1. When is the deadline for questions on this RFP? **The deadline was on November 7th, but has been extended to November 28th at 11:59 PM, please see addendum.**

2. On page 4, the RFP states "The work described requires that the Consultant be licensed by the State of California as an Electrical Engineer. Engaging with an electrical consultant (C-10) and / or Electric Vehicle Infrastructure Training (EVIT) certified installer as part of this work may enhance the work product requested." Our question is does the prime consultant need to be licensed by the State of California as an Electrical Engineer or can another team member be a registered EE such as a subcontractor/subconsultant? **It is sufficient for anyone on the team to have this certification/training.**

3. Please provide the 2019 preliminary Transit fleet and facility electrification plan referenced on page 6. **Please see the attached document. Attachment 1**

4. Would the City consider extending the proposal deadline by one week? **After receiving multiple requests to extend, staff have decided to extend the deadline until December 5th at 11:59pm. The new deadline to submit questions is November 28th at 11:59pm.**

5. There is no content on pages 13 and 14 of the RFP (pages 17 and 18 of the pdf). Is there additional content that was intended to be on those pages? **No**

6. Attachment 1: Living Wage Ordinance is not included in the RFP documents. Would the City please provide this form? **Yes—please see attached. Attachment 2**

7. There are two response structures requested. Would the City please clarify which order the submittal items should be in?

   Responses shall be limited to a maximum of 10 pages, excluding resumes, and the Fee Proposal Sheet. Responses shall be organized and numbered in the order presented below and emailed as a PDF document.

   - **Cover Letter**
   - **Introduction**
   - **Section 1: Project Management Approach**
   - **Section 2: Technical Approach/Scope of Work**
   - **Section 3: Experience and Qualifications**
   - **Section 4: Cost Proposal**
   - **Section 5: Living Wage Acknowledgment**
   - **Appendix A – Resumes**
   - **Separate PDF Document: Fee Proposal Sheet**

8. The scope of work appears to be focused on the EV charger infrastructure needs only, and does not include fleet transition planning. Is that Correct? **Yes**

   a. Does the City have identified goals and a timeline for transitioning fleet vehicles to plug-in hybrid or electric? **The City is currently in the process of fleet transition. Staff is in the process of drafting an EV preferred purchasing policy and is committed to only**

purchasing EVs unless the vehicle is designated an emergency vehicle. In these circumstances, the City leases the most environmentally option available.

b. Will the City be providing the consultant with a detailed timeline of fleet electrification, including the number and type of electric vehicles to be adopted by facility per year? Ideally, this is across a 10-yr period. **The City will provide as much information as possible to the consultant.**

9. In order to complete the scope of work task to "estimate fleet electrical use for current and future vehicles", will the City provide the consultant with detailed information about vehicle duty cycle and operations? **To the best of the ability of staff. Staff is currently reviewing fleet management software to help track this information.**

    a. Does the City already have data to characterize fleet vehicle operations to share with the consultant? **The consultant will obtain this data from appropriate City staff for each department.**

    b. Will the consultant gather this information from a single City staff member of work with multiple departments? **The consultant will work with multiple departments in conjunction with a lead contact.**

    c. Do City fleet vehicles have telematics? **The City is reviewing telematics currently.**

10. For facilities where the City identifies the desire for fleet, workplace, and public-facing charging, for example, the City Hall, PWU Field Office, and Ellis Creek Water Recycling Facility sites:

    a. Do these facilities currently have designated parking spaces reserved for fleet, staff, and public? **Some yes—some no.**

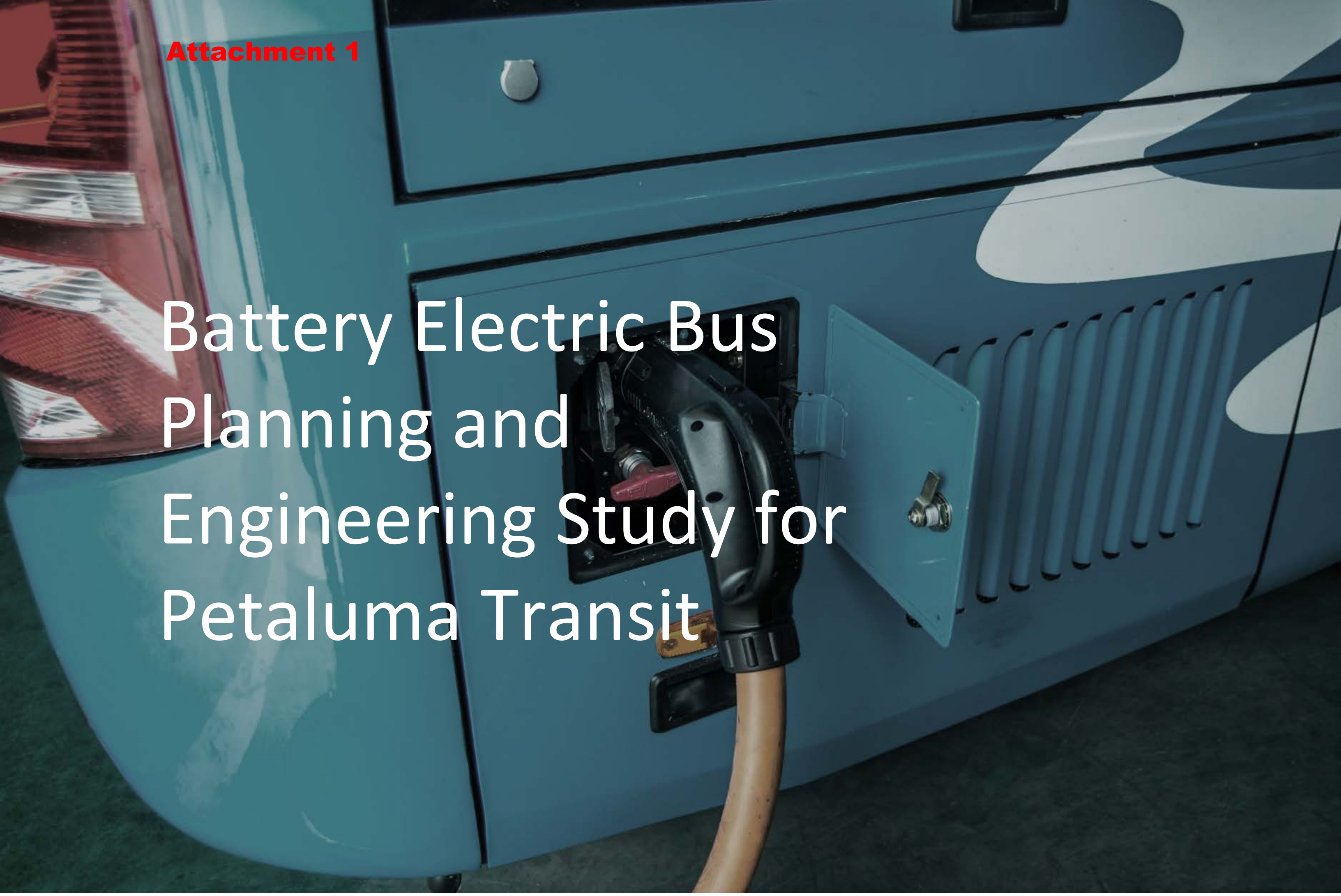
    b. Does the City intend to have separate fleet chargers from workplace and public? **Depends on the facility and the number of dedicated fleet vehicles at that facility.**

