# Chapter 5 | Battery Electric Bus Feasibility

## 5.1 Introduction

Yuba-Sutter Transit is faced with an important decision for the future direction of their transit operating and maintenance facility. With the State of California Air Resources Board's proposed direction to change all bus transit fleets in the state to zero emission vehicles by 2040 beginning with purchase mandates as early as 2023, planning for this transition must begin now. Yuba-Sutter Transit is beginning this transition with the anticipated purchase of up to four 35' battery electric buses (BEBs) from Gillig LLC to be put into operation by the end of 2020. The questions which this BEB Memorandum must answer are:

1. What is the maximum number of BEBs that can be effectively operated from the existing facility given the existing space limitations? How can the initial implementation phase for new BEBs be charged on the current site with the existing space limitations?
2. Can the current facility accommodate a transition to 51 bus BEB deployment or is a new facility recommended? What are the PG&E electrical power requirements to charge the first group of BEBs and the whole fleet of 51 buses?
3. How much electrical power through the PG&E FleetReady Program can reasonably be brought into this facility before becoming cost prohibitive?
4. What is the estimated cost per installed charging unit for Gillig BEB and ChargePoint chargers?

### 5.1.1 Current Site Electrical Service

Preliminary contact was initiated with representatives from PG&E, including Cal Silcox, (Electric Vehicle Expert Analyst), Dean Kunesh (Strategic Account Manager), and Josh Deadmore (Yuba-Sutter Transit's Local Service Coordinator). The existing facility has two separate electric utility services. Each service is 600 amps at 240 volt, 3-phase. The proposed ChargePoint system requires 480 volt, 3-phase, and represents a load of 156 kW (188 amps @ 480 volts). *It is not practical to convert existing 240 volt services to 480 volts for the following reasons*:

- The existing 240 volt panels would still need to be re-fed, which will require an onsite transformer to step down from 480 volt to 240 volt. This will cost more than bringing in new 480 service and will take up more space.
- The size of the existing service would need to be increased substantially to provide enough additional capacity to provide sufficient power for the new ChargePoint systems.

### 5.1.2 Equipment Requirements for the First Charge Stations:

The proposed ChargePoint system is comprised of a power block that serves two charging dispensers. Each power block is 156 kW and can therefore charge up to four buses simultaneously. For the initial phase of four BEBs, there will be two power blocks. The total load for this phase is 312 kW, or approximately 375 amps at 480 volt, 3-phase power.

A new 480 volt 3-phase service will need to be brought to the site for the new charging equipment. The existing 240 volt services would be left intact to serve the maintenance and site loads that already exist. As a conservative assumption for the initial rollout of BEBs, this 480 volt service would be proposed at 1000 kVA. This will support the initial four (4) buses and will allow for the future support of an additional eight (8) buses over the coming years. As Yuba-Sutter Transit continues their conversion to BEBs, additional services would be brought to the site. Initial discussions with PG&E indicate that this new service will require minor modifications to their infrastructure and will not pose any roadblocks to proceeding with this initial BEB deployment. The required modifications will be determined by PG&E distribution engineers, and cannot be determined until project specifics are known.

- Equipment required includes a; 480V, 1000 kVA transformer and site mounted switchboard which together requires approximately 12'W x 25'L of space which includes California Electrical Code required free space around the transformer and switchboard
- The service will feed two ChargePoint Express Plus power blocks 6'-3" H x 2'-11"W x 5' x 9" D
- Each charge station will charge two buses simultaneously with the size of each at 7'-4" H x 2'-4"W x 1'-4"D

