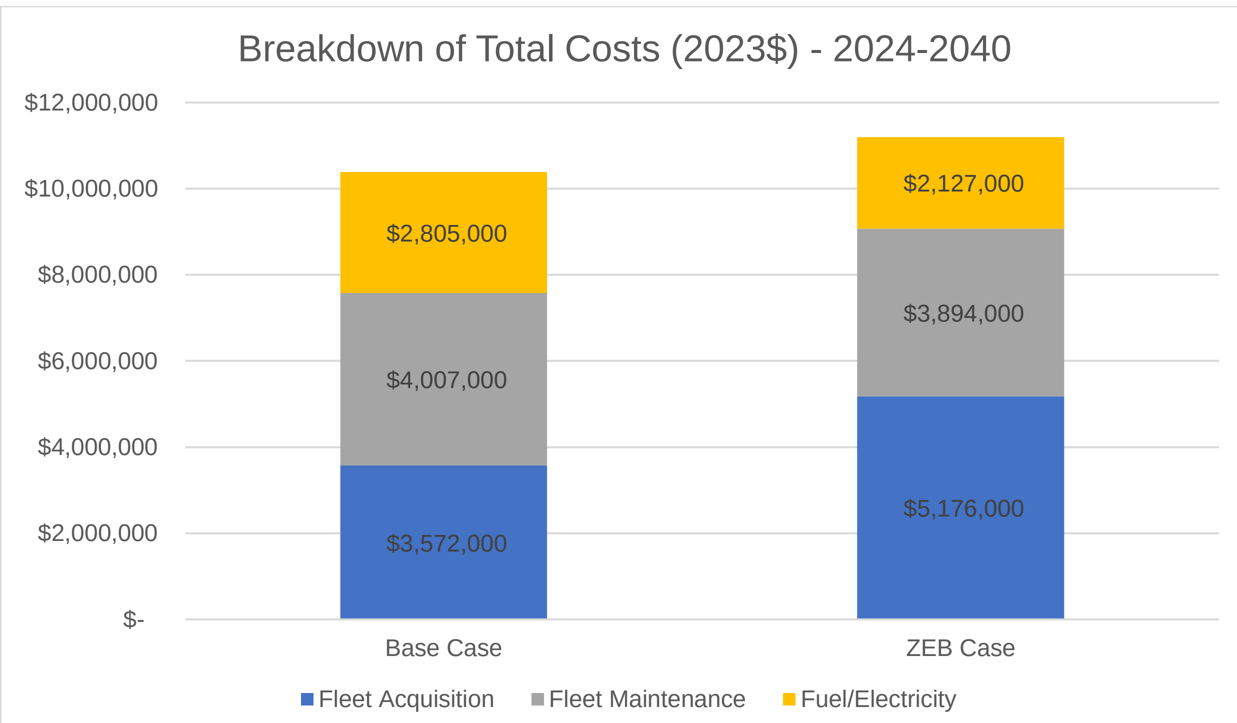
the difference in the price between the two scenarios. It does not include operator labor, administrative costs, and other costs not directly impacted by propulsion changes.

Table 17: Cost Comparison 2024-2040 – Valley Express

	Base Case	ZEB Case	Cost difference (ZEB – Base)
Fleet Acquisition	$3,572,000	$5,176,000	$1,604,000
Fleet Maintenance	$4,007,000	$3,894,000	($113,000)
Fuel/Electricity	$2,805,000	$2,127,000	($678,000)
Total	$10,384,000	$11,197,000	$813,000

Figure 29 displays the breakdown of total costs by category—the largest difference between the two scenarios is the capital expenses related to fleet procurement.

Figure 29: Breakdown of Cost Categories for the Base Case and ZEB Case – Valley Express



The procurement of ZEBs represents $813,000 more in expenses due to the higher purchase price of BEBs compared to fossil fuel vehicles.

The use of electricity as a 'fuel' represents an economic benefit of approximately $678,000 when compared to the existing gasoline refueling. These savings are a direct reflection of the improved efficiency that BEBs have with respect to legacy technologies, particularly with regard to the price volatility of gasoline when compared to the predictable price increases of utility rates. Furthermore, based on our assumptions, slightly lower overall maintenance costs are also seen with the BEB Case, representing a savings of $113,000 compared to the Base Case.[29]

Figure 30 shows the year-to-year comparison between the Base Case and the ZEB Case. In both scenarios, in 2025, the purchase of 15 new cutaways causes the large spike in annual costs. The higher costs for the ZEB scenario occur in the years when BEB cutaways are procured—in 2034, 2035, and 2036. Once the fleet is 100% ZEB in 2036, the ZEB Case is expected to express cost savings largely due to the decreased dependence on gas fuel.

Figure 30: Annual Total Cost Comparison – Valley Express

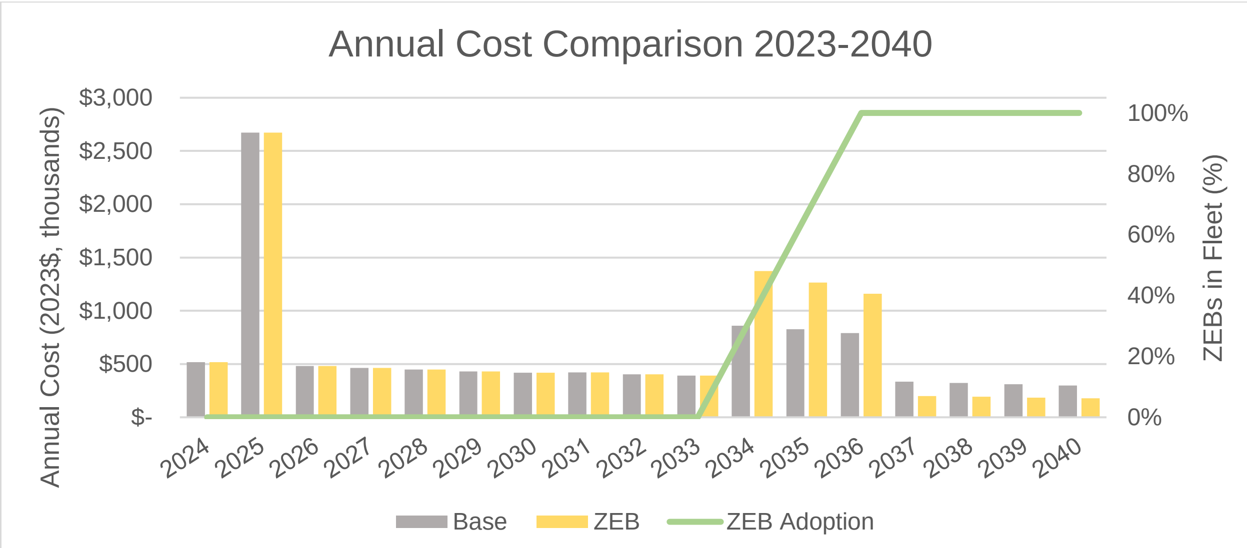
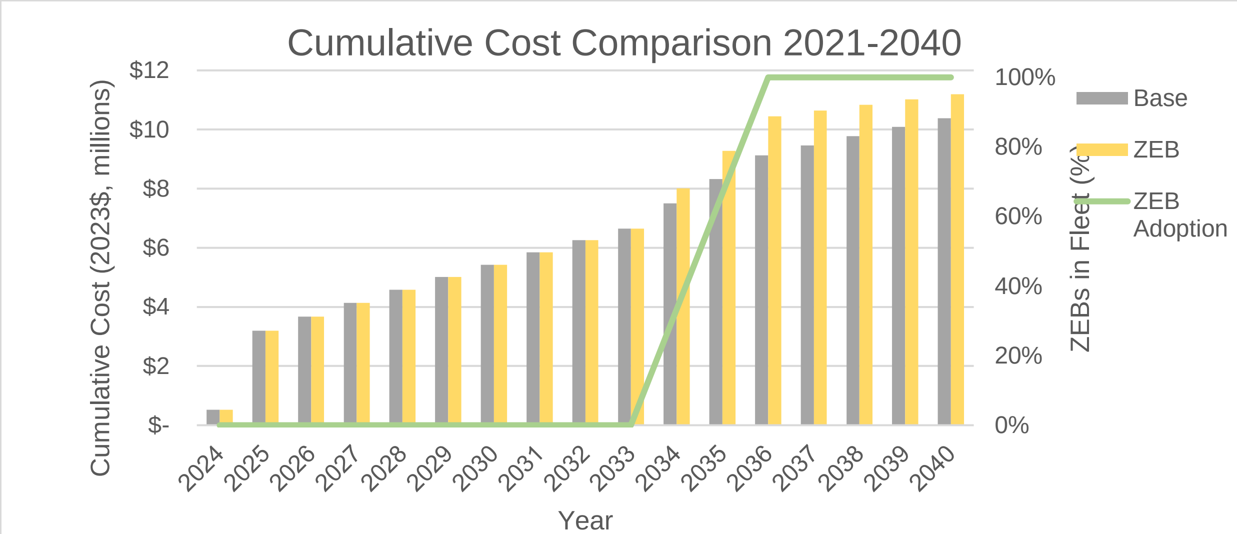


Figure 31 provides a different view of the financial analysis and shows the cumulative costs from 2024 and 2040. Overall, the ZEB Case will exceed the cost of the Base Case by over $813,000 through 2040, largely due to the capital costs associated with ZEBs themselves.

[29] It is important to note that potential savings would be seen in a phased capacity.

Figure 31: Cumulative Cost Comparison – Valley Express



9.3 ADDITIONAL COSTS

In addition to the costs captured above that can be estimated with more certainty, there are other costs associated with the transition that are harder to predict for different reasons, including lack of public information from vendors, and particularly in VCTC's case, because of the lack of certainty around operations and maintenance facilities. The chief costs that will need to be considered but have yet to be determined include:

- Recurring and ongoing training costs for operators and maintenance staff. While initial training can be purchased along with new vehicles, ongoing training schedules and costs will need to be determined year to year.
- Charging software that controls BEB chargers to ensure that power loads are distributed and to avoid demand charges. More information about smart charging is described further below, and these costs are typically monthly subscription type fees.
- Charger maintenance costs are currently unknown but may be minimal. Contracts with vendors may be required.
- Costs associated with Intercity fueling at the GCTD facility, including potential labor costs for fuelers (GCTD and/or VCTC staff) and usage fees. Furthermore, facility upgrades will be required for the storage facility of the Intercity fleet to conform with safety requirements for hydrogen gas leak detection.
- Costs associated with Valley Express charging, including potential land acquisition, facility improvements, and so on, all depending on the business model for BEB charging.

10.0 OPERATIONAL AND PLANNING CONSIDERATIONS

This section provides guidance and strategies for various operational and planning requirements when implementing FCEBs and/or BEBs.

10.1 PLANNING, SCHEDULING, AND RUNCUTTING

Key considerations for BEB planning and scheduling include the fact that the usable energy of the battery is 80% of the nameplate capacity. In other words, while VCTC may purchase buses that have a 120-kWh battery, for instance, it should plan for 80% of that capacity or ~96 kWh. This fact, together with the modeling conducted by the Stantec team in this study, will help guide the deployment and charging parameters for BEBs in VCTC's operations scheduling.

Developing a guide like the depot planning tool from Siemens below (Figure 32) that tracks the requirements for SOC, energy (kWh), estimated and planned mileages, and fuel economy (kWh per mile) will be important for planning and dispatching.

Figure 32: Depot planning tool to understand scheduling and operations of BEBs (Source: Siemens).

Example – 4 buses and 2 chargers c/w 2 dispensers each

Parameter	Value	Notes
	filter data...	
Scheduled buses	4 / 4	
Used chargers	2 / 2	
Total energy required, KWh	969.2544	
Total energy delivered, KWh	1091.76	
Maximum power, KW	105.11	

BusID	Capacity, KWh	EleCon, KWh/km	Planned distance, km	Max distance, km	SoC start, %	SoC end planned, %	SoC end expected, %
filter data..							
191	349	1.29	195.79	243.48837209302326	17	90	90
192	349	1.29	179.89	243.48837209302326	23	90	90
193	349	1.29	179.89	243.48837209302326	23	90	90
194	349	1.29	195.79	243.48837209302326	17	90	90

Non-revenue tests during vehicle commissioning should be conducted in different parts of VCTC's service area to establish actual range and fuel economy on longer routes, routes with topography variations, and with simulated passenger loads and HVAC testing. Regarding HVAC testing, it is important to keep in mind that energy consumption varies with seasonality.

Training for the scheduling and planning team will be needed to understand the importance of scheduling BEBs and FCEBs to the correct blocks. Training will also likely be needed in collaboration with VCTC's scheduling software provider to account for hybrid deployments of ZEB and fossil fuel buses, and finally an entirely-ZEB operation.

In the long term, it is also important to consider battery capacity degradation; most BEB battery warranties specify that expected end of life capacity is 70% to 80% of the original capacity over sixtwelve years[30]. With an estimated 2% battery degradation per year, VCTC will also need to rotate buses so that older buses are assigned shorter blocks, while newer BEBs are assigned the longest blocks. Transit agencies can improve battery outcomes through efforts like avoiding full charging and discharging events, avoiding extreme temperature exposure, and performing regular maintenance on auxiliary systems that consume energy.