11. For facilities participating in the PG&E EV Fleet program (Fleet Ready):

    a. How many facilities have applied or are currently enrolled in the program? **The Transit facility is currently participating in that program and applications for three more facilities are being worked on.**

    b. Is PG&E covering design and construction of both To-the-Meter and Behind-the-Meter at all of these facilities? **Potentially. The scope includes coordination between the consultant and PG&E.**

Attachment 1



Battery Electric Bus Planning and Engineering Study for Petaluma Transit

SPONSORED BY SONOMA CLEAN POWER

December 31, 2019

Prepared for:

City of Petaluma

555 North McDowell Blvd

Petaluma, CA 94954

Prepared by:

The Cadmus Group

Table of Contents

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Acronyms and Abbreviations

Acronym	Definition
BEB	Battery electric bus
BEBCM	Battery Electric Bus Corridor Model
BTC Power	Broadband Telcom Power, Inc.
BTM	Behind-the-meter
CEV	Commercial electric vehicle
DER	Distributed energy resource
EV	Electric vehicle
EVSE	Electric vehicle service equipment
LCFS	Low Carbon Fuel Standard
OCPP	Open Charge Point Protocol
OpenADR	Open Automated Demand Response
PACE	Property Assessed Clean Energy program
PG&E	Pacific Gas and Electric Company
PV	Photovoltaic
SCP	Sonoma Clean Power
SJRTD	San Joaquin Regional Transit District
SRJC	Santa Rosa Junior College
TOD	Transit-oriented development

Executive Summary

This report serves as a resource to help Petaluma Transit map out its near-term pathway for transition to battery electric buses (BEBs). High-level findings of the *Existing Conditions and Assets* analysis, the Available Technologies analysis, and the Short-Term Recommendations are presented here.

The report begins with an introduction to the sites (*Existing Conditions and Assets*). The approach included having discussions with Petaluma Transit about its interests and constraints, visiting sites to assess existing infrastructure, reviewing utility distribution system capacity, and conducting in-depth analysis of combinations of solar, storage, and bus electrification. There are several high-level findings:

At the City of Petaluma Transit Yard,

1. Existing electrical infrastructure on the customer should be able to accommodate the City's near-term electric bus plans, including associated electric vehicle service equipment (EVSE) and some behind-the-meter (BTM) resources.
2. The Pacific Gas and Electric Company (PG&E) circuit maps for this area indicate that there may not be sufficient existing capacity on the feeder to add significant BEB charging without investing in grid upgrades. Further conversations with PG&E will be required to determine the site's true hosting capacities.
3. The primary options for PV installation are on the roof of the maintenance building and as part of a solar parking canopy over the bus parking areas. Up to 114 kW-DC of solar could be installed, which could offset the annual energy consumption of nearly one and a half BEBs.

Source: Photo taken by Randy Mead.

At the Copeland/Petaluma Transit Mall

1. Coordination with third parties could increase the future cost-effectiveness of electrical upgrades to support BEB opportunity charging, since there is a proposed transit-oriented development (TOD) immediately to the southwest of the Transit Mall, which will require utility changes including undergrounding and any upgrades required on the distribution system for the new service.
2. PG&E circuit maps indicate limited capacity on the line section that would serve the Transit Mall. High-powered on-route chargers, the technology best suited for the Transit Mall application, can be rated to supply 200 kW to 500 kW of power, yet no more than 142 kW of load can be introduced on the nearby line section without potentially triggering a system upgrade. A nearby substation can provide an alternative approach but would require a new dedicated feeder.
3. Neither PV nor energy storage would be feasible at this location due to land ownership constraints and future shading constraints.

The second section of this report (*Available Technologies*) delves into technology surveys of energy storage, charging equipment, data management systems, and the actual BEBs. These overviews cover the breadth of available solutions and their potential, as well as available funding sources:

- **Storage.** The value proposition of storage will be eroded by the recently approved PG&E commercial electric vehicle (CEV) tariff, which replaces conventional demand charges with a much less costly subscription fee. Nonetheless, storage can provide value from price arbitrage, management of CEV subscription costs, and resilience. Five energy storage technologies and seven relevant funding and financing options were evaluated and summarized in *Appendix B* and *Appendix C*. Lithium-ion batteries are the most cost-effective and market-ready option for transit agencies at this time. California's Self-Generation Incentive Program is the most promising funding source for storage, and the California Energy Commission and other agencies are offering grants and financing opportunities.
- **Battery Electric Buses.** There are many BEB models available. Both the cost and the weight of the battery will affect bus performance and should be considered in the overall decision-making process. Buses that drive longer routes work best with a bigger battery or well-managed recharging cycles to serve their higher energy requirements. Weather and terrain are also important factors. Available options are rapidly changing and a current survey of 13 leading available models is provided in *Appendix H*. The availability of buses is also subject to legislative and trade policies. For instance, a provision in the National Defense Authorization Act (signed into law on December 20, 2019) would bar Chinese companies (like BYD) from supplying BEBs to U.S. transit agencies after the grace period.[1]
- **Charging Equipment and Charge Management.** Depot charging solutions were evaluated with the expectation that in the short term, the agency's BEBs will be charged overnight. Approximately 20 leading options are summarized in *Appendix D* and *Appendix E*. To manage

[1] Wehrman, Jessica. December 10, 2019. "NDAA Provision Targets Chinese Rail Cars And Electric Buses." *Roll Call*. https://www.rollcall.com/news/congress/ndaa-chinese-transit

charging capabilities, the agency can use features like remote monitoring of bus battery status, prioritizing which buses get charged, and regulating the amount of power each bus receives at any point in time to reduce or mitigate demand charges or subscription fees. These capabilities can either be provided by the electric vehicle service equipment (EVSE) product manufacturer or a third party such as an electric vehicle (EV) network service provider.

To select a suitable depot charging system, the agency must confirm the total kilowatt-hours needed for daily operation, determine the power needed, determine its charger-to-bus ratio, and consider operational constraints such as availability of maintenance staff to manually move charger nozzles between buses at night. Tradeoffs must be weighed between upfront cost, system redundancy, and ongoing operational impacts of the infrastructure. A wide range of funding opportunities are available and described in *Appendix G*. A notable opportunity is presented by PG&E's EV Fleet program, through which the utility offers design and construction services, cost offsets, and EV charger rebates for eligible equipment (*Appendix D* lists which chargers are currently eligible). There are opportunities to leverage cooperative procurement contracts developed by the State of California to achieve a streamlined procurement process and favorable pricing.

