



**CITY OF ELK GROVE  
CITY COUNCIL STAFF REPORT**

**AGENDA TITLE:** Receive and file the Zero-Emission Bus (ZEB) Strategy and Final Report: Elk Grove ZEB Rollout and Implementation Plan for the City of Elk Grove’s fixed-route transit system, pursuant to the Innovative Clean Transit (ICT) regulation

**MEETING DATE:** May 26, 2021

**PREPARED BY:** Mike Costa, Transit System Manager

**DEPARTMENT HEAD:** Jeff Werner, P.E., Public Works Director / City Engineer

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**RECOMMENDED ACTION:**

Staff recommends that the City Council receive and file the Zero-Emission Bus (ZEB) Strategy and Final Report: Elk Grove ZEB Rollout and Implementation Plan for the City of Elk Grove’s fixed-route transit system, pursuant to the Innovative Clean Transit (ICT) regulation.

**BACKGROUND INFORMATION:**

In 2018, the California Air Resources Board (CARB) adopted the Innovative Clean Transit (ICT) regulation, which requires public transit agencies to transition their fixed-route transit fleet to 100-percent ZEB technology, such as battery-electric and/or fuel-cell electric, by 2040. Pursuant to the ICT regulation, small transit agencies, such as the City of Elk Grove, are required to submit a plan adopted by the governing body by July 1, 2023, which identifies the necessary strategies and a schedule/timeline for converting the transit fleet’s vehicles and supporting fueling infrastructure to zero-emission technology (Rollout Plan). The Rollout Plan further supports the ICT regulation’s subsequent requirement for small transit agencies to begin purchasing ZEB buses in 2026.

In May 2019, the City was awarded a grant through the California Department of Transportation (Caltrans) Sustainable Communities grant program to fund a ZEB strategy and fleet conversion study (ZEB Study) and establish a Rollout Plan that would satisfy the ICT regulations. In December 2019, an RFP was released for a consultant to complete both the ZEB Study and Rollout Plan. Stantec Consulting Services, Inc. (Stantec) was ultimately selected as the City's consultant following the competitive procurement process, and work started on these planning efforts in early April 2020.

### **DISCUSSION/ANALYSIS:**

Stantec has prepared the ZEB Study and Rollout Plan, included as Attachment 1 to this staff report, in close collaboration with the City's Transit Division and Fleet and Facilities Division staff. Multiple stakeholders, including members of the public and other external supporting agencies including the Sacramento Area Council of Governments (SACOG), the Sacramento Regional Transit District (SacRT), the Sacramento Municipal Utilities District (SMUD), and the Sacramento Metropolitan Air Quality Management District (SMAQMD) were also provided with the opportunity to participate in the planning process for this effort. This satisfies the Caltrans grant program's public participation requirements and ensures that the proper stakeholders are aware of and involved in the City's ZEB planning efforts.

As part of the ZEB Study, Stantec conducted an extensive analysis of the City's existing fixed-route bus fleet and supporting infrastructure, current fixed-route transit services and operation schedules, and the supporting maintenance and fleet replacement functions in order to identify the opportunities and constraints associated with implementing zero-emission technology in the City's transit system. Comprehensive modeling was subsequently conducted to identify the specific zero-emission infrastructure and charging schemes that would be necessary to support the City's current transit services as well as the total capital and operating costs associated with implementing the zero-emission fleet conversion and operations in the future. Both battery-electric and hydrogen fuel-cell technologies were evaluated as potential technologies that the City could implement to address the ICT regulation. However, due to the higher forecasted capital costs associated with current hydrogen fuel-cell technologies, the ZEB Study and Rollout Plan focuses on implementation of battery-electric technology and fleet conversion for the purposes of implementing the ICT regulation's ZEB requirements.

Pursuant to the ZEB requirements established in the ICT regulation, the Rollout Plan contained in Attachment 1 includes the following components:

- Type(s) of ZEB technologies a transit agency is evaluating, and which types will be deployed;
- A schedule for all ZEB and conventional bus purchases demonstrating adherence to the targets established in the ICT regulation;
- A schedule for the agency's facility and supporting charging infrastructure upgrades and all necessary modifications to accommodate ZEB technologies;
- Identification of the operational and capital costs associated with implementing the ZEB technology and fleet conversion, as well as potential funding sources to support this effort;
- A plan to deploy ZEBs in disadvantaged communities within the transit agency's service area;
- A training plan for operators and maintenance staff to implement ZEB fleet charging and maintenance functions; and
- The strategies and timeline established to ensure that the transit agency can meet the ICT goal of full bus fleet transition to ZEB technology by 2040.

It is important to note that the planning efforts for this ZEB Study and Rollout Plan started well before the City Council's decision to annex the City's transit services and operations into SacRT, which occurred in April 2021. Upon annexation, which becomes effective on July 1, 2021, the City will no longer be responsible for the operations and maintenance of the existing transit fleet and/or the administration of any transit services provided within the City's jurisdictional boundaries by SacRT. Therefore, SacRT will become solely responsible for addressing the ICT regulation's ZEB fleet conversion requirements under their own ZEB Rollout Plan. At this time, SacRT staff has not yet determined how they will address the ZEB fleet conversion and infrastructure planning efforts in Elk Grove considering that SacRT only plans to lease the City's Corporation Yard for approximately six to eight years following annexation. If SacRT determines to establish supporting ZEB infrastructure at the City's Corporation Yard during their lease term, then City staff will continue to collaborate with their planning efforts and provide the City Council with future updates accordingly.

It is for these reasons that staff recommends that the City Council receive and file the ZEB Strategy and Final Report: Elk Grove ZEB Rollout and Implementation Plan, and that no formal adoption is necessary for the Rollout

Plan considering the City's annexation of its transit services into SacRT. Timely adoption of any necessary ZEB strategy, and compliance with ICT regulations, will now be the responsibility of SacRT.

**ALTERNATIVE ACTION:**

Because this item is only a transmission of the report to the City Council, there is no feasible alternative action. Caltrans staff supports City staff's presentation of the ZEB Strategy and Final Report to the City Council in order to fully satisfy the City's funding agreement with Caltrans for spending the grant program award on this planning effort. Should the report not be so presented, the City could be responsible for the repayment of the awarded grant program funding (in the amount of \$150,000) to Caltrans.

**FISCAL IMPACT:**

There is no fiscal impact associated with the City Council receiving and filing the ZEB Rollout Plan prepared by Stantec. Pursuant to the terms and conditions established in the City's Annexation Agreement with SacRT, it will be the sole responsibility of SacRT to address the ICT regulation's ZEB fleet conversion and implementation requirements following annexation. Any potential improvements to the City's Corporation Yard and/or other City-owned facilities associated with SacRT's implementation of their ZEB Rollout Plan to support SacRT's transit services provided to the City post annexation must be authorized by the City. The City is not obligated to pay for any part of SacRT's ZEB planning and/or implementation efforts under the Annexation Agreement's established terms and conditions.

**ATTACHMENT:**

1. Zero-Emission Bus (ZEB) Strategy and Final Report: Elk Grove ZEB Rollout and Implementation Plan



**ZEB Strategy and Final Report**

**Elk Grove ZEB Rollout and Implementation Plan**

**Final Report**

Prepared for the City of Elk Grove  
Prepared by Stantec

May 2021



A study funded by a **Caltrans Sustainable Communities Grant**



**ZEB Strategy and Final Report**

ZEB Rollout Plan and Analysis Services

May 12, 2021

Prepared for:

The City of Elk Grove

Prepared by:

Stantec Consulting Services Inc.

**Acknowledgements**

We thank Caltrans for funding this study through a Sustainable Communities Grant.

We thank Michael Costa, Terry Easley, and staff at the City of Elk Grove.

Finally, we thank all participants and community members who provided valuable feedback during the community outreach meeting.



## ZEB STRATEGY AND FINAL REPORT

### Release Version

Rev.	Description	Date
0	Draft Report Issued to e-tran	April 9, 2021
	Comments from e-tran received	April 30, 2021
1	Final Report Issued to e-tran	May 12, 2021

This document entitled *ZEB Strategy and Final Report* was prepared by Stantec Consulting Services Inc. (“Stantec”) for the account of the City of Elk Grove (e-tran) (the “Client”). Any reliance on this document by any third party is strictly prohibited. The material in it reflects Stantec’s professional judgment in light of the scope, schedule and other limitations stated in the document and in the contract between Stantec and the Client. The opinions in the document are based on conditions and information existing at the time the document was published and do not take into account any subsequent changes. In preparing the document, Stantec did not verify information supplied to it by others. Any use which a third party makes of this document is the responsibility of such third party. Such third party agrees that Stantec shall not be responsible for costs or damages of any kind, if any, suffered by it or any other third party as a result of decisions made or actions taken based on this document.

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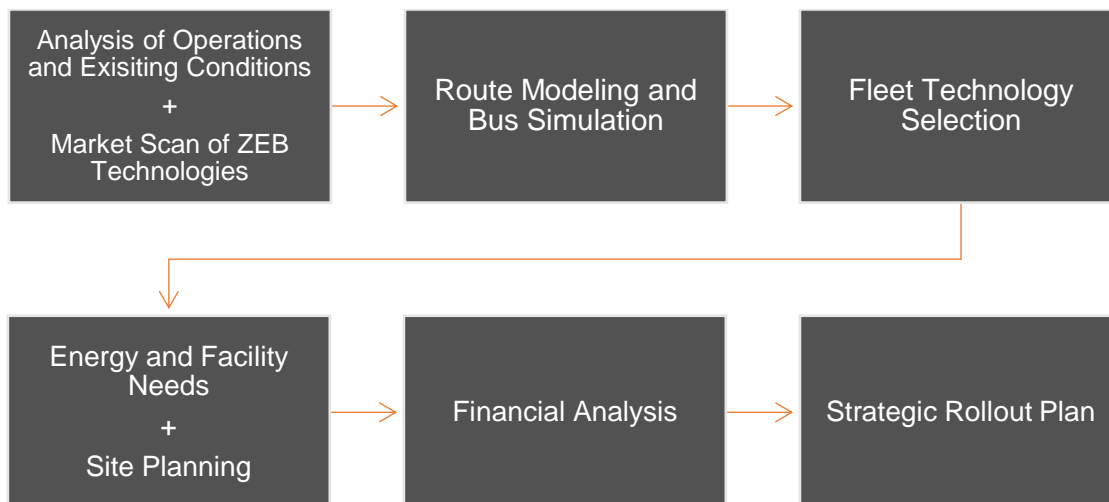
## EXECUTIVE SUMMARY

The City of Elk Grove (e-tran) provides local bus service within the City of Elk Grove and commuter service to downtown Sacramento and Rancho Cordova. As a small transit agency in California, e-tran is required to transition to a zero-emission bus (ZEB) fleet by 2040 under the California Air Resources Board (CARB) Innovative Clean Transit (ICT) mandate.

E-tran operates seven local and 10 commuter routes with an active fleet of 46 40-ft CNG vehicles. E-tran’s Corporation Yard maintenance facility is located centrally within the city of Elk Grove where vehicles are fueled onsite. The entirety of e-tran’s bus service is in the Sacramento Municipal Utility District (SMUD) territory.

As a first step in the transition process, each small transit agency is required to develop and submit a ZEB Rollout Plan to CARB by July 1, 2023. E-tran has retained Stantec to develop its rollout plan and create a clear roadmap to a full ZEB transition by 2040. This report acts as the final step in this ZEB planning process, and presents a full ZEB implementation schedule as well as a summary of all the steps taken to get to this point. However, it is also important to note that CARB has stated that the ZEB rollout and implementation plans should be treated as living documents, to be updated over time to reflect new information and maturity in ZEB technologies while still staying true to the 2040 goal.

Figure 2 presents an overview of the ZEB planning process that was used to determine the preferred ZEB fleet mix for e-tran based on e-tran’s operating conditions.



**Figure 1: Schematic representation of ZEB planning process**

The previous phases of this project (summarized in this report) laid the foundation for this plan by understanding e-tran’s existing conditions, and the power and fuel requirements to meet e-tran’s service through a ZEB fleet. With this information, the initial ZEB fleet was refined through an optimization



process including quantitative and qualitative measures, including a cost of ownership analysis. This led to the preferred fleet composition of an entirely depot-charging battery electric bus (BEB) fleet.

With the preferred fleet composition established, the next steps included determining the facility upgrades and modifications required to support ZEB operations at e-tran's Corporation Yard. In addition, a financial ZEB model was developed for comparative purposes against a base case (or business as usual with CNG buses) and developing a phasing or implementation plan. Overall, implementing the ZEB fleet will cost \$477,856,000 (cumulative capital and operating costs) compared to \$449,619,000 for base case operations within a 20-year timeframe. Stated otherwise, the transition to BEBs adds an incremental capital and operating costs of \$28,237,000 to e-tran 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 CNG buses.

Based on e-tran's existing fleet replacement schedule and ZEB purchase schedule outlined by CARB, this plan recommends that the ZEB procurement begins in 2023 and gradually continues through 2040 as CNG vehicles reach the end of their useful life and are retired. This coincides with a phased plan for construction and infrastructure upgrades at the Corporation Yard beginning in 2022. This phased approach allows for e-tran to implement a small number of BEBs and learn from the process and slowly scaling up to reach a 100% BEB fleet while still adhering to ICT guidelines and goals. The full phasing and implementation plan is outlined in Table 1.

Throughout this document, information is provided that corresponds to the required sections of the ICT ZEB Rollout Plan (provided in full in Appendix A). Taken together, this plan provides a prudent and feasible approach for e-tran to implement ZEBs that meets the City's vision of providing environmentally sustainable public transportation.



Table 1: ZEB implementation phasing plan, FY2021-2040

Year	Construction – Corporation Yard	Fleet	Charging equipment	Training - operators	Training – maintenance staff/technicians	Training - other	Capital expenses (2021\$)	O&M expenses (2021\$)	Annual budget (2021\$)
FY2021		6 CNGs					\$3,667,000	\$10,496,000	\$14,163,000
FY2022	Underground work starts for conduit installation in Area-A (please refer to site plans) or work to install canopies in Area-A						\$2,261,000	\$10,624,000	\$12,885,000
FY2023		4 BEBs	2 150 kW power modules installed 6 plug-in dispensers installed	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-24 hours 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	\$3,613,000	\$11,273,000	\$14,886,000
FY2024				Annual refreshers	Annual refreshers	No activity	\$0	\$11,999,000	\$11,999,000
FY2025		2 CNGs		Annual refreshers	Annual refreshers	Local fire and emergency response department training on new technology	\$1,484,000	\$12,772,000	\$14,256,000
FY2026		1 CNG 1 BEB		Annual refreshers	Annual refreshers	No activity	\$1,751,000	\$13,584,000	\$15,336,000
FY2027		1 CNG 1 BEB		Annual refreshers	Annual refreshers	Local fire and emergency response department training on new technology	\$1,823,000	\$14,449,000	\$16,271,000
FY2028		1 CNG		Annual refreshers	Annual refreshers	No activity	\$2,182,000	\$15,368,000	\$17,550,000

ZEB STRATEGY AND FINAL REPORT

Year	Construction – Corporation Yard	Fleet	Charging equipment	Training - operators	Training – maintenance staff/technicians	Training - other	Capital expenses (2021\$)	O&M expenses (2021\$)	Annual budget (2021\$)
		1 BEB							
FY2029		2 BEBs		Annual refreshers	Annual refreshers	Local fire and emergency response department training on new technology	\$2,171,000	\$16,334,000	\$18,505,000
FY2030		2 BEBs	5 150 kW power modules installed 15 plug-in dispensers installed	Annual refreshers	Annual refreshers	No activity	\$6,946,000	\$17,361,000	\$24,307,000
FY2031	Underground work starts for conduit installation in Area-B or work to install canopies in Area-B	2 BEBs		Annual refreshers	Annual refreshers	Local fire and emergency response department training on new technology	\$2,382,000	\$18,452,000	\$20,834,000
FY2032		3 BEBs		Annual refreshers	Annual refreshers	No activity	\$3,867,000	\$19,597,000	\$23,464,000
FY2033		4 BEBs		Annual refreshers	Annual refreshers	Local fire and emergency response department training on new technology	\$5,352,000	\$20,796,000	\$26,148,000
FY2034		4 BEBs		Annual refreshers	Annual refreshers	No activity	\$5,668,000	\$22,068,000	\$27,736,000
FY2035		2 BEBs	2 150 kW power modules installed 6 plug-in dispensers installed	Annual refreshers	Annual refreshers	Local fire and emergency response department training on new technology	\$6,664,000	\$23,455,000	\$30,119,000
FY2036		3 BEBs		Annual refreshers	Annual refreshers	No activity	\$5,277,000	\$24,908,000	\$30,185,000
FY2037		2 BEBs		Annual refreshers	Annual refreshers	Local fire and emergency response department training on new technology	\$3,388,000	\$26,473,000	\$29,861,000
FY2038		8 BEBs		Annual refreshers	Annual refreshers	No activity	\$14,491,000	\$27,998,000	\$42,489,000
FY2039		2 BEBs		Annual refreshers	Annual refreshers	Local fire and emergency response department training on new technology	\$13,017,000	\$29,755,000	\$42,772,000
FY2040		6 BEBs	5 150 kW power modules installed	Annual refreshers	Annual refreshers	No activity	\$12,573,000	\$31,518,000	\$44,091,000

Year	Construction – Corporation Yard	Fleet	Charging equipment	Training - operators	Training – maintenance staff/technicians	Training - other	Capital expenses (2021\$)	O&M expenses (2021\$)	Annual budget (2021\$)
			15 plug-in dispensers installed  1 fast charger pantograph (600 kW) installed						

## Abbreviations

AHSC	Affordable Housing and Sustainable Communities
AQMD	Air Quality Management District
AVTA	Antelope Valley Transit Authority
BEB	Battery electric bus
BESS	Battery energy storage system
BUILD	Better Utilizing Investments to Leverage Development
BTM	Behind the Meter
CAP	Community Air Protection
CARB	California Air Resources Board
DC	Direct current
ESS	Energy Storage System
EV	Electric vehicle
FCEB	Hydrogen fuel cell electric bus
FTA	Federal Transit Administration
GHG	Greenhouse gases
GTFS	General Transit Feed Specification
HVIP	Hybrid and Zero-Emission Truck and Bus Voucher Incentive Program
IC	Internal combustion
ICT	Innovative Clean Transit
LCFS	Low Carbon Fuel Standard
LCTOP	Low Carbon Transit Operations Program
LPG	Liquid petroleum gas



LPP	Local Partnership Program
MPO	Metropolitan Planning Organization
NFPA	National Fire Protection Association
OCPP	Open Charge Point Protocol
OEHHA	Office of Environmental Health Hazard Assessment
PV	Photovoltaic panels
SACOG	Sacramento Area Council of Governments
SCCP	Solutions for Congested Corridors Program
SMUD	Sacramento Municipal Utility District
SOC	State of charge
STEP	Sustainable Transportation Equity Project
STIP	State Transportation Improvement Program
TIP	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
ZEV	Zero-emission vehicle



### 1.0 INTRODUCTION

The City of Elk Grove's transit service, branded as e-tran, provides local bus service in the City of Elk Grove, as well as commuter services between Elk Grove and downtown Sacramento, as well as Sacramento Regional Transit District's (SacRT's) Consumes River College and Butterfield light rail stations. Elk Grove is located in the Sacramento Metro Air Quality Management District (AQMD) and located in the Sacramento Valley Air Basin.

In December 2018, the California Air Resources Board (CARB) adopted the Innovative Clean Transit (ICT) regulation, establishing a goal that all bus transit agencies in the state to gradually transition to an entirely zero-emission bus (ZEB) fleet by 2040. A first step in achieving this goal is the mandate that all transit agencies must submit a ZEB rollout plan that describes how the agency is planning to achieve a full transition within this timeframe. Specific elements required in the rollout plan include:

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

As e-tran is designated as a small transit agency as per the ICT regulation,<sup>1</sup> the agency is mandated to submit their rollout plan to CARB by June 30, 2023. Small agencies like e-tran must ensure that 25% of their vehicle purchases beginning in 2026 are zero emission (ZE), and by 2029, all vehicle purchases must be ZE. However, other bus types, including motor coach vehicles, are exempt from the purchase schedule until 2026 (or later, dependent on Altoona testing). Moreover, if an agency has a legitimate reason for not being able to operate ZEBs, they are allowed to apply for exemptions.

This document serves as the source for e-tran's rollout plan submission to CARB; this document provides a detailed plan of the technology, needs, and strategies that will help e-tran transition to a ZEB fleet. To develop this rollout plan, a number of steps must be taken to determine the best ZEB strategy for e-tran. To date, these have included:

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<sup>1</sup> Defined as an agency with fewer than 100 vehicles and a population area smaller than 200,000.

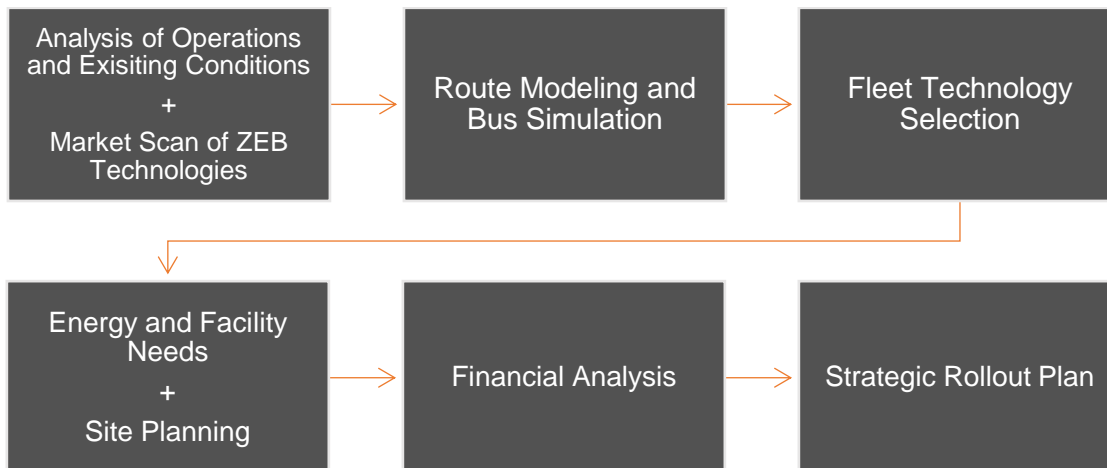
## ZEB STRATEGY AND FINAL REPORT

- A review of existing conditions to understand characteristics and constraints of e-tran's operations and service area
- Energy and power modeling to understand performance under different ZE technology options
- A quantitative and qualitative analysis of modeling results to determine the preferred ZE fleet composition for e-tran

While this report is intended to act as a roadmap to guide e-tran through the ZEB transition to full ZEB deployment and implementation by 2040 as well as to fulfill CARB guidelines as outlined in the ICT mandate, it is also important to keep in mind that the ICT-mandated rollout plan is intended to be a living document that can, and should, change and be updated over time as ZE technologies continue to evolve.

## 2.0 APPROACH TO ZEB PLANNING

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



**Figure 2: Schematic representation of ZEB planning**

The first step involved a review of existing conditions of e-tran to provide a foundation and understanding of e-tran'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. Moreover, a site visit of the Corporation Yard in Elk Grove provided insights into the constraints and opportunities for implementing ZEBs, such as fueling and charging assets, 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 e-tran'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 4.0).

## ZEB STRATEGY AND FINAL REPORT

Project partner CUTRIC modeled block-level and vehicle-level fuel economies to understand the predicted performance of different ZEB technologies under e-tran's operating parameters. Together with a multicriteria trade-off analysis and in consultation with key stakeholders, Stantec and e-tran determined that the best path forward to a ZE future is with BEBs (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 each division (Section 5.3). 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 for the Corporation Yard 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 solar power generation (Sections 7.0 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 14.0).

Considering the ever-evolving nature of ZE technologies and the need to be flexible, Stantec also developed guidance for e-tran if they want to explore hydrogen fuel cell electric buses (FCEBs; Section 16.0). While Stantec's analyses demonstrate that BEBs satisfy e-tran'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.

All steps described here, along with others found in this document, provide e-tran 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 SUMMARY OF KEY EXISTING CONDITIONS

This section provides an overview of existing conditions that will be impacted and need to be considered for ZEB implementation.

#### 3.1 OPERATIONS AND SERVICE

The current e-tran fleet composition for fixed route services is comprised of 46 CNG-fueled 40-ft buses with purchase years between 2008 and 2020 (Table 2)<sup>2</sup>.

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<sup>2</sup> Current fleet as of June 2019 as provided by e-tran.

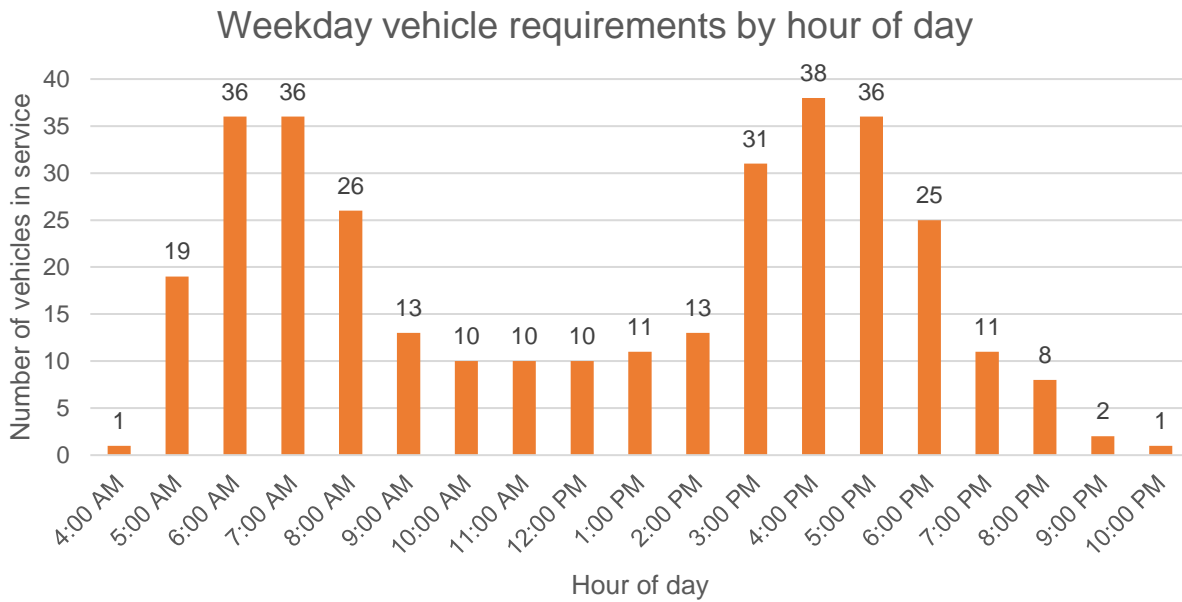
**Table 2: E-tran current fleet composition**

Year	Number of buses	Make	Length (ft)	Seating capacity	Fuel type	FTA useful life <sup>3</sup>	Scheduled replacement year
2008	8	Orion	40'	39	CNG	12	6 in 2021 2 in 2023
2010	8	New Flyer	40'	40	CNG	12	2 in 2025 2 in 2026 2 in 2027 2 in 2028
2011	6	New Flyer	40'	40	CNG	12	2 in 2029 2 in 2030 2 in 2031
2014	3	New Flyer	40'	40	CNG	12	3 in 2032
2015	8	New Flyer	40'	40	CNG	12	4 in 2033 4 in 2034
2018	5	New Flyer	40'	40	CNG	12	2 in 2035 3 in 2036
2020	8	New Flyer	40'	40	CNG	12	2 in 2037 2 in 2038 2 in 2039 2 in 2040
<b>Total</b>	<b>46</b>						

The city’s current transit fleet is all entirely within the useful life benchmarks set by FTA (with the exception of the two Orion V vehicles, which underwent an 8-year refurbishment and are scheduled for replacement in 2022 and 2023) and thus are all expected to be in good working condition. Currently, Elk Grove has a fleet replacement schedule through 2040 to ensure vehicles are maintained in a state of good repair.

Figure 3 shows the weekly vehicle requirements by hour of day. This figure shows hourly vehicle requirements for fixed route services regardless of whether the vehicle is operating on a local or commuter route.

<sup>3</sup><https://www.transit.dot.gov/sites/fta.dot.gov/files/docs/FTA%20TAM%20ULB%20Chart%20Sheet%202016-10-26.pdf>



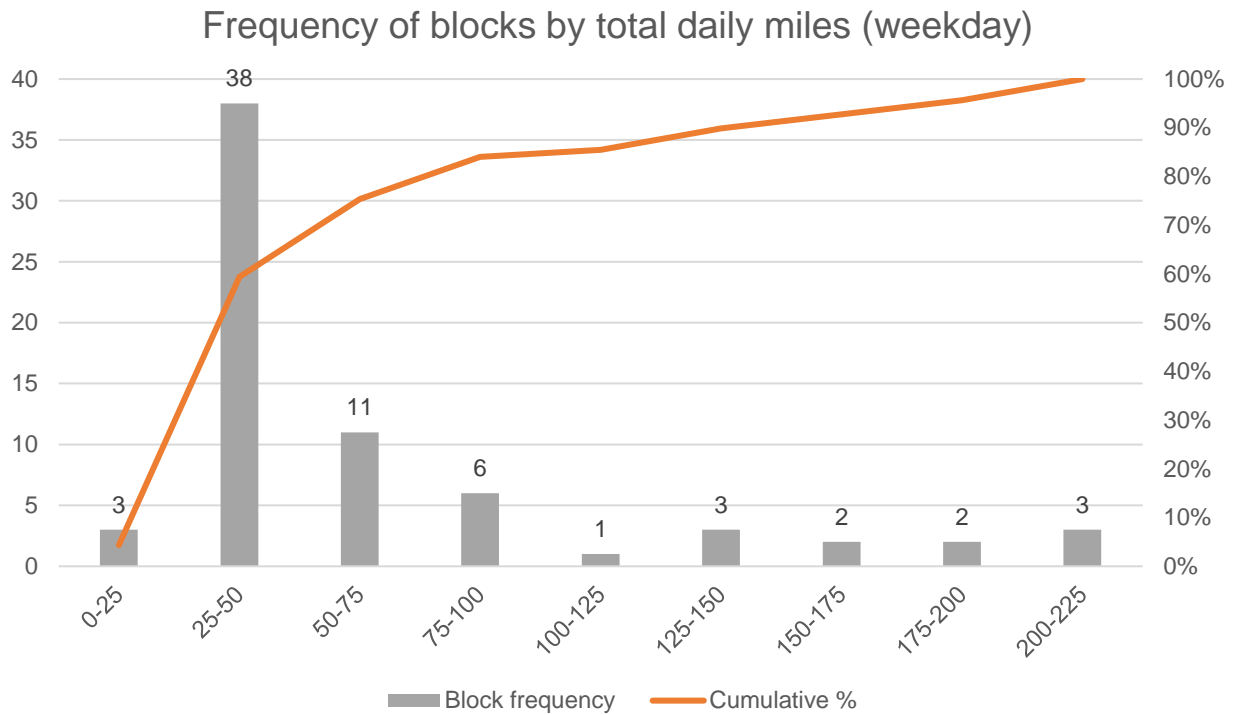
**Figure 3: Weekday vehicle requirements by hour of day**

As much of e-tran service is commuter-focused, the pattern of vehicles in use that spikes during standard AM and PM commute periods is typical and expected. The peak vehicle requirement of 38 vehicles occurs at 4 pm and translates to a spare ratio of 21%. As a spare ratio of 20% is recommended by the FTA, the city’s fleet is well-sized to deliver service efficiently.

One of the largest challenges associated with transitioning to ZEBs are the range limitations associated with both BEBs and (to a lesser extent) FCEBs. Agency-specific circumstances (such as long routes and block lengths, challenging topography, etc.) can also exacerbate this issue by presenting additional constraints that must be accounted for to not interrupt service provision or negatively affect the rider experience. For e-tran, a key challenge is the commuter routes that travel long distances between Elk Grove and Sacramento or Rancho Cordova, resulting in long routes that translate to long block lengths.

Block lengths by frequency of blocks by total daily miles traveled (including revenue service and deadhead) for an average weekday is shown in Figure 4<sup>4</sup>.

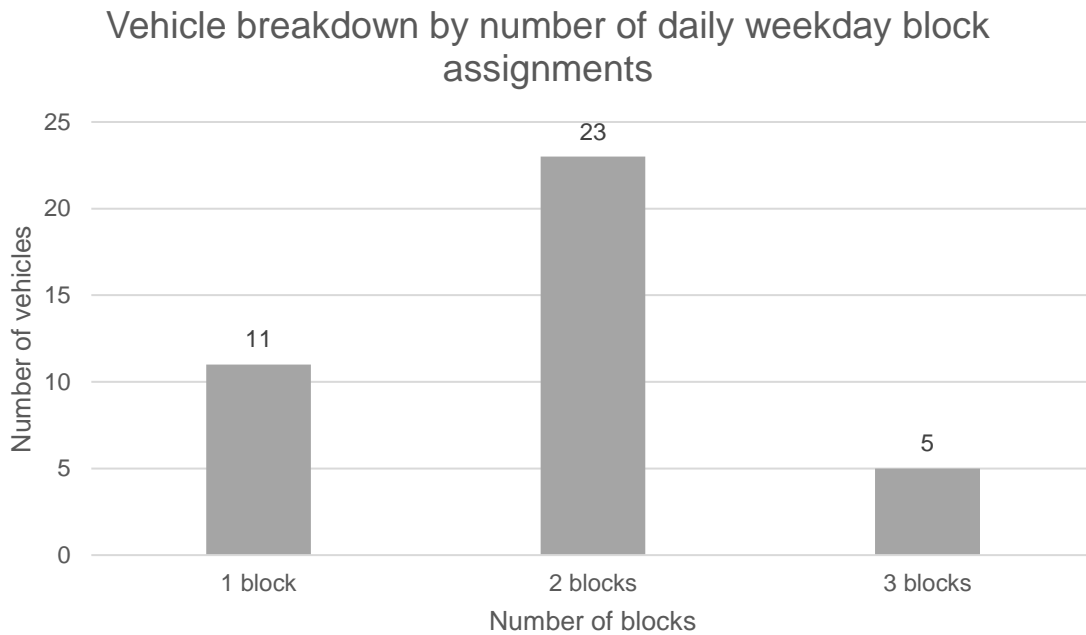
<sup>4</sup> While e-tran provides some local Saturday service, the majority of service is provided on weekdays and thus the analysis focuses on weekday operations.



**Figure 4: Frequency of blocks by daily total vehicle miles (weekday)**

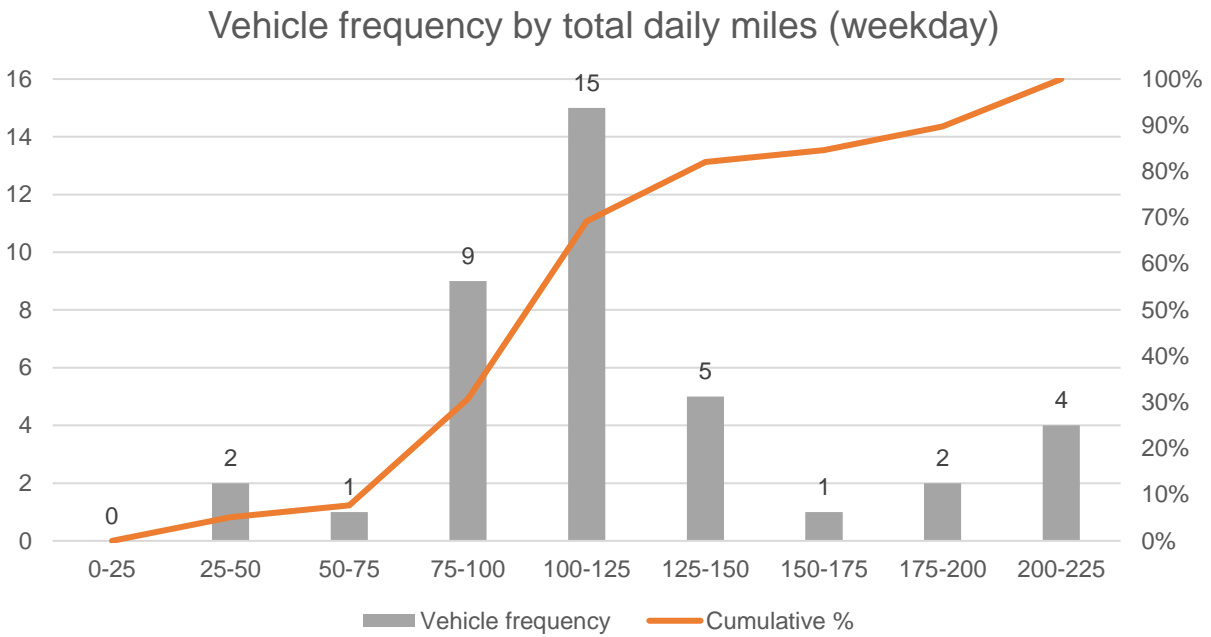
While daily block length averages 68 miles, block lengths vary between a minimum of ten miles and a maximum of 221 miles. The vast majority (84%) of blocks travel less than 100 miles in a day, which is encouraging as these blocks are safely within the daily range limitations of BEBs (the average current operational range of a BEB is 120-150 miles without on-route charging). However, it is still important to consider that seven (or 10%) blocks travel over 150 miles on an average weekday. There are multiple strategies that an agency can employ to mitigate this, such as reblocking to create shorter block lengths, installation of opportunity charging for BEBs, operating longer range FCEBs, or using two ZEBs to complete a block that was previously completed by one CNG vehicle.

As e-tran vehicles are assigned multiple blocks throughout the course of a day, it is important to examine operations from the perspective of how many miles each vehicle travels on an average weekday. Figure 5 shows the breakdown of vehicles in revenue service on a typical weekday based on their number of daily block assignments.



**Figure 5: Vehicle breakdown by number of daily weekday block assignments**

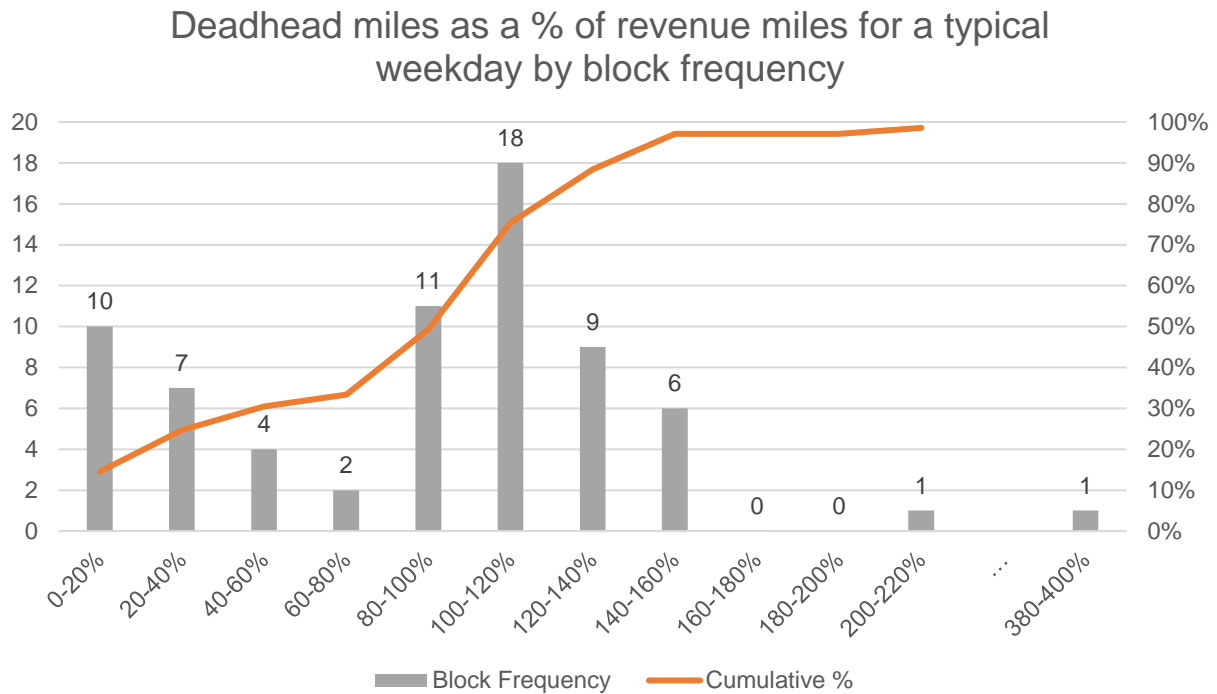
The majority (or 59%) of vehicles are assigned to complete two blocks on a typical weekday. Twenty-eight percent of vehicles are assigned to one block, and the remaining 13% are assigned to complete three blocks. While there are 69 blocks in operation on the sample weekday, some blocks are completed by more than one vehicle, so the total number of blocks shown above is 72. Because the majority of vehicles complete multiple blocks in a day, this may mean that the daily distances vehicles travel exceed the maximum ranges of current ZEB technologies. To understand if this is the case, a breakdown of total daily miles by vehicle frequency is presented in Figure 6 below.



