ZEB Strategy and Final Report

El Dorado County Transportation Commission ZEB Rollout and Implementation Plan

Draft Report

September 2021

Stantec

A study funded by a **Caltrans Sustainable Transportation Planning Grant**

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EL DORADO TRANSIT

Stantec

ZEB Strategy and Final Report
DRAFT

ZEB Rollout Plan and Analysis Services

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El Dorado County Transportation Commission

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ZEB STRATEGY AND FINAL REPORT

DRAFT

Release Version

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	Comments received	8/30/2021
1	Revised Draft Report Issued to EDCTC	9/10/2021
2	Final Report Issued to EDCTC	TBD

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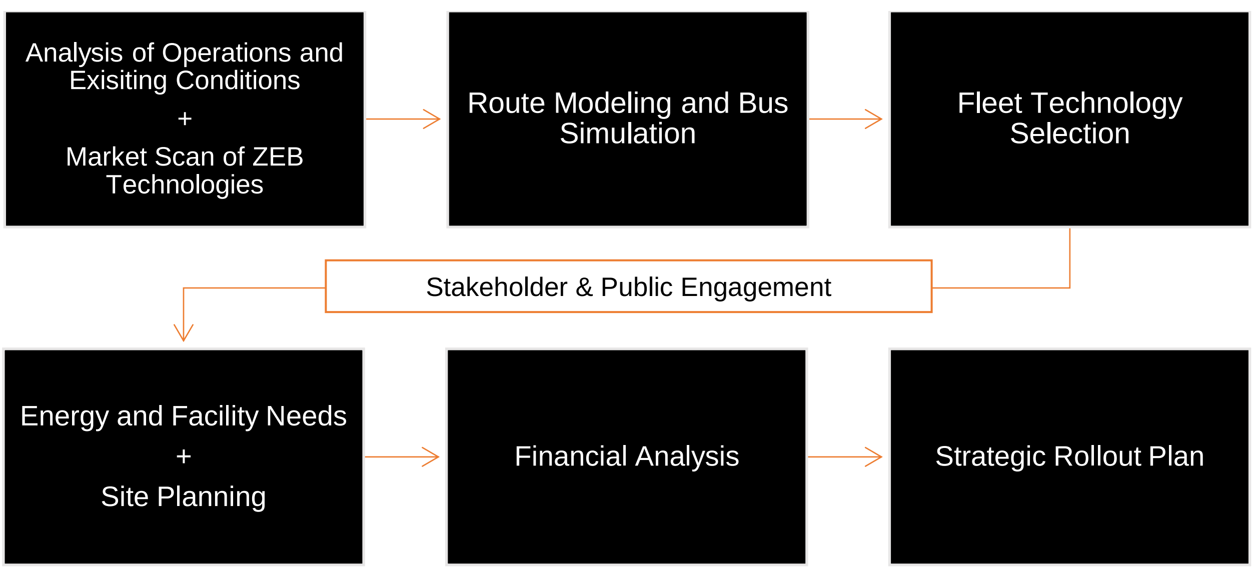
Executive Summary

The El Dorado County Transit Authority (EDT) provides a variety of fixed-route and demand response services throughout Western El Dorado County as well as commuter services to downtown Sacramento and Folsom in Sacramento County. Together with the El Dorado County Transportation Commission (EDCTC), the Regional Transportation Planning Agency (RTPA) for the west slope of El Dorado County, EDT and EDCTC provide and promote sustainable mobility throughout the county and surrounding areas.

With a service area population of 147,200[1] and a fleet of 28 standard[2] and motor coach buses for fixed-route services, EDT 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 July 1, 2023 and begin ZEB purchases in 2026. While the ICT regulation is directed primarily at larger, heavy-duty transit buses[3], EDT and EDCTC have chosen to be a leader in the zero-emission (ZE) space and to transition its entire fleet, including demand response cutaways, vans, and non-revenue light-duty vehicles. This report provides a strategic transition plan for all revenue and non-revenue vehicles in EDT's fleet.

The figure below presents an overview of the ZEB planning process that was used to determine the preferred ZEB fleet mix for EDT based on EDT's operating conditions.



[1] NTD 2019 agency profile
[2] In this document, "standard" refers to 35-ft or 40-ft buses
[3] Specifically, the ICT regulation mandates the transition of vehicles with a gross vehicle weight rating (GVWR) of greater than 14,000 lbs.

This document serves as the source for EDT's rollout plan submission to CARB and provides a detailed plan of the technology, needs, and strategies that will help EDT transition to a ZEB fleet. The previous phases of this project (summarized in this report) laid the foundation for this plan by assessing EDT's existing conditions and modeling the power and fuel requirements needed to meet EDT's service through a ZEB fleet. With this information, the initial ZEB fleet was refined through a collaborative optimization process that led to the preferred fleet composition of an entirely battery-electric bus (BEB) fleet.

With the preferred fleet composition established, the next steps included determining the facility upgrades and modifications—such as new electrical equipment and vehicle chargers—required to support ZEB operations at EDT's maintenance facility. In addition, a financial ZEB model was developed for comparative purposes against a base case (or business as usual with fossil fuel buses) and developing a phasing or implementation plan. Overall, implementing the ZEB fleet will cost $436M (cumulative capital and operating costs) compared to $389M for business-as-usual (fossil fuel technology) within a 20-year timeframe. Stated otherwise, the transition to ZEBs adds incremental capital and operating costs of $47M to EDT over the 20-year period. The infrastructure requirements are also captured in this plan to accommodate the phased acquisition of BEBs while still operating and eventually phasing out fossil fuel vehicles.

Based on EDT's existing fleet replacement schedule and the required ZEB purchase schedule outlined by CARB, this plan recommends that the ZEB procurement begins in 2026 and gradually continues through 2040 as fossil fuel vehicles reach the end of their useful lives and are retired. This coincides with a phased plan for construction and infrastructure upgrades at the maintenance facility beginning in 2025. This phased approach allows for EDT to implement a small number of BEBs and learn from the process and slowly scaling up to reach a 100% ZE revenue vehicle fleet by 2040 and adhering to ICT guidelines and goals. The full phasing and implementation plan is outlined in Table 1. With a 100% transition to BEB, EDT can reduce its greenhouse gas emissions by approximately 80% (~3,100 tons annually), with the remainder coming from California's electric grid.

Throughout this document, information is provided that corresponds to the required sections of the ICT ZEB Rollout Plan. Taken together, this plan provides a prudent and feasible approach for EDT to implement ZEBs that meets the County's vision of providing environmentally sustainable public transportation.

Table 1: ZEB implementation phasing plan, FY2021-2040

Year	Construction – maintenance facility	Revenue Fleet	Non-Revenue Fleet	Charging equipment	Training - operators	Training – maintenance staff/technicians	Training - other	Capital expenses (2021$)	O&M expenses (2021$)	Annual budget (2021$)
FY2021								$0	$8,729,172	$8,729,172
FY2022		2 35-ft. diesel 1 gas cutaway 5 gas vans	1 gas staff vehicle					$1,463,216	$9,339,556	$10,802,772
FY2023								$0	$9,901,216	$9,901,216
FY2024		5 gas vans	2 gas staff vehicles					$639,439	$10,496,721	$11,136,160
FY2025	Underground work starts for conduit installation in Area-A (please refer to site plans Figure 20)	9 diesel motor coaches						$9,256,384	$11,128,114	$20,384,498
FY2026		4 gas cutaways 2 BEB cutaways 5 gas vans		**Area-A** 1 power cabinet (150 kW) +3 dispensers 1 power cabinet (60 kW) + 2 dispensers 1.5 MW Transformer **Area-B** none	Drive training-4 sessions-4 hours each Overall vehicle/system orientation-20 sessions-2 hours each	Preventative maintenance training-4 sessions-8 hours each Electrical/electronic training-6 sessions-8 hours each Multiplex training-4 sessions-3x8 days per session HVAC training-4 sessions-4 hours each Brake training-4 sessions-4 sessions ESS, lithium-ion battery and energy management hardware and software training-6 sessions-8 hours each Electric drive/transmission training-6 sessions-8 hours each	Agencywide orientation to new BEB technology Local fire and emergency response department introduction to new technology	$2,351,543	$11,780,482	$14,132,025
FY2027		1 BEB motor coach			Annual refreshers	Annual refreshers	No activity	$1,748,618	$12,480,193	$14,228,812

Year	Construction – maintenance facility	Revenue Fleet	Non-Revenue Fleet	Charging equipment	Training - operators	Training – maintenance staff/technicians	Training - other	Capital expenses (2021$)	O&M expenses (2021$)	Annual budget (2021$)
FY2028		5 gas vans	5 staff ZEVs		Annual refreshers	Annual refreshers	Local fire and emergency response department training on new technology	$1,039,021	$13,231,081	$14,270,101
FY2029	Underground work starts for conduit installation in Area-B	1 BEB motor coach	1 staff ZEV	**Area-A** 3 power cabinet (150 kW) **Area-B** 1 power cabinet (150 kW) + 12 dispensers 6 power cabinet (60 kW) + 12 dispensers 7 power cabinet (Level 2) + 14 dispensers	Annual refreshers	Annual refreshers	No activity	$7,679,726	$14,016,935	$21,696,661
FY2030		6 BEB cutaways 5 ZEB vans			Annual refreshers	Annual refreshers	Local fire and emergency response department training on new technology	$2,876,251	$14,740,166	$17,616,417
FY2031					Annual refreshers	Annual refreshers	No activity	$0	$15,626,151	$15,626,151
FY2032		6 35-ft. BEBs 1 BEB cutaway 5 ZEB vans			Annual refreshers	Annual refreshers	Local fire and emergency response department training on new technology	$9,355,059	$16,415,637	$25,770,696
FY2033		5 BEB motor coaches			Annual refreshers	Annual refreshers	No activity	$11,063,602	$17,333,784	$28,397,386
FY2034		5 ZEB vans		7 150-kW cabinet (21 dispensers) 7 60-kW cabinet (14 dispensers) 10 Level 2 cabinets (20 dispensers)	Annual refreshers	Annual refreshers	Local fire and emergency response department training on new technology	$1,863,816	$18,372,674	$20,236,490
FY2035		4 35-ft. BEBs			Annual refreshers	Annual refreshers	No activity	$5,883,855	$19,412,162	$25,296,017
FY2036		6 BEB cutaways 5 ZEB vans			Annual refreshers	Annual refreshers	Local fire and emergency response department training on new technology	$6,539,226	$20,508,333	$27,047,559
FY2037		3 35-ft. BEBs	1 staff ZEV		Annual refreshers	Annual refreshers	No activity	$5,019,578	$21,732,137	$26,751,715

Year	Construction – maintenance facility	Revenue Fleet	Non-Revenue Fleet	Charging equipment	Training - operators	Training – maintenance staff/technicians	Training - other	Capital expenses (2021$)	O&M expenses (2021$)	Annual budget (2021$)
FY2038		5 ZEB vans			Annual refreshers	Annual refreshers	Local fire and emergency response department training on new technology	$3,447,287	$23,030,327	$26,477,613
FY2039			2 staff ZEVs	**Area-A** None	Annual refreshers	Annual refreshers	No activity	$6,474,797	$24,404,775	$30,879,572
FY2040		10 BEB motor coaches 6 BEB cutaways 5 ZEB vans		**Area-B** 4 power cabinet (150 kW) + 12 dispensers 3 power cabinet (Level 2) + 6 dispensers	Annual refreshers	Annual refreshers	Local fire and emergency response department training on new technology	$41,707,830	$25,703,147	$67,410,977

Abbreviations

AHJ	Authorities Having Jurisdiction
AHSC	Affordable Housing and Sustainable Communities Program
AIM	AIM Consulting
AQMD	Air Quality Management District
AVTA	Antelope Valley Transit Authority
BEB	Battery electric bus
BESS	Battery electric storage system
BEV	Business Electric Vehicle
BTM	Behind the Meter
BUILD	Better Utilizing Investments to Leverage Development
CARB	California Air Resources Board
DC	Direct current
EDCTC	El Dorado County Transportation Commission
EDT	El Dorado Transit
FCEB	Hydrogen fuel cell electric bus
GHG	Greenhouse gas
HVIP	Hybrid and Zero-Emission Truck and Bus Voucher Incentive Program
ICT	Innovative Clean Transit
IRR	Internal Rate of Return
LCFS	Low Carbon Fuel Standard
LCTOP	Low Carbon Transit Operations Program
LPG	Liquid petroleum gas

LPP	Local Partnership Program
MCAB	Mountain Counties Air Basin
NEM	Net Energy Metering
NFPA	National Fire Protection Association
NPV	Net Present Value
NREL	National Renewable Energy Laboratory
OCPP	Open Charge Point Protocol
OEHHA	Office of Environmental Health Hazard Assessment
PDT	Project Development Team
PG&E	Pacific Gas & Electric
PSPS	Public Safety Power Shutoff
PV	Photovoltaic
RTPA	Regional Transportation Planning Agency
SAC	Stakeholder advisory committee
SACOG	Sacramento Area Council of Governments
SCCP	Solutions for Congested Corridors Program
STEP	Sustainable Transportation Equity Project
STIP	State Transportation Improvement Program
TIRCP	Transit and Intercity Rail Capital Program
TOU	Time of use
TTC	Toronto Transit Commission
ZE	Zero emission
ZEB	Zero-emission bus

1.0 INTRODUCTION

The El Dorado County Transit Authority (EDT) provides a variety of fixed-route and demand response services throughout Western El Dorado County as well as commuter services to downtown Sacramento and Folsom in Sacramento County. Together with the El Dorado County Transportation Commission (EDCTC), the Regional Transportation Planning Agency (RTPA) for the west slope of El Dorado County, EDT and EDCTC provide and promote sustainable mobility throughout the county and surrounding areas.

With a service area population of 147,200[4] and a fleet of 28 standard[5] and motor coach buses for fixed-route services, EDT 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 July 1, 2023 and begin ZEB purchases in 2026. While the ICT regulation is directed primarily at larger buses, EDT and EDCTC have chosen to be a leader in the zero emission (ZE) space and to transition its entire fleet, including demand response cutaways and non-revenue light-duty vehicles. Thus, this report provides a strategic transition plan for all revenue and non-revenue vehicles in EDT's fleet.

EDT's maintenance facility is located in Diamond Springs within the Pacific Gas & Electric (PG&E) service territory. El Dorado County is located within the Mountain Counties Air Basin (MCAB) and the El Dorado County Air Quality Management District (AQMD).

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

- A review of existing conditions to understand characteristics and constraints for EDT'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 and their viability.
- A quantitative and qualitative assessment of modeling results to determine the preferred ZE fleet composition for EDT.

[4] NTD 2019 agency profile
[5] In this document, "standard" refers to 35-ft or 40-ft buses

In addition, several public and stakeholder outreach and engagement activities have been completed to gain feedback from stakeholders and the public, and also to inform riders and the community of the changes taking place in regard to the future of EDT's fleet.

This report is intended to act as a roadmap to guide EDT 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.

2.0 APPROACH TO ZEB PLANNING

The graphic in Figure 1 provides a high-level schematic of the major steps in this project to derive a recommended fleet mix and implementation plan.

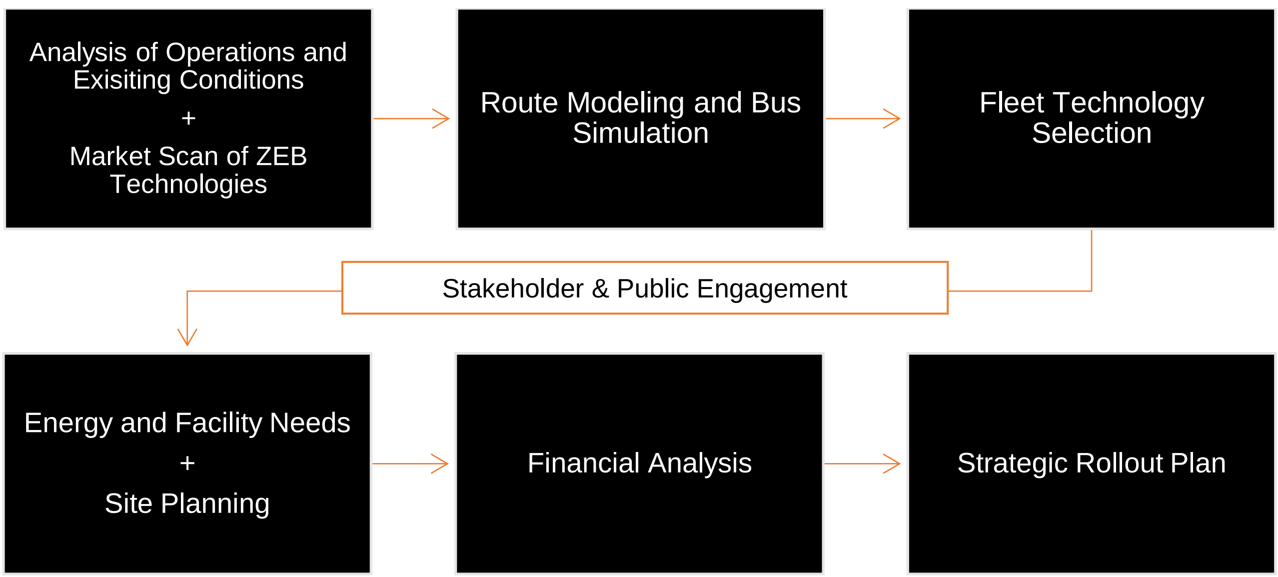


Figure 1: Schematic representation of the steps in the ZEB planning process

The first step involved a review of existing conditions of EDT to provide a foundation and understanding of EDT'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 3.0. A site visit of the operating base and maintenance facility in Diamond Springs provided insights into the constraints and opportunities for implementing ZEBs, as well as the condition of the facilities, buildings, and existing service cycle. A market scan was also conducted to analyze the current ZEB technologies, their limitations, and in-development technologies that can help shape EDT's future ZEB fleet. Moreover, Stantec and our project partner AIM Consulting, conducted public outreach to educate stakeholders and riders about this project, the importance of ZEBs, and gather feedback (Section 3.0).

Next, we modeled block-level and vehicle-level fuel economies to understand the predicted performance of different ZEB technologies under EDT's operating parameters for both fixed-route and demand response services. Together with a multicriteria trade-off analysis and in consultation with key stakeholders and EDT and EDCTC staff, Stantec, EDT, and EDCTC determined that the best path forward to a ZE future is with a BEB fleet (Section 5.0).

With an understanding of dispatching, operations, and fuel economy, Stantec then developed energy/charging profiles to assess the power and utility requirements at EDT's division (Section 5.4). The fleet procurement schedule and outlook was designed to account for the ICT Regulation's requirement of annual apportionment of ZEB purchases (Section 6.0).

Stantec designed conceptual site plans (and opinion of probable costs) for the maintenance facility that demonstrates the layout of the yard, the service cycle, and siting of chargers, dispensers, buses, and other ZEB-related equipment, including back-up infrastructure for resiliency, as well as for potential solar power generation (Sections 0 and 8.0).

With the site plans and identification of required facility modifications and impacts on capital and operating costs, Stantec developed a financial analysis for the ZEB rollout through 2040 (Section 13.0).

Considering the ever-evolving nature of ZE technologies and the need to be flexible, Stantec also developed guidance for EDT if they wish to explore alternative ZEB strategies (Section 17.0). While Stantec's analyses demonstrate that BEBs satisfy EDT's operational needs and are more affordable overall compared to FCEBs, future economics and market forces, as well as ZEB adoption of neighboring agencies, could make FCEBs a viable path, if FCEBs are developed in the vehicle types that EDT operates[6].

All steps described here, along with others found in this document, provide EDT with a 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.

3.0 STAKEHOLDER AND PUBLIC ENGAGEMENT

As part of the development of the ZEB strategy, Stantec and AIM Consulting (AIM) conducted several activities to engage key stakeholders and the public throughout El Dorado County during the planning process.

The first engagement meeting was a project development team (PDT) meeting held at the start of this project.[7] This meeting provided an overview of the project objectives, key steps, and expected outcomes. This meeting served to gather feedback as well as to build awareness among stakeholders, like PG&E and first responders, to EDT's eventual transition to ZE.

[6] Currently there are no FCEB options for motor coaches or 35-ft vehicles.
[7] March 30, 2021.

The next event was the first of two stakeholder advisory committee (SAC) meetings. The SAC consists of a group of ten stakeholder representatives from the following organizations and agencies:

- Coloma Lotus Advisory Committee
- El Dorado County
- El Dorado County Air Quality Management District
- Pacific Gas & Electric Company (PG&E)
- Shingle Springs Alliance
- El Dorado County District 1 Supervisor John Hidahl

On May 20, 2021, EDCTC and EDT held the first virtual SAC meeting for the El Dorado Transit ZEB Plan. The meeting served to introduce the plan, share why EDCTC and EDT are currently developing the plan, present existing conditions, discuss preliminary fleet solutions, and provide next steps to stakeholder representatives. AIM staff facilitated the meeting, while Stantec staff presented technical information. After the presentation, the project team facilitated a large group discussion with the stakeholder participants. Stakeholders were encouraged to ask questions about any of the topics presented, and were also asked to respond to a series of discussion questions.

Key themes that emerged from the group discussion included:

- How the modeling is conducted and what's considered in the power modeling
- Battery degradation and disposal
- The capital costs of vehicles and auxiliary charging infrastructure
- Availability and evolution of ZE technologies
- Financial support for transit agencies and ZE transition
- Potential priority areas for ZE rollout
- Service delivery alternatives, like on-demand microtransit to replace some fixed-route services

Many of the themes and questions were not only addressed in the roundtable discussion but are touched upon directly in this report.

The third engagement activity was the development of an informational video hosted on a page[8] of EDCTC's website along with a short survey. The video described the ZEB project and acted as a promotional and educational piece to broaden awareness of the study and of the future technology that EDT will need to adopt. In total, 135 community members responded to the short survey after viewing the video. Key highlights include:

- Respondents were concerned mainly about how bus fare may change because of the cost of ZEB adoption

[8] https://www.edctc.org/zero-emission-bus-fleet-conversion-plan; https://www.surveymonkey.com/r/ElDoradoZEB

- While most respondents were not current riders, about 24% of non-riders indicated that ZEBs may encourage them to try EDT, while 21% of current riders indicated that ZEBs could entice them to ride more often

Based on the comments received on the survey, some key messages that EDT should communicate to the broader community and to riders include:

- Fares will not be impacted because of technology changes
- The transition to ZEBs is not choice—it is a mandate from the state to help achieve air quality targets
- EDT will strive to minimize the impact of ZEB limitations on operations and service delivery
- The benefits of ZEBs include cleaner air, a smoother more comfortable ride, a healthier environment for transit staff and riders, and more reliable service since ZEBs require less maintenance

The final engagement events will include a second SAC meeting to the recommendations and strategies outlined in this planning document, as well as a final informational video for the community to community the recommendations of the final plan. The summaries of these meetings will be provided as separate documents.

4.0 SUMMARY OF KEY EXISTING CONDITIONS

The Existing Conditions report provided a comprehensive review of EDT's existing conditions, encompassing operations, facilities, and finances to lay the groundwork for the modeling and understand current (pre-COVID-19) operating conditions. This contextual analysis is important as the goal of the modeling is to provide an understanding of how we expect ZEBs to perform in *EDT's* environment according to *EDT's* operations, to inform fuel economy, operating range, and ultimately, the feasibility of different ZEB technologies. The major findings from the existing conditions report that will affect the ZEB transition are summarized here.

4.1 OPERATIONS AND SERVICE

- EDT operates in a large service area (1,551 sq. miles[9]) with dispersed destinations.
- Western El Dorado County is characterized by challenging topography (4% average elevation grade). Elevation can have a major effect on fuel economy and needs to be accounted for in the modeling.

[9] 2019 NTD agency profile.

- EDT operates 35-ft. buses for local fixed-routes, 45-ft. motor coaches for commuter service, and vans and cutaways for demand response service. While these vehicle types have been selected by EDT for specific reasons (demand, roadway constraints, etc.), there are currently limited ZEB equivalents for these vehicle types. Available ZEB equivalents to EDT's current fleet are summarized in Table 2. Most notably, there are currently no FCEB equivalents available, and overall, BEB options are also more limited when compared to options for 40-ft. buses. While it is the hope that there will be more options available as the technology continues to evolve, we cannot model hypothetical non-existent bus models, and thus modeling is constrained to today's technology.[10] It is also important to note that ZEBs tend to be more expensive than conventional vehicles, and need to account for additional costs associated with charging technology (which can range from $50-500K, depending on power output, specifications, configuration, etc.)

Table 2: Current fleet and ZEB considerations

Type of vehicle	Services	Current technology	Current fleet size	Est. unit cost	ZEB options	ZEB cost est.
35-ft heavy duty bus	Local fixed-route	Diesel	12	$500K	BEB **No FCEB options in 35-ft.*	$700-800K
45-ft commuter coach	Commuter services	Diesel	16	$600K	BEB **No FCEB options*	$1.0-1.7M
Cutaways	Contracted DR and NEMT	Unleaded gasoline	13	$100K	BEB **No FCEB options*	$200K+
Vans	DAR, Paratransit	Unleaded gasoline	10	$67-75K	BEB **No FCEB options*	$100K+

- Sixty-one percent of vehicles for fixed-route services (local and commuter service) complete more than one block on weekdays. These include some commuter coach vehicles, which complete AM and PM portions of service. It is important to aggregate blocks at the vehicle assignment-level to understand the full mileage that vehicles travel in a day for modeling and ZEB feasibility (Figure 2). However, even though local routes are only assigned to one block, these blocks are very long and predominately span the entirety of the service day, which could prove challenging for BEB conversion (see Figure 3, where seven vehicles operate on local routes from 6 am to 6 pm).

[10] In theory, with technology improvement, our analysis provide an indication of the baseline expectations.

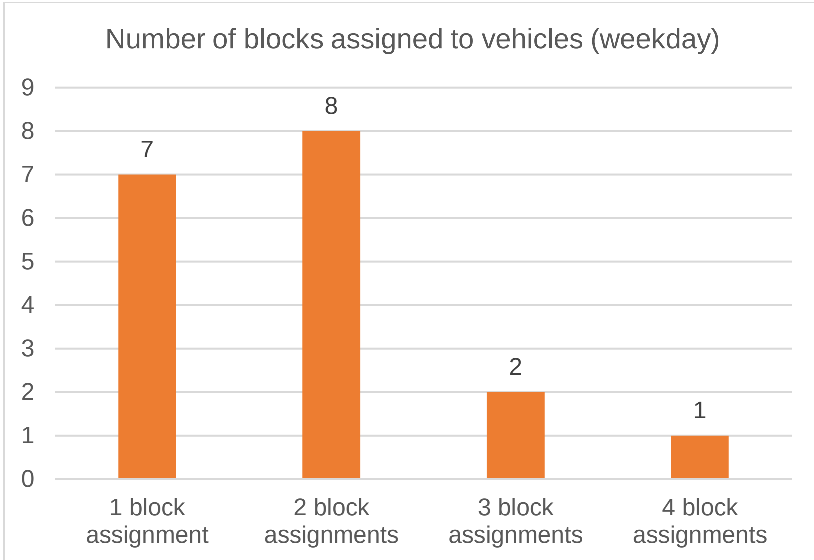


Figure 2: Number of blocks assigned to vehicles (weekday, fixed-route services)

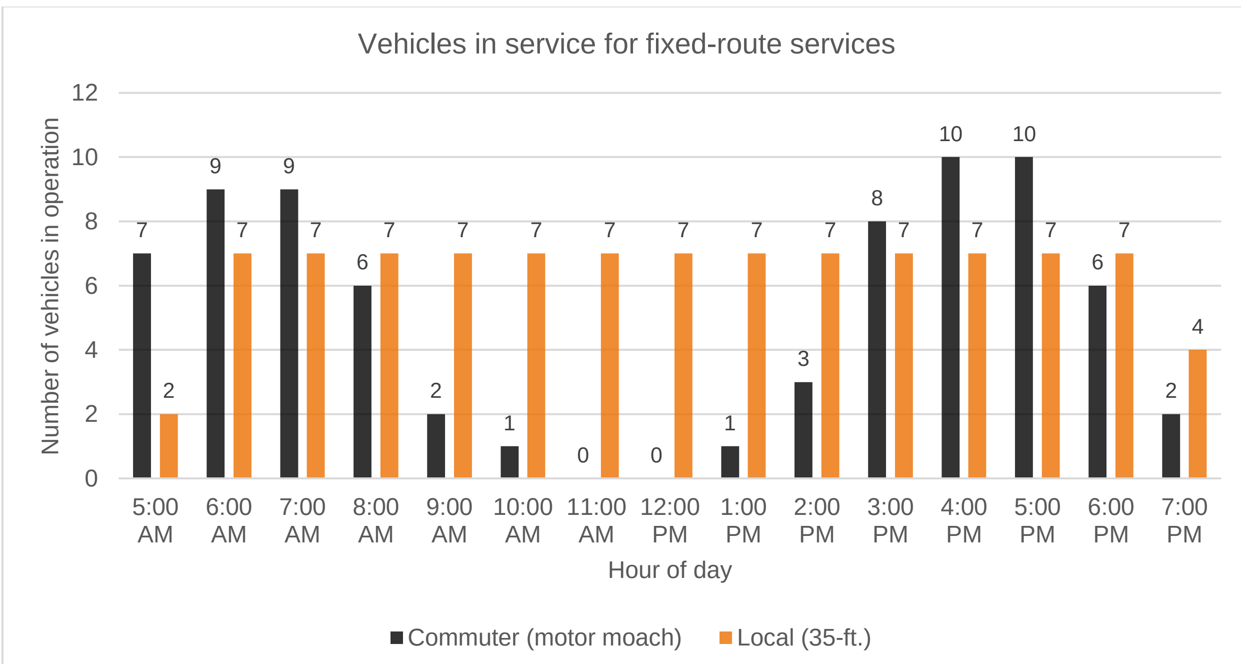


Figure 3: Number of vehicles in service (weekday, fixed-route services)

- Vehicles completing fixed-route services travel long distances, specifically:
    - Commuter motor coaches average 189 miles per vehicle.