The third section of this report (*Short-Term Recommendations*) provides short-term recommendations for the transit agency. This includes analysis of route energy requirements, suggested infrastructure upgrades, charging patterns and policies, and optimized recommendations for BTM distributed energy resources (DERs). Key findings include:

1. BEB models that can meet Petaluma Transit's energy needs for routes 3 and 24 are commercially available; for its remaining routes, energy needs are much higher, but strategic mapping between BEBs and route energy needs could facilitate electrification. Route 11 could also be covered by a larger battery capacity BEB.
2. If the agency chooses to comply meet the requirements of the Innovative Clean Transit Rule with an entirely BEB fleet, its long-term energy requirements will substantially increase the agency's consumption of electricity to approximately 2.5 MWh per day. This will create the need for substantial long-term investments in power supply.
3. While Petaluma Transit could technically meet its short-term energy needs for the 4 BEBs it plans to procure with as few as two chargers, this approach would be risky because operations would be constrained if even one charger needed maintenance or was otherwise out of service. Installing three chargers would provide extra capacity in the case of a charger being out of commission but would still require charging multiple buses per charger overnight.
4. A new 480V service would be necessary to meet the charging needs of full-sized transit buses at the Petaluma Transit Yard, and the eastern side of the property has a good location for such an installation. Required equipment and expected costs are described in the report.
5. Regardless of the charging protocol used for short-term bus electrification, PG&E's new CEV rate will provide substantial savings to the agency, and will require bus charging to be separately metered. The agency should subscribe to the CEV rate when it is made available, then ensure that EVSE is separately metered from other site loads in order to qualify for that rate.

6. The new CEV rate will increase the importance of avoiding charging during peak periods from 4 p.m. to 9 p.m. The CEV rate provides a strong incentive to charge buses midday, when possible.
7. The results of modeling the solar and storage opportunities suggest that the most economical way to meet the fleet's short-term energy needs is to select the CEV rate and forgo installing any solar and storage resources. Since buses are to be primarily charged overnight, the price arbitrage between the off-peak and super-off-peak rates that storage would enable is only $0.02 per kilowatt-hour, which is far less than the cost of the battery.
8. Despite their challenging economics, in the long term, on-site storage and generation are appealing for their reliability and resilience characteristics, particularly since the North Bay is increasingly subject to Public Safety Power Shutoffs. In order to be capable of limited operation during an outage, the agency likely needs a backup generator in addition to any solar and storage.
9. Low Carbon Fuel Standard (LCFS) credits associated with the agency's short-term BEB procurements could provide up to $710,000 in net present value under optimistic assumptions about credit prices.

Recommended Next Steps

Petaluma Transit is already on a path toward fleet electrification. It would benefit the agency to consider the findings within this report as it moves more concretely to implementing its short-term plan and considers its mid- and long-term energy planning.

To expand beyond the initial four buses that have been shown to be feasible for electrification (on routes 3 and 24), the agency will benefit from considering operational changes or considering higher battery capacity buses. For instance, the agency can offer driver training for efficient operation of BEBs to ensure that it gets the highest possible range, or make modifications of additional routes that would be more challenging for BEBs.

Additionally, the agency could benefit from further analysis to support additional scaling of its BEB deployments including modeling additional routes, engaging more with PG&E to ensure that current plans will enable it to seamlessly enroll in the CEV rate, exploring innovative financing approaches with Sonoma Clean Power (SCP) and PG&E, and pursuing regional collaboration opportunities such as with SCP, with the Bay Area Air Quality Management District, and with peer agencies.

Figure 1. Snapshot of Petaluma Transit's Battery Electric Bus Transition

Key Decisions to Make

- Charger and BEB specifications and sequencing of new procurements
- Initial infrastructure design – charger locations, BTM equipment, and to-the-meter infrastructure requirements

Key Obstacles

- Funding the additional up-front capital costs of electric buses
- Space limitations at the Petaluma Transit bus yard

Key Opportunities

- Collaborate with PG&E to participate in the EV Fleet program
- Capture LCFS credits to offset fueling costs
- Plan initial infrastructure for mid- to long-term needs

Existing Conditions and Assets

This BEB study covers two Petaluma Transit facilities: the Petaluma Transit Yard at 555 North McDowell Boulevard and the Copeland/Petaluma Transit Mall on Copeland Street between Washington and D Streets, both located in the City of Petaluma. The focus of the description is to understand the near-term issues related to setting up BEB charging infrastructure to service select transit routes over the next five years. Petaluma is in the early stages of its planning process, but recognizes the value of centering a vision to the long-term when all their routes will be serviced by BEBs. It is important to consider these longer-term plans so that short-term decisions do not add unnecessary complications to long-term plans, and to ensure efficient deployment and reduce the risk of stranded assets later.

Figure 2. Petaluma Transit Welcome

Source: Photo taken by Randy Mead.

Short-term planning also includes scoping for solar PV systems and energy storage that might augment the grid electricity supply to the proposed BEBs at both facilities. The rate structures used for these BEB charging facilities will greatly impact their cost-effectiveness. While cost-effectiveness is a key factor for integrating PV and energy storage with BEB charging, agencies are also interested in enhancing resilience in the case of power disruptions. The following sections discuss the potential for PV and energy storage at the Petaluma facilities from the perspective of physical constraints. The scenarios for integrating this generation, as well as storage options, are outlined in the *Behind-the-Meter Energy Resources* section.

Approach to Site Visits

The project was initiated with an intake call between the project team and Petaluma Transit Manager, Jared Hall. The intake process set the priorities for evaluating the facilities and existing infrastructure. The descriptions below are based on in-person site visits to both facilities and discussions with site personnel. Prior to undertaking site visits, internal site visit memos were prepared to facilitate the collection of key facility information, later augmented by thorough photographic documentation of the facilities. A high-level review of the available space to install PV and energy storage was also considered as part of these in-person evaluations.

Approach to Distribution System Capacity

To augment the information collected during site visits, details on the capacity of the grid to serve new BEB load and absorb BTM generation were obtained using an integration capacity analysis map, designed to help contractors and developers find information on potential project sites for DERs.[2] The map details available load hosting capacity and generation capacity on the distribution feeders and line sections serving a site. This analysis is the first step for transit agencies and DER project developers to determine whether their sites are appropriate for introducing BEB load or DERs without the need for significant upgrades to the local electrical infrastructure.

> "***Hosting Capacity*** is the amount of DERs that the electric distribution system can reliably accommodate without significant grid upgrades. In conducting a thorough hosting capacity analysis, utilities consider voltage/power quality constraints, thermal constraints, protection limits, safety, and overall reliability to arrive at a capacity (kW, MW) of new generation or load which can be accommodated at a specific location on a distribution circuit."

Source: Solar Energy Industries Association (Gahl, Dave, Brandon Smithwood, and Rick Umoff). September 2017. "Hosting Capacity: Using Increased Transparency of Grid Constraints to Accelerate Interconnection Processes." Whitepaper Series: Improving Opportunities for Solar through Grid Modernization. https://www.seia.org/sites/default/files/2017-09/SEIA-GridMod-Series-3_2017-Sep-FINAL.pdf

It is important to note that the model provides the most conservative estimates of these values. For example, it often produces an estimate of zero capacity at a site when in fact the model only finds a few hours during the entire year where the threshold hits a zero value. Even in these cases, the tool provides valuable details about whether the limiting factor is a thermal, voltage, or protection violation. PG&E's "Distribution-Resource Planning Data Portal" provides additional caveats about the information provided:

1. Information is illustrative and is likely to change or be modified over time for reasons such as circuit upgrades, new loads, new DERs, new circuits, and seasonal switching.
2. Many factors affect interconnection capability and costs, and the maps do not guarantee that generators can interconnect.