**Figure 6: Vehicle frequency by total daily miles (weekday)**

While the most frequent mileage span for a block to complete in a day is between 25 and 50 miles, this number increases when looking at the distance a *vehicle* completes in a day, which peaks at 15 vehicles completing between 100 and 125 miles. While the average block length is 68 miles, the average distance a vehicle operates in a day is significantly higher and almost twice as much for vehicles, at 120 miles. This indicates that while most block lengths are in the range of current ZEB technologies, daily vehicle distances are more likely to fall outside this range. While only 10% of blocks travel over 150 miles on an average weekday, this jumps to 18% when looking at how many vehicles travel this distance. However, the maximum distance of 221 miles does not change, indicating that, in this instance, the vehicle that completes this block is not assigned to any other blocks.

When an agency operates long block lengths that might pose challenges for ZEB implementation, it is important to understand how much of the total block length is attributed to deadheading, and if blocking, run cutting, or scheduling changes can minimize the amount of deadhead to better fit daily total block lengths into the parameters of ZEB ranges. Figure 7 presents deadhead miles as a percentage of revenue miles for a typical weekday by block frequency.



**Figure 7: Deadhead miles as a percent of revenue miles for a typical weekday**

Slightly less than half (49%) of blocks operate deadhead miles that are less than their daily revenue miles. However, this means that the majority of blocks are operating deadhead mileage that exceeds their daily revenue miles. Specifically, blocks average 21 miles of daily deadhead mileage and 47 miles of revenue service. While the highest frequency of blocks feature daily deadhead mileage between 100% and 120% of revenue miles, some blocks’ deadhead mileage significantly exceeds daily revenue mileage, as seen in the two blocks that exceed revenue mileage by 200% or more. However, these blocks are short compared to the overall system and together only account for 3% of total daily deadhead miles.

Significant deadhead is often a feature of transit agencies who only have one facility that vehicles operate out of. For e-tran, 86% of total daily deadhead miles can be attributed to commuter services, as vehicles deadhead back to the facility in Elk Grove after their AM run, and deadhead back to downtown Sacramento prior to the PM run. While this contributes to both increased deadheading and long block lengths, it also presents an opportunity to charge or refuel vehicles during the midday period when these vehicles are in the yard. This service characteristic will need to be taken into consideration when determining the optimal ZEB option for e-tran.

### 3.2 MAINTENANCE FACILITY

The City of Elk Grove's Corporation Yard, located in the south of the city, houses the transit operations and maintenance facility, and is shared with the City's police and public works departments.

Buses, including paratransit vehicles, are stored and maintained on-site and parked outdoors. The current facility is in good condition and has adequate space for the current fleet size and room for expansion.

Looking ahead from a ZEB perspective, the available yard space provides little constraint for future fueling needs, either for BEBs or FCEBs. However, Stantec notes that all CNG fueling occurs off-site, whereby a service attendant will drive the bus to a fueling station less than one mile away and fill the bus and return it to the yard. If a similar arrangement is desired for potential FCEBs, e-tran would need to locate a nearby hydrogen fueling station, which currently, does not exist. Finally, Stantec notes that any resiliency planning to a degree more granular than in the rollout plan should include the Police Department as a stakeholder, since backup generators would need to accommodate the vital Police Department functions.

### 3.3 CHALLENGES AND OPPORTUNITIES

Based on Stantec's appraisal of e-tran's operations and service profiles, maintenance yard, and discussions with e-tran, Stantec notes the following preliminary challenges and opportunities for ZEB transition:

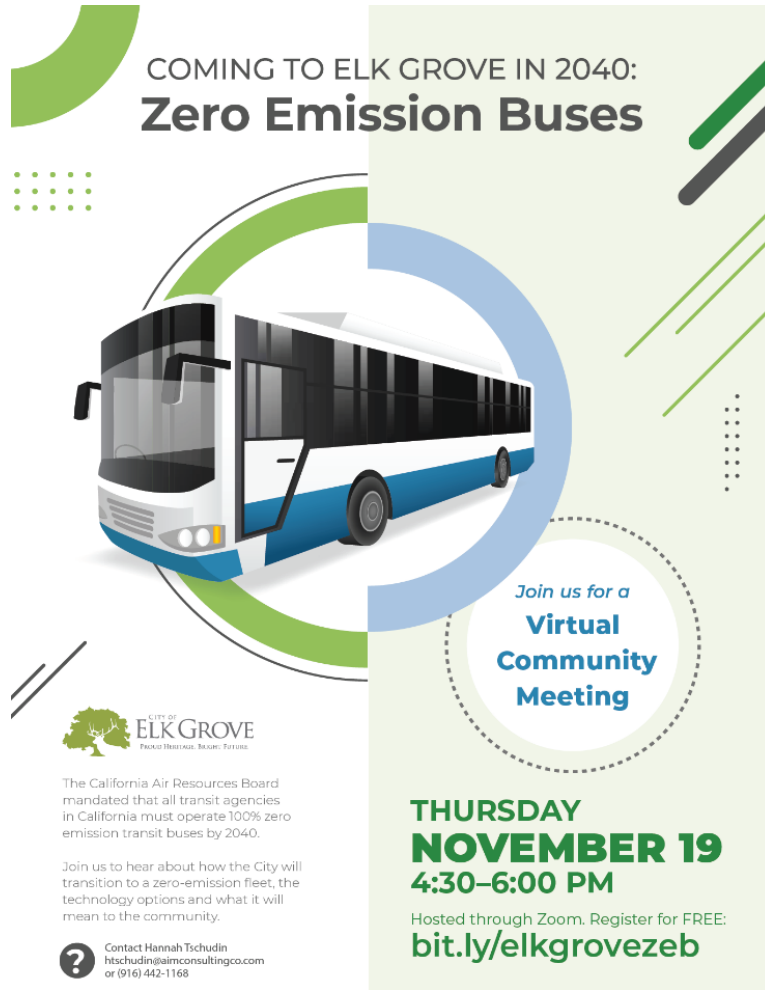
- E-tran's service area is relatively flat and unchallenging from the perspective of ZEBs and elevation changes.
- 84% of vehicle blocks are assigned daily mileages of less than 100 miles which is within the operating range of BEBs.
- While commuter service may be a challenge from a trip mileage perspective, local service is likely a greater challenge for ZEBs since vehicles are assigned to 10+ hour blocks.
- E-tran has a large complement of vehicles that are not in use during the midday (i.e., service is very 'peaked'), providing a substantial reserve pool to draw upon if required by the limitations of ZEB technology.
- The Corporation Yard is not space constrained to a significant degree.
- Fueling occurs off-site; if e-tran decided to adopt a similar strategy for FCEBs, then a hydrogen fueling service station would need to be identified nearby.
- The large number of regional transit operators could provide partnership opportunities for e-tran when purchasing vehicles or other assets, as well as learning opportunities.

## 4.0 PUBLIC AND STAKEHOLDER OUTREACH

On Thursday, November 19, 2020 from 4:30 – 6:00 p.m., the City of Elk Grove held a Virtual Community Meeting for the Zero-Emission Bus Fleet Transition Plan. Twenty-two community members participated in this meeting. Below is a list of project team members that were in attendance:

<b>City of Elk Grove</b>	<b>Stantec</b>	<b>AIM Consulting</b>
Michael Costa	Sasha Pejic	Gladys Cornell
Terry Easley	Amanda McDaniel	Nicole Porter
	David Verbich	Hannah Tschudin

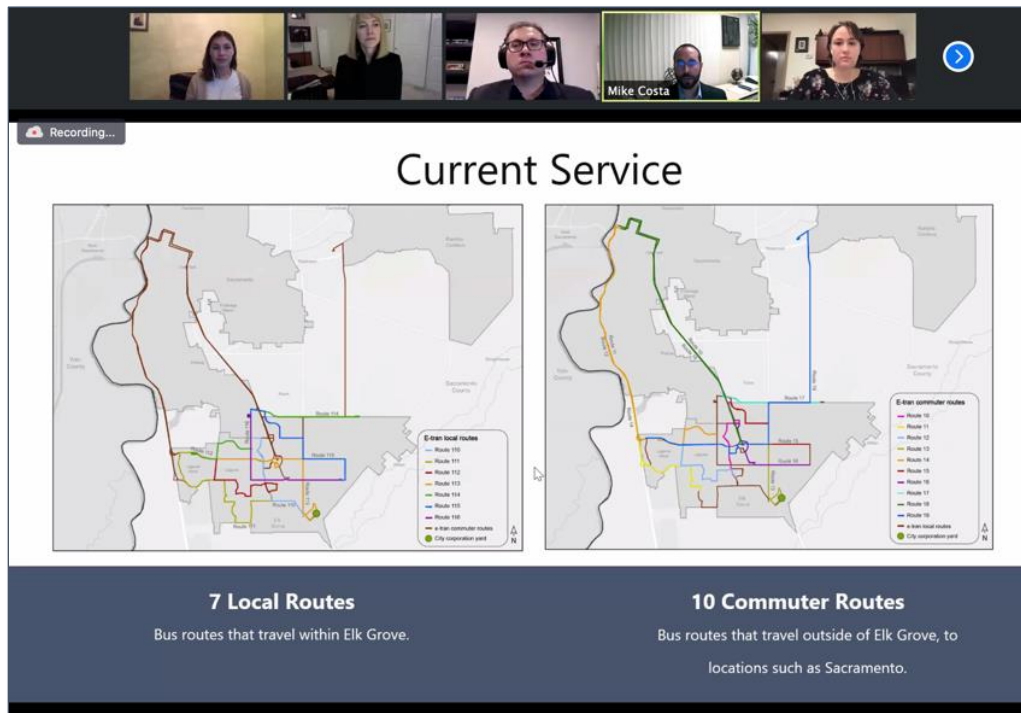
Several weeks prior to the meeting, the Elk Grove City website was updated to include the flier below to advertise the webinar. Furthermore, AIM Consultants who led the outreach, directly contacted, and invited over 80 stakeholders throughout the region who are invested in transit, transportation, and sustainability.



**Figure 8: Advertising flatsheet for the outreach meeting**

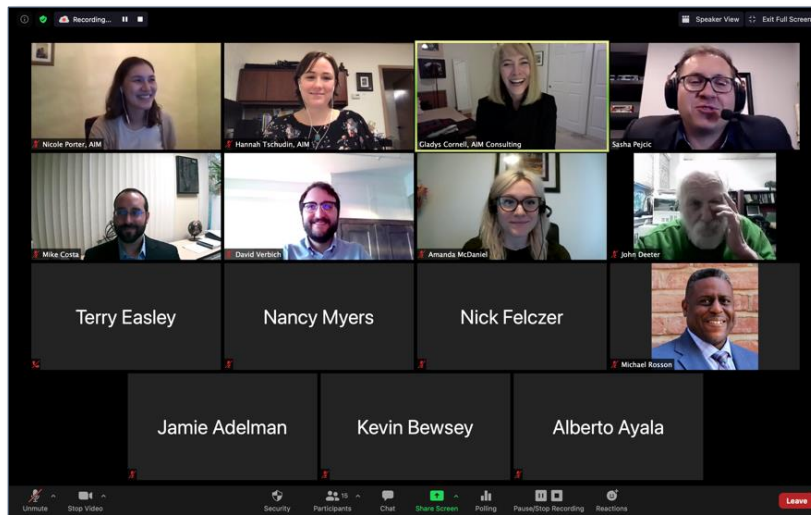
The Virtual Community Meeting provided an opportunity for the project team to brief the community and stakeholders on this Project, educate them about the benefits and opportunities of ZEBs, and solicit comments and feedback.

## ZEB STRATEGY AND FINAL REPORT



**Figure 9: Screenshot of the meeting presentation**

We first started with a background on e-tran as a transit agency, including its current fleet, operations, and service. Then, Stantec discussed the project team’s approach to developing the plan, provided an update on the technical work that has been done, and gave an overview of how the plan will be deployed.



**Figure 10: Screenshot of the meeting discussion**

## ZEB STRATEGY AND FINAL REPORT

During the discussion portion of the Virtual Community Meeting, participants asked several questions about the e-buses related to cost, sourcing and additional amenities. The project team clarified that the City is required to purchase vehicles made in United States (compliant with all FTA requirements), however some components may come from offshore sources. The cost of electric batteries for the buses is heavily reliant on supply and demand, which regularly fluctuates and makes it difficult to predict future price changes (batteries currently account for over 25% of the purchase price of a BEB). The project team also noted that bike racks will be available on the new electric buses, and the City is planning on purchasing 40-foot buses, as it currently does, to facilitate social distancing during the COVID-19 pandemic (although the first BEBs would be arriving in at least 2+ years). Attendees also had questions about the timeline of the fleet transition, and funding for the conversion. The CARB mandate requires that agencies need to start purchasing at least 25% of new vehicles with zero-emission technology in 2023 and to completely transition the fleet to 100% zero-emission buses by 2030. The project team stated that they will be providing guidance on available funding from federal grants, state grants, Caltrans sustainable grants, and other sustainability-focused grants to fund the bus fleet transition.

Overall, the community feedback was positive and supportive of this important project and transition to ZEBs. After the discussion portion, the project team thanked attendees and concluded the meeting.

### Online Web Forum

- To ensure that every community member had an opportunity to provide their input and learn more about the project, the Elk Grove Zero-Emission Bus Fleet Transition Virtual Community Meeting was recorded and posted to the project website with an Online Web Forum to collect public feedback. More than **25 community members** watched the recording of the Virtual Community Meeting. Of those viewers, three participated in the Online Web Forum where they were asked to rate the plan and leave comments.

Below is a table depicting the ratings on a scale of 1 to 5 with 1 being Strongly Disagree and 5 being Strongly Agree and open-ended feedback left by participants.

Rating	Feedback
5	I am so glad the City is being proactive about Climate Change.
2	This transition needs to happen now. It should be done by 2025, not 2040.
5	Great, I know that hydrogen is the most expensive, but I would say truly think about the ability to always have fuel. In Louisiana during the flood, they lost the use of their fleet to assist with evacuations. It wasn't due to fueling but why leave ourselves open to the possibility of not being able to fuel in times of an emergency? Working with other local agencies to support one another in Sacramento and Stockton is great. I love seeing Emissions Guidelines on the move.

### 5.0 PREFERRED/RECOMMENDED FLEET COMPOSITION

The Stantec team commissioned subconsultant CUTRIC to perform a block-based study of e-tran's current service to assess how blocks perform under different technology options and bus specifications. The modeling was conducted at the block-level to model how the different ZEB technologies would operate under e-tran's conditions and for e-tran's operations. This section provides a high-level summary of CUTRIC's modeling methodology and results<sup>5</sup>.

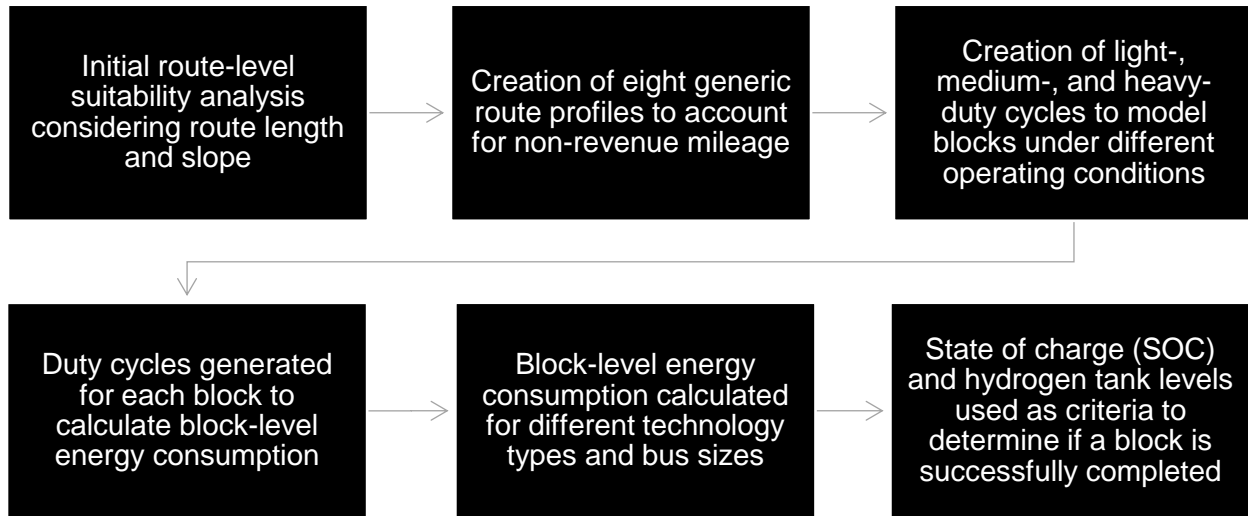
#### 5.1 POWER MODELING OVERVIEW

CUTRIC's predictive modeling exercise involves several steps that work to incorporate various inputs and parameters to assess energy performance of both BEBs and FCEBs in e-tran's service area and according to e-tran's current service schedules. The goal of the modeling is to provide an understanding of how a ZEB is expected to perform in e-tran's operating environment to inform fuel economy, energy consumption, operation range, and ultimately, the feasibility of different ZEB technologies. The predictive ZEB performance modeling is dependent on several inputs that can impact fuel efficiency and operating ranges, including route alignment, terrain and topography, traffic impediments, vehicle specifications, speed limit data, and passenger loading information.

The full modeling methodology process is outlined in Figure 11. First, a high-level route-level suitability analysis is conducted to understand the overall feasibility of electrification. Then, generic non-revenue (deadhead) profiles were created to account for deadheading—generic profiles were created since no spatial information in a GIS exists of deadheading alignments. Three duty cycles were generated based on simulating strenuous (stopping at every impediment, a hot day, heavy passenger load, etc.) to light conditions (empty bus, temperate day, etc.) to generate a range of different possible fuel economies. Duty cycles are then generated for each block (comprised of all trips) and block-level energy consumption is modeled for the different vehicle technologies considered. Finally, blocks are deemed successful if the state of charge (SOC) is at least 20 percent at the end of a block or the hydrogen tank is at least 5 percent full.

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<sup>5</sup> For an in-depth overview please refer to CUTRIC's Fleet Electrification Analysis Final Report (Appendix B)



**Figure 11: CUTRIC route modeling process**

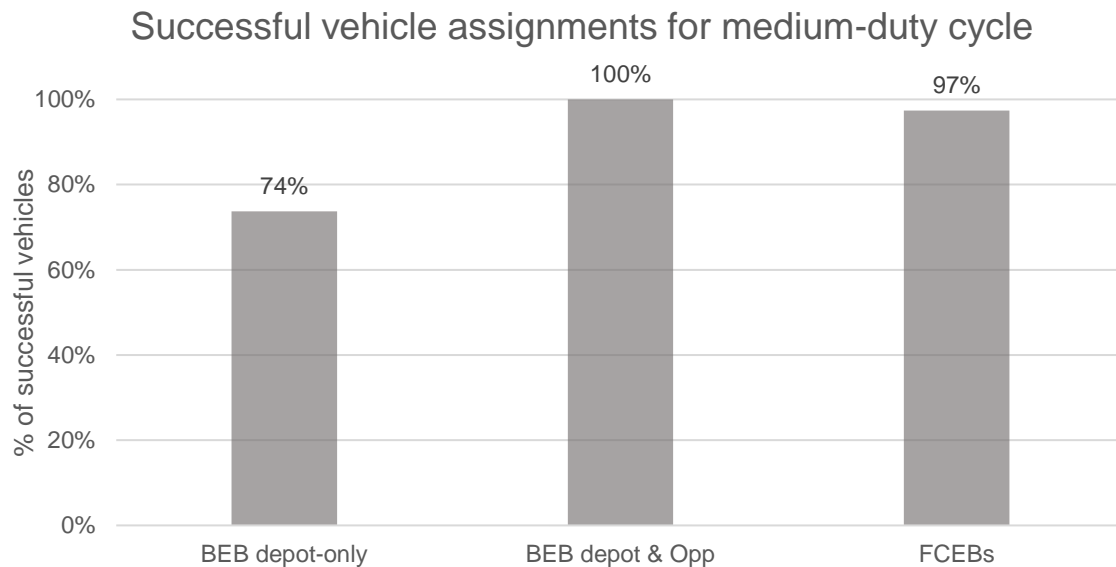
Several different inputs are utilized by CUTRIC to accurately represent ZEB performance in e-tran's operating conditions, which are outlined below.

- **Transit schedules:** CUTRIC's simulation tool is designed to work with transit-scheduling data provided in GTFS format. The essential elements used as inputs include the polyline which represents the course of the block along specific routes, scheduled stop times on a given service, and sequence of routes which constitute the whole block.
- **Topography:** to accurately model the vehicle battery discharge and regenerative recharge as the bus travels on varying grades, topographic data needs to be joined with bus polylines to simulate the actual incline experienced by a bus as it traverses its block.
- **Traffic impediments:** traffic impediments must be included to accurately model a duty cycle of a bus along a given block. This would include anything that would hinder the bus from its normal flow of travel.
- **Speed limits:** speed limit data is also required to accurately model the bus duty cycle. This data in the form of line segments delineating speed zones, was also provided by e-tran.
- **Vehicle specifications:** as previously stated, modeling was completed for depot-only charging BEBs, on-route charging BEBs, and FCEBs. Various modeled vehicle specifications included:
  - BEBs with 400+ kWh battery and 600+ kWh battery (for both depot-only and on-route charging BEBs).
  - FCEBs with a 90+ kWh battery and 30+ kg fuel-cell module.

### 5.1.1 Modeling Results

SOC was the criteria used to determine if a block can be successfully completed under the different BEB technology options, and a block was deemed successful under FCEBs if it can successfully complete its service if the hydrogen tank was at least 5% full. Results from the modeling exercise for each of the three technology options under the medium-duty cycle was consolidated by Stantec at the vehicle assignment level and shown in Figure 12. As the fleet composition is based on the medium-duty cycle because this cycle best represents average operating conditions for e-tran, it is the only cycle presented throughout this report.

These figures show on a typical service day the percent of vehicles that can successfully complete their scheduled service under the different technology options. For example, Figure 12 shows that 74% of vehicles are successful with only depot-charging BEBs, and 100% of vehicles are successful with both depot and opportunity charging BEBs, and 97% of vehicles are successful as FCEBs.



**Figure 12: Percent of successful vehicles under the medium-duty cycle**

According to the results from the modeling, we can draw the following conclusions regarding the medium-duty cycle:

- Seven vehicles are unable to successfully complete service under depot-only charging BEBs
- All vehicle assignments are successful if at least three on-route chargers are deployed under depot and opportunity-charging BEBs
- One vehicle assignment is unsuccessful with only overnight fueling FCEBs.

Based on the modeling results and these considerations, three preliminary fleet concepts were developed for assessment and refinement:

- **Fleet Concept A: depot-charging BEBs**
  - Install one fast charger (600 kW) at the depot and have midday charging for vehicles operating on routes 110 and 113
  - Split three blocks that fail into new sub-blocks (either through expanding the fleet with three new buses or servicing these new blocks with vehicles in the existing fleet)
- **Fleet Concept B: FCEBs**
  - Would require construction of a fueling yard onsite or assessing potential offsite locations for the hydrogen station
  - For contingency, refueling during the day may be needed for vehicles operating on routes 110 and 113 and refueling at a public hydrogen station in Sacramento will lessen range anxiety for commuter routes. Alternatively, e-tran can procure four FCEBs with larger hydrogen tanks for longer blocks
- **Fleet Concept C: on-route charging BEBs**
  - Install two 600 kW on-route chargers at two strategic locations to charge vehicles operating on routes 111, 115, and 116
  - Recut schedules to allow for on-route charging (app. 10 minutes per charging event)
  - Still requires in-depot charging (and installation of one fast charger in the depot for midday charging of vehicles operating on routes 110 and 113)

## 5.2 FLEET COMPOSITION REFINEMENT

After development of these initial, preliminary fleet concepts, a high-level cost assessment was completed to compare the different options (Table 3). *Please note that this assessment was developed to preliminary understanding of costs and trade-offs, and is not a detailed financial analysis.*<sup>6</sup>

**Table 3: High-level cost comparison of different fleet options**

	Capital cost estimates <sup>7</sup>	Operating cost estimates	Other considerations
<b>Depot-only BEBs</b>	50 BEBs X \$874K= \$43.70M 25 Chargers (150 kW) X \$170K= \$4.25M 1 Charger (600 kW) X \$500K= \$0.50M	- Electricity at the depot for charging - Overnight charging needs to be managed using software or operators	- Three additional buses or fast charging at the depot - Inefficiencies due to splitting blocks

<sup>6</sup> Cost estimates may differ here from those presented later in Section 0.

<sup>7</sup> Does not take into consideration facility and other infrastructure modifications.

## ZEB STRATEGY AND FINAL REPORT

	Capital cost estimates <sup>7</sup>	Operating cost estimates	Other considerations
	1 Transformer X \$260K= \$0.26M <b>TOTAL = \$48.71M</b>	- Fuel cost might be lower than hydrogen - Mid-life battery replacement	- Extra deadhead to switch buses at garage or additional drivers for the split blocks - Chargers can be phased-in
<b>FCEBs</b>	46 FCEBs X \$1.02M = \$46.92M Fueling Station = \$3.90M <b>TOTAL = \$50.82M</b>	- Operators or contracts needed for off-site fueling events - Fuel cell power plants can be refurbished - Higher fuel cost	- Similar operations to CNG - Fueling yard requires large footprint - Off-site hydrogen refueling might be needed or FCEBs with bigger hydrogen tanks - Hydrogen distribution availability - Fast refueling
<b>On-route BEBs</b>	46 BEBs X \$894K <sup>8</sup> = \$41.12M 25 Chargers (150 kW) X \$170K = \$4.25M 3 chargers (600 kW) X \$500K = \$1.50M 1 Transformer X \$260K = \$0.26M <b>TOTAL = \$47.13M</b>	- Depot chargers are still required - Overnight charging needs to be managed using software or operators - Fuel cost might be lower - Mid-life battery replacement	- On-route fast charging are difficult to build/own - Creating on-route charger locations - Chargers can be phased-in

Based on discussions with e-tran leadership and the considerations summarized in Table 3, it was determined that Fleet Concept A is the preferred ZEB fleet composition. Fleet Concept A is relatively straightforward to implement, comparably on the lower end of the price spectrum, does not require costly and complex offsite consideration (on-route charging, and/or hydrogen fueling) and can be achieved without significantly expanding the fleet.

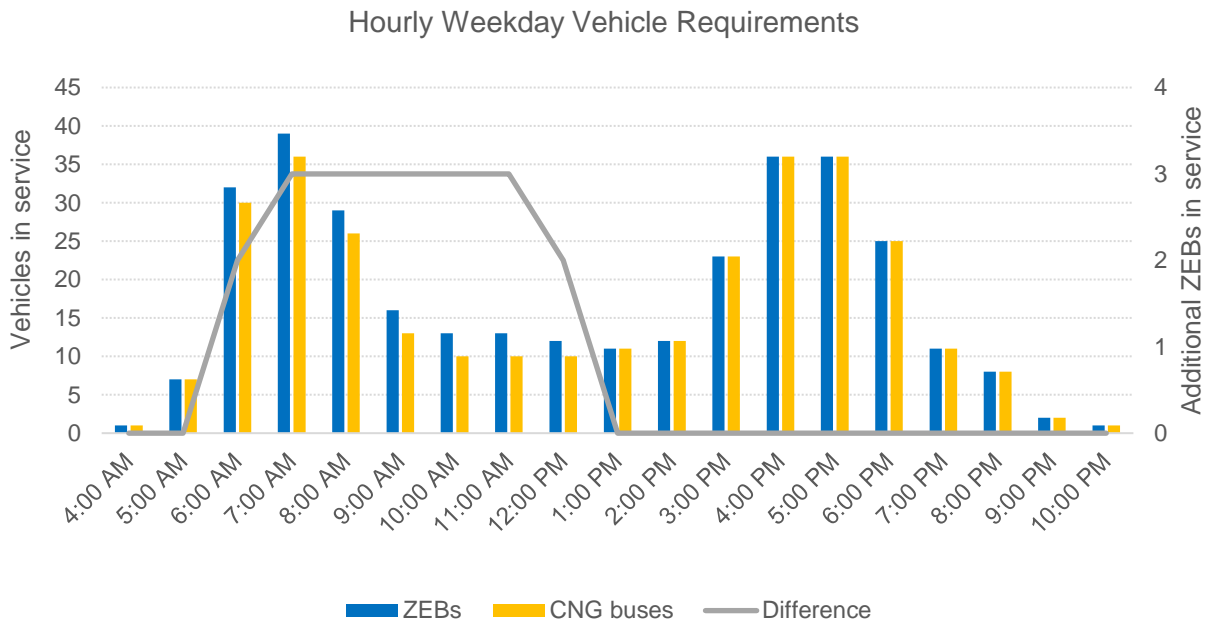
Stantec next worked with e-tran to determine reblocking strategies that would minimize disruptions from current service by splitting the unsuccessful blocks and assigning portions of these to vehicles that were originally assigned to short blocks. The results of this exercise are presented in Table 4.

**Table 4: Reblocking exercise of unsuccessful blocks**

Block #	Route(s)	Service Span	Vehicle #	Original vehicle mileage	Revised vehicle mileage
1111a	111	5:45 am – 11:40 am	558	63	160
1111b	111	11:40 am – 8:30 pm	777	221	137
1161a	115, 116	5:50 am – 11:55 am	560	37	104
1161b	115, 116	11:55 am – 9:10 pm	848	164	102
1163a	115, 116	6:50 am – 12:55 pm	567	37	103
1163b	115, 116	12:55 pm – 8:40 pm	832	147	85
113, 155, 1102a	11, 15, 110	6:00 am – 10:10 am; 3:40 pm – 6:50pm	566	96	131
1102b	110	6:30 am – 8:00 am; 10:15 am – 5:45 pm	838	176	143

<sup>8</sup> On-route BEBs will require additional charging connections on the bus rooftop (charge rails) that connect to the fast-charging pantograph for on-route charging (this is in addition to plug-in receptacles for in-depot charging). The additional charging connection on the rooftop adds an additional ~\$20,000 price difference between on-route BEBs and depot-only BEBs.

To maintain the current level of service at e-tran, a combination of fast charging and a few block modifications would result in an increase in peak vehicle use<sup>9</sup> from 37 to 39; a decrease in the spare ratio at peak hours from 20% to 15%. Therefore, two extra vehicles are recommended to be added to the fleet size in order to maintain the same level of spares at peak hours. However, the use of the additional vehicles is not needed until after once all the CNG vehicles have been phased out, since the CNG vehicles can be used for the longer blocks (ID# 1102 and 1111) for as long as they are part of the fleet, which will be the case past 2040.



**Figure 13: Fleet size comparison (CNG vs. ZEB)**

Figure 13 demonstrates the hourly quantity of vehicles in use currently (orange bars) compared to the predicted ZEBs in service. Because of the need to create new blocks, more vehicles are in needed in service during the morning peak as well as for part of the late morning.

Furthermore, in order to avoid increasing the fleet beyond two vehicles one overhead charger is required at a power capacity of 600 kW at the yard so that four vehicles can have fast-charging events during service hours. Vehicles assigned to blocks 1143, 1142, and 1141 will require fast charging at the end of route 13 (Vehicles 563, 770, and 821) and the vehicle assigned to block 171 will require high power charging before starting the next block (Vehicle 565). A minimum of 10 minutes is required per charging event to have seven minutes of effective charge. Figure 7 shows the suggested fast-charging events that are needed for the vehicles with longer daily mileage than the range of the modeled BEBs.

<sup>9</sup> Also known as vehicles operated at maximum service (VOMS).

Figure 14: Fast charging events for vehicles with long daily mileage

OFF PEAK																
Vehicle #	4:00:00 AM	4:30:00 AM	5:00:00 AM	5:30:00 AM	6:00:00 AM	6:30:00 AM	7:00:00 AM	7:30:00 AM	8:00:00 AM	8:30:00 AM	9:00:00 AM	9:30:00 AM	10:00:00 AM	10:30:00 AM	11:00:00 AM	11:30:00 AM
563	0	0	0	\$	\$	\$	\$	\$	\$	Fast Charge	\$	\$	\$	\$	\$	Fast Charge
565	0	0	0	0	\$	\$	\$	\$	\$	\$	\$	\$	Fast Charge	0	0	0
770	0	0	0	0	0	\$	\$	\$	\$	\$	\$	Fast Charge	\$	\$	\$	\$
821	0	0	0	\$	\$	\$	\$	Fast Charge	\$	\$	\$	\$	Fast Charge	\$	\$	\$

MID PEAK										
Vehicle #	12:00:00 PM	12:30:00 PM	1:00:00 PM	1:30:00 PM	2:00:00 PM	2:30:00 PM	3:00:00 PM	3:30:00 PM	4:00:00 PM	4:30:00 PM
563	\$	\$	\$	\$	\$	Fast Charge	\$	\$	\$	\$
565	0	0	\$	\$	\$	\$	\$	\$	\$	\$
770	\$	Fast Charge	\$	\$	\$	\$	Fast Charge	\$	\$	\$
821	\$	\$	\$	Fast Charge	\$	\$	\$	\$	\$	Fast Charge

S = in service  
 0 = not in service and not charging

### 5.3 POWER DEMAND MODEL AND CHARGING PROFILE

After determining the preferred fleet composition for e-tran, it’s necessary to determine the power capacity at the division to meet the energy demand for an all-BEB fleet in order to identify the required utility upgrades. Several operational factors were incorporated as parameters for the modeling, including,

- Charging/recharging time window: Stantec assumed all buses start charging overnight and can charge during the day between blocks at times that they are not in service according to the service schedules and vehicle assignments for the representative day and according to the blocking and scheduling changes made during fleet composition refinement, as well as times for fast charging as determined in the fleet composition process.
- 150 kW in-depot chargers (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)
- Assuming negligible time between when a bus enters the facility and is connected to charger and starts charging

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.

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

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

## ZEB STRATEGY AND FINAL REPORT

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 charging schedule (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) for each division.

The number of hours each charger at a division needs to be online provides the power requirement, and the addition of connected chargers at a specific hour represents the total power 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 possible when they return to the base
- Charging during hours that the bus is not in service based on block schedules
- Avoid charging during peak hours (5 – 8pm) according to SMUD summer rates
- Accommodating fast charging through one 600 kW charger in the depot for four vehicles that require midday fast charging
- A smart charging software will be implemented to optimize the charging times and guarantee all vehicles will be charged and ready for service.

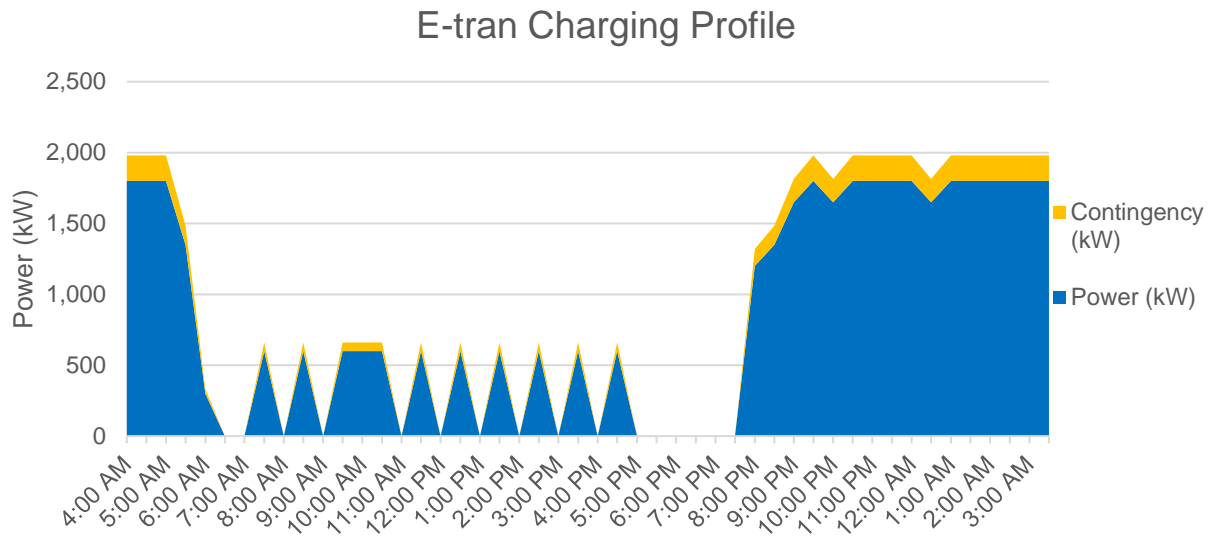
The power modeling provides the following outputs:

- The maximum number of chargers that need to be connected at each hour of the day
- Representative daily charging schedule at e-tran's Corporation Yard
- Maximum power requirements at e-tran's depot

Figure 15 shows the charging schedule and daily power requirements at e-tran's division and Table 5 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 fails in the smart charging system. The burst of charging events that occur between 7 am and 5 pm in Figure 14 represent the fast-charging needed for four of the vehicles to avoid increasing the fleet size<sup>10</sup>.

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<sup>10</sup> Based on the representative day that was modeled, vehicles assigned to blocks 1143, 1142, and 1141 will require fast charging during the day (vehicles 563, 770, and 821, respectively). As well as any vehicle assigned to block 171 will require high power charging during the day (vehicle 565).



**Figure 15: E-tran charging profile and power requirements**

**Table 5: Summary of maximum power demand and total energy requirements**

Division	No. of 150 kW Chargers	No. of 600 kW Chargers	Total daily energy requirement	Maximum power demand
City of Elk Grove Corporation Yard	13	1	15,000 kWh	1,980 kW

The charging profile and total number of online chargers will vary if using a smart charging management software, but this analysis ensures that a high demand service day for e-tran can be fulfilled under a maximum power demand of 1.98 MW.

## 6.0 FLEET PROCUREMENT SCHEDULE/OUTLOOK<sup>11</sup>

E-tran has specified a fleet replacement schedule for their current CNG fleet as detailed in Table 6. This replacement schedule provides the basis for the ZEB Phasing strategy.

**Table 6: CNG fleet replacement schedule**

Year	Vehicles needed to be replaced	Bus Type
2021	6	Orion VII
2022	0	--
2023	4	(1) Orion V (3) Orion VII
2024	0	--
2025	2	New Flyer C40 LFR
2026	2	New Flyer C40 LFR
2027	2	New Flyer C40 LFR
2028	2	New Flyer C40 LFR
2029	2	New Flyer C40 LFR
2030	2	New Flyer C40 LFR
2031	2	New Flyer C40 LFR
2032	3	New Flyer Xcelsior
2033	4	New Flyer XN40
2034	4	New Flyer XN41
2035	2	New Flyer XN42
2036	3	New Flyer
2037	2	New Flyer
2038	2	New Flyer
2039	2	New Flyer
2040	2	New Flyer

Based on the bus modeling and route simulations completed by CUTRIC and further analysis by the Stantec team, it was determined that a combination of fast charging and modifications to certain vehicle blocks/assignments is needed in order to maintain the current level of service at e-tran. This approach:

- Provides the same level of service as today (pre-pandemic)

<sup>11</sup> This section provides information relevant for Section C and D of the ICT Rollout Plan

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- Does not require a significant increase to the total fleet size

However, this approach necessitates an increase of vehicles in service during peak from 37 to 39 vehicles; this decreases the calculated spare ratio of buses from 20% to 15%.

While Stantec does not recommend acquiring more vehicles at the moment to achieve this spare ratio, if e-tran desires a 20% spare ratio, two additional vehicles could be acquired once all CNG vehicles are retired. Note, however, since CNGs will still be in service through 2040, this potential increase in fleet size is not captured in the replacement schedule in Table 7, since the project horizon ends in 2040.

Note that the assumption is that all the vehicles will be BEBs with 440+kWh battery packs to maintain a homogenous fleet, as opposed to having different battery sizes that would result in restricting which blocks can be assigned to specific vehicles. Stantec also recommends that e-tran include charge rails on its BEB specs that can be added at a cost of \$15,000 to \$20,000 (~2-3% of the bus purchase price), depending on the bus manufacturer. This flexibility is important since Stantec's fleet concept and charging plan includes rapid charging for certain vehicle blocks.

Table 7 illustrates the recommended fleet schedule for CNG buses and BEBs. This plan was developed by accounting for CNG bus retirement, ICT's purchase requirement, and e-tran's ZEB study with Willdan.