- Local route 35-ft. buses average 200 miles per vehicle. Vehicles that travel over 200 miles on an average weekday can be challenging to transition to ZEB operations given current range limitations of ZEBs. Figure 4 shows that 39% of vehicle assignments are over 200 miles.

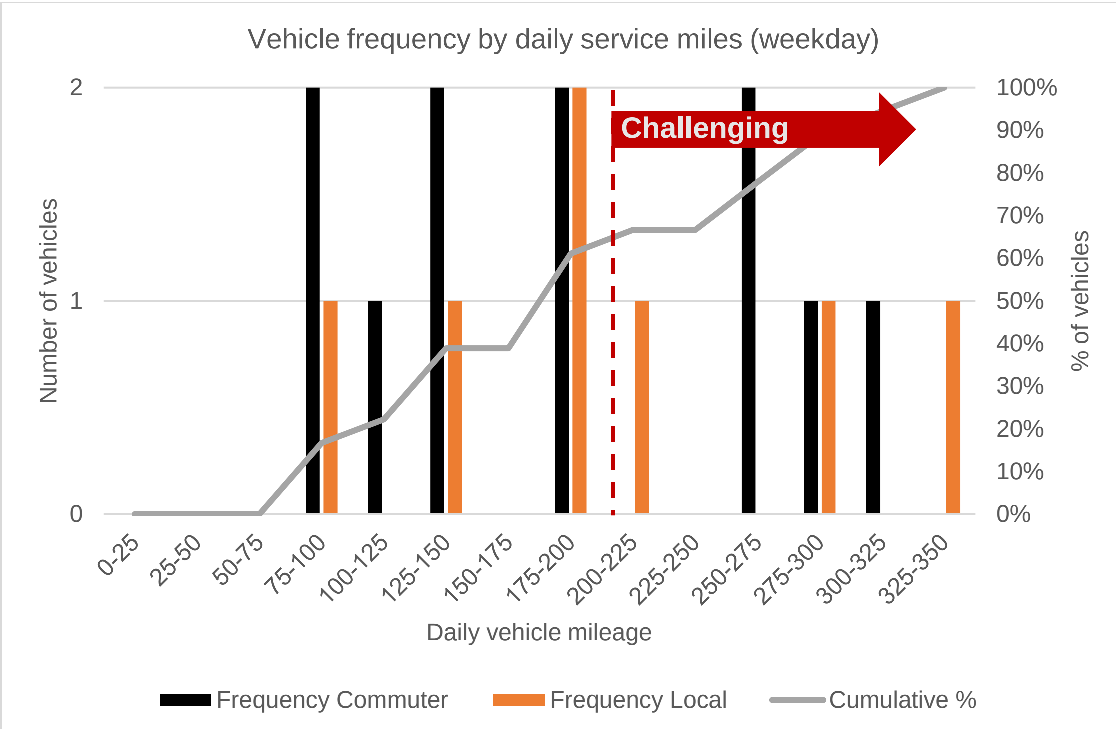
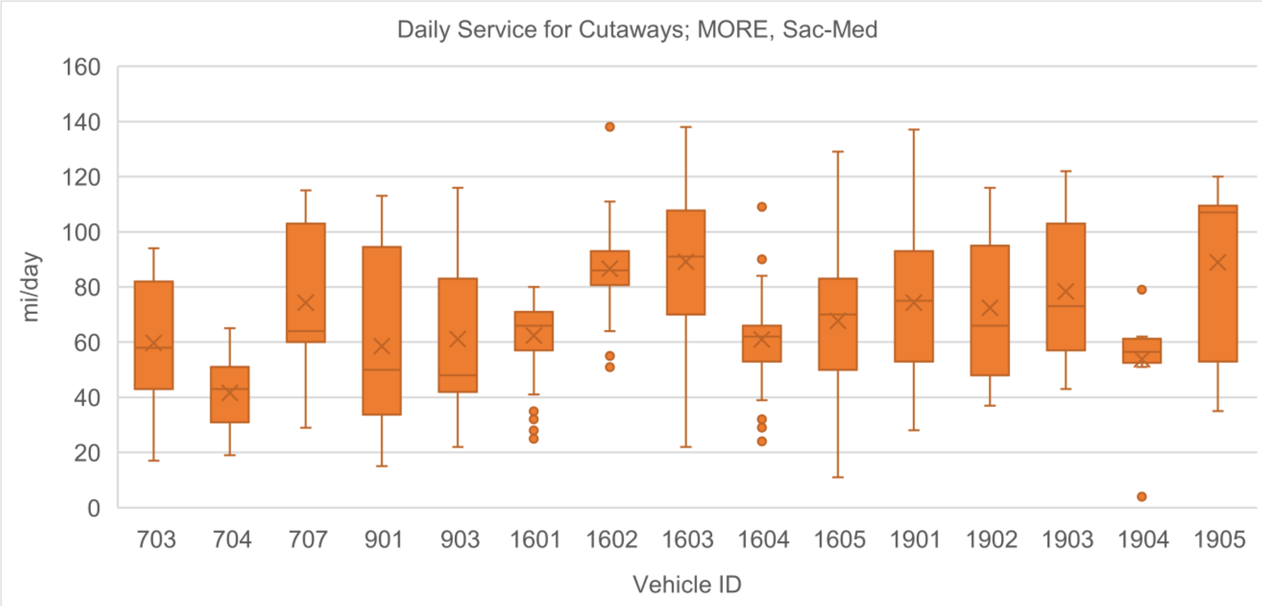


Figure 4: Vehicle frequency by daily service miles (weekday, fixed-route services)

- Demand response vehicle mileage varies widely as there is no fixed schedule and service is based on demand (i.e., trip requests), with vans tending to travel longer distances than cutaways. Average daily service distance for the data provided (which spans 2019 and 2020) is detailed in Figure 5. Overall, vehicles completed roughly the same average daily mileage in 2019 and 2020, but more total annual mileage was provided in 2019.



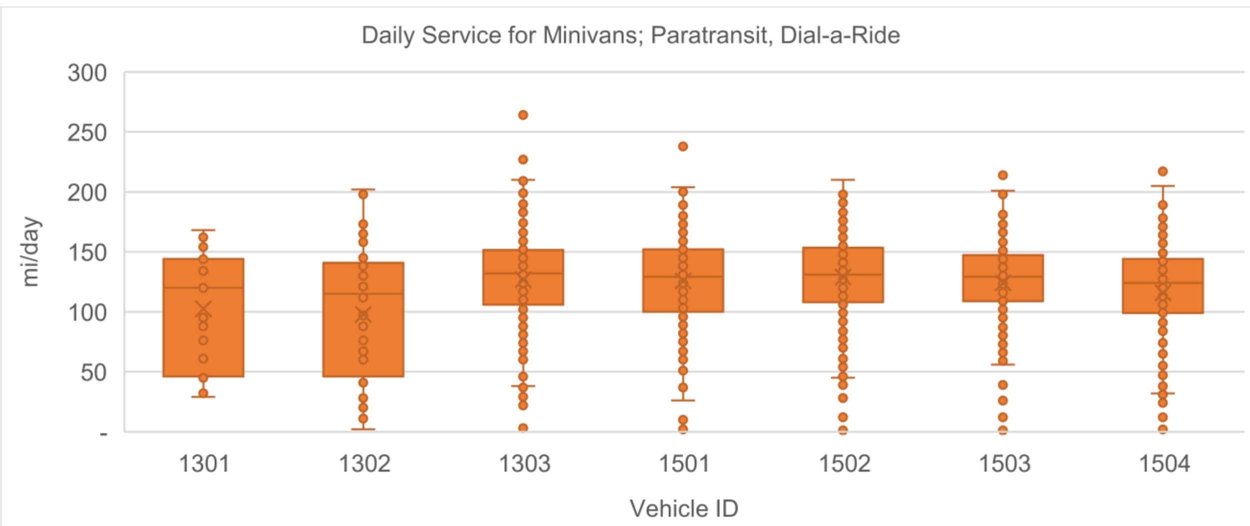


Figure 5: Daily mileage for demand response vehicles

4.2 MAINTENANCE FACILITY

Early in the project process, Stantec conducted a site visit to EDT's operations and maintenance facility in Diamond Springs. This assessment was conducted to understand the conditions at the current site and provide preliminary considerations for facility, utility, and infrastructure modifications, which will be provided in detail in in Section 7.0.

Some major findings from the site visit include:

- The site has limited space, but there is some potential room in the parking lot.
- Fueling currently occurs offsite.
- Current transformers would need upgrading for BEBs.

Figure 6: Aerial image of facility (source: Google Maps)

4.3 CHALLENGES AND OPPORTUNITIES

How EDT operates service and the service environment that EDT operates in present some initial challenges and opportunities that will need to be addressed as part of the approach to the ZEB transition. These include:

- A large service area and challenging topography.
- Operation of a variety of vehicle types for which there is currently a limited ZEB market.
- Long route lengths, blocks, and vehicle assignments that may exceed current ZEB mileage ranges.
- Demand response operations that are inherently difficult to plan for, as daily vehicle mileage can vary widely.
- A maintenance facility that is currently in good condition, adjacent to PG&E, but is somewhat constrained and currently does not have any onsite fueling.

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 EDT'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 EDT's fixed-route, demand response, and non-revenue fleets.

5.1 FLEET AND POWER MODELING OVERVIEW

ZEBDecide, Stantec's fleet modeling tool, was used to determine the feasible and ideal ZEB composition for EDT's fleet. The predictive ZEB performance modeling (schematic overview shown in Figure 7) 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.

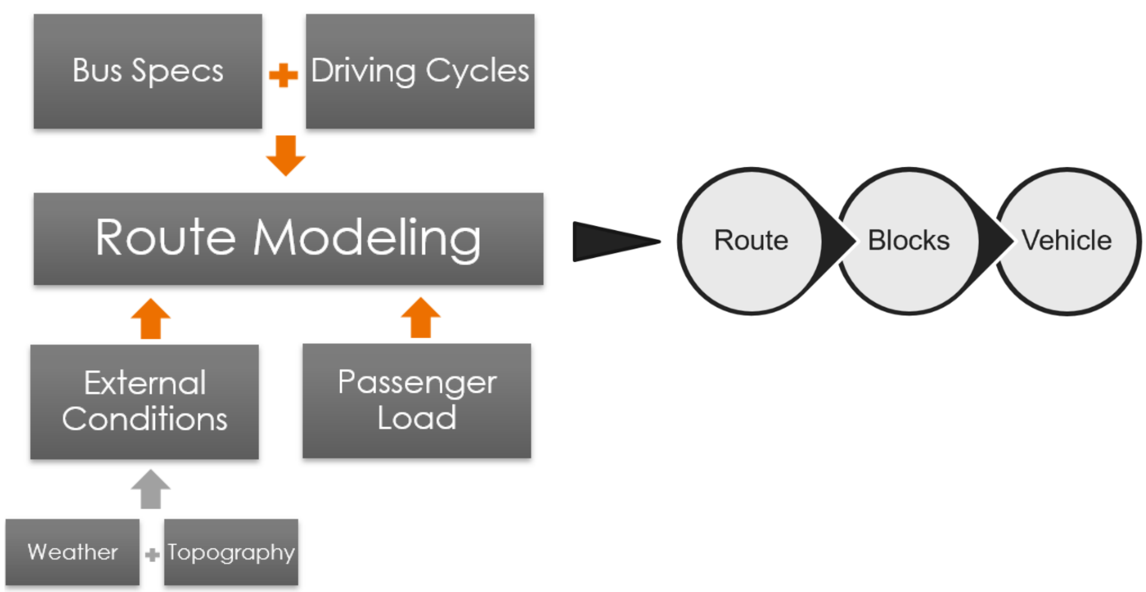


Figure 7: ZEBDecide modeling overview

5.1.1 Modeling Inputs

ZEBDecide's modeling process predicts ZEB drivetrain power requirements specific to given acceleration profiles. The following inputs are included in the model to determine feasibility of different ZEB technologies under EDT's operating conditions:

- **Bus/vehicle specifications:** the bus specification inputs used in the modeling are shown in Figure 8. For EDT, the key bus specifications used in the modeling process for each service type are shown in Table 3. These specifications are based on currently available models and available information. There are no FCEBs available on the US market for any vehicle type in EDT's fleet, so only BEB options were modeled.

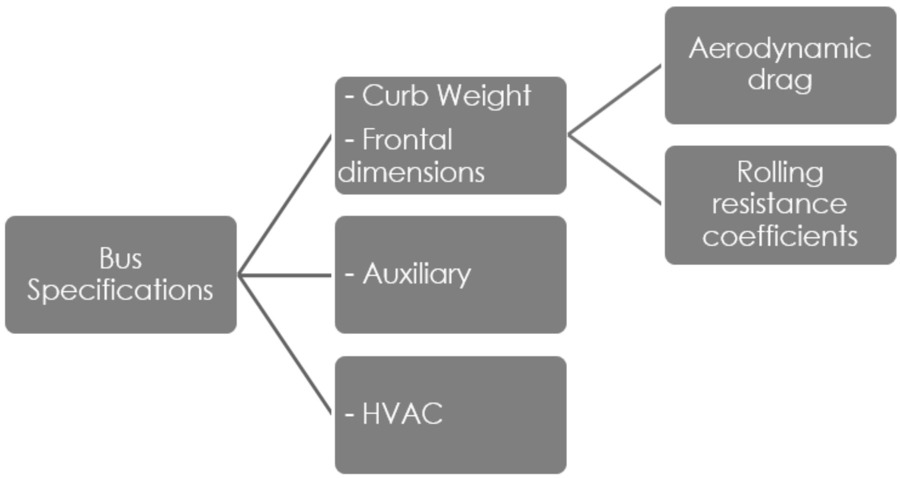


Figure 8: Schematic of the inputs for bus specifications.

Table 3: Vehicle specifications for energy modeling

	35-ft.	Motor coach (45-ft.)	Cutaway
EDT service type	Local fixed-route	Commuter fixed-route	Demand response
Modeled battery size (kWh)	450	544	120
Modeled curb weight (lbs.)	29,700	45,000	16,200

- **Representative driving cycles:** also called acceleration profiles or duty cycles, representative driving cycles are speed versus tie profiles that are used to simulate vehicle performance and energy use. Cycles were assigned to all routes based on EDT's operations and observed driving condition and are derived from the National Renewable Energy Laboratory's (NREL) drive cycle database called DriveCAT[11]. Some routes were assigned two driving cycles to simulate different

[11] NREL DriveCAT - Chassis Dynamometer Drive Cycles. (2019). National Renewable Energy Laboratory. www.nrel.gov/transportation/drive-cycle-tool

driving conditions across different parts of the route. The complete assignment of driving cycles to all routes is presented as an appendix in the energy modeling report. For demand response services, the model used the average driving speeds for each individual run instead of assigning representative driving cycles.

- **Passenger loads:** to examine the weight associated impacts of passenger loads experienced by EDT's fleet, we used actual EDT loading data for each trip during a typical service day. Fuel efficiency was modeled under three conditions for fixed routes:

  - A moderate, typical condition with passenger loads at 50% of the actual maximums recorded for local and commuter service, respectively

  - A more strenuous, extreme condition with passenger loads at 80% of the actual maximums recorded for local and commuter service, respectively

  - A deadheading condition, which assumes no passengers onboard either vehicle type.

  For demand response services, an average of four passengers onboard was assumed for modeling purposes.

- **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 47°F[12].

- **Topography and elevation:** given that portions of EDT's service area are highly impacted by elevation and topography, it is important to account for the impacts of terrain and elevation on the energy efficiency of ZEBs. Each route alignment was imported into Google Earth to create an elevation profile to understand the total elevation gains/losses seen for each route in the system (see example in Figure 9).

Source: Google Earth

Figure 9: Elevation profile example (Route 20)

- The average and maximum grades for each route were similarly determined using these elevation profiles, which were used as the inputs in the topography analysis (Table 4). Modeling

[12] US Climate Data https://www.usclimatedata.com/climate/california/united-states/usca0987

for demand response did not directly account for topography. Instead, the model used information about gain and loss in grade from local fixed route to correct fuel economy.

Table 4: Elevation analysis for fixed routes

Route	Average route length (one way, mi)[13]	Total elevation gain (one way, ft)	Total elevation loss (one way, -ft)	Average Slope	Average Maximum Slope
20 - Placerville	22.00	2,455	2,004	4.0%	21.7%
30 – Diamond Springs/El Dorado	21.88	1,278	1,088	2.8%	14.4%
40 – Cameron Park/Shingle Springs	26.07	1,351	1,194	3.0%	17.8%
50X – Express	70.93	2,333	3,810	3.0%	8.8%
60 – Pollock Pines/Camino	26.82	1,527	3,750	4.0%	17.1%
25 – Saturday Express	26.04	3,409	1,901	3.0%	12.6%
35 – Diamond Springs/El Dorado Saturday	19.21	1,140	932	3.0%	16.7%
C – Sacramento Commuter	62.68	1,805	3,628	1.3%	7.3%

5.1.2 Modeling Process

Using the inputs above, predictive power and energy modeling was completed for fixed-route and demand response services. The energy modeling process for fixed-routes first aggregates results at the route level, then at the block level, and is then aggregated at the vehicle assignment level to determine total daily energy consumption per vehicle. This process is described in Figure 10.

[13] GTFS data.

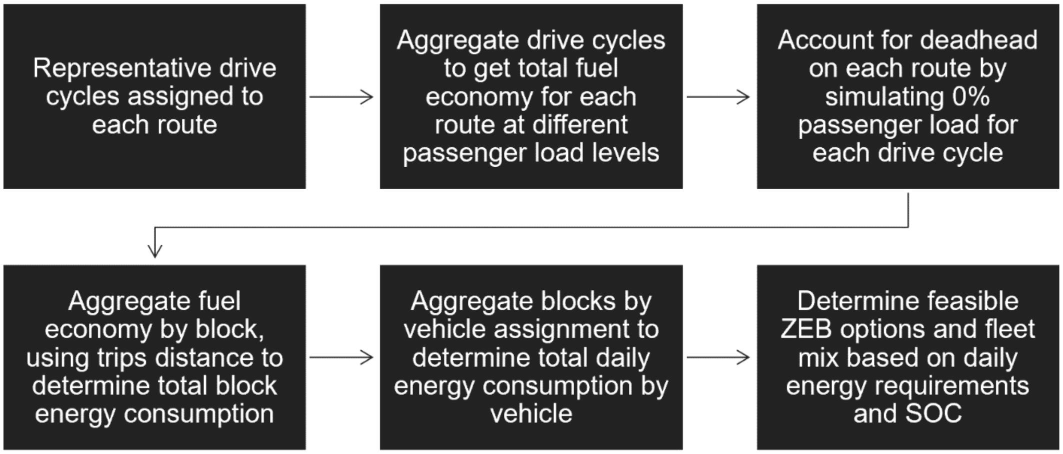


Figure 10: ZEBDecide energy modeling process

The graphic in Figure 11 demonstrates a typical relationship between routes, deadheading, blocks, and vehicle assignments.

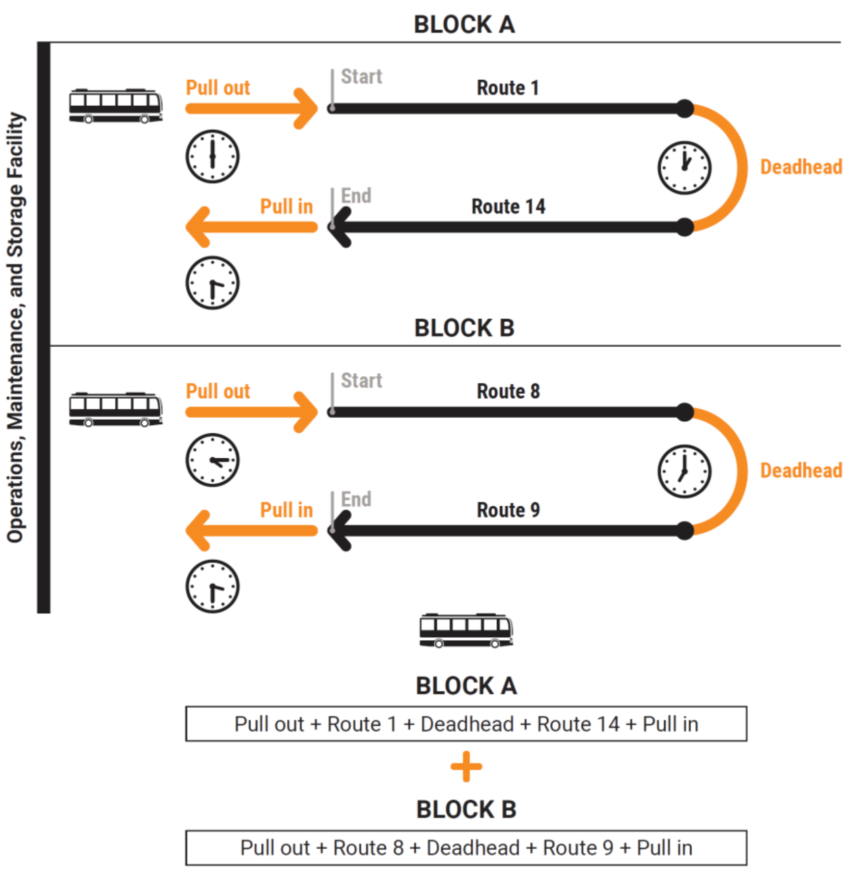


Figure 11: Relationships between routes, block, and vehicle assignments

The results of the modeling provide insight into:

- Fuel economy and energy requirements
- Operating range
- The feasibility of a BEB to complete its assigned service by estimating the 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 remaining.

As mentioned above, modeling for demand response services included all individual runs and vehicle assignments for 2019 and 2020 (1,230 minivan and 900 cutaway vehicle assignments accounting for over 4,800 runs). The energy requitement for each individual trip was aggregated at the vehicle level to calculate the total energy consumed by each vehicle per weekday. A statistical analysis was conducted on the entire dataset to determine the average fuel efficiency and daily energy use per vehicle to evaluate success levels. This process is shown in Figure 12.

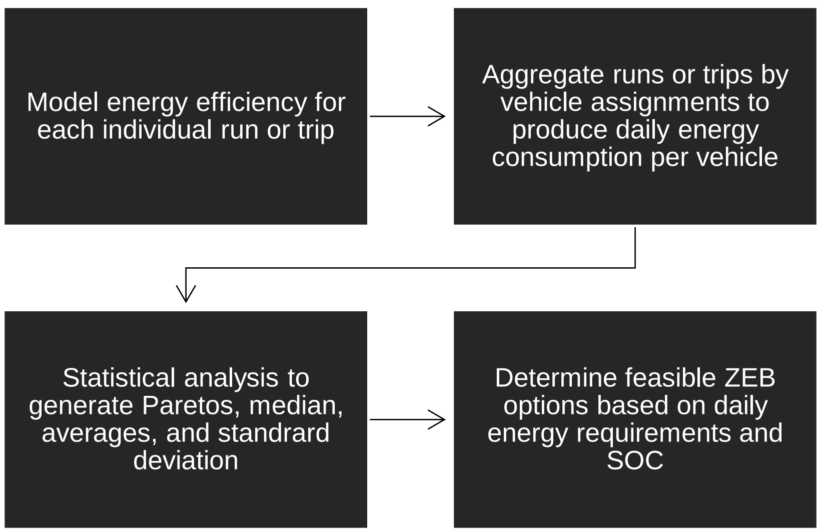


Figure 12: ZEBDecide energy profile process (demand response services)

Similar to the fixed-route modeling, the results of the modeling for demand response service provide insights into:

- Average fuel economy
- Probability of energy requirements
- Probability of operating range
- The feasibility of a BEB to complete its assigned service by estimating the SOC under the same rules for success as for fixed-route services

5.1.3 Modeling Results

Block-level modeling results for fixed-route services are shown in Figure 13. The criteria to deem if a block can be successfully served by a BEB is if the SOC of the battery is above 20% after completing all the trips in a block. A block is deemed unsuccessful if the battery SOC drops below 20% after completing the block. These results show that 100% of commuter blocks and 14% of local route blocks can be successfully completed with BEB equivalents.

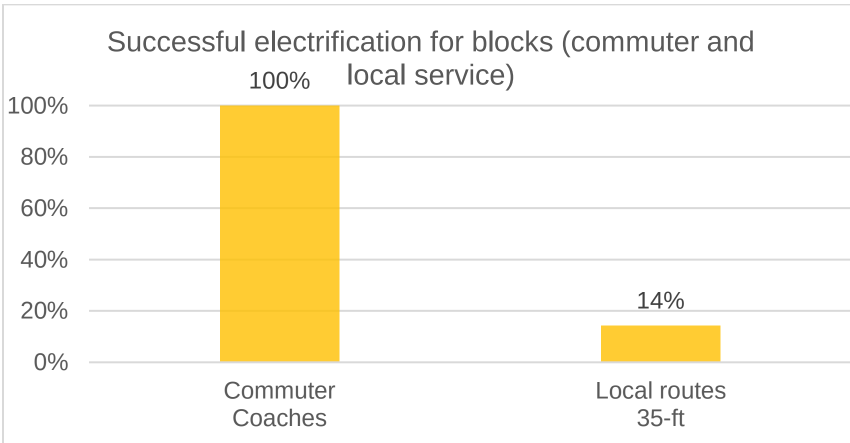


Figure 13: Successful block electrification (fixed routes)

While vehicles operating on local routes do not complete multiple blocks, commuter vehicles do complete multiple blocks and thus these blocks must be aggregated at the vehicle assignment level to understand if the vehicles are able to complete their daily assigned service. Figure 14 aggregates block-level modeling results at the vehicle assignment level.

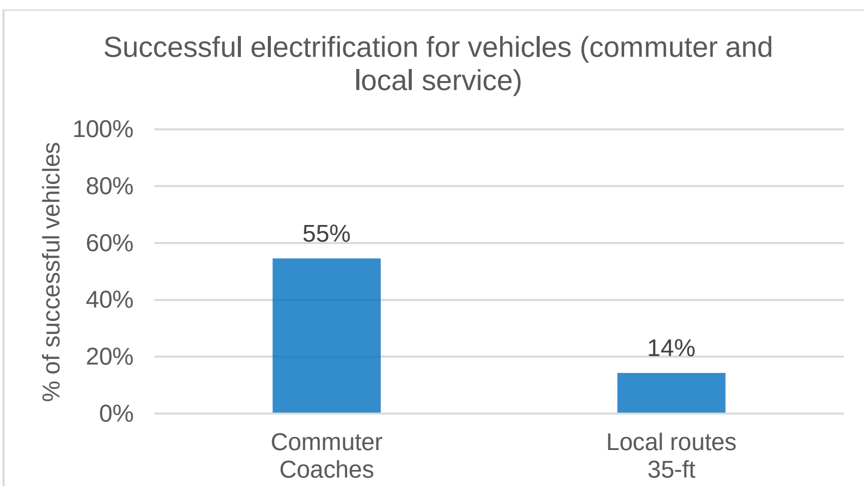


Figure 14: Successful vehicle electrification (fixed routes)

Figure 14 shows that when commuter blocks are aggregated at the vehicle assignment level, the success rate drops to 55%; in other words, only 55% of commuter service can be successfully completed with

BEB equivalents, while as with block-level results, only 14% of local service can be directly replaced with a BEB.

The same procedure was completed for demand response services. Modeling results for individual runs are shown in Figure 15.