### 5.1.3 Full Conversion of Fleet to BEBs

An important initial step in assessing the feasibility of full conversion of the fleet to BEBs at the current facility is for Yuba-Sutter Transit to develop a procurement schedule for replacing the entire bus fleet with BEBs, including any anticipated growth to the fleet. It is anticipated that the charging infrastructure can be engineered to fit on the site for the existing fleet of 51 buses. However, it would be extremely difficult to add any BEBs to the fleet considering parking limitations and the necessity to charge buses during night time hours. The possibility of future growth would be severely limited. Assuming the full conversion of today's fleet to BEBs, the required number of ChargePoint power blocks would be 26. The total electrical load for 26 power blocks is approximately 4MW. Following the initial 1000 kVA electric service, serving the first twelve buses, there would likely be two subsequent increases in service brought in when needed to accommodate procurement of additional BEBs beyond the first twelve. These service increases would be 1500–2000 kVA each, and they would be added together to provide the cumulative 4MW capacity that is ultimately required. Initial discussions with PG&E have indicated that a large load study will be required if total customer load exceeds 2000 kVA, and would certainly have significant impacts to the PG&E distribution system. Preliminary discussions with PG&E indicated that such quantity of power may even require service from a transmission level voltage, which could incur significant expense to PG&E and possibly negatively influence their financial participation in the project. On the other hand, assuming the procurement schedule will be phased over several years, the required utility services will also be phased incrementally over a similar number of years. This gradual introduction of new load over a few years may possibly provide a means to delay the need for PG&E to conduct a large load study. In any case, this analysis and determination by PG&E will need to be done before Yuba-Sutter Transit outgrows the

charging capacity of the initial twelve buses. It is concluded that the predictability of the implementation of the later electrical service upgrades is quite tenuous and represents a significant risk.

### 5.1.4 Space Requirements

Currently, Yuba Sutter Transit only has 47 official parking locations for the 51 vehicle fleet. Vehicles beyond the 47 spaces are parked in the shop, wash bay or squeezed into various locations on the property. It is essential that none of the existing parking locations are eliminated due to space needed for charging infrastructure. As the facility currently exists, some of a fleet of 51 BEBs would have to be rotated each day in order for each to get charged.

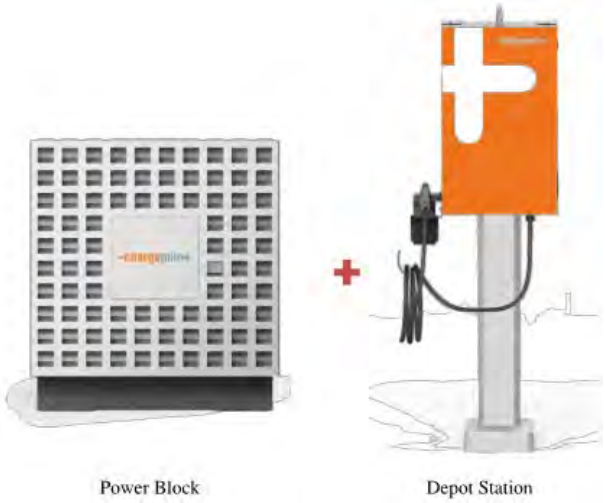
In order to determine the space required for electrical equipment, the sizes of utility transformers, electrical switchboards, power blocks and chargers must be taken into account along with California Electrical Code requirements for working clearances.

The Site Plan shows where electrical infrastructure is recommended to be placed for charging the fleet.

Three potential options have been developed for the placement and arrangement of the charging equipment:

#### Design Option 1 for charge stations: Ground Mounted

Option 1 is a more traditional approach with all utilities being installed underground from new service to power blocks and to the ground mounted charge stations. Concrete pads will be required for the transformer, switchboard, power blocks and charge stations. The charge stations are to be placed at the ends of the parking spaces, along the site perimeter. This will push the parking spaces a few feet away from the yard fence, slightly reducing the drive path widths. Since the charge connection inputs on the Gillig buses are on the right rear corner, the buses will need to be backed into their parking spaces to be charged. This may require the current bus parking angle to be reversed to maintain the current site bus flow. Otherwise, the entry/exit points and circulation patterns may need to be reversed which could be problematic during peak pull-in periods as queued buses could block the driveway from B Street.




**ChargePoint Ground Mounted Equipment**

(Utilized in Option 1)

### Design Option 2 for charge stations: Gantry Structure

Option 2 will require installing underground power to a long-span overhead gantry structure. The gantry structure will be built over the rear of bus parking spaces, allowing bus orientation to remain unchanged as the charging receptacles on Gilligs are located at the rear of the bus. Power blocks will be supported on shelves designed on the gantry vertical supports and the chargers will be mounted overhead to further reduce the footprint of the system. It is anticipated that ChargePoint's planned compact equipment and gantry system will be commercially available by 2020. Charging cables will run from the power blocks to overhead chargers and cable reels mounted on the gantry to charge the vehicles below.