The interconnection process can be the most onerous, lengthy, and costly aspect of DER project development. This is especially true for smaller-scale projects that can be made uneconomic due to unpredictable interconnection costs and timelines.[3] The insights provided from the integration capacity analysis map will facilitate agencies' conversations with the distribution grid operator when they initiate full engineering designs for infrastructure needed to support BEB charging loads and new on-site DERs.

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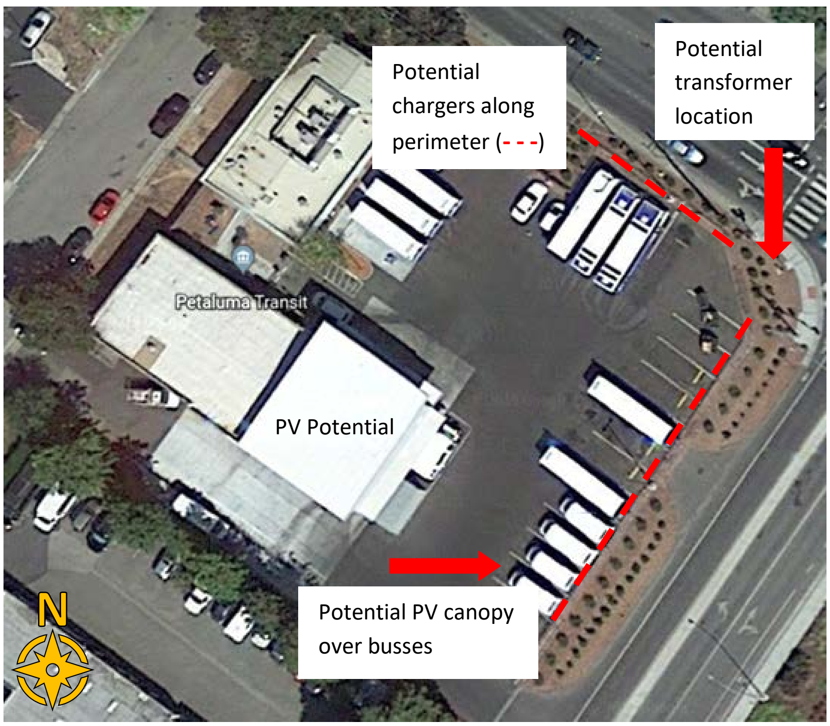
[2] Pacific Gas and Electric Company. Last updated 2019. "Distribution-Resource Planning Data Portal." https://www.pge.com/en_US/for-our-business-partners/distribution-resource-planning/distribution-resource-planning-data-portal.page?ctx=large-business

[3] Solar Builder. January 14, 2019. "After Some Drama, California's Major Utilities have Published Updated Interconnection Capacity Analysis Maps." https://solarbuildermag.com/news/californias-major-utilities-have-published-updated-interconnection-capacity-analysis-maps/

City of Petaluma Transit Yard

The Petaluma Transit Yard is a compact facility with a fully used bus parking area and 16 buses under current operations, as shown in Figure 3. Office buildings and a maintenance garage occupy the western side of the lot and buses park side-by-side along the northeast and southeast perimeters of the yard. The site currently has one 9.6 kW "Juicebox" charger installed, which can serve the needs of light-duty vehicles. One concern is that if a higher spare ratio is needed for operating electric buses, the site does not have capacity to house these additional vehicles. A few extra buses could be stored at another City facility to serve as spares; these buses can be non-electric to avoid the need for additional electrical upgrades at the secondary location. Beyond this risk and despite the agency's relatively small yard, it should be able to accommodate the City's near-term electric bus plans, including associated electric vehicle service equipment (EVSE) and some BTM resources. In the long-term, the range and operational reliability of electric buses is expected to continue to improve such that the need for a higher spare ratio for electric buses may become less critical.

Figure 3. Petaluma Transit Potential Charger Locations



Source: Amended Google Earth image.

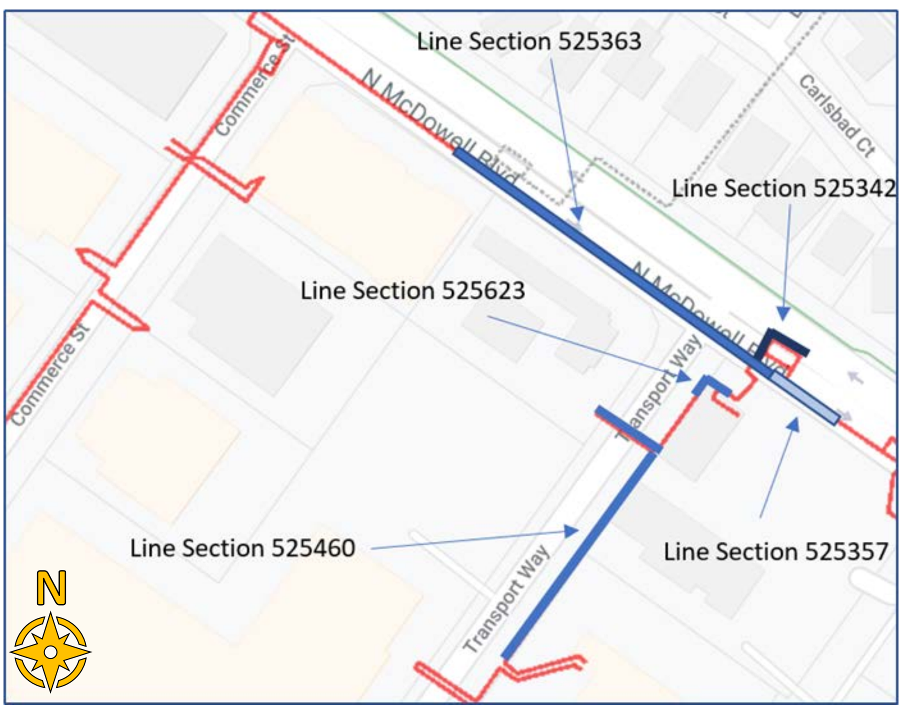
Electrical Service, Backup Generation, PV, and Storage

The site is served by a 12 kV line that is stepped down to an existing 208 V service. The transformer capacity could not be deciphered but is estimated as less than 500 kVA. The existing 208 V electrical infrastructure includes both 200 A and 800 A panels on the maintenance building, as well as a 125 A three-phase panel on the office building.