FCEBs come closest to matching the operating ranges of fossil fuel vehicles (200+ miles). VCTC can launch FCEBs first on routes/blocks with shorter daily distances to get a feel for them in terms of range and handling—placing them on routes that remain relatively close to the facility would be a pragmatic strategy at first. Like with BEBs, non-revenue tests with FCEBs should be conducted to understand actual driving range and fuel economy, particularly as a function of route operating conditions, ambient temperature, passenger loads, and driver behavior.

Overall, developing specific performance measures, goals, and objectives for ZEB deployment can also help to track ZEB progress and understand if adjustments to the ZEB deployment strategy will be required.

10.2 OPERATOR NEEDS

As BEBs have different components and controls than conventional buses, BEB bus performance also differs. Operators should understand how to maximize BEB efficiency—mastering regenerative braking and handling during slick conditions—and have practice on how to do so prior to ZEB deployment for revenue service. Operations staff should also be briefed on expected range and limitations of BEBs (such as variability in energy consumption from HVAC under different weather conditions) as well as expected recharging times and procedures.

BEB operators should be able to understand battery SOC, remaining operating time, estimated range, and other system notifications as well as become familiar with the dashboard controls and warning signals. In addition, operators should be familiar with the correct procedures when a warning signal appears.

It is well known that driving habits have a significant effect on BEB energy consumption and overall performance and range (i.e., fuel economy can vary significant between operators). Operators should become knowledgeable on the principles of regenerative braking, mechanical braking, hill holding, and roll back. Operators should be trained on optimal driving habits including recommended levels of acceleration and deceleration that will maximize fuel efficiency. Another option is to implement a positive incentive program that encourages operators to practice optimal driving habits for BEBs through rewards like priority parking in the employee lot, certificates, or other incentives. The Antelope Valley Transit Authority (AVTA) in Lancaster, California, an early adopter of BEBs, has a program of friendly competition between operators, where, for instance, an operator with the best average monthly fuel economy (the lowest kWh per mile) receives one month of a preferred parking spot in the employee lot.

[30] National Academies of Sciences, Engineering, and Medicine 2020. Guidebook for Deploying Zero-Emission Transit Buses. Washington, DC: The National Academies Press. https://doi.org/10.17226/25842.

The presence of hydrogen gas and the safety issues that relate to this must be addressed as well as any differences to gauges and instrumentation. An overview of the technology must be included during training. An additional increment of time beyond just the vehicle layout and driving characteristics needs to be added to training sessions to address the technology and unique safety considerations. Additional training time for different start-up and shut-down procedures and proper procedures regarding what to do if there is a failure on route should be accounted for as well.

Finally, ZEBs are much quieter than conventional fuel buses. Operators should be aware of this and that pedestrians or people around the bus may not be aware of its presence or that it is approaching. Agencies have also stated that due to the vehicle’s lack of noise, some operators forget to turn off the bus after parking. Operator training should include a process for ensuring that this happens.

10.3 MAINTENANCE NEEDS

Early data suggests that ZEBs may require less preventative maintenance than their counterparts with combustion engines since they have fewer moving parts; however, not enough data currently exists to provide detailed insights into long-term maintenance practices for large-scale ZEB deployment in North America, particularly for cutaways and vans. One early finding is that spare parts may not be readily available, so one maintenance consideration is to coordinate with OEMs and component manufacturers to develop spare parts inventories and understand lead times for spare parts. It will also be important for VCTC to coordinate spare parts procurement needed for ongoing ZEB maintenance sooner rather than later so maintenance can be completed without interruption.

In terms of preventative maintenance, BEB propulsion systems are more efficient than internal combustion engines and thus can result in less wear and tear. Without the diesel engine and exhaust, there are 30% fewer mechanical parts on a BEB. BEBs also do not require oil changes and the use of regenerative braking can help to extend the useful life of brake pads. Early studies from King County Metro show that the highest percentage of maintenance costs for BEBs came from the cab, body, and accessories system. It is recommended that VCTC require OEMs to provide a list of activities, preventative maintenance time intervals, skills needed, and required parts needed to complete each preventative maintenance task for BEBs.

Many current BEBs also contain on-board communication systems, which are helpful in providing detailed bus performance data and report error messages, which can assist maintenance personnel in quickly identifying and diagnosing maintenance issues.

For FCEBs, while a smaller high voltage battery installation is present and will require inspection and eventual changeout, the inspection and possible replacement of hydrogen fuel cell stack may be necessary depending on manufacturer warranty policies and actual vehicle use. Hydrogen tanks will have the same ruggedness as CNG products and should fulfill in excess of a heavy-duty bus 12-year service design life cycle.

10.4 VEHICLE PROCUREMENT GUIDANCE

Currently, VCTC operates a fleet of cutaways and motorcoaches, and this same fleet composition will be carried over through the ZEB transition. BEB and FCEBs options on the market today for these vehicle types are extremely limited, particularly for motorcoaches, and by extension procurement options are more limited as well.

For motorcoaches, only MCI and BYD are producing BE motorcoaches. For MCI, only the D45 CRTe LE has been Altoona-tested[31]. However, modeling was completed assuming a 544-kWh battery size, which necessitates the purchase of the J4500 CHARGE model. A hydrogen motorcoach product is still in an infancy stage with the Hyzon 35-ft FCEB motorcoach as one early option. However, we note that this vehicle is significantly shorter than the traditional 45-ft MCIs operated by VCTC. Alexander Dennis in the UK has developed a hydrogen FCEB double decker bus. Given the size of the commuter and longer distance coach market, it is likely that MCI and other bus manufacturers will eventually offer hydrogen motorcoach buses. CARB has noted that Caltrans is exploring a fuel cell electric motorcoach pilot project that could see vehicles in 3-4 years. To account for the uncertainty around FCEB motorcoaches, the ZEB plan here sees the first potential FCEB motorcoaches in 2030, likely providing enough lead time for the development and Altoona-testing of FCEB motorcoaches.

For cutaways, there is a clear and growing need for more ZE cutaway alternatives with longer ranges for agencies that operate in rural settings and demand-response services, like the Valley Express. Currently, three BE cutaways are on the market but none have been Altoona-tested. Our modeling assumed that Altoona testing will be completed prior to any VCTC procurements. A key assumption is that battery capacity will improve enough to meet the needs of VCTC's service. This assumption is based on the growing number of ZE cutaways on the market in the past few years, improved efficiencies in batteries and fuel efficiency, and market response to a growing demand for cutaways with larger batteries and longer ranges. Another potential improvement could be the ability to fast charge smaller cutaway type vehicles with more high power chargers than currently available. Furthermore, for smaller hydrogen-powered vehicles, one passenger van model is currently available, and some prototype cutaways models have been developed. Overall, however, this market is still immature.

For BEBs, the Lightning Systems E450 Shuttle Bus has a 129-kWh battery with a range of up to 120 miles. The vehicle is eligible for a $60,000 incentive per vehicle under the Hybrid and Zero-Emission Truck and Bus Voucher Incentive Program (HVIP) program[32]. Another cutaway available for a $60,000 HVIP voucher is the GreenPower EV Star+ with a battery size of 118 kWh and stated range of up to 150 miles[33]. Finally, the Optimal-EV S1LF is a low-floor cutaway with a 113-kWh battery and 125-mile range. The vehicle utilizes Proterra's battery management system. Currently, only the GreenPower EV Star+ is listed in the CalACT/MBTA Purchasing Cooperative, but as more agencies begin to purchase BEBs, it is expected that more vehicles will be added. VCTC should specify two rear-mounted charging ports accepting a minimum charging rate of 60 kW (200 ADC) at 480 VDC or greater via SAE J1772 to maximize flexibility when parking and charging the vehicles.

31 https://www.altoonabustest.psu.edu/bus-list.aspx
32 https://californiahvip.org/vehicles/lightning-systems-lev110e-bus-ford-e-450-with-lightning-powertrain/
33 https://californiahvip.org/vehicles/greenpower-ev-star-plus/

With regard to hydrogen cutaways, US Hybrid has repowered a 2014 gasoline El Dorado Aero Elite with a 40-kW hydrogen fuel cell and a proprietary electric drive system[34]; this vehicle is capable of traveling 100 miles. US Hybrid is also working on converting two other cutaways for the Hawai'i Mass Transit Agency, so while no commercial hydrogen-powered cutaways are currently available, repowers are possible.

In addition to cutaways, there are also limited ZE passenger vans available for purchase based on the Ford eTransit vans chassis. These vehicles can typically be outfitted to accommodate six ambulatory passengers with one wheelchair position, four ambulatory passengers with two wheelchair positions, or three ambulatory passengers with three wheelchair positions. Currently, we are aware of two BE models, as well as one FCE model from US Hybrid being tested by SunLine Transit in Thousand Palms, CA as well as the transit agency in Stark County, OH.

Some example vehicles are summarized Table 18, and these provide illustrative examples only. VCTC should develop a competitive tendering process for its fleet procurement and use programs like the CalACT/MBTA Purchasing Cooperative to streamline procurement. VCTC should also leverage APTA's Standard Bus Procurement Request for Proposal (RFP) which contains language about charger specifications, data logging and telematics, and other information that would be useful to include for vehicle and charger procurements[35]. To help offset the capital costs of these ZEBs, VCTC can apply for vouchers through the California HVIP program[36], as well as take advantage of other grant opportunities summarized in Section 13.0.

Table 18: Summary of vehicle options

Vehicle type	ZEB type	Make and model	Battery size (kWh) or Tank size (kg)	Range (miles)	Notes	Example Vehicle Photos
Cutaway	BE	Lightning Systems E450 Shuttle Bus	129	120	Eligible for $60,000 HVIP voucher. Supports both Level 2 and DC fast chargers.	

[34] https://www.ushybrid.com/press-release/hawaiis-first-hydrogen-bus/
[35] https://www.apta.com/research-technical-resources/standards/procurement/apta-bts-bpg-gl-001-13/
[36] https://californiahvip.org/vehicle-category/medium-duty-bus/

Vehicle type	ZEB type	Make and model	Battery size (kWh) or Tank size (kg)	Range (miles)	Notes	Example Vehicle Photos
	BE	GreenPower EV Star+	118	150	Eligible for $60,000 HVIP voucher. Supports both Level 2 and DC fast chargers.	
	BE	Optimal-EV S1LF	113	125	Uses Proterra battery management systems. Supports both Level 2 and DC fast chargers.	
	FCE	US Hybrid repower of an El Dorado Aero Elite cutaway	Unknown	100+	Not commercially available, and based on a repower of a gasoline-powered cutaway.	
Passenger Van	BE	Lightning Systems Electric Zero Emission Transit Passenger Van	80-120	140-170	Eligible for $45,000 HVIP voucher. Low-floor vehicle and CARB certified Uses Proterra battery management systems.	

Vehicle type	ZEB type	Make and model	Battery size (kWh) or Tank size (kg)	Range (miles)	Notes	Example Vehicle Photos
					Supports both Level 2 and DC fast chargers.	
	BE	US Hybrid by Ideanomics Ford Transit T-350HD DRW[37]	180	210	Supports both Level 2 and DC fast chargers.	
	FCE	US Hybrid by Ideanomics Ford Transit 350 HD[38]	12.8 kg (40 kW fuel cell)	300	Supports 350 bar fueling.	

10.5 O&M CONTRACTOR PROCUREMENT GUIDANCE

Like many transit agencies throughout the country, VCTC's bus operations and vehicle maintenance are handled by third-party contractors, currently RATP Dev for the Intercity services, and MV Transportation for Valley Express. The O&M contractors invoice an all-inclusive billing rate for operations based on scheduled vehicle hours with a fixed monthly fee for a set contract term, with option rates for additional terms.

Based on this service delivery model, one of the chief factors that could result in cost savings from a ZEB transition is maintenance and the savings would in theory flow to the O&M contractor. For the Valley Express service, VCTC's O&M contractor provides a lean staff, so savings originating from maintenance is likely to be negligible. For Intercity service, a larger maintenance staff is required so larger cost savings are possible, but the need to fuel at GCTD (and the added labor to drive and fuel offsite) may offset some cost savings; this is unknown until service is actually operational. Nonetheless, Stantec recommends that in future procurement documents, VCTC should stipulate language for conditions to revisit the contracted rate once a certain portion of the fleet is transitioned to ZEBs to ensure than any cost savings realized by

[37] https://www.ushybrid.com/wp-content/uploads/2022/05/USH_eVan_Productsheet_2022_V8.pdf
[38] https://www.ushybrid.com/wp-content/uploads/2022/05/USH_CaseStudies_SARTAVan_2022_DIGITAL.pdf

the O&M contractor is passed on to VCTC. Example language from a recent procurement document drafted by Stantec is shown below:

> *The Contractor acknowledges that, as of the Commencement Date, the County's fleet comprises the Buses listed in Appendix E to the SOP and includes **[XX] Electric Buses and Hydrogen Buses**. The Contractor further acknowledges that the County intends to increase the number of Electric Buses available for Service and the Contractor shall cooperate fully with the County in the transition from diesel to Electric Buses, in accordance with the terms of this Contract and the SOP.*
>
> *…*
>
> *The Contractor shall support the County during the transition from a fossil fuel fleet to a zero-emission fleet. If the County transitions greater than **35 percent (35%)** of the fleet to zero-emission buses, the **County may request the Contractor to review the Hourly (or per Mile) Rate to identify reductions associated with zero-emission bus maintenance programs and requirements**. Within thirty (30) days of receipt of the request from the County, the Contractor shall submit a proposal setting out the proposed new Hourly (or per Mile) Rate.*

Stantec highly encourages VCTC to ensure that as it goes out to procurement when the current contract ends, that protections are built in such that any cost benefits the O&M contractor accrues due to ZEB operations is passed along to VCTC. In addition, future contracts will need to include language to address the need to operate and maintain ZEBs to comply with the CARB regulation.