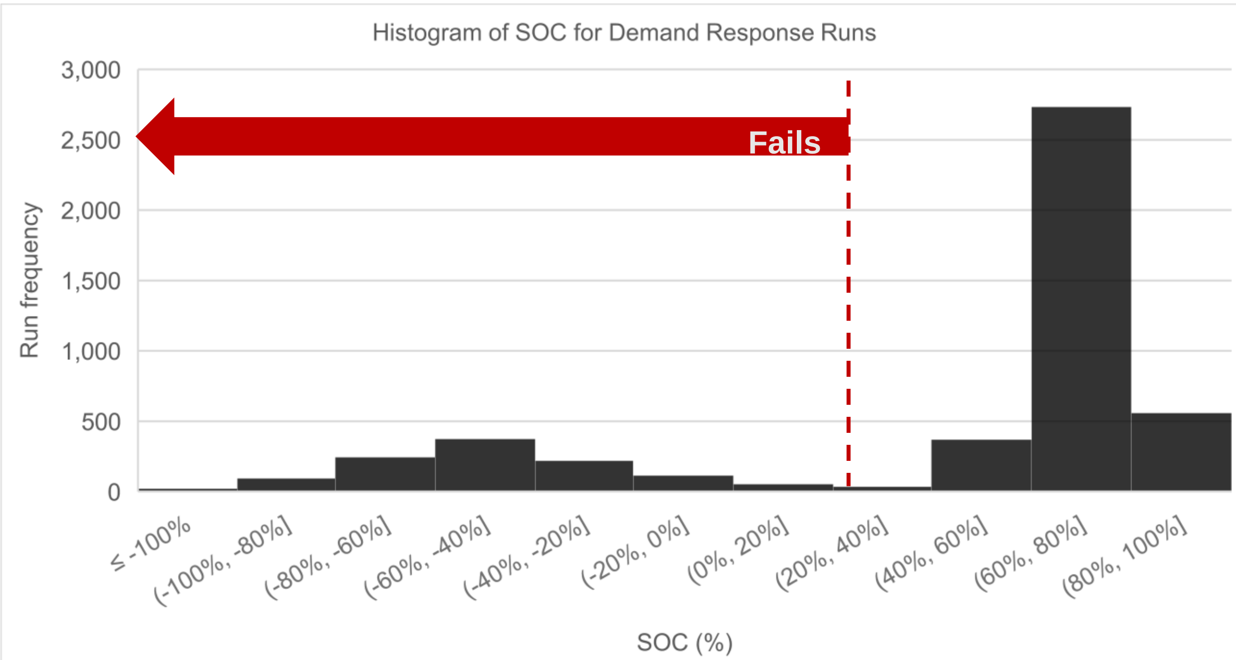


Figure 15: Successful electrification for demand response runs

The same criteria for success (20% battery SOC) were used for demand response vehicles. The large dataset is also important to model and understand the fluctuations and variability in daily schedules of demand response services.

Figure 15 shows that 76% of individual runs that took place were successful under battery-electric cutaway equivalents. Next, runs were aggregated at the vehicle assignment level and results are divided by vehicle type: vans and cutaways.[14] Successful rates of electrification for demand response vehicles are shown in Figure 16 (vans) and Figure 17 (cutaways).

[14] Due to technology limitations, demand response services operated with vans are modeled with the battery-electric cutaway as there is currently no ZE minivan readily available on the market.

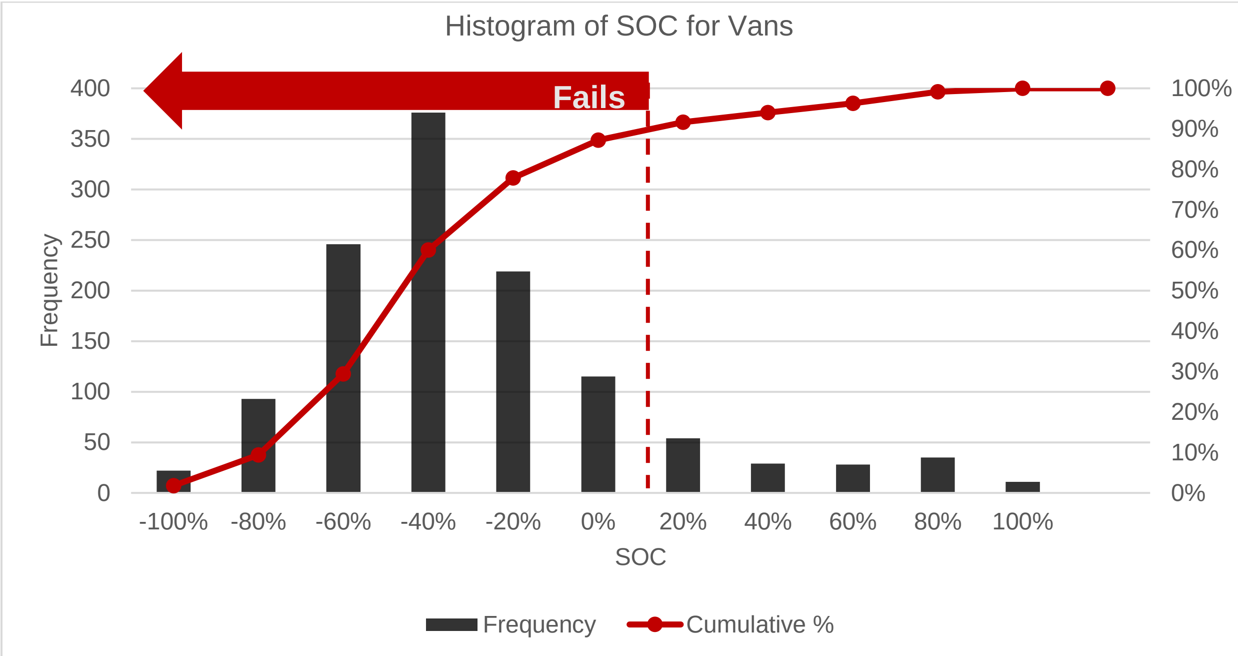


Figure 16: Successful electrification for vans in daily service (demand response services)

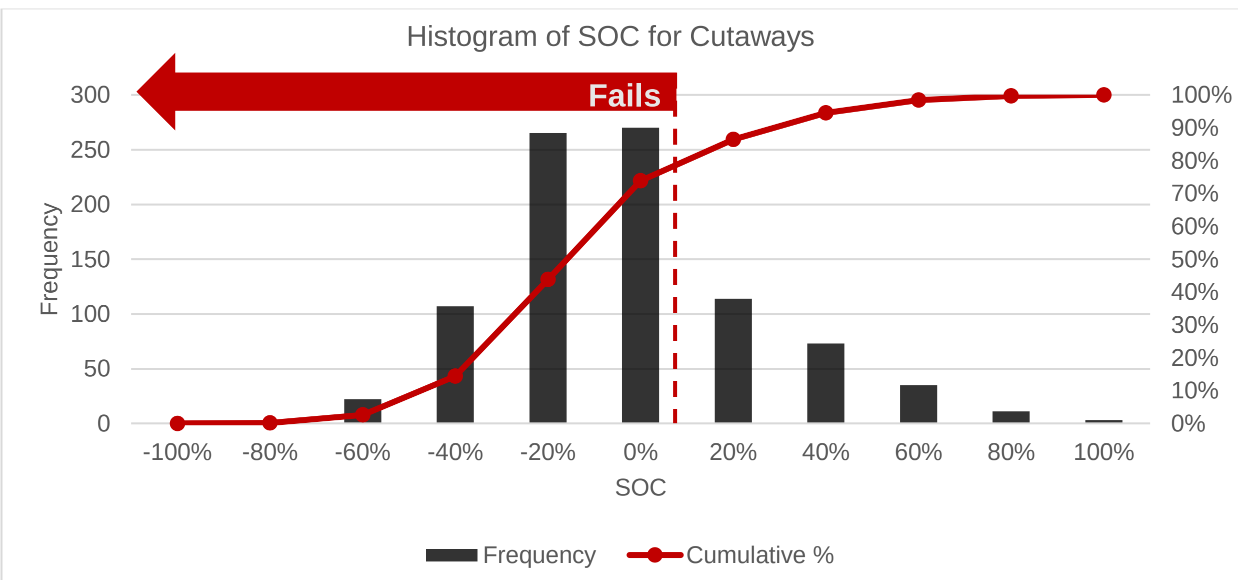


Figure 17: Successful electrification for cutaways in daily service (demand response services)

For vans, only 10% of all vehicle assignments operated in 2019-2020 can be completed by an electric cutaway, showing that the service profile for vans is predominately too strenuous for the current cutaway

ZE technologies (Figure 16). The outlook is similar for cutaway-delivered service, as only 15% of all vehicle assignments operated between 2019 and 2020 can be completed with an electric cutaway (Figure 17).

5.2 CONSIDERATIONS FOR LAKE TAHOE CAPITAL CORRIDOR SERVICE

As EDT assumed operations of the Sacramento to South Lake Tahoe Capitol Corridor service from Amtrak, Stantec developed a preliminary feasibility assessment of electrification options for the motor coach serving this route. Currently, the only option on the market for a motor coach is a BEB. The preliminary assessment considered the Connecting Bus Schedule provided by EDT—214 round-trip revenue miles, 42 deadhead miles, and the specific topography for the route alignment.

Our analysis found a predicted fuel economy of 2.79 kWh/mi, which considers an average slope of 3% with peak slopes of up to 7%. Given the challenging topography of this route, the round-trip with a 544-kWh battery size battery-electric coach is not feasible (resultant SOC of -30%). The successful electrification of the Sacramento to South Lake Tahoe route depends on charging infrastructure available near the Sacramento Amtrak Station and the South Lake Tahoe Stateline Transit Center. Without midday charging, the battery-electric coach will not be able to successfully complete service. If the BEB can have a two-hour charging event before starting the return one-way trip (with a charger of at least 150 kW power capacity), then the route can be successfully electrified. Schedule adjustments may be required (or a more powerful charger is required instead), since current layover times on weekdays is 45 minutes and our estimate is a two-hour charging event needed for sufficient refueling for the return trip.

These results only consider a predicted or modeled energy efficiency and not real-world operating conditions. Therefore, it is important for EDT to conduct real-world test drives with actual battery-electric motor coaches to ensure they can handle the power and torque requirements of the challenging topography encountered along the route.

5.3 SUMMARY AND FLEET RECOMMENDATIONS

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

- For local service, ~14% (1/7 daily vehicles assignments) of service is successful in the modeling—for most local routes, vehicles are in service all day and the service cannot be provided through a one-to-one replacement of vehicles with the current ZEB technology options for 35-ft vehicles.

- For commuter service, ~55% (6/11 daily vehicle assignments) is successful in the modeling. Most of the vehicles that fail are the vehicles assigned two blocks, with a morning block and an afternoon block. Exploring midday charging between blocks could help to increase success rates.

- For demand response services, 10% of van-delivered service is successful and 15% of cutaway-delivered service is successful. Future technology advancements in ZE cutaways and vans with longer ranges, improved fuel economies, and denser battery packs could help to improve this outlook.

- Modeling for the Lake Tahoe Capital Corridor service indicated that midday charging (or charging at the end of a one-way trip) is necessary given the current technology profile of battery-electric motor coaches. As such, EDT would need to work with Amtrak and other responsible parties to plan for charging infrastructure in South Lake Tahoe and Sacramento. Schedule adjustments may be required (or a more powerful charger is required instead), since current layover times on weekdays is 45 minutes and our estimate is a two-hour charging event needed for sufficient refueling for the return trip or 40 min with a 450-kW fast charger to complete the day service. Additionally, it is recommended to test drive an electric coach in the specific route to ensure the topography is not more than the vehicle can perform.

Following the modeling results, a variety of potential solutions were developed for each service type to weigh the pros and cons of different solutions across different areas of interest, including financial, facility, and operational considerations. Following the development of the preliminary solutions, Stantec met with EDCTC and EDT staff to workshop the feasibility of the different solutions and come to a preferred fleet concept that best fits the needs of EDT. The recommended ZE approach is summarized in Table 5.

Table 5: Recommended fleet summary

Vehicle type	Service	ZEB type	Battery size required (kWh)	Quantity	Change from current quantity	Notes
35-ft. buses	Local fixed route	BEB (in-depot charging)	450	13 to maintain spare ratio over 20%	+1 BEB	Increase from 7 to 10 active buses in a day
Motor coaches	Commuter fixed route	BEB (in-depot charging)	544	17	+1 BEB	Requires equipment for midday charging in Sacramento. Midday charging also required at EDT's facility
Cutaways	Demand response	N/A; CARB exemption	At least 230	N/A; CARB exemption	N/A	Current available battery size is ~120 kWh. According to the modeling, to meet operational requirements, minimum battery size required is ~230 kWh. For the CARB plan, Stantec assumed 1:1 replacement with recommended battery size. EDT can potentially test feasibility of Ford E-Transit van.

Vehicle type	Service	ZEB type	Battery size required (kWh)	Quantity	Change from current quantity	Notes
Vans	Demand response	N/A; CARB exemption	80	N/A; CARB exemption	N/A	For the CARB plan, Stantec assumed 1:1 to replacement of non-ZE vans with ZE vans. Power demand modeling assumed ZE equivalent can achieve 0.45 kWh/mi fuel efficiency.[15] EDT can potentially test feasibility of Ford E-Transit van with a battery size of 67 kWh.
Non-revenue sedans and vans	Non-revenue	Light-duty EVs (Chevy Bolt, Nissan Leaf, etc.)	80	10	N/A	Potential procurement partnership with County to reduce capital costs

5.4 POWER DEMAND MODELING AND CHARGING PROFILE

After determining the preferred and recommended fleet composition for EDT, the subsequent step is to estimate the power capacity at the transit facility to meet the energy demand for an all-BEB fleet to identify the required utility upgrades. Several operational factors were incorporated as parameters for the power modeling, including:

- Charging/recharging time window: Stantec assumed all buses start charging overnight and can charge during the day between blocks, i.e., charging can occur during out-of-service times. This input is the service schedule of vehicle pull-out and pull-in times for a representative day and according to the blocking and scheduling changes made during fleet composition refinement.
- 150 kW in-depot chargers for motor coach and 35-ft buses (Charger Output in Equation 1)
- 60 kW in-depot chargers for cutaway vehicles (Charger Output in Equation 1)
- Level II (~12 kW) in-depot chargers for light-duty vehicles such as vans and non-revenue cars (Charger Output in Equation 1)
- A 90% charger efficiency (Eff. in Equation 1)
- A 25% contingency factor to account for the limits of onboard charging equipment that limit the maximum power capacity from the chargers (Contingency in Equation 1)

[15] Based on available vehicle models, estimated average actual fuel efficiency is 1.80 kWh/mi.

- Assuming negligible time between when a bus enters the facility and is connected to charger and starts charging

Other assumptions specific to the charging profile of demand response vehicles include:

- Since the modeling revealed that only a portion of the demand-response vehicles (between 10% and 15%) can complete their daily service with currently available vehicle models with battery sizes 80-120 kWh, to estimate the power requirements for a 100% successful service, we assumed that (hypothetically), vehicles for cutaway-delivered service will have batteries that are 230 kWh in capacity, and that vehicles with 80 kWh will be operated for the van-delivered service with an average fuel economy of 0.45 kWh/mi.
- Service period for cutaways was assumed to be between 6:30 to 10 am and from 2 to 7:30 pm. Cutaway vehicles would return to the facility for midday charging between 10 am and 2 pm and the battery will need to charge for at least 2 hours to replenish 80% of the SOC.
- Service period for vans providing dial-a-ride and ADA services is assumed to start at 6:30 am and end at 8:00 pm, leaving no time for midday charging.
- Non-revenue vehicles were also modeled assuming a battery size of 80 kWh.

Using the technical specifications and assumptions from the charging equipment, the charging hours (hours of charging required per block) that are required based on the daily energy demand were calculated using Equation 1 for each vehicle type.

Equation 1: Hours of charging needed to serve daily energy demand

$$Hrs.Charging = \left[\left(\frac{kWh}{day} * \frac{1}{Charger\ Output\ kW}\right) * \frac{1}{eff.}\right] * (1 + Contingency)$$

Equation 1 was applied to the daily energy demand calculated for all blocks and vehicle assignments. The total charge time per block per vehicle was then used to develop a vehicle charging schedule for El Dorado's division (i.e., hours during the day that each bus needs to charge in order to have enough energy to go into service at the time specified by the service or dispatching schedule).

The number of hours each charger needs to be online provides the power requirement, and the cumulative number of connected chargers at a specific hour represents the total power required at each hour of the day. For example, if 10 chargers with a maximum capacity of 150 kW are connected at the same time for one hour, the power demand during this hour is 1,500 kW.

The key aspect of calculating the power demand for each hour of the day is assigning the correct charging schedule to every bus serving a specific block. Assigning charging times to the vehicles was based on the following parameters:

- Charging buses as soon as they return to the base

- Charging during vehicle not-in-service hours based on block schedules
- Avoiding charging during peak hours (4 – 9 pm) according to PG&E rates (Table 6)

Table 6: Electric Schedule BEV from PG&E

Charge Type	Rate	TOU Period
Super Off-Peak (SOP)	$0.1004/kWh	9:00 am to 2:00 pm
Off-Peak	$0.1231/kWh	9:00 pm to 9:00 am 2:00 pm to 4:00 pm
Peak	$0.3320/kWh	4:00 pm to 9:00 pm

- Accommodating midday charging in the depot for three vehicles to complete commuter services. One of the commuter vehicles will require midday charging during its layover in Sacramento. The power requirement for this vehicle was not accounted for in the charging profile presented below since the charging will occur off-site.
- Non-revenue vehicles will be charged using three different shifts, 1) between 9 pm to 12 am, 2) from 2:30 am to 5 am, and 3) from 6:00 am to 8:30 am
- For cutaways and vans, overnight charging is assumed from 9 pm to 6 am
- Smart charging software will be implemented to optimize the charging times and guarantee all vehicles will be charged and ready for service

The power modeling provides the following outputs:

- The maximum number of chargers that need to be connected at each hour of the day
- Representative daily charging schedule
- Maximum power requirements

Figure 18 displays the charging schedule and daily power requirements at EDT’s division, while Table 7 shows total daily energy requirements and maximum power required. A 10% contingency was added to the calculated power capacity to account for additional chargers coming online or for any failures in the smart charging system.

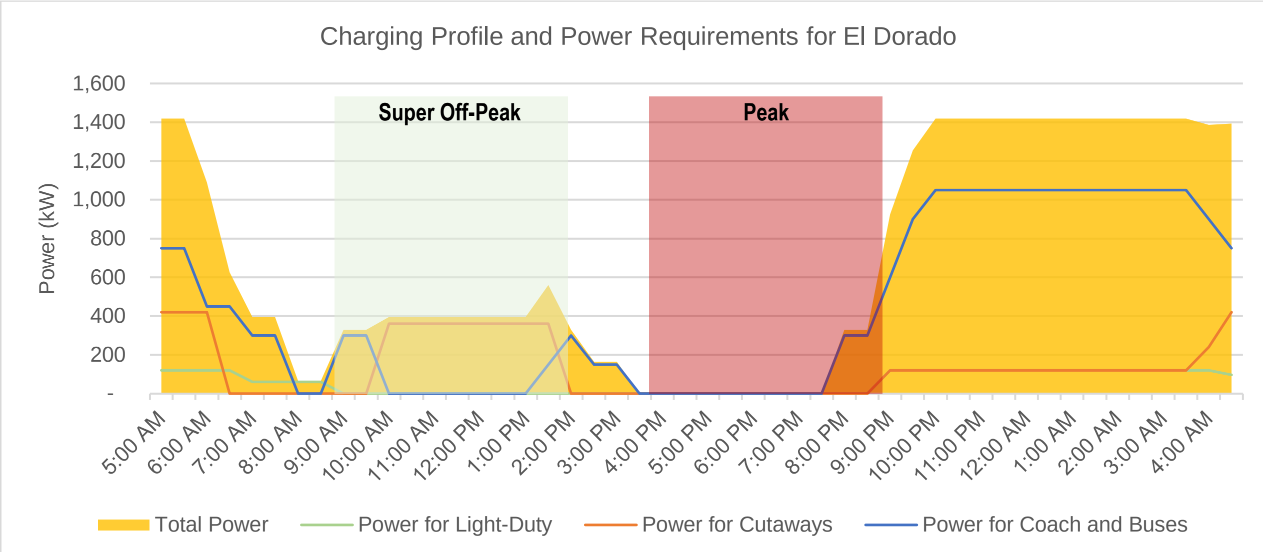


Figure 18: EDT charging profile and power requirements

Table 7: Summary of maximum power demand and total energy requirements

No. of active 150 kW Chargers	No. of active 60 kW Chargers	No. of active Level II Chargers	Total daily energy requirement	Maximum power demand
9	7	10	11,500 kWh	1,419 kW

The charging profile and total number of online chargers will vary if using smart charging management software, but the analysis shown here ensures that a high demand service day for EDT can be achieved under a maximum power demand of 1.42 MW.

6.0 FLEET PROCUREMENT SCHEDULE/OUTLOOK

EDT has specified a fleet replacement schedule for their current fleet as summarized in Table 8. This replacement schedule provides the basis for the ZEB phasing strategy and builds off EDT's vehicle replacement schedule from April 2021.

Table 8: Fleet replacement schedule

Year	Staff Vehicles	Demand Response Vans	Demand Response Cutaways	35-ft Buses	Commuter (Motor Coach) Buses	Total
2021	-	-	-	-	-	-
2022	1	5	-	2	-	7
2023	-	-	-	-	-	-
2024	2	5	-	-	-	7
2025	-	-	-	-	9	9
2026	-	5	6	-	-	11
2027	-	-	-	-	1	1
2028	5	5	-	-	-	10
2029	1	-	-	-	1	2
2030	-	5	6	-	-	11
2031	-	-	-	-	-	-
2032	-	5	-	6	-	11
2033	-	-	-	-	5	5
2034	-	5	-	-	-	5
2035	-	-	-	4	-	4
2036	-	5	6	-	-	11
2037	1	-	-	2	-	3
2038	-	5	-	-	-	5
2039	2	-	-	-	-	2
2040	-	5	6	-	9	20

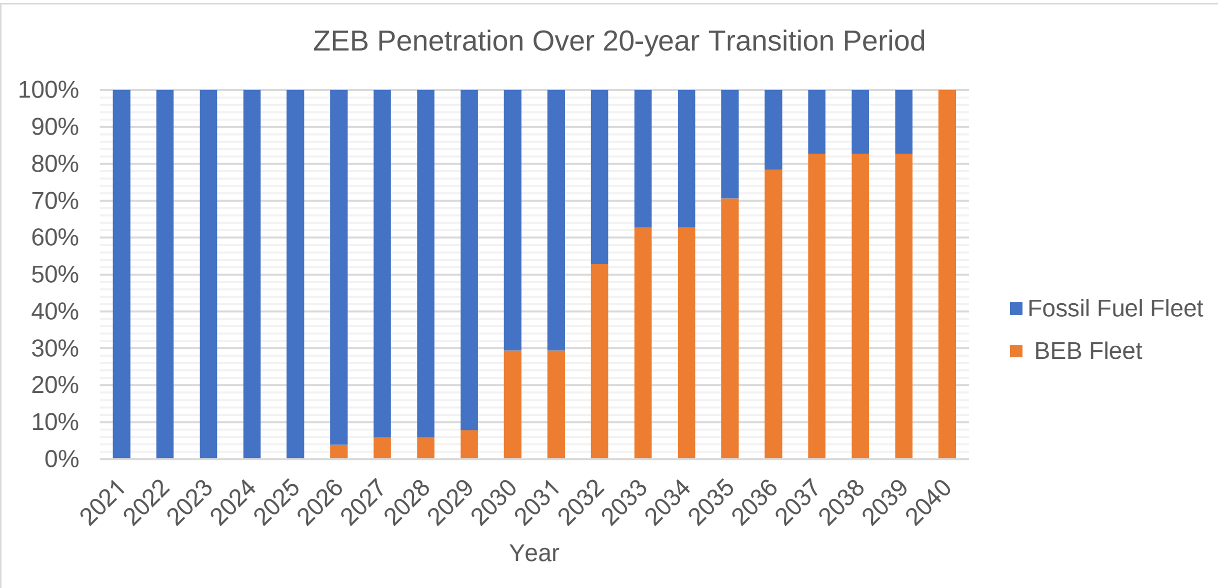
Table above does not include vehicles for the Lake Tahoe corridor service.

Based on the bus modeling, route simulations, and further analysis by the Stantec team, it was determined that a BEB fleet with re-blocking and midday charging for certain vehicle assignments is required to maintain the current service levels. This approach:

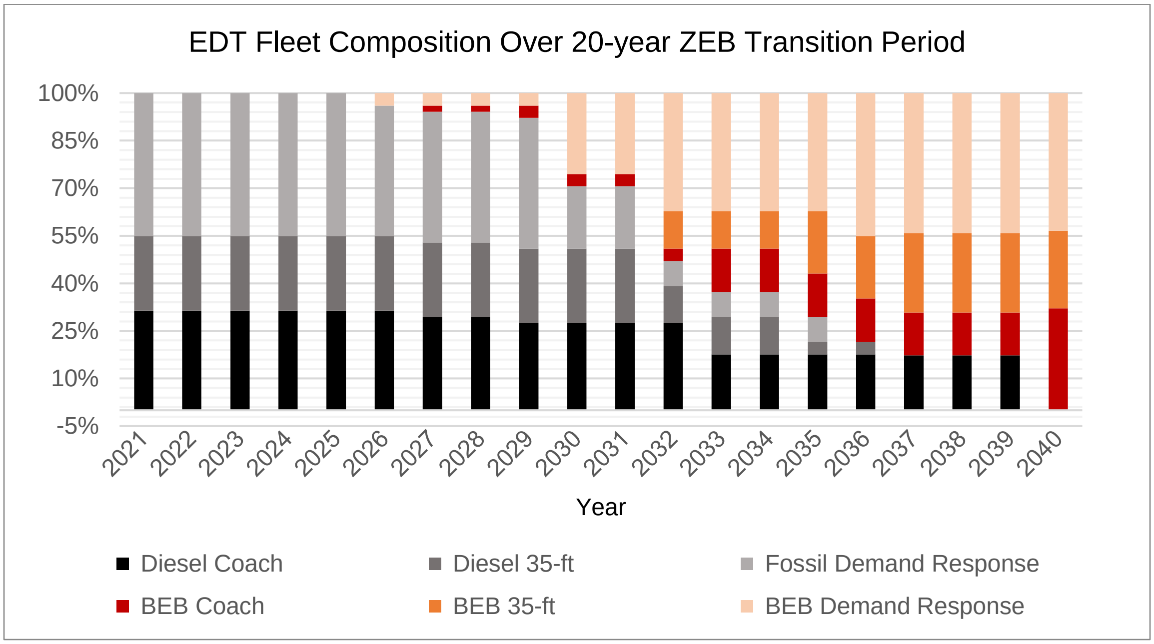
- Provides the same level of service as pre-pandemic conditions.
- Does not require a significant increase to the total fleet size.

This approach may require an increase in the total number of vehicle pulls in a day from 7 to 10 35-ft buses, and from 11 to 12 for motor coaches. While more total vehicles are likely required throughout the day, vehicles operating at peak increase by small degree; this increases the utilization ratio and, in turn, decreases the spare ratio.

While Stantec does not recommend acquiring more vehicles to maintain the current spare ratio, if EDT desires to maintain the same bus utilization ratio[16], two additional vehicles (one 35-ft bus and one motor coach) could be acquired once all fossil fuel vehicles are retired (i.e., past 2040). Figure 19 displays graphs demonstrating the proportion of the fleet by service type over time as the transition from carbon-emitting vehicles to ZEVs proceeds.



[16] Utilization ratio is defined as number of active vehicles in a day divided the total number of vehicles in the fleet.



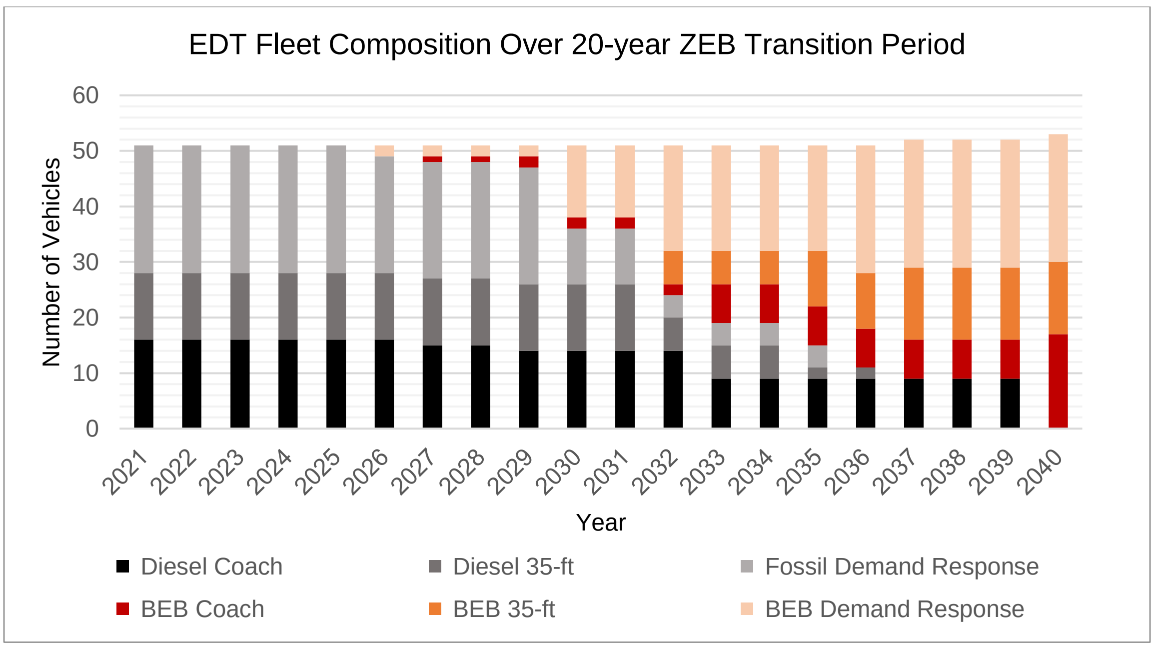


Figure 19: EDT fleet composition through 2040 by service type and technology

Table 9 displays the recommended fleet acquisition schedule for diesel/gasoline medium and heavy-duty vehicles. This plan was developed by accounting for fossil fuel vehicle retirement and the ICT purchase requirement—2026 as the starting year of acquiring ZEBs. While the acquisition schedule assumes the first purchase for cutaways in 2026, the purchase of these ZE vehicles can be postponed (and acquired as gasoline vehicles) if technology does not satisfy EDT's operating needs and applies for exemption from CARB.