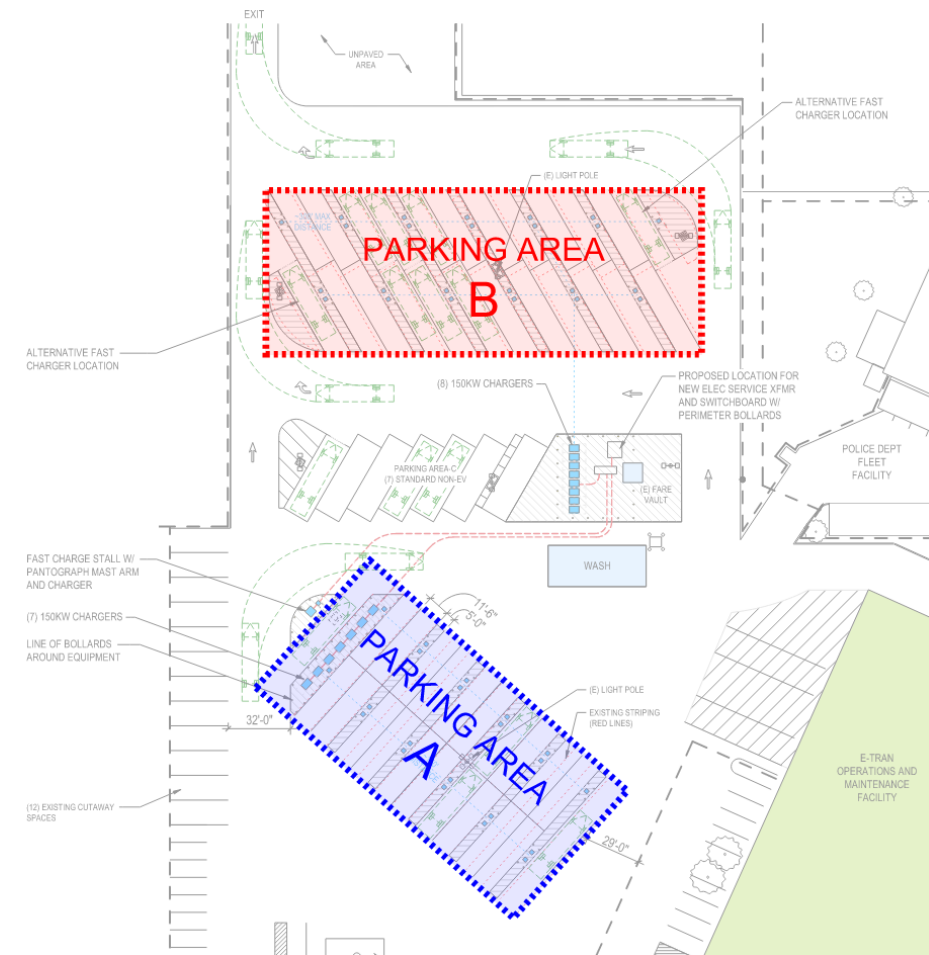
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Table 7: 2021-2040 Fleet Forecast

FLEET FORECAST		21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
CNG 40-ft Bus	New	6				2	1	1	1												
	Retire	-6		-4		-2	-2	-2	-2	-2	-2	-2	-3	-4	-4	-2	-3	-2	-8	-2	-2
<b>Total CNG</b>		46	46	42	42	42	41	40	39	37	35	33	30	26	22	20	17	15	7	5	3
BEB 40-ft Bus (450 kWh)	New			4			1	1	1	2	2	2	3	4	4	2	3	2	8	2	6
	Retire																				-4
<b>Total BEBs</b>				4	4	4	5	6	7	9	11	13	16	20	24	26	29	31	39	41	43
Totals 40 ft Bus	TOTAL	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46
Actual ZEB Proportion (of purchased)	%ZEB	0%	100%	NA	0%	50%				100%											
ICT Requirement	%ZEB	0%					25%				100%										

## 6.1 PHASING OF CHARGING EQUIPMENT

Given the established phasing strategy of vehicles into e-tran’s facility, the charging equipment should be set in place prior to the arrival of each BEB procurement. As described in Section 5.3, 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 16 for schematic of the recommended phasing of BEB deployment at e-tran’s facility), will depend on the manufacturer selection.



**Figure 16: Parking area diagram phasing**

Table 8 describes the charging equipment requirements for a generic charger manufacturer with a power capacity of at least 150 kW. It is assumed that the years associated with the phases in the table below are to extend to the end of the calendar year. This schedule was also designed with the Willdan study in mind.

**Table 8: Charger equipment requirements per year**

	Phase 1 2023	Phase 1-a 2030	Phase 2 2035	Phase 2-a 2040
Accumulative BEB (including spares)	4	11	29	41
Facility Parking Area (refer to Figure 16)	A		B	
Total Power Modules to be installed (150 kW)	2	4	3	4
Total Plug-in dispensers <sup>12</sup> to be installed	6	12	9	12
Fast Charger Pantograph (600 kW)	NA	NA	NA	1
Cumulative modules at facility	2	6	9	13
Cumulative dispensers at facility	6	18	27	39

## 7.0 FACILITY AND INFRASTRUCTURE MODIFICATIONS<sup>1314</sup>

### 7.1 MAINTENANCE FACILITY INFRASTRUCTURE CONSIDERATIONS

This section outlines the proposed facility modifications for BEB implementation to e-tran’s bus operations and maintenance facility in Elk Grove. Two master plan options have been developed to propose 1) ground-mounted dispensers and 2) overhead-mounted dispensers. Fortunately, the facility has ample space opportunity for ground-mounted dispensers, but this type of installation will reduce parking and yard flexibility due to the considerable amount of physical infrastructure on the ground plane. The key advantage of the overhead-mounted solution is that it frees the ground plane of the majority of the obstacles created with a ground-mounted approach, but still creates barriers due to the columns needed to support the overhead structures. The overhead approach also presents an ideal opportunity to implement photovoltaic systems to generate electricity. These solar systems are further discussed in Section 8.0. Unfortunately, the overhead approach will have higher upfront costs due to the additional costs associated with the actual canopy structure. This cost could potentially be offset over time with the implementation of PV systems, but that is also dependent of the energy rates through the life of the facility which are also discussed in Section 8.0 of this report.

<sup>12</sup> In order to have a one-to-one plug-in dispenser to active-bus ratio, we assumed that three plug-in dispensers can be connected to one power module. It’s assumed that spare vehicles can charge during morning hours.

<sup>13</sup> This section provides information relevant for Section E of the ICT Rollout Plan

<sup>14</sup> Please see Appendix C for full site plans

The existing service cycle can be maintained and is not required to be changed for BEB implementation, but potential optimization options are also presented in the master plan concepts. Since the liquid fueling system used by the agency is off-site, there are no considerations for phasing out this equipment and phasing can be relatively simple to install the new infrastructure required for BEB's.

Note that since the facility will require new electrical service connections from SMUD, the utility may 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 SMUD to determine if the local power distribution system has the excess capacity to serve e-tran'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.

### 7.1.1 Proposed Maintenance Facility Modifications – Option 1: Ground Dispensers

The following summarizes the proposed improvements for Option 1, which only considers ground-mounted dispensers (Figure 17):

- A new 2,000 kVA transformer and 4,000 A switchboard to provide adequate additional power to the facility, along with associated equipment pads and bollards.
- A new 825 kW generator with 1,000 gallons of onsite fuel storage (diesel or LPG) in order to support 50% bus service. The quantity of fuel maintained on site will depend on the anticipated utility outage duration and the availability of fuel deliveries. Alternatively, the generator could be fueled using pipeline natural gas that is available in the street in front of the facility.<sup>15</sup>
- One fast charger with at least 600 kW power rate capacity and a pantograph arm for fast charging onsite. Inverted pantograph mounted to mast arm structure provided by charger manufacturer.
  - Equipment pads and associated bollard protection around charger.
  - Power main feeder and sub feeders.
  - Communication system panel / distribution cabinet and conduits to the pantograph.
- A minimum of 13 150 kW vehicle chargers with a 1:3 charger to dispenser ratio to serve a maximum of 39 active (in revenue service) BEBs.
  - 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.
- Pavement replacement/repair for trenching associated with electrical distribution throughout the bus yard.

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<sup>15</sup> Details on the generator size calculations are described in Section 8.2

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- New pavement markings/stripping as required for parking reconfigurations.
- No proposed modifications to the buildings.
- No changes to existing site lighting poles.

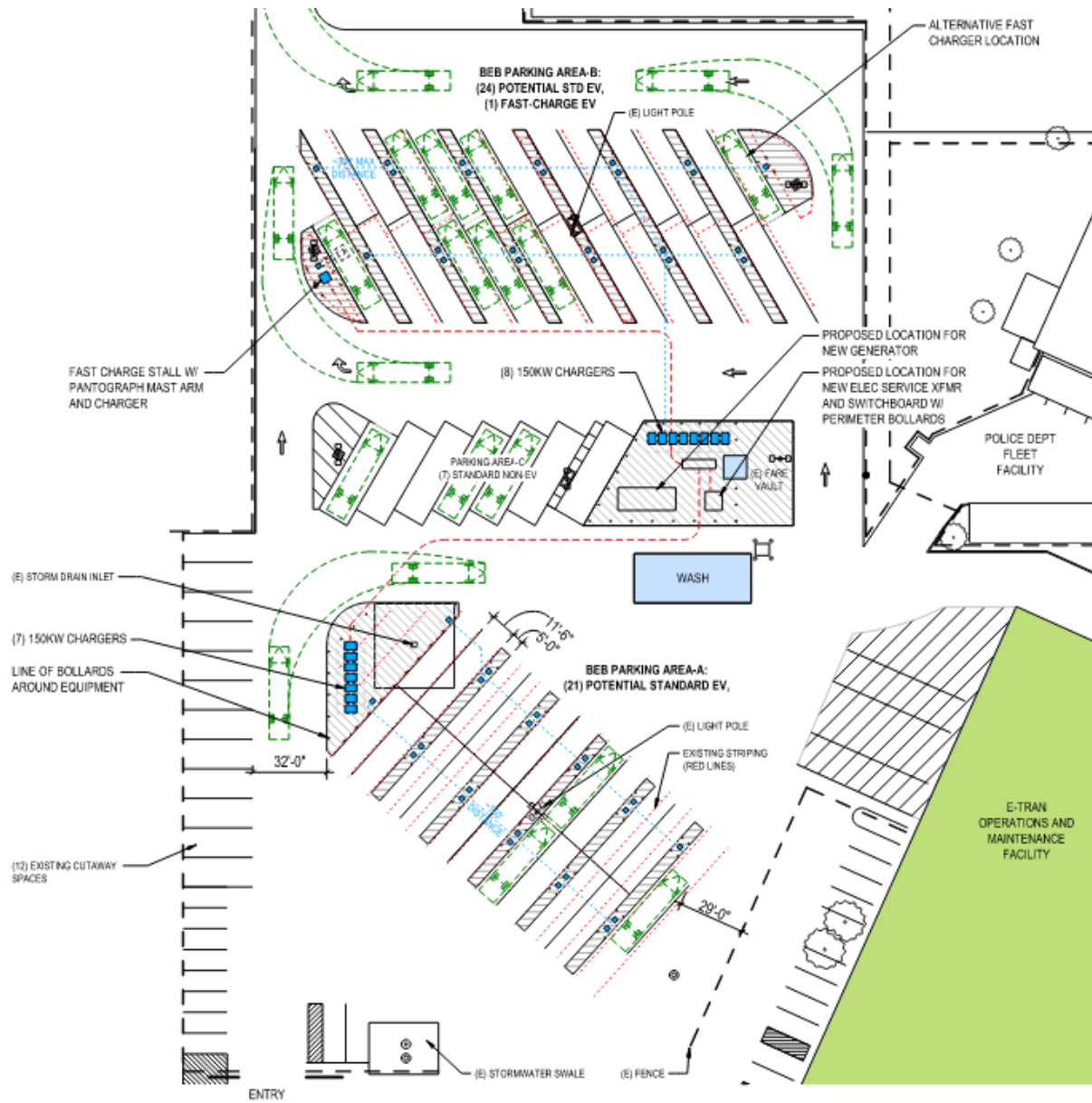


Figure 17: Option 1 Master Plan

### 7.1.2 Proposed Maintenance Facility Modifications – Option 2: Overhead Dispensers

The following summarizes the proposed improvements for Option 2 that considers overhead plug-in dispensers using a canopy structure over the bus parking areas (Figure 18):

- Canopy structure, complete with eight posts & foundations for Area A
- Canopy structure, complete with twelve posts & foundations for Area B
- A new 2,000 kVA transformer and 4,000 A switchboard to provide adequate additional power to the facility, along with associated equipment pads and bollards.
- A new 825 kW generator with 1,000 gallons of onsite fuel storage (diesel or LPG) in order to support 50% bus service. The quantity of fuel maintained on site will depend on the anticipated utility outage duration and the availability of fuel deliveries. Alternatively, the generator could be fueled using pipeline natural gas that is available in the street in front of the facility.
- One fast charger with at least 600 kW power rate capacity and a pantograph arm for fast charging onsite. Mounted to underside of canopy structure.
  - Equipment pads and associated bollard protection around charger.
  - Power main feeder and sub feeders.
  - Communication system panel / distribution cabinet and conduits to the pantograph.
- A minimum of 13 150 kW vehicle chargers with a 1:3 charger to dispenser ratio to serve a maximum of 39 active (in revenue service) BEBs.
  - 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.
- Pavement replacement/repair for trenching associated with electrical distribution throughout the bus yard.
- New pavement markings/stripping as required for parking reconfigurations.
- New lighting mounted to the underside of the canopy structures.
- No proposed modifications to the buildings.
- May potentially require minor modifications to the existing stormwater inlet surrounded by permeable pavement on the west side of parking area A.



Figure 18: Option 2 Master Plan

Full size master plan drawings have been included as appendices.

### 7.1.3 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 SMUD'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 e-tran facility is an industrial area with nearby transmission lines, we anticipate that the utility system upgrades would not be significant, if needed at all. If upgrades

to the SMUD system are necessary, the cost may be covered by the utility based on the additional electricity that they will be selling to e-tran for BEB charging. The extent and timing of the system upgrades will determine the net cost to the agency.

Funding is limited in each program and there a number of criteria in each program that may not meet e-tran's operational needs. As an example, to qualify for the DC Fast Charger rebate (up to \$70,000) the charger must be publicly available and not behind a fence. Should funding programs not be available, e-tran would be expected to pay for the required utility upgrades either through a direct fee or through a monthly facility services charge. Typically, SMUD 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.

### 7.1.4 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 e-tran'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 e-tran's local network, at least at some level.

### 7.1.5 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. 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 e-tran'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.

With the potential use of canopies over bus parking, particularly with photovoltaic panels (PVs), an NFPA 13 compliant automatic sprinkler system will be required because the canopy has a 'use' underneath it as defined by the California Fire Code. However, if the structure is built without PVs the

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need for fire protection system can be phased in at a later date along with the installation of the PVs. It is recommended that e-tran consider the installation at the time of any other site disturbing work to minimize disruption to operations and to take advantage of trenching work being performed for electrical work. The supply piping could simply be stubbed in at a convenient location to serve the potential future areas with canopy coverage.

Furthermore, all modifications to the facility should be reviewed with the local AHJ's, in particular the fire marshal. Fire truck access to the site and hydrant access will need to be reviewed and approved by the pertinent AHJ's 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 may trigger additional FP system upgrades to the facilities.

### 7.1.6 Fall Protection and Safety Infrastructure Considerations

Fall protection systems are recommended for any vehicle maintenance and inspection shop but considering that e-tran 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, e-tran should consider additional fall protection systems throughout the shop.

## 7.2 FACILITY AND INFRASTRUCTURE MODIFICATIONS CONCLUSION

Table 9 summarizes the minimum facility and infrastructure requirements for ZEB implementation at the agency's operations and maintenance facility. Table 10 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 very feasible relative to the size of the facility and SMUD's utility rates, **Option 1 for ground-mounted dispensers is the recommended approach for e-tran**. A hybrid approach may ultimately be appropriate for e-tran as charging technology changes or if electrical utility rates change in the future.

**Table 9: Infrastructure modification summary**

Division Name	Address	Main Function(s)	Type(s) of Infrastructure	Service Capacity	Needs Upgrade (Yes/No)
Elk Grove Corporation Yard	10250 Iron Rock Way, Elk Grove, CA	Operations, Maintenance, Training  (also houses Elk Grove Police and Public Works	New BEB charging equipment, additional electrical utility service and	46 - 40' buses	Yes

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Division Name	Address	Main Function(s)	Type(s) of Infrastructure	Service Capacity	Needs Upgrade (Yes/No)
		Department fleet and functions)	associated site improvements.		

**Table 10: Infrastructure modification detailed outlook**

Year	On-site construction work	Equipment to be installed	Accumulative Equipment required to be online
2022	Underground work starts for conduit installation in Area-A (please refer to site plans) or work to install canopies in Area-A		
2023		<b>Area-A</b> 2 power cabinet 6 dispensers	<b>Area-A</b> 2 power cabinet 6 dispensers  <b>Area-B</b> none
2030		<b>Area-A</b> 4 power cabinet 12 dispensers	<b>Area-A</b> 6 power cabinets 18 dispensers  <b>Area-B</b> none
2031	Underground work starts for conduit installation in Area-B or work to install canopies in Area-B		
2035		<b>Area-B</b> 9 power cabinets 9 dispensers	<b>Area-A</b> 6 power cabinets 18 dispensers  <b>Area-B</b> 3 power cabinets 9 dispensers
2040		<b>Area-B</b> 4 power cabinets 12 dispensers  <b>Area-A or Area-B</b> 1 Fast pantograph charger (600 kW)	<b>Area-A</b> 6 power cabinets 18 dispensers  <b>Area-B</b> 7 power cabinets 21 dispensers  <b>Area-A or Area-B</b> 1 Fast pantograph charger (600 kW)

## 8.0 RESILIENCY

Planning for redundancy and resiliency is necessary not only to support operations during emergencies or other disruptions, but also to ensure that if e-tran's yard loses power, BEBs can still be operated. This is particularly important when considering a transition to electricity-powered buses.

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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 harvest 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. Based on the route modeling and bus simulations, Stantec developed energy and power estimates for 50% of the revenue service operated by e-tran, focused on protecting commuter service primarily, followed by local service (Table 11)<sup>16</sup>. One line of reasoning behind this prioritization is to ensure that commuters are not stranded in Sacramento during a possible emergency and that BEBs are able to charge sufficiently to complete the trips between Elk Grove and Sacramento (~30 miles round trip).

**Table 11: Estimated energy required for 50% of revenue service**

	Generator Capacity (kW)	Charging Energy (kWh/day)
<b>Service at 50% prioritizing commuter services</b>	825	7,000

The following sections:

- Describe the planning for emergencies (i.e., assuming that during an emergency, e-tran would operate 50% of its service) and we describe the required size of the backup diesel-fired generator.
- Describe the potential for solar energy generation based on solar canopy structured installed at the various divisions. Implicit in these assumptions is that stationary batteries would be deployed as well to capture the energy for later use.

<sup>16</sup> For modeling purposes, Stantec analyzed vehicles scheduled for commuter service on Feb. 25, 2020 as a ‘typical day’ of revenue service. Vehicle IDs are: 559, 561, 564, 568, 771, 772, 773, 778, 790, 791, 793, 794, 822, 831, 833, 835, 837, 846, 847, and 849. These 20 vehicles operate a total of 2,100 miles on Feb. 25, 2020. Stantec calculated the energy required to fully charge these vehicles, assuming no midday charging or charging between blocks. Additionally, the sizing of the fuel tank for the generator assumes two charging cycles with a maximum power output of 750 kW.

## 8.1 BACKUP PLANNING

Another strategy transit agencies need to consider is the percentage of the BEB fleet that will be deployed 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 19 shows an example of a mobile generator at 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 19: Backup mobile diesel generator at LA Metro Division 13, Los Angeles, CA.**

Based on Stantec’s estimates, Table 12 illustrates the size of the generator needed to maintain 50% of service for one average weekday of revenue service. 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 each charging site. If e-tran 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 depend on environmental regulations and local policies.

**Table 12: Estimated fuel consumption for back-up generation.**

	Generator Capacity (kW)	Charging Energy (kWh/day)	Fuel consumption (gal/day)	
			Diesel	LPG
Elk Grove Corporation Yard	825	7,000	504	650

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

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

For the purposes of the financial analysis, Stantec assumed the use of one 825 kW generator with storage capacity for 1,000 gallons of diesel in order to serve two revenue days at 50% capacity. However, we are also cognizant that the e-tran bus yard shares its footprint and electrical utility with the Elk Grove Police Department fleet. Giving that the Police Department owns a portable generator that’s used to operate minimal lighting within their facility, the load from the Police Department was excluded from the 825 kW generator suggested for the transit fleet.

Adequate space is available on-site for either a new permanent generator or accommodations for a mobile generator. The area just north of the wash bay is shown on the master plan options as a central location for the new electrical service equipment as well as a generator. 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 Air Quality Management District (AQMD) and will have annual limitations on the durations it is allowed to be run. However, a temporary mobile generator that has been certified by the California Air Resources Board (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 e-tran should consider close coordination with both the Sacramento Metropolitan AQMD and CARB in part of any plan to install a generator at the facility.

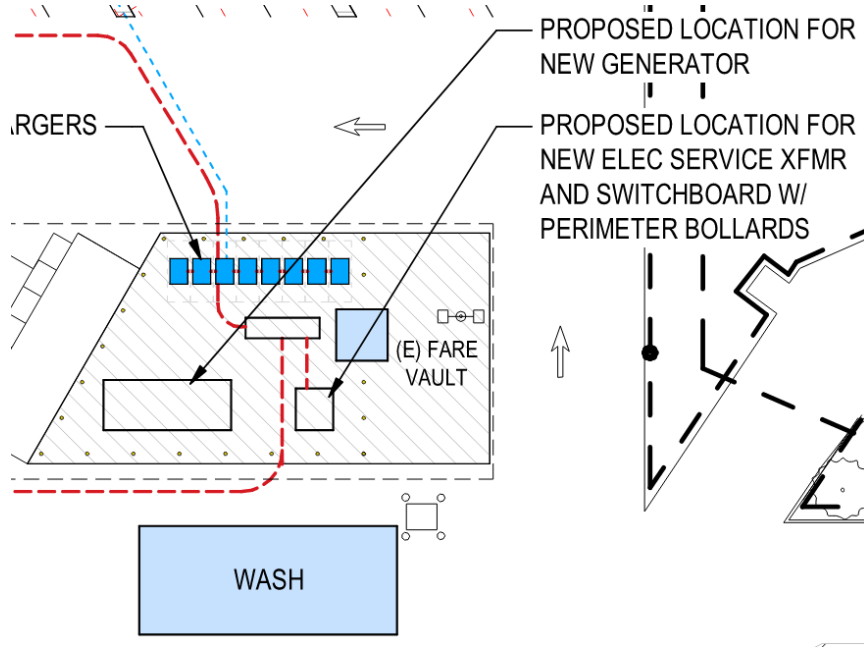


Figure 20: Proposed generator location

## 8.2 SOLAR PV AND ENERGY STORAGE

Solar studies were performed for the e-tran facility to understand the potential energy generation if solar PV panels were installed. Two configurations of solar PV were analyzed<sup>17</sup>:

1. *Option 1*—Panels only on the rooftop of existing buildings (Figure 21)<sup>18</sup>.
2. *Option 2*—Panels on the rooftop in addition to two canopy structures over the bus parking (Figure 22).

<sup>17</sup> The full analysis is provided in Appendix E. Daily and yearly meter data/costs are provided in a separate document and can be made available upon request.

<sup>18</sup> Prior to finalizing the location of the solar panels, structural load calculations need to be studied to determine if the building structure can support a solar array in the future.

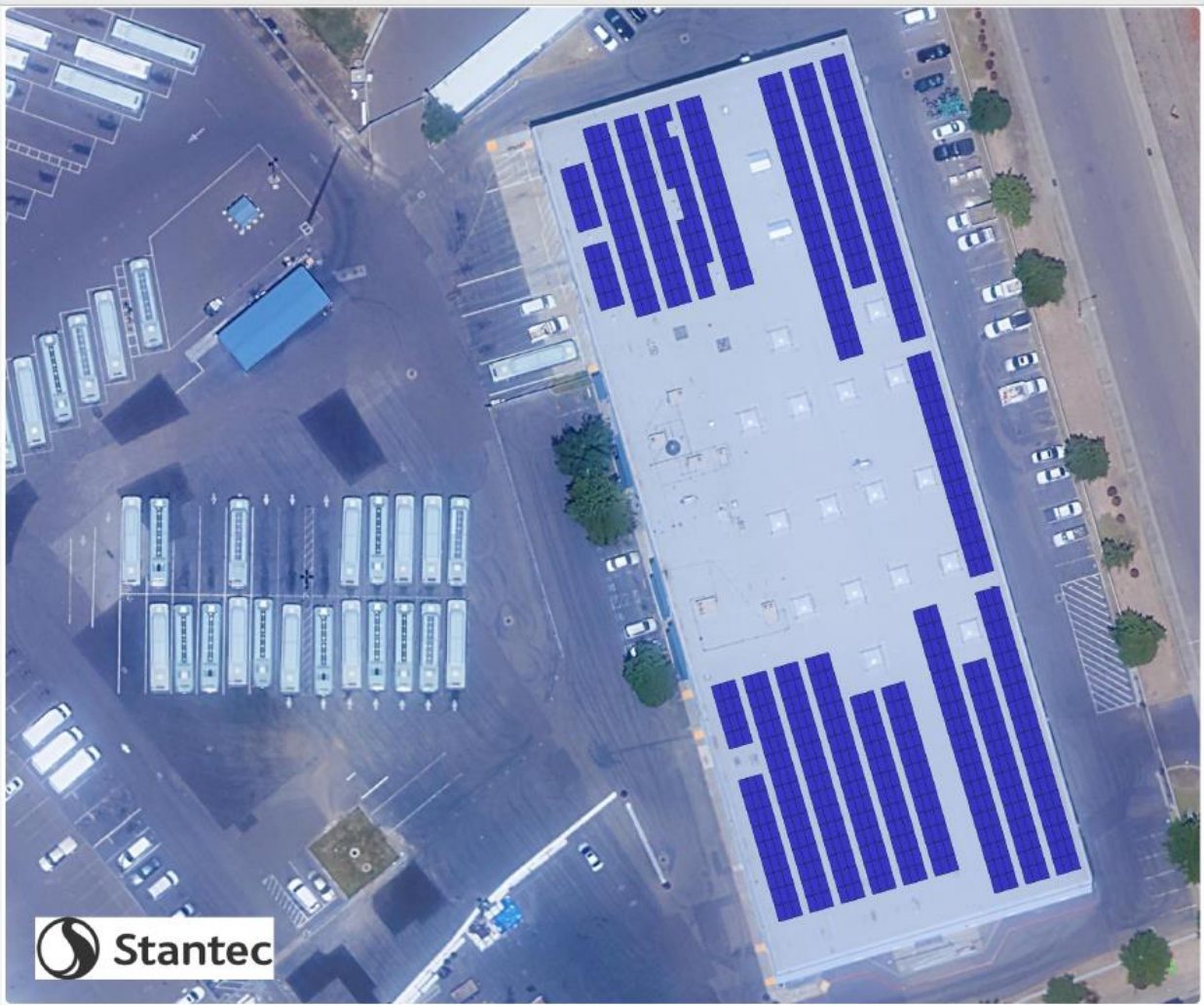
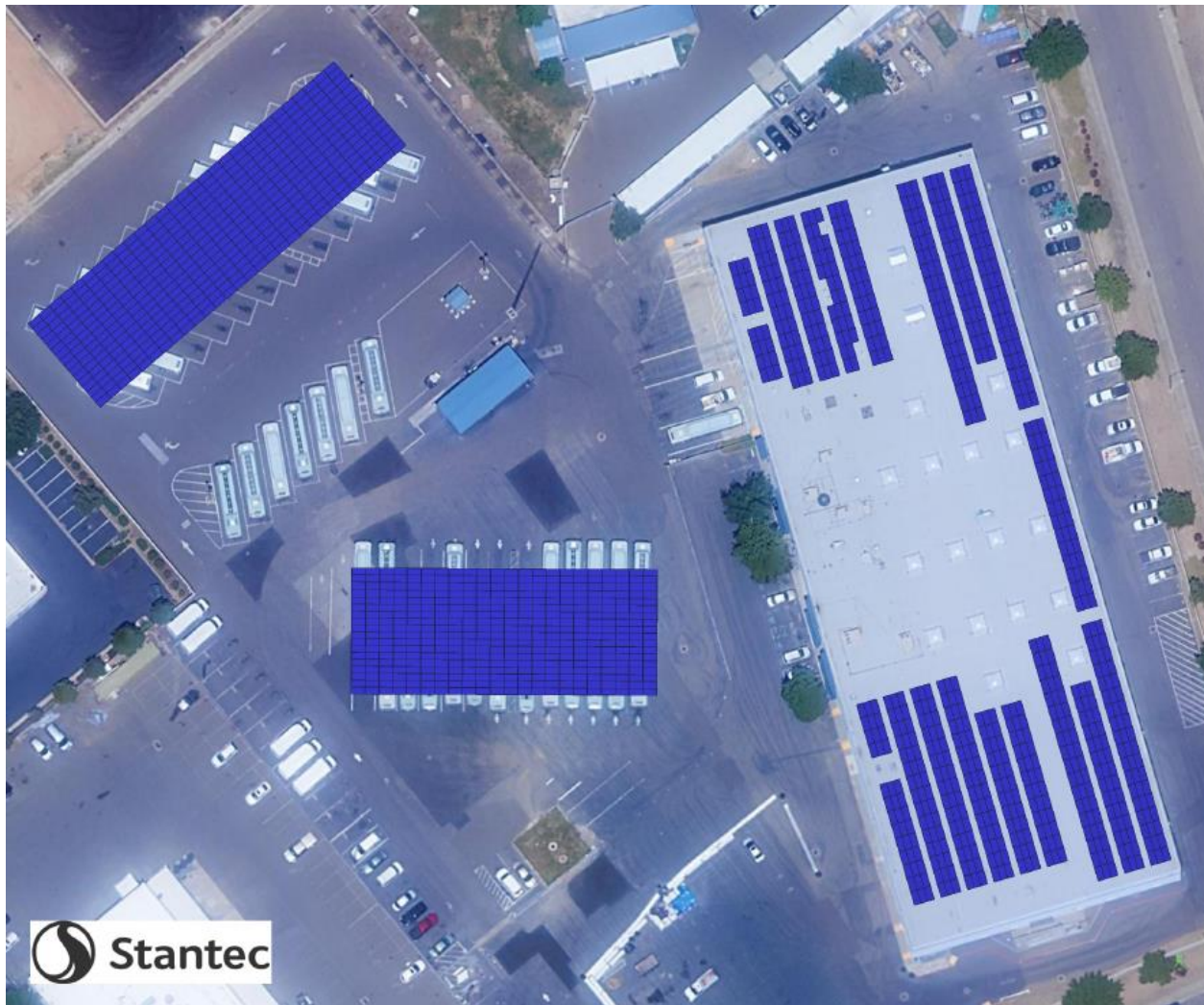


Figure 21: Option 1 for Solar Panels Configuration



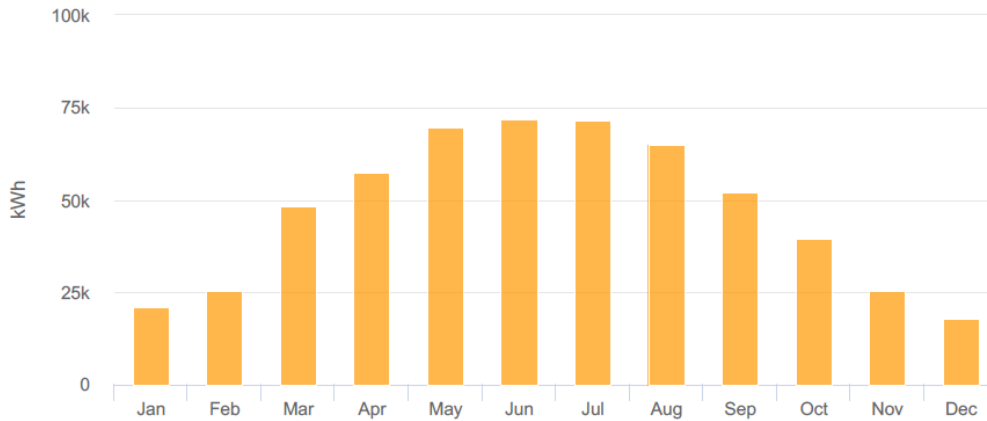
**Figure 22: Option 2 for Solar Panels Configuration**

The canopies serve the dual purpose of supporting the charging dispensers and also generating electricity by housing the PV panels, plus the added benefit of providing some weather protection for the buses. Table 13 presents a summary of the sizes and performance specifications for the solar PV panels for each option, as well as the estimated generation that can be harvest annually.

**Table 13: Solar PV specifications and generation capacity for each facility configuration**

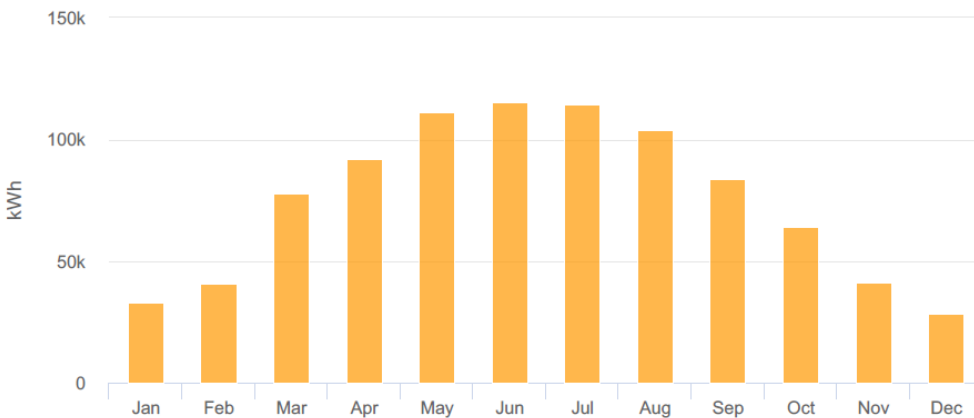
Option	Solar PV Size (kW DC)	Inverter Size (kW AC)	Average DC to AC Ratio	Estimated Generation - year 1 (MWh)	Performance Ratio
Option 1	405.5	330.0	1.23	564.1	74.0%
Option 2	869.9	730.0	1.19	1,306	78.4%

The projected annual production is estimated to be 564 MWh using a direct current (DC) module of 405.5 kW for Option 1. The energy that can be harvested using PV panels under Option 1 was calculated for each month and is presented in Figure 23.



**Figure 23: Option 1 – Monthly PV Energy Harvested with Solar Panels**

The additional area covered by solar panels in Option 2 allows for a higher annual production of 1,306 MWh (x2.4 more than option 1), using a DC module of 870 kW (Table 13). Figure 24 shows the monthly energy that can be harvested with Option 2.



**Figure 24: Option 2 – Monthly PV Energy Harvested with Solar Panels**

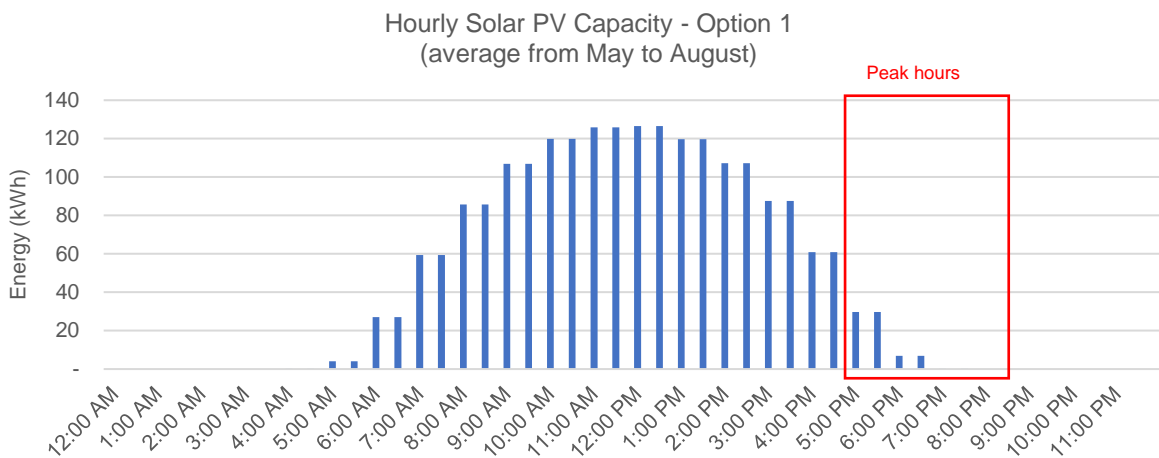
The annual energy that can be harvested with PV panels accounts for 10% of the total energy demand at the facility for Option 1 and 24% for Option 2. However, because the hours of solar generation do not match the hours of charging demand, the solar energy cannot be utilized in its totality unless a battery storage system is in place.

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 of high electricity demand when the buses need to receive 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 demand (and associated cost) can be reduced. The key to sizing the BESS is to determine the energy that can be displaced from the peak-hours in the time of use (TOU) utility’s rate, the most expensive cost per kWh. The following subsections present a more detailed assessment for each option of the solar configurations, and a brief overview of BESS.

### 8.2.1 Option 1 for Solar PV Configuration

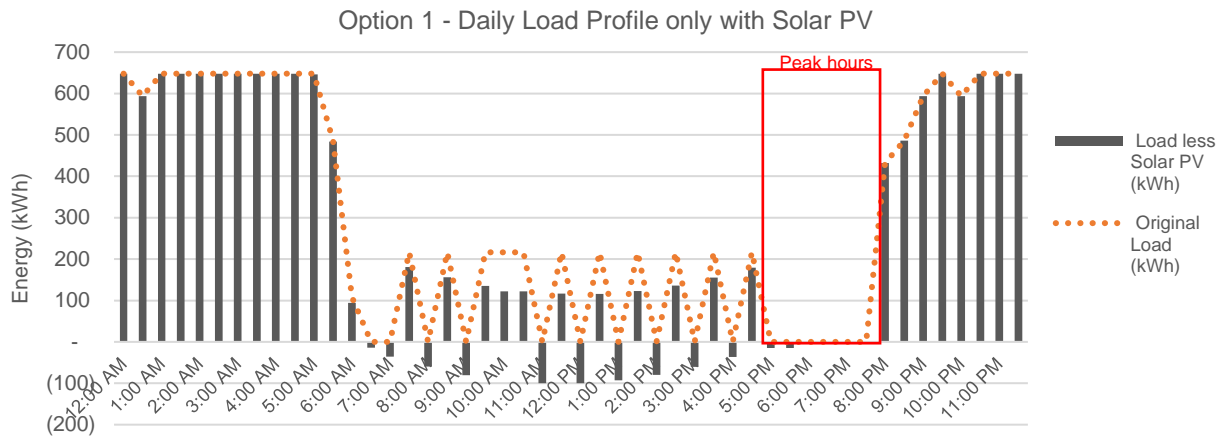
Option 1 for the solar PV Configuration considers the use of panels only on the rooftop of the existing building. The output of the solar assessment generated over 17,500 data points which were aggregated to determine the average hourly production possible at the facility. The average hourly production from solar PV for Option 1 is presented in Figure 25.



**Figure 25: Hourly PV Capacity for Option 1**

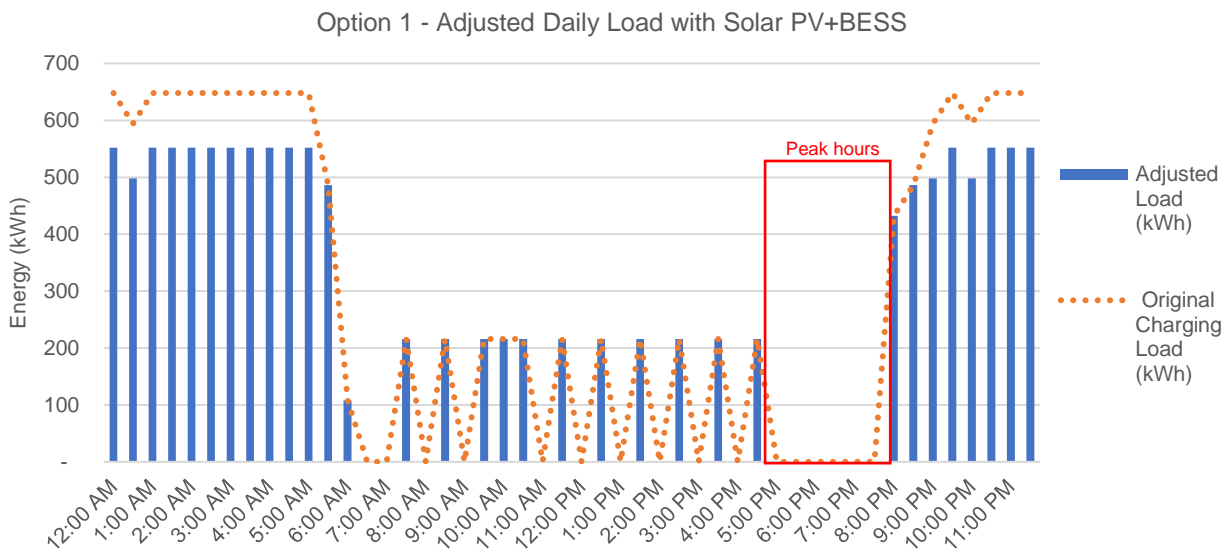
On average during summer months, the solar panels can accumulate as much as 1.5 MWh per day (the sum of the bars in the graph in Figure 25). Therefore, a BESS could be installed to store excess PV during off-peak hours to then discharge the battery during peak or mid-peak hours to avoid the higher electricity rate of \$0.3105 or \$0.1765 per kWh, respectively.

If a BESS is not installed at the e-tran facility, then 45% of solar PV would have to be curtailed (wasted) if the grid is not able to purchase it back. Furthermore, without a BESS all the electricity used to charge the buses at nighttime will originate from the local grid. Figure 26 shows the adjusted load when using only solar PV, without a BESS. The dotted orange line marks the original load, and the gray bars mark the new load the grid has to provide after using the solar PV energy. Note that the solar PV is only able to reduce the load between 7:30 a.m. and 5 p.m., and the gray bars with negative values represent the energy from the solar PV that would have to be wasted.