10.6 FUELING NEEDS

BEB recharging is substantially different than fueling a diesel or fossil fuel bus. As part of the recommendations, plug-in chargers (60 and 100-120 kW; charger standard SAE J1772) are proposed for BEB charging for Valley Express and for the BYD BEB motorcoaches. Smart charging software, described in Section 11.0 below would monitor and control overall charging levels to balance energy needs with overall power demand, in essence helping ensure that BEBs are charged but that this charging is spread out to avoid large surges in power demand.

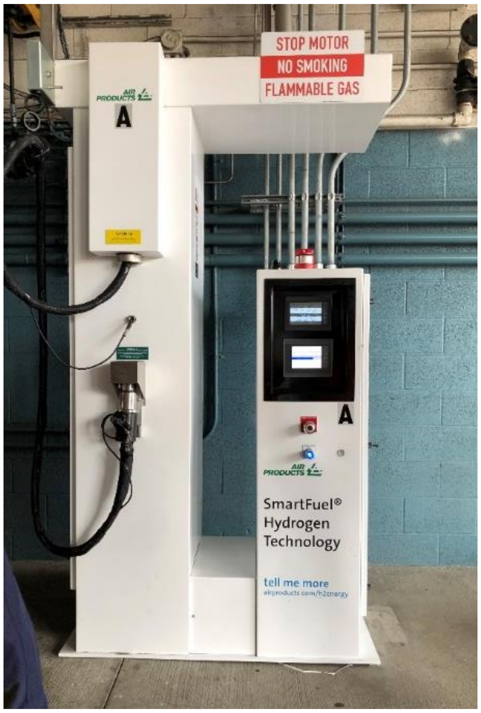
Figure 33: A BE passenger van plugged into a charger

It is worthwhile mentioning that typical heavy-duty 40-ft BEBs are capable of conductive, pantograph charging (via SAE J3105) at much higher power levels (over 300 kW) compared to plug-in dispenser because these buses are equipped with overhead charging rails; this allows these types of buses to receive quick bursts (~10 min) of charge to extend operating range. However, current BEB cutaways and motorcoaches are not equipped with charge rails and as such, are generally limited to sub-150-kW charging via plug-in dispensers.[39] Given this limitation for cutaways and motorcoaches, fast, top-up charging is not possible for the current models of these vehicles, also limiting VCTC's ability to recharge them within minutes rather than hours.

Fueling an FCEB is very similar to fueling a traditional CNG or diesel bus. Attaching a dispenser nozzle to the vehicle and fueling for ~8-12 minutes will yield a full tank. The hydrogen nozzle is completely sealed to the bus while refueling due to the high-pressure delivery method (above 350 bars). The operation of the nozzle and the pump are virtually the same but specific training needs to be provided to staff for safety reasons.

Figure 34: Hydrogen fueling dispenser at OCTA for heavy-duty transit buses

[39] Plug-in chargers can have air-cooled or liquid-cooled cables, with air-cooled being more common. Air-cooled cables have a current limit of 200 A, therefore the total power delivered is dependent on the bus voltage.



The strategy for VCTC's Intercity hydrogen-powered vehicles is for offsite fueling at the eventual hydrogen facility of GCTD. Bus operators will need to be trained on fueling protocols and VCTC will need to work together with GCTD to determine logistics like site access permissions and cost sharing. Coordination will be necessary to understand fueling windows for VCTC's fleet relative to GCTD fleet. VCTC will also need to build in time into the schedule for maintenance technicians, fuelers, or operators who would need to fuel the vehicles offsite and this may likely increase the billable hours of a third-party O&M contractor.

10.7 BATTERY DEGRADATION

Battery degradation is unavoidable due to battery use and charging/recharging cycles. To some extent, the magnitude and rate of degradation can be controlled by the user. FCEBs have smaller batteries so degradation is not as much of an issue compared to BEBs.

Following the recommendations of the manufacturer becomes especially important to preserve the battery life for BEBs. This includes charging the battery to a maximum of 90% SOC and not allowing the battery to dip below 10% SOC. Furthermore, minimizing fast charging (below 300 kW) can help expand the lifespan of the batteries, which will be the case for VCTC according to the charging equipment recommendations detailed in Section 7.0.

Nevertheless, natural battery degradation will always occur, and vehicle manufacturers are offering extended warranties in their purchase agreements to account for battery degradation of 20% of its nameplate capacity. Battery replacements for cutaways are also assumed to be available but might not be necessary to go beyond the warranty given the utilization cycle that cutaways will have at VCTC (10-

12 years). Actual experience may differ, and VCTC will need to work with its vendors to understand warranty terms.

For FCE vehicles, battery degradation is unlikely to be a concern because the battery packs are smaller than on BE vehicles. Furthermore, the fuel cell stack for commuter coaches that have 12+ years of expected life can be refurbished; VCTC will need to work with vehicle manufacturers to understand warranty terms and potential replacement policies.

11.0 TECHNOLOGY

Technology for ZEBs will help VCTC manage the fleet and its investment into zero-emission propulsion. First, for BEBs, charge management or smart charging technology is imperative to manage electrical demand and to curb potentially costly demand charges and to mitigate maximum power requirements of bus charging. Second, fleet tracking software, also known as telematics, typically provided by an OEM will help track useful analytics related to the fleet and operations to help VCTC make informed decisions.

11.1 SMART CHARGING

To optimize BEB charging by minimizing charging during peak times of the day and to restrain the total power demand required for a BEB fleet, transit agencies deploy **smart charging**. Smart charging refers to software, artificial intelligence, and switching processes that control when and how much charging occurs, based on factors such as time of day, number of connected BEBs, and SOC of each BEB. This requires chargers that are capable of being controlled as well as a software platform that can effectively aggregate and manage these chargers. A best practice is to select chargers where the manufacturers are participants in the Open Charge Point Protocol (OCPP), a consortium of over 50 members focused on bringing standardization to the communications of chargers with their network platform.

A simple example of smart charging is if buses A, B and C return to the bus yard and all have an SOC of about 25%, all have 440 kWh battery packs, and all are plugged in in the order they arrived (A, B, C, though within a few minutes of each other). Without smart charging, they would typically get charged sequentially based on arrival time or based on SOC, with A getting charged first in about 2.2 hours, then B would be charged after 4.4 hours, and C about 6.6 hours. But if bus C is scheduled for dispatch after three hours, it would not be adequately charged.

But by implementing smart charging, the system would ‘know’ that bus C is to be dispatched first and therefore would get the priority, would be charged first in 2.2 hours, and would be ready in time for its ‘hour three’ rollout.

Another implementation is to mitigate energy demand when possible. For example, if two buses are each connected to their own 150 kW charger and they both need 300 kWh of energy and if the buses do not need to be dispatched for five hours, the system will only charge one bus at a time, thus generating a demand of only 150 kW, while still fully charging both buses in four hours. However, if both buses need to be deployed in two hours, the system will charge both simultaneously as needed to make rollout. A smart charging system would help optimize costs by also avoiding or minimizing charging during the most expensive times of day and help curb potential demand charges.

Well-planned and coordinated smart charging can significantly reduce the electric utility demand by timing when and how much charging each bus receives. Estimations on the ideal number of chargers is critical to the successful implementation of smart charging strategies.

There are several offerings in the industry for smart charging, charger management, and fleet management from companies such as ViriCiti, I/O Systems, AMPLY Power, BetterFleet, and Siemens.

Additionally, the charger manufacturers all have their own native charge management software and platforms. These platforms have management functionality and integration that often exceeds the abilities of the other platforms and provide data and functionality similar to that of the third-party systems, particularly in the yard when BEBs are connected to the chargers. However, the third-party platforms provide more robust data streams while the BEBs are on route, including real-time information on SOC and usage rates. These platforms can cost well over $100 per bus per month, depending on the number of buses, and type of package procured.

Three leading charge management system (CMS) providers have been evaluated as shown in Table 19. Information within this table was provided by the providers. This table indicates this point in time—at the time of procurement the features and criteria should be verified with the provider. Note that Viriciti was purchased by ChargePoint in 2021, though the intent is to operate Viriciti separately from ChargePoint. A Buy America evaluation will be required for these providers.

Table 19: Charge Management System Vendor Comparison

Item No.	Criteria Description	Amply Power - OMEGA	Viriciti - Agnostic Management Platform	ChargePoint - CMS
1	Number of installations (facilities) with multiple HVDC chargers utilizing the software	14	More than 300	300+
2	Quantify uptime % of cloud base service	99.99%	99.99%	99.99%
3	What networking protocols or modes are supported, i.e., wired Ethernet, cellular, other	Hardwired ethernet is recommended, cellular and facility WIFI are supported	Cellular is recommended, wired Ethernet, and WIFI are supported	Cellular
4	OCPP 1.6 compatibility	Yes	Yes	Yes
5	OCPP 2.0 compatibility	Yes	Yes	Yes
6	List available data fields that can be reported (such as starting and ending SoC, bus ID, charging power, …)	SOC: start and end of charging session, SOC all the time whether bus in plugged in, parked or in the field. Rate of charge (kW) of each charger port. Bus ID all the time whether bus is plugged in or not. Location of bus (in-depot, in field, etc.) Charging session: Energy dispensed Duration of charging, Power and energy consumed at electrical meter and dispensed at each charger port. Charger health: Available Faulted Maintenance needed, etc.	Reports: Uptime, Downtime, and Offline chargers (in hours, percentage, and total for a group) Energy Reports (in kWh and hours of duration) Transactions: Charger OEM, Charger Name, Connector type, Connector/port number (1 or 2) Vehicle Name/Number Start Time and End Time Start SOC and End SOC Power Reason for ending charge session Duration of Charging session kWh Charged Range at start of transaction Range at the end of the transaction A visual graph representation of Power, SOC, and Energy throughout each transaction A complete list of charging transactions (equipped with the data previously stated) A complete list of user logs and documentation of user interactions.	
7	OpenADR2.0b or better common signals	Yes. In addition to OpenADR, also support custom DR integrations including CPower and Leap Energy.		Yes

Item No.	Criteria Description	Amply Power - OMEGA	Viriciti - Agnostic Management Platform	ChargePoint - CMS
8	Support Network Time Protocol (NTP/UTC) time synchronization	Yes	Yes	Yes
9	Describe software security features for system integrity and reliability	AMPLY has implemented security procedures at multiple levels for protecting customer information: • AMPLY databases are encrypted using industry standard AES-256 encryption • Both the database and application are running inside a VPC which has tightly managed access using IAM • The database is accessible only to the application nodes • No passwords are stored in the database and authentication is done using AWS Cognito • Authorization is tightly managed as part of the lower layers of the Amply software framework • Credentials are not stored in the database or code and are managed via the AWS systems manager • Software packages and dependencies are regularly reviewed for security vulnerabilities • Cloud infrastructure, roles & security groups are regularly reviewed for ensuring security		ISO 27000:2015
10	Capable of remote software upgrades	Yes – automatic, over the air updates	Yes – Updates happen though the Cloud	Yes
11	Is user interface web based or is any local app or software required	Web based UI accessible from any web enabled device	The system operates through a cloud-based platform which can be accessed through any web browser on a computer or mobile device. Web base only.	Web based
12	Ability to set charge-power limit to reduce energy charges while also maximizing bus availability	Yes. Pause or curtail charging session during peak energy costs. Optimized charging during off-peak or vehicle dwell times to achieve target SOC by defined roll-out times.	Yes, this is a customizable application which allows the user to create and manipulate charging parameters as needs or schedules change.	Yes
13	Ability to set charging to minimize demand charges while also maximizing bus availability	Demand (kW) management and reduction to achieve roll-out but will spread out charging. Sequential, dynamics and parallel charging capable (limitations are determined by EVSE not AMPLY system).	Yes, this is a customizable application which allows the user to create and manipulate charging parameters as needs or schedules change.	Yes
14	Ability to recognize bus stall and bus number and evaluate charge needs by block and state of charge (i.e., park management)	Yes	Yes	Yes