For light-duty vehicles, as presented in Table 10, since the ICT regulation does not cover this vehicle class, we assumed that 2030 would be the starting year of acquisition to simplify the logistics of construction, tendering, and rollout of zero-emission vehicles. This schedule, nonetheless, does not preclude EDT from piloting zero-emission vehicles.

Table 9: 2021 – 2040 Fleet Forecast for Medium- and Heavy-Duty Vehicles

Forecast Year		21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Diesel Motor coach	New					9															
	Retire					(9)		(1)		(1)				(5)							(9)
Total Diesel Motor coaches		16	16	16	16	16	16	15	15	14	14	14	14	9	9	9	9	9	9	9	
ZEB Motor coach	New							1		1				5							10
	Retire																				
Total ZEB Motor coaches								1	1	2	2	2	2	7	7	7	7	7	7	7	17
Diesel 35-ft	New		2																		
	Retire		(2)										(6)			(4)		(2)			
Total 35-ft Diesel Buses		12	12	12	12	12	12	12	12	12	12	12	6	6	6	2	2				
ZEB 35-ft	New												6			4		3			
	Retire																				
Total 35-ft ZEBs													6	6	6	10	10	13	13	13	13
Gas Cutaways	New		1				4														
	Retire		(1)				(6)				(6)		(1)				(4)				
Total Gas Cutaways		12	13	13	13	13	13	11	11	11	11	5	5	4	4	4	4				
ZEB Cutaways	New						2				6		1				6				6
	Retire																(2)				(6)
Total ZEB Cutaways								2	2	2	2	8	8	9	9	9	9	13	13	13	13
Total ZEB vehicles	**Total**	**-**	**-**	**-**	**-**	**-**	**2**	**3**	**3**	**4**	**10**	**10**	**17**	**22**	**22**	**26**	**30**	**33**	**33**	**33**	**43**
Actual ZEB Portion (of purchase)	**%ZEB**	0%					33%	100%	N/A	100%											
ICT Requirement	**%ZEB**	0%					25%			100%											

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Table 10: 2021 – 2040 Fleet Forecast for Light-Duty Vehicles

Forecast Year		21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Gas Vans (revenue)	New		5		5		5		5												
	Retire		(5)		(5)		(5)		(5)		(5)		(5)								
Total Gas Vans		10	10	10	10	10	10	10	10	10	5	5									
ZEB Vans (revenue)	New										5		5		5		5		5		5
	Retire														(5)		(5)		(5)		(5)
Total ZEB Vans		0	0	0	0	0	0	0	0	0	5	5	10	10	10	10	10	10	10	10	10
Staff Vehicles (non-revenue)	New		1		2				5	1											
	Retire		(2)		(2)			(1)	(5)	(1)								(1)	-	(2)	-
Total Staff Vehicles		11	11	10	10	10	10	10	9	9	9	9	9	9	9	9	9	9	8	8	6
Staff ZEVs (non-revenue)	New																	1		2	
	Retire																				
Total Staff ZEVs																			1	1	3
Total light-duty ZEV	**Total**	-	-	-	-	-	-	**-**	**-**	**-**	**5**	**5**	**10**	**10**	**10**	**10**	**10**	**11**	**11**	**13**	**13**
Actual ZEV Portion (of purchase)	**%ZEB**	0%									100%										
ICT Requirement	**%ZEB**	N/A																			

6.1 PHASING OF CHARGING EQUIPMENT

Given the established phasing strategy of vehicles into EDT's facility, the charging equipment should be set in place prior to the arrival of each BEB procurement. As described in Section 5.4, the total number of active charging modules and plug-in dispensers were modeled to minimize the power requirements at the facility. The final number of charging modules, as well as the phasing strategy (see Figure 20 for schematic of the recommended phasing of BEB deployment at El Dorado's facility), will depend on the final manufacturer selection. In this schematic, Area A would be constructed first to install transformers and related electrical equipment, while Area B would be constructed subsequently.

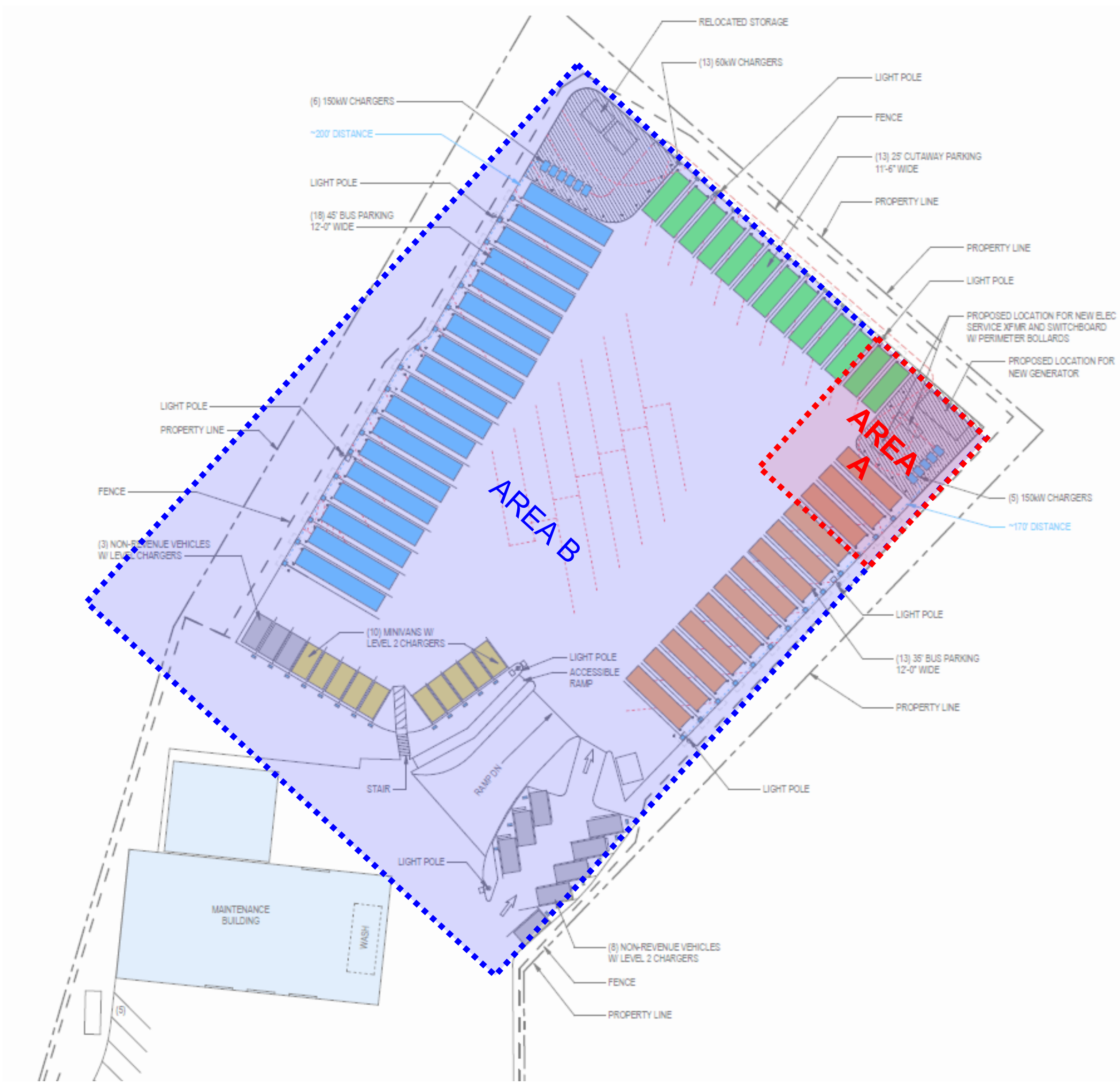

Figure 20: Parking area diagram phasing

Table 11 provides a summary of the total number of ZE vehicles at EDT's facility at key years of acquisition.

Table 11: Summary of Fleet Phasing Strategy

		Cumulative ZEB Quantity				
Type of vehicle	**Services**	**2026**	**2030**	**2035**	**2040**	**Post-2040**
45-ft Coach	Commuter services	-	2	7	11	17
35-ft Bus	Local fixed-route	-	-	10	13	13
Cutaways	Contracted DR and NEMT	2	8	9	13	13
Vans	DAR, Paratransit	-	5	10	10	10
Light-duty vehicles	Staff vehicles	-	-	-	3	9

The supporting infrastructure equipment will need to be in place prior to the vehicles arriving. Therefore, based on the ZEB vehicle count, while minimizing operational disruptions due to construction, the equipment phasing strategy was designed as described in Table 12. The phasing strategy (Table 12) was divided in three phases.

Table 12: Charger equipment requirements per year

		2025 / 2026		**2029 / 2030**		**2039 / 2040**	
		Cabinets	**Dispensers**	**Cabinets**	**Dispensers**	**Cabinets**	**Dispensers**
Facility Parking Area (refer to Figure 20)		**A**		**A & B**			
150 kW Cabinets for Coaches and 35-ft buses	To be Installed	1	3	4	12	4	12
	Cumulative	1	3	5	15	9	27
60 kW Cabinets for Cutaways	To be Installed	1	2	6	12	-	-
	Cumulative	1	2	7	14	7	14
Level II Cabinets for Vans and Staff Vehicles	To be Installed	-	-	7	14	3	6
	Cumulative	-	-	7	14	10	20

For each phase, the table lists charging equipment specifications for generic charger manufacturers with power capacity of at least 150 kW for the coach and 35-ft buses, 60 kW for cutaways, and Level II (~12 kW) for light-duty vehicles (including vans). It is assumed that the years associated with the phases in the table are to extend to the end of the calendar year.

7.0 MAINTENANCE FACILITY INFRASTRUCTURE MODIFICATIONS

This section outlines the proposed facility modifications for BEB implementation to EDT's bus operations and maintenance facility. The master plan option has been developed proposing ground-mounted dispensers. Fortunately, the facility has sufficient space opportunity for ground-mounted dispensers, avoiding the reduction in parking stalls while keeping yard flexibility since a considerable amount of physical infrastructure can be placed along the back of curb around the perimeter of the north parking area of the property. An overhead approach was also considered since it presents an ideal opportunity to implement photovoltaic (PV) systems to generate electricity. However, given the additional costs associated with the canopy structure and the lack in return of investment of the solar PV system (the solar PV systems are further discussed in Section 8.2), this option was not considered further.

The existing service cycle can be maintained and is not required to be changed for BEB implementation. Since the liquid fueling system used by the EDT is currently offsite, there are no considerations for phasing out this equipment and phasing can be relatively simple to install the new infrastructure required for BEBs. As operators currently fuel the vehicles at the offsite location, work rules do not preclude operators from 'fueling' and as such, operators would be responsible for plugging in buses for charging (or bus servicers, depending on when the bus needs to be charged).

Note that since the facility will require new electrical service connections from PG&E, the utility will likely require that a service study be performed to identify any transmission or distribution system upgrades that may be needed to support the additional power demands. While the additional electric demand due to the BEB fleet deployment is not large relative to what is often experienced at larger transit agencies, it will be up to PG&E to determine if the local power distribution system has the excess capacity to serve EDT's new charging loads as well as any other planned loads in the area. The recommendations below are focused on those infrastructure upgrades that are to be located on the agency's property and do not include any system upgrades that the service study may identify. The extent and timing of the system upgrades will determine the net cost to the agency.

7.1 PROPOSED MAINTENANCE FACILITY MODIFICATIONS

The following summarizes the proposed improvements for the ground-mounted dispensers (Figure 21):

- A new 1,500 kVA transformer and 4,000 A switchboard to provide adequate additional power to the facility, along with associated equipment pads and bollards.
- A new 1,500 kW generator with 800 gallons of onsite diesel fuel storage (or 2,000 gallons of LPG) in order to support 100% bus service for one day[17]. The quantity of fuel maintained on

[17] Details on the generator size calculations are described in Section 8.2

site will depend on the anticipated utility outage duration and the availability of fuel deliveries. The current calculation assumes fuel needed for one day of outage. Alternatively, the generator could be fueled using pipeline natural gas if infrastructure is readily available near the facility.

- A minimum of 9 150 kW vehicle chargers with a 1:3 charger-to-dispenser ratio to serve a maximum of 24 active (in revenue service) electric coaches and 35-ft buses, a minimum of 7 60 kW vehicle chargers with a 1:2 charger-to-dispenser ratio to serve a maximum of 14 cutaways, and a minimum of 10 Level II (12 kW) light-duty chargers with two dispensers each for 10 non-revenue vehicles and 10 vans.
  - Equipment pads and associated bollard protection around chargers and dispensers
  - Power main feeder and sub feeders
  - Communication system panel/distribution cabinet and conduits to each charger
  - We assumed that all service conduit connecting the power cabinets to the dispensers will be underground following the perimeter of the facility.
- Pavement replacement/repair for trenching associated with electrical distribution for Area A where new electrical service and switchboard will be allocated.
- New pavement markings/striping as required for parking reconfigurations.
- No proposed modifications to the buildings.
- Existing site lighting poles will need to be removed and new lighting systems installed for the parking area.

DRAFT

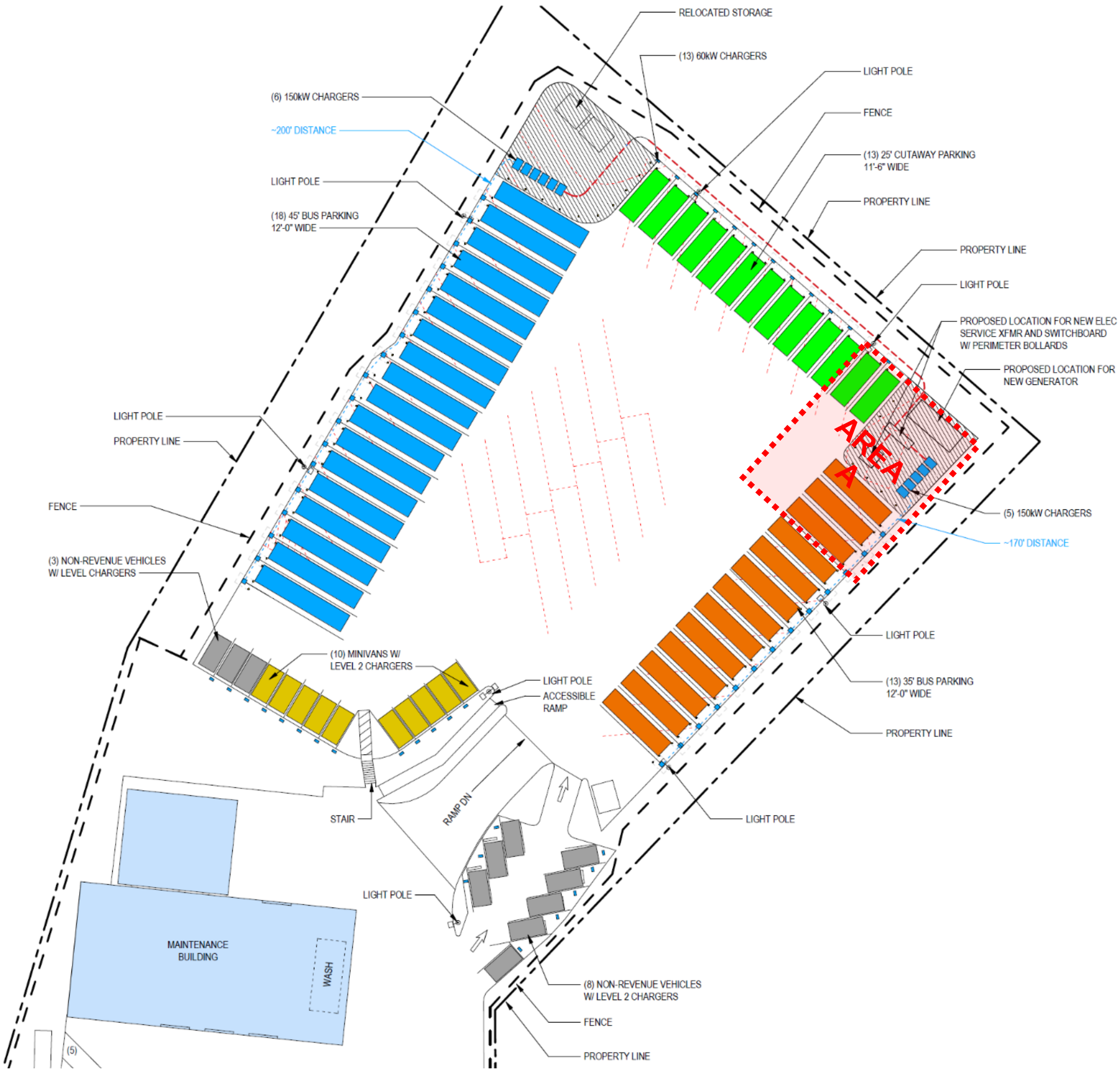

Figure 21: El Dorado ZEB Site Conceptual Master Plan

7.2 GRID CONNECTION UPGRADES

The primary service conduit included in the master plan options and estimate extends from the utility point of connection (meter) to the main distribution panel on the site. The extent of upgrades that will be necessary on PG&E's side of the meter will need to be determined by the utility based on an analysis of the local power distribution system. Since the EDT facility is a commercial area, we anticipate that the utility system upgrades would not be significant. If upgrades to the PG&E system are necessary, the cost may be covered by the utility based on the additional electricity that they will be selling to EDT for BEB charging. However, it could be expected for EDT to pay for the required utility upgrades either through a direct fee or through a monthly facility services charge.

Typically, PG&E will perform a service study 12-18 months prior to the new service start so they can include the most up to date information on anticipated new loads from all their customers in the area. The extent and timing of the system upgrades will determine the net cost to the agency.

7.3 COMMUNICATION INFRASTRUCTURE

Infrastructure for data communications within the charging system will include IP Ethernet wiring between each charger and its associated dispensers, as well as between each charger and a local data switch. The actual wiring will be conventional Cat 5E or Cat 6 Ethernet cable between devices. As the maximum length allowed for Ethernet is 100 meters or 328 ft., the dispensers cannot be too far from their respective charger. And though longer distances are possible with fiberoptic cable, the DC power cables that need to run parallel with the Ethernet cables begin to have problems with voltage drop at this distance, so 328 ft. is a recommended limit.

Once the Ethernet lines from each charger are routed back to the facility's data switch, the data can be contained within EDT's local network and managed directly by the agency. Alternately, the data can be routed to a cloud-based system – as needed to provide smart-charging and data aggregation—that is managed by a third party and/or is provided by the charger manufacturer. However, this would likely require coordination and approval of security and access, as it would necessitate outside entities operating within EDT's local network, at least at some level.

7.4 FIRE PROTECTION CONSIDERATIONS

With the implementation of BEBs, fire protection and life-safety concerns can be significant. However, due to the relatively new advent of these associated technologies, building and fire protection codes have not specifically addressed most of these concerns. National Fire Protection Association (NFPA) 855 'Standard for the Installation of Stationary Energy Storage Systems' is a standard that can potentially be applied to BEB storage, but this particular standard is excessive relative to the capacity of the batteries onboard buses and considering all of EDT's buses are stored outside. The need for enhanced fire protection systems has not been determined as a baseline requirement for BEB implementation and would be left up to the discretion of the local fire marshal and the local building officials. The need for additional fire lanes or fire 'breaks' within long continuous rows of bus parking may need to be discussed with the local fire department but is unlikely considering the size of the fleet stored onsite.

If EDT decides to install PV panels above the buses parking stalls, an NFPA 13 compliant automatic sprinkler system could be required because the canopy has a ‘use’ underneath it as defined by the California Fire Code.

Furthermore, all modifications to the facility should be reviewed with the local Authorities Having Jurisdiction (AHJs), in particular the fire marshal. Fire truck access to the site and hydrant access will need to be reviewed and approved by the pertinent AHJs prior to implementation of any additional infrastructure for charging equipment or solar canopies. However, since the site is designed for bus movements, fire truck access is relatively straightforward and should be accommodated without significant changes to the facility.

In summary, no fire protection systems are required for minimal BEB implementation but considerations for covered canopies could trigger additional fire protection system upgrades to the facilities.

7.5 FALL PROTECTION AND SAFETY INFRASTRUCTURE CONSIDERATIONS

Fall protection systems are recommended for any vehicle maintenance and inspection shop but considering that EDT has already implemented a fall-arrest system in the facility, it is unlikely that additional fall protection systems would be required to safely access the rooftop of buses for potential battery inspection and maintenance. If considerable rooftop access is necessary in the future, El Dorado should consider additional fall protection systems throughout the shop.

7.6 FACILITY AND INFRASTRUCTURE MODIFICATIONS CONCLUSION

Table 13 summarizes the minimum facility and infrastructure requirements for ZEB implementation at the agency’s operations and maintenance facility.

Table 13: Infrastructure modification summary

Division Name	Address	Main Function(s)	Type(s) of Infrastructure	Service Capacity	Needs Upgrade (Yes/No)
El Dorado Transit Offices	6565 Commerce Way, Diamond Springs, CA 95619	Operations, Maintenance, Training, Recharging ZEB	New BEB charging equipment, additional electrical utility service and associated site improvements.	14 – Coaches 10 – 35 ft-buses 14 – Cutaways 10 – Vans 10 – Light-duty cars	Yes

Table 14 provides a year-by-year description of planned infrastructure modifications. Since adequate space is available onsite and the payback potential for PV canopies is not feasible relative to the size of the facility and PG&E utility rates, **ground-mounted dispensers and no solar PV is the**

recommended approach for EDT. A hybrid approach may ultimately be appropriate for EDT as charging technology changes or if electrical utility rates change in the future.

Table 14: Infrastructure modification detailed outlook

Year	On-site construction work	Equipment to be installed	Cumulative Equipment required to be online
2025	Underground work starts for conduit installation in Area-A (please refer to site plans Figure 20)		
2026		**Area-A** 1 power cabinet (150 kW) + 3 dispensers 1 power cabinet (60 kW) + 2 dispensers **Area-B** none	**Area-A** 1 power cabinet (150 kW) 1 power cabinet (60 kW) 5 dispensers **Area-B** none
2029	Underground work starts for conduit installation in Area-B		
2030		**Area-A** 3 power cabinets (150 kW) **Area-B** 1 power cabinet (150 kW) + 12 dispensers 6 power cabinets (60 kW) + 12 dispensers 7 power cabinets (Level II) + 14 dispensers	**Area-A** 4 power cabinets (150 kW) 1 power cabinet (60 kW) 5 dispensers **Area-B** 1 power cabinet (150 kW) 6 power cabinets (60 kW) 7 power cabinets (Level II) 38 dispensers
2039	Underground work for conduit installation in Area-B		
2040		**Area-A** None **Area-B** 4 power cabinets (150 kW) + 12 dispensers 3 power cabinets (Level II) + 6 dispensers	**Area-A** 4 power cabinets (150 kW) 1 power cabinet (60 kW) 5 dispensers **Area-B** 5 power cabinets (150 kW) 6 power cabinets (60 kW) 10 power cabinets (Level II) 56 dispensers

8.0 RESILIENCY

Planning for resiliency and redundancy is necessary not only to support operations during emergencies or other disruptions, but also to ensure that if the yard loses power, BEBs can still be operated. This is particularly important when considering a transition to electricity-powered buses and when considering Northern California's predisposal to PSPS (Public Safety Power Shutoff) events in response to severe weather and to prevent wildfires.

Several agencies have deployed solar PV assets to generate renewable energy to power functions like administration buildings. With the adoption of a BEB fleet, additional harvesting of solar PV energy, together with storage of this energy in stationary batteries, can be used to charge a portion of the fleet with energy that does not come 'from the grid'. As such, this strategy could be used to diminish some of the costs associated with charging, particularly during peak time-of-use periods.

Nevertheless, 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. In the event of an emergency, relying solely on solar energy is impractical. As such, deploying complementary fossil fuel-powered generators is necessary to generate the power required to charge a BEB fleet.

The following sections:

- Describe the planning for emergencies (i.e., assuming that during an emergency, EDT would operate 100% of its service for one day) and the required size of the backup diesel-fired generator.
- Describe the potential for solar energy generation based on solar canopy structures installed at the yard. Implicit in these assumptions is that stationary batteries would be deployed as well to capture the energy for later use.

8.1 BACKUP PLANNING

Transit agencies need to consider the portion of service (and thus of their BEB fleet) that will be deployed or operated during grid-outage conditions. This percentage will require backup power to charge for the anticipated emergency period. Some transit agencies consider the use of a battery electric storage system (BESS) to provide temporary relief; however, these additional assets require favorable energy policies to compensate such facilities for the additional services a BESS can provide.

Most agencies deploying BEBs in California have deployed generator systems using fossil fuels, mostly diesel-fired generators. Figure 22 shows an example of a mobile generator at LA Metro's Division 13 Bus Operations and Maintenance Facility in Los Angeles. Additional facility space will need to be allocated for such a backup generator in addition to emergency fuel storage (if desired).

Figure 22: Backup mobile diesel generator at LA Metro Division 13, Los Angeles, CA.

Based on Stantec's estimates, Table 15 illustrates the size of the generator needed to maintain 100% of revenue service for one average weekday. The level of service that is desired, percentage of all normal runs, as an example, sets the requirement for the size of the generator required at the charging site.

Table 15: Estimated fuel consumption for back-up generation.

Generator Capacity (kW)	Charging Energy (kWh/day)	Fuel consumption (gal/day)	
		Diesel	LPG
1,500	11,000	800	2,000

Fuel consumption values are assuming operation on one fuel type only.

If EDT wishes to operate for more 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 on environmental regulations and local policies.

For the purposes of the financial analysis, Stantec assumed the use of one 1,500 kW generator with storage capacity for 800 gallons of diesel in order to serve one revenue day at 100% service levels.

Adequate space is available on-site for either a new permanent generator or accommodations for a mobile generator. The area in the north-east corner is shown on the master plan options as a central location for the new electrical service equipment as well as a generator (Figure 23). If a permanent generator is installed, bollards should be installed surrounding the entire electrical equipment yard, but if a mobile generator is chosen as the preferred method of backup power, then the protective elements should be installed in a manner to allow a mobile generator to be parked near the switchboard to minimize the connection cable distance.

A permanent generator on-site will require an additional permit by the AQMD and will have annual limitations on the durations it is allowed to run. However, a temporary mobile generator that has been certified by the CARB would not require a permit by the AQMD but will have further restrictions on when they can be used such as actual or imminent blackouts. Under any scenario EDT should consider close coordination with both the AQMD and CARB in part of any plan to install a generator at the facility.

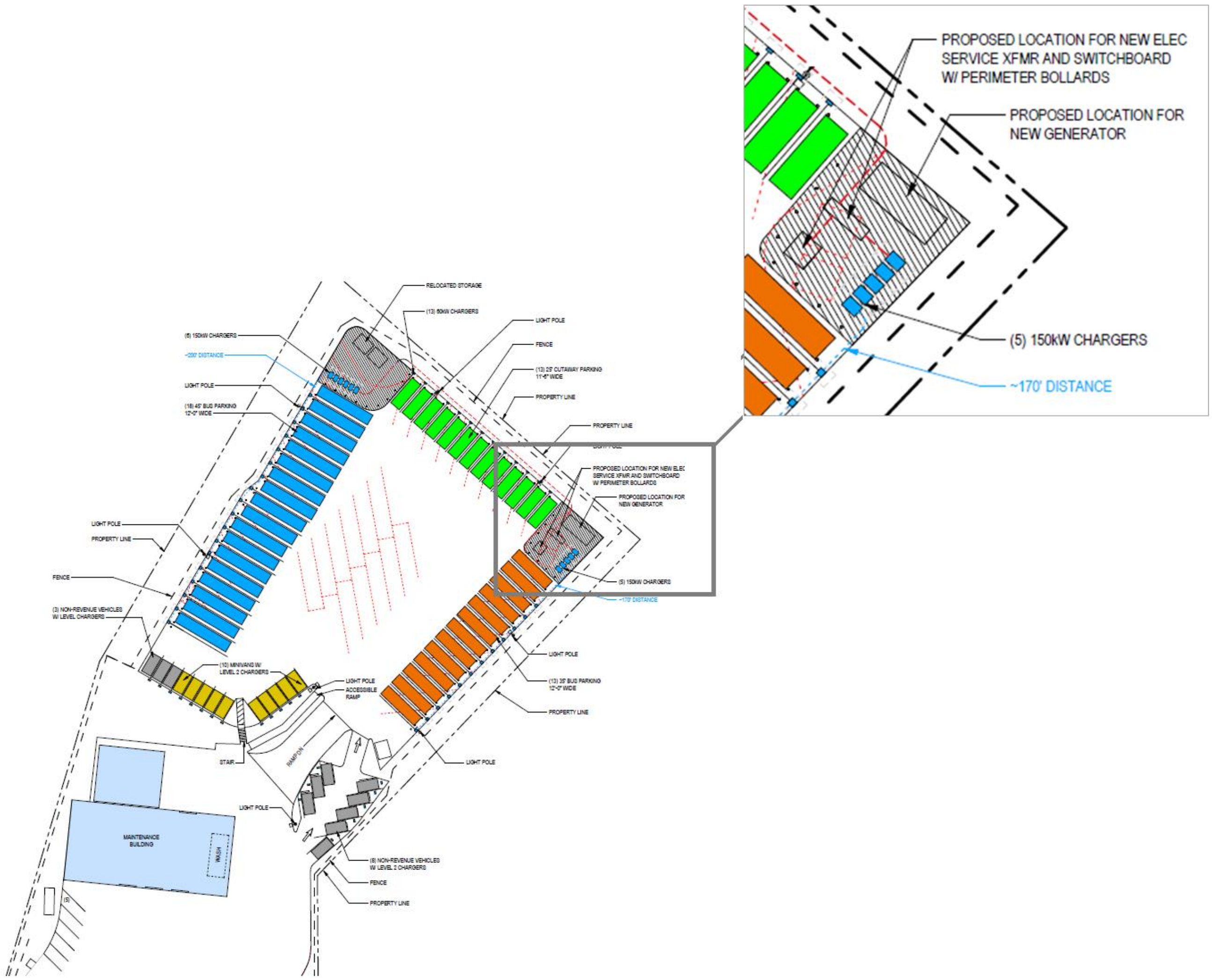

Figure 23: Proposed generator location

8.2 SOLAR PV AND ENERGY STORAGE

8.2.1 Solar PV Configuration

A solar study was performed for EDT's bus facility to understand the potential energy generation if solar PV panels were installed. Analyzed configuration of the solar PV panels assumes a canopy structure on top of all the proposed parking stalls along the perimeter of the facility, excluding any future parking spaces in the middle of the lot (Figure 24).