**Figure 26: Option 1 Daily Load Profile only with Solar PV.**

Given that the availability of solar PV does not align with the energy requirements to charge the vehicles between 7 a.m. and 5 p.m., a more efficient strategy would be to utilize a BESS to reduce the higher power peaks. Figure 27 shows the adjusted daily energy profile for the Option 1 when using a BESS to reduce the peak demand. The BESS would displace 11% of the energy that has to be provided by the grid. Additionally, the peak power demand without the BESS is estimated at 1.98 MW, and with a BESS in place, the power peak drops to 1.81 MW.



**Figure 27: Option 1 Daily Load with Solar PV + BESS**

Details on the charge and discharge hours of the battery, as well as how much solar is used directly to charge the battery are presented in Table 14. The charging strategy is to store all the of solar PV into the battery and then to use it to reduce the peak loads during the day.

Table 14: Option 1 Power Assessment Data for an Adjusted Load Profile

	Hour	i		ii		L = i-ii
		Original Charging Load (kWh)	Solar PV Capacity (kWh)	Solar PV to charge BESS (kWh)	BESS Discharge (kWh)	Adjusted Load (kWh)
Off-Peak Summer Rate \$0.1277/kWh	12:00 AM	648	-	-	96	552
	12:30 AM	594	-	-	-	498
	1:00 AM	648	-	-	96	552
	1:30 AM	648	-	-	96	552
	2:00 AM	648	-	-	96	552
	2:30 AM	648	-	-	96	552
	3:00 AM	648	-	-	96	552
	3:30 AM	648	-	-	96	552
	4:00 AM	648	0	0	96	552
	4:30 AM	648	0	0	96	552
	5:00 AM	648	4	4	96	552
	5:30 AM	486	4	4	-	486
	6:00 AM	108	27	27	-	108
	6:30 AM	-	27	27	-	-
	7:00 AM	-	59	59	-	-
	7:30 AM	216	59	59	-	216
	8:00 AM	-	86	86	-	-
	8:30 AM	216	86	86	-	216
9:00 AM	-	107	107	-	-	
9:30 AM	216	107	107	-	216	
10:00 AM	216	120	120	-	216	
10:30 AM	216	120	120	-	216	
11:00 AM	-	126	126	-	-	
11:30 AM	216	126	126	-	216	
Mid-Peak Summer Rate \$0.1765/kWh	12:00 PM	-	126	126	-	-
	12:30 PM	216	126	126	-	216
	1:00 PM	-	120	120	-	-
	1:30 PM	216	120	120	-	216
	2:00 PM	-	107	107	-	-
	2:30 PM	216	107	107	-	216
	3:00 PM	-	88	88	-	-
	3:30 PM	216	88	88	-	216
	4:00 PM	-	61	61	-	-
4:30 PM	216	61	61	-	216	
Peak Summer Rate \$0.3105/kWh	5:00 PM	-	30	30	-	-
	5:30 PM	-	30	30	-	-
	6:00 PM	-	7	7	-	-
	6:30 PM	-	7	7	-	-
	7:00 PM	-	0	0	-	-
	7:30 PM	-	0	0	-	-
Mid-Peak Summer Rate \$0.1765/kWh	8:00 PM	432	-	-	-	432
	8:30 PM	486	-	-	-	486
	9:00 PM	594	-	-	-	498

Hour	i		Solar PV Capacity (kWh)	ii		L = i-ii
	Original Charging Load (kWh)	Solar PV Capacity (kWh)		Solar PV to charge BESS (kWh)	BESS Discharge (kWh)	Adjusted Load (kWh)
9:30 PM	648	-	-	96	552	
10:00 PM	594	-	-	-	498	
10:30 PM	648	-	-	96	552	
11:00 PM	648	-	-	96	552	
11:30 PM	648	-	-	96	552	

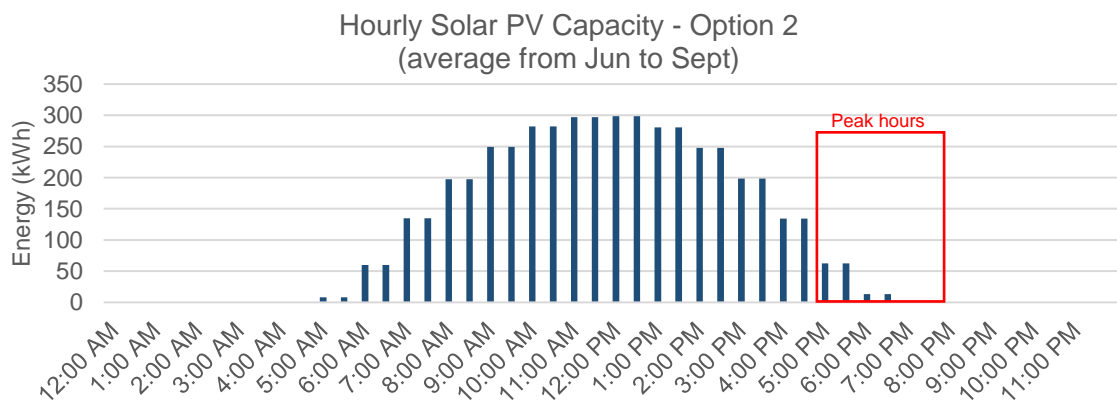
A preliminary bill of materials needed for an integrated solar PV-BESS for e-tran under Option 1 is presented in Table 15. Option 1 only considers solar PV panels on top of the building rooftops, a solar string inverter, and the battery storage system.

**Table 15: Bill of Material for Solar PV Option A + 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 200 kW / 2 MWh	200

### 8.2.2 Option 2 for Solar PV Configuration

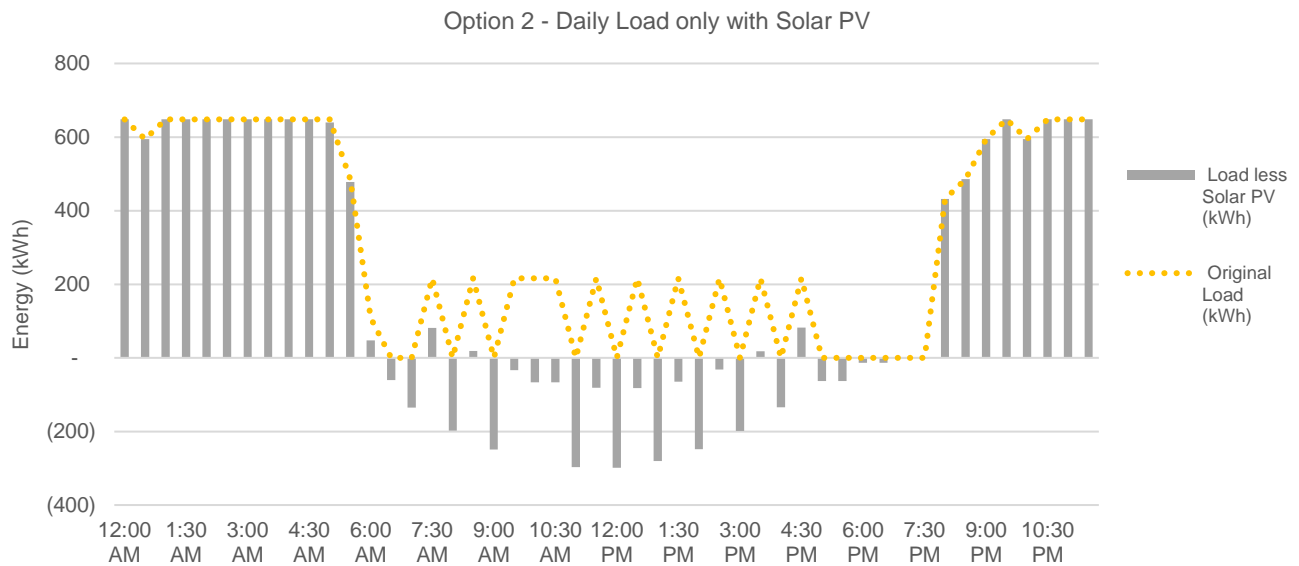
Option 2 for the solar PV configuration considers the use of panels on the rooftop of existing buildings in addition to panels using two canopies over the parking areas. The average hourly production from solar PV for Option 2 is presented in Figure 28.



**Figure 28: Hourly PV Capacity for Option 2**

On average during summer months, the solar panels can accumulate as much as 5 MWh per day (the sum of the bars in the graph in Figure 28), around 3.5 MWh more than Option 1.

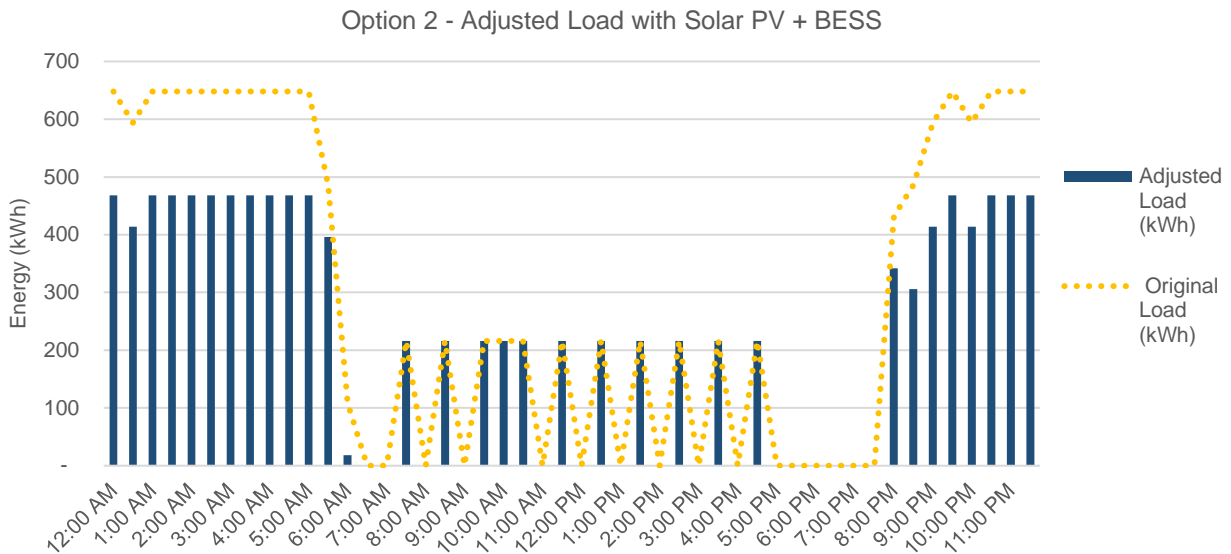
If a BESS is not put in place at the e-tran facility, then 52% of solar PV would have to be curtailed (wasted) if the grid is not able to purchase it back. Furthermore, without a BESS all the electricity used to charge the buses overnight will originate from the local grid. Figure 29 shows the adjusted load when using only the solar PV Option 2. The dotted yellow line marks the original load, while the gray bars mark the new load the grid has to provide after using the solar PV energy. Note that the solar PV is only able to reduce the load between 7:30 a.m. and 5 p.m., and the gray bars with negative values represent the energy from the solar PV that would have to be wasted.



**Figure 29: Option 2 Daily Load Profile only with Solar PV.**

The percentage of solar that has to be curtailed is higher for Option 2 than for Option 1. However, the total energy used by the grid under Option 2 is also reduced, representing higher economic benefits than when deploying Option 1. Without considering the capital cost of the solar systems, Option 2 would create \$76,000 in yearly savings by displacing the energy purchased from the grid during the day; Option 1 would only create \$38,000 in savings per year. Furthermore, if the excess solar PV energy can be exported back to grid, the revenue would be even greater for Option 2.

Given that the availability of Solar PV does not align with the energy requirements to charge the vehicles between 7 a.m. and 5 p.m., a more efficient strategy would be to utilize a BESS to reduce the higher power peaks. Figure 30 shows the adjusted daily load profile for Option 2 when using a BESS to reduce the peak demand. The BESS would displace 24% of the energy that has to be provided by the grid. Additionally, the peak power demand without the BESS is estimated at 1.98 MW, and with a BESS in place, the power peak drops to 1.62 MW



**Figure 30: Option 2 Daily Load with Solar PV + BESS**

Details on the charge and discharge hours of the battery, as well as how much solar is used directly to charge the battery are presented on Table 16. The charging strategy is to store all the of solar PV and then used it to reduce the peak loads during the day.

**Table 16: Option 2 Power Assessment Data for Adjusted Load Profile**

	Hour	i		ii		L = i-ii
		Original Charging Load (kWh)	Solar PV Capacity (kWh)	Solar PV to charge BESS (kWh)	BESS Discharge (kWh)	Adjusted Load (kWh)
Off-Peak Summer Rate \$0.1277/kWh	12:00 AM	648	-	-	180	468
	12:30 AM	594	-	-	180	414
	1:00 AM	648	-	-	180	468
	1:30 AM	648	-	-	180	468
	2:00 AM	648	-	-	180	468
	2:30 AM	648	-	-	180	468
	3:00 AM	648	-	-	180	468
	3:30 AM	648	-	-	180	468
	4:00 AM	648	-	-	180	468
	4:30 AM	648	-	-	180	468
	5:00 AM	648	8	8	180	468
	5:30 AM	486	8	8	90	396
	6:00 AM	108	60	60	90	18
	6:30 AM	-	60	60	-	-
	7:00 AM	-	135	135	-	-
	7:30 AM	216	135	135	-	216
	8:00 AM	-	198	198	-	-
8:30 AM	216	198	198	-	216	
9:00 AM	-	249	249	-	-	

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	Hour	i			ii		L = i-ii
		Original Charging Load (kWh)	Solar PV Capacity (kWh)		Solar PV to charge BESS (kWh)	BESS Discharge (kWh)	Adjusted Load (kWh)
	9:30 AM	216	249		249	-	216
	10:00 AM	216	282		282	-	216
	10:30 AM	216	282		282	-	216
	11:00 AM	-	297		297	-	-
	11:30 AM	216	297		297	-	216
Mid-Peak Summer Rate \$0.1765/kWh	12:00 PM	-	298		298	-	-
	12:30 PM	216	298		298	-	216
	1:00 PM	-	281		281	-	-
	1:30 PM	216	281		281	-	216
	2:00 PM	-	248		248	-	-
	2:30 PM	216	248		248	-	216
	3:00 PM	-	198		198	-	-
	3:30 PM	216	198		198	-	216
	4:00 PM	-	134		134	-	-
	4:30 PM	216	134		134	-	216
Peak Summer Rate \$0.3105/kWh	5:00 PM	-	63		63	-	-
	5:30 PM	-	63		63	-	-
	6:00 PM	-	13		13	-	-
	6:30 PM	-	13		13	-	-
	7:00 PM	-	-		-	-	-
	7:30 PM	-	-		-	-	-
Mid-Peak Summer Rate \$0.1765/kWh	8:00 PM	432	-		-	90	342
	8:30 PM	486	-		-	180	306
	9:00 PM	594	-		-	180	414
	9:30 PM	648	-		-	180	468
	10:00 PM	594	-		-	180	414
	10:30 PM	648	-		-	180	468
	11:00 PM	648	-		-	180	468
	11:30 PM	648	-		-	180	468

A preliminary bill of materials for an integrated solar PV-BESS for e-tran under Option B is presented in Table 17. Option B considers solar PV panels on top of the building rooftops in addition to panels on top of a canopy over parking stalls, a solar string inverter, and the battery storage system.

**Table 17: Bill of Material for Solar PV Option B + BESS**

Description	kW
Solar PV Fixed Tilt for building frames and modules (DC)	405.5
Solar PV canopy frames and modules (DC)	464.4
Solar string inverter (AC)	730.0
Battery Energy Storage System 350 kW / 5 MWh	350.0

Many of the larger bus charger OEMs like ABB and Siemens are exploring the pairing or integration of battery storage systems with their charging infrastructure. An Ontario, Canada company named eCamion focuses exclusively on storage systems for electric vehicle charge buffering.

### 8.2.3 Economic Assessment of a Solar PV Strategy

To determine whether installing a solar PV system together with a BESS makes financial sense, an appraisal of several uncertain components, such as the future of tax credits, commercial rates for electric fleets, and the actual solar energy that can be harvest 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 present financial opportunities that would require further and more detailed analysis.

The basis of this initial assessment is confirming that the price per kilowatt hour resulting from using solar PV panels and BESS could be lower than the electricity rate SMUD will have in place for Electric Vehicles presented in Table 18<sup>19</sup>.

**Table 18: SMUD Electric Vehicle Rate**

Summer - Weekday		
Charge Type	Rate	TOU Period
Off-Peak	\$0.1277 /kWh	12:00 am to 12:00 pm
Mid-Peak	\$0.1765 /kWh	12:00 pm to 5:00 pm 8:00 pm to 12:00 am
Peak	\$0.3105 /kWh	5:00 pm to 8:00 pm

The following were the primary assumptions for the cost calculations:

- 20 years for equipment lifespan of BESS and solar PV panels.
- Solar PV panels and BESS have a 0.7% power loss per year.
- Energy storage systems need to be installed at the same time as the solar PV system.
- BESS needs to be charged with 100% renewable energy, in this case, solely from the solar panels.
- A 6% annual escalation between 2022 and 2030 when it's assumed the panels will be installed.

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

- Sizing of the BESS was completed using the average productions of summer months.
- The cost comparison is based on summer rates from SMUD.
- Rates from SMUD still need to be approved by the utility commission and can change in the future, such as incorporating demand charges that would help justify the use of BESS.

<sup>19</sup> Assuming SMUD approves a similar Time-of-Day (5-8 p.m.) Rate for electric fleets.

**8.2.3.1 Levelized Electricity Cost with a Solar PV System**

The first step was calculating the levelized cost of electricity when only using the solar PV panels. The levelized cost is the total investment plus maintenance and operations cost over 20 years divided by the total amount of energy that can be harvested from the solar panels over that lifespan of the equipment.

Table 19 shows the cost assumptions for solar configuration, as well as the levelized cost of electricity. For example, for the Option 1, the cost of electricity when using the solar PV panels to charge BEBs would be \$0.31 per kWh. Similarly, for Option 2, electricity costs would be \$0.35 per kWh.

Overall, charging the BEBs with the electricity from the solar PV panels is more expensive than using the grid. However, this analysis is subject to change if 1) the electricity rate for using the grid for mid-peak hours ever increases above \$0.28 per kWh, 2) if SMUD implements demand chargers, or 3) if the utility can purchase excess solar PV energy back at a price of at least \$0.12 per kWh.

**Table 19: Summary of levelized electricity cost when using Solar PV.**

	Option 1	Option 2
Solar PV size (kW DC)	405	870
Capital Investment	\$1,014,000	\$2,315,000
Project usable MWh in 20yrs	5,793	11,703
Total Cost with escalation	\$1.8M	\$4.1M
<b>Levelized Cost \$/kWh</b>	<b>\$0.31</b>	<b>\$0.35</b>

**8.2.3.2 Levelized Electricity Cost with a Solar PV + BESS**

The second step of the preliminary cost assessment is investigating whether the electricity cost that results from having solar PV + BESS is cheaper than the rate structure from the utility. On average, e-tran would pay around \$0.12 per kWh if SMUD approves a similar Time-of-Day (5-8 p.m.) rate for large electric fleets. The levelized cost is the total investment plus maintenance and operations cost over 20 years divided by the total amount of energy that can be stored in the batteries over that lifespan of the equipment.

The levelized electricity cost of Solar PV and BESS for the two array options is presented in Table 20.

**Table 20: Summary of Levelized Electricity Cost when Using Solar PV Panels and BESS**

	Option 1	Option 2
Battery Size	200 kW / 2 MWh	350 kW / 5 MWh
Solar Size	562 kW	870 kW
Capital	\$0.26	\$0.25

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	Option 1	Option 2
O&M	\$0.0016	\$0.006
<b>Levelized Cost (\$/kWh)</b>	<b>\$0.26</b>	<b>\$0.25</b>

For Option 1, the levelized cost of electricity results in \$0.26 per kWh. The main component driving the cost is the capital investment. Since the primary purpose of a solar PV-BESS system is to reduce the peak demand at the facility, the \$0.26 per kWh cost is not cheaper than the tariff from the utilities during mid-peak of \$0.1765 per kWh nor during the off-peak tariff of \$0.1277 per kWh. Therefore, it is likely that installing a BESS to accompany the solar PV system under Option 1 will not create an economic benefit for e-tran, unless certain incentives can reduce the capital cost of the solar PV panels and the battery system.

The cost analysis for Option 2 estimated the renewable electricity cost at \$0.25 per kWh, making it slightly better option than option 1. However, the installation of a BESS still is not justified since the price per kWh is higher than the electricity cost when using the grid (average of \$12 per kWh).

Because having a BESS could shave peak power demand, the cost implications of having a smaller transformer could be further analyzed to determine whether power demand savings would justify the investment in batteries. Lastly, the battery system under the two options would be able to store between 10% and 24% of the daily energy requirement, which could create savings by reducing the investment needed in other types of backup power systems for emergency situations.

A final summary of the technical specifications for the solar PV and BESS for each option is shown in Table 21, as well as a brief description of the benefits of such systems with the levelized cost of renewable electricity. In conclusion, the implementation of solar PV-BESS systems under both options is not expected to generate savings under the assumed conditions for e-tran.

**Table 21: Summary of Solar PV + BESS benefits, specifications, and levelized cost**

	Solar PV Size (kW DC)	BESS Size	Benefits	SMUD average cost (\$/kWh)	Levelized cost with Solar PV <sup>20</sup> (\$/kWh)	Levelized cost with Solar PV + BESS (\$/kWh)
Option 1	405.6	200 kW / 2 MWh	<ul style="list-style-type: none"> <li>Reduces energy use during off-peak and mid-peak hours.</li> <li>Avoids curtailing 45% of solar PV.</li> <li>Reduces peak power demand</li> </ul>	\$0.12	\$0.31	\$0.26

<sup>20</sup> Assuming benefits from the ITC and depreciation tax benefits

	Solar PV Size (kW DC)	BESS Size	Benefits	SMUD average cost (\$/kWh)	Levelized cost with Solar PV <sup>20</sup> (\$/kWh)	Levelized cost with Solar PV + BESS (\$/kWh)
Option 2	870	350 kW / 5 MWh	<ul style="list-style-type: none"> <li>Reduces energy use during off-peak and mid-peak hours.</li> <li>Avoids curtailing 52% of solar PV.</li> <li>Reduces peak power demand</li> </ul>	\$0.12	\$0.35	\$0.25

### 8.2.4 Limitations of Solar PV Analysis and Configuration Recommendation

The proliferation of renewable energy sources feeding into SMUD’s grid have 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, SMUD, 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. SMUD is currently completing the rollout of a new rate schedule that will cover power exports going forward. It is referred to as NEM 2.0. 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 SMUD provides is generated from hydroelectric sources and other renewables, wholesale power costs are low. SMUD is projecting that the value of power exported to their grid under the NEM 2.0 rate will be in the range of \$0.02 per kWh to \$0.03 per kWh. Since SMUD does not yet have a specific rate tariff for charging buses, e-tran will be purchasing power under the SMUD GS-TOU1 rate or a rate similar to Time-of-Day (5-8 p.m.), which as noted above, has an average cost of \$0.12 per kWh.

SMUD is also implementing a new Grid Access Charge that is based on the rated capacity of the solar array. This charge is being phased in between 2020 and 2025. The charge in 2021 is \$5.50/kW and it increases to \$8.00/kW in 2025.

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 NEM 2.0 wholesale price. Even at the higher end of the projected value range, the levelized cost of energy from the PV array (without 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, the levelized cost with BESS is still higher than the retail energy cost. This analysis implies that a PV-BESS system is not economically viable under the assumptions listed above.

Energy rates are continuously changing to better reflect the 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, e-tran should monitor the evolving tariffs to identify possible future opportunities.

## 9.0 OPERATIONAL AND PLANNING CONSIDERATIONS

This section provides guidance and strategies for various 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 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.

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 2023, but construction and deployment of chargers will need to be occur prior to that.

Key considerations for BEB planning and schedule include the fact that the useable energy of the battery is 20% of the nameplate capacity. In other words, while e-tran 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 e-tran’s operations scheduling.

Developing a ‘cheat sheet’ like the depot planning tool from Siemens below (Figure 31) 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 31: 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 e-tran’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 e-tran’s scheduling software provider to account for combined BEB, diesel, and hybrid operations, 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<sup>21</sup>. With an estimated 2% battery degradation per year, e-tran will also need to rotate buses so that older buses are assigned shorter blocks, while newer BEBs are assigned the longest blocks.

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.

### 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 current 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 coordination with OEMs and component manufacturers to develop spare parts inventories and understand lead times for spare parts. It will also be important for e-tran 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 e-tran 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. Personnel at the divisions will be required to coordinate and implement the charging schedule to ensure all buses are sufficiently charged

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<sup>21</sup> 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>.

prior to beginning service. The complication of creating and executing a daily charging schedule can be minimized through smart charging software, discussed in detail below.

As part of the recommendations for e-tran, most charging will be of the low-power, plug-in variety that should be managed by smart charging software (see more in Section 10.1). However, a small portion of vehicle blocks will require fast midday charging so Stantec has designed the ZEB strategy to include one high-power overhead charger at the depot. A 600-kW pantograph charger can provide the necessary boost to the vehicle blocks described in Section 5.0 in about 10 minutes.

## 10.0 TECHNOLOGY

Technology for ZEBs will help e-tran 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 e-tran 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 3 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, and would be charged first in 2.2 hours, and would be ready in time for its 'hour 3' 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 5 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 4 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 32), but other OEMs also offer similar tools (like ViriCiti) all depending on an agency's preference.

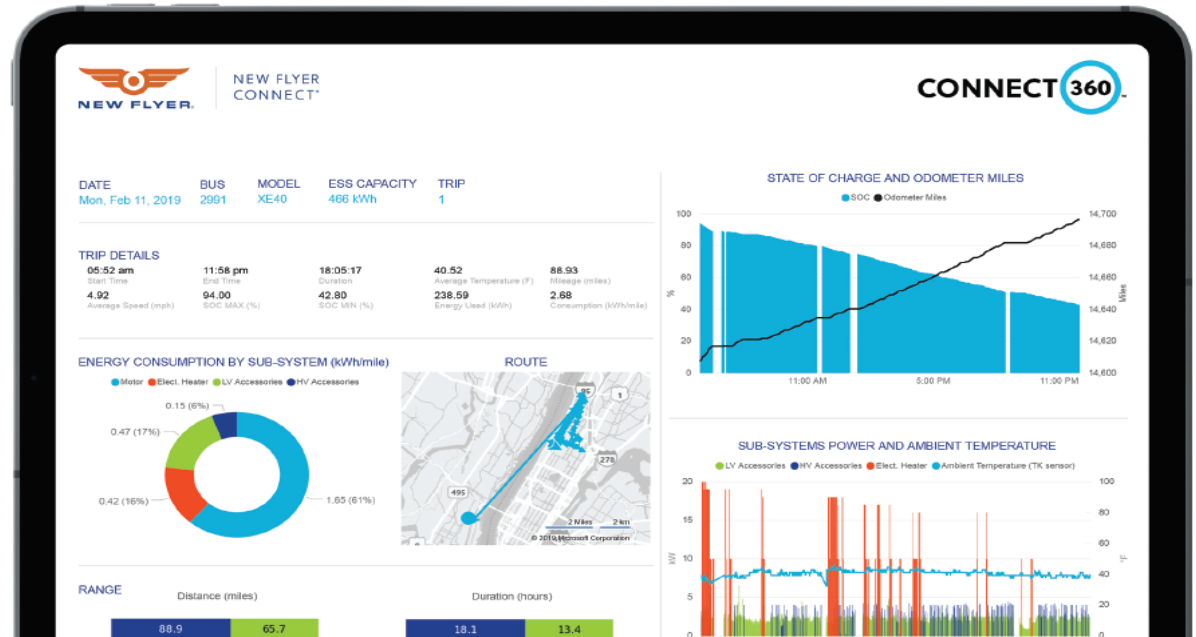


Figure 32: Example of New Flyer Connect 360.<sup>22</sup>

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, the Antelope Valley Transit Authority (AVTA) that operates a near 100% BEB fleet of over 50 vehicles, AVTA 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

<sup>22</sup> <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 internal combustion (IC) buses (Figure 33).

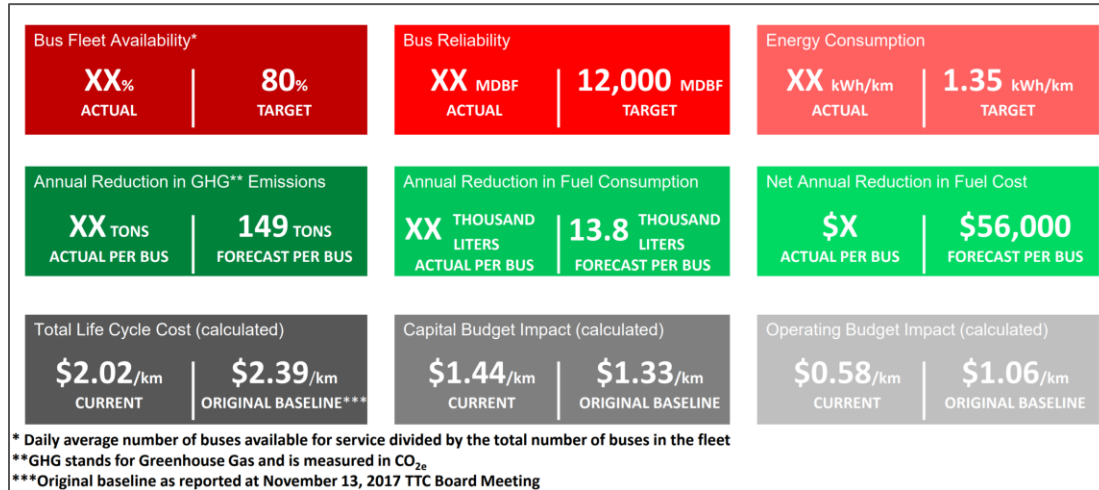


Figure 33: Example of TTC eBus KPIs.<sup>23</sup>

Other suggested KPIs would include the reduction in GHGs as a benefit to the community.

All ZEB equipment should be connected to e-tran’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 e-tran to track utility usage data from SMUD to understand energy and power demand and costs.

## 11.0 WORKFORCE TRAINING<sup>24</sup>

Ensuring e-tran’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 California Department of General Services (DGS) Statewide Contract for Zero-Emission Buses and is meant to be

<sup>23</sup>

[https://www.ttc.ca/About\\_the\\_TTC/Commission\\_reports\\_and\\_information/Commission\\_meetings/2018/June\\_12/Reports/27\\_Green\\_Bus\\_Technology\\_Plan\\_Update.pdf](https://www.ttc.ca/About_the_TTC/Commission_reports_and_information/Commission_meetings/2018/June_12/Reports/27_Green_Bus_Technology_Plan_Update.pdf)

<sup>24</sup> This section provides information relevant for Section G of the ICT Rollout Plan

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a general guide to training requirements. It is also important to note that close collaboration with the appropriate unions will be required to fully develop and execute the training.

With a focus on safety, it is highly recommended that all local fire and emergency response departments be given training regarding 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 considered 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 a planning department representative 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, 24 hours each<sup>25</sup>)
  - 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)

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<sup>25</sup> Each session consists of three, 8-hour days for a total of 24 hours per session

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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 2023 to coincide with the introduction of the first BEBs at the Corporation Yard.

**Table 22: Workforce training schedule**

<b>Timeline (year)</b>	<b>Operator Training</b>	<b>Maintenance/Technician Training</b>	<b>Other Training</b>
<b>FY2023</b>	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-24 hours each  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
<b>FY2024</b>	Annual refreshers	Annual refreshers	No activity
<b>FY2025</b>	Annual refreshers	Annual refreshers	Local fire and emergency response department training on new technology
<b>FY2026</b>	Annual refreshers	Annual refreshers	No activity
<b>FY2027</b>	Annual refreshers	Annual refreshers	Local fire and emergency response department training on new technology
<b>FY2028</b>	Annual refreshers	Annual refreshers	No activity
<b>FY2029</b>	Annual refreshers	Annual refreshers	Local fire and emergency response department training on new technology
<b>FY2030</b>	Annual refreshers	Annual refreshers	No activity
<b>FY2031</b>	Annual refreshers	Annual refreshers	Local fire and emergency response department training on new technology

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<b>Timeline (year)</b>	<b>Operator Training</b>	<b>Maintenance/Technician Training</b>	<b>Other Training</b>
<b>FY2032</b>	Annual refreshers	Annual refreshers	No activity
<b>FY2033</b>	Annual refreshers	Annual refreshers	Local fire and emergency response department training on new technology
<b>FY2034</b>	Annual refreshers	Annual refreshers	No activity
<b>FY2035</b>	Annual refreshers	Annual refreshers	Local fire and emergency response department training on new technology
<b>FY2036</b>	Annual refreshers	Annual refreshers	No activity
<b>FY2037</b>	Annual refreshers	Annual refreshers	Local fire and emergency response department training on new technology
<b>FY2038</b>	Annual refreshers	Annual refreshers	No activity
<b>FY2039</b>	Annual refreshers	Annual refreshers	Local fire and emergency response department training on new technology
<b>FY2040</b>	Annual refreshers	Annual refreshers	No activity

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

### 12.0 POTENTIAL FUNDING SOURCES<sup>26</sup>

As a clear cost driver for transit agencies, funding the zero-emission transition will require external aid. Due to the long timeframe over which buses will be procured and infrastructure will be constructed, it is imperative that e-tran constantly monitors funding and financing opportunities to stay up to date with existing sources and be aware of when new sources are created. Below are major current programs available for ZEB transition (Table 23).

Overall, e-tran staff should actively monitor the opportunities since as noted, many become oversubscribed quickly after opening. Furthermore, staff should actively determine local matching contributions which are a prerequisite for many of the grant and funding opportunities. It is likely that the Sacramento Area Council of Governments (SACOG) is aware of ICT and the costs associated with ZEB transition for all bus transit agencies operating in the Sacramento area as they are responsible for administering much of the federal funding to local transit agencies. It is also important that Elk Grove submits relevant projects annually to SACOG's Transportation Improvement Program (TIP) so that they are eligible for the funding opportunities which are administered through the TIP.

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<sup>26</sup> This section provides information relevant for Section H of the ICT Rollout Plan

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**Table 23: Grants and potential funding options for ZEB transition**

<b>Fund/Grant</b>	<b>Level of government</b>	<b>Description</b>	<b>Applicability</b>	<b>Average/ Maximum Award Amount</b>
<b>Low or No Emission Program (Low-No Program)</b>	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.	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 <sup>27</sup> In 2020, the Antelope Valley Transit Authority (AVTA) received over \$6 million to assist in the purchase of ZEBs <sup>28</sup>
<b>Buses and Bus Facilities Program (5339)</b>	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. <sup>29</sup> 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 <sup>30</sup>
<b>Urbanized Area Formula Grants (5307)</b>	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.	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 .	The San Francisco-Oakland urbanized area was awarded \$141,934,573 in 5307 funds for FY19 <sup>31</sup> .

<sup>27</sup> Average and median 2020 award amounts.

<sup>28</sup> <https://www.transit.dot.gov/funding/grants/fiscal-year-2020-low-or-no-emission-low-no-bus-program-projects>

<sup>29</sup> [https://www.transit.dot.gov/sites/fta.dot.gov/files/docs/5339\\_Bus\\_and\\_Bus\\_Facilities\\_Fact\\_Sheet.pdf](https://www.transit.dot.gov/sites/fta.dot.gov/files/docs/5339_Bus_and_Bus_Facilities_Fact_Sheet.pdf)

<sup>30</sup> [https://mtc.ca.gov/sites/default/files/\\_S4\\_Draft%202021%20Tip%20Publication%20Report-transit.pdf](https://mtc.ca.gov/sites/default/files/_S4_Draft%202021%20Tip%20Publication%20Report-transit.pdf)

<sup>31</sup> <https://www.transit.dot.gov/funding/apportionments/table-3-fy-2019-section-5307-and-5340-urbanized-area-formula-appropriations>

<https://www.transit.dot.gov/funding/grants/urbanized-area-formula-grants-5307#:~:text=Program%20Overview,and%20for%20transportation%2Drelated%20planning.>

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Fund/Grant	Level of government	Description	Applicability	Average/ Maximum Award Amount
<b>Better Utilizing Investments to Leverage Development (BUILD)</b>	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 <sup>32</sup>
<b>Hybrid and Zero-Emission Truck and Bus Voucher Incentive Program (HVIP)</b>	State/CARB	Voucher program aimed at reducing the purchase cost of zero-emission vehicles. A transit agency would decide on a vehicle, contact the vendor directly, and then the vendor would apply for the voucher.	HVIP anticipates accepting new voucher requests beginning in late spring 2021, when FY20-21 funding becomes available. Agency should apply for this once a vendor has been selected and if funds are available	Maximum: up to \$315,000 per FCEB; up to \$175,000 per BEB. <sup>33</sup> CARB is proposing to allocate a total of \$25 million for HVIP funding for FY20-21. <sup>34</sup>
<b>Carl Moyer and AB 923</b>	State/CARB	Funding to help procure low-emission vehicles and equipment. Transit buses are eligible for up to \$80,000 funding.	The Sacramento Metro AQMD is currently not accepting applications, but Elk Grove should continue to monitor for when the AQMD opens the application period again. <sup>35</sup>	Average: \$29,578.02 <sup>36</sup>
<b>Caltrans Transportation Planning Grants – Adaptation Planning Grants</b>	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 <sup>37</sup>

<sup>32</sup> Average and median 2020 award amounts for capital projects; however, many of the awarded projects are non-transit projects

<https://www.transportation.gov/BUILDgrants>

<https://www.transportation.gov/sites/dot.gov/files/2020-09/BUILD%202020%20Fact%20Sheets-.pdf>

<sup>33</sup> <https://ww3.arb.ca.gov/msprog/lct/hvip.htm>. Voucher amount is per vehicle

<sup>34</sup> [https://ww2.arb.ca.gov/sites/default/files/2020-11/proposed\\_fy2020-21\\_fundingplan.pdf](https://ww2.arb.ca.gov/sites/default/files/2020-11/proposed_fy2020-21_fundingplan.pdf)

<sup>35</sup> <http://www.airquality.org/businesses/incentive-programs/carl-moyer-program>

<sup>36</sup> Average award amount for South Coast AQMD on-road vehicle projects between 2008 and 2019

<sup>37</sup> <https://dot.ca.gov/-/media/dot-media/programs/transportation-planning/documents/final-2021-award-listcopya11y.pdf>

## ZEB STRATEGY AND FINAL REPORT

Fund/Grant	Level of government	Description	Applicability	Average/ Maximum Award Amount
<b>Caltrans Transportation Planning Grants - Strategic Partnership Grants</b>	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 <sup>38</sup>
<b>State Transportation Improvement Program (STIP)</b>	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 <sup>39</sup>
<b>Sustainable Transportation Equity Project (STEP)</b>	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, or local government representing a public transit agency.	The application window closed as of August 31, 2020. It is unclear whether more funding will be made available in the Low Carbon Transportation Funding Plan for 2020-21.	\$1.75 million available for Planning and Capacity Building grants, \$17.75 million available for Implementation grants. <sup>40</sup> Award amounts ranged from \$184,000 to a maximum of over \$7 million. <sup>41</sup>
<b>Low Carbon Transit Operations Program (LCTOP) and Transit and Intercity Rail Capital Program (TIRCP)</b>	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 used 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. <sup>42</sup>	LCTOP average: \$912,840 LCTOP median: \$193,572 <sup>43</sup> TIRCP average: \$6,027,500 TIRCP median: \$6,225,500 <sup>44</sup>

<sup>38</sup> <https://www.grants.ca.gov/grants/strategic-partnerships/>

<sup>39</sup> <https://catc.ca.gov/-/media/ctc-media/documents/programs/stip/2020-stip/2020325-2020-stip-resolution-a11y.pdf>

<sup>40</sup> <https://ww2.arb.ca.gov/news/grant-awards-announced-new-195-million-pilot-funding-equitable-clean-transportation-options>

<sup>41</sup> <https://ww2.arb.ca.gov/our-work/programs/low-carbon-transportation-investments-and-air-quality-improvement-program-1>

<sup>42</sup> <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>

<sup>43</sup> LCTOP average and median award amount from FY 2019-20 Awarded Project List

<sup>44</sup> 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

## ZEB STRATEGY AND FINAL REPORT

Fund/Grant	Level of government	Description	Applicability	Average/ Maximum Award Amount
<b>SB1 State of Good Repair</b>	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. <sup>45</sup>	Average: \$560,197 Median: \$104,210 <sup>46</sup>
<b>SB1 Local Partnership Program (LPP)</b>	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 <sup>47</sup>
<b>Solutions for Congested Corridors Program (SCCP)</b>	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 <sup>48</sup>
<b>Affordable Housing and Sustainable Communities Program (AHSC)</b>	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 disadvantaged communities through increasing accessibility via low-carbon transportation. The program distributed \$193 million for transportation projects in FY18-19.	Sustainable transportation infrastructure projects, transportation-related amenities, and program costs (including transit ridership) are eligible activities. Agencies can use program funds for assistance in construction or modification of infrastructure for ZEB conversion as well as new vehicle purchases.	Maximum award amount is not to exceed \$30 million per project. Average: \$7,757,862 Median: \$7,557,513 <sup>49</sup>

<sup>45</sup> <https://dot.ca.gov/programs/rail-and-mass-transportation/state-transit-assistance-state-of-good-repair>

<sup>46</sup> Average and median award amounts from FY2020-21 approved project list

<sup>47</sup> FY2020 formulaic funding: <https://catc.ca.gov/-/media/catc-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.