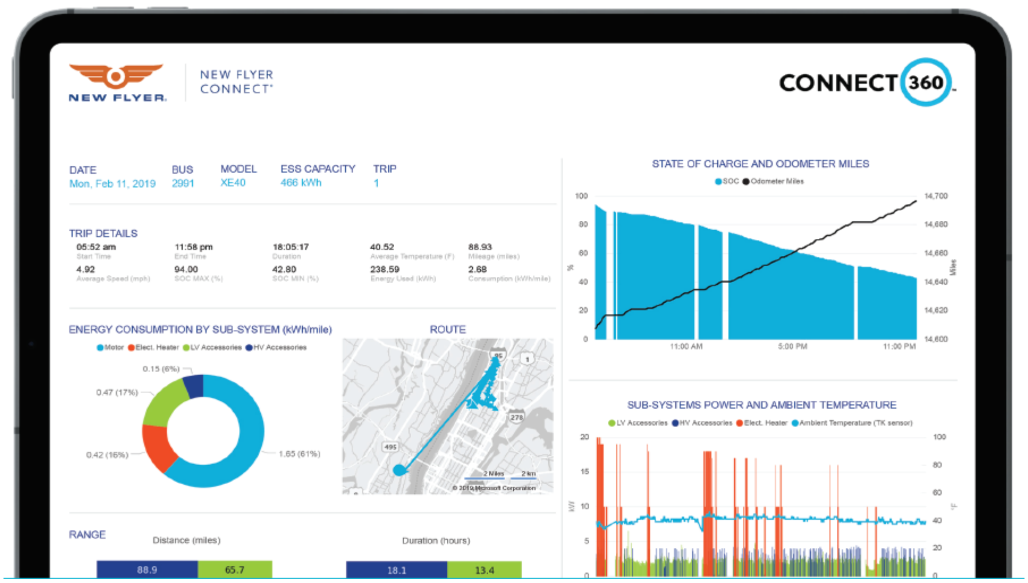
Item No.	Criteria Description	Amply Power - OMEGA	Viriciti - Agnostic Management Platform	ChargePoint - CMS
15	Manual override (computer/HMI input) for selection of (bus) charging sequence	Yes. Manual override button located within UI accessible by a specific user creditable. Override can also be performed by email, phone call or ticket request.	Yes, users can manually prioritize groups of chargers or single chargers in order to meet the demand as needed.	Yes
16	Describe desktop output/reports for charge telematics	• Energy Report - net (panel) load, modelled load (assuming no CMS), aggregate and individual charger load • Charge Detail Records - plug-in and session start & stop times, session duration, session energy, vehicle start & end soc, vehicle ID • Health Records - % normal, faulted, offline and uptime for EVSEs, controllers, system & software components • Vehicle Logs - Geo location and SOC information • Charge Ready Transport - CRT formatted report for PG&E, SCE and other Utilities Fleet Ready Programs	• Uptime, Downtime, and Offline chargers (in hours, percentage, and total for a group) • Energy Reports (in kWh and hours of duration) • A complete list of charging transactions (equipped with the data previously stated) • A complete list of user logs and documentation of user interactions.	No response
17	Is there a local controller to preserve the same control functionality in case cloud connectivity fails (e.g., WIFI outage)?	Yes, AMPLY Site Controller (ASC) installed at electrical main and is connected to breaker. CT's will meter 3- phases of power for real- time demand management. ASC can be hardwired to each EVSE via CAT6 to send OCPP directly to charger. If CMS cellular connection temporarily down, ASC has programmed commands to continue charging until cellular connection is restored.	With all communications we send to the charger, there are two signals that are sent: The set parameter and a failsafe value. If connection is disrupted for any reason or duration of time, the charger will revert to the failsafe value until connectivity is reestablished.	Yes
18	Other features criteria, or comments	OMEGA supports algorithmic optimization across a wide set of use cases in addition to TOU energy management including load management, tariff-based optimization across usage, demand and subscription charges, factoring in unmanaged loads, demand response signals from OpenADR and other providers. It also offers flexible alerting and notifications for EVSE faults and other conditions.	• Provided system is built to scale. If charging needs change or if a new OEM is desired, the system is able to monitor any charging infrastructure (assuming that charger OEM is OCPP compliant) and easily exchange chargers in the system. • Through an API, there is the ability to integrate with other planning or ITCMS platforms to optimize planning. • Other features may include our agnostic telematics system, which is capable of monitoring any vehicle OEM and operates off the same platform as the charger monitoring infrastructure - decreasing operational complexity by reducing software applications and increasing visibility into energy usage/expenditure.	No response

11.2 FLEET TRACKING SOFTWARE

Software like Fleetwatch provides agencies with the ability to track vehicle mileage, work orders, fleet maintenance, consumables, and other items. However, with more complex technologies like ZEBs, it becomes crucial to monitor the status of batteries, fuel consumption, and so on of a bus in order to track its performance and understand how to improve fuel efficiency. Many OEMs offer fleet tracking software. Tracking fuel consumption and fuel economy will start to form important key performance metrics for fleet management as well as help inform operations planning (by informing operating ranges, among other elements).

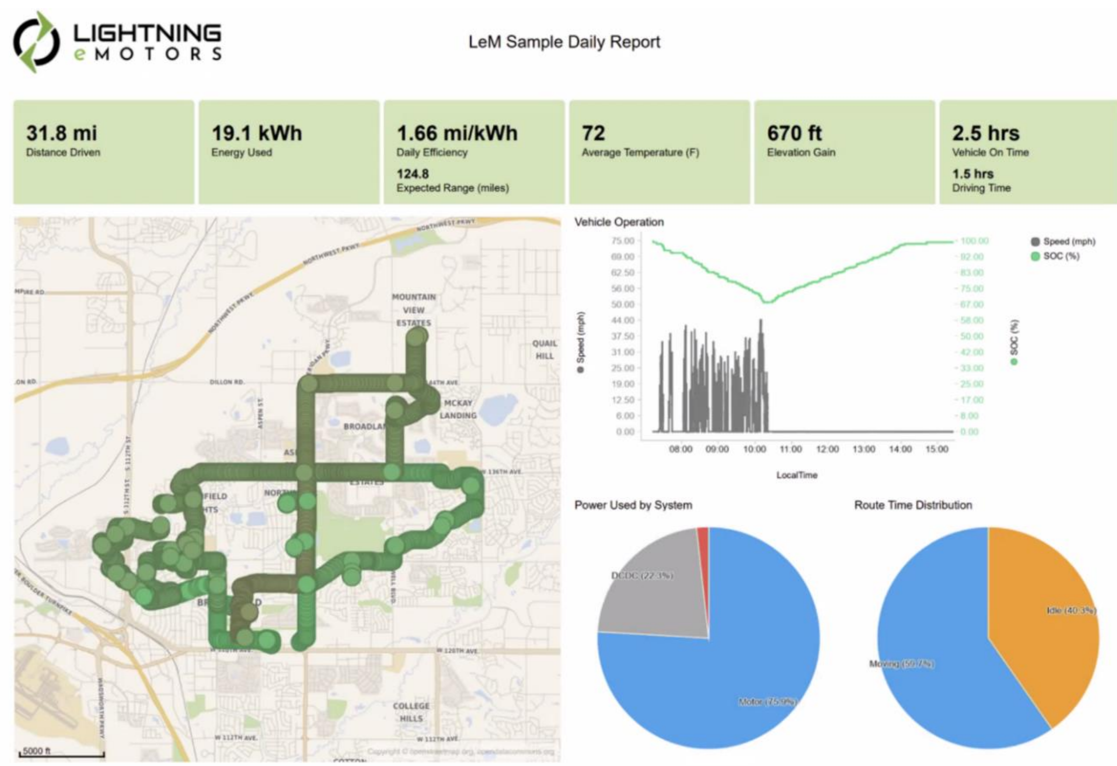
The screenshot below is an example of New Flyer's tool (New Flyer Connect 360; Figure 35), Lightning's dashboard (Figure 36), while other OEMs also offer similar tools (like ViriCiti) all depending on an agency's preference.

Figure 35: Example of New Flyer Connect 360.[40]



40 https://www.newflyer.com/tools/new-flyer-connect/

Figure 36: Example of Lighting eMotors daily report summary.



At a minimum, the fleet tracking software should track a vehicle's SOC, energy consumption, distance traveled, hours online, etc. Tracking these KPIs can help compare a vehicle's performance on different routes, under different ambient conditions, and even by different operators.

Beyond the BEB itself, charger data should be collected as well, such as the percentage of battery charge status and kWh rate of charge. Furthermore, it will be important for VCTC to track utility usage data from SCE to understand energy and power demand and costs.

Regarding FCEBs, VCTC should similarly collect information around mileage (range), fuel efficiency (miles per kg of hydrogen), and other relevant statistics. For fueling, VCTC will need to work with GCTD to track fueling transactions for invoicing purposes.

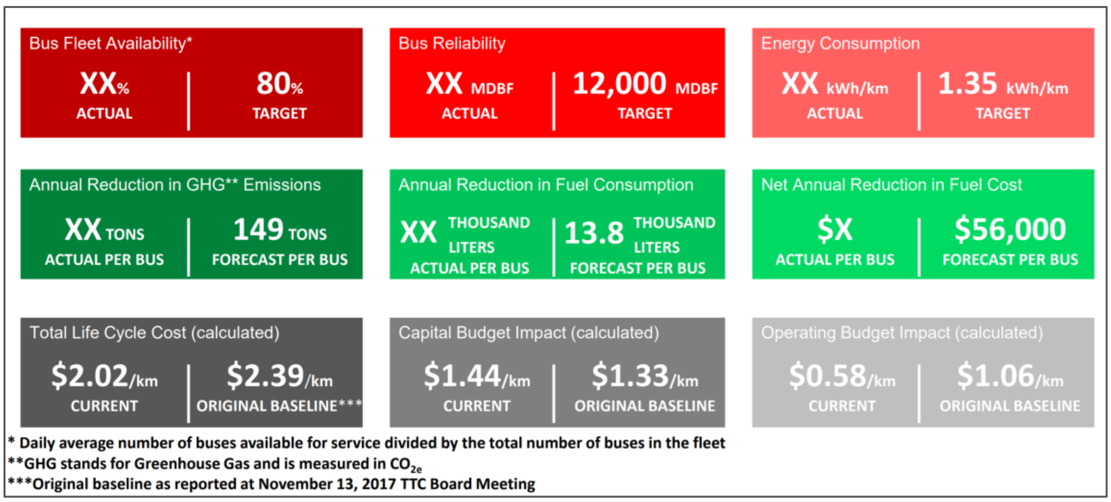
As VCTC transitions from a fossil fuel fleet to ZEB fleet, it will be important to collect and compare data between the fleet types to understand the benefits (and costs) of the transition. Example key performance indicators (KPIs) can include:

- ZEB vs. non-ZEB miles traveled
- ZEB vs. non-ZEB maintenance cost per mile
- ZEB vs. non-ZEB fuel/energy costs by month ($ per kWh or kg vs. $ per gallon)

- ZEB vs. non-ZEB fuel/energy cost per mile
- Average fuel consumption/fuel economy per month
- Total ZEB vs. non-ZEB fuel and maintenance costs per month
- Mean distance between failures
- ZEB vs. non-ZEB fleet availability

The Toronto Transit Commission (TTC) is currently testing BEBs from three different OEMs and is tracking the following KPIs for its BEBs to compare with its fossil fuel buses (Figure 37).

Figure 37: Example of TTC eBus KPIs.[41]



All ZEB equipment should be connected to VCTC's current data collection software, networks, and integrated with any existing data collection architecture. All data should be transmitted across secure VPN technology and encrypted.

41 https://www.ttc.ca/About_the_TTC/Commission_reports_and_information/Commission_meetings/2018/June_12/Reports/27_Green_Bus_Technology_Plan_Update.pdf

12.0 WORKFORCE CONSIDERATIONS

The deployment of a new propulsion technology will require new training regimes for operators and maintenance staff. This section describes some key training considerations as well as the implications for the adoption of BEBs and FCEBs.

12.1 IMPLICATIONS OF BEBS AND FCEBS ON WORKFORCE

Early data suggest that BEBs and FCEBs may require less preventative maintenance than their fossil fuel counterparts since they have fewer moving parts. However, ZEBs (particularly smaller, non-heavy-duty transit buses) are so new that there is not enough data to provide detailed insights into long-term maintenance practices for large-scale ZEB deployments in North America.

Because ZEBs have fewer moving components that can malfunction and require replacement, repair, and general maintenance, transit agencies could theoretically save on maintenance costs because: 1) fewer parts could break and need replacement (capital) and 2) less labor is needed to work on the vehicles (operating). The broader concern is related to a possible reduction in the number of maintenance staff required for a ZEB fleet vs. a traditional diesel or gasoline fleet.