**Overhead Gantry Structure**

(Similar to Option 2)

**Power Cable Reel**

(Utilized in Option 2A)

### Design Option 2A for charge stations: Solar Canopy Structure

Option 2A will require an overhead canopy to be built over the parked buses with power blocks supported on shelves designed on the canopy vertical supports. Charging cables will run from the power blocks to overhead charging station reels to charge the vehicles below. The canopy will also be designed to support high efficiency solar panels to help offset PG&E power required for charging the vehicles. These solar panels will send energy off-site to the PG&E grid during daylight hours in order to reduce nighttime charging costs by receiving credit for the daytime generated power. On-site battery power storage can be installed as an additional option to provide power during the day time if emergency charging is needed while avoiding peak hour pricing.

**Column Mounted Equipment**

(Utilized on Options 2 & 2A)

**PV Solar Canopy**

(Similar to Option 2A)

To help save ground space and prevent restriction of bus movement, the solar canopies can be designed to place the support columns at the head of the parking slots, near the perimeter fence, and cantilever the structure over the bus. The non-solar gantries can also be designed to cantilever in order to keep columns out of the parking spaces. In the photo below, the cantilever frames can either have the charging cable reels suspended at the end of the arm (Option 2) and/or have solar panels mounted on top (Option 2A).

**Cantilevered Gantry/Canopy Structure**

(Potentially Utilized on Options 2 and 2A)

Under all options, ground space can also be saved by mounting power blocks on accessible roof spaces such as the fueling lane canopy, which was designed to accept additional weight (solar panel system).

### Advantages of Option 1

- Initial cost is cheaper
- Construction only done as needed

### Advantages of Option 2

- Provides better locations for power blocks off the ground
- Provides quicker construction for future charging stations
- Provides less chance to damage charging stations than ground mounted stations
- Structure, cables and charging equipment can potentially be moved to a new site if a new transit center is constructed

### Advantages of Option 2A

Includes all of the advantages of Option 2, but in addition:

- Provides a structure for solar panels
- Provides shade to keep the buses cooler and minimize UV heat gain for energy conservation during operation

- Provides a life-cycle cost advantage to help offset costs for charging equipment, canopy and electrical fuel for the buses with power generation from the solar panels

## 5.2 Summary

With the above discussion in mind, the questions posed by Yuba-Sutter Transit are addressed below:

*What is the maximum number of BEBs that can be effectively operated from the existing facility given the existing space limitations? How can the initial implementation phase for new BEBs be charged on the current site with the existing space limitations?*

Yuba-Sutter Transit can install charging related infrastructure within a layout similar to the current 47 bus parking configuration. Slight adjustments to striping will create adequate room for the gantries, columns, and charging equipment. However, this leaves no room for future growth to the existing facility or bus fleet. Some shuffling of buses may be needed to ensure all buses in the fleet are fully charged and ready for service each day. Charging infrastructure options are outlined above.

*Can the current facility accommodate a transition to 51 bus BEB deployment or is a new facility recommended? What are the PG&E electrical power requirements to charge the first group of BEBs and the whole fleet of 51 buses?*

As mentioned above, the current fleet of 51 buses can be converted to BEBs, but without any room for additional buses. To charge the first four Gillig BEBs, new electrical service equipment will be required, including a 480V, 1000 kVA transformer with a site mounted switchboard. This type of utility service is typical for a commercial site and should have little impact to PG&E infrastructure.

The current Yuba-Sutter Transit site is already space constrained with minimal room for the fleet to grow. A new facility will provide more space for better bus circulation and parking while providing better separation of employee vehicles, transit vehicles and support vehicles. It will also provide a chance to better separate employee pedestrian flow from vehicular flow on site. With a well-designed facility with solar panels, LED lighting, water conserving plumbing and equipment, Yuba-Sutter Transit stands to greatly reduce operational costs at a new site. However, much of the savings will be dependent upon energy rates set forth in the PG&E FleetReady Program.