Despite the constrained space in the Transit Yard, Petaluma can still pursue a variety of distributed resources to bolster its transition to a fully electrified bus fleet. The primary options for PV installation are on the roof of the maintenance building and as part of a solar parking canopy over the bus parking areas. The site had a solar feasibility and cost-effectiveness study performed in 2017, focused on the primary roof locations. Agency leadership staff are especially intrigued about solar parking canopies, which were successfully implemented at the nearby Casa Grande High School; however, the cost-effectiveness of such a system may hinge on whether the agency stays at this same site long enough to achieve a return on the investment. Another key opportunity is on-site energy storage, optimally located at the same corner as the new service line. Because of the layout of the parking spaces, there is an unoccupied area with a few dumpsters that could fit a substantial quantity of battery storage.

As shown in Figure 4, PG&E circuit maps for this area indicate that there may not be sufficient existing capacity on the feeder to add significant BEB charging without investing in grid upgrades (see Table 1). All the line sections reviewed face thermal constraints in their ability to host additional load. However, the local grid appears to have capacity to absorb between 1.1 MW to 2.3 MW of new BTM PV generation. The line sections located at the corner of North McDowell Boulevard and Transport Way have the highest capacities to absorb that additional generation, according to the integration capacity analysis model. The agency will need to initiate conversations with PG&E regarding infrastructure assessment and planning to make a final determination on the site's hosting capacities, reinforcing the importance of recognizing the limitations of the mapping tool for scoping grid capacity to absorb DER loads and generation.

Figure 4. Line Section Map: Petaluma Transit Yard



Line sections are denoted by areas filled in blue. Adjacent line sections are separated by a different fill shade of blue.

Table 1. Integration Capacity Analysis results: Petaluma Transit Yard

Feeder Name	Feeder #	Line Section	Load Hosting Capacity	PV Generation Hosting Capacity
Petaluma C 1106	42631106	525460	Thermal limited	1,101 kW
Petaluma C 1106	42631106	525623	Thermal limited	1,100 kW
Petaluma C 1106	42631106	525363	Thermal limited	2,265 kW
Petaluma C 1106	42631106	525357	Thermal limited	2,265 kW
Petaluma C 1106	42631106	525342	Thermal limited	2,265 kW

Location of Charging Stations

The buses are parked overnight at the facility side by side along the northeastern and southeastern perimeters of the yard. There appears to be enough space between the bus parking spaces and the road rights-of-way to install the necessary vehicle chargers, especially if the agency procures dual-port pedestal chargers. It is key to ensure that charger cables are long enough to reach the far side of some buses, depending on configuration of chargers and bus parking.

Copeland/Petaluma Transit Mall

The Copeland/Petaluma Transit Mall is a few blocks from downtown Petaluma and a five-minute walk from the Sonoma-Marin Area Rail Transit station. The site, which hosts service for the City of Petaluma, Sonoma County Transit, and Golden Gate Transit, is a pull-through facility with stops for the various agencies located nose-to-end along Copeland Street. County buses may lay over for up to 50 minutes at the site after unloading passengers. City of Petaluma buses have shorter layovers at the site, usually 10 to 15 minutes at most. The street is quite narrow, offering limited space for long dwell times to pursue on-route charging at the site.

Description of Location

The Transit Mall occupies the length of one city block between two large, undeveloped plots of land. Both plots are under consideration for improvement, including a proposed multi-story, transit-oriented development (TOD) to the southwest of the Transit Mall. This TOD project would include burying the existing overhead feeder, shown in Figure 5, which creates the opportunity for construction efficiencies if developers coordinate with the transit agencies for electrical upgrades to the Transit Mall. Sonoma County Transit and the City of Petaluma would benefit from a coordinated approach and should take advantage of the City's role as a regulator of the TOD to initiate conversations about possible partnership arrangements. This TOD project is still at least a few years from completion, especially considering recent litigation and remaining uncertainties in the development process.[4] This delayed timing may align well with agency charging needs because on-route charging is not in the near-term plans.

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[4] Argus-Courier Staff. August 1, 2019. "SMART Deal within Reach." *Argus-Courier.* https://www.petaluma360.com/opinion/9831032-181/smart-deal-within-reach?sba=AAS

Figure 5. Copeland/Petaluma Transit Mall Site

Source: Amended Google Earth image.

Electrical Service, Backup Generation, PV, and Storage

The only power that currently serves the site is for street lights and a few canopy lights along the sidewalk. There is no existing transformer, so a new transformer would need to be set and tapped into nearby lines. Across the street from the Transit Mall there are medium voltage PG&E feeder lines, from which the transit agencies could install conduit to the potential location of a future transformer to serve Transit Mall charging stations.

However, PG&E circuit maps for the area indicate limited capacity on this line section (see 530077 in Table 2). High-powered on-route chargers, the technology best suited for the Transit Mall application, can be rated to supply 200 kW to 500 kW of power, yet no more than 142 kW of load can be introduced on that nearby line section without potentially triggering a system upgrade. There is also a major substation for the City of Petaluma located less than 200 yards to the southwest of the Transit Mall site, which provides an alternative solution. A dedicated feeder could be installed from the nearby substation if there is not enough available capacity on the existing lines. While a new feeder would be a significant additional investment, it is a relatively short distance and could be sized to match future load. Sonoma County Transit and the City of Petaluma will need to initiate conversations with PG&E and the TOD developer to determine the best approach to these upgrades. The opportunity to save resources by aligning with the impending upgrades for the TOD must be weighed against the risk of moving forward with investments when there are significant uncertainties surrounding plans, both for BEB charging at the Transit Mall in the near to mid term and for the proposed adjacent TOD.

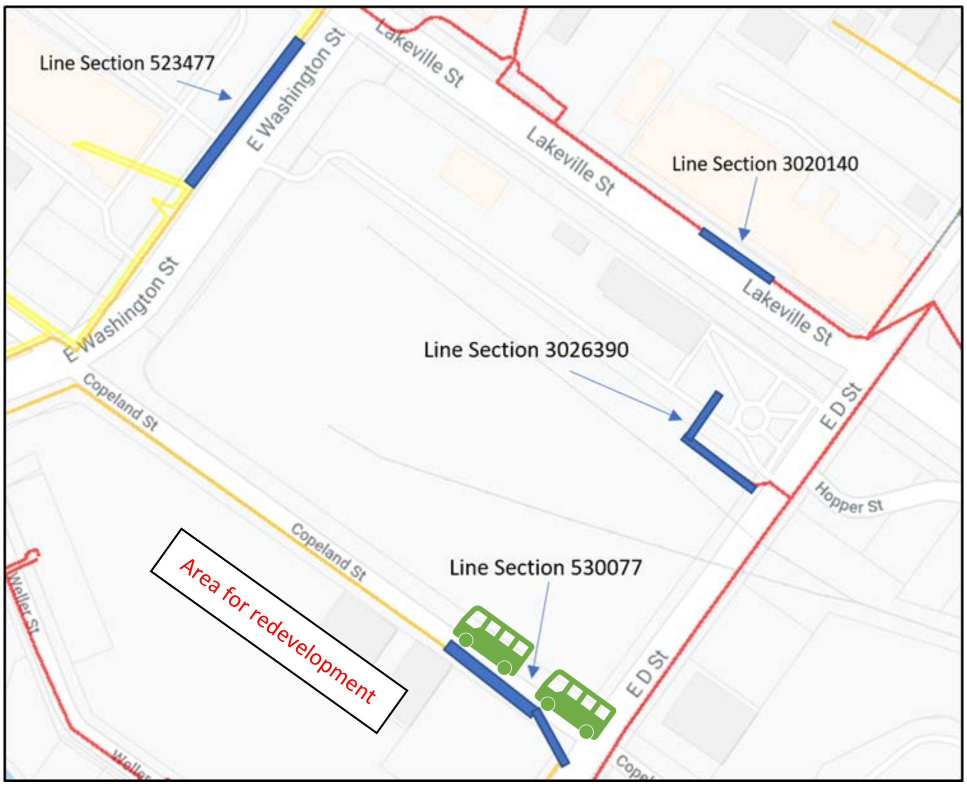
Table 2. Integration Capacity Analysis Results: Copeland/Petaluma Transit Mall