Nonetheless, while a future 100% fleet of ZEBs may require a smaller complement of maintenance staff, during the transition period, it is highly improbable that a reduction in staff would be warranted. In particular, the maintenance staff of VCTC's O&M contractor is already very lean (especially for the Valley Express service) so reducing staff any further would not be feasible. Furthermore, for the Intercity fleet, diesel technicians will be required until the last diesel motorcoach is retired in 2040. Generally, fewer maintenance practices may be needed, such as oil and lube changes, but new ones may emerge, such as checking cabling and other electric motor components; at the moment, without any agency operating a ZEB for a full lifetime, it is difficult to know how maintenance practices may evolve and the full costs of maintenance, particularly outside of warranty. As technology continues to mature and become more sophisticated, technicians will need to be trained not only on machinery and high-voltage safety, but also on components that require computer and diagnostic skills.

12.2 TRAINING

BEBs

BEB manufacturers include basic training modules for bus operators and maintenance technicians that are typically included in the purchase price of the vehicle, with additional training modules and programs also available for purchase. VCTC leadership needs to work with its O&M operator and staff to understand how best to approach training for BEBs, and whether in addition to basic training from OEMs, additional training is needed.

The minimum required training recommendations are as follows for operators and maintenance technicians:

- BEB Operator training (total 56 hours)
    - Operator drive training (four sessions, four hours each)
    - Operator vehicle/system orientation (20 sessions, two hours each)

- BEB Maintenance technician training (total 304 hours)
    - Preventative maintenance training (four sessions, eight hours each)
    - Electrical/electronic training (six sessions, eight hours each)
    - Multiplex training (four sessions, each session consisting of three eight-hour days)
    - HVAC training (four sessions, four hours each)
    - Brake training (four sessions, four hours each)
    - Energy Storage System (ESS), lithium-ion battery and energy management hardware and software training (six sessions, eight hours each)
    - Electric drive/transmission training (six sessions, eight hours each)

Acquiring the following tools and safety materials should be a top priority to ensure successful in-house ZEB maintenance and management.

- Operational training module
- High voltage interface box
- Virtual training module
- High voltage insulated tools
- Insulated PPE
- Electrical safety hooks
- Arc flash clothing

Table 20 below provides a framework of potential training methods and strategies to bolster VCTC's workforce development and successfully transition to a 100% ZEB fleet.

Table 20: Potential training methods

Plan	Description
Train-the-trainer	Small numbers of staff are trained, and subsequently train colleagues. This maintains institutional knowledge while reducing the need for external training.
Bus vendor training and fueling vendor	OEM training provides critical, equipment-specific operations and maintenance information. Prior to implementing ZEB technology, VCTC staff will work with the OEMs to ensure all employees complete necessary training.
Retraining & refresher training	Entry level, intermediate, and advanced continuous learning opportunities will be offered to all VCTC staff.
ZEB training from other transit agencies	VCTC should leverage the experience of agencies who were early ZEB adopters, such as the ZEB University program offered by AC Transit as well as local partner agencies like GCTD and Thousand Oaks
National Transit Institute (NTI) training	NTI offers zero-emissions courses such as ZEB management and benchmarking and performance.

Plan	Description
Local partnerships and collaborations	VCTC could work with local schools to showcase potential careers in bus and facilities management to students; GCTD is exploring this method
Professional associations	Associations such as the Zero Emission Bus Resource Alliance offer opportunities for sharing and lessons learned across transit agencies.

The priority in maintenance needs will be the issue of safety in dealing with high-voltage systems. All maintenance personnel in the garage, whether doing servicing, inspection, or repairs and those in other routines (e.g., plugging and unplugging BEBs), must be educated on the characteristics of this technology. One essential component is the provision and mandate of additional Personal Protective Equipment (PPE) beyond that which is required by automotive garage workplace legislated standards or VCTC's policies. Examples of such apparel include high voltage insulated work gloves, flame retardant clothing, insulated safety footwear, face shields, special insulated hand tools, and grounding of apparatus that staff may be using. Also, procedures in dealing with accidents and injuries must be established with instructions and warning signs posted.

Current BEBs also contain on-board communication systems, which are helpful in providing detailed bus performance data and report error messages, which can assist maintenance personnel in quickly identifying and diagnosing maintenance issues.

In addition, agencywide orientation to familiarize the agency with the new technology should also be conducted prior to the first BEBs deployment.

FCEBs

In the case of an FCEB implementation, the presence of hydrogen gas and the safety issues that relate to this would need to be addressed as well as any differences to gauges and instrumentation. An overview training of the technology would also be included. An additional increment of time beyond just the vehicle layout and driving characteristics needs to be added to training sessions to address the technology and unique safety considerations. Additional training time for different start-up and shut-down procedures and proper procedures regarding what to do if there is a failure on route should be accounted for as well.

Maintenance staff would need to be trained on safety, scheduled maintenance, diagnostics, and repair of multiple systems that may be new to them. While a smaller high voltage battery installation is present and may require inspection and eventual changeout, the inspection and diagnosis of hydrogen fuel cell apparatus may be necessary.

According to the statewide contract procurement from ZEB OEMs, FCEB technicians should receive training on:

- Hydrogen systems, including fuel cell engine
- Hydrogen fuel system

- Hydrogen detection and fire suppression systems
- Hydrogen cooling system package

In addition to this training before putting FCEBs in operation, refresher modules should be required of ongoing training for maintenance staff and technicians. Furthermore, newly hired maintenance staff and technicians should also receive training and orientation on both technologies until VCTC phases out fossil fuel-powered vehicles.

Coordination with Emergency Responders

There are two important and related conversations and planning actions that must occur between VCTC and emergency responders—first, the ability of VCTC to provide emergency transportation services during emergencies or disasters and implications of transitioning to alternative fuels, and second, the need to have local fire and emergency response departments aware and prepared for responding to potential bus fires related to batteries and electric components.

As described throughout this report, ZEBs have shorter operating ranges and BEBs in particular not only have shorter operating ranges than fossil fuel buses, but they also take much longer to refuel. As such, VCTC and respective emergency responders need to collaborate to identify how a BEB fleet may change expectations for major incidents and disaster support to improve recovery services. Emergency response plans should re-evaluate evacuation responsibilities especially in light of capabilities/requirements of an electrified fleet. Furthermore, if VCTC explores portable chargers or generators, VCTC should collaborate with emergency responders to determine the location of such infrastructure and susceptibility to natural disasters in order to minimize risks.

Bus fires due to battery explosions or other accidents are a concern with the adoption of ZEBs. Following recommendations from the Transportation Emergency Preparedness Plan (TEPP), as infrastructure and vehicles are added to each operator within the County, the Vehicle Inventory should be updated. Training and exercises should also be prioritized for all non-transit staff that may come into contact in some shape or form with these ZE technologies. Communication protocols should also be updated as it relates to incidents that occur with the ZE technologies. It is highly recommended that VCTC coordinate with all local fire and emergency response departments. This can include reaching out to the fire marshal and other authorities having jurisdiction (AHJs) to inform these agencies about the storage, layout, componentry, safety devices, and other features of ZEBs. This coordination with fire and emergency responders should reoccur every few years, but the specific frequency can be dependent on agency discretion. Important safety precautions and warnings should be installed in the appropriate locations in the facility and more information can be found on NFPA's website for emergency response guides for different OEMs[42].

[42] https://www.nfpa.org/Training-and-Events/By-topic/Alternative-Fuel-Vehicle-Safety-Training/Emergency-Response-Guides

13.0 POTENTIAL FUNDING SOURCES

As a cost driver for transit agencies, funding the ZE transition will require external financial aid. Due to the long timeframe over which buses will be procured and potential infrastructure will be constructed, it is imperative that VCTC constantly monitors existing funding and financing opportunities and is aware of when new sources are created. Below are major current programs available for ZEB transition (Table 21).

Table 21: Grants and potential funding options for ZEB transition

Type	Agency	Fund/Grant/Program	Description	Applicability & Details
Federal	Federal Transit Administration (FTA)	Low or No Emission Program (Low-No Program) (5339(c))	Low-No provides competitive funding for the procurement of low or no emission vehicles, including the leasing or purchasing of vehicles and related supporting infrastructure. This has been an annual program under the FAST Act since FY2016 and is a subprogram of the Section 5339 Grants for Bus and Bus Facilities. There is a stipulation for a 20% local match.	In FY2022 the FTA awarded $1.6 billion to 150 projects for the Low-No program.[43] $1.7 billion has been announced for FY2023 projects.[44]
Federal	Federal Transit Administration (FTA)	Buses and Bus Facilities Program (5339(a) formula, 5339(b) competitive)	Grants applicable to rehab buses, purchase new buses, and invest and renovate related equipment and facilities for low or no emission vehicles or facilities. A 20% local match is required.	FY2022 5339 funding totaled $372 million in grants. $469.4 million has been announced for FY2023 grants.[45]
Federal	Federal Transit Administration (FTA)	Urbanized Area Formula Grants (5307)	5307 grant funding makes federal resources available to urbanized areas for transit capital and operating assistance. Eligible activities include capital investments in bus and bus-related activities such as replacement, overhaul and rebuilding of buses. The federal share is not to exceed 80% of the net project cost for capital expenditures. The federal share may be 90% of the cost of vehicle-related equipment attributable to compliance with the Clean Air Act.	Typically, the MPO or another lead public agency is the direct recipient of these funds and distributes these to local transit agencies based on TIP allocation. Agencies can allocate these funds for the purchase of ZEBs.
Federal	Department of Transportation (DOT)	Rebuilding American Infrastructure with Sustainability and Equity (RAISE)	Previously known as BUILD and TIGER, RAISE is a discretionary grant program aimed to support investment in infrastructure. RAISE funding supports planning and capital investments in roads, bridges, transit, rail, ports, and intermodal transportation. A local match is required.[46]	FY2022 provided $2.2 billion in RAISE grants to 166 projects with a stipulation requiring 50% of funding for projects in rural areas. In FY2023, $1.5 billion in funding was announced for the RAISE Grant Program.[47]
State	California Air Resources Board (CARB)	Hybrid and Zero-Emission Truck and Bus Voucher Incentive Program (HVIP)	Voucher program created in 2009 aimed at reducing the purchase cost of zero-emission vehicles. A transit agency would decide on a vehicle, contact the vendor directly, and then the vendor would apply for the voucher. Voucher rebates vary by vehicle type and model.[48]	$65 million in transit funding for the FY22-23 year was announced in November 2022.[49] Hydrogen fuel cell vehicles are eligible for HVIP but must not have plug-in capacity.[50]

43 https://www.transit.dot.gov/funding/grants/fy22-fta-bus-and-low-and-no-emission-grant-awards
44 https://www.transit.dot.gov/about/news/biden-harris-administration-announces-availability-nearly-17-billion-modernize-fleets
45 https://www.transit.dot.gov/bus-program
46 https://www.transportation.gov/RAISEgrants/about
47 RAISE Discretionary Grants | US Department of Transportation
48 https://californiahvip.org/vehiclecatalog/
49 https://californiahvip.org/funding
50 https://californiahvip.org/wp-content/uploads/2022/03/HVIP-FY21-22-Implementation-Manual-03.15.22.pdf

Type	Agency	Fund/Grant/Program	Description	Applicability & Details
State	California Air Resources Board (CARB)	Carl Moyer Memorial Air Quality Standards Attainment Program	The Carl Moyer Program provides funding to help procure low-emission vehicles and equipment. It is implemented as a partnership between CARB and local air districts (in the case of Ventura County, the Ventura County Air Pollution Control District, or VCAPCD[51]).	Transit buses are eligible for up to $80,000 funding. $52 million has been awarded to Ventura County businesses through the program since 1999. In March 2022, the Ventura County Air Pollution Control Board approved 21 new grants totaling over $2.8 million.[52]
State	California Air Resources Board (CARB)	Low Carbon Fuel Standard (LCFS) Program	LCFS credits are not necessarily funding to be applied for; rather, they are generated credits which can be sold on the LCFS market. The program is based upon carbon intensity standards set by CARB and the LCFS program which allows users who incur a deficit from polluting above the standard can purchase credits from those users operating below the standard.	Chargers or equipment for hydrogen production must be registered with the LCFS program to be eligible for credit generation. The CARB set price of $221.76 per credit in 2021 has created a price ceiling with most credits trading around $200 per credit. Both hydrogen and electricity used as fuels are eligible for LCFS credits.
State	California Air Resources Board (CARB)	Volkswagen Environmental Mitigation Trust Funding	VW's settlement provides nearly $130 million for zero-emission transit, school, and shuttle bus replacements.	Transit may be eligible for up to $65 million. Applications are open for transit agencies and are processed on a first come, first serve basis. Maximum: $400,000 per FCEB and maximum of $3,250,000 total funding per agency.[53]
State	California Air Resources Board (CARB)	Sustainable Transportation Equity Project (STEP)	STEP was a pilot that took a community-based approach to overcoming barriers to clean transportation. The future of STEP is currently being determined by CARB and stakeholder groups through the FY22-23 Funding Plan and Three-Year Plan for Clean Transportation Incentives.[54]	There are two different grant types: Planning and Capacity Building Grants (up to $1.75 million for multiple grantees) and Implementation Grants (up to $17.75 million for between one and three grantees). Lead applicants must be a CBO, federally-recognized tribe, or local government representing a public transit agency. Award amounts ranged from $184,000 to a maximum of over $7 million.[55]
State	California Transportation Commission (CTC)	SB1 Local Partnership Program (LPP)	The Local Partnership Program provides funding to counties, cities, districts and regional transportation agencies to improve aging infrastructure, road conditions, active transportation, transit and rail, and health and safety benefits. Funds are distributed through competitive and formulaic components.[56]	To be eligible, counties, cities, districts, and regional transportation agencies must have approved fees or taxes dedicated solely to transportation improvements. $200 million is available annually.[57]
State	California Transportation Commission (CTC)	Solutions for Congested Corridors Program (SCCP)	The SCCP includes programs with both formula and competitive funds. Funding is available to projects that make specific performance improvements and are a part of a multimodal comprehensive corridor plan designed to reduce congestion in highly traveled corridors by providing more transportation choices for residents, commuters, and visitors.	Improvements to transit facilities are eligible projects. Cycle 2 funding of $500 million covers two years (FY2022 and FY2023). To submit a SCCP application, the applicant needs to know exactly what sources will be funding the project and when the funds will be used, as well as which project phase they will be used for. Total estimated funding: $500 million for FY22-23.[58]