*How much electrical power through the PG&E FleetReady Program can reasonably be brought into this facility before becoming cost prohibitive?*

In May 2018, the California Public Utility Commission approved Senate Bill 350, which authorized funding for electric vehicle charging infrastructure for medium and heavy duty fleet vehicles through PG&E's FleetReady program. This program has just been approved by regulators, but has not yet been officially launched. Expected launch date is early 2019. Under this program, PG&E will install and maintain the electric vehicle (EV) service connection and electrical infrastructure to support fleet vehicles. PG&E plans to allocate certain percentages of funding to various types of electrified fleet vehicles. The current plan authorizes $236 million for PG&E to provide infrastructure improvements. Of this total, 15% is slated to serve transit agencies. PG&E may

advise customers on the types of charging equipment available for their vehicles and may offer charger rebates to customers. PG&E has provided a website for early applications (https://www.pge.com/en_US/business/solar-and-vehicles/your-options/clean-vehicles/charging-stations/fleetready.page). Yuba-Sutter Transit has completed and submitted an early application to PG&E through the website. However, until the program is officially launched, no PG&E funding is available. The current information available for the FleetReady program does not indicate that applications will be limited to either new or existing sites.

*What is the estimated cost per installed charging unit for Gillig BEB and ChargePoint chargers?*

See the attached cost estimate covering the new equipment to be installed. As indicated in the estimate, the cost for the first four (4) BEBs is: $878,464 / 2 = $439,232 per charging unit.

## 5.3 Risk Factors to the Project

A risk to Yuba-Sutter Transit moving forward with a program to purchase and deploy BEBs beyond the first four (4) buses is the unknown specifics related to PG&E assistance through the FleetReady program. These issues include:

- The percentage of new on-site electrical and charging costs that PG&E is willing to fund for each phase of new BEB deployment
- PG&E's timely completion of a large load study, quantifying the scale of electrical infrastructure needed to support Yuba-Sutter Transit's BEB deployment program
- The total amount of off-site infrastructure that PG&E deems feasible and is willing to construct in order to support a facility with up to 51 BEBs
- An inefficient use of Yuba-Sutter Transit and PG&E funds by over improving the electrical service on the current site, in the future event Yuba-Sutter Transit relocates to a new site to accommodate growth
- Participants in the FleetReady Vehicle Charging Infrastructure Programs must maintain and operate their purchased Electric Vehicle Supply Equipment (EVSE) for at least 10 years. PG&E must require site hosts to provide the utility with data for at least five years after the EVSE is installed. [1]

Not having this critical information about PG&E's participation in the funding and logistics of this BEB conversion project may delay Yuba-Sutter Transit's ability to make critical decisions to move the project forward.

## 5.4 Recommendations

It is strongly recommended that Yuba-Sutter Transit coordinate with PG&E at the earliest date possible to determine PG&E's ability to provide the infrastructure needed to support the planned procurement of

[1] State of California, Public Utilities Commission on Decision on the *Transportation Electrification Standard Review Projects. Application of San Diego Gas & Electric Company (U 902E) for Approval of SB 350 Transportation Electrification Proposals.* Application numbers: 17-01-020, 17-01-021, and 17-01-022. Decision 18-05-040 May 31, 2018. Date of Issuance June 6, 2018. (Ordering Paragraph 42 (pg. 161). Sacramento, CA, 2018.

new BEBs. With this information, Yuba-Sutter Transit can make proper decisions on BEB procurement to enable them to move forward with plans for this project.

As stated above, the current site is space constrained. In light of this fact, the current site is not feasible for full electrification because it provides limited space for future fleet growth. As with transit agencies throughout California, ridership is expected to increase in the coming years. Many in the industry would agree that anticipating zero growth of the fleet is not a viable policy. It is recommended that Yuba-Sutter Transit develop a plan to find a new site and build a new facility well before converting beyond twelve (12) battery electric buses.

For the initial deployment from up to four (4) to as many as twelve (12) BEBs, Option 1 (Ground Mounted Charge Stations) is recommended at the angled parking spots in the southern half of the yard (at transformer #1 on the attached site plan). The triangular space created at the head of each angled parking space should provide adequate area to install power blocks and depot stations, providing the most economical short term investment.

If deployment beyond the first twelve (12) BEBs becomes necessary, Option 2 (Gantry Structure Charge Stations) or 2A (Solar Canopy Structure Charge Stations) is recommended to minimize congestion at the ground level. Any newly installed structures and charging system can be designed to be relocated to a new site if the decision is made to move. The solar panels in Option 2A can also be moved and reinstalled at the new site at the optimum orientation to provide optimum efficiency.