Feeder Name	Feeder #	Line Section	Load Hosting Capacity	PV Generation Hosting Capacity[a]
Petaluma C 1110	42631110	530077	142 kW	Protection limited
Petaluma C 1109	42631109	3020140	Voltage limited	870 kW
Petaluma C 1109	42631109	3026390	Voltage limited	220 kW
Petaluma C 1102	42631102	523477	1,095 kW	Protection limited

[a] Note that PV generation hosting capacity is moot because of site constraints.

Because very little land at the site is under the transit agencies' control, it is unrealistic to consider either PV or storage at this location. Furthermore, any PV that was located along the Transit Mall side of Copeland Street would likely be shaded by the planned multi-story TOD. See the line section map in Figure 6.

Figure 6. Line Section Map: Copeland/Petaluma Transit Mall



Line sections are denoted by areas filled in blue. Green bus icons denote potential bus charging locations featured in subsequent satellite images.

Location of Charging Stations

The most likely eventual location for BEB chargers at this facility is the southeast end of Copeland Street near the Sonoma County Transit bus stop. Sonoma County is more likely to use these chargers regularly because its somewhat longer layovers are a better fit for on-route charging than the City of Petaluma's quick stopovers at this facility. If chargers were placed at this location and its bus technologies were compatible, the City of Petaluma could potentially use the chargers for emergency charging, increasing the resilience of the transit systems in the region. Figure 7 shows the infrastructure locations for both plug-in and wireless inductive chargers. The security of any installed equipment is a concern since this area is not fenced but is open to the public, requiring exploration of a variety of strategies to enhance security and reduce liabilities.

Figure 7. Copeland/Petaluma Transit Mall Site

Source: Amended Google Earth image.

Approach to Solar Potential

This report section details both the physical design and pertinent technical details of potential solar installations at the Petaluma Transit Yard. This includes estimated capacity, production, and performance, all based on publicly available satellite images and information provided by City of Petaluma staff. The estimated annual production offered in this analysis can be used to estimate annual energy savings for the potential PV arrays. Site-specific energy savings are expected to continue over a 20-year timeline with minimal performance degradation (approximately 0.5% per year).

Cost assumptions were obtained by collecting data from private research and governmental data resources and databases such as Energy Sage, the Tracking the Sun 2019 annual report,[5] California DG Stats, Energy Sage, Massachusetts Clean Energy Center's Production Tracking System, and reports from the National Renewable Energy Laboratory. Insight from these reports and resources was combined with our own expertise in energy markets and trends to build these estimates. The California DG Stats website lists the average cost for installed commercial solar in PG&E's territory as $3 per watt. The systems under review for Petaluma Transit are larger than typical commercial solar installations and will likely benefit from decreases in both hard and soft costs, suggesting that $2.50 per watt is a conservative estimate for roof-mounted solar arrays. A 3.5% adjuster was then used to account for additional costs associated with ground-mounted systems (based on relative cost ratios documented in

[5] Lawrence Berkeley National Laboratory (Barbose, Galen, and Naim Darghouth). October 2019. "Tracking the Sun: Pricing and Design Trends for Distributed Photovoltaic Systems in the United States." https://emp.lbl.gov/sites/default/files/tracking_the_sun_2019_report.pdf

the 2019 Tracking the Sun report). Likewise, based on industry knowledge and actual price data from the Massachusetts market, a weighting was applied to reflect the costs of solar canopy systems. These estimates were also compared to the quoted price offered by Simply Solar for the Petaluma Yard site to ensure that our rough estimates align with market standards. These estimates are for the entire installation, including labor, but likely do not include any permitting costs.

Technical Specifications for the Modeled Solar Installation

This analysis was conducted using Helioscope, a web-based PV design software, to generate a conceptual PV system design.[6] The models assume industry standard LG, LG365Q1C-A5 (365 watt) panels, and either SGI 500PE-480 (Solectria) or IQ7PLUS-72-ACM-US (240V) (Enphase) inverters, depending on the system size. The design does not maximize the total number of panels at each site, but instead aims to maximize efficiency and effectiveness. When reviewing the Helioscope model results, the small blue rectangles represent where panels can be located, while orange areas are blocked off for necessary maintenance alleys or to indicate pre-existing obstructions to development. These designs do not account for compliance with local zoning rules, such as roof setbacks, or for unique utility interconnection requirements, and are provided to indicate the likely technical potential at each site.

Petaluma Transit Yard (Design 1)

Design 1, shown in Figure 8, represents a scenario in which the City takes full advantage of its limited space through a combination of solar canopies and roof-mounted systems. The proposed solar parking canopies could double as infrastructure for the EVSE gantries or cabling. This design is modeled to produce over 100 kW without hindering the functionality of the space (see Table 3).

Figure 8. Transit Yard Solar Potential: Design 1 (Helioscope)

Table 3. Solar Potential Specifications: Petaluma Design 1

DC Capacity (kW)	114.6
No. Modules	314
Estimated Annual Production (MWh)	170
Combined $/W	$3.19
Total Cost	$365,000

6 Helioscope is a cloud-based solar PV design modeling software that integrates system design and performance modeling to develop preliminary layouts and energy yield calculations for measuring solar PV feasibility (https://www.helioscope.com/).

Petaluma Transit Yard (Design 2)

Design 2, shown in Figure 9, is a simpler alternative, as it does not require any new construction. Instead, it takes advantage of the unused roof pitch on the maintenance building. Though this design offers significantly less PV generation than Design 1, it would still produce about 38 MWh annually (Table 4) and would likely be a fraction of the cost of Design 1.