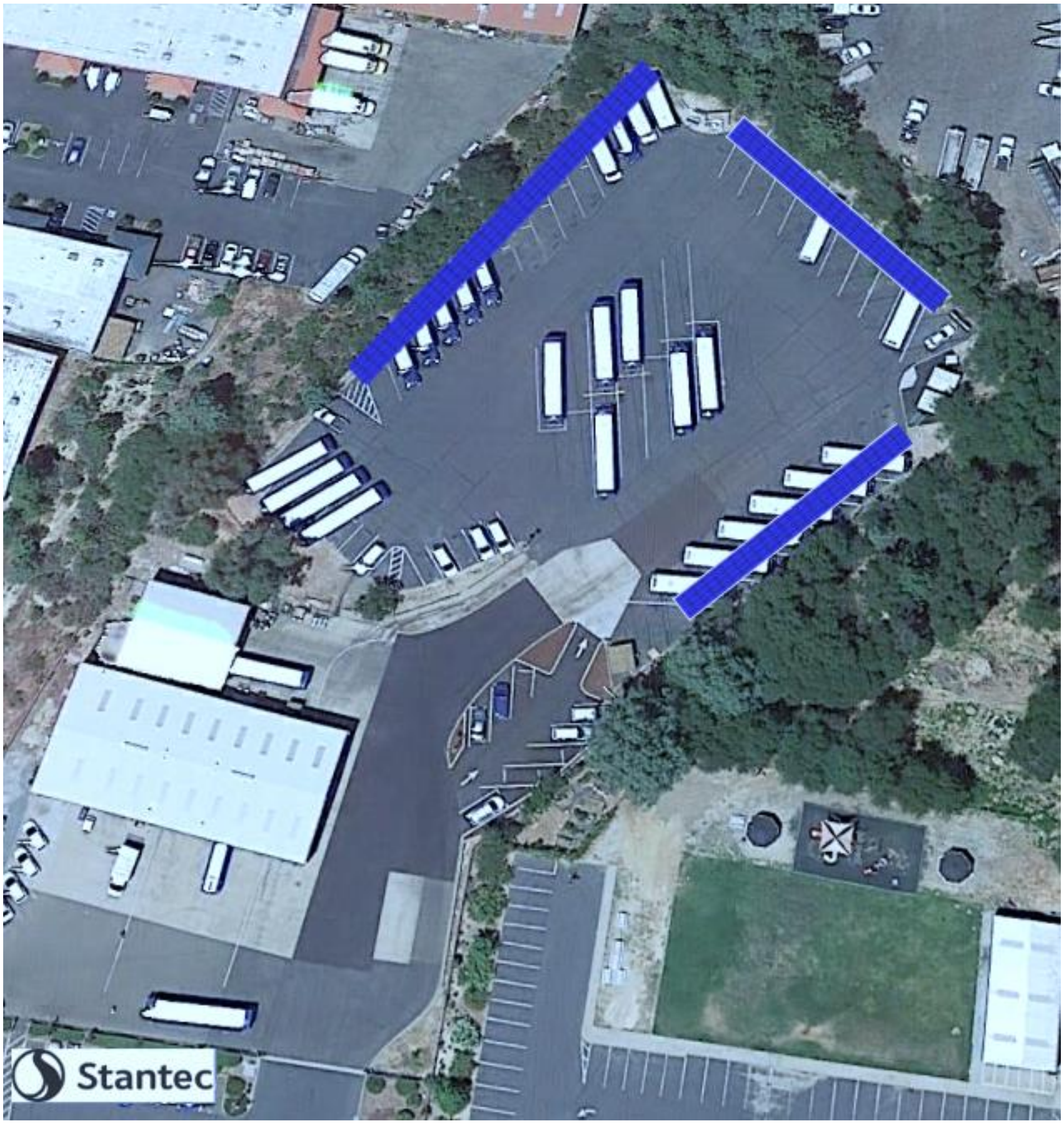

Figure 24: Solar panel configuration

The canopies serve the dual purpose of generating electricity by housing the PV panels, plus the added benefit of providing some weather protection for the assets. However, the proposed layout for EDT does not require any overhead infrastructure since ground-mounted dispensers can be accommodated with the existing footprint. Therefore, the cost for the canopies is an extra expense that needs to be considered when evaluating the financials of the solar PV system. Table 16 presents a summary of the sizes and performance specifications for the solar PV panels, as well as the estimated generation that can be harvested annually.

Table 16: Solar PV specifications and generation capacity

	Solar PV Size (kW DC)	Inverter Size (kW AC)	Average DC to AC Ratio	Estimated Generation - year 1 (MWh)	Performance Ratio
Solar PV System	405.5	330.0	1.23	564.1	74.0%

The projected annual production is estimated to be 564 MWh using a direct current (DC) module of 405.5 kW. The energy that can be harvested using PV panels was calculated for each month and is presented in Figure 25. Energy production peaks in the summer months with the prolonged duration of sunshine hours compared to winter months.

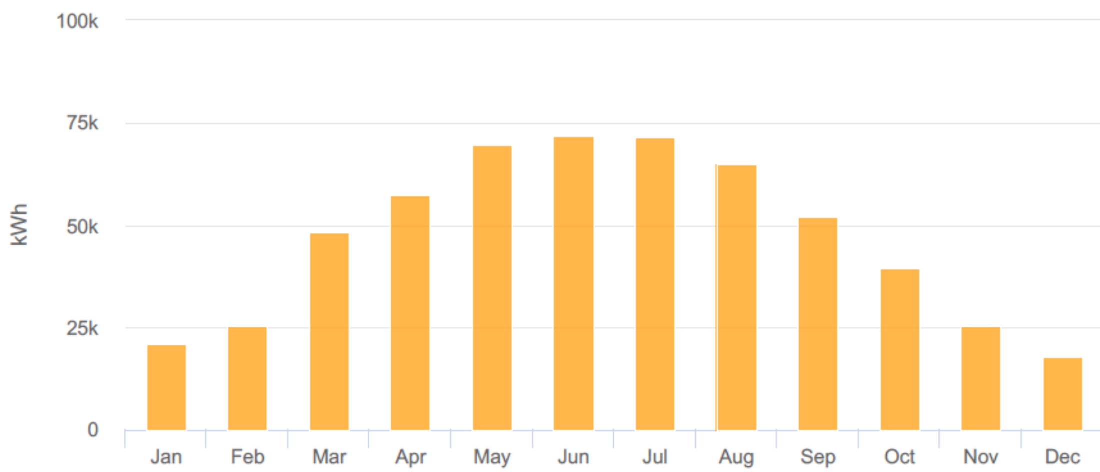

Figure 25: Monthly PV Energy Harvested with Solar Panels

The annual energy that can be harvested with PV panels accounts for 14% of the total energy demand at the facility. However, because the hours of solar generation do not align with the hours of charging demand (i.e., solar PV generation is greatest during the day when the buses are out in service), the solar energy cannot be utilized in its totality unless a battery storage system is in place.

The solar PV configuration considers the use of panels only on the potential canopies above the bus parking lots. The output of the solar assessment generated over 17,500 data points which were aggregated to determine the average hourly production possible at the facility. On average, the solar panels can accumulate as much as 1.5 MWh per day.

Using the hourly energy load needed to charge the vehicles and the projected hourly solar PV energy generation, a new adjusted energy load was modeled for the facility (to account for reduced grid-based power). Figure 26 shows the adjusted load when using only solar PV, without a BESS. The dotted gray line marks the original load, and the orange bars mark the new load the grid has to provide after accounting for the solar PV energy.

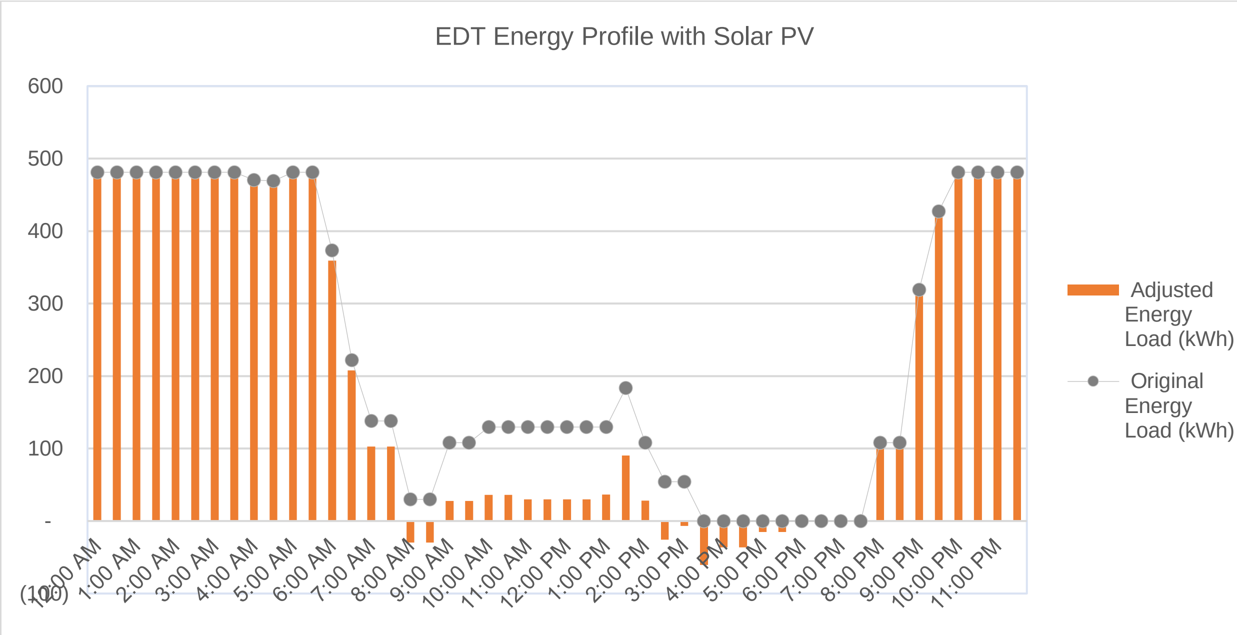

Figure 26: Daily Energy Profile only with Solar PV.

Note that the solar PV is only able to reduce the load between 7:30 am and 5 pm by 1.3 MWh, and the orange bars with negative values represent the energy from the solar PV that would have to be sold back to the grid or be wasted (260 kWh).

If a BESS is not installed at the EDT facility, then 17% of solar PV would have to be curtailed (wasted) if the grid is not able to purchase it back. However, a large portion of consumed solar PV is possible assuming that cutaways and coaches will need midday charging but given the unpredictability of solar generation, that 17% portion might be an underestimate. Therefore, the use of a BESS could help store any excess solar to then be discharged during peak hours, when electricity is the most expensive ($0.3320/kWh).

8.2.2 BESS Configuration

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 solely from the PV generation, and then discharged during periods where the electricity is most expensive (peak hours), and the buses need to charge. Such storage systems deploying 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 usage (and associated cost) can be reduced by minimizing using the grid when the electricity is most expensive.

Table 17 shows the rate for each hour of the day according to PG&E Business Electric Vehicle (BEV) rates. The key to sizing the BESS is to determine how much excess energy generated from the solar PV panels can be stored to then displace using energy from the grid at peak hours. The following subsections present a more detailed assessment for the solar PV configuration used in combination with a battery energy storage system (BESS).

Table 17: Electric Schedule BEV from PG&E.

Charge Type	Rate	TOU Period
Super Off-Peak (SOP)	$0.1004/kWh	9:00 am to 2:00 pm
Off-Peak	$0.1231/kWh	9:00 pm to 9:00 am 2:00 pm to 4:00 pm
Peak	$0.3320/kWh	4:00 pm to 9:00 pm

A preliminary bill of materials needed for an integrated solar PV-BESS for EDT is presented in Table 18. The combined system considers solar PV panels on canopies added above the bus parking stalls, a solar string inverter, and the battery storage system.

Table 18: Bill of Material for Solar PV panels + BESS

Description	kW
Solar PV Fixed Tilt for building frames and modules (DC)	405.5
Solar string inverter (AC)	330.0
Battery Energy Storage System	300 kWh / 200 kW

Details on the average charge and discharge hours of the battery, as well as how much solar is used directly to charge the battery are presented in Table 19. The charging strategy is to store all the excess solar PV into the battery and then to use it to reduce the peak requirements during the day.

Table 19: Option 1 Power Assessment Data for an Adjusted Load Profile

		i	ii			iii	L = i-ii-iii
	Hour	**Original Charging Load (kWh)**	**Solar PV Capacity (kWh)**		**Solar PV to charge BESS (kWh)**	**BESS Discharge (kWh)**	**Adjusted Load (kWh)**
Off-Peak Rate $0.1231/kWh	12:00 AM	481	-		-	-	481
	12:30 AM	481	-		-	-	481
	1:00 AM	481	-		-	-	481
	1:30 AM	481	-		-	-	481
	2:00 AM	481	-		-	-	481
	2:30 AM	481	-		-	-	481
	3:00 AM	481	-		-	-	481
	3:30 AM	481	-		-	-	481
	4:00 AM	470	-		-	-	470
	4:30 AM	469	-		-	-	469
	5:00 AM	481	2		-	-	479
	5:30 AM	481	2		-	-	479
	6:00 AM	373	14		-	-	359
	6:30 AM	222	14		-	-	208
	7:00 AM	138	35		-	-	103
	7:30 AM	138	35		-	-	103
	8:00 AM	30	60		30	-	-
	8:30 AM	30	60		30	-	-
SOP Rate $0.1004/kWh	9:00 AM	108	80		-	-	28
	9:30 AM	108	80		-	-	28
	10:00 AM	130	94		-	-	36
	10:30 AM	130	94		-	-	36
	11:00 AM	130	100		-	-	30
	11:30 AM	130	100		-	-	30
	12:00 PM	130	100		-	-	30
	12:30 PM	130	100		-	-	30
	1:00 PM	130	93		-	-	37
	1:30 PM	184	93		-	-	91
Off-Peak Rate $0.1231/kWh	2:00 PM	108	80		-	-	28
	2:30 PM	54	80		26	-	-
	3:00 PM	54	61		7	-	-
	3:30 PM	-	61		61	-	-
Peak Rate $0.3320/kWh	4:00 PM	-	36		36	-	-
	4:30 PM	-	36		36	-	-
	5:00 PM	-	15		15	-	-
	5:30 PM	-	15		15	-	-
	6:00 PM	-	3		3	-	-
	6:30 PM	-	3		3	-	-
	7:00 PM	-	0		0	-	-
	7:30 PM	-	0		0	-	-
	8:00 PM	108	-		-	**108**	-
	8:30 PM	108	-		-	**108**	-

		i	ii			iii	L = i-ii-iii
	Hour	**Original Charging Load (kWh)**	**Solar PV Capacity (kWh)**		**Solar PV to charge BESS (kWh)**	**BESS Discharge (kWh)**	**Adjusted Load (kWh)**
Off-Peak Rate $0.1231/kWh	9:00 PM	319	-		-	-	319
	9:30 PM	427	-		-	-	427
	10:00 PM	481	-		-	-	481
	10:30 PM	481	-		-	-	481
	11:00 PM	481	-		-	-	481
	11:30 PM	481	-		-	-	481

8.2.3 Economic Assessment of Renewable Systems

To determine whether installing a solar PV and/or BESS system is economical, an appraisal of several uncertain components, such as the future of commercial rates for electric fleets, and the actual solar energy that can be harvested during the lifetime of the equipment is needed. In lieu of this, Stantec conducted a preliminary assessment to identify whether solar PV and/or BESS presents a financial opportunity that would require further and more detailed analysis.

The basis of this initial assessment is confirming that the payback period for the investment will happen before the end-of-life of the installed equipment. If this is the case for any of the renewable systems, any year past the payback period will bring savings and financial benefits to EDT.

The following were the primary assumptions for the cost calculations:

- 30 years of manufacturer's degradation warranty for solar PV panels
- 20 years of manufacturer's degradation warranty for BESS
- Excess energy generated from solar PV is assumed to be purchased back at $0.02 per kWh
- Energy storage systems need to be installed at the same time as the solar PV system
- 5.0% (nominal) discount rate used in the financial modeling
- The solar PV system is assumed to be purchased at $1,100/kWh
- A 6% annual escalation between 2022 and 2030 (2030 is the assumed year of panel installation)
- 32.5% for design contingency and general conditions
- 8.5% for bonds, insurance, and contractor's fees
- The electricity cost escalation has been assumed at 2% per year

This preliminary approach is a static model and has the following limitations:

- Sizing of the BESS was completed using the average yearly energy production
- The cost comparison is based on rates from PG&E for Business Electric Vehicles Time of Use (TOU) Rate
- Rates from PG&E can still change in the future, such as incorporating demand charges that would help justify the use of BESS

8.2.3.1 Solar PV System Economic Assessment

The first step was calculating the return on investment when only using the solar PV panels. The payback period is the amount of time (measured in years) it takes to recover an initial investment. For example, if a payback period is stated as 10 years, it means it will take 10 years to receive your entire initial investment back and start seeing economic benefits.

The capital cost, annual costs and savings, and net present value of the system are shown in Table 20.

Table 20: Financial Analysis for Solar PV System

Capital Cost	
Estimated Capital Cost (with escalation to 2030 and contingency)	$1,409,000
Annual Cost & Savings	
Annual Electricity Cost without Solar PV System	$476,200
Annual Electricity Savings with Solar PV System (includes annual maintenance cost and excess electricity purchased)	$45,230
Annual Electricity Cost with Solar PV System (includes annual maintenance cost)	$430,970
Net Present Value	
Net Present Value (NPV, 30 years)	-$492,000
Discounted Payback Period (at 5% nominal rate)	No Payback
Simply Payback Period	31 years
Internal Rate of Return (IRR, 30 years)	2.0%

Figure 27 illustrates the discounted cash flows and NPV over the assessed period. The discounted payback period occurs when the NPV crosses the x-axis (i.e., becomes a positive cash flow). However, for the solar PV system at EDT, the payback period does not occur before the end of the usable life of the equipment, rending the project financially unfeasible.

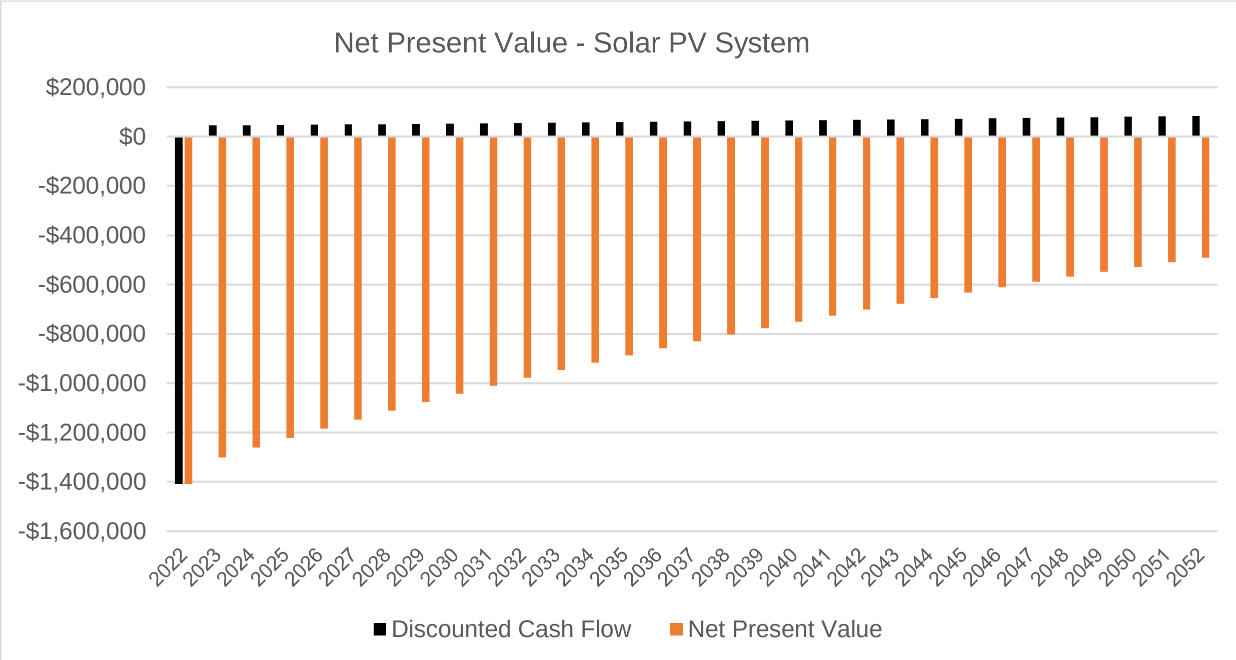

Figure 27: Net Present Value for Solar PV System

Overall, charging the BEBs with the electricity from the solar PV is not economically viable when compared to using electricity from the grid to charge the vehicles. However, this analysis is subject to reconsideration if 1) the electricity rate for using the grid for off-peak hours ever increases, 2) if PG&E implements demand charges, 3) if the utility can purchase excess solar PV energy back at a price higher than $0.02/kWh or 4) if total escalation rates to 2030 midpoint are lower than 75.9%.

8.2.3.2 Solar PV + BESS Economic Assessment

The first step to estimate the needed battery size to capture solar energy involves calculating how much excess solar could be stored to then offset using the grid during peak hours. The BESS was sized to be 300 kWh / 200 kW. Similar to the stand-alone solar PV system, the payback period is the amount of time (measured in years) it takes to recover an initial investment. The capital cost, annual costs and savings, and net present value of the solar PV + BESS system is shown in Table 21.

Table 21: Financial Analysis for Solar PV +BESS

Capital Cost	
Estimated Capital Cost (with escalation to 2030 and contingency)	$1,730,000
Annual Cost & Savings	
Annual Electricity Cost without Solar PV + BESS	$476,200
Annual Electricity Savings with Solar PV + BESS (includes annual maintenance cost)	$68,400
Annual Electricity Cost with Solar PV + BESS (includes annual maintenance cost)	$407,800
Net Present Value	
Net Present Value (NPV, 30 years)	-$461,500
Discounted Payback Period (at 5% nominal rate)	No Payback
Simply Payback Period	27 years
Internal Rate of Return (IRR, 30 years)	2.8%

Figure 28 illustrates the discounted cash flows and NPV over the assessed period. The discounted payback period occurs when the NPV crosses the x-axis (i.e., becomes a positive cash flow). However, for the solar PV + BESS at EDT, the payback period does not occur before the end of the usable life of the equipment, rending the project financially unfeasible.

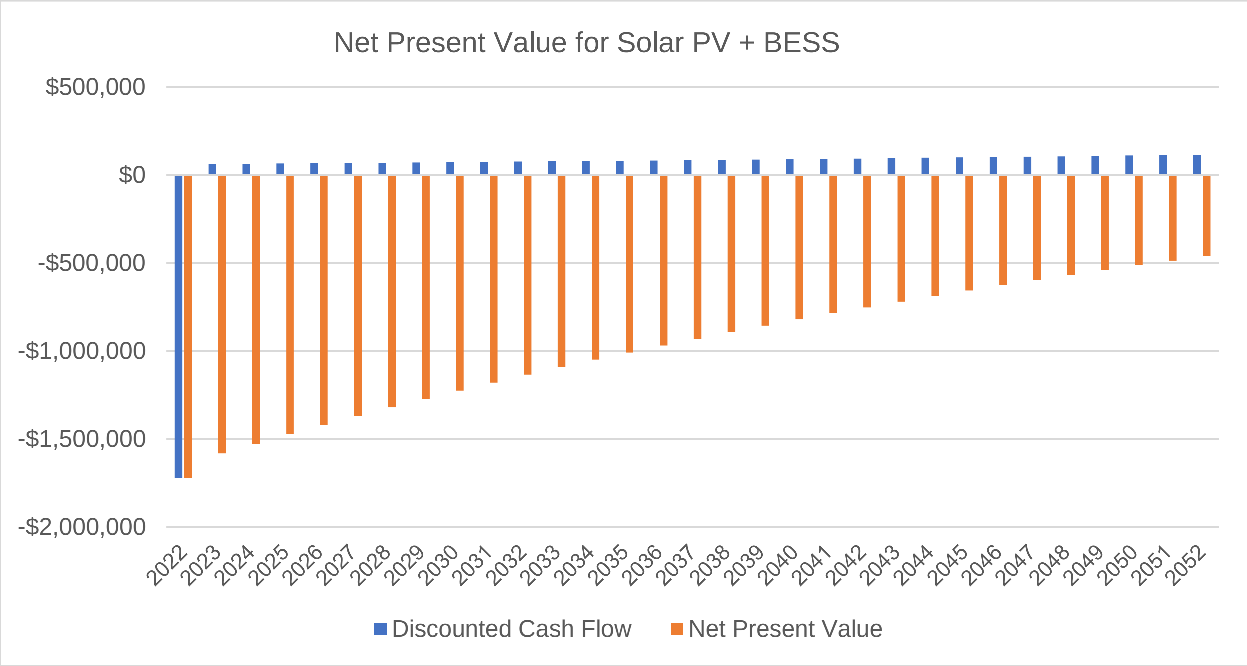

Figure 28: Net Present Value for Solar PV + BESS System

Even when implementing a BESS in combination with the solar PV panels, the system is not economically viable when compared to using electricity from the grid to charge the vehicles. However, this analysis is subject to change if 1) the electricity rate for using the grid for off-peak hours ever increases, 2) if PG&E implements demand charges, 3) if the utility can purchase excess solar PV energy back at a price higher than $0.02/kWh or 4) if total escalation rates to 2030 midpoint are lower than 75.9%.

8.2.4 Limitations of the Solar PV Analysis and Configuration Recommendation

The proliferation of renewable energy sources feeding into PG&E's grid has resulted in evolving electric rate tariffs that attempt to reflect the real-time value of energy more accurately being consumed and energy being exported to the grid. Historically, PG&E, like most utilities in California, has varied the cost of electricity based on the time of day (and season) and the corresponding cost to acquire and supply the power to the customer. Energy production that exceeds the local site demand and that is exported to the utility has been credited at the retail cost of power during the time period that the export occurs. This is generally referred to as Net Energy Metering (NEM). The credits that are accrued from energy exports are applied against the cost of power that the facility imports (consumes). The credits and costs are done on a dollar basis, not on a kWh basis.

The amount of renewable energy being exported to the grid during the day, primarily from solar PV installations, has caused the utility to reconsider how they calculate the value of the exports under the NEM contracts. PG&E is currently completing the rollout of a new rate schedule that will cover power exports going forward. Under this new rate, power exported to the grid will be valued at the wholesale cost of power, not the retail cost. Since much of the power PG&E provides is generated from hydroelectric sources and other renewables[18], excess power generated by PV will create low resale prices, in part, due to low wholesale electricity prices when compared to the price at mid and off-peak hours. PG&E is projecting that the value of power exported to their grid under a wholesale price will be in the range of $0.02 per kWh to $0.03 per kWh. EDT will be purchasing power under the PG&E BEV, which as noted above, has an average cost of $0.12 per kWh.

To determine whether PV is a viable option, the cost of generation can be compared to the value of the energy generated. Since the majority of the power produced by a PV array will occur when there is little charging load, most of the PV array output would be valued at the wholesale price. Even at the higher end of the projected value range, the levelized cost of energy from the PV array (even with battery storage) is higher than the value of the power produced. That being the case, it is not economically feasible to install a PV system.