ChargePoint equipment installed at the current site can be relocated if Yuba-Sutter Transit moves to a new site, but the electrical service equipment from PG&E may not be as mobile. Yuba-Sutter Transit should coordinate with PG&E to determine the level of investment that should be made to the electrical service equipment at the current site within the context that Yuba-Sutter Transit may relocate to a larger site in the future to accommodate both the conversion of the full fleet to BEB operation and anticipated growth to the bus fleet.

**Figure 5-1: Site Plan**

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**Table 5-1. Cost Estimate**

| ITEM NUMBER | DESCRIPTION | UNIT | ESTIMATED QUANTITY | UNIT PRICE | SUB-TOTAL |
|---|---|---|---|---|---|
| **Initial 4-Bus Installation** | | | | | |
| 1 | PG&E DESIGN | LS | 1 | $50,000 | $50,000 |
| 2 | PG&E 1000 kVA TRANSFORMER & PAD | EA | 1 | $30,000 | $30,000 |
| 3 | 1200A, 480/277V 3Ø, 4W SWITCHBOARD, WITH PG&E METER AND MAIN, DISTRIBUTION SECTION AND NEMA 3R ENCLOSURE, WITH CONCRETE PAD | EA | 1 | $270,000 | $270,000 |
| 4 | POWER DISTRIBUTION DUCTBANK | FT | 75 | $1,350 | $101,250 |
| 5 | CONCRETE CHARGING ISLAND | CY | 10 | $1,500 | $15,000 |
| 6 | CHARGING STATION INSTALLED & TESTED | EA | 2 | $40,000 | $80,000 |
| 7 | BOLLARDS | EA | 8 | $2,156 | $17,248 |
| 8 | PAVEMENT REMOVAL (6" NOMINAL) | CY | 22 | $350 | $7,700 |
| 9 | PAVEMENT REPLACEMENT (HMA TYPE A) | TN | 10 | $750 | $7,500 |
| 10 | MOBILIZATION @ 10% | LS | 1 | $57,870 | $57,870 |
| | **TOTAL ESTIMATED CONSTRUCTION COST** | | | | **$636,568** |
| | **ESTIMATED DESIGN FEE (18%)** | | | | **$114,582** |
| | **CONTINGENCY (20%)** | | | | **$127,314** |
| | **TOTAL ESTIMATED PROJECT COST** | | | | **$878,464** |
| **Option 1 - 51 Bus Installation** | | | | | |
| 1 | PG&E DESIGN | LS | 1 | $150,000 | $150,000 |
| 2 | PG&E 1000 kVA TRANSFORMER & PAD | EA | 5 | $30,000 | $150,000 |
| 3 | 1200A, 480/277V 3Ø, 4W SWITCHBOARD, WITH PG&E METER AND MAIN, DISTRIBUTION SECTION AND NEMA 3R ENCLOSURE, WITH CONCRETE PAD | EA | 5 | $270,000 | $1,350,000 |
| 4 | POWER DISTRIBUTION DUCTBANK | FT | 540 | $1,350 | $729,000 |
| 5 | CONCRETE CHARGING ISLAND | CY | 62 | $1,500 | $93,000 |
| 6 | CHARGING STATION INSTALLED & TESTED | EA | 26 | $40,000 | $1,040,000 |
| 7 | BOLLARDS | EA | 102 | $2,156 | $219,912 |
| 8 | PAVEMENT REMOVAL (6" NOMINAL) | CY | 120 | $350 | $42,000 |
| 9 | PAVEMENT REPLACEMENT (HMA TYPE A) | TN | 72 | $750 | $54,000 |
| 10 | MOBILIZATION @ 10% | LS | 1 | $382,791 | $382,791 |
| | **TOTAL ESTIMATED CONSTRUCTION COST** | | | | **$4,210,703** |
| | **ESTIMATED DESIGN FEE (18%)** | | | | **$757,927** |
| | **CONTINGENCY (20%)** | | | | **$842,141** |
| | **TOTAL ESTIMATED PROJECT COST** | | | | **$5,810,770** |
| **Option 2 - 51 Bus Installation With Overhead Gantry** | | | | | |
| 1 | PG&E DESIGN | LS | 1 | $150,000 | $150,000 |
| 2 | PG&E 1000 kVA TRANSFORMER & PAD | EA | 5 | $30,000 | $150,000 |
| 3 | 1200A, 480/277V 3Ø, 4W SWITCHBOARD, WITH PG&E METER AND MAIN, DISTRIBUTION SECTION AND NEMA 3R ENCLOSURE, WITH CONCRETE PAD | EA | 5 | $270,000 | $1,350,000 |
| 4 | POWER DISTRIBUTION DUCTBANK | FT | 540 | $1,350 | $729,000 |
| 5 | CONCRETE CHARGING ISLAND | CY | 62 | $1,500 | $93,000 |