<sup>48</sup> <https://www.grants.ca.gov/grants/solutions-for-congested-corridors-program/>

<sup>49</sup> 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>

## ZEB STRATEGY AND FINAL REPORT

Fund/Grant	Level of government	Description	Applicability	Average/ Maximum Award Amount
<b>VW Environmental Mitigation Trust Funding</b>	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 <sup>50</sup>
<b>Community Air Protection (CAP) Program Incentives</b>	Regional/ Sacramento Metro AQMD	Funding is being implemented through Carl Moyer Program and Goods Movement Emission Reduction Program funds allocated to the Sacramento Metro AQMD to help public agencies and businesses purchase less polluting and zero-emission equipment and infrastructure.	Transit agencies in the Sacramento Metro AQMD can apply to receive funding for electric charging infrastructure. Sacramento Metro AQMD has noted that the application period for 2021 will be open from March 29-May 28, 2021.	In FY2019-2020, over \$13 million were distributed to eligible projects. For FY2019-2020, SacRT received \$194,885 for electric charging infrastructure to support its fleet transition to ZE vehicles. <sup>51</sup>
<b>Low Carbon Fuel Standard (LCFS credits)</b>	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. Both hydrogen and electricity used as fuels are eligible for LCFS credits	Credit prices range, but average credit price between 2016 and 2019 was between \$65 and \$200 per credit Average: \$10,000 per vehicle <sup>52</sup>

<sup>50</sup> <http://vwbusmoney.valleyair.org/documents/FAQ.pdf>

<sup>51</sup> <http://www.airquality.org/air-quality-health/community-air-protection/community-air-protection-program-incentives/cap-projects>  
Only eligible for agencies in the Sacramento Metro AQMD

<sup>52</sup> <https://www.srectrade.com/markets/lcfs/california>  
Assuming 40,000 miles/year at \$100 per credit per 2018 amendments

### 13.0 SERVICE IN DISADVANTAGED COMMUNITIES<sup>53</sup>

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.

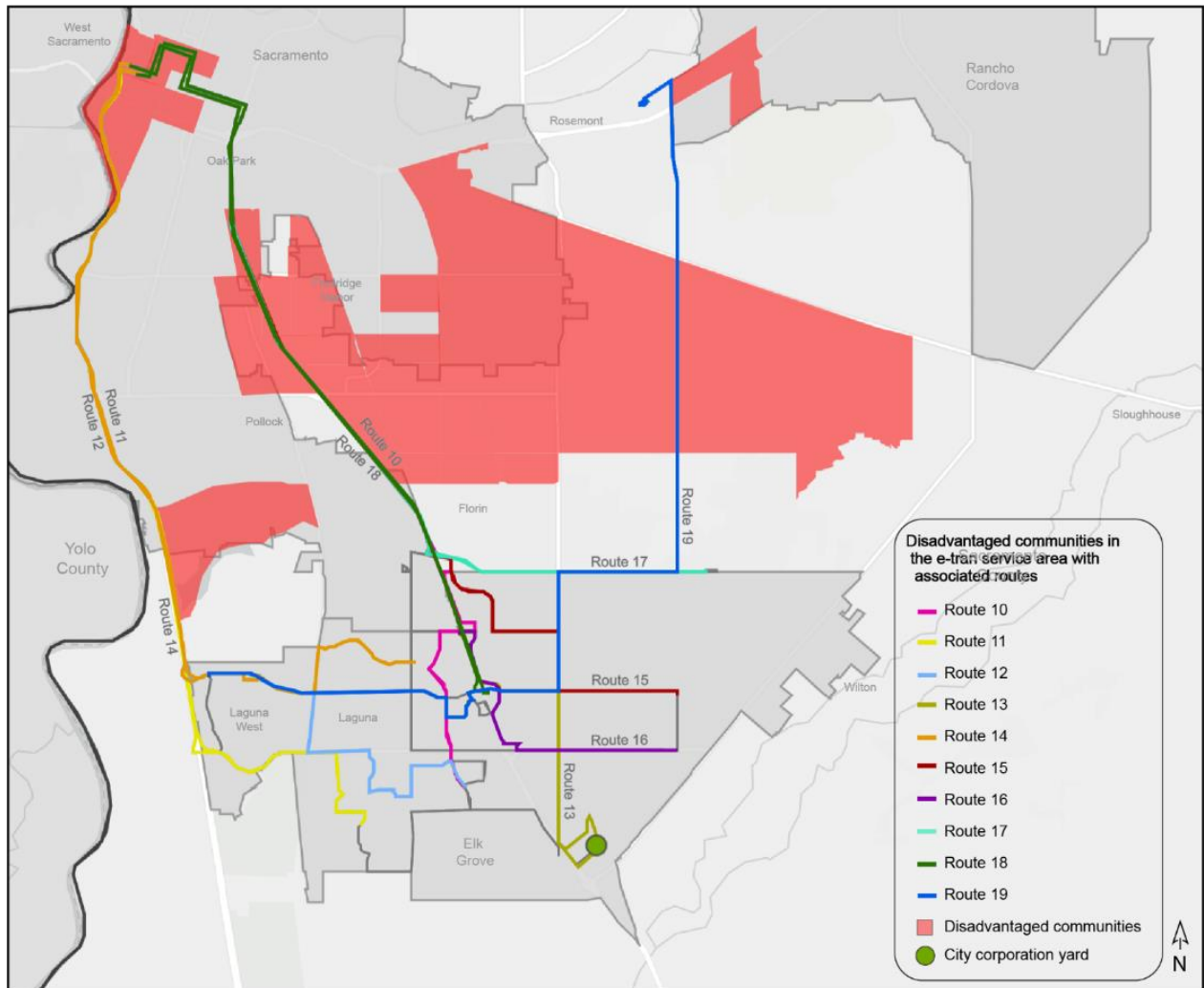
ICT provisions require that transit agencies describe how they are planning to deploy ZEBs in disadvantaged communities by outlining the location of the disadvantaged community (census tract) where the ZEB will be deployed, how many ZEBs, and in what year the ZEBs will be deployed.

For e-tran, all census tracts that are categorized as disadvantaged communities are located north of the city of Elk Grove and are touched by commuter routes traveling to Sacramento and Rancho Cordova (Figure 34). No local routes touch any disadvantaged communities. Specifically, routes that travel through at least one disadvantaged community are:

- Commuter routes 10, 11, 12, 13, 14, 15, 16, 17, 18 and 19

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<sup>53</sup> This section provides information relevant for Section F of the ICT Rollout Plan



**Figure 34: Disadvantaged communities and associated routes**

Based on this information, e-tran should prioritize BEB deployment along commuter routes that touch these disadvantaged communities. So that Elk Grove can more accurately plan for deployment in disadvantaged communities, Table 24 details the specific census tracts that are classified as disadvantaged communities with the associated routes.

**Table 24: Disadvantaged communities census tracts**

Census tract ID	Location	Routes
6067000800	Sacramento	10, 11, 12, 13, 14, 15, 16, 17, 18
6067001101	Sacramento	10, 11, 12, 13, 14, 15, 16, 17, 18
6067002100	Sacramento	11, 12, 14
6067002200	Sacramento	11, 12, 14
6067003700	Sacramento	10, 13, 15, 16, 17, 18
6067004501	Sacramento	10, 13, 15, 16, 17, 18

## ZEB STRATEGY AND FINAL REPORT

Census tract ID	Location	Routes
6067004602	Sacramento	10, 13, 15, 16, 17, 18
6067004701	Sacramento County	10, 13, 15, 16, 17, 18
6067004702	Sacramento	10, 13, 15, 16, 17, 18
6067005002	Sacramento County	10, 13, 15, 16, 17, 18
6067009006	Rancho Cordova	19
6067009601	Sacramento	11, 12, 14

Finally, based on CUTRIC’s modeling of greenhouse gas emissions, e-tran’s CNG fleet emits 4,600 tons of GHGs compared to the BEB fleet of 800 tons (residual GHG due to the carbon-intensity of California’s electric grid). In essence, a completely BEB can reduce e-tran’s GHG footprint by 3,800 tons annually.

## 14.0 FINANCIAL ANALYSIS/IMPACT

The financial analysis for e-tran’s ZEB rollout consisted of the modeling of a Base Case (assuming continued use of CNG vehicles or ‘business-as-usual’) and a ZEB Rollout (assuming a transition to 100% ZEB operations by 2040 and the phasing out of CNG vehicles), and a comparison between the two scenarios to quantify the financial impacts of the transition and of ZEB operations. The 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<sup>54</sup>.

The main assumptions for the cost modeling are:

- 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. Financial modeling was completed in real 2021 dollars (2021\$).
- Annual fleet vehicle mileage was set at 1.26M miles or 27,300 miles per vehicle<sup>55</sup>.
- A 3% discount rate was applied for all calculations.
- 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 considered the operations of CNG vehicles during the transition period until they are phased-out in 2040.

### 14.1 BASE CASE APPROACH

Stantec developed the forecast for the Base Case (business-as-usual) scenario, assuming that the existing fleet of CNG buses is maintained and renewed through to 2040. This model is inclusive of all

<sup>54</sup> Provided as Appendix D.

<sup>55</sup> As a reference, e-tran reported ~1.20M vehicles miles in 2019 in NTD (commuter bus and motor bus modes).

## ZEB STRATEGY AND FINAL REPORT

scheduled fleet replacements and overhauls required during the time window. It should be 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 most recent “TRANSIT OPERATIONS FIVE YEAR FORECAST” provided by e-tran<sup>56</sup>. The following cost sub-categories were created:

- Fuel Cost: The cost per mile of the revised FY2021 budget ( $\$850,000 / 1.26\text{M miles} = \$0.68$  per mile) was used with an annual 2% increase.
- Bus Maintenance: The cost per mile of the revised FY2021 budget ( $\$158,170 / 1.26\text{M miles} = \$0.126$  per mile) was used with an annual 1% increase.
- Admin & Other Expenses: the following expense line items were aggregated from e-tran’s forecast into a single category and increased at 3.5% annually:
  - Salaries and Benefits
  - Other Operating and Admin Expenses
  - Overhead Allocation
  - Internal Services
  - Purchased Transportation

### 14.2 ZEB CASE APPROACH

The ZEB Case foresees a gradual transition to 100% ZEB operations by 2040 (with the exception of one vehicle) in alignment with ICT regulations. The transition follows the purchase schedule presented in Table 7. Therefore, the operations of CNG vehicles are considered until 2028 so financial benefits of the BEB would be more 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 (17 years for CNG, 18 years for BEBs).

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. Note, 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

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<sup>56</sup> Dated October 2020.

## ZEB STRATEGY AND FINAL REPORT

remain unchanged; the main difference is the acquisition and implementation of a new bus technology—BEBs.

Vehicle overhauls were assumed to only include a single battery replacement, in line with current operating practice of ZEBs in other jurisdictions. However, the business case includes the purchase of the extended vehicle warranty which covers the first battery replacement. It was determined that additional battery replacements would occur into the thirteenth year of useful life.

Electricity/fuel costs were calculated based on the expected blended SMUD rate, calculated by Stantec based on e-tran’s fleet and operational profiles.

The infrastructure costs consist of the conversion and modifications required for the e-tran facility. This includes outfitting the base with the charging infrastructure required to operate the ZEBs. The construction cost estimates include both a base option and a PV option, which consists of additional solar panels on the roofs where feasible. However, the solar PV option was not modelled in the business case but the full cost estimation from Jacobus & Yuang, Inc. is provided as an appendix.

### 14.3 ASSUMPTIONS AND INPUTS

Table 25 presents a brief description, as well as the sources for the cost inputs of the Base Case and the ZEB Case. The cost categories not considered in this analysis include:

- Liability expenses
- Taxes
- Utilities unrelated to fueling

**Table 25: Summary of cost inputs for e-tran’s Financial Analysis**

Cost categories	Description	Inputs for Base Case	Inputs for ZEB Case
1. Fuel cost	Prices provided in \$/kWh and \$/kg for every year between 2021 and 2040	\$0.68 per mile calculated using inputs from the “Transit Operations Five Year Forecast”	Initial value of \$0.12 per kWh with a price trend from the EIA.
2. Bus purchase price	Bus purchase price for every year between 2020 and 2040 including extended warranty cost	\$600,000 in 2021 with a price trend based on market projections.	\$874,000 in 2021 for a BEB with 450 kWh battery pack and a price trend based on market projections.
3. Bus maintenance cost	Considers labor and parts for scheduled and unscheduled maintenance.	\$0.126 per mile obtained from the “Transit Operations Five Year Forecast”	\$0.21 per mile
4. Admin. & Others	Salaries and Benefits Other Operating and Admin Expenses Overhead Allocation Internal Services Purchased Transportation	\$9.5M in 2021 with an annual 3.5% increase	\$9.5M in 2021 with an annual 3.5% increase

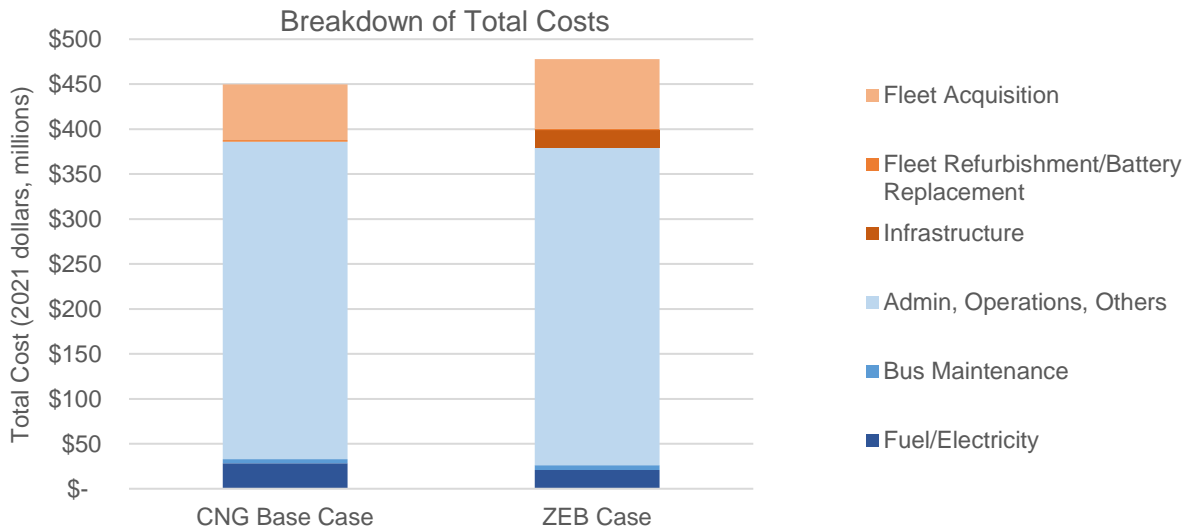
Cost categories	Description	Inputs for Base Case	Inputs for ZEB Case
5. Replacement of equipment for charging infrastructure	Replacement of charging equipment after 12 years	N/A	\$131,200 per 150 kW charger
6. Electrical infrastructure upgrades	Includes transformers and control systems paid by the transit agency	N/A	N/A Final upgrade values will require input from SMUD
7. Battery replacement and CNG midlife overhaul	Replacement of batteries after expiration of extended warranty coverage (past 500,000 miles)	\$38,000 per CNG bus	Battery: \$183 per kWh in 2036 and a price trend was applied based on market assessment
8. Infrastructure Cost	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

## 14.4 COMPARISON AND OUTCOMES

The cost comparison between the CNG Base Case and the ZEB Case transition scenario is presented in Table 26 and Figure 35, incorporating both capital (orange) and operating (blue) expenses. The ZEB Case has a total cumulative cost of \$477,856,000 versus \$449,619,000 for the Base Case, a difference of \$28,237,000.

**Table 26: Cost Comparison 2021-2040**

	in 2021 Dollars		
	CNG Base Case	BEB Case	Difference
Fleet Acquisition	\$61,789,000	\$77,720,000	\$(15,931,000)
Fleet Refurbishment/Battery Replacement	\$1,893,000	\$1,256,000	\$637,000
Infrastructure	\$-	\$19,600,000	\$(19,600,000)
Admin, Operations, Others	\$352,927,000	\$352,927,000	\$-
Bus Maintenance	\$4,725,000	\$5,625,000	\$(900,000)
Fuel/Electricity	\$28,285,000	\$20,728,000	\$7,557,000
<b>Total</b>	<b>\$449,619,000</b>	<b>\$477,856,000</b>	<b>\$(28,237,000)</b>



**Figure 35: Breakdown of Cost Categories for the CNG and BEB Scenarios**

The procurement of ZEBs represents \$15.9 million more in expenses due to the higher purchase price of BEBs compared to CNG. The conversion and upgrades to the facility to install charging infrastructure represents another added cost of \$19.6 million. However, the main cost driver for 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 as of City of Elk Grove 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 CNG engine components in the Base Case.

Lastly, the use of electricity as a ‘fuel’ represents an economic benefit of almost \$7.6 million when compared to the existing CNG refueling agreement. These savings are a direct reflection of the improved efficiency that BEBs have with respect to CNG buses, with the added benefit of eliminating third-party refueling contracts.

Figure 36 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 (2022, 2030, 2035, and 2039).

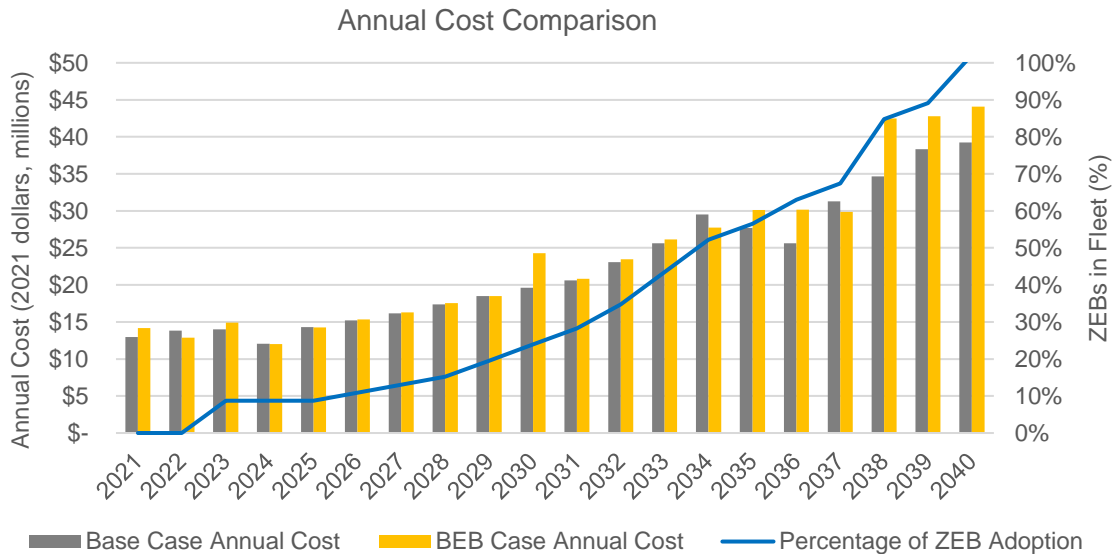


Figure 36: Annual Total Cost Comparison

## 15.0 OTHER TRANSITION ITEMS

### 15.1 JOINT ZEB GROUP AND ASSESSMENT OF MULTI-OPERATOR VEHICLE PROCUREMENT

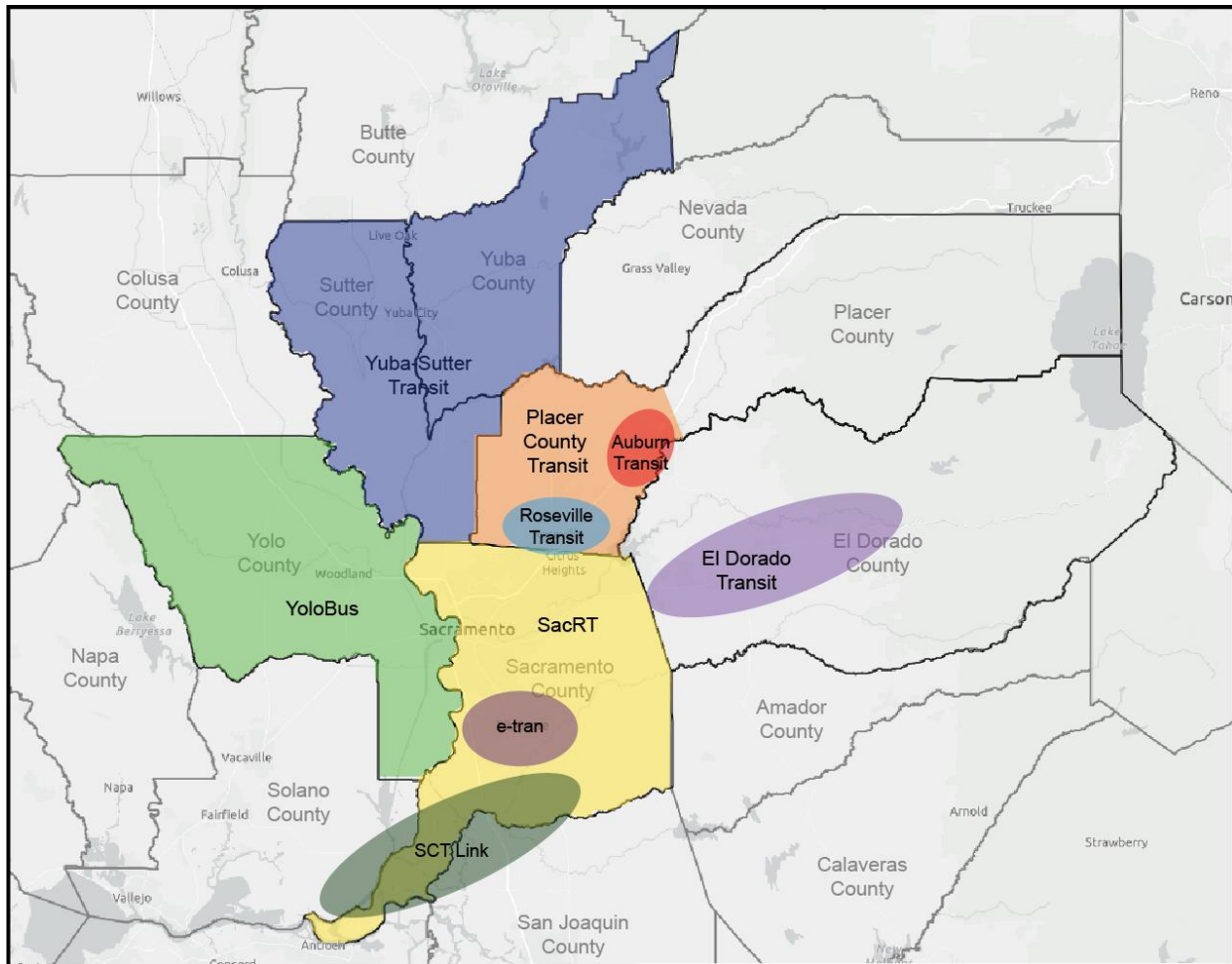
According to ICT regulation, transit agencies can pool resources when acquiring ZEB infrastructure if they:

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

Elk Gove’s MPO is SACOG, which oversees 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. Elk Grove is located in the Sacramento Metro AQMD and located in the Sacramento Valley Air Basin. Table 27 lists the agencies that operate fixed route bus transit service in the SACOG planning area and Figure 37 shows the service areas of these transit agencies.

**Table 27: Other bus transit agencies in the SACOG planning area**

Agency	Fleet Size	ZEB Choice	Notes
<i>Elk Grove</i>	46	In-depot charging <b>BEBs</b>	<i>TBD</i>
<b>Auburn Transit</b>	5	TBD	
<b>El Dorado Transit</b>	28	TBD	ZEB study in progress
<b>Placer County Transit</b>	41	TBD	2018 SRTP noted preference for <b>BEBs</b> but requires a more detailed study
<b>Roseville Transit</b>	11	In-depot and on-route charging <b>BEBs</b>	
<b>SacRT</b>	216	In-depot charging <b>BEBs</b>	Noted option to integrate FCEBs after 2027 if they became more affordable
<b>SCT Link</b>	19	TBD	ZEB study in progress soon
<b>Yolobus</b>	57	<b>BEBs</b>	First <b>BEB</b> procurement scheduled for 2021
<b>Yuba-Sutter Transit</b>	35	TBD	No ZEB plan but 2018 study included <b>BEB</b> feasibility study with anticipated purchase of 4 BEBs in 2020



**Figure 37: Regional transit operators.**

Based on the rules outlined above, e-tran could potentially partner with any of these transit agencies to form a joint ZEB group. However, due to the large size of the Sacramento area, if e-tran wished to explore the creation of a joint ZEB group, it would make most sense to do so with SCT Link and SacRT due to the overlaps in their service areas and a higher likelihood of shared infrastructure.

It is another possibility to form a joint ZEB group with other agencies who provide commuter service to downtown Sacramento if there is an interest in coordinating with several agencies investing in shared infrastructure at a common location close to where commuter services terminate in downtown Sacramento.

E-tran 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 that are required through the ICT regulation. Thus, e-tran will only benefit from a joint ZEB group if it is not the largest agency in the group.

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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.

Another recommended strategy is developing a multi-operator vehicle procurement group. That is, e-tran could join with any of the agencies outlined above to produce common specifications for ZEBs, thus potentially driving down the purchase costs of ZEBs. Most judiciously, e-tran 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.

### 15.2 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, unions representing bus operators and maintenance technicians should be included due to the large role they will play in the success of the ZEB transition and implementation. Thus, it is prudent for e-tran to form a steering committee or task force composed of staff from each major functional division and union representation to help ensure the impact of ZEBs are considered for each department. 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 (such as potential layover charging). ZEB conversion also offers an excellent marketing opportunity for e-tran to promote its climate commitments.

### 16.0 CONSIDERATIONS FOR FCEBS

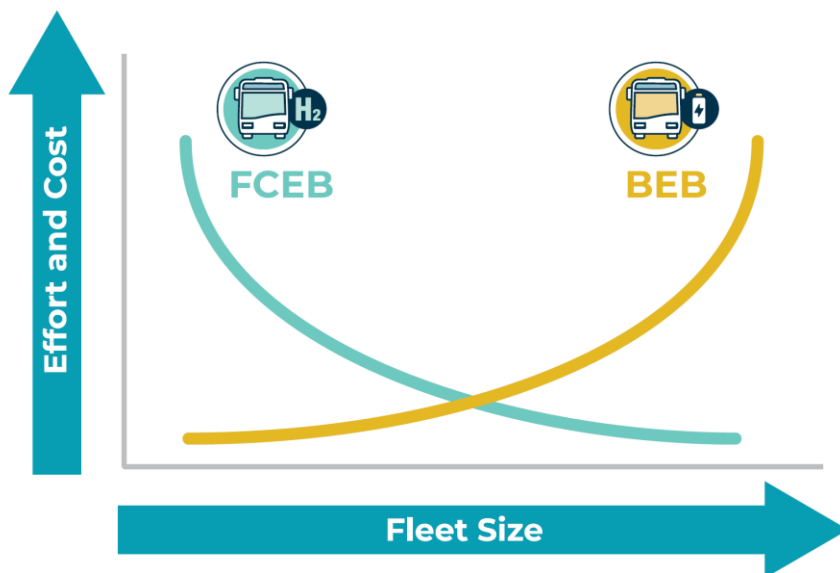
Stantec's recommendation, based on our analysis of current service and operations, route modeling and bus simulations, site audits, and meeting with stakeholders and e-tran staff, is for e-tran to deploy in-depot charging BEBs. Regionally, Sacramento area bus operators are also favoring BEBs in their 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<sup>57</sup>.

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. For this reason, for a smaller bus fleet, the large fixed costs for hydrogen fueling infrastructure is untenable.

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<sup>57</sup>

[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](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)



**Figure 38: 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 e-tran’s fleet is the one presented here, Stantec also provides important considerations and decision points that e-tran could weigh if, at some point in the ZEB transition, FCEBs become more attractive.<sup>58</sup>

## 16.1 OPERATIONS CONSIDERATIONS

By best approximating the operating range of CNG buses, FCEBs would have minimal disruption on the service cycle and operations of bus service. Based on the modeling work completed by CUTRIC and further analysis by Stantec, all 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.

## 16.2 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<sup>59</sup>. 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.

<sup>58</sup> Additional information regarding considerations for FCEBs more generally were presented in the Market Scan and Existing Conditions report.

<sup>59</sup> However, if more BEBs are required to maintain service compared to the CNG fleet size, the capital vehicle cost of a BEB fleet could approach the capital vehicle cost of a FCEB fleet.

Nonetheless, the major advantage of a FCEB is its operating range of ~300 miles, approaching the operating ranges of CNG and 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 like midday fast charging for BEB, e-tran can deliver the same revenue service with a fleet size of 46 BEBs as it does with a fleet of 46 CNG buses. Simply put, the fleet size and peak hour needs of e-tran facilitate BEB adoption.

If FCEB prices drop to align with BEBs, e-tran 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 e-tran does wish to explore FCEB options, it will need to plan for fueling.

### **16.3 FUELING CONSIDERATIONS**

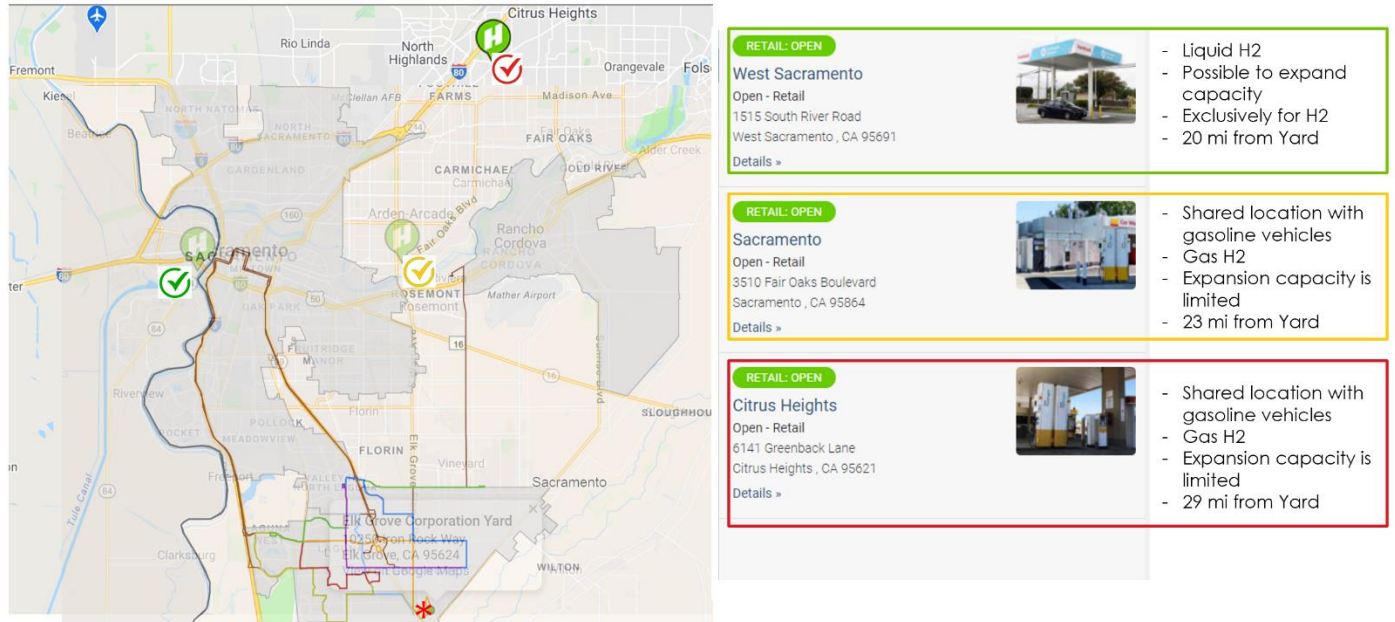
Currently, all CNG bus fueling occurs offsite at a nearby fueling station. For hydrogen fueling, e-tran can proceed through a few different routes.

One route would be to build a hydrogen fueling facility on-site. Fueling is comparable to a CNG 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 e-tran is 660 kg/day. A gaseous hydrogen station would only be able to serve around 15 FCEBs at e-tran and would cost around \$2 million to construct. Therefore, the approximate cost of a liquid hydrogen station for e-tran would be close to \$4 million and would require one pump and one hydrogen dispenser with an average flow rate of 10 kg/min.

**Table 28: Characteristics for different hydrogen production sources and distribution methods**

	<b>Compressed hydrogen gas</b>	<b>Liquid hydrogen</b>	<b>Local SMR</b>	<b>Local electrolysis</b>
<b>Overall</b>	Good for smaller volumes (<200 kg/day)	Suited for large volumes	Good for large volumes	Good for large volumes
<b>Distribution Costs</b>	High; price impacted by location from supply	Nominal; range flexibility	Nominal	Nominal
<b>Price volatility</b>	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
<b>Infrastructure costs</b>	Lower (~\$2 million)	Higher (~\$4-\$6 million)	Depends on production capacity	Depends on production capacity
<b>Carbon emission reductions</b>	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 e-tran can proceed through is offsite fueling, similar to how it currently operates with CNG buses. Presently, there are three hydrogen fueling facilities in the Sacramento region (Figure 39).



**Figure 39: Hydrogen fueling stations in the Sacramento Region.**

All are 20 miles or farther from the corporation yard and 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, e-tran will need to consider if operators are permitted to fuel buses. In the second scenario, the added cost of deadheading vehicles 20+ miles to fuel could be considerable and reduce starting range. Overall, the current locations and capacities of the fueling stations in Figure 39 are not favorable for e-tran.

Nevertheless, as the demand for hydrogen grows, it is possible that hydrogen fueling stations become more prevalent and closer to e-tran’s yard. However, as Stantec noted above, the regional transit operators are currently favoring BEBs. If a hydrogen fueling station opens within 5 miles or less of the City’s corporation yard and has the capacity for 40-ft buses, e-tran could investigate the feasibility of FCEBs and fueling from a such a yard.

## 16.4 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 e-tran would only need to incorporate 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, depending on model and make of FCEB acquired, could be interchangeable, such as, for instance, New Flyer FCEBs built on the same Xcelsior platform as e-tran's most recent CNG acquisitions (the same goes for BEBs on the same platform<sup>60</sup>).

## 16.5 WORKFORCE CONSIDERATIONS

### 16.5.1 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 procedure 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 CNG 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 e-tran phases out CNG buses.

### 16.5.2 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 CNG 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

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<sup>60</sup> <https://www.newflyer.com/buses/>; Stantec is not endorsing any particular bus manufacturer, but rather identifying the possibility of overlap in spare parts and other similarities for buses, regardless of propulsion technology, built on a common platform.

## ZEB STRATEGY AND FINAL REPORT

- 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 e-tran phases out CNG buses.

### 16.5.3 Planning, Scheduling, and Run Cutting

FCEBs come closest to matching the current CNG 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.

E-tran 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 the divisions 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 e-tran/SacRT's scheduling software provider to account for combined FCEB and CNG bus operations, and finally an entirely FCEB operation.

## 17.0 PHASING AND IMPLEMENTATION

Table 29 provides an overview of the phasing plan for e-tran'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 6 for more details.

**Table 29: ZEB implementation phasing plan, FY2021-2040**

Year	Construction – Corporation Yard	Fleet	Charging equipment	Training - operators	Training – maintenance staff/technicians	Training - other	Capital expenses (2021\$)	O&M expenses (2021\$)	Annual budget (2021\$)
FY2021		6 CNGs					\$3,667,000	\$10,496,000	\$14,163,000
FY2022	Underground work starts for conduit installation in Area-A (please refer to site plans) or work to install canopies in Area-A						\$2,261,000	\$10,624,000	\$12,885,000
FY2023		4 BEBs	2 150 kW power modules installed  6 plug-in dispensers installed	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-24 hours 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	\$3,613,000	\$11,273,000	\$14,886,000
FY2024				Annual refreshers	Annual refreshers	No activity	\$0	\$11,999,000	\$11,999,000
FY2025		2 CNGs		Annual refreshers	Annual refreshers	Local fire and emergency response department training on new technology	\$1,484,000	\$12,772,000	\$14,256,000
FY2026		1 CNG 1 BEB		Annual refreshers	Annual refreshers	No activity	\$1,751,000	\$13,584,000	\$15,336,000

ZEB STRATEGY AND FINAL REPORT

Year	Construction – Corporation Yard	Fleet	Charging equipment	Training - operators	Training – maintenance staff/technicians	Training - other	Capital expenses (2021\$)	O&M expenses (2021\$)	Annual budget (2021\$)
FY2027		1 CNG 1 BEB		Annual refreshers	Annual refreshers	Local fire and emergency response department training on new technology	\$1,823,000	\$14,449,000	\$16,271,000
FY2028		1 CNG 1 BEB		Annual refreshers	Annual refreshers	No activity	\$2,182,000	\$15,368,000	\$17,550,000
FY2029		2 BEBs		Annual refreshers	Annual refreshers	Local fire and emergency response department training on new technology	\$2,171,000	\$16,334,000	\$18,505,000
FY2030		2 BEBs	5 150 kW power modules installed  15 plug-in dispensers installed	Annual refreshers	Annual refreshers	No activity	\$6,946,000	\$17,361,000	\$24,307,000
FY2031	Underground work starts for conduit installation in Area-B or work to install canopies in Area-B	2 BEBs		Annual refreshers	Annual refreshers	Local fire and emergency response department training on new technology	\$2,382,000	\$18,452,000	\$20,834,000
FY2032		3 BEBs		Annual refreshers	Annual refreshers	No activity	\$3,867,000	\$19,597,000	\$23,464,000
FY2033		4 BEBs		Annual refreshers	Annual refreshers	Local fire and emergency response department training on new technology	\$5,352,000	\$20,796,000	\$26,148,000
FY2034		4 BEBs		Annual refreshers	Annual refreshers	No activity	\$5,668,000	\$22,068,000	\$27,736,000
FY2035		2 BEBs	2 150 kW power modules installed  6 plug-in dispensers installed	Annual refreshers	Annual refreshers	Local fire and emergency response department training on new technology	\$6,664,000	\$23,455,000	\$30,119,000
FY2036		3 BEBs		Annual refreshers	Annual refreshers	No activity	\$5,277,000	\$24,908,000	\$30,185,000
FY2037		2 BEBs		Annual refreshers	Annual refreshers	Local fire and emergency response department training on new technology	\$3,388,000	\$26,473,000	\$29,861,000
FY2038		8 BEBs		Annual refreshers	Annual refreshers	No activity	\$14,491,000	\$27,998,000	\$42,489,000

## ZEB STRATEGY AND FINAL REPORT

Year	Construction – Corporation Yard	Fleet	Charging equipment	Training - operators	Training – maintenance staff/technicians	Training - other	Capital expenses (2021\$)	O&M expenses (2021\$)	Annual budget (2021\$)
FY2039		2 BEBs		Annual refreshers	Annual refreshers	Local fire and emergency response department training on new technology	\$13,017,000	\$29,755,000	\$42,772,000
FY2040		6 BEBs	5 150 kW power modules installed 15 plug-in dispensers installed 1 fast charger pantograph (600 kW) installed	Annual refreshers	Annual refreshers	No activity	\$12,573,000	\$31,518,000	\$44,091,000

## APPENDIX A: ZERO EMISSION BUS ROLLOUT PLAN (CARB ICT SUBMISSION)



# Zero-Emission Bus Rollout Plan

## Section A: Transit Agency Information

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*Please provide the following information regarding your agency.*

**The City of Elk Grove Transit (e-tran)**

8401 Laguna Palms Way  
Elk Grove, CA 95758

E-tran is part of the Sacramento Metro Air Quality Management District (AQMD) and part of the Sacramento Valley Air Basin.

Peak Vehicles: 39  
Population: 174,025<sup>1</sup>

**Contact Information:**

Costa, Michael  
Transit System Manager  
916-687-3030  
[mcosta@elkgrovecity.org](mailto:mcosta@elkgrovecity.org)

E-tran is not part of a Joint Zero-Emission Bus Group.

## Section B: Rollout Plan General Information

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1. *Does your transit agency's Rollout Plan have a goal of full transition to zero-emission technologies by 2040 that avoids early retirement of conventional transit buses? Yes*
2. *The ICT regulation requires 100% ZEB purchases in 2029. Conventional transit buses that are purchased in 2028 could be delivered in or after 2029. Please explain how your transit agency plans to avoid potential early retirement of conventional buses in order to meet the 2040 goal.*  
Optional
3. *When did your transit agency's board or governing body approve the Rollout Plan?*
  - a. **Approval date (MM/DD/YYYY)**
  - b. **Resolution number (optional)**
  - c. **Is a copy of the board approved resolution attached to the Rollout Plan submitted to CARB? Yes (required)**
4. *Contact information for follow-up on details of the Rollout Plan (optional)*
  - a. Michael Costa
  - b. Transit System Manager
  - c. 916-687-3030
  - d. [mcosta@elkgrovecity.org](mailto:mcosta@elkgrovecity.org)
5. *Who created the rollout plan? My transit agency/A consultant (optional)*
  - a. *If consultant, please identify the company name*

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<sup>1</sup> Vehicles operated in maximum service and service area population from NTD 2019 profile



6. Cost for Rollout Plan creation (optional)
7. How many person-hours did it take to create the Rollout Plan? (optional)

## Section C: Technology Portfolio

What type(s) of zero-emission bus technologies (e.g. battery electric and fuel cell electric buses) does your transit agency plan to deploy through 2040?