Figure 9. Transit Yard Solar Potential: Design 2 (Helioscope)

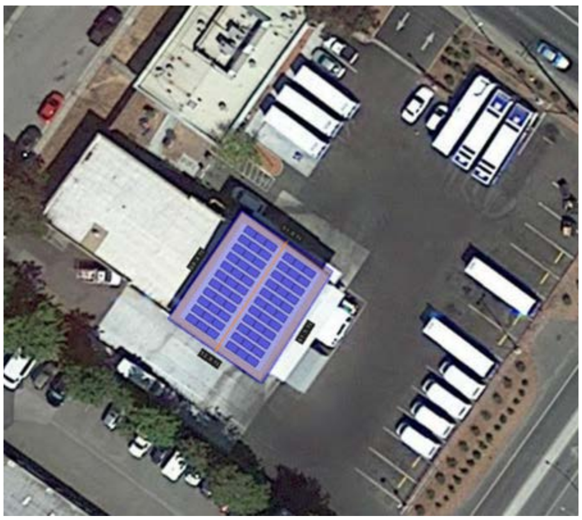


Table 4. Solar Potential Specifications: Petaluma Design 2

DC Capacity (kW)	24.1
No. Modules	16.5
Estimated Annual Production (MWh)	37.84
Combined $/W	$2.50
Total Cost	$60,250

Solar Opportunity in Context

To provide a sense of scale for this solar opportunity, consider that a BEB with a 440 kWh battery that recharges to 100% from a 20% state of charge, 360 days per year, would consume just over 125 MWh annually. This suggests that the incremental on-site generation at the Petaluma Transit Yard as modeled in Design 2 could provide about 30% of the energy required to fulfill the charging needs of a full-sized electric transit bus (Design 1 is the equivalent of 1.4 such buses).

Note that this order of magnitude calculation is exclusive of losses due to battery inefficiencies, any potential consumption for cooling/heating while the bus battery is connected to the grid, and other uncertainties. Furthermore, an economic analysis (such as that outlined in the *Depot Chargers* section of this report) is necessary to illustrate how time-of-use electricity rates and projected generation and consumption profiles might interplay with net energy metering policy to determine the actual benefit of installing on-site PV generation to offset BEB energy needs.

Available Technologies

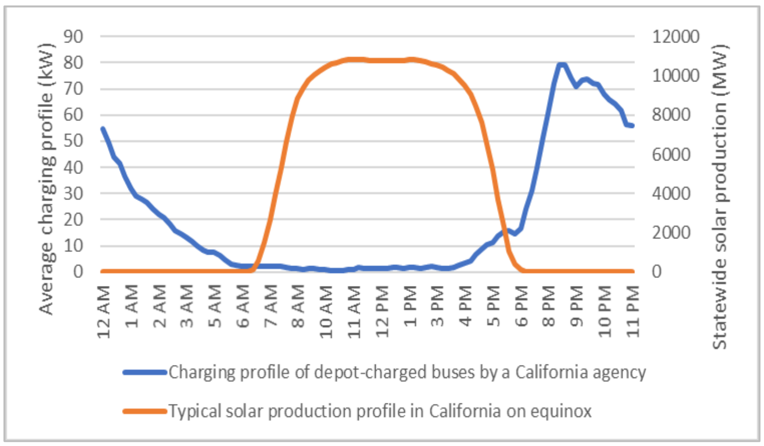
Transit electrification requires consideration of on-site electrical infrastructure, as discussed above, but also presents opportunities to integrate many other technologies and services to achieve sustainable, resilient systems. This section presents a snapshot of commercially available technologies to guide agencies as they navigate planning and procurement decisions.

Energy Storage

Opportunities for on-site energy storage at transit agency facilities were reviewed with an eye toward reducing demand charges and enhancing resiliency. This section covers the available technologies and their characteristics, as well as cost estimates and potential funding sources.

While opportunities for PV at transit facilities have been identified, solar production hours often overlap directly with the hours buses are in use. Figure 10 illustrates the charging profile of a fleet of depot-charged buses in California compared against typical solar production hours in the state. These typical charging profiles, as well as the structure of the Commercial Electric Vehicle (CEV) tariff approved in October 2019, will have an adverse effect on the economics of solar systems without storage.

Figure 10. Daily Solar Production Compared with Daily Bus Charging Patterns



Transit agencies pursue energy storage for a variety of reasons. Some value propositions are complementary, while others require tradeoffs; agencies should identify the most important technology purposes for their context, then measure the options against these priorities. Table 5 lays out principle drivers for transit agency procurement of energy storage.

Table 5. Energy Storage Value Propositions

Purpose	Value Proposition	Questions to Ask
Price Arbitrage and Load Shifting	Energy storage and BTM resources allow users to take advantage of load-shifting abilities to participate in price arbitrage. By charging batteries during low-demand, lower-priced time intervals and discharging them during high-demand, higher-priced hours, these technologies produce cost savings to their owners and others reliant on the grid.[a]	Without storage, would the agency need to charge from the grid outside the lower-priced hours? What is the value of shifting charging? Does the agency already regularly have buses available to charge during lower-priced hours (rush hour/peak buses)?

Purpose	Value Proposition	Questions to Ask
Demand Charge Management	Utilities use demand charge revenues to distribute the costs of building and maintaining their common infrastructure assets. Demand charges are based on peak demand, which is measured as the highest level of electricity drawn from the grid within a certain time interval, and can be responsible for 30% to 70% of electricity bills.[b] Storage and BTM technologies can be used during peak hours to satisfy transit agencies' energy demands and lower subsequent demand charges. Demand charges are less of a concern if agencies adopt the recent CEV rate, but under that framework, storage can help transit agencies stay within their subscription limit.	Do available rate tariffs allow opportunities for using BTM energy storage to mitigate metered costs, specifically to manage peak loads? Can the chargers selected support software to limit charging power if needed?
Resilience	Resilience is a system's capability to prepare for, adapt to, withstand, and recover from changes and disruptions. Energy storage and BTM options provide resilience in the face of power disruptions and related threats emerging from severe weather, climate change impacts, and cyber and terror attacks.[c]	Will this technology be reasonable to meet agency targets for resilience?
Cost-Effectiveness	The cost-effectiveness of energy storage is crucial to its financial viability. The price, estimated lifetime, and cost savings potential of these technologies can reveal the economic value of the system.	Will this system allow the agency to realize savings on electricity bills or in other areas of its operations?

[a] Salles, Mauricio B. C., Junling Huang, Michael J. Aziz, and William W. Hogan. July 2017. *Potential Arbitrage Revenue of Energy Storage Systems in PJM*. https://www.mdpi.com/1996-1073/10/8/1100/pdf

[b] Clean Energy Group and the National Renewable Energy Laboratory. August 2017. "Identifying Potential Markets for Behind-the-Meter Battery Energy Storage: A Survey of U.S. Demand Charges." https://www.cleanegroup.org/ceg-resources/resource/NREL-demand-charges-storage-market/

[c] Sandia National Laboratories. April 2015. *Energy Infrastructure Resilience: Framework and Sector-Specific Metrics*. Prepared for U.S. Department of Energy National Nuclear Security Administration. https://www.energy.gov/sites/prod/files/2015/01/f19/SNLResilienceApril29.pdf

Approach to Energy Storage

The process for developing storage recommendations for the Sonoma Clean Power (SCP) BEB study began with a literature review of recent energy storage technology advancements. This covered white papers, fact sheets, and case studies with the aim of defining common terminology within the subject, outlining several advantages and disadvantages of various storage technologies, and identifying related programs and resources, with a special focus on development in California. This initial review was used to refine the list of potential technologies that merited further consideration.