Adding a BESS to the PV system allows the storage of the PV power so that it can be used to directly offset the much higher retail cost of power. As noted in Table 21, there is no return on investment. This analysis implies that a PV-BESS system is not economically viable under the assumptions listed above either.

Energy rates are continuously changing to better reflect evolving energy markets. The expansion of EV charging, and in particular large buses and transport trucks, is causing utilities to develop special tariffs designed to encourage the adoption of those technologies. While the current and upcoming tariffs do not make a PV system economically attractive, EDT should monitor the evolving tariffs to identify possible future opportunities.

9.0 OPERATIONAL AND PLANNING CONSIDERATIONS

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

9.1 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 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

[18] About 33% of PG&E's total energy comes from renewable sources.

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 mi) gets one month of a preferred parking spot in the employee lot.

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. CARB has 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 as well.

9.2 PLANNING, SCHEDULING, AND RUNCUTTING

According to the phasing schedule, the first ZEBs to be introduced will be 2026, but construction and deployment of chargers will need to be occur prior to that.

Key considerations for BEB planning and scheduling include the fact that the useable energy of the battery is 20% of the nameplate capacity. In other words, while EDT may purchase buses that have a 440-kWh battery, for instance, it should plan for 80% of that capacity or 352 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 EDT’s operations scheduling.

Developing a ‘cheat sheet’ like the depot planning tool from Siemens below (Figure 29) 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.

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

Figure 29: Depot planning tool to understand scheduling and operations of BEBs (Source: Siemens).

Non-revenue tests during vehicle commissioning should be conducted in different parts of EDT's service area to ascertain 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 so that they understand the importance of scheduling BEBs to the correct blocks. Training will also likely be needed in collaboration with EDT's scheduling software provider to account for combined BEB, diesel, and finally an entirely-BEB operation.

In the long term, it is also important to consider battery capacity degradation early on, as most BEB battery warranties specify that expected end of life capacity is 70% to 80% of the original capacity over six-12 years[19]. With an estimated 2% battery degradation per year EDT 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.

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

One further complication is the diversity of EDT's fleet for its several service types. So while the heavy-duty fixed-route bus fleet may be more predictable on a day to day basis, demand response services, like Dial-A-Ride, will likely require a phased in approach that is conservative. In other words, when EDT starts to deploy BEB cutaways or vans, it should deploy on short assignments close of the facility to avoid stalling or failures that would result in a towing event.

[19] 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.

For the commuter bus fleet, EDT needs to work with partners like SACOG and Amtrak to collaborate on potential charging infrastructure in downtown Sacramento and in South Lake Tahoe, respectively. The potential implementation of charging infrastructure at these facilities may facilitate on-route/layover charging for commuter coaches.

9.3 MAINTENANCE NEEDS

Early data suggests that ZEBs may require less preventative maintenance than their diesel counterparts 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. 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 EDT to coordinate spare parts procurement needed for ongoing BEB maintenance sooner rather than later so maintenance can be completed without interruption.

In terms of preventative maintenance, ZEB propulsion systems are more efficient than internal combustion (IC) engines and thus can result in less wear and tear. Without the diesel engine and exhaust, there are 30% fewer mechanical parts on a ZEB. ZEBs 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 EDT require OEMs to provide a list of activities, time interval, skill needed, and required parts needed to complete each preventative maintenance task for BEBs.

Many current ZEBs 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.

9.4 CHARGING NEEDS

Research suggests that depot charging stations require minimal maintenance. Depot charging stations that are modular in design allow malfunctioning components to be replaced without disruption to the entire charging system.

The specific charger capacity may differ based on the OEM, but typical low power depot plug-in chargers range from 60 kW to 150 kW. The specific capacity will dictate the required charging time. However, the modular design of most plug-in chargers includes a configuration that has multiple dispensers and can provide charge to multiple vehicles at a time. Operations personnel will be required to coordinate and implement the charging schedule to ensure all buses are sufficiently charged prior to beginning service. The complication of creating and executing a daily charging schedule can be minimized through smart charging software, discussed in detail in Section 10.1.

As part of the recommendations for EDT, the three different low-power chargers (12 kW, 60 kW, and 150 kW) with plug-in dispensers should be managed by smart charging software given the difference in power rates of the various charging equipment to be installed (see more in Section 10.1).

10.0 TECHNOLOGY

Technology for ZEBs will help EDT 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 typically provided by an OEM will help track useful analytics related to the fleet and operations to help EDT make informed decisions.

10.1 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 would charge both simultaneously as needed to make rollout.

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, 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.

10.2 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 BEBs and FCEBs, 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. While AVL and APCs will continue to play important roles in operations planning, 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, among other elements).

The screenshot below is an example of New Flyer’s tool (New Flyer Connect 360; Figure 30), but other OEMs also offer similar tools (like ViriCiti) all depending on an agency’s preference.

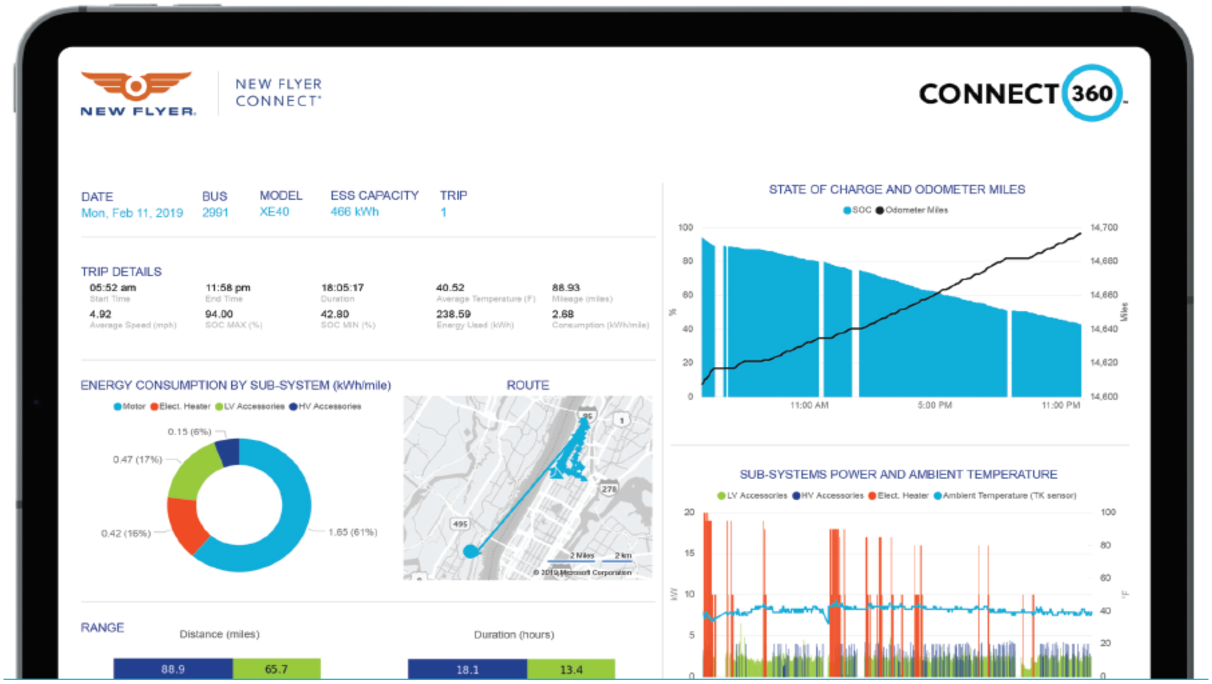

Figure 30: Example of New Flyer Connect 360.[20]

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.

When looking at other transit agencies, AVTA operates a near 100% BEB fleet of over 50 vehicles, and collects and reports the following information at its monthly board meetings:

- 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 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

[20] https://www.newflyer.com/tools/new-flyer-connect/

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 IC buses (Figure 31).

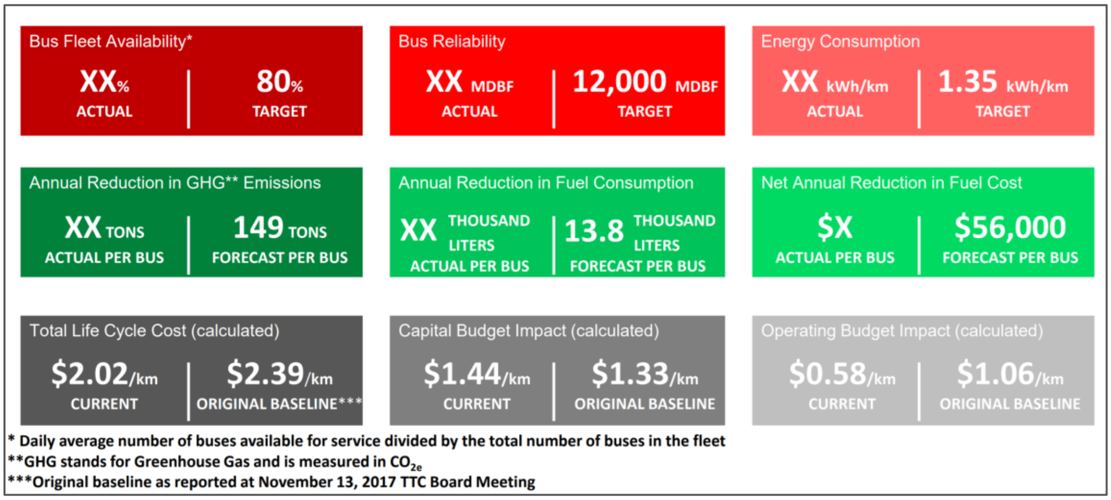

Figure 31: Example of TTC eBus KPIs.[21]

All ZEB equipment should be connected to EDT'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.

Beyond the ZEB 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 EDT to track utility usage data from PG&E to understand energy and power demand and costs.

11.0 WORKFORCE TRAINING

Ensuring EDT's workforce is sufficiently prepared for the introduction of ZEBs is of vital importance to make sure that service continues to operate smoothly and without interruption. Presented in this section are high-level training considerations, specifically for operations and maintenance staff/technicians. Also presented is a workforce training schedule based on guidance from OEM recommendations from the statewide contract procurement for ZEBs and the phased ZEB procurement schedule presented in Section 6.0. The recommendations are based on information provided by OEMs from the DGS Statewide Contract for Zero-Emission Buses and is meant to be a general guide to training requirements. It is also important to note that close collaboration with the Transit Operator's union will be required to fully develop and execute the training.

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

With a focus on safety, it is highly recommended that all local fire and emergency response departments be given training as the layout, componentry, safety devices, and other features on the new technology. This should reoccur every few years. In the example workforce training schedule below, this training is provided every other year, but the specific frequency can be dependent on agency discretion. In addition, agencywide orientation to familiarize the agency with the new technology should also be conducted prior to the first BEB deployment.

Although not specifically training, dry runs on each route should be done with the ZEBs to validate range and identify opportunities for coasting and adjustment to the vehicle's acceleration profile. In turn, changes in timing points may be necessary or beneficial for all parties. This should be done with planning staff on board and schedules should be adjusted as appropriate. In tandem, based on having several vehicle types particularly during transition, dispatching training and instructions to staff on parking routines will be necessary.

In summary, 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)

Operator training will need to occur prior to the deployment of BEBs, in accordance with the phasing schedule. The training schedule in Table 22 begins in 2026 to coincide with the introduction of the first BEBs at EDT's facility.

Table 22: Workforce training schedule

Timeline (year)	Operator Training	Maintenance/Technician Training	Other Training
FY2026	Drive training-4 sessions-4 hours each Overall vehicle/system orientation-20 sessions-2 hours each	Preventative maintenance training-4 sessions-8 hours each Electrical/electronic training-6 sessions-8 hours each Multiplex training-4 sessions-3x8 days per session HVAC training-4 sessions-4 hours each Brake training-4 sessions-4 sessions ESS, lithium-ion battery and energy management hardware and software training-6 sessions-8 hours each Electric drive/transmission training-6 sessions-8 hours each	Agencywide orientation to new BEB technology Local fire and emergency response department introduction to new technology
FY2027	Annual refreshers	Annual refreshers	No activity
FY2028	Annual refreshers	Annual refreshers	Local fire and emergency response department training on new technology
FY2029	Annual refreshers	Annual refreshers	No activity
FY2030	Annual refreshers	Annual refreshers	Local fire and emergency response department training on new technology
FY2031	Annual refreshers	Annual refreshers	No activity
FY2032	Annual refreshers	Annual refreshers	Local fire and emergency response department training on new technology
FY2033	Annual refreshers	Annual refreshers	No activity
FY2034	Annual refreshers	Annual refreshers	Local fire and emergency response department training on new technology
FY2035	Annual refreshers	Annual refreshers	No activity
FY2036	Annual refreshers	Annual refreshers	Local fire and emergency response department training on new technology

Timeline (year)	Operator Training	Maintenance/Technician Training	Other Training
FY2037	Annual refreshers	Annual refreshers	No activity
FY2038	Annual refreshers	Annual refreshers	Local fire and emergency response department training on new technology
FY2039	Annual refreshers	Annual refreshers	No activity
FY2040	Annual refreshers	Annual refreshers	Local fire and emergency response department training on new technology

Recommendations in table above based on DGS Statewide Contract for ZEBs.

While the above focuses on training for BEBs of the heavy-duty transit variety, for coaches and for cutaways, EDT, as part of its tendering process, should mandate training for maintenance staff and operators as part of its procurement process.

Other training that EDT will need to be involved with include first-responder training due to the nature of the new technology, particularly fire and emergency personnel. Additionally, training for staff involved in related functions like facility maintenance, tow truck providers, and utility service works.

12.0 POTENTIAL FUNDING SOURCES

As a clear 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 infrastructure will be constructed, it is imperative that EDT 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 23).

Table 23: Grants and potential funding options for ZEB transition

Fund/Grant	Level of government	Description	Applicability	Average/ Maximum Award Amount
Low or No Emission Program (Low-No Program)	Federal/FTA	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 local match.	Based on federal budget adoption of a new transportation appropriations bill, it's likely a similar program will continue. In FY2020, the FTA awarded $130 million to 41 projects for the Low-No program. $180 million has been announced for FY2021 projects.	Average: $3,169,674 Median: $3,017,280 In 2020, the Antelope Valley Transit Authority (AVTA) received over $6 million to assist in the purchase of ZEBs[22][23]
Buses and Bus Facilities Program (5339)	Federal/FTA	Grants applicable to rehabbing buses, purchase new buses, and invest and renovate related equipment and facilities for low or no emission vehicles or facilities. For FY20, FTA announced ~$455 million in competitive grant funding. Requires a 20% local match.	FY2020 5339 funding totaled $808 million, which is a combination of formula, bus discretionary, and Low-No funding. The JPA in Merced County ("The Bus") was awarded $2 million for ZEB electric buses and associated charging equipment in FY19.	Average: $4,503,500[24] [25]
Urbanized Area Formula Grants (5307)	Federal/FTA	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.	The Alameda Contra Costa Transit District (AC Transit) has allocated $979,000 in 5307 funds in the MTC's 2021 Draft TIP to assist in the purchase of 10 ZEBs.
Better Utilizing Investments to Leverage Development (BUILD)	Federal/USDOT	Formerly TIGER, BUILD is a discretionary grant program aimed to support investment in infrastructure. BUILD funding supports planning and capital investments in roads, bridges, transit, rail, ports, and intermodal transportation. A local match is required.	FY2020 provided $1 billion in BUILD grants to 70 projects with a stipulation requiring 50% of funding for projects in rural areas.	Average: $16,891,781 Median: $20,000,000[26][27]
Hybrid and Zero-Emission Truck and Bus	State/CARB	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	$165 million in funding for the 2020-2021 year was announced in June 2021 to be distributed in two "waves." The first wave of $84 million was opened	Maximum: up to $315,000 per FCEB; up to $175,000 per BEB CARB is proposing to allocate a

[22] Average and median 2020 award amounts. Award amounts for 2019 ranged from $356,000 to a maximum of $7,000,000
[23] https://www.transit.dot.gov/funding/grants/fiscal-year-2020-low-or-no-emission-low-no-bus-program-projects
[24] https://mtc.ca.gov/sites/default/files/_S4_Draft%202021%20Tip%20Publication%20Report-transit.pdf
[25] https://www.transit.dot.gov/sites/fta.dot.gov/files/docs/5339_Bus_and_Bus_Facilities_Fact_Sheet.pdf
[26] https://www.transit.dot.gov/funding/grants/urbanized-area-formula-grants-5307#:~:text=Program%20Overview,and%20for%20transportation%2Drelated%20planning.
[27] https://www.transportation.gov/BUILDgrants, https://www.transportation.gov/sites/dot.gov/files/2020-09/BUILD%202020%20Fact%20Sheets-.pdf

Fund/Grant	Level of government	Description	Applicability	Average/ Maximum Award Amount
Voucher Incentive Program (HVIP)		vendor directly, and then the vendor would apply for the voucher.	on June 8, 2021 and fully requested within three hours of opening. The second wave of $83 million will open on a first-come, first-served basis beginning on August 10, 2021.	total of $25 million for HVIP funding for FY20-21[28][29]
Carl Moyer and AB 923	State/CARB	Funding to help procure low-emission vehicles and equipment. Transit buses are eligible for up to $80,000 funding.	The El Dorado County AQMD is accepting, evaluating, and awarding projects that meet Carl More guidelines on an ongoing basis. The AQMD also encourages submittal of proposals to the Sacramento Metropolitan AQMD Sacramento Emergency Clean Air & Transportation (SECAT) grant, as the Sacramento Metropolitan AQMD oversees this grant program for the El Dorado County AQMD.	Average: $29,578.02[30][31][32]
Caltrans Transportation Planning Grants – Adaptation Planning Grants	State/California Transportation Commission	The overarching goal of this grant program is to support planning actions at local and regional levels that advance climate change adaptation efforts on the transportation system, especially efforts that serve the communities most vulnerable to climate change impacts. The program awarded $6 million in FY 2019-20 funds in May 2019. There is a grant minimum of $100,000 and maximum of $1 million. An 11.47% minimum match is required and may be in the form of an eligible in-kind contribution (e.g., staff time from the primary applicant counts as cash match).	The programs could fund planning that furthers the state goal of reducing GHG emissions.	Average Sustainable Transportation Planning Grant FY 2020-2021: $254,300[33]
Caltrans Transportation Planning Grants - Strategic Partnership Grants	State/California Transportation Commission	The FY 2020-21 cycle made $4.5 million available to identify and address statewide, interregional, or regional transportation deficiencies on the State highway system in partnership with Caltrans. The program's transit component funds planning projects that address multimodal transportation deficiencies with a focus on transit.	The programs could fund planning that furthers the state goal of reducing GHG emissions. MPO or RTPA must be primary applicant	Grant minimum: $100,000; maximum: $500,000[34]

28 https://ww3.arb.ca.gov/msprog/lct/hvip.htm. Voucher amount is per vehicle, https://ww2.arb.ca.gov/sites/default/files/2020-11/proposed_fy2020-21_fundingplan.pdf

29 https://www.californiahvip.org/, https://ww2.arb.ca.gov/our-work/programs/low-carbon-transportation-investments-and-air-quality-improvement-program/low-1

30 Average award amount for South Coast AQMD on-road vehicle projects between 2008 and 2019

31 https://ww3.arb.ca.gov/msprog/moyer/ab923/ab923.htm, https://www.baaqmd.gov/funding-and-incentives/funding-sources/carl-moyer-program

32 https://www.edcgov.us/Government/AirQualityManagement/pages/grants_and_incentive_refunds.aspx#:~:text=El%20Dorado%20County%20residents%20and,awarded%20on%20an%20ongoing%20basis.

33 https://dot.ca.gov/-/media/dot-media/programs/transportation-planning/documents/final-2021-award-listcopya11y.pdf

34 https://www.grants.ca.gov/grants/strategic-partnerships/

Fund/Grant	Level of government	Description	Applicability	Average/ Maximum Award Amount
State Transportation Improvement Program (STIP)	State/Caltrans	The STIP is a program of formula funds adopted by the CTC by April of each even year (i.e., 2020, 2022, 2024).	The ZEB Fleet Replacement project could compete for STIP funding but only for FY 2022 and beyond and in even years only.	Distributed via a formula for a variety of projects. 2020 STIP included $569 million in available funding[35]
Sustainable Transportation Equity Project (STEP)	State/CARB	A new pilot that takes a community-based approach to overcoming barriers to clean transportation. 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 applicant must be a CBO, federally-recognized tribe, of local government representing a public transit agency.	The application window closed as of August 31, 2020. It still has not been announced if there will be additional funding for future years.	$1.75 million available for Planning and Capacity Building grants, $17.75 million available for Implementation grants. Award amounts ranged from $184,000 to a maximum of over $7 million[36]
Low Carbon Transit Operations Program (LCTOP) and Transit and Intercity Rail Capital Program (TIRCP)	State/CARB/Caltrans	5% and 10% of the annual Cap and Trade auction proceeds fund these programs. These programs fund projects that support new or expanded bus and rail services, improve multimodal facilities and can include equipment, fueling, maintenance and other costs. Projects must reduce greenhouse gas emissions. LCTOP is formula funding transit agencies commonly use for operations and TIRCP is a competitive program.	Many agencies are already recipients of these funds and can use these funds to purchase ZEBs and related equipment.	LCTOP average: $912,840 LCTOP median: $193,572 TIRCP average: $6,027,500 TIRCP median: $6,225,500[37][38]
SB1 State of Good Repair	State/Caltrans	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.	Average: $560,197 Median: $104,210[39][40]
SB 350	State/California Energy Commission	Clean Energy and Pollution Reduction Act will enable transformation of energy production to zero-emission. Primarily provides funding to public utilities to reduce GHG emissions. Also supports transportation electrification by providing rebates of up to 50% of the electric vehicle supply equipment (chargers, etc.) for transit fleets.	If agency proceeds with BEBs, agency should apply for SB 350 at the appropriate time to reduce infrastructure costs. Funds are distributed through utility companies. Currently, SCE, PG&E, and SDG&E have received funding for electrification programs.	PG&E has received a total of $269 million to execute the FleetReady and Fast Charge programs SCE has received $356 million to execute Medium/Heavy Duty

35 https://catc.ca.gov/-/media/ctc-media/documents/programs/stip/2020-stip/2020325-2020-stip-resolution-a11y.pdf

36 https://ww2.arb.ca.gov/news/grant-awards-announced-new-195-million-pilot-funding-equitable-clean-transportation-options

37 LCTOP average and median award amount from FY 2019-20 Awarded Project List; TIRCP 2020 average and median award amounts for ZEB-related projects (purchasing of vehicles and charging infrastructure). Overall average 2020 award amount was $29,411,765 and median $12,100,000

38 https://dot.ca.gov/programs/rail-and-mass-transportation/low-carbon-transit-operations-program-lctop, https://calsta.ca.gov/subject-areas/transit-intercity-rail-capital-prog

39 Average and median award amounts from FY2020-21 approved project list

40 https://dot.ca.gov/programs/rail-and-mass-transportation/state-transit-assistance-state-of-good-repair

Fund/Grant	Level of government	Description	Applicability	Average/ Maximum Award Amount
				Infrastructure Program and New Commercial EV Rate Design[41][42]
Clean Transportation Program	State/California Energy Commission	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 project throughout the state, including specific projects for heavy-duty public transit buses. Agency should continue to monitor program website for when relevant funding opportunities open.	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)[43][44]
SB1 Local Partnership Program (LPP)	State/California Transportation Commission	The LPP includes both a formulaic and competitive program to distribute funds to local and regional transportation agencies to further projects that improve transit and rail, aging infrastructure, and more. Funds are distributed to eligible agencies through a 60% formulaic component and 40% competitive component.	SB1 created the LPP and continuously appropriates $200 million annually to local and regional transportation agencies that are within jurisdictions with voter approved taxes, tolls, or fees which are dedicated solely for transportation improvements.	Maximum formulaic funding amount: $37,506,000[45][46]
Solutions for Congested Corridors Program (SCCP)	State/California Transportation Commission	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 to the area of the corridor while preserving the character of the local community and creating opportunities for neighborhood enhancement projects.	Improvements to transit facilities are eligible projects. Cycle 2 funding of $500 million covers two years (FY2022 and FY2023). To submit a LPP/SCCP application, you need 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.	NA; total estimated funding: $500,000,000 for FY2022 and 2023[47]
Affordable Housing and Sustainable	State/Department of Housing and Community Development	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	Sustainable transportation infrastructure projects, transportation-related amenities, and program costs (including transit ridership) are eligible activities. Agencies can use program funds for assistance in	Maximum award amount is not to exceed $30 million per project.

41 Must be within one of the following utility territories: SCE, PG&E, or SDG&E
42 https://www.cpuc.ca.gov/sb350te/
43 https://www.energy.ca.gov/programs-and-topics/programs/clean-transportation-program
44 https://www.energy.ca.gov/media/4983
45 FY2020 formulaic funding: https://catc.ca.gov/-/media/ctc-media/documents/programs/local-partnership-program/adopted-resolution/2020-lpp-formulaic-funding-distribution-and-adopting-resolution-g-20-34-a11y.pdf, FY2020 competitive funding recipients have not yet been released.
46 https://catc.ca.gov/programs/sb1/local-partnership-program
47 https://www.grants.ca.gov/grants/solutions-for-congested-corridors-program/

Fund/Grant	Level of government	Description	Applicability	Average/ Maximum Award Amount
Communities Program (AHSC)		disadvantaged communities through increasing accessibility via low-carbon transportation. The program distributed $193 million for transportation projects in FY18-19.	construction or modification of infrastructure for ZEB conversion as well as new vehicle purchases.	Average: $7,757,862 Median: $7,557,513[48][49]
PG&E EV Fleet Program	State/PG&E	Objective is to support the conversion of fleets to electric by lowering the upfront cost of electric charging infrastructure, specifically through installation of level 2 and DC fast chargers at 700+ sites by the end of 2023, supporting 6,500 medium- and heavy-duty vehicles, including transit buses. This program offers incentives and rebates for chargers and associated infrastructure.	PG&E offers two ownership structures: Option 1: customer designs, builds, owns, operates, and maintains BTM infrastructure, where PG&E constructs, owns, and maintains all TTM costs and provides an incentive for BTM costs Option 2: PG&E designs, builds, owns, operates, pays for, and maintains all infrastructure Agency must commit to a ten year term of agreement for operation and maintenance of the chargers. Agencies can apply for vehicles that will be operated in the future as long as vehicles are procured within five years of program contract execution.	Transit agencies are eligible for up to $9,000 per vehicle (up to 25 vehicles per site) for infrastructure incentives and charger rebates of up to 50% of the cost of the charger[50][51]
VW Environmental Mitigation Trust Funding	State	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 funding for transit buses is still available. The grant is a one-time deal. Applications are processed on a first come, first serve basis and will be considered for funding if eligible and while project funds are available. As of January 2021, according to the CTE, California's solicitation for transit and shuttle buses remains open on a first-come, first-served basis until all funds have been committed. Currently, this program has approximately $10 million of available funding.	Maximum: $400,000 per FCEB and $180,000 per BEB, maximum of $3,250,000 total funding per agency[52][53]
Low Carbon Fuel Standard (LCFS credits)	N/A	LCFS credits are not necessary funding to be applied for; rather, they are offset credits that are traded (through a broker) to reduce operating costs.	Once ZEBs are acquired and operating, agencies can collect LCFS and 'sell' them to reduce operating costs of ZEBs.	Credit prices range, but average credit price between 2016 and 2019 was between $65 and $200 per

48 Average award amount for FY18-19 transportation projects, https://www.hcd.ca.gov/grants-funding/active-funding/ahsc/docs/award%20listing%20form%20-%20posting.pdf

49 https://www.hcd.ca.gov/grants-funding/active-funding/ahsc.shtml, https://sgc.ca.gov/programs/ahsc/docs/20180731-Update-Fact%20Sheet-AHSC.pdf

50 Only available in PG&E service area, https://www.pge.com/en_US/large-business/solar-and-vehicles/clean-vehicles/ev-fleet-program/ev-fleet-program.page

51 https://www.pge.com/en_US/large-business/solar-and-vehicles/clean-vehicles/ev-fleet-program/ev-fleet-program-customer-faq.page

52 http://vwbusmoney.valleyair.org/documents/FAQ.pdf

53 http://vwbusmoney.valleyair.org/

Fund/Grant	Level of government	Description	Applicability	Average/ Maximum Award Amount
			Both hydrogen and electricity used as fuels are eligible for LCFS credits	credit Average: $10,000 per vehicle[54][55]
Congestion Mitigation and Air Quality (CMAQ)	EDCTC	The Congestion Mitigation and Air Quality Improvement (CMAQ) Program provides funds to States for transportation projects designed to reduce traffic congestion and improve air quality, particularly in areas of the country that do not attain national air quality standards.	Projects that reduce criteria air pollutants regulated from transportation-related sources, including ZEBs.	Typical awards range from $300,000 to approximately $2 million.

54 https://www.srectrade.com/markets/lcfs/california, Assuming 40,000 miles/year at $100 per credit per 2018 amendments.