[51] http://www.vcapcd.org/grant_programs.htm
[52] VCAPCD - Grants / Incentive Programs
[53] http://vwbusmoney.valleyair.org/documents/FAQ.pdf
[54] https://ww2.arb.ca.gov/lcti-step
[55] https://ww2.arb.ca.gov/news/grant-awards-announced-new-195-million-pilot-funding-equitable-clean-transportation-options
[56] https://catc.ca.gov/programs/sb1/local-partnership-program
[57] https://www.vcstar.com/story/news/local/2021/10/22/group-proposing-transit-sales-tax-measure-countys-2022-ballot/5988391001/
[58] https://www.grants.ca.gov/grants/solutions-for-congested-corridors-program/

Type	Agency	Fund/Grant/Program	Description	Applicability & Details
State	California Department of Transportation (Caltrans)	SB1 State of Good Repair (SGR)	SGR funds are formula funds eligible for transit maintenance, rehabs, and capital programs. Agencies receive yearly SB1 SGR funding through their MPO, based on population and farebox revenues.	Agencies can decide to devote its portion of SB 1 funds to ZEB transition.
State	California Department of Transportation (Caltrans)	Low Carbon Transit Operations Program (LCTOP)	The LCTOP provides capital assistance to transit agencies in order to reduce greenhouse gas emissions and improve mobility. 5% and 10% of the annual Cap and Trade auction proceeds fund this program.	Many agencies are already recipients of these funds and can use these funds to purchase ZEBs and related equipment.
State	California Department of Transportation (Caltrans)	Transit and Intercity Rail Capital Program (TIRCP)	The TIRCP was created to fund capital improvements that reduce emissions of greenhouse gases, vehicle miles traveled, and congestion through modernization of California's intercity, commuter, and rail, bus, and ferry transit systems.[59]	The five cycles of TIRCP funding have awarded $6.6 billion in funding to nearly 100 projects throughout California. In 2022, Santa Barbara Metropolitan Transit District received $14.5 million to procure 8 battery electric buses and 3 electric micro transit vans as well as fund for general transit improvements and facility improvements at two terminals.[60]
State	California Department of Transportation (Caltrans)	State Transportation Improvement Program (STIP)	The STIP is a five-year plan for future allocations of certain state transportation funds including state highway, active transportation, intercity rail, and transit improvements. The STIP is updated biennially in even-numbered years.[61]	ZEB procurement could compete for STIP funding. The 2022 STIP was adopted in March 2022 and included $796 million in available funding.[62] Funding is distributed via a formula for a variety of projects.
State	California Department of Transportation (Caltrans)	Transportation Development Act (Mills-Alquist-Deddeh Act (SB 325))	The TDA law provides funding to improve existing public transportation services and encourage regional transportation coordination. There are two funding sources: the Local Transportation Fund (LTF) and the State Transit Assistance (STA) fund.[63]	Funding opportunities include transportation program activities, pedestrian and bike facilities, community transit services, public transportation, and bus and rail projects.
State	California Department of Transportation (Caltrans)	Clean Transportation Program (Alternative and Renewable Fuel and Vehicle Technology Program)	The California Energy Commission's Clean Transportation Program provides funding to support innovation and acceleration of development and deployment of zero-emission fuel technologies. A local match is often required.	The Clean Transportation Program provides up to $100 million annually for a variety of renewable and alternative fuel transportation projects throughout the state, including specific projects for heavy-duty public transit buses. Current program funding is being allocated for FY22-23 and the first half of FY23-24. In 2021, between $4 million and $6 million were awarded to the following transit agencies to assist with zero-emission transit fleet infrastructure deployment: Anaheim Transportation Network ($5 million), LADOT ($6 million), Sunline Transit ($5 million), and North County Transit District ($4 million)

59 https://calsta.ca.gov/subject-areas/transit-intercity-rail-capital-prog
60 https://calsta.ca.gov/-/media/calsta-media/documents/tircp---program-of-projects-as-of-july-2022---cycle-5-only-a11y.pdf
61 https://catc.ca.gov/programs/state-transportation-improvement-program
62 https://catc.ca.gov/-/media/ctc-media/documents/programs/stip/2022-stip/2022-adopted-stip-32522.pdf
63 https://dot.ca.gov/programs/rail-and-mass-transportation/transportation-development-act

Type	Agency	Fund/Grant/Program	Description	Applicability & Details
State	California Department of Housing and Community Development	Affordable Housing and Sustainable Communities Program (AHSC)	The AHSC Program funds land use, housing, and transportation projects to support development that reduces GHG emissions. The program provides both grants and loans that reduce GHG emissions and benefit disadvantaged communities through increasing accessibility via low-carbon transportation. $405 million in available funds was announced in 2021.[64] The maximum award amount is not to exceed $30 million per project, with a minimum award of at least $1 million.[65]	Sustainable transportation infrastructure projects, transportation-related amenities, and program costs (including transit ridership) are eligible activities. Agencies can use program funds for assistance in construction or modification of infrastructure for ZEB conversion as well as new vehicle purchases.
State	California Climate Investments	Clean Mobility Options (CMO) Voucher Pilot Program	CMO awards up to $1 million vouchers to develop and launch zero-emission mobility projects including the purchase of zero-emission vehicles, infrastructure, planning, outreach, and operations projects in low-income and disadvantaged communities.[66] Funding is limited.	In 2020, the CMO Voucher Pilot Program awarded $20 million worth of mobility project vouchers, with $18 million going to eligible under-resourced communities. For example, the City of Chula Vista received funding to launch an on-demand community shuttle service in northwest Chula Vista using four electric vehicles. Also, Fresno County Rural Transit Agency is on a wait list to potentially receive $36,885 in funding.
State	California Pollution Control Financing Authority (CPCFA)	Medium-Heavy-Duty (MHD) Zero Emission Vehicle Financing Program	The CPCFA is developing a purchasing assistance program for MHD ZEV fleets. This will provide financial support and technical assistance to fleet managers deploying ZEV fleets. The program was established on January 1, 2023.[67]	CPCFA will designate high priority fleets based on implications for climate change, pollution, environmental justice, and post-COVID economic recovery. A minimum of 75% of financing must be directed towards fleets that directly impact or operate in underserved communities.
State	California Department of Transportation	Transportation Development Credits	Although they are not funds for projects, Transportation Development Credits, also called “Toll Credits”, satisfy the federal government requirement to match federal funds.[68]	Toll credits provide a credit toward a project’s local share for certain expenditures with toll revenues. FHWA oversees the toll credits within each state.[69]
Utility	Southern California Edison (SCE)	Charge Ready Transport (CRT)	SCE provides utility distribution service upgrades to support the installation of charging equipment and provides rebates to participants for the purchase and installation of approved EV charging equipment.	SCE customers must lease or purchase a minimum of two EV, purchase and install SCE-approved charging equipment, and maintain charging equipment for at least five 10 years. Data sharing requirement for five years as well as grant easements depending on the build option.
Ventura County	Ventura County Air Pollution Control District (VCAPCD)	Clean Air Fund (CAF)	The CAF provides financial support for projects that reduce emissions of greenhouse gases and the global warming impact of carbon emissions via mitigation.[70]	Approximately $25,000 is available for project funding each year on January 1st. Projects are reviewed and recommended based on their ability to reduce air pollution in Ventura County.
	Ventura County Regional Energy Alliance (VCREA)	EV Ready Communities Challenge Grant: Ventura County EV Blueprint	VCREA and Community Environmental Council (CEC) are creating an EV Ready Blueprint for electrifying transportation in Ventura County.[71]	Eligibility for a second phase of funding through this program will be granted and would go towards EV charging installations in Ventura County if the Blueprint project is completed.

64 https://www.hcd.ca.gov/grants-funding/active-funding/ahsc/docs/final_ahsc_nofa_round_6.pdf
65 https://www.hcd.ca.gov/affordable-housing-and-sustainable-communities#:~:text=Communities%20Program%20(AHSC)-,Affordable%20Housing%20and%20Sustainable%20Communities%20Program%20(AHSC),(%22GHG%22)%20emissions
66 https://cleanmobilityoptions.org/about/#
67 https://afdc.energy.gov/laws/12858
68 https://dot.ca.gov/-/media/dot-media/programs/rail-mass-transportation/documents/f0010121-toll-credit-fact-sheet.pdf
69 https://dot.ca.gov/-/media/dot-media/programs/rail-mass-transportation/documents/f0009899-2-toll-credits-fact-sheet-a11y.pdf
70 http://www.vcapcd.org/pubs/Incentive-Programs/What-is-the-Clean-Air-Fund-Program.pdf
71 https://www.vcenergy.org/electric-vehicle-blueprint/

An important source of potential funding is the FTA's Low-No funding opportunity. In December 2021, the FTA released a Dear Colleague letter outlining new requirements for Low-No and Bus and Bus Facility Grant Applications. The letter details the requirement for a Zero-Emission Fleet Transition plan in response to amendments in the statutory provisions for these programs as part of the Bipartisan Infrastructure Law. The FTA Zero-Emission Fleet Transition plan includes six major elements, presented in Table 22. Moving forward, to qualify for these funding opportunities, a transit agency must include a transition plan with these elements. VCTC can use much of the material in the ZEB Rollout Plan document to develop a ZE Fleet Transition Plan to comply with the FTA's requirements[72].

Table 22: FTA Zero-Emission Fleet Transition Plan Requirements

Element	Description
1: Long-Term Fleet Plan and Application Request	Demonstrate a long-term fleet management plan with a strategy for how the applicant intends to use the current application and future acquisitions.
2: Current and Future Resources to Meet Transition	Address the availability of current and future resources to meet costs for the transition and implementation
3: Policy and Legislative Impacts	Consider policy and legislation impacting relevant technologies.
4: Facility Evaluation and Needs for Technology Transition	Include an evaluation of existing and future facilities and their relationship to the technology transition.
5: Utility Partnership	Describe the partnership of the applicant with the utility or alternative fuel provider.
6: Workforce Training and Transition	Examine the impact of the transition on the applicant's current workforce by identifying skill gaps, training needs, and retraining needs of the exiting workers of the applicant to operate and maintain ZEVs and related infrastructure and avoid displacement of the existing workforce.

[72] To view a list of winners and projects, please see https://www.transit.dot.gov/funding/grants/fy22-fta-bus-and-low-and-no-emission-grant-awards

14.0 SERVICE IN DISADVANTAGED COMMUNITIES

CARB defines Section F of the rollout plan as “Providing Service in Disadvantaged Communities” based on disadvantaged communities as identified by CalEnviroScreen, an online mapping tool developed by the Office of Environmental Health Hazard Assessment (OEHHA). The tool identifies (at the census tract level) the state’s most pollution-burdened and vulnerable communities based on geographic, socioeconomic, public health, and environmental hazard criteria.

ICT provisions require that transit agencies describe how they are planning to deploy ZEBs in disadvantaged communities by outlining the location of the disadvantaged community (census tract) where the ZEB will be deployed, how many ZEBs, and in what year the ZEBs will be deployed.

Figure 38 shows that there are eight census tracts that are classified as ‘disadvantaged communities’ according to CalEnviroScreen 4.0, and Table 23 details the routes that operate within or touch these census tracts.