E-tran plans to deploy battery electric buses (BEBs).

## Section D: Current Bus Fleet Composition and Future Bus Purchases

Please complete Table 2 regarding expected future bus purchases, including the number of buses in total expected to be purchased or leased in the year of purchase. Identify the number and percentage of ZEBs of the total bus purchases each year, as well as bus types and fuel types. Identify the same type of information for purchases of conventional buses. Bus types include standard, articulated, over-the-road, double decker, and cutaway buses. For zero-emission technologies, identify the fuel type as diesel, CNG, LNG, diesel hybrid (dHEB), gasoline hybrid (gHEB), propane, or gasoline.

2. Table 2 represents the anticipated 40' buses that will be purchased in the future.

Table 2: Future 40' Bus Purchases (Required)

<u>Timeline (Year)</u>	<u>Total # of Buses to Purchase</u>	<u># of ZEB Purchases</u>	<u>% of Annual ZEB Purchases</u>	<u>ZEB Bus Type(s)</u>	<u>ZEB Fuel Type(s)</u>	<u># of Conv. Bus Purchases</u>	<u>% of Annual Conv. Bus Purchases</u>	<u>Type(s) of Conv. Buses</u>	<u>Fuel Type(s) of Conv. Buses</u>
2021	6	0	0%	N/A	N/A	6	100%	40'	CNG
2022	0	0	N/A	N/A	N/A	0	N/A	40'	N/A
2023	4	4	100%	40'	BEB	0	0%	N/A	N/A
2024	0	0	N/A	N/A	N/A	0	N/A	N/A	N/A
2025	2	0	0%	N/A	N/A	2	100%	40'	CNG
2026	2	1	50%	40'	BEB	1	50%	40'	CNG
2027	2	1	50%	40'	BEB	1	50%	40'	CNG
2028	2	1	50%	40'	BEB	1	50%	40'	CNG
2029	2	2	100%	40'	BEB	0	0%	N/A	N/A
2030	2	2	100%	40'	BEB	0	0%	N/A	N/A
2031	2	2	100%	40'	BEB	0	0%	N/A	N/A
2032	3	3	100%	40'	BEB	0	0%	N/A	N/A
2033	4	4	100%	40'	BEB	0	0%	N/A	N/A
2034	4	4	100%	40'	BEB	0	0%	N/A	N/A
2035	2	2	100%	40'	BEB	0	0%	N/A	N/A



<u>Timeline (Year)</u>	<u>Total # of Buses to Purchase</u>	<u># of ZEB Purchases</u>	<u>% of Annual ZEB Purchases</u>	<u>ZEB Bus Type(s)</u>	<u>ZEB Fuel Type(s)</u>	<u># of Conv. Bus Purchases</u>	<u>% of Annual Conv. Bus Purchases</u>	<u>Type(s) of Conv. Buses</u>	<u>Fuel Type(s) of Conv. Buses</u>
2036	3	3	100%	40'	BEB	0	0%	N/A	N/A
2037	2	2	100%	40'	BEB	0	0%	N/A	N/A
2038	8	8	100%	40'	BEB	0	0%	N/A	N/A
2039	2	2	100%	40'	BEB	0	0%	N/A	N/A
2040	6	6	100%	40'	BEB	0	0%	N/A	N/A

- E-tran is not considering converting some conventional buses to zero-emission buses. E-tran will purchase zero-emission vehicles for replacement of buses per the timeline above.

## Section E: Facilities and Infrastructure Modifications

1. Please complete Table 5 with names, locations, and main functions of transit agency divisions or facilities that would be involved in deploying and maintaining zero-emission buses. Please limit the facilities to bus yards and facilities with maintenance, fueling, and charging functions, and exclude other operational functions like training centers, information and trip planning offices, and administrative buildings.

- E-tran will have some modifications to its divisions to accommodate the transition to zero-emission. Below is a table of facilities and infrastructure modifications.

Table 5: Facilities Information and Construction Timeline (Required)

<u>Division/ Facility Name</u>	<u>Address</u>	<u>Main Function(s)</u>	<u>Type(s) of Infrastructure</u>	<u>Service Capacity</u>	<u>Needs Upgrade? (Yes/No)</u>	<u>Estimated Construction Timeline</u>
<b>Elk Grove Corporation Yard</b>	10250 Iron Rock Way, Elk Grove, CA	Operations, maintenance, training. Also houses Elk Grove Police Department fleet and functions.	New BEB charging equipment, additional electrical utility service and associated site improvements.	46 - 40' buses	Yes	2022, before first introduction of BEBs in 2023.

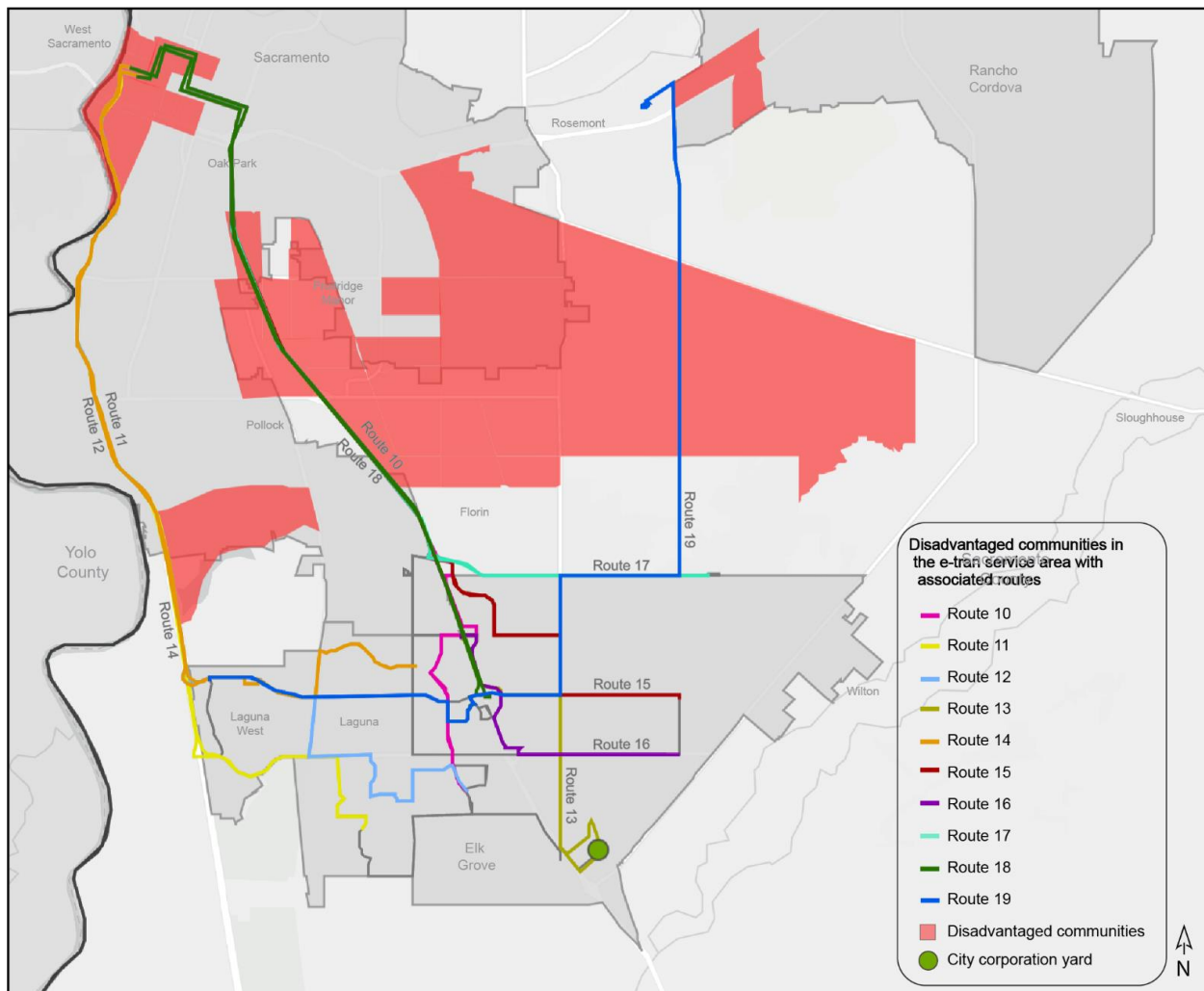
- Electric utilities in e-tran's service area is Sacramento Municipal Utility District (SMUD).

## Section F: Providing Service in Disadvantaged Communities

1. E-tran does serve one or more disadvantaged communities as listed in the latest version of CalEnviroScreen.

For e-tran, all census tracts that are categorized as disadvantaged communities are located north of the city of Elk Grove and are touched by commuter routes traveling to Sacramento and Rancho Cordova (see map below). No local routes touch any disadvantaged communities. Specifically, routes that travel through at least one disadvantaged community are:

- Commuter routes 10, 11, 12, 13, 14, 15, 16, 17, 18 and 19



So that Elk Grove can more accurately plan for deployment in disadvantaged communities, the following table details the specific census tracts that are classified as disadvantaged communities with the associated routes.



Census tract ID	Location	Routes
6067000800	Sacramento	10, 11, 12, 13, 14, 15, 16, 17, 18
6067001101	Sacramento	10, 11, 12, 13, 14, 15, 16, 17, 18
6067002100	Sacramento	11, 12, 14
6067002200	Sacramento	11, 12, 14
6067003700	Sacramento	10, 13, 15, 16, 17, 18
6067004501	Sacramento	10, 13, 15, 16, 17, 18
6067004602	Sacramento	10, 13, 15, 16, 17, 18
6067004701	Sacramento County	10, 13, 15, 16, 17, 18
6067004702	Sacramento	10, 13, 15, 16, 17, 18
6067005002	Sacramento County	10, 13, 15, 16, 17, 18
6067009006	Rancho Cordova	19
6067009601	Sacramento	11, 12, 14

## Section G: Workforce Training

*Describe your transit agency's plan and schedule for the training of bus operators and maintenance and repair staff on zero-emission bus technologies. (Required)*

The table below provides a high-level overview of e-tran's plan and schedule for the training of bus operators and maintenance and repair staff on ZEB technologies.

Timeline (year)	Operator Training	Maintenance/Technician Training	Other Training
<b>FY2023</b>	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-24 hours each  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
<b>FY2024</b>	Annual refreshers	Annual refreshers	No activity



<b>Timeline (year)</b>	<b>Operator Training</b>	<b>Maintenance/Technician Training</b>	<b>Other Training</b>
<b>FY2025</b>	Annual refreshers	Annual refreshers	Local fire and emergency response department training on new technology
<b>FY2026</b>	Annual refreshers	Annual refreshers	No activity
<b>FY2027</b>	Annual refreshers	Annual refreshers	Local fire and emergency response department training on new technology
<b>FY2028</b>	Annual refreshers	Annual refreshers	No activity
<b>FY2029</b>	Annual refreshers	Annual refreshers	Local fire and emergency response department training on new technology
<b>FY2030</b>	Annual refreshers	Annual refreshers	No activity
<b>FY2031</b>	Annual refreshers	Annual refreshers	Local fire and emergency response department training on new technology
<b>FY2032</b>	Annual refreshers	Annual refreshers	No activity
<b>FY2033</b>	Annual refreshers	Annual refreshers	Local fire and emergency response department training on new technology
<b>FY2034</b>	Annual refreshers	Annual refreshers	No activity
<b>FY2035</b>	Annual refreshers	Annual refreshers	Local fire and emergency response department training on new technology
<b>FY2036</b>	Annual refreshers	Annual refreshers	No activity
<b>FY2037</b>	Annual refreshers	Annual refreshers	Local fire and emergency response department training on new technology
<b>FY2038</b>	Annual refreshers	Annual refreshers	No activity
<b>FY2039</b>	Annual refreshers	Annual refreshers	Local fire and emergency response department training on new technology
<b>FY2040</b>	Annual refreshers	Annual refreshers	No activity

## Section H: Potential Funding Sources

*Please identify all potential funding sources your transit agency expects to use to acquire zero-emission technologies (both vehicles and infrastructure).*



The table below shows all potential funding sources e-tran will explore to use to acquire zero-emission technologies.

Fund/Grant	Level of government	Description	Applicability	Average/ Maximum Award Amount
<b>Low or No Emission Program (Low-No Program)</b>	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.	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 <sup>2</sup> In 2020, the Antelope Valley Transit Authority (AVTA) received over \$6 million to assist in the purchase of ZEBs <sup>3</sup>
<b>Buses and Bus Facilities Program (5339)</b>	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. <sup>4</sup> 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 <sup>5</sup>
<b>Urbanized Area Formula Grants (5307)</b>	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.	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 .	The San Francisco-Oakland urbanized area was awarded \$141,934,573 in 5307 funds for FY19 <sup>6</sup> .
<b>Better Utilizing Investments to</b>	Federal/ USDOT	Formerly TIGER, BUILD is a discretionary grant program aimed to	FY2020 provided \$1 billion in BUILD grants to 70 projects with	Average: \$16,891,781 Median: \$20,000,000 <sup>7</sup>

<sup>2</sup> Average and median 2020 award amounts.

<sup>3</sup> <https://www.transit.dot.gov/funding/grants/fiscal-year-2020-low-or-no-emission-low-no-bus-program-projects>

<sup>4</sup> [https://www.transit.dot.gov/sites/fta.dot.gov/files/docs/5339\\_Bus\\_and\\_Bus\\_Facilities\\_Fact\\_Sheet.pdf](https://www.transit.dot.gov/sites/fta.dot.gov/files/docs/5339_Bus_and_Bus_Facilities_Fact_Sheet.pdf)

<sup>5</sup> [https://mtc.ca.gov/sites/default/files/\\_S4\\_Draft%202021%20TIP%20Publication%20Report-transit.pdf](https://mtc.ca.gov/sites/default/files/_S4_Draft%202021%20TIP%20Publication%20Report-transit.pdf)

<sup>6</sup> <https://www.transit.dot.gov/funding/apportionments/table-3-fy-2019-section-5307-and-5340-urbanized-area-formula-appropriations>

<https://www.transit.dot.gov/funding/grants/urbanized-area-formula-grants-5307#:~:text=Program%20Overview,and%20for%20transportation%2Drelated%20planning.>

<sup>7</sup> Average and median 2020 award amounts for capital projects; however, many of the awarded projects are non-transit projects



Fund/Grant	Level of government	Description	Applicability	Average/ Maximum Award Amount
<b>Leverage Development (BUILD)</b>		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.	a stipulation requiring 50% of funding for projects in rural areas.	
<b>Hybrid and Zero-Emission Truck and Bus Voucher Incentive Program (HVIP)</b>	State/CARB	Voucher program aimed at reducing the purchase cost of zero-emission vehicles. A transit agency would decide on a vehicle, contact the vendor directly, and then the vendor would apply for the voucher.	HVIP anticipates accepting new voucher requests beginning in late spring 2021, when FY20-21 funding becomes available. Agency should apply for this once a vendor has been selected and if funds are available	Maximum: up to \$315,000 per FCEB; up to \$175,000 per BEB. <sup>8</sup> CARB is proposing to allocate a total of \$25 million for HVIP funding for FY20-21. <sup>9</sup>
<b>Carl Moyer and AB 923</b>	State/CARB	Funding to help procure low-emission vehicles and equipment. Transit buses are eligible for up to \$80,000 funding.	The Sacramento Metro AQMD is currently not accepting applications, but Elk Grove should continue to monitor for when the AQMD opens the application period again. <sup>10</sup>	Average: \$29,578.02 <sup>11</sup>
<b>Caltrans Transportation Planning Grants – Adaptation Planning Grants</b>	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 <sup>12</sup>
<b>Caltrans Transportation Planning Grants - Strategic Partnership Grants</b>	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 <sup>13</sup>

<https://www.transportation.gov/BUILDgrants>

<https://www.transportation.gov/sites/dot.gov/files/2020-09/BUILD%202020%20Fact%20Sheets-.pdf>

<sup>8</sup> <https://www3.arb.ca.gov/msprog/lct/hvip.htm>. Voucher amount is per vehicle

<sup>9</sup> [https://www2.arb.ca.gov/sites/default/files/2020-11/proposed\\_fy2020-21\\_fundingplan.pdf](https://www2.arb.ca.gov/sites/default/files/2020-11/proposed_fy2020-21_fundingplan.pdf)

<sup>10</sup> <http://www.airquality.org/businesses/incentive-programs/carl-moyer-program>

<sup>11</sup> Average award amount for South Coast AQMD on-road vehicle projects between 2008 and 2019

<sup>12</sup> <https://dot.ca.gov/-/media/dot-media/programs/transportation-planning/documents/final-2021-award-listcopya11y.pdf>

<sup>13</sup> <https://www.grants.ca.gov/grants/strategic-partnerships/>

Fund/Grant	Level of government	Description	Applicability	Average/ Maximum Award Amount
<b>State Transportation Improvement Program (STIP)</b>	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 <sup>14</sup>
<b>Sustainable Transportation Equity Project (STEP)</b>	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, or local government representing a public transit agency.	The application window closed as of August 31, 2020. It is unclear whether more funding will be made available in the Low Carbon Transportation Funding Plan for 2020-21.	\$1.75 million available for Planning and Capacity Building grants, \$17.75 million available for Implementation grants. <sup>15</sup> Award amounts ranged from \$184,000 to a maximum of over \$7 million. <sup>16</sup>
<b>Low Carbon Transit Operations Program (LCTOP) and Transit and Intercity Rail Capital Program (TIRCP)</b>	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. <sup>17</sup>	LCTOP average: \$912,840 LCTOP median: \$193,572 <sup>18</sup> TIRCP average: \$6,027,500 TIRCP median: \$6,225,500 <sup>19</sup>
<b>SB1 State of Good Repair</b>	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. <sup>20</sup>	Average: \$560,197 Median: \$104,210 <sup>21</sup>
<b>SB1 Local Partnership Program (LPP)</b>	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,	SB1 created the LPP and continuously appropriates \$200 million annually to local and regional transportation agencies that are within jurisdictions with	Maximum formulaic funding amount: \$37,506,000 <sup>22</sup>

<sup>14</sup> <https://catc.ca.gov/-/media/ctc-media/documents/programs/stip/2020-stip/2020325-2020-stip-resolution-a11y.pdf>

<sup>15</sup> <https://ww2.arb.ca.gov/news/grant-awards-announced-new-195-million-pilot-funding-equitable-clean-transportation-options>

<sup>16</sup> <https://ww2.arb.ca.gov/our-work/programs/low-carbon-transportation-investments-and-air-quality-improvement-program-1>

<sup>17</sup> <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>

<sup>18</sup> LCTOP average and median award amount from FY 2019-20 Awarded Project List

<sup>19</sup> 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

<sup>20</sup> <https://dot.ca.gov/programs/rail-and-mass-transportation/state-transit-assistance-state-of-good-repair>

<sup>21</sup> Average and median award amounts from FY2020-21 approved project list

<sup>22</sup> 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.



Fund/Grant	Level of government	Description	Applicability	Average/ Maximum Award Amount
		aging infrastructure, and more. Funds are distributed to eligible agencies through a 60% formulaic component and 40% competitive component.	voter approved taxes, tolls, or fees which are dedicated solely for transportation improvements.	
<b>Solutions for Congested Corridors Program (SCCP)</b>	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 <sup>23</sup>
<b>Affordable Housing and Sustainable Communities Program (AHSC)</b>	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 disadvantaged communities through increasing accessibility via low-carbon transportation. The program distributed \$193 million for transportation projects in FY18-19.	Sustainable transportation infrastructure projects, transportation-related amenities, and program costs (including transit ridership) are eligible activities. Agencies can use program funds for assistance in construction or modification of infrastructure for ZEB conversion as well as new vehicle purchases.	Maximum award amount is not to exceed \$30 million per project. Average: \$7,757,862 Median: \$7,557,513 <sup>24</sup>
<b>VW Environmental Mitigation Trust Funding</b>	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 <sup>25</sup>
<b>Community Air Protection (CAP)</b>	Regional/ Sacramento Metro AQMD	Funding is being implemented through Carl Moyer Program and Goods Movement Emission	Transit agencies in the Sacramento Metro AQMD can apply to receive funding for	In FY2019-2020, over \$13 million were distributed to eligible projects.

<sup>23</sup> <https://www.grants.ca.gov/grants/solutions-for-congested-corridors-program/>

<sup>24</sup> 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>

<sup>25</sup> <http://vwbusmoney.valleyair.org/documents/FAQ.pdf>

Fund/Grant	Level of government	Description	Applicability	Average/ Maximum Award Amount
<b>Program Incentives</b>		Reduction Program funds allocated to the Sacramento Metro AQMD to help public agencies and businesses purchase less polluting and zero-emission equipment and infrastructure.	electric charging infrastructure. Sacramento Metro AQMD has noted that the application period for 2021 will be open from March 29-May 28, 2021.	For FY2019-2020, SacRT received \$194,885 for electric charging infrastructure to support its fleet transition to ZE vehicles. <sup>26</sup>
<b>Low Carbon Fuel Standard (LCFS credits)</b>	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. Both hydrogen and electricity used as fuels are eligible for LCFS credits	Credit prices range, but average credit price between 2016 and 2019 was between \$65 and \$200 per credit Average: \$10,000 per vehicle <sup>27</sup>

## Section I: Start-up and Scale-up Challenges

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N/A

## Appendix

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Resolution/Council Approval

Full Rollout Plan/any other relevant documents or reports

<sup>26</sup> <http://www.airquality.org/air-quality-health/community-air-protection/community-air-protection-program-incentives/cap-projects>  
Only eligible for agencies in the Sacramento Metro AQMD

<sup>27</sup> <https://www.sretrade.com/markets/lcfs/california>  
Assuming 40,000 miles/year at \$100 per credit per 2018 amendments

**APPENDIX B: CUTRIC FLEET ELECTRIFICATION ANALYSIS FINAL REPORT**



# e-tran

## Fleet Electrification Analysis Final Report

November 16, 2020

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## Disclaimer

CUTRIC's modeling is a predictive simulation and not based on empirical evidence. It is expected to have discrepancies to a certain extent between model predictions and real world operations.





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## List of Acronyms

DEM	digital elevation model
BEBs	battery electric buses
CNG	compressed natural gas
CSV	comma separated values
CUTRIC	Canadian Urban Transit Research and Innovation Consortium
EV	electric vehicle
FCEBs	fuel cell electric buses
GIS	geographic information system
NR	non-revenue
GTFS	general transit feed specification
SOC	state of charge
ZEB	zero emission bus





## 1 – Introduction

Recent technology advances in battery-electric buses (BEBs) and fuel cell electric buses (FCEBs) make transit fleet electrification possible without the use of overhead catenaries. The substitution of fossil fuel vehicles with zero emission alternatives can potentially bring significant reductions in greenhouse gas (GHG) emissions, especially in jurisdictions where electricity and/or hydrogen could be generated using green sources. Moreover, electric buses may present lower operational costs and lower maintenance costs [1].

The Canadian Urban Transit Research and Innovation Consortium (CUTRIC) performed a vehicle-based modeling analysis for the e-tran system. In this analysis, CUTRIC used its proprietary RoutΣ.i™ simulation tool. The outcomes of this study include predictions of total energy (electricity and hydrogen) for full fleet electrification at e-tran along with energy efficiencies for BEB and FCEB systems. The study also compares GHG emissions among different vehicle configurations with various fuel sources.





## 2 – RoutΣ.i™ simulation tool

This section describes the methodology of the study. The methodology explains the necessary input data as well as the critical stages of data processing and analysis. This section also summarizes the energy consumption outcomes.

### 2.1 – Analysis of transit routes

To aid transit agencies in reducing the complexities involved in planning fleet electrification, CUTRIC has developed a simulation tool (i.e. RoutΣ.i™) which models various types of Zero-Emission Buses (ZEBs) and predicts the overall performance applied to blocks/vehicles or routes. The outcomes of the RoutΣ.i™ tool include energy usage, energy efficiency, electricity costs, and GHG emission reductions associated with the substitution of compressed natural gas (CNG) vehicles with zero-emission alternatives.

The RoutΣ.i™ modeling tool is comprised of three main parts:

1. Geographic information system (GIS) modeling
2. Duty cycle generation
3. Energy consumption calculations and analysis

Several sets of input data such as route geometry, terrain topography, traffic impediments, and speed profile along with vehicle and charger specifications are integrated into the modeling methodology to calculate the energy consumption of various ZEB configurations.

To model e-tran full fleet operations, CUTRIC identified a total of 38 active vehicles during weekdays. Due to inconsistencies in input data, CUTRIC could not simulate the performance of vehicle 838 along with the rest of fleet. Instead, the performance of vehicle 838 is estimated using the performance of a similar vehicle (vehicle 848) that covers comparable revenue and non-revenue mileage<sup>1</sup> during its operation. This estimation determines that all the results for vehicle 848 are considered to be the same for vehicle 838.

### 2.2 – GIS modeling

The GIS modeling requires four separate data types to describe drive cycles for a bus following its schedule. These data inputs are:

1. Transit schedules
2. Traffic impediments
3. Speed limits
4. Topography

---

<sup>1</sup> Vehicle 838 runs 176 miles and vehicle 848 runs 166 miles on the sampled day.





A more detailed explanation of these inputs is given below.

### 2.2.1 – Transit schedules

The RoutΣ.i™ tool is designed to work with transit scheduling data in standard general transit feed specification (GTFS) format, which includes essential elements such as polylines representing the course of a bus along a given route and a given service (e.g. weekday). It also describes the bus stops along that route, the scheduled stop times and the sequence of routes a bus makes in its allocated “block” (e.g. during a shift a bus might execute Route 111 ten times). e-tran provided the GTFS data as a collection of CSV files connected by CUTRIC through the correction of primary and foreign indices followed by the execution of complex queries.

### 2.2.2 – Traffic impediments

In addition to scheduled bus stops, the RoutΣ.i™ tool also includes traffic impediments such as stop signs and pedestrian crossings to accurately model the duty cycle along a given block. Ideally, transit agencies provide such data, but CUTRIC has designed a methodology by which traffic impediments can be expediently digitized from satellite imagery when the data are not provided. In this project, e-tran provided necessary traffic impediments data.

### 2.2.3 – Speed limits

The RoutΣ.i™ tool also requires speed limit data to accurately model the duty cycle of a bus. e-tran provided a portion of speed limit data in the form of line segments delineating speed zones. CUTRIC digitized and interpolated the missing speed zones.

### 2.2.4 – Topography

To accurately model gradient changes of the road, the RoutΣ.i™ tool combines topographic data with bus polylines as discussed above. Concatenating a series of polylines with elevation data and associating them with a given vehicle produces a simulation of the actual incline experienced by a bus as it travels around the blocks. CUTRIC uses DEM data with 98-ft resolution and obtains 88-ft precision by interpolation of the DEM data.

A significant portion of the operational load on a BEB, performing on a particular route, is obtained through the concatenation of topographic profiles, traffic impediments, and scheduled and unscheduled stops.

### 2.2.5 – Non-revenue mileage

To calculate the energy consumption for non-revenue (NR) distances, CUTRIC relies on the summary statistics of total NR distances to create separate route profiles to simulate these distances for each vehicle. CUTRIC takes the following steps to accomplish this task:

1. Identifying the total NR distances for each vehicle using provided tables, and





- 2. Generating NR route profiles and speed profiles for each active vehicle during weekdays.

As **Table 1** shows, each vehicle, depending on its total NR mileage, is assigned to one of the five NR routes. For example, the modeling tool assigns route B to all the vehicles with total NR distances between 8.4 miles and 31.2 miles.

**Table 1:** NR route assignment for vehicles

NR route	Range	Vehicle assignments
A	8.4 miles	Blocks with the total NR distances of < 8.4 miles
B	31.2 miles	Blocks with the total NR distances of 8.4 miles ≤ OR < 31.2 miles
C	46.4 miles	Blocks with the total NR distances of 31.2 miles ≤ OR < 46.4 miles
D	58.6 miles	Blocks with the total NR distances of 46.4 miles ≤ OR < 58.6 miles
E	68.3 miles	Blocks with the total NR distances of ≤ 58.6 miles

### 2.3 – Duty cycles

In this analysis, two different duty cycles are used to represent two different scenarios (i.e. medium-duty cycle (average) and heavy-duty cycle (least energy efficient)).

In the medium-duty cycle, the bus drives according to the speed limit of the road and stops at half of the bus stops and other optional stops along its route, but at all of the stop signs. The passenger load data provided by e-tran and the auxiliary loads are simulated to draw half of the maximum power. Figure 1 shows the medium-duty cycle example of vehicle 560 while Figure 3 shows the medium-duty cycle example of vehicle 563. The road topography presents striking differences for these two vehicles.

The heavy-duty cycle represents the most energy-intensive service usage periods like those that occur during the rush hours during a hot summer day. In the heavy-duty cycle, the bus is simulated to run according to the speed limit of the road with the passenger load during rush hours drawing the maximum auxiliary load. The bus stops at all stopping opportunities on the road. Figure 2 and Figure 4 show the example heavy-duty cycles for vehicle 560 and vehicle 563, respectively. As the heavy-duty cycles contain more stops than the corresponding medium-duty cycles, longer simulated service times result.





In this analysis, the model generates a total number of 76 duty cycle files for the service of a weekday and 10 duty cycle files for NR mileages.

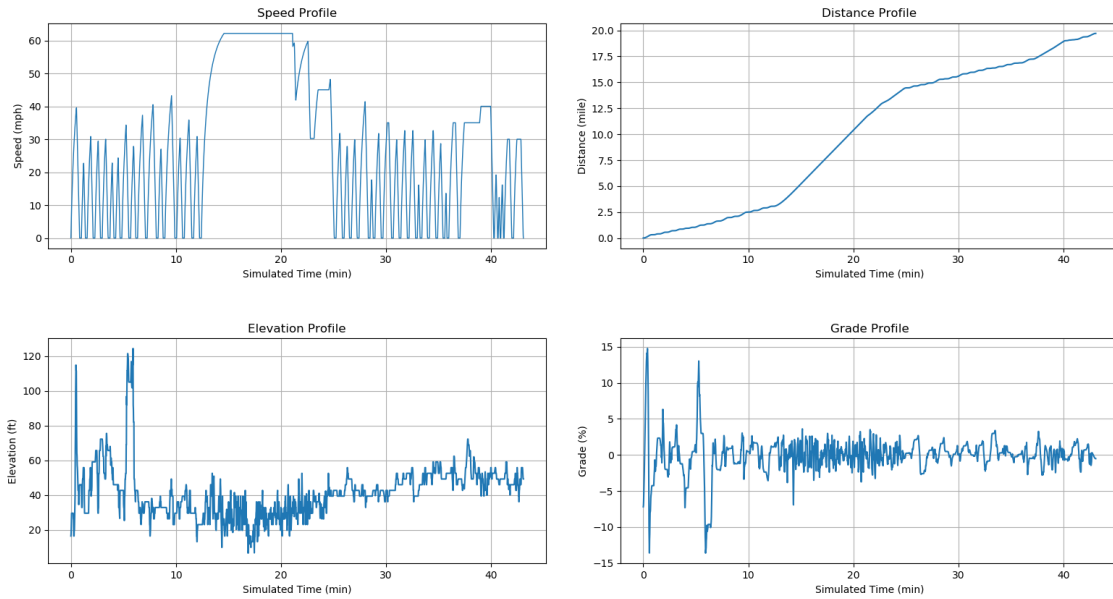


Figure 1. Medium-duty cycle for vehicle 560.

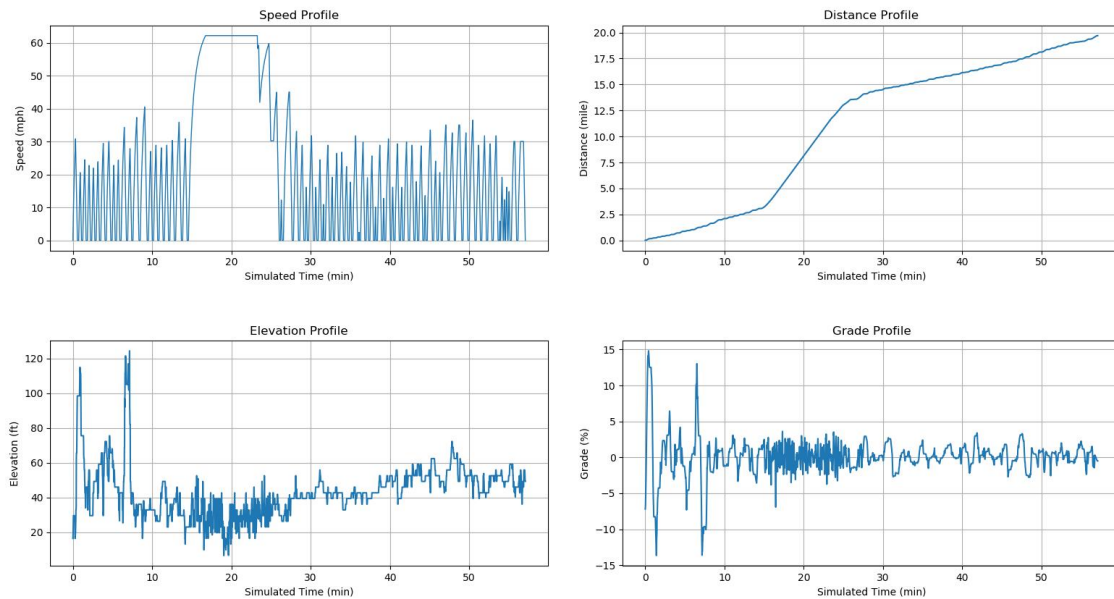


Figure 2. Heavy-duty cycle for vehicle 560.



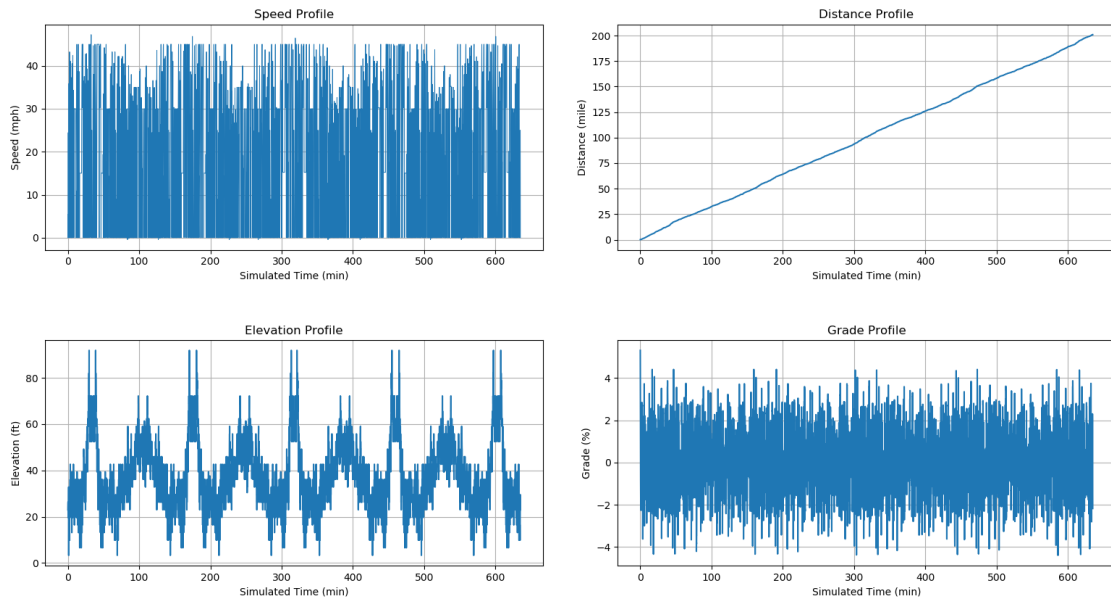


Figure 3. Medium-duty cycle for vehicle 563.

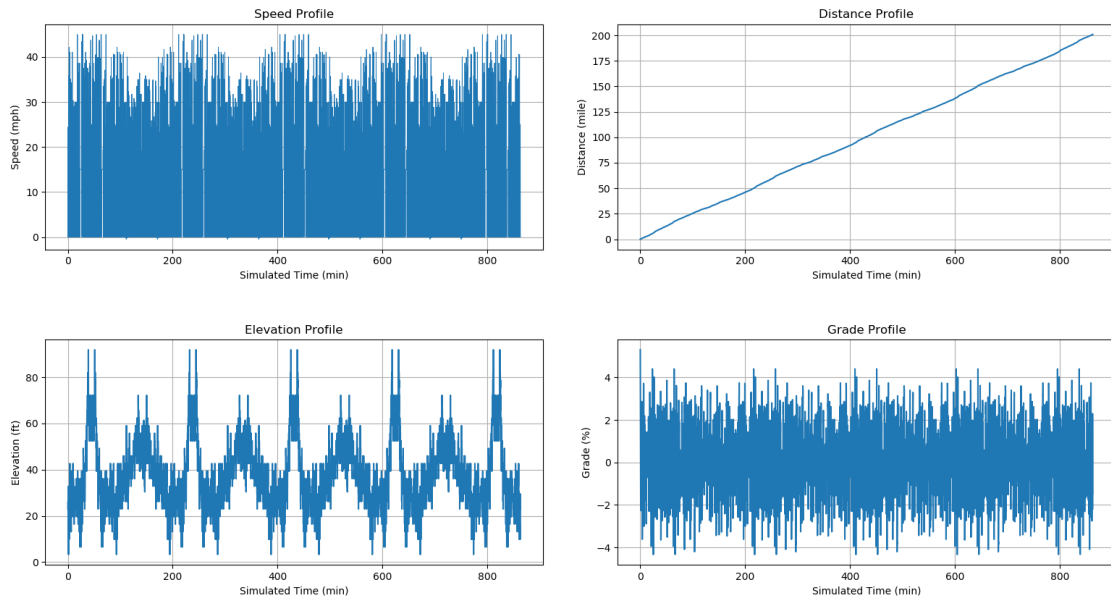


Figure 4. Heavy-duty cycle for vehicle 563.





### 3 – Energy consumption analysis results

The simulation uses three different 40-foot BEB configurations listed in **Table 2**. Bus 1 and Bus 2 are BEBs that have the capabilities of using both depot and opportunity chargers. The depot-only charging bus configurations present almost the same physical properties as the depot with opportunity charging leading to similar results in terms of energy efficiency and energy usage. For all charging processes, the model uses a 90+ percent efficiency. Bus 3 is an FCEB.

**Table 2.** Simulated bus configurations with the battery size or hydrogen storage.

	Bus 1 (Depot & opportunity charging)	Bus 2 (Depot & opportunity charging)	Bus 3 (Fuel cell electric)
Battery	400+ kWh	600+ kWh	90+ kWh
Hydrogen	N/A	N/A	30+ kg

#### 3.1 – Depot-only charging electric BEBs

**Table 3** summarizes the overall energy efficiency of Bus 1 and Bus 2 for medium- and heavy-duty cycles of a weekday. **Table 4** shows the total required electricity from the electricity grid on each instance modeled: Weekday, Saturday and Sunday.<sup>2</sup> As there is a 90+ percent charging efficiency in the charging process, the energy received by the BEBs is 90+ percent of the values in **Table 4**.

**Table 3.** The average energy efficiency for weekday using depot-only charging BEBs.

	Bus 1 (400+ kWh)		Bus 2 (600+ kWh)	
Unit: kWh/mile	Medium	Heavy	Medium	Heavy
Weekday	2.21	3.02	2.18	2.97

<sup>2</sup> The energy usage of one Saturday is equivalent to 25 percent of the energy usage of one Weekday; the energy usage of one Sunday is equivalent to 10 percent of the energy usage of one Weekday.



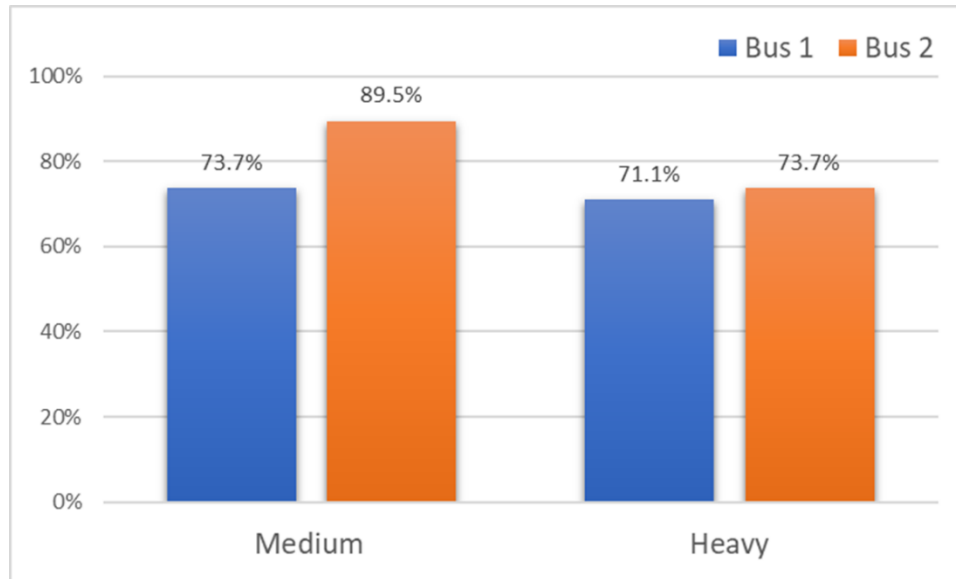


**Table 4.** The total required electricity for Weekday, Saturday and Sunday using depot-only chargers.

Unit: kWh	Bus 1 (400+ kWh)		Bus 2 (600+ kWh)	
	Medium	Heavy	Medium	Heavy
Weekday	12,000	16,400	11,800	16,100
Saturday*	3,000	4,100	3,000	4,000
Sunday*	1,200	1,600	1,200	1,600

\*Results from Saturday and Sunday are estimated based on the results of a weekday.