**Table 5-1. Cost Estimate**

| ITEM NUMBER | DESCRIPTION | UNIT | ESTIMATED QUANTITY | UNIT PRICE | SUB-TOTAL |
|---|---|---|---|---|---|
| 6 | CHARGING STATION INSTALLED & TESTED | EA | 26 | $40,000 | $1,040,000 |
| 7 | BOLLARDS | EA | 102 | $2,156 | $219,912 |
| 8 | PAVEMENT REMOVAL (6" NOMINAL) | CY | 120 | $350 | $42,000 |
| 9 | PAVEMENT REPLACEMENT (HMA TYPE A) | TN | 72 | $750 | $54,000 |
| 10 | OVERHEAD GANTRY | EA | 4 | $61,000 | $244,000 |
| 11 | MOBILIZATION @ 10% | LS | 1 | $407,191 | $407,191 |
| | **TOTAL ESTIMATED CONSTRUCTION COST** | | | | **$4,479,103** |
| | **ESTIMATED DESIGN FEE (18%)** | | | | **$806,239** |
| | **CONTINGENCY (20%)** | | | | **$895,821** |
| | **TOTAL ESTIMATED PROJECT COST** | | | | **$6,181,162** |
| **Option 2A - 51 Bus Installation With Canopy & Solar Panels** | | | | | |
| 1 | PG&E DESIGN | LS | 1 | $150,000 | $150,000 |
| 2 | PG&E 1000 kVA TRANSFORMER & PAD | EA | 5 | $30,000 | $150,000 |
| 3 | 1200A, 480/277V 3Ø, 4W SWITCHBOARD, WITH PG&E METER AND MAIN, DISTRIBUTION SECTION AND NEMA 3R ENCLOSURE, WITH CONCRETE PAD | EA | 5 | $270,000 | $1,350,000 |
| 4 | POWER DISTRIBUTION DUCTBANK | FT | 540 | $1,350 | $729,000 |
| 5 | CONCRETE CHARGING ISLAND | CY | 62 | $1,500 | $93,000 |
| 6 | CHARGING STATION INSTALLED & TESTED | EA | 26 | $40,000 | $1,040,000 |
| 7 | BOLLARDS | EA | 102 | $2,156 | $219,912 |
| 8 | PAVEMENT REMOVAL (6" NOMINAL) | CY | 120 | $350 | $42,000 |
| 9 | PAVEMENT REPLACEMENT (HMA TYPE A) | TN | 72 | $750 | $54,000 |
| 10 | CANOPY INCLUDES FOUNDATION | EA | 4 | $137,500 | $550,000 |
| 11 | SOLAR INSTALLED & TESTED | KW | 1,000 | $3,500 | $3,500,000 |
| 12 | MOBILIZATION @ 10% | LS | 1 | $787,791 | $787,791 |
| | **TOTAL ESTIMATED CONSTRUCTION COST** | | | | **$8,665,703** |
| | **ESTIMATED DESIGN FEE (18%)** | | | | **$1,559,827** |
| | **CONTINGENCY (20%)** | | | | **$1,733,141** |
| | **TOTAL ESTIMATED PROJECT COST** | | | | **$11,958,670** |

Notes to Estimate
1. PG&E equipment may be discounted based on the PG&E distribution rate schedule used for the project.
2. Solar demand assumes 1000KW with utility power providing the balance plus full back-up in the event solar capacity is inadequate.
3. PG&E rates and discounts are based on anticipated usage. Failure to use expected demand may result in forfeiture of any discounts and alter rate schedule.
4. This estimate represents the probable cost of the installation for each option. It does not represent the life-cycle costs associated with each option.