Figure 38: CalEnviroScreen disadvantaged communities in VCTC service area

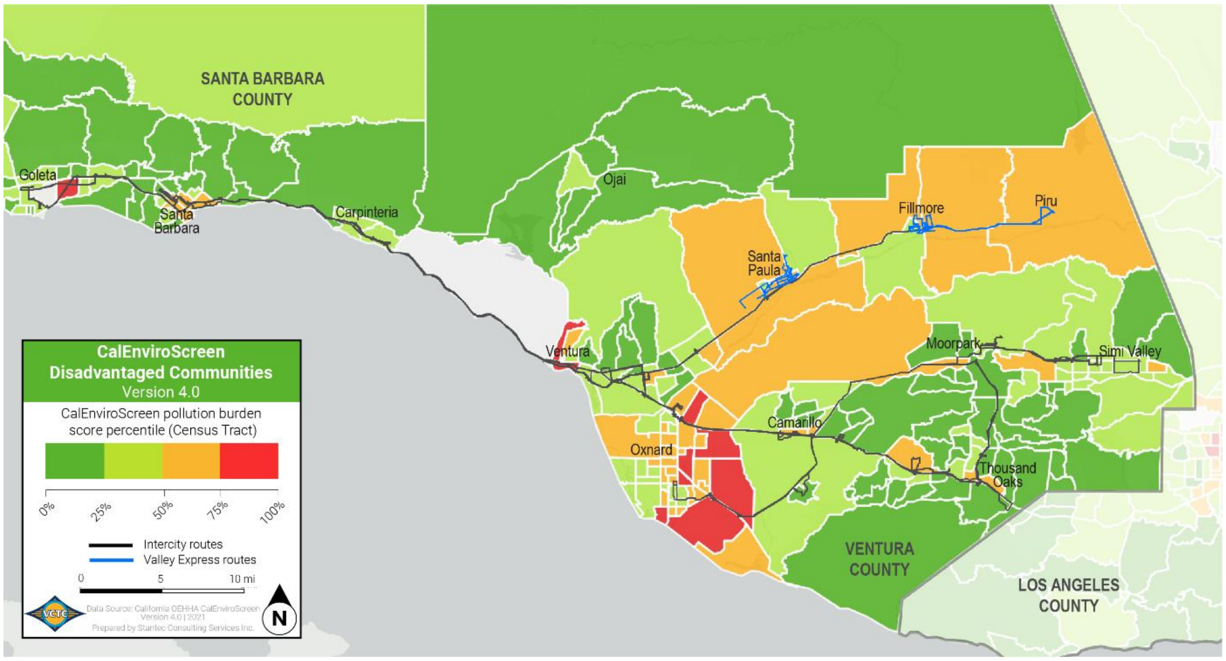


Table 23: Disadvantaged communities - census tracts and routes

Census tract	Approx. Geographic Area	Intercity Route(s)
6083003001	Goleta (Santa Barbara County)	84u, 85, 85c, 86, 87, 88, 89

Census tract	Approx. Geographic Area	Intercity Route(s)
6111002300	Ventura (Ventura County)	80, 80c, 81, 81b, 84, 84u, 85, 85c, 87, 88, 89
6111002400	Ventura (Ventura County)	50, 52, 60, 80, 80c, 80x, 81, 81b, 84, 84u, 85, 85c, 86, 87, 88, 89
6111004704	Oxnard (Ventura County)	90, 99
6111004715	Oxnard (Ventura County)	90, 99
6111003900	Oxnard (Ventura County)	90, 99
6111004902	Oxnard (Ventura County)	77, 80, 80c, 81, 81b, 84, 84u, 85, 85c, 86, 87, 89
6111005003	El Rio (Ventura County)	50, 52, 52x, 77, 80, 80c, 81, 81b, 84, 84u, 85, 85c, 86, 87, 89

Due to the dispersed nature of the tracts throughout the service area, almost every Intercity route serves or passes through a disadvantaged community. To make the biggest positive impact on disadvantaged communities in the service area, VCTC should prioritize ZEB deployment along routes 80 to 89, as these routes serve the most disadvantaged communities in the service area if technically and financially feasible. And while none of the census tracts served by Valley Express are classified as disadvantaged under this definition, deployment of ZEBs through these communities will help to reduce pollution and improve air quality.

15.0 GHG IMPACTS

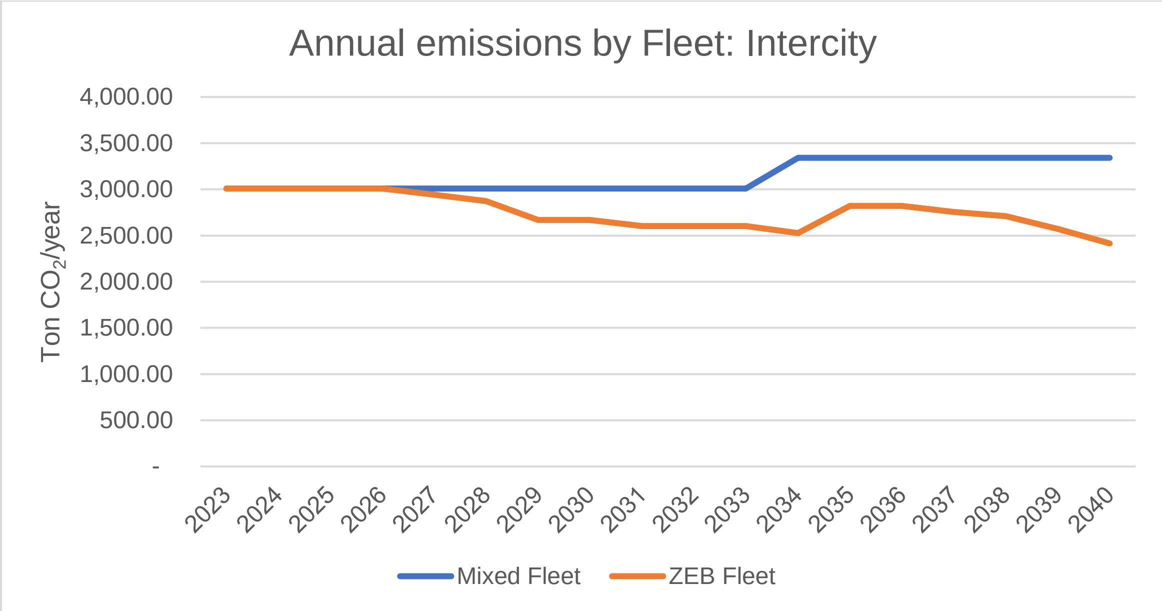
ZEVDecide greenhouse gas emissions (GHG) modeling determines the total difference in emissions between a ZEB fleet and non-ZEB/conventional fleet through to full ZEB implementation to understand the cumulative difference in total emissions. In other words, the model calculates the total emissions (inclusive of both upstream and tailpipe) between 2023 and 2040 under a ZEB Case scenario using the fleet transition schedule presented in Section 6.0 and compares that to the total emissions of a fleet scenario in which VCTC does not procure ZEBs and instead continues to procure diesel and gasoline vehicles.

By operating ZEBs, VCTC will be able to completely eliminate tailpipe GHGs and other harmful emissions, providing a clean, quiet ride for operators and passengers, while also eliminating emissions linked to respiratory diseases from the neighborhoods VCTC serves. Nonetheless, the current production of hydrogen does result in GHG emissions and is not a completely 'carbon-free' process. Residual GHGs resulting from the carbon-intensity of generating hydrogen through a process that is 33% green (carbon neutral) and the remainder via SMR, means that significant upstream emissions are associated with hydrogen in the short term. It is expected for hydrogen production to become cleaner over time; a 5% annual reduction in emissions related to hydrogen production can be expected beginning in 2030. To maintain conservative estimates, this was not integrated into the modeling, but it can be expected that the actual emissions VCTC sees through 2040 will be lower than the conservative estimates presented here.

Based on this modeling, VCTC's Intercity fleet will emit a total of 49,610 tons of CO_2 between now and 2040 as it transitions to FCEBs, compared to 56,482 tons of CO_2 if VCTC did not procure FCEBs and instead continued to procure diesel motorcoaches[73] (**Error! Reference source not found.**). The 2034 i ncrease in emissions seen in both the ZEB and Mixed fleets corresponds to the five BE motorcoaches being replaced with hydrogen coaches (diesel for Mixed fleet), which have higher upstream emissions compared to BEBs. On average, the ZEB fleet will produce 382 fewer tons CO_2 per year starting in 2027. The Intercity fleet will begin to see zero tailpipe emissions beginning in 2040 when the fleet is entirely transitioned to FCEBs. In total, transitioning to a ZEB fleet will reduce Intercity's GHG emissions by 6,872 tons of CO_2 by 2040. Once fully transitioned, the Intercity fleet will produce 927 fewer tons CO_2 per year compared to the diesel fleet.

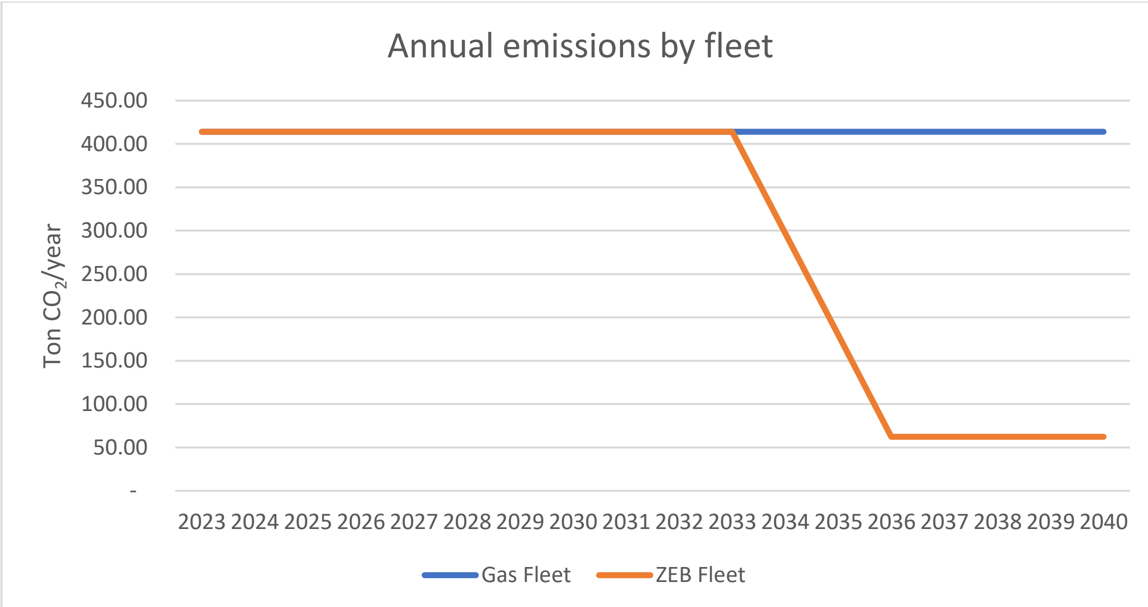
[73] All GHG calculations are presented in tons (not metric tons) of CO_2 equivalent, which is calculated using the short-term 20-year global warming potential of CO_2, methane, black carbon, and particulate matter.

Figure 39: Annual emissions by fleet comparison: Intercity



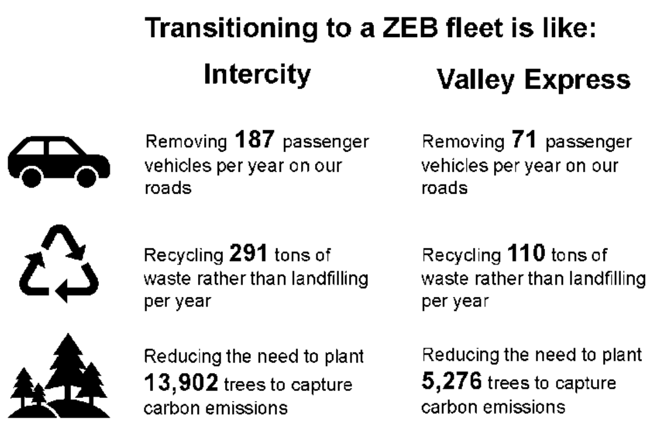
VCTC's Valley Express fleet will emit a total of 5,343 tons of CO_2 as it transitions to BE cutaways, compared to a total of 7,453 tons if it maintained a gasoline fleet (Figure 40), a 30% reduction. The fleet will begin to see zero tailpipe emissions in 2036 when the fleet is entirely transitioned to BE cutaways. In total, transitioning to a BEB fleet will reduce Valley Express GHG emissions by a total of 2,110 tons of CO_2 by 2040. Once transitioned to BE cutaways in 2036, 352 tons CO_2 emissions will be avoided each year.

Figure 40: Annual emissions by fleet comparison: Valley Express



As presented in Figure **41**, implementing a ZEB fleet across both Intercity and Valley Express services will annual eliminate emissions equivalent to removing emissions from 258 passenger vehicles per year, recycling 401 tons of waste per year rather than landfilling, or reducing the need to plant over 19,000 trees to capture carbon emissions[74].

Figure 41: Equivalent benefits of implementing a ZEB fleet at VCTC



[74] https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator

16.0 OTHER TRANSITION ITEMS

16.1 JOINT ZEB GROUP AND ASSESSMENT OF MULTI-OPERATOR VEHICLE PROCUREMENT

According to the ICT regulation, transit agencies can pool resources when acquiring ZEB infrastructure if they:

- Share infrastructure
- Share the same MPO, transportation planning agency, or Air District
- Are located within the same Air Basin

The Southern California Association of Governments (SCAG) is the MPO for Ventura County and provides regional transportation funding and planning for Ventura County, Los Angeles County, Orange County, Imperial County, Riverside County, and San Bernardino County. VCTC's service area is located within the Ventura County APCD and South-Central Coast Air Basin. Table 24 lists the agencies that operate fixed route transit services within Ventura County. These agencies also are within the same air basin and air district. While VCTC could theoretically partner with any transit agency in the SCAG region, the list was limited to Ventura County due to geographic proximity and service area overlaps that could make a joint group feasible and beneficial.