55 https://ww2.arb.ca.gov/our-work/programs/low-carbon-fuel-standard

13.0 FINANCIAL ANALYSIS AND IMPACT

The financial analysis for EDT's ZEB rollout consisted of the modeling of a Base Case (assuming continued use of diesel and gasoline vehicles or 'business-as-usual') and a ZEB Rollout (assuming a transition to 100% ZEB operations and the phasing out of diesel/gasoline vehicles), and a comparison between the two scenarios to quantify the financial impacts of the transition and of ZEB operations. Stantec team's cost estimator, Jacobus & Yuang, Inc., provided a detailed cost estimate of materials, soft costs, constructions, and other line items for the ZEB case[56].

The main assumptions for the cost modeling are:

- Financial modeling was completed in real 2021 dollars (2021$).
- A 3% discount rate was applied for all calculations.
- Consistent levels of service with pre-pandemic levels, i.e., no operational growth was considered in the Base Case or the ZEB Rollout over the next twenty years.
- Annual fleet vehicle mileage is 1,350,000 miles or 26,500 miles per vehicle[57].
- The model was completed using a consistent format for both the Base Case and the ZEB Rollout to facilitate clear comparison between the two. The modeling was developed on an annual basis from 2021 through to 2040.
- The ZEB case included the operation of diesel and gasoline vehicles (as well as ZE vehicles) during the transition period until fossil fuel vehicles are phased out past 2040.
- While Stantec's recommended strategy is to request CARB an exemption from purchasing cutaways and electric vans until the range and efficiency sufficiently improve to satisfy the operating needs of EDT, the financial modeling assumes the purchase and implementation in 2026 for cutaways and 2030 for electric vans with a 1:1 replacement ratio. While is possible that the technology will evolve sufficiently so that these are viable options at those points in time, no current electric cutaway or van have the range required to satisfy the needs of the demand response services provided by EDT without requiring significant increases in fleet size and restricting of operations.

13.1 BASE CASE APPROACH

Stantec developed the forecast for the Base Case (business-as-usual) scenario, assuming that the existing fleet of diesel and gasoline vehicles is maintained and renewed through to 2040. This model is inclusive of all scheduled fleet replacements and overhauls required during the time window. It should be

[56] Provided as an appendix.
[57] As a reference, EDT reported ~1.4M vehicles miles in 2019 in NTD (fixed routes and demand response).

noted that this Base Case would be non-compliant with the ICT regulatory requirements and is thus used only for illustrative purposes to determine the financial impacts of a ZEB rollout.

Capital expenses modeled consist of fleet acquisition and vehicle overhaul costs. Vehicle overhauls were assumed to consist of a single transmission overhaul for the buses after seven years of service.

Operations and Maintenance costs were based on the historical data from the "ADOPTED FINAL OPERATING BUDGETS" provided by EDT and the data fueling and mileage data reported to the NTD. The following cost sub-categories were created:

- Fuel Cost: The cost per mile of the "2018/2019 NTD fueling and operational expenses" was used with an annual 2% increase ($0.38 per mile for demand response, $0.80/mi for commuter coaches, and $0.30/mi for local fixed routes)
- Bus Maintenance: The historical maintenance cost was extracted from EDT's adopted budgets starting on 2015/2016 up to 2020/2021 and was used in combination with the revenue mileage reported to the NTD for the corresponding fiscal years. In addition, the increase trend (or trend line) calculated from the historical data was used to predict the future maintenance price. The average maintenance cost for 2018/2019 was estimated at $0.33 per mile)
- Admin & Other Expenses: the following expense line items were aggregated into a single category from EDT's adopted budget 2019/2020 and increased according to the calculated trend line from the historical data starting on 2015/2016:
    - Total from the Salaries and Benefits Accounts
    - Insurances
    - Fixed maintenance items (for buildings, equipment, bust stops, and grounds)
    - Rents and equipment purchase
    - Marketing
    - Staff Expenses (travels, professional services, employee medical exams, background checks, legal notices)
    - Bank and credit card charge fees
    - Utilities, including for Park & Ride
    - Other Operating and Admin Expenses (e.g., uniforms, communications, clothing, memberships, office expenses, printing, etc.)
    - Contingency

13.2 ZEB CASE APPROACH

The ZEB Case foresees a gradual transition to 100% ZE revenue vehicle operations by 2040 in alignment with ICT regulations.[58] The transition follows the purchase schedule presented previously in Table 9. Therefore, the last purchase of diesel and gasoline vehicles is considered 2028 so the financial benefits

[58] The forecast does not include the purchase and operations of light-duty vehicles but includes related infrastructure costs.

of the BEB would be fully realized past the 20-year timeframe considered here, reflecting the fully electric fleet. To minimize the financial burden, it is assumed that all vehicles will operate for their full useful design life:

- 5 years for vans
- 10 years for cutaways
- 15 years for low floor 35-ft buses
- 15 years for commuter coaches

Capital expenses modeled consist of fleet acquisition, extended vehicle warranties, vehicle charging infrastructure, vehicle overhaul and battery replacement costs. Operational expenses consist of general maintenance, fuel/electricity, and the same values as the Admin. & Other cost category from the Base Case above. For the ZEB Case, the Admin & Other expenses were kept the same as the Base Case since the level of service is the main driver of these line items, and we assumed that service levels would remain unchanged; the main difference is the acquisition and implementation of a new bus technology—BEBs.

Vehicle overhauls for BEBs were assumed to include two battery replacements for low-floor and coach vehicles, in line with current operating practice of ZEBs in other jurisdictions. While the first battery replacement would be covered by an extended warranty purchased with the vehicle during initial procurement, we included a subsequent out-of-warranty battery replacement to capture a more conservative approach and preempt battery degradation and range reduction. We assumed that the second (out of warranty) battery replacement would occur into the tenth year of the life span for coaches and 35-ft. buses (no battery replacements were assumed for vans/cutaways or light-duty vehicles).

Electricity/fuel costs were calculated based on the expected blended PG&E rate, calculated by Stantec based on EDT's fleet and operational profiles.

The infrastructure costs consist of the conversion and modifications required for the EDT facility. This includes outfitting the base with the charging infrastructure required to operate the ZEBs. The full cost estimation from Jacobus & Yuang, Inc. is provided as an appendix.

13.3 ASSUMPTIONS AND INPUTS

Table 24 presents a brief description, as well as the sources for the cost inputs of the Base Case and the ZEB Case.

Table 24: Summary of cost inputs for EDT Financial Analysis

Cost categories	Description	Inputs for Base Case	Inputs for ZEB Case
1. Fuel cost	Non-ZE: Fuel cost of diesel or gasoline per mile ZE: Electricity cost per kWh	$0.38/mile for demand response, $0.80/mi for commuter coaches, and $0.30/mi for local fixed routes calculated using inputs from the “2018/2019 NTD fueling and operational expenses”; 2% increase per year based on EDT practices for budget projections	Initial value of $0.141 per kWh with a price trend from the EIA.
2. Bus purchase price	Bus purchase price for every year between 2021 and 2040 including extended warranty cost	Purchase prices in 2021 extracted from EDT Capital Improvement Plan with a price trend based on market projections: $650,000 for coaches $466,000 for 35-ft $115,100 for cutaways $70,400 for vans	Purchase prices in 2021 with a price trend based on market projections: $1,500,000 for E-coaches $864,000 for 35-ft BEBs $234,500 for E-cutaways $175,300 for E-vans Sources include CalDGS and MBTA/CalAct
3. Bus maintenance cost	Considers labor and parts for scheduled and unscheduled maintenance.	$0.26 per mile obtained from EDT’s adopted budgets and revenue mileage reported to the NTD. A yearly increase of 3% was assumed based on EDT practices for budget projections	$0.21 per mile based on an average of observed maintenance costs from ZEB pilots, with a 3% increase annually
4. Admin. & Others	Salaries and Benefits Other Operating and Admin Expenses Overhead Allocation Internal Services Purchased Transportation	$7.7M in 2021 with a 3% increase annually based on EDT’s practices for their budget projections.	$7.7M in 2021 with a 3% increase annually based on EDT’s practices for their budget projections.
5. Electrical infrastructure upgrades	Includes transformers and control systems paid for by the transit agency	N/A	Final values for Primary Power Service (transmission and distribution upgrades) will require input from PG&E. $218,300 for transformer, switchboard, and installation (Cost estimation provided by Jacobus & Yuang, Inc.)
6. Battery replacement and/or diesel midlife overhaul	Non-ZE: Transmission overhaul ZE: Replacement of batteries after expiration of extended warranty coverage (past 500,000 miles or 12 years)	$38,000 per non-ZEB	Battery: $255 per kWh in 2032 and a price trend was applied based on market assessment

Cost categories	Description	Inputs for Base Case	Inputs for ZEB Case
7. Infrastructure Modification Costs	Includes equipment, installation, testing, civil and electrical work, as well as contractor's fees and escalation factors.	N/A	Cost estimation provided by Jacobus & Yuang, Inc.
8. Backup resiliency	Generator set and diesel fuel storage with piping	N/A	Cost estimation provided by Jacobus & Yuang, Inc. $417,300

13.4 COMPARISON AND OUTCOMES

The cost comparison between the diesel/gasoline Base Case and the ZEB Case transition scenario is presented in Table 25 and Figure 32, incorporating both capital (orange) and operating (blue) expenses. The ZEB Case has a total cumulative cost of $436,792,000 versus $389,675,000 for the Base Case, a difference of $47,117,000 or 11% increase. The financial assessment 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.

Table 25: Cost Comparison 2021-2040

	Base Case	ZEB Case	Cost difference (ZEB – Base)
Fleet Acquisition	$64,219,000	$103,124,000	$38,905,000
Fleet Refurbishment/Battery Replacement	$2,097,000	$902,000	($1,195,000)
Infrastructure	$—	$14,383,000	$14,383,000
Admin, Operations, Others	$286,588,000	$286,588,000	$—
Fleet Maintenance	$16,173,000	$13,396,000	($2,777,000)
Fuel/Electricity	$20,598,000	$18,399,000	($2,199,000)
Total	**$389,675,000**	**$436,792,000**	**$47,117,000**

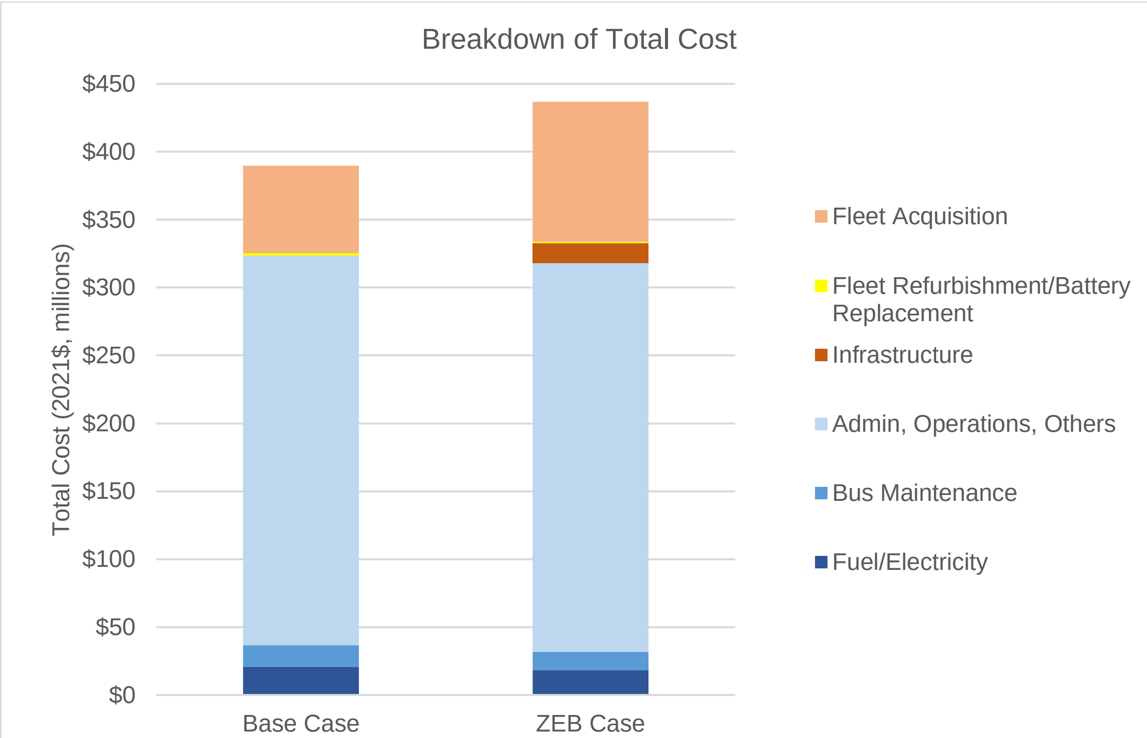

Figure 32: Breakdown of Cost Categories for the Diesel/Gasoline and BEB Scenarios

The procurement of ZEBs represents $38.9 million more in expenses due to the higher purchase price of BEBs compared to fossil fuel vehicles. The conversion and upgrades to the facility to install charging infrastructure represents another added cost of $14.4 million. However, the main cost driver in both scenarios is the Admin & Other expenses; this category consists mainly of labor (salaries and benefits of operators and staff related to service delivery, as well admin staff), overhead allocation, and internal services.

Capital costs associated with vehicle overhauls and battery replacements are relatively minor in comparison, although the simplicity of BEB propulsion systems means that these costs are lower for this technology compared to diesel engine components in the Base Case.

Lastly, the use of electricity as a ‘fuel’ represents an economic benefit of $2.2 million when compared to the existing diesel and gasoline refueling. These savings are a direct reflection of the improved efficiency that BEBs have with respect to old technologies, with the added benefit of eliminating emissions.

Figure 33 shows the year-to-year comparison between the Base Case and the ZEB Case. The higher costs for the BEB scenario occur during the years that new modifications are conducted at the yard and when a higher purchase of vehicles is made (2025, 2029, 2032, 2033, and 2040).

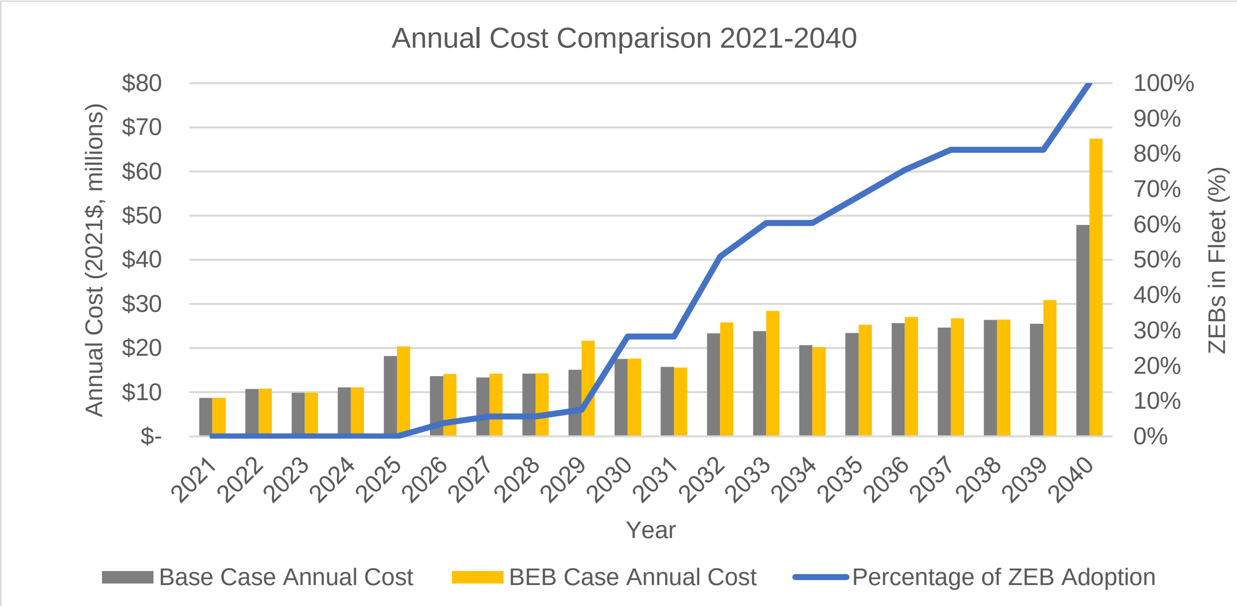

Figure 33: Annual Total Cost Comparison

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.

For EDT, all census tracts that are categorized as disadvantaged communities are located in Sacramento County, and are touched by commuter routes traveling to Sacramento and Rancho Cordova. Only EDT’s commuter route, and no other routes, traverse any disadvantaged communities.

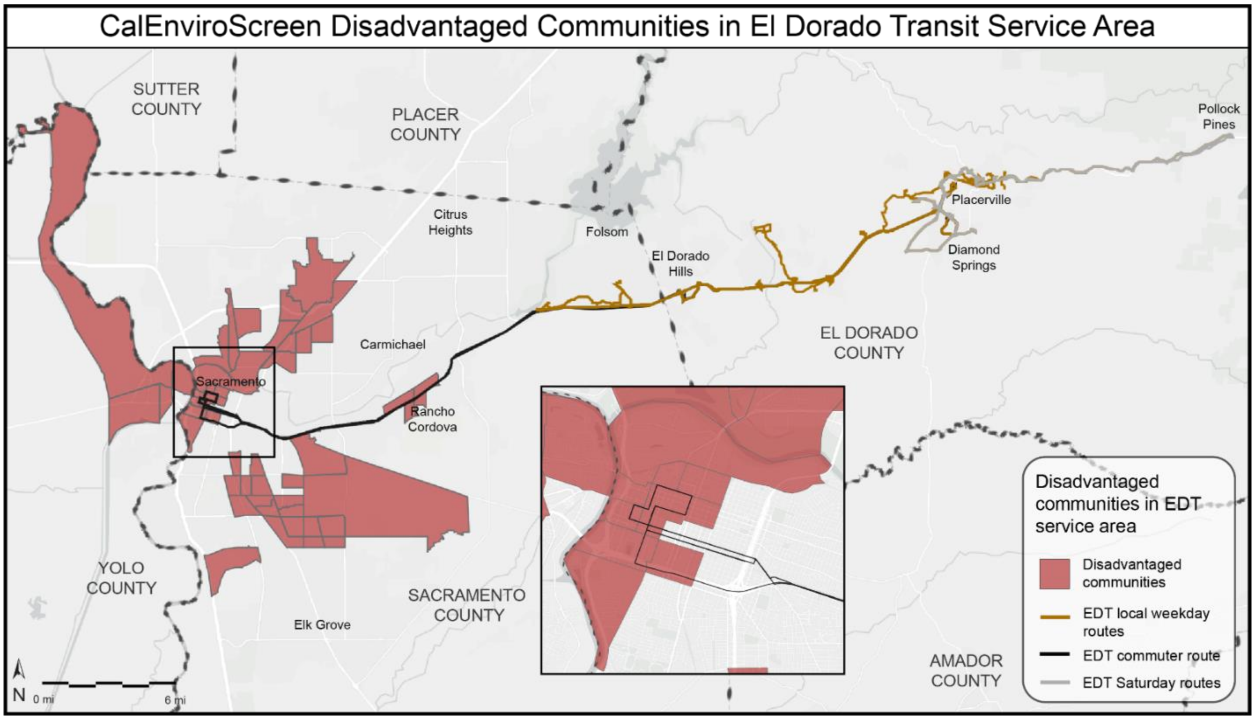

Figure 34: CalEnviroScreen disadvantaged communities in EDT service area

Specifically, the census tracts defined as disadvantaged communities that the commuter service travels to are shown in Table 26.

Table 26: Disadvantaged communities census tracts

Census Tract	City	County
6067009008	Rancho Cordova	Sacramento County
6067009006	Rancho Cordova	Sacramento County
6067009007	Rancho Cordova	Sacramento County
6067005205	Sacramento	Sacramento County
6067002000	Sacramento	Sacramento County
6067002100	Sacramento	Sacramento County
6067000800	Sacramento	Sacramento County
6067001101	Sacramento	Sacramento County

Based on this information, EDT can prioritize BEB deployment along the commuter route with commuter coaches. This aligns with the fleet replacement schedule in Table 9, which shows the first ZEB motor coach purchase in 2027. As this is before the first ZEB 35-ft bus purchase scheduled for 2032, ZEB motor coaches for commuter services will be purchased and placed into revenue service before 35-ft vehicles that are used for local fixed route services. Thus, providing service first in CalEnviroScreen-defined disadvantaged communities naturally aligns with the fleet replacement schedule and EDT will be fulfilling this section of the ICT mandate.

15.0 GHG IMPACTS

Based on the ZEBDecide modeling of greenhouse gas emissions (GHG), EDT's diesel/gasoline fleet emits 3,800 tons of GHGs in a year.[59] In contrast, the future BEB fleet will only emit close to 750 tons annually; while tailpipe emissions of BEBs is nil, residual GHGs result from the carbon-intensity of California's electric grid. As modeled, a completely BEB fleet can reduce EDT's GHG footprint by ~3,100 tons annually. Table 27 shows the annual emissions of the fleet by service type and Table 28 presents a summary and the average emissions per vehicle.

Table 27: Annual Emission in Tons of CO_2 per year for EDT's fleet by service type

	Zero Emissions		Diesel/Gasoline	
	Commuter and Local Fleet	**Demand Response Fleet**	**Commuter and Local**	**Demand Response**
Fleet tailpipe emissions (ton CO_2/year)	-	-	2,209	178
Upstream emissions (ton CO_2/year)	658	96	798	652
Total Ton CO_2/year	**658**	**96**	**3,007**	**830**

Table 28: Summary of Annual Emissions for EDT's fleet

	Fleet Emissions (Ton CO_2/year)	**Emissions per Vehicle (Ton CO_2/vehicle/year)**
BEB fleet	754	41
Diesel/Gasoline Fleet	3,837	203
Difference	**3,083**	**162**
	80%	80%

On average, implementing BEBs reduces the annual emissions by 80% when compared to the conventional diesel/gasoline fleet.

[59] 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.

Using the EPA GHG equivalent calculator[60], we used the annual emissions that will be displaced by the BEB fleet to create relative comparisons to the benefits. As presented in Figure 35, implementing a ZEB fleet will eliminate emissions equivalent to removing 600 passenger vehicles per year or reducing emissions of 340 households in a year.

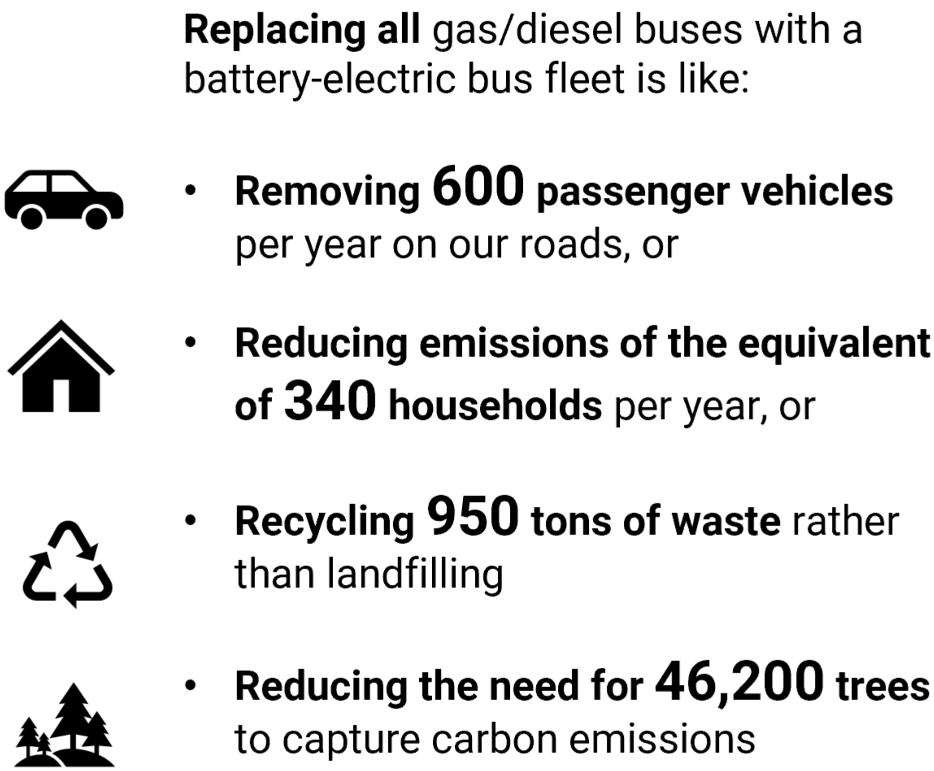

Figure 35: Equivalent benefits of implementing a BEB fleet at EDT.

16.0 OTHER TRANSITION ITEMS

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

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

- Share infrastructure

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

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

The Sacramento Area Council of Governments (SACOG) is the MPO for El Dorado County and provides regional transportation funding and planning for El Dorado County, Placer County, Sacramento County, Sutter County, Yolo County, Yuba County, and the 22 cities within these counties. El Dorado County is located within the Mountain Counties Air Basin under the El Dorado County AQMD. Table 29 lists the agencies that operate fixed route bus transit service in the SACOG planning area and Figure 36 shows the service areas of these transit agencies.

Table 29: Other bus transit agencies in the SACOG planning area

Agency	Fleet Size[61]	ZEB Choice	Notes
EDT	*28*	In-depot charging **BEBs**	
Auburn Transit	5	TBD	
Elk Grove	46	In-depot charging **BEBs**	e-tran services are in the process of being annexed by SacRT.
Placer County Transit	41	TBD	2018 SRTP noted preference for **BEBs** but requires a more detailed study
Roseville Transit	11	In-depot and on-route charging **BEBs**	
SacRT	216	In-depot charging **BEBs**	Noted option to integrate FCEBs after 2027 if they became more affordable
SCT/Link	19	TBD	ZEB study in progress
Yolobus	57	**BEBs**	First **BEB** procurement scheduled for 2021
Yuba-Sutter Transit	35	TBD	No ZEB plan but 2018 study included **BEB** feasibility study with anticipated purchase of 4 BEBs in 2020

[61] Fixed-route fleet only, does not include demand response and non-revenue vehicles.

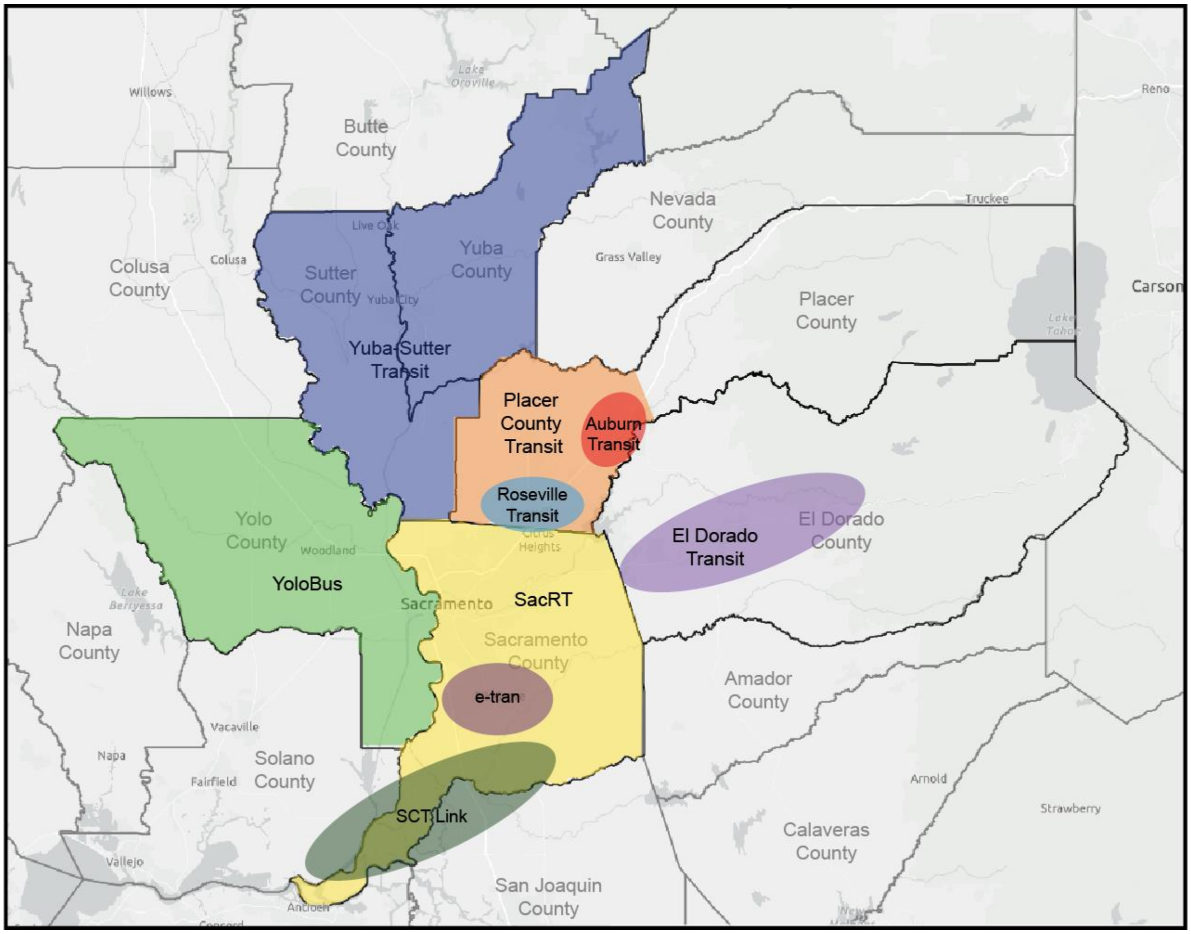

Figure 36: Regional transit operators.