Figure 5 displays the success rates of a weekday for a one-to-one replacement of CNG buses with the simulated BEBs using depot-only chargers. The criterion for determining whether a BEB can successfully replace a CNG bus is based on the battery state of charge (SOC) threshold. If the battery SOC drops below the 20 percent mark at any time during the service, the BEB is not considered successful in replacing the CNG bus on a one-to-one basis.



**Figure 5.** Success rates of a one-to-one replacement of CNG buses with BEBs using depot-only chargers (weekday services).





### 3.2 – Depot with opportunity charging BEBs

The results of depot-only charging BEBs show that this strategy of only charging in-depot cannot replace all CNG buses on a one-to-one basis. The situation worsens when a battery degrades after years of operation. Thus, adding opportunity chargers is important to improve the success rates. The opportunity chargers are assumed to operate at a power level of 400+ kW, with 90+ percent efficiency. In this simulation analysis, the BEBs are only allowed to receive an opportunity charging episode with a maximum duration of five minutes for every round trip. Each five-minute opportunity charging episode can add about 34 kWh energy into the battery, equivalent to about 11 to 15 extra miles depending on the road and duty cycle. Nevertheless, in some cases the BEBs do not need to use the full five minutes to fully charge their batteries.

**Table 5** shows the average efficiencies for Bus 1 and Bus 2 on weekday. **Table 6** summarizes the total required electricity from the grid for each day of the week. Similarly, the results for each Saturday and Sunday are estimated as fixed fractions (25 percent and 10 percent, respectively) of the results of a weekday. The results show that heavy-duty cycles consume more energy per mile than corresponding medium-duty cycles. With more passengers onboard, more stops on the road and higher auxiliary load than the corresponding medium-duty cycles, heavy-duty cycles use significantly more energy than medium-duty cycles. Bus 2 has a bigger size battery but is more efficient than Bus 1 under the same duty cycle and the lower overall weight of Bus 2 contributes to this effect.

**Table 5.** The average energy efficiency for weekday using depot and opportunity charging BEBs.

	Bus 1 (400+ kWh)		Bus 2 (600+ kWh)	
Unit: kWh/mile	Medium	Heavy	Medium	Heavy
Weekday	2.22	3.03	2.18	2.97

**Table 6.** Total required electricity for Weekday, Saturday and Sunday using depot and opportunity chargers.

	Bus 1 (400+ kWh)		Bus 2 (600+ kWh)	
Unit: kWh	Medium	Heavy	Medium	Heavy
Weekday	12,000	16,400	11,800	16,100
Saturday*	3,000	4,100	3,000	4,000
Sunday*	1,200	1,600	1,200	1,600

\*Results from Saturday and Sunday are estimated based on the results of a weekday.





Figure 6 illustrates the success rates when both depot and opportunity charging episodes are utilized. These success rates display significant increases from those of depot-only charging BEBs. The medium-duty cycle operations reach 100 percent of success when opportunity charging is employed. To provide an estimation of the absolute worst case energy utilization scenario, the results of heavy-duty cycles are calculated based on the assumption that the operation of the entire day is under rush hour conditions with extremely hot temperatures, such as 90 degrees F and above. That the success rates are equal or close to 100 percent seem likely even for the most challenging scenarios if opportunity charging is included.

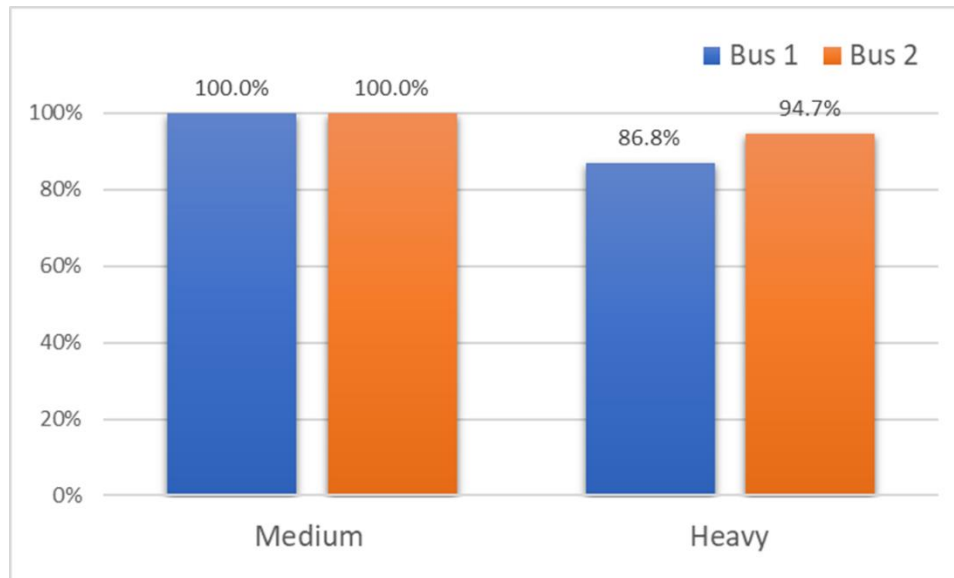


Figure 6. Success rates of a one-to-one replacement of CNG buses with BEBs using depot and opportunity chargers (weekday services).

### 3.3 – Fuel cell electric buses

Fuel cell modules on FCEBs generate electric power to charge the battery keeping the SOC at optimal levels throughout the vehicle operation. This mode of operation makes FCEBs, in essence, BEBs with a fuel cell range extender. When an FCEB is in operation, its battery SOC generally drops significantly once the hydrogen in the tank is completely depleted.

However, for operational instances of very prolonged and demanding loads, the charging power of the fuel cell module is not able to meet the requirement of producing the combined power draw for the electric motor and for the auxiliary loads. This power draw causes a continuous SOC drop, possibly below the 20 percent threshold, even if there is still hydrogen left in the tank. Factors such as challenging topography, long high-speed road sections, high passenger loads and high usage of auxiliary loads can potentially disrupt the balance between demand and production of





electrical power drawing the battery below the 20% threshold before the depletion of the hydrogen tank.

In all simulation instances, the 20 percent SOC threshold is used as the criterion for deciding whether the FCEB is able to complete the required block regardless of whether there is hydrogen remaining in the tank.

**Table 7** shows the average hydrogen consumption rate of Bus 3. **Table 8** summarizes the total amount of hydrogen consumption on each weekday, Saturday and Sunday. Again, the results for Saturday and Sunday are calculated based on the weekday outcome.

**Table 7.** The average consumption rate of hydrogen.

Unit: mile/kg	Medium	Heavy
Weekday	7.09	5.19

**Table 8.** The total hydrogen consumption for Weekday, Saturday and Sunday.

Unit: kg	Medium	Heavy
Weekday	700	950
Saturday*	180	240
Sunday*	70	100

\*The results for Saturday and Sunday are estimated based on the results of a weekday.

Figure 7 shows the success rates of a one-to-one replacement of CNG buses with Bus 3. The success rates of Bus 3 are in between the results of depot-only charging BEBs and depot with opportunity charging BEBs. Considering that refiling of an FCEB takes about 10 minutes [2], the success rates can reach 100 percent if the FCEBs can receive one or more refills during the day.



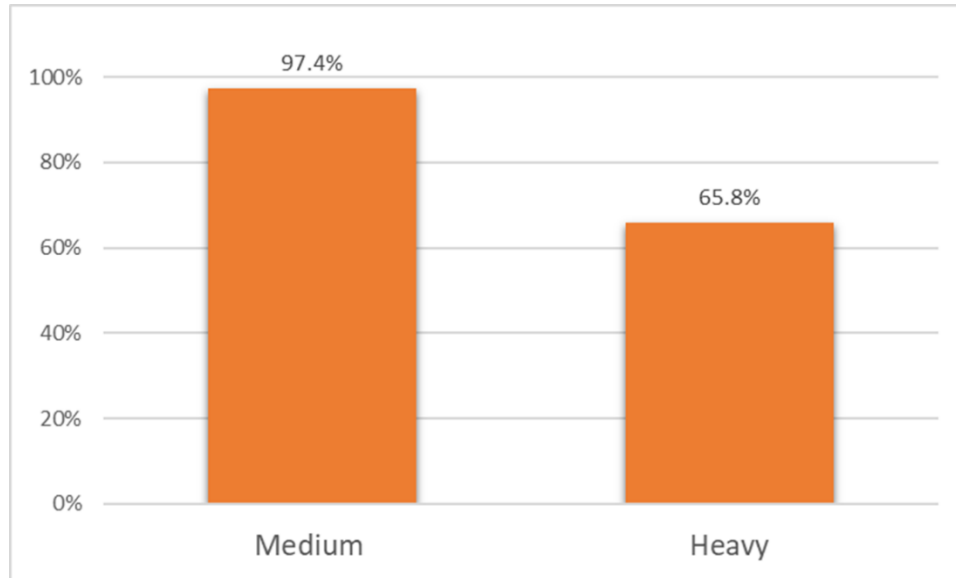


Figure 7. Success rates of a one-to-one replacement of CNG buses with Bus 3 based on weekday service.

In the heavy-duty cycle simulation, five vehicles fail to complete the weekday service. This failure is not due to a lack of hydrogen, but because the charging power of the fuel cell module cannot match the combined power draw of the motor and auxiliary loads. Enabling the FCEBs to have more downtime so that the fuel cell modules can have more time to charge the batteries may be a reasonable consideration for e-tran.





## 4 – GHG analysis

This study also includes a comparative analysis of the GHG emissions for current CNG buses and prospective zero emission alternatives, including BEBs and FCEBs. Only conventional CNG is considered in this study.

### 4.1 CNG buses

Based on the data sent by e-tran, the total natural gas usage is 27,439 gasoline gallon equivalent for the month of February 2020. The natural gas usage is equivalent to  $3.3 \times 10^{12}$  J of energy, assuming that each gallon of gasoline contains about 33.41 kWh energy [3]. Extrapolating from the February fuel usage data, the energy usage for the year 2020 (366 days) is found to be around  $41.6 \times 10^{12}$  J.

According to research conducted by the Argonne National Laboratory [4], the life-cycle of GHG emissions for conventional CNG, used for the estimations in this work, is about 100 g CO<sub>2</sub>e/MJ on a 20-year time horizon. **Table 9** provides the annual GHG emissions for CNG buses using conventional CNG.

**Table 9.** The annual GHG emissions for CNG buses.

Unit: Ton	Conventional CNG (Full fleet)
Annual GHG Emissions	4,600

### 4.2 Battery electric buses

BEBs do not emit GHGs directly from their tail pipe; however, the electricity generation process results in GHG emissions. According to the California Air Resources Board, the generation of electricity in California in the year 2017 resulted in the emission of 0.22 tonne CO<sub>2</sub>e per MWh [5].

As the fuel usage data provided reflects average fuel efficiency, the results of BEBs under medium-duty cycles are used for comparison. **Table 10** shows the annual electricity usage for Bus 1 and Bus 2 with their corresponding GHG emissions. Electricity usage is based on Table 4 and 52 weeks are assumed to be present in each year.





**Table 10.** The annual electricity usage and corresponding GHG emissions based on medium-duty cycles.

	Bus 1 (Full fleet)	Bus 2 (Full fleet)
Annual Electricity Usage (MWh)	3,300	3,300
Annual GHG Emissions (Ton)	800	800

### 4.3 Fuel cell electric bus

To ensure consistency in comparison by using the same type of duty cycle as the BEBs, the results of FCEBs under medium-duty cycles are used to calculate the GHG emissions. Similar to BEBs, FCEBs do not emit GHG directly. However, generating hydrogen could result in GHG emissions. In general, two common ways to generate hydrogen exist (i.e. electrolysis and steam methane reforming (SMR) processes).

For electrolysis, the average efficiency of large-scale production plants is between 70 to 75 percent while the efficiency of smaller systems can reach 80 to 85 percent [3]. This analysis uses 80 percent efficiency for calculation. Based on this efficiency, approximately 49 kWh of electricity is required to generate one kilogram of hydrogen. **Table 11** summarizes the annual hydrogen usage with its corresponding electricity usage and GHG emissions.

**Table 11.** The annual hydrogen generation by electrolysis with corresponding electricity usage and GHG emissions.

	Bus 3 (Full fleet)
Annual Hydrogen Usage (kg)	195,000
Annual Electricity Usage (MWh)	9,600
Annual GHG Emissions (Ton)	2,300

The SMR process emits about 10 kg CO<sub>2</sub> for producing one kilogram of hydrogen [6]. **Table 12** shows the annual GHG emissions for using hydrogen produced by the SMR process.





**Table 12.** The annual hydrogen production by the SMR process with corresponding GHG emissions.

Bus 3 (Full fleet)	
Annual Hydrogen Usage (kg)	195,000
Annual GHG Emissions (Ton)	2,200

Figure 8 displays the GHG emissions of all buses enabling a visual comparison. In general, BEB usage results in the lowest GHG emissions. Although using FCEBs results in about three times the emissions from BEBs, the GHG emissions from FCEBs are still half of the emissions from CNG buses using conventional CNG. As the grid has been cleaner in California over the years [5], the GHG emissions from both BEBs and FCEBs using electrolysis will continue to decline in the future.

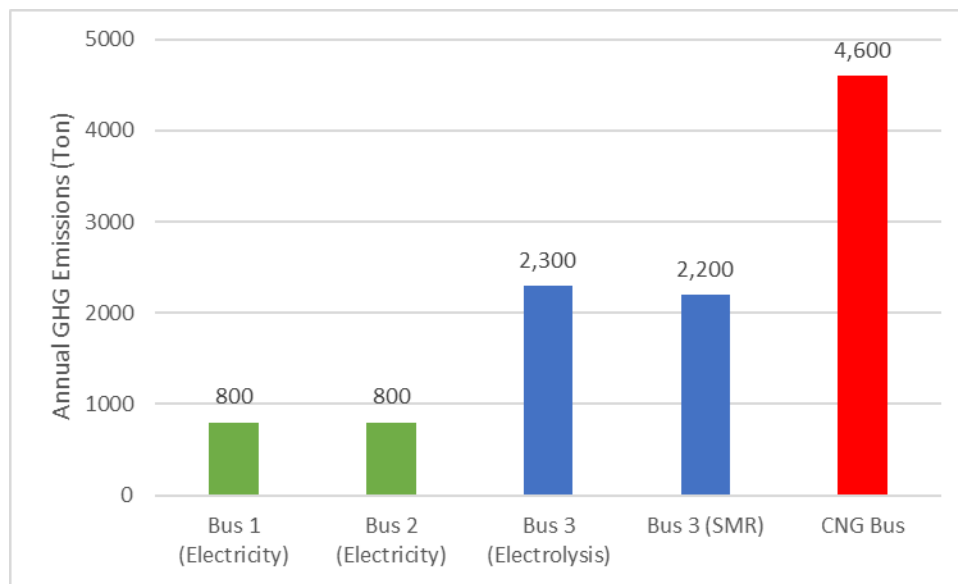


Figure 8. Annual GHG emission comparison among different types of buses.





## 5 – Conclusion

CUTRIC conducted a highly robust and comprehensive modeling analysis to predict the performance of BEBs and FCEBs on the e-tran transit system. The analysis assesses two major charging strategies: depot-only and depot with opportunity charging. This study also assesses two principal hydrogen generation methodologies (i.e. electrolysis and a SMR process).

The simulation analysis provides key electrification guidance information on the fuel efficiency of BEBs and FCEBs, total electricity usage and hydrogen consumption that e-tran needs to plan for to fully electrify their fleet, and the degree of success expected for a one-to-one replacement of CNG buses. The simulation analysis clearly demonstrates that electrification that replaces all CNG buses in the e-tran system fleet with BEBs using different charging strategies and FCEBs is highly feasible.

Additionally, the GHG emission analysis further establishes a strong environmental business case for the integration of BEBs as they have the lowest GHG emissions. Although FCEBs emit about two times more GHG than BEBs, the GHG emission reduction achieved is still statistically significant when compared to what CNG buses emit.





## References

- [1] K. K. N. Quarles, M. Mohamed, "Costs and Benefits of Electrifying and Automating Bus Transit Fleets," *Sustainability*, vol. 12, 2020.
- [2] L. Eudy and M. Post. (December 2018, 2019-12-01). *Fuel Cell Buses in U.S. Transit Fleets: Current Status 2018*. Available: <https://www.nrel.gov/docs/fy19osti/72208.pdf>
- [3] Ronald M. Dell, Patrick T. Moseley, and D. A. J. Rand, "Chapter 8 - Hydrogen, Fuel Cells and Fuel Cell Vehicles," in *Towards Sustainable Road Transport*, P. T. M. Ronald M. Dell, David A.J. Rand, Ed.: Academic Press, 2014, pp. 260-295.
- [4] Andrew Burnham, Jeongwoo Ham, Corrie E. Clark, Michael Wang, Jennifer B. Dunn, and I. Palou-Rivera, "Life-Cycle Greenhouse Gas Emissions of Shale Gas, Natural Gas, Coal, and Petroleum," *Environ. Sci. Technol.*, vol. 46, pp. 619-627, 2012.
- [5] "Global and China Fuel Cell Industry Chain Report , 2019-2025," 2019.
- [6] "British Columbia Hydrogen Study," ZEN, British Columbia 2019, Available: <https://bcbioenergy.ca/resources/bcbsn-publications/british-columbia-hydrogen-study/>.



**APPENDIX C: MASTER SITE PLANS**

**EXISTING SERVICE CYCLE:**

- 1. PARK
- 2. WASH
- 3. FARE
- 4. PARK
- 5. ROLL-OUT

**CURRENT PARKING:**

- (59) STANDARD 40' BUSES (STRIPED SPACES)
- (12) CUTAWAY SPACES

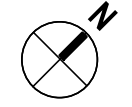


E-TRAN ZEB FACILITY MASTER PLAN  
10250 IRON ROCK WAY, ELK GROVE, CA

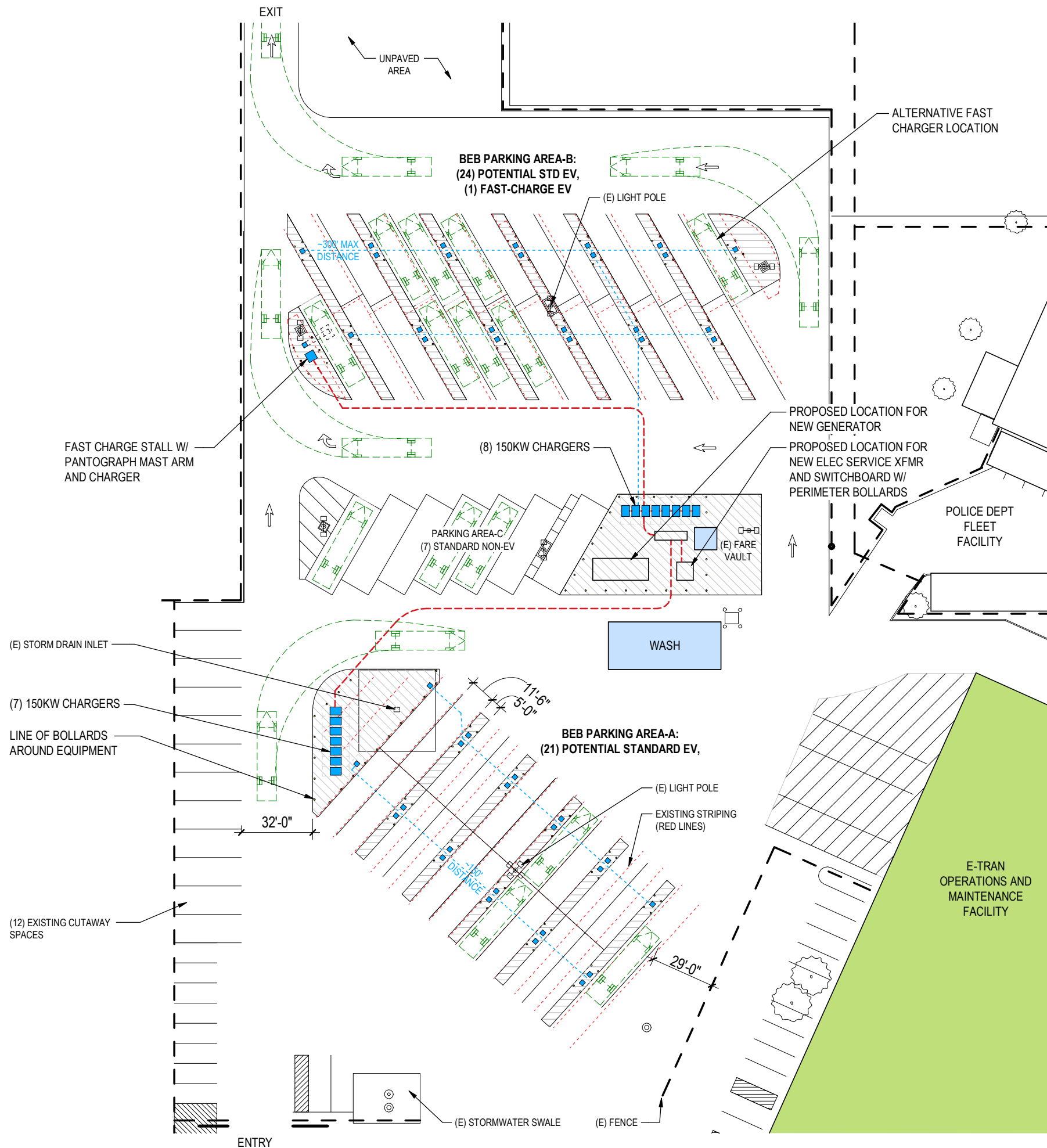
E-TRANS FACILITY  
EXISTING CONDITION PLAN

DATE:  
5/12/21

DWG:



**1.0**



**NOTES:**

- OPTION 1 SUMMARY: REMOTE CHARGERS W/ GROUND MOUNTED, PEDESTAL DISPENSERS.
- ASSUMES 1:3 CHARGER TO DISPENSER RATIO AND THAT DISPENSERS CAN NOT EXCEED A 450' DISTANCE FROM CHARGER BASE
  - LAYOUT ASSUMES 5-FOOT CLEAR AISLE NEEDED BETWEEN EVERY OTHER PARKING STALL FOR DISPENSERS AND BOLLARD CLEARANCE
  - LAYOUT PRESERVES CURRENT OPERATIONAL FLOW OF TRAFFIC AND PARKING CONFIGURATION W/ DRIVE-THROUGH STALLS
  - LAYOUT PROVIDES FOR UP TO (45) POTENTIAL STANDARD BEB CHARGING CAPABLE PARKING SPACES IN JUST PARKING AREAS-A & B. ADDITIONAL CHARGING CAPABLE SPACES COULD BE PROVIDED IN AREA-C OR WITHIN UNPAVED AREA TO THE NORTH OF AREA-B ALONG EXIT DRIVE.
  - (1) 600kW FAST CHARGER LOCATED AT EDGE OF PARKING AREA-A FOR EASY PULL-IN AND PULL-OUT FOR MIDDAY CHARGING.
  - LOSS OF (6) TOTAL 40' BUS SPACES
  - PHOTOVOLTAIC CANOPIES NOT REQUIRED
  - ALL EXISTING LIGHT POLES TO REMAIN IN PLACE

**PROPOSED FLEET PARKING:**

- (52) STRIPED 40' BUS PARKING TOTAL
- (44) EV SPACES
  - (7) NON-EV SPACES

**ASSUMPTIONS:**

- (46) TOTAL 40' BUS FLEET  
(39) ACTIVE 40' BUSES DURING THE DAY

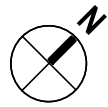
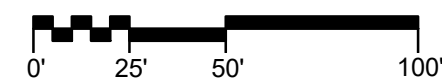
1:3 STANDARD CHARGER TO DISPENSER RATIO:  
(13) MIN TOTAL QTY OF CHARGERS (W/ 10% CONTINGENCY)  
= (39) TOTAL QTY OF DISPENSERS  
+ (1) 600kW FAST CHARGER W/ INVERTED PANTOGRAPH

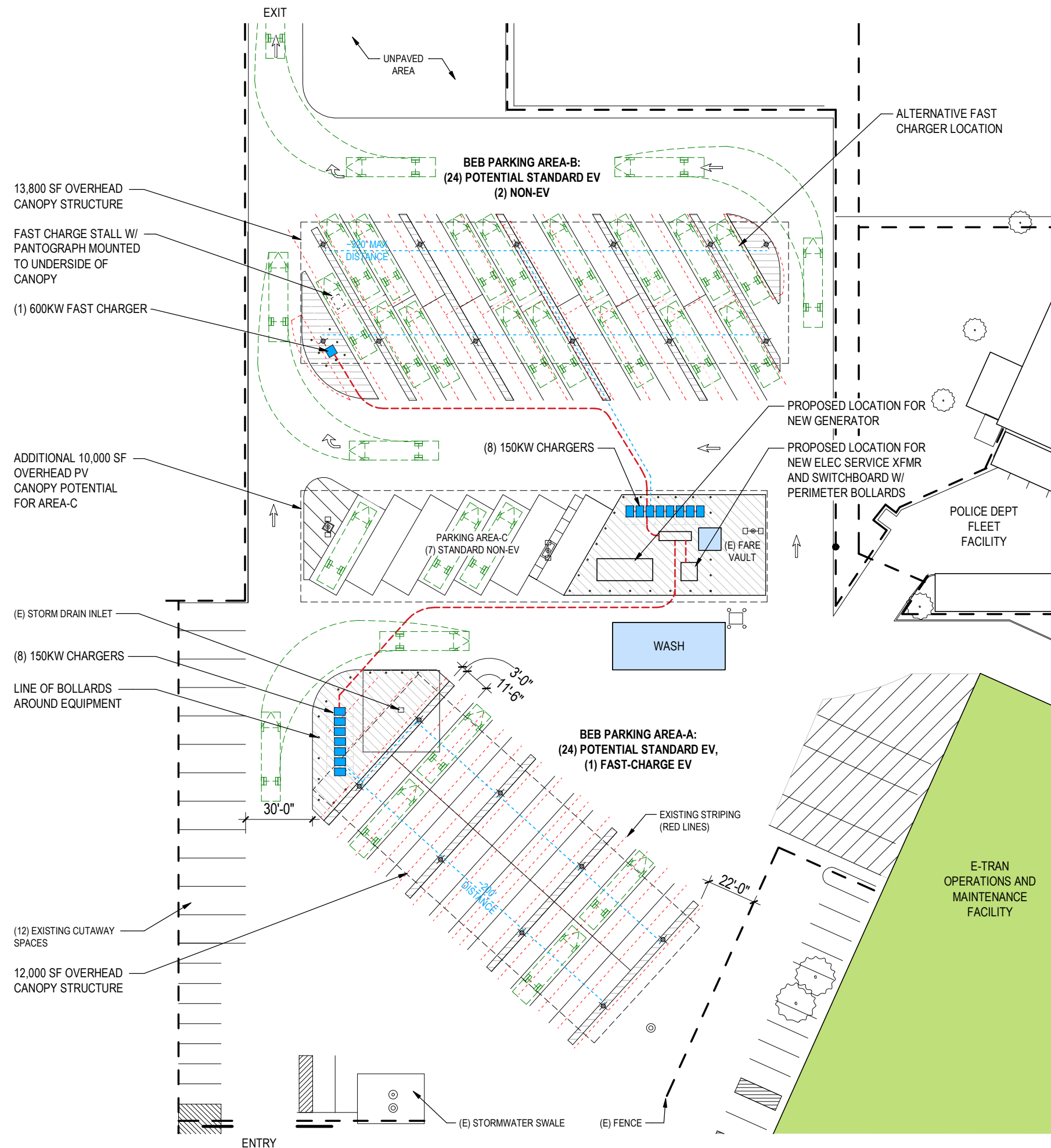
E-TRAN ZEB FACILITY MASTER PLAN  
10250 IRON ROCK WAY, ELK GROVE, CA

E-TRANS FACILITY  
MASTER PLAN OPTION 1

DATE:  
5/12/21

DWG:





**NOTES:**

OPTION 2 SUMMARY: REMOTE CHARGERS W/ OVERHEAD MOUNTED, DISPENSER REELS.

- ASSUMES 1:3 CHARGER TO DISPENSER RATIO AND THAT DISPENSERS CAN NOT EXCEED A 450' DISTANCE FROM CHARGER BASE.
- APPROACH ASSUMES AN OVERHEAD STRUCTURE TO SUPPORT POWERED DISPENSER REELS MOUNTED OVERHEAD BETWEEN EVERY BUS PARKING SPACE.
- LAYOUT ASSUMES 3-FOOT CLEAR AISLE NEEDED BETWEEN EVERY THIRD OR FOURTH PARKING SPACE FOR CANOPY COLUMN CLEARANCE.
- LAYOUT PRESERVES CURRENT OPERATIONAL FLOW OF TRAFFIC AND PARKING CONFIGURATION W/ DRIVE-THROUGH STALLS
- LAYOUT PROVIDES FOR UP TO (48) POTENTIAL STANDARD BEB CHARGING CAPABLE PARKING SPACES IN JUST PARKING AREAS-A & B. ADDITIONAL CHARGING CAPABLE SPACES COULD BE PROVIDED IN AREA-C OR WITHIN UNPAVED AREA TO THE NORTH OF AREA-B ALONG EXIT DRIVE.
- (1) 600KW FAST CHARGER LOCATED AT EDGE OF PARKING AREA-A FOR EASY PULL-IN AND PULL-OUT FOR MIDDAY CHARGING.
- LOSS OF (1) TOTAL 40' BUS SPACE
- APPROXIMATELY 25,800 SF OF POTENTIAL PV CANOPY OVER CHARGING AREAS.
- LAYOUT REQUIRES NEW SITE LIGHT UNDER CANOPY TO REPLACE REMOVED LIGHT POLES.
- LAYOUT WOULD ALSO WORK WITH PANTOGRAPH CHARGERS FOR ALL EV SPACES IN LIEU OF POWERED REEL DISPENSERS. INVERTED PANTOGRAPH WOULD BE MOUNTED DIRECTLY OVER EACH BUS SPACE.
- MINOR MODIFICATIONS TO STORMWATER AREA AT PARKING AREA-A MAY BE REQUIRED.

**PROPOSED FLEET PARKING:**

- (57) STRIPED 40' BUS PARKING TOTAL
- (48) EV SPACES, POTENTIAL
  - (9) NON-EV SPACES

**ASSUMPTIONS:**

- (46) TOTAL 40' BUS FLEET  
(39) ACTIVE 40' BUSES DURING THE DAY

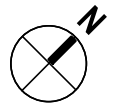
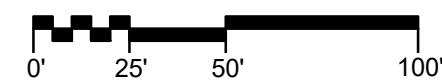
1:3 STANDARD CHARGER TO DISPENSER RATIO:  
(13) MIN TOTAL QTY OF CHARGERS (W/ 10% CONTINGENCY)  
= (39) TOTAL QTY OF DISPENSERS  
+ (1) 600KW FAST CHARGER W/ INVERTED PANTOGRAPH

E-TRAN ZEB FACILITY MASTER PLAN  
10250 IRON ROCK WAY, ELK GROVE, CA

E-TRANS FACILITY  
MASTER PLAN OPTION 2

DATE:  
5/12/21

DWG:



**1.2**

**APPENDIX D: E-TRAN ZEB FACILITY MASTER PLAN  
CONCEPTUAL DESIGN OPINION**

**E-TRAN ZEB FACILITY MASTER PLAN**  
**ELK GROVE, CALIFORNIA**

**CONCEPTUAL DESIGN**  
**OPINION OF PROBABLE COST**

JYI #: C2510A-R2

March 17, 2021  
Revised: April 5, 2021

PREPARED FOR:

**STANTEC**

BY:

**JACOBUS & YUANG, INC.**

355 North Lantana Street, #220  
Camarillo, CA 93010  
Tel (213) 688-1341 or (805) 339-9434

<b>PROJECT: E-TRAN ZEB FACILITY MASTER PLAN</b>	<b>JYI #: C2510A-R2</b>
<b>LOCATION: ELK GROVE, CA</b>	<b>DATE: 17-Mar-21</b>
<b>CLIENT: STANTEC</b>	<b>REVISED: 05-Apr-21</b>
<b>DESCRIPTION: R.O.M. OPINION OF PROBABLE COST - SUMMARY</b>	

ITEM NO.	DESCRIPTION	YEAR 2022 / 2023 COST				YEAR 2030 / 2031 COST				YEAR 2035 COST				YEAR 2040 COST			
		EST QTY	U N I T	UNIT COST	TOTAL COST	EST QTY	U N I T	UNIT COST	TOTAL COST	EST QTY	U N I T	UNIT COST	TOTAL COST	EST QTY	U N I T	UNIT COST	TOTAL COST
<b>SUMMARY OF ESTIMATE - OPTION 1</b>		<b>\$</b>				<b>\$</b>				<b>\$</b>				<b>\$</b>			
	GROUND-MOUNTED PEDESTAL DISPENSERS	14,850	SF	152.25	2,260,896	32,500	SF	143.89	4,676,546	32,500	SF	111.54	3,625,134	32,500	SF	278.07	9,037,206
<b>R.O.M. TOTAL OF OPINION OF PROBABLE CONSTRUCTION COST W/ PRORATES + ESCALATION - OPTION 1</b>		<b>14,850</b>	<b>SF</b>	<b>152.25</b>	<b>2,260,896</b>	<b>32,500</b>	<b>SF</b>	<b>143.89</b>	<b>4,676,546</b>	<b>32,500</b>	<b>SF</b>	<b>\$111.54</b>	<b>3,625,134</b>	<b>32,500</b>	<b>SF</b>	<b>278.07</b>	<b>9,037,206</b>

ITEM NO.	DESCRIPTION	YEAR 2022 / 2023 COST				YEAR 2030 / 2031 COST				YEAR 2035 COST				YEAR 2040 COST			
		EST QTY	U N I T	UNIT COST	TOTAL COST	EST QTY	U N I T	UNIT COST	TOTAL COST	EST QTY	U N I T	UNIT COST	TOTAL COST	EST QTY	U N I T	UNIT COST	TOTAL COST
<b>SUMMARY OF ESTIMATE - OPTION 2</b>		<b>\$</b>				<b>\$</b>				<b>\$</b>				<b>\$</b>			
	OVERHEAD PV CANOPIES W/ OVERHEAD DISPENSER REELS	15,200	SF	328.59	4,994,529	33,000	SF	374.61	12,362,234	33,000	SF	106.42	3,511,787	33,000	SF	241.51	7,969,681
<b>R.O.M. TOTAL OF OPINION OF PROBABLE CONSTRUCTION COST W/ PRORATES + ESCALATION - OPTION 2</b>		<b>15,200</b>	<b>SF</b>	<b>328.59</b>	<b>4,994,529</b>	<b>33,000</b>	<b>SF</b>	<b>374.61</b>	<b>12,362,234</b>	<b>33,000</b>	<b>SF</b>	<b>\$106.42</b>	<b>3,511,787</b>	<b>33,000</b>	<b>SF</b>	<b>241.51</b>	<b>7,969,681</b>

**ESCALATION CALCULATION PARAMETERS**

BASE MONTH	Mar-21	Mar-21	Mar-21	Mar-21
CONSTRUCTION START MONTH	<b>Aug-22</b>	<b>Aug-30</b>	<b>Mar-35</b>	<b>Mar-40</b>
CONSTRUCTION DURATION (MONTHS)	7	7	5	5
MID POINT OF CONSTRUCTION	Nov-22	Nov-30	May-35	May-40
% ANNUAL ESCALATION	6.00%	6.00%	6.00%	6.00%
ALLOWANCE FOR ESCALATION (TO MIDPOINT OF CONSTRUCTION)	10.40%	75.97%	128.69%	206.07%

**NOTES:**

SPECIFIC INCLUSIONS

- 1 PREVAILING WAGE RATES IN THE AREA OF THE PROJECT
- 2 REPLACEMENT OF EXISTING ASPHALT PAVING WITHIN AREA A AND AREA B INTO REINFORCED CONCRETE PAVING
- 3 PRIMARY POWER SERVICE CONDUIT BROUGHT FROM IRON ROCK WAY STREET
- 4 UTILITY TRANSFORMER PAD OR SLAB BOX
- 5 4000A MAN SWITCHBOARD
- 6 825 KW GENERATOR SET WITH 1000 GAL FUEL STORAGE AND PIPINGS
- 7 FIFTEEN (15) 150KW EV CHARGER CABINET FOR OPTION 1 AND SIXTEEN (16) 150 KW EV CHARGER CABINET FOR OPTION 2
- 8 FORTY FIVE (45) GROUND-MOUNTED DISPENSERS FOR OPTION 1
- 9 FORTY EIGHT (48) OVERHEAD DISPENSERS FOR OPTION 2
- 10 ONE (1) FAST CHARGER STALL WITH PANTOGRAPH MAST ARM BOTH OPTION 1 AND OPTION 2
- 11 POWER MAIN FEEDER AND SUB FEEDERS
- 12 COMMUNICATIONS MAIN FEEDER AND SUB FEEDERS
- 13 BUS CANOPY STRUCTURE FOR OPTION 2 COMPLETE W/ LIGHTING AND FIRE SPRINKLER SYSTEMS
- 14 PHOTO-VOLTAIC PANELS OVER BUS CANOPY COMPLETE WITH CIRCUITRY
- 15 STORM DRAINS FOR OPTION 2

**PROJECT: E-TRAN ZEB FACILITY MASTER PLAN**

**LOCATION: ELK GROVE, CA**

**CLIENT: STANTEC**

**DESCRIPTION: R.O.M. OPINION OF PROBABLE COST - SUMMARY**

**JYI #: C2510A-R2**

**DATE: 17-Mar-21**

**REVISED: 05-Apr-21**

SPECIFIC EXCLUSIONS

- 1 ASBESTOS OR HAZARDOUS MATERIAL ABATEMENT
- 2 PROJECT SOFT COSTS & CONSTRUCTION CONTINGENCY
- 3 UTILITY TRANSFORMER
- 4 CABLINGS AND CONNECTIONS FOR PRIMARY POWER SERVICE CONDUIT
- 5 STORM DRAINS FOR OPTION 1
- 6 ELECTRICAL SERVICE FEES

GENERAL NOTES

- 1 ESTIMATE ASSUMES THAT ALL COMPONENTS WILL BE BID AS A SINGLE BID PACKAGE
- 2 ESTIMATE ASSUMES WORK TO BE DURING NORMAL WORKING HOURS
- 3 ESTIMATE ASSUMES BID COVERAGE FROM AT LEAST 4-5 RESPONSIVE BIDDERS
- 4 ESTIMATE IS BASED ON CONCEPTUAL DESIGN DRAWINGS AND REPORT PREPARED BY STANTEC DATED 02/05/2021, RECEIVED 02/06/2021

ASSUMPTIONS

- 1 PRIMARY POWER SERVICE CONDUIT ASSUMED AT (2) SETS OF 5" CONDUIT
- 2 SECONDARY POWER SERVICE ASSUMED AT (11) SETS OF 4" CONDUIT W/ 3 #500 MCM AND 1 #500 GND WIRE
- 3 GENSET AND ATS POWER FEEDERS IS ASSUMED AT (11) SETS OF 4" CONDUIT W/ 3 #500 MCM AND 1 #500 GND WIRE
- 4 BUS CHARGER POWER FEEDER IS ASSUMED AT (2) SETS OF 3" CONDUIT W/ 3 #500 MCM AND 1 #1/0 GND WIRE
- 5 FAST CHARGER POWER FEEDER IS ASSUMED AT (7) SETS OF 3" CONDUIT W/ 3 #500 MCM AND 1 #350 GND WIRE
- 6 DISPENSER UNDERGROUND POWER FEEDER IS ASSUMED AT (1) SET OF 2" CONDUIT W/ 3 #3/0 AND 1 #1/6 GND WIRE
- 7 DISPENSER ABOVE GROUND POWER FEEDER IS ASSUMED AT (1) SET OF 1 1/2" CONDUIT W/ 3 #3/0 AND 1 #1/6 GND WIRE
- 8 MAIN COMMUNICATIONS FEEDER IS ASSUMED AT (1) SET OF 4" CONDUIT W/ 12FOSM CABLE
- 9 DISPENSER COMMUNICATIONS UNDERGROUND FEEDER IS ASSUMED AT (1) SET OF 2" CONDUIT W/ CAT 6 CABLE
- 10 DISPENSER COMMUNICATIONS ABOVE GROUND FEEDER IS ASSUMED AT (1) SET OF 1 1/2" CONDUIT W/ CAT 6 CABLE

**DEFINITIONS**

ESTIMATE OF COST

An Estimate of Cost is prepared from a survey of the quantities of work-items prepared from written or drawn information provided at the Design Development, Working Drawing or Bid Document stage of design.