Table 24: Other bus transit agencies in Ventura County

Agency	Total revenue vehicles[75]	ZEB Choice	Notes
Ventura County Transportation Commission[76]	***56***	***FCEB and BEB***	
Gold Coast Transit District	87	FCEB	GCTD will begin construction on the hydrogen fueling facility in 2023/2024 and plans to collaborate with VCTC for hydrogen fueling
Thousand Oaks Transit[77]	38	BEB	Currently developing a ZEB plan and is open to collaborating with BEB charging at locations like the Thousand Oaks Transportation Center

75 Based on NTD 2021 data.
76 Includes both Valley Express Bus and VCTC Intercity.
77 Also includes Kanan Shuttle and ECTA InterCity Dial-A-Ride.

Agency	Total revenue vehicles[75]	ZEB Choice	Notes
Simi Valley Transit	21	BEB	2019 SRTP notes BEBs are the likely technology option, but a full ZEB study is recommended.
Camarillo Area Transit	19	TBD	VCTC and Camarillo are exploring joint charging opportunities in Camarillo
Moorpark City Transit	5	BEB	Partnering with TOT for transition planning
Ojai Trolley	6	BEB	

VCTC and GCTD have formed a strategic partnership as GCTD is keen to have VCTC fuel at its future hydrogen fueling facility in Oxnard. Beyond working with transit agencies in Ventura County, VCTC needs to explore potential non-transit partners for charging infrastructure for the BEBs in the Valley Express fleet, such as municipal agencies.

Beyond Ventura County, VCTC and SBCAG are regular collaborators given their common goals of reducing car travel and encouraging transit use, particularly for cross county trips between Santa Barbara County and Ventura County along the 101 Freeway. SBCAG used its prior grant money to fund the purchase of 5 BYD BEBs for VCTC, as discussed throughout this report.

Regardless of whether it makes sense to explore formation of a joint ZEB group or not, VCTC should remain in constant communication with other Ventura County agencies to understand how the agencies can work together to leverage resources and coordinate efforts on a regional level, learn from one another's experiences during ZEB adoption, and potentially pursue joint grant opportunities for ZEB vehicles and infrastructure.

Another recommended strategy is developing a multi-operator vehicle procurement group. That is, VCTC could join with any of the agencies outlined above to produce common specifications for ZEBs, specifically for cutaways, thus potentially driving down the purchase costs of ZEBs. Leveraging joint procurement through the CalACT/MBTA purchasing cooperative is a prudent approach, as the Cooperative offers a variety of ADA-compliant vehicles like vans and cutaways; currently, ZE options are limited, however. Most judiciously, VCTC and other operators may wish to encourage OEMs to develop vehicles with longer ranges and more hydrogen options, especially vehicle types like cutaways and motorcoaches.

16.2 CHANGE MANAGEMENT

Because a ZEB transition and implementation is an agencywide endeavor that also includes the need to actively consider utilities as a stakeholder and partner, an agencywide approach is required. It would be prudent for VCTC to form a steering committee or task force to guide the transition to ZEBs and this may require additional VCTC staff to serve as a program or project manager. Communication will be critical during the transition to ensure customers are made aware of potential disruptions and changes to bus operations. ZEB conversion also offers an excellent marketing opportunity for VCTC to promote its climate and clean air commitments.

17.0 PHASING AND IMPLEMENTATION

Table 25 provides an overview of the phasing plan for VCTC's ZEB rollout strategy. Note that expenses are in the year of cost incurred. See Section 6.0 for more details regarding the fleet replacement schedule.

This plan is a living document that is intended to provide a practical framework for VCTC to deploy and transition to ZEBs in response to CARB's mandate. Like any other strategic plan, the implementation and transition plan should be revisited and adjusted in response to funding realities, changes in service delivery, and the needs of VCTC and its ridership, particularly given the long-term (~20 years) outlook.

Table 25: ZEB implementation phasing plan, FY2023-2040

Year	Intercity ZEB Fleet Procurements	Intercity Capital Costs (2023$)	Intercity O&M Costs (2023$)	Intercity Total (2023$)	Valley Express ZE Fleet Procurements	VE Capital Costs (2023$)	VE O&M Costs (2023$)	VE Total (2023$)	VCTC Grand Total (2023$)	Infrastructure Notes
FY2023	N/A	$0	$2,410,000	$2,410,000	N/A	$0	$536,000	$536,000	$2,946,000	Intercity – Potential deployment of BEB motorcoach chargers and related equipment in Camarillo
FY2024	N/A	$0	$2,352,000	$2,352,000	N/A	$0	$518,000	$518,000	$2,870,000	
FY2025	N/A	$1,968,000	$2,265,000	$4,233,000	N/A	0	$498,000	$2,674,000	$6,907,000	
FY2026	N/A	$1,255,000	$2,183,000	$3,438,000	N/A	$0	$480,000	$480,000	$3,918,000	Intercity – Potential facility modifications for gas leak detection and other precautions for hydrogen technologies
FY2027	3 FCEB motorcoaches	$7,063,000	$2,079,000	$9,142,000	N/A	$0	$463,000	$463,000	$9,605,000	
FY2028	3 FCEB motorcoaches	$7,288,000	$1,972,000	$9,260,000	N/A	$0	$447,000	$447,000	$9,707,000	
FY2029	9 FCEB motorcoaches	$9,266,000	$1,803,000	$11,069,000	N/A	$0	$431,000	$431,000	$11,500,000	
FY2030	N/A	$0	$1,724,000	$1,724,000	N/A	$0	$417,000	$417,000	$2,141,000	
FY2031	3 FCEB motorcoaches	$2,776,000	$1,675,000	$4,451,000	N/A	$0	$420,000	$420,000	$4,871,000	
FY2032	N/A	$0	$1,604,000	$1,604,000	N/A	$0	$404,000	$404,000	$2,008,000	
FY2033	NA	$46,000	$1,541,000	$1,587,000	N/A	$0	$390,000	$390,000	$1,977,000	Valley Express – Deployment of BEB cutaway chargers and related equipment
FY2034	NA	$43,000	$1,475,000	$1,518,000	5 BEB cutaways	$1,048,000	$327,000	$1,375,000	$2,891,000	
FY2035	5 FCEB motorcoaches	$3,899,000	$1,433,000	$5,332,000	5 BEB cutaways	$999,000	$268,000	$1,267,000	$6,596,000	
FY2036	NA	$0	$1,371,000	$1,371,000	5 BEB cutaways	$953,000	$212,000	$1,165,000	$2,532,000	
FY2037	3 FCEB motorcoaches	$2,086,000	$1,277,000	$3,363,000	N/A	$0	$203,000	$203,000	$3,563,000	
FY2038	2 FCEB motorcoaches	$1,301,000	$1,199,000	$2,500,000	N/A	$0	$196,000	$196,000	$2,692,000	
FY2039	9 FCEB motorcoaches	$5,569,000	$1,078,000	$6,647,000	N/A	$0	$188,000	$188,000	$6,832,000	
FY2040	10 FCEB motorcoaches	$5,888,000	$953,000	$6,841,000	N/A	$0	$181,000	$181,000	$7,019,000	

APPENDIX A: COST ESTIMATES

Please see attached cost estimates.

APPENDIX B: FINANCIAL MODELING INPUTS AND ASSUMPTIONS

Table 26 presents a description as well as the sources for the cost inputs (in 2023$) of the Intercity Base Case and ZEB Case.

Table 26: Summary of cost inputs (Intercity)

Main Category	Item	Description	Inputs for Base Case	Additional Inputs for ZEB Case	Sources and comments
Capital					
Fleet acquisition	Bus purchase price	Purchase price of a bus/vehicle inclusive of options and extended warranty	Diesel motorcoach: $717,000 BEB motorcoach: $1,200,000	Hydrogen motorcoach: $1,500,000	Diesel motorcoach: Group TAM plan BEB motorcoach: Prior Stantec projects Hydrogen motorcoach: Stantec estimate
Fleet refurbishment	Mid-life rehabs	Any heavy mid-life work needed to achieve the useful life minimum benchmark	N/A	Hydrogen motorcoach: $30,000 for fuel cell replacement	Stantec estimate based on Ballard information
Operating					
Operating	Vehicle fuel	Cost of fuel commodity for revenue vehicles	Diesel: $4.61/gallon Electricity: $0.1835/kWh	Hydrogen: $6/kg	Diesel: Weighted average of July to December 2022 fuel costs. BEB and hydrogen: Stantec estimate Price projections based on US EIA forecasts for energy prices, US West
Maintenance	Vehicle maintenance costs	Maintenance costs (per mile) inclusive of labor and parts for scheduled and unscheduled maintenance	Diesel motorcoach: $0.64/mile BEB motorcoach: $0.57/mile	Hydrogen motorcoach: $0.64/mile	Based on NTD data. BEB motorcoach: Stantec assumption of 10% cost savings compared to diesel. Hydrogen motorcoach: No assumed savings as potential savings will be offset by labor to fuel offsite at GCTD.

Table 27 presents a description as well as the sources for the cost inputs (in 2023$) of the Valley Express Base Case and ZEB Case.

Table 27: Summary of cost inputs (Valley Express)

Main Category	Item	Description	Inputs for Base Case	Additional Inputs for ZEB Case	Sources and comments
Capital					
Fleet acquisition	Bus purchase price	Purchase price of a bus/vehicle inclusive of options and extended warranty	Gasoline cutaway: $158,512	BEB cutaway: $207,002	Gasoline cutaway: Weighted average of quotes BEB cutaway: Group TAM plan
Fleet refurbishment	Mid-life rehabs	Any heavy mid-life work needed to achieve the useful life minimum benchmark	N/A	N/A	
Operating					
Operating	Vehicle fuel	Cost of fuel commodity for revenue vehicles	Gasoline: $6.13	Electricity: $0.1835	Gasoline: Average of VCTC data Electricity: Stantec estimate

Main Category	Item	Description	Inputs for Base Case	Additional Inputs for ZEB Case	Sources and comments
					Price projections based on US EIA forecasts for energy prices, US West
Maintenance	Vehicle maintenance costs	Maintenance costs (per mile) inclusive of labor and parts for scheduled and unscheduled maintenance	Gasoline cutaway: $1.31/mile	BEB cutaway: $1.18/mile	Gasoline cutaway: NTD data BEB cutaway: Stantec assumption of 10% cost savings compared to gasoline.

APPENDIX C: FLEET TRANSITION ALTERNATIVE WITH CARB CREDITS

VCTC's Intercity fleet currently includes the operations of 5 BYD BEBs. Under CARB regulation, agencies deploying ZEB technology prior to mandated ZEB compliances (starting 2026 with 25% purchase requirements) are eligible for credits used to defer the purchase of ZEBs. While these vehicles are included in VCTC's fleet, they were procured by SBCAG. CARB applies ZEB credits to the agency with ownership of the vehicles, thus, VCTC is not eligible for the use of those credits.

Should VCTC choose to take ownership of those five vehicles from SCBAG, they would then be eligible for credits, and able to defer purchase of ZEBs until 2029 as outline below in the Table 28Table 24. This would potentially enable VCTC to more adequately prepare for the transition to FCEBs and hydrogen fueling. While this alternative transition schedule pushes the initial purchase of FCEBs to 2029, 100% transition of VCTC's to hydrogen would still occur in 2040, remaining compliant with CARB's ICT regulation.

Table 28: 2023 – 2040 Fleet Forecast for Intercity Vehicles with ICT Credits

	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
BEB																		
In fleet	5	5	5	5	5	5	5	5	5	5	5	5	0	0	0	0	0	0
Retire	0	0	0	0	0	0	0	0	0	0	0	0	-5	0	0	0	0	0
New	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Diesel																		
In fleet	36	36	36	36	36	36	27	27	24	24	24	24	24	24	21	19	10	0
Retire	0	0	-3	-2	-9	-10	-9	0	-3	0	0	0	0	0	-3	-2	-9	-10
New	0	0	3	2	9	10	0	0	0	0	0	0	0	0	0	0	0	0
Hydrogen																		
In fleet	0	0	0	0	0	0	9	9	12	12	12	12	17	17	20	22	31	41
Retire	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
New	0	0	0	0	0	0	9	0	3	0	0	0	5	0	3	2	9	10
Total																		
Total ZEB	5	5	5	5	5	5	14	14	17	17	17	17	17	17	20	22	31	41
% ZEB Fleet	12%	12%	12%	12%	12%	12%	34%	34%	41%	41%	41%	41%	41%	41%	49%	54%	76%	100%
% ZEB Procurement	NA	NA	NA	NA	NA	NA	100%	NA	100%	NA	NA	NA	100%	NA	100%	100%	100%	100%