Based on the rules outlined above, EDT could potentially partner with any of these transit agencies to form a joint ZEB group. EDT is the only transit service provider in western El Dorado County and only overlaps service with SacRT and other agencies providing commuter services into the Sacramento area. Because of this, if EDT wishes to explore the formation of a joint ZEB group, it might make the most sense to coordinate among these agencies for shared charging infrastructure at a common location where commuter services in Sacramento terminate.

EDT is producing its own ZEB rollout plan without collaborating with other agencies in a Joint ZEB Group. Within a joint ZEB group, most of the benefits stem from the fact that smaller agencies in the group are allowed to parse the ZEBs they require as they see fit between agencies and the largest agency in the group is stipulated to purchase the number of ZEBs are required through the ICT regulation. Thus, EDT will only benefit from a joint ZEB group if it is not the largest agency in the group. For example, this could be possible if SacRT created a joint ZEB group and included multiple smaller agencies, with SacRT acting as the largest agency.

Regardless of whether it makes sense to explore formation of a joint ZEB group or not, EDT should remain in constant communication with other SACOG agencies to understand how the agencies can work together to leverage resources and coordinate efforts on a regional level.

Another recommended strategy is developing a multi-operator vehicle procurement group. That is, EDT could join with any of the agencies outlined above to produce common specifications for ZEBs, 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, EDT and other operators may wish to encourage OEMs to develop vehicles with longer ranges, given the predominance of commuter services with long routes in the Sacramento area.

16.2 CHANGE MANAGEMENT

Because the 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 to the rollout is required. Additionally, the union representing the bus operators should also be included due to the large role they will play in the success of the ZEB transition and implementation. Thus, it is prudent for EDT and EDCTC to form a steering committee or task force composed of staff from each major functional department and union representation to help ensure the impact of ZEBs are considered for each. Using the rollout plan as a guide, the task force can develop action items, performance indicators, and risk assessments. The task force should also name a leader who acts as a champion for the ZEB conversion within the agency and to external stakeholders. 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 EDT to promote its climate commitments.

17.0 CONSIDERATIONS FOR ALTERNATIVE ZEB STRATEGIES

Stantec's recommendation, based on our analysis of current service and operations, route modeling and bus simulations, market considerations, site audits, and meeting with stakeholders and EDT and EDCTC staff, is for EDT to deploy in-depot charging BEBs. Nonetheless, our analysis also considers alternative technologies so that EDT can be flexible in its ZE transition. We provide guidance on alternatives to depot charging BEBs below.

17.1 FCEB

Regionally, Sacramento area bus operators are favoring BEBs in their rollout plans. However, SacRT is examining the possibility of deploying FCEBs, particularly for longer vehicle blocks. Moreover, the ZEB technology space is evolving very rapidly, and California is at the forefront of pushing toward cheaper and renewable hydrogen fuel for bus and truck fleets[62].

There are drawbacks to FCEBs—namely, the increase in cost when deploying a FCEB fleet. With a small bus fleet, a BEB fleet is generally less expensive and simpler to implement. For a larger bus fleet, BEB implementation becomes challenging because of the number of chargers required and their utility upgrade requirements. Conversely, with a large bus fleet, the larger fixed-cost of hydrogen fueling infrastructure becomes cheaper on a per bus basis (Figure 37). For this reason, for a smaller bus fleet, the large fixed costs for hydrogen fueling infrastructure is untenable.

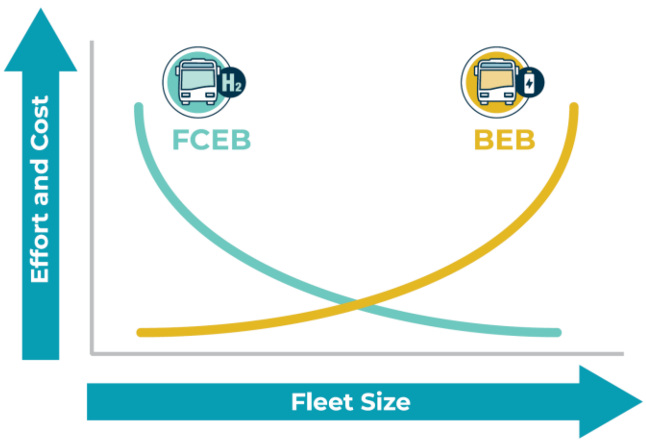

Figure 37: Comparative capital costs and effort for BEB and FCEB deployment size (Source: TCRP; CTE).

The CARB ICT regulation regarding the rollout planning notes that these rollout plans are flexible, accounting for rapidly evolving technology and the challenge that transit operators face when implementing a new technology. So, while the recommendation of BEBs for EDT's fleet is the one presented on this report, Stantec also provides important considerations and decision points that EDT could weigh if, at some point in the ZEB transition, FCEBs become more attractive.[63] Rapidly evolving technologies could also mean that while FCE motor coaches currently do not exist, they may become a reality in the near future. Interestingly, at the time of this writing, Lightening Motors, an OEM that produces electric fleet medium- and heavy-duty vehicles, including delivery trucks, shuttle buses, passenger vans, chassis-cab models, and city transit buses cutaways and vans, is advertising a Ford Transit passenger van with FCE technology offering up to 250 miles in range.[64] Currently, no transit agencies are operating FCE cutaways, but new offerings like the one from Lightening are positive developments showing the interest in new tech for different vehicle styles and the rapid evolution of the

[62] https://cafcp.org/sites/default/files/Road%2BMap%2Bto%2Ba%2BUS%2BHydrogen%2BEconomy%2BFull%2BReport.pdf?utm_source=greenrope&utm_medium=email&utm_content=11290&utm_campaign=7082284

[63] Additional information regarding considerations for FCEBs more generally were presented in the Market Scan and Existing Conditions report.

[64] https://lightningemotors.com/lightningelectric-ford-transit-shuttle/ ; https://lightningemotors.com/transit-vans-ford-vs-lightning/

ZE field. In addition, improvements in battery technology could also improve operational ranges enabling an easier transition to BEBs.

17.1.1 Operations Considerations

By best approximating the operating range of diesel buses, FCEBs would have the minimal disruption on the service cycle and operations of bus service. Based on the modeling work completed by Stantec for fixed and commuter routes, all of EDT's vehicle assignments are within the operating range of FCEBs. Therefore, operations will unlikely be impacted. Indeed, this is one of major advantages of FCEBs over BEBs.

17.1.2 Fleet Considerations

One of the major obstacles to deploying FCEBs over BEBs is that they are, depending on configurations, 20% more expensive than a BEB[65]. This price premium results from a combination of the fuel cell stack and related technology, which results in an increase in the number of specialized parts on a FCEB compared to BEBs, which have resulted in costlier maintenance in pilots to date.

Nonetheless, the major advantage of a FCEB is its operating range of ~300 miles, approaching the operating ranges of diesel buses. This permits a one-to-one replacement scheme.

At this time, Stantec's modeling and analysis demonstrate that with reblocking and operational considerations, EDT can deliver the same revenue service with fleet size of 13 35-ft BEBs and 17 E-coaches as it does with a fleet of 12 35-ft diesel buses and 16 diesel coaches. Simply put, the fleet size and peak hour needs of EDT facilitate BEB adoption.

If FCEB prices drop to align with BEBs, EDT may consider exploring FCEBs as part of its fleet. Operating a blended fleet of BEBs and FCEBs is not unheard of—SunLine and AC Transit both operate FCEBs and BEBs to match operating and service conditions. However, if EDT does wish to explore FCEB options, it will need to plan for fueling.

17.1.3 Fueling Considerations

Currently, all vehicles fuel offsite at a nearby fueling station. For hydrogen fueling, EDT can proceed through a few different routes.

One route would be to build a hydrogen fueling facility onsite. Fueling is comparable to a CNG or diesel bus, and takes, on average, 8-12 minutes per bus. The refueling facility would have to store hydrogen as a liquid since gaseous hydrogen stations are only used for a max of 180 kg/day and the anticipated hydrogen demand for EDT is 650 kg/day. A gaseous hydrogen station would only be able to serve around 15 FCEBs at EDT and would cost around $2 million to construct. Therefore, the approximate

[65] However, if more BEBs are required to maintain service compared to the diesel fleet size, the capital vehicle cost of a BEB fleet could approach the capital vehicle cost of a FCEB fleet.

cost of a liquid hydrogen station for EDT would be close to $4 million and would require one pump and one hydrogen dispenser with an average flow rate of 4 kg/min.

Table 30: Characteristics for different hydrogen production sources and distribution methods

	Compressed hydrogen gas	Liquid hydrogen	Local SMR	Local electrolysis
Overall	Good for smaller volumes (<200 kg/day)	Suited for large volumes	Good for large volumes	Good for large volumes
Distribution Costs	High; price impacted by location from supply	Nominal; range flexibility	Nominal	Nominal
Price volatility	Dependent on fuel prices; available bulk discounts	Dependent on fuel prices; available bulk discounts	Dependent on maintenance and fuel costs	Dependent on maintenance and electricity
Infrastructure costs	Lower (~$2 million)	Higher (~$4-$6 million)	Depends on production capacity	Depends on production capacity
Carbon emission reductions	N/A	N/A	Renewable biogas available at higher costs	Clean hydropower available or infrastructure can be installed for local solar or wind electricity generation

Another route EDT can proceed through is offsite fueling, similar to how it currently operates with diesel and gasoline buses. Presently, there are four hydrogen fueling facilities (green markers) in the Sacramento region and one proposed (purple marker)[66] (Figure 38).

[66] https://cafcp.org/stationmap

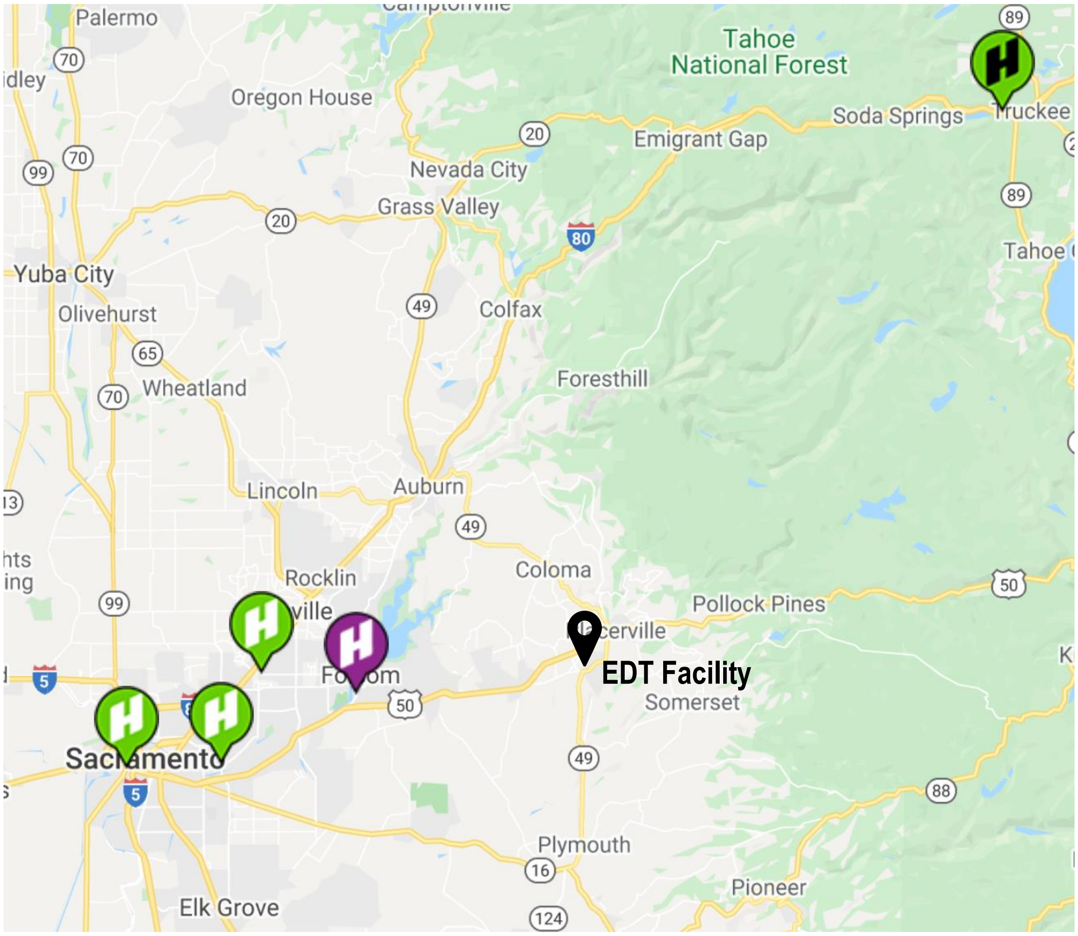

Figure 38: Hydrogen fueling stations in the Sacramento Region. (Source: California Fuel Cell Partnership)

The three existing stations in Sacramento are 30 to 40 miles away from EDT's transit facility would thus require careful planning to either integrate fueling during a vehicle block for those routes that operate near an existing fueling facility, or would require a fueling attendant to drive the FCEB to fuel at the fueling station. In the first scenario, operators would fuel vehicles (which they do already), and fueling time would need to be built into run cuts and schedules. In the second scenario, the added cost of deadheading vehicles 30+ miles to fuel could be considerable and reduce starting range. Overall, the current locations and capacities of the fueling stations in Figure 38 are not favorable for EDT.

The location in Truckee is over 90 miles away and thus not feasible. Depending on the type of station and station capacity opened in Folsom, which is 25 miles away from EDT's facility, this fuel station may be a viable option.

Nevertheless, as the demand for hydrogen grows, it is possible that hydrogen fueling stations become more prevalent and closer to EDT's facility. However, as Stantec noted above, the regional transit operators are currently favoring BEBs. If a hydrogen fueling station opens with 5 miles or less of the corporation yard and has the capacity for heavy-duty transit buses, EDT could investigate the feasibility of FCEBs and fueling from a such a yard.

17.1.4 Facility Considerations

If fueling infrastructure is implemented on-site, then certain upgrades to accommodate the fueling yard as discussed above would be required (hydrogen storage and dispensers, electric utility modifications to provide necessary power for the compressors and other related electronics, etc.), in addition to items like installing hydrogen gas detection systems.

If fueling occurs off-site, then EDT would only need to install hydrogen gas leak detection systems, along with other safety precautions, but little else of the facilities would need alteration.

In both scenarios, the maintenance facilities would require additional tools and equipment specifically for repairs and upkeep of hydrogen fuel cell specific items. In addition, spare bus parts would need to be acquired as well.

17.1.5 Workforce Considerations

17.1.5.1 Operators

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 training of the technology should 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.

Interaction outside the garage should be similar to what is done with the diesel fleet, which is fueled as part of the service line process.

According to the statewide contract procurement for ZEBs, the OEMs recommend:

- Operator drive training
- Overall vehicle/system orientation

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

17.1.5.2 Maintenance Staff and Technicians

Maintenance staff will 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 will require inspection and eventual changeout, the inspection and diagnosis of hydrogen fuel cell apparatus may be necessary. Tanks will have the same ruggedness as diesel products and should fulfill in excess of the heavy-duty bus 12-year service design life cycle.

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 EDT phases out fossil fuel-powered vehicles.

17.1.5.3 Planning, Scheduling, and Runcutting

FCEBs come closest to matching the current CNG or diesel bus range and the APTA White Book guidelines for heavy duty bus range of 280-360 miles. Impacts on planning, scheduling, run cutting and dispatching parameters should be minimal, and if the small difference in range is addressed through product technical improvements in the interim, conversion to this type of propulsion would be seamless. FCEBs will be the most versatile in assignment and dispatching. Where disruptions or non-time defined extra assignments occur, this version of ZEBs will be the choice vehicle.

EDT could launch FCEBs 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 its facility would be a pragmatic strategy at first. Non-revenue tests should be conducted to ascertain actual range and fuel economy on longer routes, routes with topography variations, and with simulated passenger loads and HVAC testing.

In all likelihood, training for the scheduling team will be needed and collaboration with EDT's scheduling software provider to account for combined FCEB and fossil fuel bus operations, and finally an entirely FCEB operation.

17.2 ON-ROUTE/LAYOVER CHARGING

This section outlines the operational considerations if EDT decides to incorporate on-route charging to minimize blocking modifications.

One of the key challenges with on-route charging is determining optimal locations for the chargers throughout the service area. Often, the most strategic locations are major stops and transfer centers where multiple routes come together so the chargers can be used by multiple buses operating on multiple routes. EDT's service area is large and characterized by dispersed activity centers and trip generators. Because of the character of the service area, on-route chargers would need to be dispersed throughout the service area to serve buses operating on different routes, but this is an unworkable solution since investments in fixed infrastructure would be underused.

Park-and-ride lots are an obvious choice for EDT's on-route charging locations, but this implies that many of the on-route chargers would only be used for one or two routes (Figure 39), which is a significant financial investment for a relatively small level of use. This also brings up potential issues of stranded assets; expanding or altering service would be dependent on the location of the on-route chargers.

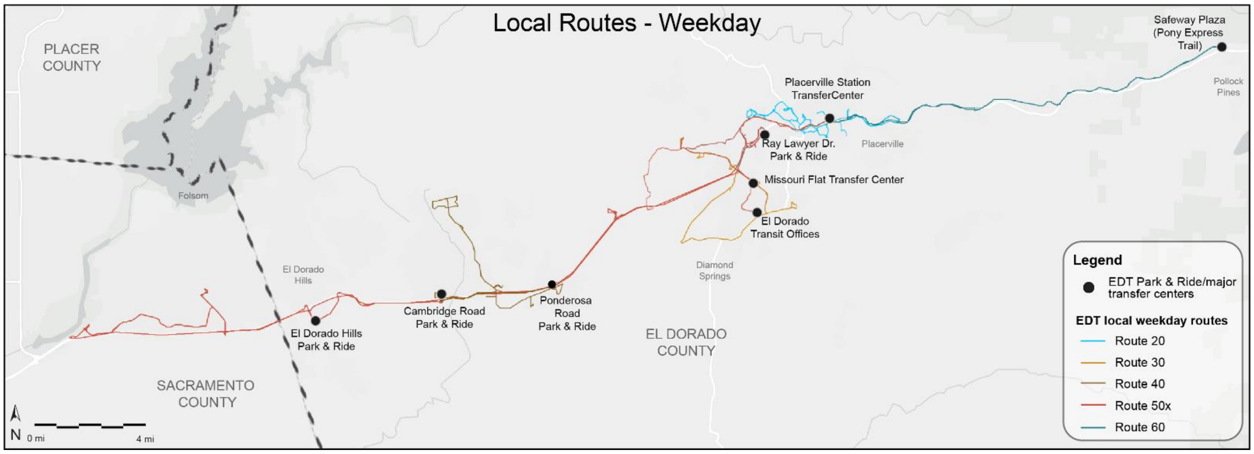

Figure 39: Location of EDT local weekday routes and Park & Ride lots/major transfer centers

Based on the route modeling and considering strategic placement of the on-route chargers at a park-and-ride with significant route connectivity, we conducted a high-level assessment of on-route charging for routes 50X and 60.

The technical specifications to allow for on-route charging that were considered in this analysis for routes 50X and 60 are as follows:

- Placerville Station Transfer Center was the location evaluated for the fast-charging equipment
- Pantograph fast charging equipment of a power capacity of least 600 kW
- Pantograph and plug-in connections for vehicles serving route 50X and 60 since in-depot charging will still be required
- Each charging event should also include between one to two minutes in the layover for the connection/disconnection of the pantograph

Stantec calculated the number of charging events and the duration of each to successfully electrify routes 50X and 60. Results for each block are presented in Table 31.

Table 31: On-route charging concepts.

Vehicle ID	Block	Route/ Run	First stop time	Last stop time	No. of Trips	Charging Events	Duration of charging Event (min)[67]	SOC at end of day
1701	1701	50 Express 1	6:00 AM	7:17 PM	4.5	3	**10**	23%
1704	1704	50 Express 3	7:01 AM	7:02 PM	4	3	**6**	21%
1706	1706	50 Express 2	6:22 AM	6:32 PM	4	3	**7**	22%
0903	0903	60 Pollock Pines	7:03 AM	6:50 PM	12	6	**4**	21%

While the approach of on-route charging may alleviate some of the challenges and constraints related to blocking and operations**,** on-route charging only serves to augment and not replace in-depot, overnight charging. That is, in-depot charging would still be necessary to ensure that vehicles are 'full' and ready for each service day. Regarding on-route charging, this would entail the purchase of at least two or three on-route charging units, costing around $500,000 each plus costs related to installation and grid connection upgrades, in addition to the in-depot charging infrastructure.

Operators would require additional training for on-route charging, electric grid connection upgrades would be required at each location, and there is the potential for operational/traffic disruptions during installation and construction. EDT would also need to train and plan for routine charger maintenance.

18.0 CONSIDERATIONS FOR ZEB AND ALTERNATIVE SERVICE DELIVERY

EDT, like many transit agencies across the country, are contemplating the feasibility of alternative service delivery methods to help reduce the inefficiencies of fixed-route, fixed-schedule services, particularly in communities that are dispersed, low-density, or both. Several forms of alternative service delivery typically employ a dial-a-ride or demand-response scheme, where customers hail a ride via a phone number or app on a device—either the day before or even the same day of a planned journey—and the transit agency schedules the trip and attempts to create a shared-ride trip delivery. Trip delivery is typically curb-to-curb from 'virtual' stops, like street intersections, or major destinations. Other forms also include, for example, a circulator for a portion of a community, or flexible routing for fixed routes, enabling deviation from a route. Microtransit is a term that has gained traction, and several transit agencies are deploying this service to attempt to balance customer needs, trip demand, and limited resources like

[67] Assuming a 600-kW charger with an efficiency of 90%.

operators and vehicles. Close to EDT, the best examples include SmaRT Ride[68] by SacRT in Folsom, and San Joaquin RTD's Van Go! Service[69].

These microtransit services are typically delivered with smaller vehicles, like cutaways or passenger vans. If EDT wishes to implement a microtransit-style service with cutaway or van EVs, there are several considerations, much like for the current dial-a-ride services. First, existing vehicles have limited battery sizes and thus operating ranges. AVTA in Lancaster is using GreenPower EV Stars and have reported to Stantec operating ranges below 125 miles per charge for their on-demand shared ride microtransit service[70]. As with EDT's demand-response service, overcoming the operating range challenge is key to a successful EV transition for potential on-demand services, like microtransit. Some elements to consider include:

- The style of service delivery. Is it flexible and on-demand allowing customers to hail a ride the same day, or is it subscription based, more like dial-a-ride today? The more flexible and more spontaneous the service delivery, the more challenging for EVs if the area of operation is unconstrained, if operating hours do not allow for midday charging, and if passenger trips are more difficult to group, resulting in more solo trips.
- The zone of service delivery. A larger zone may require more vehicles to service not only a larger area, but potentially to relieve vehicles with limited operating ranges.
- Technology and battery size. If vehicles for microtransit evolve to have larger battery packs and if fuel efficiency improves, longer ranges can be expected. In addition, depending on the vehicle specifications, if Level II charging is a possibility, vehicles could be charged or topped-off at public charging sites, if the schedule is permissible. If FCE vans or cutaways with longer operating ranges become viable, this is another option for EDT but fueling on-site or off-site trade-offs would need to be considered.

Overall, similar to the dial-a-ride service, adopting a ZE fleet for on-demand microtransit purposes will be challenging given current operating limits of ZEV options. Nonetheless, with evolving technology, a maturing market, and increasing demand for ZE cutaways for paratransit and other service needs, ZEVs will likely attain characteristics that will facilitate longer range and flexible service delivery.

68 https://www.sacrt.com/apps/smart-ride/
69 https://sanjoaquinrtd.com/van-go/
70 https://www.avta.com/onrequest-ride-service.php

19.0 PHASING AND IMPLEMENTATION

Table 32 provides an overview of the phasing plan for EDT's ZEB rollout strategy. Note that expenses are in the year of cost incurred, while the fleet quantity columns show when vehicles are delivered, which is offset from the purchase year. See Table 8 for more details regarding the fleet replacement schedule.

Table 32: ZEB implementation phasing plan, FY2021-2040

Year	Construction – maintenance facility	Revenue Fleet	Non-Revenue Fleet	Charging equipment	Training - operators	Training – maintenance staff/technicians	Training - other	Capital expenses (2021$)	O&M expenses (2021$)	Annual budget (2021$)
FY2021								$0	$8,729,172	$8,729,172
FY2022		2 35-ft. diesel 1 gas cutaway 5 gas vans	1 gas staff vehicle					$1,463,216	$9,339,556	$10,802,772
FY2023								$0	$9,901,216	$9,901,216
FY2024		5 gas vans	2 gas staff vehicles					$639,439	$10,496,721	$11,136,160
FY2025	Underground work starts for conduit installation in Area-A (please refer to site plans Figure 20)	9 diesel motor coaches		**Area-A** 1 power cabinet (150 kW) +3 dispensers 1 power cabinet (60 kW) + 2 dispensers 1.5 MW Transformer **Area-B** none				$9,256,384	$11,128,114	$20,384,498
FY2026		4 gas cutaways 2 BEB cutaways 5 gas vans			Drive training-4 sessions-4 hours each Overall vehicle/system orientation-20 sessions-2 hours each	Preventative maintenance training-4 sessions-8 hours each Electrical/electronic training-6 sessions-8 hours each Multiplex training-4 sessions-3x8 days per session HVAC training-4 sessions-4 hours each Brake training-4 sessions-4 sessions ESS, lithium-ion battery and energy management hardware and software training-6 sessions-8 hours each Electric drive/transmission training-6 sessions-8 hours each	Agencywide orientation to new BEB technology Local fire and emergency response department introduction to new technology	$2,351,543	$11,780,482	$14,132,025

Year	Construction – maintenance facility	Revenue Fleet	Non-Revenue Fleet	Charging equipment	Training - operators	Training – maintenance staff/technicians	Training - other	Capital expenses (2021$)	O&M expenses (2021$)	Annual budget (2021$)
FY2027		1 BEB motor coach			Annual refreshers	Annual refreshers	No activity	$1,748,618	$12,480,193	$14,228,812
FY2028		5 gas vans	5 staff ZEVs		Annual refreshers	Annual refreshers	Local fire and emergency response department training on new technology	$1,039,021	$13,231,081	$14,270,101
FY2029	Underground work starts for conduit installation in Area-B	1 BEB motor coach	1 staff ZEV	**Area-A** 3 power cabinet (150 kW) **Area-B** 1 power cabinet (150 kW) + 12 dispensers 6 power cabinet (60 kW) + 12 dispensers 7 power cabinet (Level 2) + 14 dispensers	Annual refreshers	Annual refreshers	No activity	$7,679,726	$14,016,935	$21,696,661
FY2030		6 BEB cutaways 5 ZEB vans			Annual refreshers	Annual refreshers	Local fire and emergency response department training on new technology	$2,876,251	$14,740,166	$17,616,417
FY2031					Annual refreshers	Annual refreshers	No activity	$0	$15,626,151	$15,626,151
FY2032		6 35-ft. BEBs 1 BEB cutaway 5 ZEB vans			Annual refreshers	Annual refreshers	Local fire and emergency response department training on new technology	$9,355,059	$16,415,637	$25,770,696
FY2033		5 BEB motor coaches			Annual refreshers	Annual refreshers	No activity	$11,063,602	$17,333,784	$28,397,386
FY2034		5 ZEB vans		7 150-kW cabinet (21 dispensers) 7 60-kW cabinet (14 dispensers) 10 Level 2 cabinets (20 dispensers)	Annual refreshers	Annual refreshers	Local fire and emergency response department training on new technology	$1,863,816	$18,372,674	$20,236,490
FY2035		4 35-ft. BEBs			Annual refreshers	Annual refreshers	No activity	$5,883,855	$19,412,162	$25,296,017

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Year	Construction – maintenance facility	Revenue Fleet	Non-Revenue Fleet	Charging equipment	Training - operators	Training – maintenance staff/technicians	Training - other	Capital expenses (2021$)	O&M expenses (2021$)	Annual budget (2021$)
FY2036		6 BEB cutaways 5 ZEB vans			Annual refreshers	Annual refreshers	Local fire and emergency response department training on new technology	$6,539,226	$20,508,333	$27,047,559
FY2037		3 35-ft. BEBs	1 staff ZEV		Annual refreshers	Annual refreshers	No activity	$5,019,578	$21,732,137	$26,751,715
FY2038		5 ZEB vans			Annual refreshers	Annual refreshers	Local fire and emergency response department training on new technology	$3,447,287	$23,030,327	$26,477,613
FY2039			2 staff ZEVs	**Area-A** None	Annual refreshers	Annual refreshers	No activity	$6,474,797	$24,404,775	$30,879,572
FY2040		10 BEB motor coaches 6 BEB cutaways 5 ZEB vans		**Area-B** 4 power cabinet (150 kW) + 12 dispensers 3 power cabinet (Level 2) + 6 dispensers	Annual refreshers	Annual refreshers	Local fire and emergency response department training on new technology	$41,707,830	$25,703,147	$67,410,977