Historical costs, information provided by contractors and suppliers, plus judgmental evaluation by the Estimator are used as appropriate as the basis for pricing.

Allowances as appropriate will be included for items of work which are not indicated on the design documents, provided that the Estimator is made aware of them, or which in the judgement of the Estimator are required for completion of the work.

JYI cannot, however, be responsible for inclusion of items or work of which we have not been informed.

BID

An offer to enter a contract to perform work for a fixed sum, to be completed within a limited period of time.

SPECIAL NOTE - MARKET CONDITIONS

In the current market conditions for construction, our experience shows the following results on competitive bids, as a differential from JYI final estimates:

Number of bids	Percentage Differential
1.....	+ 25 to 50%
2-3.....	+ 10 to 25%
4-5.....	+ 0 to 10%
6-7.....	+ 0 to - 5%
8 or more....	+ 0 to -10%

Accordingly, it is extremely important to ensure that a minimum of 4-5 valid bids are received

PROJECT: E-TRAN ZEB FACILITY MASTER PLAN				JYI #: C2510A-R2	
LOCATION: ELK GROVE, CA				DATE: 17-Mar-21	
CLIENT: STANTEC				REVISED: 05-Apr-21	
DESCRIPTION: R.O.M. OPINION OF PROBABLE COST - OPTION 1		AREA A: 14,850	AREA A & B: 32,500	AREA A & B: 32,500	AREA A & B: 32,500

ITEM NO.	DESCRIPTION	YEAR 2022 / 2023 COST			YEAR 2030 / 2031 COST			YEAR 2035 COST			YEAR 2040 COST		
		EST QTY	UNIT COST	TOTAL COST	EST QTY	UNIT COST	TOTAL COST	EST QTY	UNIT COST	TOTAL COST	EST QTY	UNIT COST	TOTAL COST
<b>SUMMARY OF ESTIMATE</b>				<b>\$</b>			<b>\$</b>			<b>\$</b>			<b>\$</b>
1	GENERAL REQUIREMENTS												
2	EXISTING CONDITIONS	5.48%	5.16	76,673	4.23%	2.36	76,831						
31	EARTHWORK	4.82%	4.54	67,395	4.25%	2.37	77,172						
32	EXTERIOR IMPROVEMENTS	29.19%	27.48	408,109	25.19%	14.06	457,014	5.07%	1.69	54,833	4.70%	2.92	94,739
33	UTILITIES	60.50%	56.96	845,892	66.32%	37.03	1,203,355	94.93%	31.61	1,027,401	95.30%	59.11	1,921,073
	<b>SUBTOTAL</b>	<b>100.00%</b>	<b>94.15</b>	<b>1,398,069</b>	<b>100.00%</b>	<b>55.83</b>	<b>1,814,372</b>	<b>100.00%</b>	<b>33.30</b>	<b>1,082,234</b>	<b>100.00%</b>	<b>62.02</b>	<b>2,015,812</b>
	GENERAL CONDITIONS / GENERAL REQUIREMENTS ESTIMATE / DESIGN CONTINGENCY	12.50%	11.77	174,759	12.50%	6.98	226,797	12.50%	4.16	135,279	12.50%	7.75	251,977
	MARKET/ COVID FACTOR - DELETED PER A/E	20.00%	21.18	314,566	20.00%	12.56	408,234	20.00%	7.49	243,503	20.00%	13.96	453,558
	<b>SUBTOTAL</b>		<b>127.10</b>	<b>1,887,393</b>		<b>75.37</b>	<b>2,449,402</b>		<b>44.95</b>	<b>1,461,016</b>		<b>83.73</b>	<b>2,721,346</b>
	BONDS & INSURANCE	2.00%	2.54	37,748	2.00%	1.51	48,988	2.00%	0.90	29,220	2.00%	1.67	54,427
	CONTRACTOR'S FEE	6.50%	8.26	122,681	6.50%	4.90	159,211	6.50%	2.92	94,966	6.50%	5.44	176,888
	<b>SUBTOTAL</b>		<b>137.90</b>	<b>2,047,822</b>		<b>81.77</b>	<b>2,657,601</b>		<b>48.78</b>	<b>1,585,202</b>		<b>90.85</b>	<b>2,952,661</b>
	ESCALATION (TO MIDPOINT)	10.40%	14.35	213,074	75.97%	62.12	2,018,945	128.69%	62.77	2,039,932	206.07%	187.22	6,084,545
	<b>R.O.M. OPINION OF PROBABLE COST - OPTION 1</b>		<b>152.25</b>	<b>2,260,896</b>		<b>143.89</b>	<b>4,676,546</b>		<b>111.54</b>	<b>3,625,134</b>		<b>278.07</b>	<b>9,037,206</b>

<b>PROJECT: E-TRAN ZEB FACILITY MASTER PLAN</b>				<b>JYI #: C2510A-R2</b>	
<b>LOCATION: ELK GROVE, CA</b>				<b>DATE: 17-Mar-21</b>	
<b>CLIENT: STANTEC</b>				<b>REVISED: 05-Apr-21</b>	
<b>DESCRIPTION: R.O.M. OPINION OF PROBABLE COST - OPTION 1</b>		<b>AREA A: 14,850</b>	<b>AREA A &amp; B: 32,500</b>	<b>AREA A &amp; B: 32,500</b>	<b>AREA A &amp; B: 32,500</b>

ITEM NO.	DESCRIPTION	YEAR 2022 / 2023 COST				YEAR 2030 / 2031 COST				YEAR 2035 COST				YEAR 2040 COST			
		EST QTY	U N I T	UNIT COST	TOTAL COST	EST QTY	U N I T	UNIT COST	TOTAL COST	EST QTY	U N I T	UNIT COST	TOTAL COST	EST QTY	U N I T	UNIT COST	TOTAL COST
<b>1</b>	<b>GENERAL REQUIREMENTS</b>				\$				\$				\$				\$
	SEE PERCENTAGE ALLOWANCE																
	<b>SUBTOTAL</b>																
<b>2</b>	<b>EXISTING CONDITIONS</b>				\$				\$				\$				\$
	SITE DEMOLITION (HAULING INCLUDED)																
	SAWCUT (E) ASPHALT PAVING	1,817	LF	8.00	14,536	878	LF	8.00	7,024								
	REMOVE (E) ASPHALT PAVING & BASE	16,425	SF	3.50	57,486	18,328	SF	3.50	64,148								
	PROTECT-IN-PLACE (E) FARE VAULT	1	EA	500.00	500												
	PROTECT-IN-PLACE (E) POLE LIGHTING	1	EA	500.00	500	4	EA	500.00	2,000								
	MISC. SITE DEMO & PROTECTION WORK	1	LS	3,651.10	3,651	1	LS	3,658.60	3,659								
	<b>SUBTOTAL</b>				<b>76,673</b>				<b>76,831</b>								
<b>31</b>	<b>EARTHWORK</b>				\$				\$				\$				\$
	SITE PREPARATION																
	SITE CLEARING	16,425	SF	0.15	2,464	18,328	SF	0.15	2,749								
	ROUGH GRADING	16,425	SF	0.65	10,676	18,328	SF	0.65	11,913								
	FINE GRADING	16,425	SF	0.45	7,391	18,328	SF	0.45	8,248								
	RAW CUT (TOPSOIL @ +/- 4" thk)	182	CY	15.00	2,723	221	CY	15.00	3,315								
	SCARIFY/COMPACT	16,425	SF	0.93	15,208	18,328	SF	0.93	16,970								
	EXPORT/ HAUL DIRT, 2.5 HRS R/T + 15% SWELL VOLUME	209	CY	79.60	16,615	254	CY	79.60	20,231								
	EROSION CONTROL	16,425	SF	0.75	12,318	18,328	SF	0.75	13,746								
	<b>SUBTOTAL</b>				<b>67,395</b>				<b>77,172</b>								
<b>32</b>	<b>EXTERIOR IMPROVEMENTS</b>				\$				\$				\$				\$
	HARDSCAPE																
	VEHICULAR CONCRETE PAVING, REINFORCED, ASSUME 8"/ 10"	13,640	SF	19.96	272,191	16,530	SF	19.96	329,862								
	CONCRETE PAVING @ CHARGER CABINET AREA					456	SF	12.26	5,591								
	RAISED CONCRETE PAVING @ EQUIPMENT AREA	1,210	SF	12.26	14,837	1,120	SF	12.26	13,733								
	ASPHALT PATCH - ELECTRICAL TRENCH	1,427	SF	7.95	11,335	150	SF	7.95	1,192								
	CONCRETE CURB	268	LF	30.00	8,040	216	LF	30.00	6,480								
	TRANSFORMER PAD/ SLAB BOX	1	EA	10,000.00	10,000												
	CONCRETE PAD - MAIN SWITCHBOARD	1	EA	1,200.00	1,200												
	CONCRETE PAD - GENSET									1	EA	1,800.00	1,800				
	CONCRETE PAD - CHARGER CABINET	6	EA	375.00	2,250	7	EA	375.00	2,625								
	CONCRETE PAD - DISPENSER	21	EA	100.00	2,100	24	EA	100.00	2,400								
	FOUNDATION - FAST CHARGER					1	EA	1,800.00	1,800								
	SITE MISCELLANEOUS																
	EQUIPMENT ANCHORAGE	9	EA	250.00	2,250	20	EA	250.00	5,000	13	EA	250.00	3,250	21	EA	250.00	5,250
	STEEL BOLLARD	40	EA	1,500.00	60,000	37	EA	1,500.00	55,500	27	EA	1,500.00	40,500	49	EA	1,500.00	73,500
	PAVING STRIPING - LINE	205	LF	2.00	409	409	LF	2.00	818	336	LF	2.00	672	370	LF	2.00	740
	PAVING STRIPING - CHEVRON	425	SF	2.50	1,063	1,700	SF	2.50	4,250	960	SF	2.50	2,400	1,895	SF	2.50	4,738
	SIGNAGE	10	EA	300.00	3,000	20	EA	300.00	6,000	12	EA	300.00	3,600	20	EA	300.00	6,000
	MISC. SITE IMPROVEMENTS ALLOWANCE	1	LS	19,433.75	19,434	1	LS	21,762.55	21,763	1	LS	2,611.10	2,611	1	LS	4,511.40	4,511
	<b>SUBTOTAL</b>				<b>408,109</b>				<b>457,014</b>				<b>54,833</b>				<b>94,739</b>
<b>33</b>	<b>UTILITIES</b>				\$				\$				\$				\$
	ELECTRICAL UTILITY																
	MAIN POWER SYSTEM - NORMAL																
	PRIMARY POWER SERVICE CONDUIT	375	LF	50.00	18,750												
	UTILITY TRANSFORMER	1	EA		PER UTILITY CO												
	SECONDARY POWER SERVICE CONDUIT	10	LF	165.00	1,650												

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<b>CLIENT: STANTEC</b>				<b>REVISED: 05-Apr-21</b>	
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	MAIN SWITCHBOARD, 4000A, NEMA 3R	1	EA	72,000.00	72,000												
	EQUIPMENT GROUNDING SYSTEM	1	LS	2,500.00	2,500												
	TRENCH/ DUCTBANK - PRIMARY/ SECONDARY SERVICE	385	LF	166.67	64,167												
	SERVICE POWER CABLING - PRIMARY				PER UTILITY CO												
	4000A POWER CABLING - SECONDARY	10	LF	1,738.00	17,380												
	EMERGENCY POWER																
	GENSET, 825 KW									1	EA	183,500.00	183,500				
	1000 GAL ON SITE FUEL STORAGE + PIPINGS, COMPLETE									1	EA	14,875.00	14,875				
	ATS, NEMA 3R + PAD/ ANCHOR									1	EA	16,500.00	16,500				
	GENSET FEEDER									20	LF	290.00	5,800				
	ATS FEEDER									20	LF	75.00	1,500				
	CONTROL FEEDER									20	LF	35.00	700				
	TRENCH/ DUCTBANK									20	LF	138.89	2,778				
	POWER FEEDERS - CHARGERS & DISPENSERS																
	U/G PVC CONDUIT - (7) CHARGER CABINETS	225	LF	25.50	5,738												
	U/G PVC CONDUIT - (8) CHARGER CABINETS					55	LF	25.50	1,403								
	U/G PVC CONDUIT - (1) FAST CHARGER	200	LF	89.25	17,850												
	U/G PVC CONDUIT - (21) DISPENSERS	2,000	LF	9.60	19,200												
	U/G PVC CONDUIT - (24) DISPENSERS					4,000	LF	9.60	38,400								
	MAIN POWER WIRES - MS TO CHARGERS	200	LF	259.00	51,800	25	LF	259.00	6,475	55	LF	259.00	14,245				
	SUB POWER WIRES - CHARGERS TO DISPENSERS	150	LF	51.80	7,770	1,850	LF	51.80	95,830	1,150	LF	51.80	59,570	2,850	LF	51.80	147,630
	DUCTBANK - COMBINED W/ COMM. CONDUITS																
	TRENCH/ DUCTBANK - CHARGER CONDUITS	225	LF	111.11	25,000	55	LF	111.11	6,111								
	TRENCH/ DUCTBANK - FAST CHARGER CONDUITS	200	LF	83.33	16,667												
	TRENCH/ DUCTBANK - DISPENSER CONDUITS	335	LF	62.50	20,938	620	LF	62.50	38,750								
	COMMUNICATIONS SYSTEM																
	COMM. SYSTEM EQUIPMENT, WP (FACILITY DATA SWITCH) + PAD/ ANCHOR - ASSUME LOCATED NEAR MAIN SWITCHBOARD	1	EA	9,500.00	9,500												
	U/G PVC CONDUIT ROUGH-INS - MAIN COMM. EQUIPMENT TO BUS CHARGER CABINETS	230	LF	15.00	3,450	60	LF	15.00	900								
	U/G PVC CONDUIT - SUB COMM. LINE FROM BUS CHARGER CABINETS TO DISPENSERS	400	LF	9.60	3,840	510	LF	9.60	4,896								
	U/G PVC CONDUIT ROUGH-INS - SUB COMM. LINE FROM MAIN COMM. EQUIPMENT TO FAST CHARGER					200	LF	9.60	1,920								
	MAIN COMM. CABLE - FIBER	230	LF	11.25	2,588					60	LF	11.25	675				
	COMM. CABLE - CAT 6 TO EACH DISPENSER	250	LF	6.30	1,575	1,300	LF	6.30	8,190	1,200	LF	6.30	7,560	2,600	LF	6.30	16,380
	COMM. CABLE - CAT 6 TO FAST CHARGER									200	LF	6.30	1,260				
	TRENCH/ DUCTBANK - INCLUDED ABOVE																
	EV BUS CHARGER EQUIPMENT, GROUND-MOUNTED																
	DISCONNECT SWITCH, NEMA 3R - QUANTITY PER A/E	2	EA	6,300.00	12,600	4	EA	6,300.00	25,200	3	EA	6,300.00	18,900	4	EA	6,300.00	25,200
	150 KW EV BUS CHARGER CABINET (INCLUDING POWER BLOCK & DC DISTRIBUTION BOX) - QUANTITY PER A/E	2	EA	125,000.00	250,000	4	EA	125,000.00	500,000	3	EA	125,000.00	375,000	4	EA	125,000.00	500,000
	GROUND-MOUNTED DISPENSERS - QUANTITY PER A/E	5	EA	22,500.00	112,500	13	EA	22,500.00	292,500	8	EA	22,500.00	180,000	13	EA	22,500.00	292,500
	TESTING/ COMMISSIONING/ ON SITE TRAINING	2	EA	3,687.50	7,375	4	EA	3,687.50	14,750	3	EA	3,687.50	11,063	4	EA	3,687.50	14,750
	FREIGHT	2	EA	1,843.75	3,688	4	EA	1,843.75	7,375	3	EA	1,843.75	5,531	4	EA	1,843.75	7,375
	SERVICES (3-YR SERVICES PLAN) & INSTALLATION SUPPORT	2	EA	4,425.00	8,850	4	EA	4,425.00	17,700	3	EA	4,425.00	13,275	4	EA	4,425.00	17,700
	INSTALLATION	2	EA	14,750.00	29,500	4	EA	14,750.00	59,000	3	EA	14,750.00	44,250	4	EA	14,750.00	59,000
	FAST CHARGER																
	DISCONNECT SWITCH, NEMA 3R													1	EA	21,250.00	21,250
	600 KW FAST CHARGER STALL W/ PANTOGRAPH MAST ARM & CHARGER - UNIT COST PER A/E													1	EA	450,000.00	450,000
	TESTING/ COMMISSIONING/ ON SITE TRAINING													1	EA	33,750.00	33,750
	FREIGHT													1	EA	11,250.00	11,250
	SERVICES (3-YR SERVICES PLAN) & INSTALLATION SUPPORT													1	EA	9,000.00	9,000
	INSTALLATION													1	EA	180,000.00	180,000
	MISCELLANEOUS																
	MISC. / TESTING	1	LS	59,015.70	59,016	1	LS	83,955.00	83,955	1	LS	71,679.15	71,679	1	LS	134,028.38	134,028
	<b>SUBTOTAL</b>				<b>845,892</b>				<b>1,203,355</b>				<b>1,027,401</b>				<b>1,921,073</b>

PROJECT: E-TRAN ZEB FACILITY MASTER PLAN				JYI #:	C2510A-R2
LOCATION: ELK GROVE, CA				DATE:	17-Mar-21
CLIENT: STANTEC				REVISED:	05-Apr-21
DESCRIPTION: R.O.M. OPINION OF PROBABLE COST - OPTION 2	AREA A:	15,200	AREA A & B:	33,000	AREA A & B: 33,000

ITEM NO.	DESCRIPTION	YEAR 2022 / 2023 COST			YEAR 2030 / 2031 COST			YEAR 2035 COST			YEAR 2040 COST		
		EST QTY	UNIT COST	TOTAL COST	EST QTY	UNIT COST	TOTAL COST	EST QTY	UNIT COST	TOTAL COST	EST QTY	UNIT COST	TOTAL COST
<b>SUMMARY OF ESTIMATE</b>				<b>\$</b>			<b>\$</b>			<b>\$</b>			<b>\$</b>
1	GENERAL REQUIREMENTS												
2	EXISTING CONDITIONS	2.50%	5.07	77,087	1.61%	2.34	77,125						
31	EARTHWORK	2.23%	4.53	68,796	1.62%	2.35	77,538						
32	EXTERIOR IMPROVEMENTS	31.33%	63.66	967,615	22.82%	33.16	1,094,432	1.55%	0.49	16,255	1.67%	0.90	29,632
33	UTILITIES	63.95%	129.93	1,974,966	73.96%	107.49	3,547,114	98.45%	31.28	1,032,141	98.33%	52.97	1,748,061
	<b>SUBTOTAL</b>	<b>100.00%</b>	<b>203.19</b>	<b>3,088,464</b>	<b>100.00%</b>	<b>145.34</b>	<b>4,796,209</b>	<b>100.00%</b>	<b>31.77</b>	<b>1,048,396</b>	<b>100.00%</b>	<b>53.87</b>	<b>1,777,693</b>
	GENERAL CONDITIONS / GENERAL REQUIREMENTS ESTIMATE / DESIGN CONTINGENCY	12.50%	25.40	386,058	12.50%	18.17	599,526	12.50%	3.97	131,050	12.50%	6.73	222,212
	MARKET/ COVID FACTOR - DELETED PER A/E	20.00%	45.72	694,904	20.00%	32.70	1,079,147	20.00%	7.15	235,889	20.00%	12.12	399,981
	<b>SUBTOTAL</b>		<b>274.30</b>	<b>4,169,426</b>		<b>196.21</b>	<b>6,474,882</b>		<b>42.89</b>	<b>1,415,335</b>		<b>72.72</b>	<b>2,399,886</b>
	BONDS & INSURANCE	2.00%	5.49	83,389	2.00%	3.92	129,498	2.00%	0.86	28,307	2.00%	1.45	47,998
	CONTRACTOR'S FEE	6.50%	17.83	271,013	6.50%	12.75	420,867	6.50%	2.79	91,997	6.50%	4.73	155,993
	<b>SUBTOTAL</b>		<b>297.62</b>	<b>4,523,828</b>		<b>212.89</b>	<b>7,025,247</b>		<b>46.53</b>	<b>1,535,638</b>		<b>78.91</b>	<b>2,603,876</b>
	ESCALATION (TO MIDPOINT)	10.40%	30.97	470,701	75.97%	161.73	5,336,987	128.69%	59.88	1,976,149	206.07%	162.60	5,365,805
	<b>R.O.M. OPINION OF PROBABLE COST - OPTION 2</b>		<b>328.59</b>	<b>4,994,529</b>		<b>374.61</b>	<b>12,362,234</b>		<b>106.42</b>	<b>3,511,787</b>		<b>241.51</b>	<b>7,969,681</b>

<b>PROJECT: E-TRAN ZEB FACILITY MASTER PLAN</b>				<b>JYI #: C2510A-R2</b>	
<b>LOCATION: ELK GROVE, CA</b>				<b>DATE: 17-Mar-21</b>	
<b>CLIENT: STANTEC</b>				<b>REVISED: 05-Apr-21</b>	
<b>DESCRIPTION: R.O.M. OPINION OF PROBABLE COST - OPTION 2</b>		<b>AREA A: 15,200</b>	<b>AREA A &amp; B: 33,000</b>	<b>AREA A &amp; B: 33,000</b>	<b>AREA A &amp; B: 33,000</b>

ITEM NO.	DESCRIPTION	YEAR 2022 / 2023 COST				YEAR 2030 / 2031 COST				YEAR 2035 COST				YEAR 2040 COST			
		EST QTY	U N I T	UNIT COST	TOTAL COST	EST QTY	U N I T	UNIT COST	TOTAL COST	EST QTY	U N I T	UNIT COST	TOTAL COST	EST QTY	U N I T	UNIT COST	TOTAL COST
<b>1</b>	<b>GENERAL REQUIREMENTS</b>				\$				\$				\$				\$
	SEE PERCENTAGE ALLOWANCE																
	<b>SUBTOTAL</b>																
<b>2</b>	<b>EXISTING CONDITIONS</b>				\$				\$				\$				\$
	SITE DEMOLITION (HAULING INCLUDED)																
	SAWCUT (E) ASPHALT PAVING	1,706	LF	8.00	13,648	802	LF	8.00	6,416								
	REMOVE (E) ASPHALT PAVING & BASE	16,748	SF	3.50	58,618	18,453	SF	3.50	64,586								
	POD/ REMOVE (E) POLE LIGHTING	1	EA	650.00	650	3	EA	650.00	1,950								
	PROTECT-IN-PLACE (E) FARE VAULT	1	EA	500.00	500												
	PROTECT-IN-PLACE (E) POLE LIGHTING					1	EA	500.00	500								
	MISC. SITE DEMO & PROTECTION WORK	1	LS	3,670.80	3,671	1	LS	3,672.60	3,673								
	<b>SUBTOTAL</b>				<b>77,087</b>				<b>77,125</b>				-				-
<b>31</b>	<b>EARTHWORK</b>				\$				\$				\$				\$
	SITE PREPARATION																
	SITE CLEARING	16,748	SF	0.15	2,512	18,453	SF	0.15	2,768								
	ROUGH GRADING	16,748	SF	0.65	10,886	18,453	SF	0.65	11,994								
	FINE GRADING	16,748	SF	0.45	7,537	18,453	SF	0.45	8,304								
	RAW CUT (TOPSOIL @ +/- 4" thk)	186	CY	15.00	2,787	221	CY	15.00	3,315								
	SCARIFY/COMPACT	16,748	SF	0.93	15,507	18,453	SF	0.93	17,086								
	EXPORT/ HAUL DIRT, 2.5 HRS R/T + 15% SWELL VOLUME	214	CY	79.60	17,006	254	CY	79.60	20,231								
	EROSION CONTROL	16,748	SF	0.75	12,561	18,453	SF	0.75	13,840								
	<b>SUBTOTAL</b>				<b>68,796</b>				<b>77,538</b>				-				-
<b>32</b>	<b>EXTERIOR IMPROVEMENTS</b>				\$				\$				\$				\$
	HARDSCAPE																
	VEHICULAR CONCRETE PAVING, REINFORCED, ASSUME 8" / 10"	13,860	SF	19.96	276,581	16,570	SF	19.96	330,660								
	CONCRETE PAVING @ CHARGER CABINET AREA					456	SF	12.26	5,591								
	RAISED CONCRETE PAVING @ EQUIPMENT AREA	1,340	SF	12.26	16,431	1,230	SF	12.26	15,082								
	ASPHALT PATCH - ELECTRICAL TRENCH	1,400	SF	7.95	11,125	125	SF	7.95	993								
	CONCRETE CURB	174	LF	30.00	5,220	250	LF	30.00	7,500								
	TRANSFORMER PAD/ SLAB BOX	1	EA	10,000.00	10,000												
	CONCRETE PAD - MAIN SWITCHBOARD	1	EA	1,200.00	1,200												
	CONCRETE PAD - GENSET									1	EA	1,800.00	1,800				
	CONCRETE PAD - CHARGER CABINET	8	EA	375.00	3,000	8	EA	375.00	3,000								
	FOUNDATION - FAST CHARGER					1	EA	1,800.00	1,800								
	BUS CANOPY																
	CANOPY STRUCTURE, COMPLETE W/ (8) POSTS & FOUNDATIONS - UNIT COST PER A/E	12,000	SF	40.00	480,000												
	CANOPY STRUCTURE, COMPLETE W/ (12) POSTS & FOUNDATIONS - UNIT COST PER A/E					13,800	SF	40.00	552,000								
	EXTRA FOR PAINTING	12,000	SF	6.75	81,000	13,800	SF	6.75	93,150								
	SITE MISCELLANEOUS																
	STEEL SUPPORT - O/H DISPENSERS	6	EA	350.00	2,100	18	EA	350.00	6,300	9	EA	350.00	3,150	15	EA	350.00	5,250
	EQUIPMENT ANCHORAGE	3	EA	250.00	750	6	EA	250.00	1,500	4	EA	250.00	1,000	6	EA	250.00	1,500
	STEEL BOLLARD	21	EA	1,500.00	31,500	12	EA	1,500.00	18,000	4	EA	1,500.00	6,000	10	EA	1,500.00	15,000
	PAVING STRIPING - LINE	97	LF	2.00	193	614	LF	2.00	1,227	206	LF	2.00	411	674	LF	2.00	1,348
	PAVING STRIPING - CHEVRON	255	SF	2.50	638	765	SF	2.50	1,913	528	SF	2.50	1,320	849	SF	2.50	2,123
	SIGNAGE	6	EA	300.00	1,800	12	EA	300.00	3,600	6	EA	300.00	1,800	10	EA	300.00	3,000
	MISC. SITE IMPROVEMENTS ALLOWANCE	1	LS	46,076.90	46,077	1	LS	52,115.80	52,116	1	LS	774.05	774	1	LS	1,411.05	1,411
	<b>SUBTOTAL</b>				<b>967,615</b>				<b>1,094,432</b>				<b>16,255</b>				<b>29,632</b>

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<b>CLIENT: STANTEC</b>				<b>REVISED: 05-Apr-21</b>	
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ITEM NO.	DESCRIPTION	YEAR 2022 / 2023 COST				YEAR 2030 / 2031 COST				YEAR 2035 COST				YEAR 2040 COST				
		EST QTY	UNIT	UNIT COST	TOTAL COST	EST QTY	UNIT	UNIT COST	TOTAL COST	EST QTY	UNIT	UNIT COST	TOTAL COST	EST QTY	UNIT	UNIT COST	TOTAL COST	
<b>33</b>	<b>UTILITIES</b>				\$				\$				\$				\$	
	<b>ELECTRICAL UTILITY</b>																	
	<u>MAIN POWER SYSTEM - NORMAL</u>																	
	PRIMARY POWER SERVICE CONDUIT	375	LF	50.00	18,750													
	UTILITY TRANSFORMER	1	EA		PER UTILITY CO													
	SECONDARY POWER SERVICE CONDUIT	10	LF	165.00	1,650													
	MAIN SWITCHBOARD, 4000A, NEMA 3R	1	EA	72,000.00	72,000													
	EQUIPMENT GROUNDING SYSTEM	1	LS	2,500.00	2,500													
	TRENCH/ DUCTBANK - PRIMARY/ SECONDARY SERVICE	385	LF	166.67	64,167													
	SERVICE POWER CABLING - PRIMARY				PER UTILITY CO													
	4000A POWER CABLING - SECONDARY	10	LF	1,738.00	17,380													
	<u>EMERGENCY POWER</u>																	
	GENSET, 825 KW									1	EA	183,500.00	183,500					
	1000 GAL ON SITE FUEL STORAGE + PIPINGS, COMPLETE									1	EA	14,875.00	14,875					
	ATS, NEMA 3R + PAD/ ANCHOR									1	EA	16,500.00	16,500					
	GENSET FEEDER - U/G CONDUIT + WIRES									20	LF	1,903.00	38,060					
	ATS FEEDER - U/G CONDUIT + WIRES									20	LF	1,903.00	38,060					
	CONTROL FEEDER - U/G CONDUIT + WIRES									20	LF	24.00	480					
	TRENCH/ DUCTBANK									20	LF	138.89	2,778					
	<u>POWER FEEDERS - CHARGERS &amp; DISPENSERS</u>																	
	U/G PVC CONDUIT - CHARGER CABINETS @ AREA A	250	LF	25.50	6,375													
	U/G PVC CONDUIT - CHARGER CABINETS @ AREA B					55	LF	25.50	1,403									
	U/G PVC CONDUIT - (1) FAST CHARGER	200	LF	89.25	17,850													
	U/G PVC CONDUIT - DISPENSERS @ AREA A	860	LF	9.60	8,256													
	U/G PVC CONDUIT - DISPENSERS @ AREA B					1,430	LF	9.60	13,728									
	PULLBOX, WP - POST MOUNT	2	EA	500.00	1,000	6	EA	500.00	3,000	3	EA	500.00	1,500	5	EA	500.00	2,500	
	GRC CONDUIT RISERS - (24) DISPENSERS	120	LF	27.00	3,240	360	LF	27.00	9,720	180	LF	27.00	4,860	300	LF	27.00	8,100	
	MAIN POWER WIRES - MS TO CHARGER	225	LF	259.00	58,275	25	LF	259.00	6,475	55	LF	259.00	14,245					
	SUB POWER WIRES - CHARGER TO PB @ POST	55	LF	51.80	2,849	805	LF	51.80	41,699	620	LF	51.80	32,116	810	LF	51.80	41,958	
	SUB POWER WIRES - PB TO DISPENSER	120	LF	51.80	6,216	240	LF	51.80	12,432	180	LF	51.80	9,324	240	LF	51.80	12,432	
	DUCTBANK - COMBINED W/ COMM. CONDUITS																	
	TRENCH/ DUCTBANK - COMBINED BUS CHARGER & FAST CHARGER	250	LF	111.11	27,778	50	LF	111.11	5,556									
	U/G CONDUITS																	
	TRENCH/ DUCTBANK - DISPENSER U/G CONDUITS	280	LF	62.50	17,500	460	LF	62.50	28,750									
	<u>EV BUS CHARGER EQUIPMENT</u>																	
	DISCONNECT SWITCH, NEMA 3R	2	EA	6,300.00	12,600	4	EA	6,300.00	25,200	3	EA	6,300.00	18,900	4	EA	6,300.00	25,200	
	150 KW EV BUS CHARGER CABINET (INCLUDING POWER BLOCK & DC DISTRIBUTION BOX) - QUANTITY PER A/E	2	EA	125,000.00	250,000	4	EA	125,000.00	500,000	3	EA	125,000.00	375,000	4	EA	125,000.00	500,000	
	OVERHEAD DISPENSERS - QUANTITY PER A/E	5	EA	18,000.00	90,000	15	EA	18,000.00	270,000	7	EA	18,000.00	126,000	12	EA	18,000.00	216,000	
	TESTING/ COMMISSIONING/ ON SITE TRAINING	2	EA	3,575.00	7,150	4	EA	3,575.00	14,300	3	EA	3,575.00	10,725	4	EA	3,575.00	14,300	
	FREIGHT	2	EA	1,787.50	3,575	4	EA	1,787.50	7,150	3	EA	1,787.50	5,363	4	EA	1,787.50	7,150	
	SERVICES (3-YR SERVICES PLAN) & INSTALLATION SUPPORT	2	EA	4,290.00	8,580	4	EA	4,290.00	17,160	3	EA	4,290.00	12,870	4	EA	4,290.00	17,160	
	INSTALLATION	2	EA	14,300.00	28,600	4	EA	14,300.00	57,200	3	EA	14,300.00	42,900	4	EA	14,300.00	57,200	
	<u>FAST CHARGER</u>																	
	DISCONNECT SWITCH, NEMA 3R													1	EA	21,250.00	21,250	
	600 KW FAST CHARGER STALL W/ PANTOGRAPH MAST ARM & CHARGER - UNIT COST PER A/E													1	EA	450,000.00	450,000	
	TESTING/ COMMISSIONING/ ON SITE TRAINING													1	EA	33,750.00	33,750	
	FREIGHT													1	EA	11,250.00	11,250	
	SERVICES (3-YR SERVICES PLAN) & INSTALLATION SUPPORT													1	EA	9,000.00	9,000	
	INSTALLATION													1	EA	180,000.00	180,000	
	<u>PV PANELS</u>																	
	PV PANELS O/ MAINTENANCE OPERATIONS BUILDING, COMPLETE W/ CIRCUITRY - ASSUMED \$2,500/KW INCLUDING SECONDARY FRAMES					405.5	KW	2,500.00	1,013,750									
	PV PANELS O/ BUS CANOPY, COMPLETE W/ CIRCUITRY - ASSUMED \$2,800/Kw (MORE THAN OPS BLDG. DUE TO STAND ALONE NATURE OF CANOPY)	12,000	SF	65.00	780,000	13,800	SF	65.00	897,000									

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	INCLUDED ARE NECESSARY SECONDARY SUPPORT FRAMES																
	<u>LIGHTING - BUS CANOPY</u>																
	LED LIGHTING SYSTEM, COMPLETE	12,000	SF	15.00	180,000	13,800	SF	15.00	207,000								
	MISCELLANEOUS																
	MISC. ELECTRICAL UTILITY SYSTEM/ TESTING	1	LS	126,471.83	126,472	1	LS	234,864.23	234,864	1	LS	71,104.20	71,104	1	LS	120,543.75	120,544
	<b>COMMUNICATIONS UTILITY</b>																
	COMM. SYSTEM EQUIPMENT, WP (FACILITY DATA SWITCH) + PAD/ ANCHOR - ASSUME LOCATED NEAR MAIN SWITCHBOARD	1	EA	9,500.00	9,500												
	U/G PVC CONDUIT ROUGH-INS - MAIN COMM. EQUIPMENT TO BUS CHARGER CABINETS	230	LF	15.00	3,450	60	LF	15.00	900								
	PULLBOX, WP - POST MOUNT	2	EA	500.00	1,000	6	EA	500.00	3,000	3	EA	500.00	1,500	5	EA	500.00	2,500
	U/G PVC CONDUIT - SUB COMM. LINE FROM BUS CHARGER CABINETS TO COMM. PB @ POSTS	860	LF	9.60	8,256	1,430	LF	9.60	13,728								
	U/G PVC CONDUIT ROUGH-INS - SUB COMM. LINE FROM MAIN COMM. EQUIPMENT TO FAST CHARGER					200	LF	9.60	1,920								
	GRC CONDUIT RISERS - (24) DISPENSERS	120	LF	27.00	3,240	360	LF	27.00	9,720	180	LF	27.00	4,860	300	LF	27.00	8,100
	MAIN COMM. CABLE - FIBER	230	LF	11.25	2,588					60	LF	11.25	675				
	COMM. CABLE - CAT 6 TO EACH DISPENSER	175	LF	6.30	1,103	1,165	LF	6.30		800	LF	6.30	5,040	1,110	LF	6.30	6,993
	COMM. CABLE - CAT 6 TO FAST CHARGER													200	LF	6.30	1,260
	TRENCH/ DUCTBANK - INCLUDED ABOVE																
	MISC. COMMUNICATIONS SYSTEM/ TESTING	1	LS	2,185.28	2,185	1	LS	2,195.10	2,195	1	LS	905.63	906	1	LS	1,413.98	1,414
	<b>PLUMBING UTILITIES</b>																
	<u>FIRE PROTECTION - BUS CANOPY</u>																
	AUTO. SPRINKLER SYSTEM, COMPLETE	12,000	SF	7.50	90,000	13,800	SF	7.50	103,500								
	EXTRA FOR MAIN FW LINE EXTENSION/ CONNECTION	1	EA	4,500.00	4,500	1	EA	4,500.00	4,500								
	<u>STORM DRAINS</u>																
	STORM DRAIN SYSTEM - BUS CANOPY	12,000	SF	2.00	24,000	13,800	SF	2.00	27,600								
	EXTRA FOR MAIN SD LINE EXTENSION/ CONNECTION	1	EA	3,250.00	3,250	1	EA	3,250.00	3,250								
	MISCELLANEOUS																
	MISC. PLUMBING UTILITY SYSTEM/ TESTING	1	LS	9,131.25	9,131	1	LS	10,413.75	10,414								
	<b>SUBTOTAL</b>				<b>1,974,966</b>				<b>3,547,114</b>				<b>1,032,141</b>				<b>1,748,061</b>

**APPENDIX E: SOLAR PV ANALYSIS**

Summary

Project Details	
Project Name	Elk Grove ZEB Fleet Transition
Address	10249 Iron Rock Way, Elk Grove, CA 95624
Project Number	2073015660
Task Number	300.200-Power

Option		Solar PV Size (kWdc)	Inverter Size (kWac)	Average DC to AC Ratio	Estimated Generation - year 1 (kWh)	Performance Ratio	Electricity From Grid Without Solar PV (kWh)	Electricity Cost Without Solar PV	Electricity From Grid With Solar PV (kWh)	Electricity From Grid Cost With Solar PV	Estimated Annual Savings With Solar PV	Solar PV On-Site Utilisation Rate	Site's Renewable Energy Fraction
0	No Solar PV	-	-	-	-	-	5,380,830	\$634,049	-	-	-	-	-
1.1	Solar PV on Roof	405.5	330.0	1.23	564,125	74.0%	5,380,830	\$634,049	5,070,525	\$595,975	\$38,073	55%	10%
1.2	Solar PV on Roof & Canopy	869.9	730.0	1.19	1,305,850	78.4%	5,380,830	\$634,049	4,754,062	\$557,582	\$76,467	48%	24%

Assumptions	
Solar PV Panel	Longi Solar, 18X-LR5-72HPH-540M (540W)
Inverter	Sungrow, various sizes
Roof - East	Flush Mount - 5°
Roof - West	Flush Mount - 3°
Canopy	Carport - 5° Tilt


Electricity Cost

Non-Summer - Weekday		
Charge Type	Rate	TOU Period
Off-Peak	\$0.1061 /kWh	12:00am to 5:00pm 8:00pm to 12:00am
Mid-Peak	-	-
Peak	\$0.1465 /kWh	5:00pm to 8:00pm

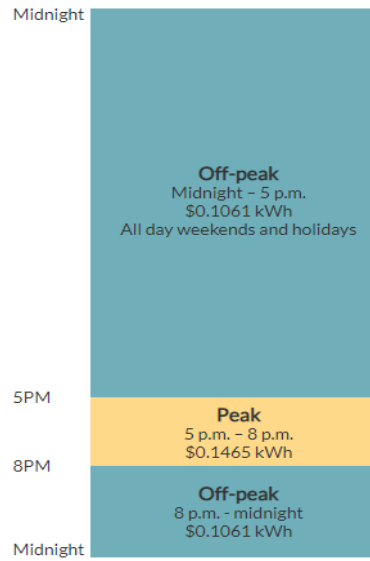
Non-Summer - Weekend		
Charge Type	Rate	TOU Period
Off-Peak	\$0.1061 /kWh	All Day
Mid-Peak	-	-
Peak	-	-


Summer - Weekday		
Charge Type	Rate	TOU Period
Off-Peak	\$0.1277 /kWh	12:00am to 12:00pm
Mid-Peak	\$0.1765 /kWh	12:00pm to 5:00pm 8:00pm to 12:00am
Peak	\$0.3105 /kWh	5:00pm to 8:00pm

Summer - Weekend		
Charge Type	Rate	TOU Period
Off-Peak	\$0.1277 /kWh	All Day
Mid-Peak	-	-
Peak	-	-

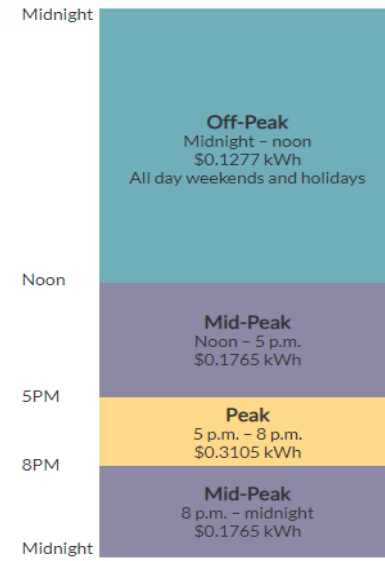
 Non-summer

January 1 - May 31



 Summer

June 1 - September 30



[Rate details \(smud.org\)](http://smud.org)