Following the literature review, a technology matrix (shown in *Appendix B*) was developed to compare the identified storage and BTM options. Accounting for the needs and constraints of the agencies, five technologies were selected for comparison: lithium-ion batteries, lead-acid batteries, sodium-sulfur batteries, vanadium redox batteries, and solid oxide fuel cells. These technologies were assessed against key criteria, outlined in Table 6, that relate to the value propositions described above, including energy density, efficiency, cost, cell potential, discharge time, and expected lifetime. A description of common applications and commercial providers of each storage technology is also provided in *Appendix B*.

Table 6. Energy Storage and Behind-the-Meter Technology Criteria

Category	Definition
Energy Density	The energy that can be stored in a specific mass of a system; the higher the number, the more energy is able to be stored.[a]
Efficiency	Using less energy to achieve the same outcome.[b]
Cost	Described in U.S. dollars per kilowatt-hour, a common way of illustrating electricity prices.
Cell Potential	The potential difference, created by the ability of electrons to flow, between two half cells in an electrochemical cell.[c]
Discharge Time	The amount of time that a storage system is able to discharge (provide energy) at its rated power capability without being recharged.[d]
Max Cycles or Lifetime	The number of cycles a technology can experiences before it can no longer meet performance criteria.[e]

[a] University of Calgary. Accessed October 2019 "Energy Density." *Energy Education*. https://energyeducation.ca/encyclopedia/Energy_density

[b] Environmental and Energy Study Institute. Accessed October 2019. "Energy Efficiency." https://www.eesi.org/topics/energy-efficiency/description

[c] Barrett, Katherine, Gianna Navarro, Joseph Koressel, and Justin Kohn. June 2019. "The Cell Potential." LibreTexts. https://chem.libretexts.org/Bookshelves/Analytical_Chemistry/Supplemental_Modules_(Analytical_Chemistry)/Electrochemistry/Voltaic_Cells/The_Cell_Potential

[d] Eyer, Jim, Joe Iannucci, and Paul C. Butler. November 2005. *Estimating Electricity Storage Power Rating and Discharge Duration for Utility Transmission and Distribution Deferral: A Study for the DOE Energy Storage Program*. Sandia National Laboratories. https://prod-ng.sandia.gov/techlib-noauth/access-control.cgi/2005/057069.pdf

[e] Massachusetts Institute of Technology. December 2008. "A Guide to Understanding Battery Specifications." https://web.mit.edu/evt/summary_battery_specifications.pdf

In addition to desk research conducted to characterize the technologies, several interviews were conducted in September 2019 with local owners of energy storage and BTM systems to gain insights into the process of planning, installing, and operating such a project. These interviews consisted of an overview of the SCP project and questions about both the technical capabilities of the system (such as capacity, lifetime, cost, and technology) and their overall experience (such as initiation and planning, procurement and design, construction, interconnection, and operation and maintenance).

Energy Storage Analysis

Depending on objectives the agency hopes to achieve with storage, different technologies may be appropriate because each technology has unique characteristics that translate to different values and purposes. For example, lithium-ion batteries boast high energy density and efficiency capabilities but degrade quickly regardless of how heavily they are used, while vanadium redox (flow) batteries are less efficient and have a higher up-front cost but have a longer expected lifetime of 20 to 30 years. An agency that considers price arbitrage as its highest priority should focus on the efficiency of the technology. Other considerations for this purpose would be the energy density and discharge time. If demand charge management is determined to be the most important factor in storage and BTM selection for an agency, rate of discharge and discharge time are the factors that would best reflect a storage system's peak-load shifting capabilities.

Energy storage and other BTM resources are often sought because they remain resilient in times of emergency and change. The transit agencies in Sonoma and Mendocino counties have expressed a desire that systems installed in their facilities are able to sufficiently supply their full level of service for at least 48 hours in the event of an emergency or grid outage. The agencies will heavily weigh efficiency, energy density, discharge time, and cell potential in their decision-making process.

Greenhouse gas emission reductions can also be a priority for selecting storage technologies. If deployed strategically, storage and BTM resources can be used for emissions mitigation. Whether by capturing zero-emission electricity generated on the site or by taking energy from the grid when it's cleanest, the storage system can displace some of the environmental impact of electricity generation. If this is a priority for an agency, the energy density, efficiency, and discharge time of a storage system should be examined as indicators of its ability to arbitrage across variation in the grid's power mix at different times of the day, days of the week, and seasons. Agencies can monitor the emissions profile of the grid on a real-time basis by referencing "Today's Outlook."[7]

Cost-effectiveness is a core decision factor for agencies considering such installations. The cost, discharge duration, and estimated lifetime of the analyzed technologies provide an overview of the financial value that the system will generate. Based on the described market research and interviews conducted for this study, it appears that **Li-ion batteries are the most cost-effective and market-ready option for transit agencies at this time**. Furthermore, agencies can look for guidance from peer entities that have applied this technology locally (see the Santa Rosa Junior College case study on the next page) and in a similar context (see the San Joaquin Regional Transit District case study on the page after that).

Funding Sources for Energy Storage

There are several energy storage and BTM resource funding and financing opportunities for agencies. These funds include local, state, federal, utility, and organization-sourced rebates, tariffs, loans, grant opportunities, and cost recovery options. A comparative analysis of these prospects, with the purpose of agencies' storage needs in mind, suggests that California's Self-Generation Incentive Program is the most financially viable option.[8]

The Self-Generation Incentive Program, administrated by the California Public Utilities Commission, encourages the continuation and development of DERs through financial incentives. Under this program, advanced energy storage systems qualify for rebates. Large storage systems (defined as those greater than 10 kW) are eligible for an incentive of $0.40 per watt-hour of energy stored, as of September 2019. The incentive rate is also dependent on the duration of the storage. PG&E is currently on Step 2 of the program and has over $16 million left in available funds.

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7 California Independent System Operator. "Current CO2 emissions (serving ISO load)." http://www.caiso.com/TodaysOutlook/Pages/Emissions.aspx

8 California Public Utilities Commission. Last updated 2019. "Self-Generation Incentive Program." https://www.cpuc.ca.gov/sgip/

There are also two grant opportunities being released at the end of December 2019 and in January 2020 through the Electric Program Investment Charge.[9] The 2019 grant solicitation aims to increase energy density and critical system energy needs through resiliency, reliability, improved safety, and lifecycle performance. The 2020 grant solicitation emphasizes long-duration energy storage that can support critical operations and community facilities. Even though the timeline of these solicitations may be too accelerated for the agencies to use for this round of funding, they indicate that further potential grant opportunities may be made available. For updated information, please check the California Energy Commission's funding solicitations page (https://www.energy.ca.gov/funding-opportunities/solicitations).

In addition to these active and upcoming programs, there are a few innovative financing options that transit agencies should monitor as potential tools that could be made available in the future. Locally, SCP previously offered a program through a partnership with Stem to provide savings opportunities to large

Storage at Santa Rosa Junior College (SRJC)

SRJC's main campus covers 144 acres throughout downtown Santa Rosa. The campus has an annual energy demand of 10 million kilowatt-hours, with a peak demand of 2,200 kW (2.2 MW) and a minimum demand of 800 kW. In 2018, SRJC installed a 3 MW solar carport project paired with a 2 MW storage system. The storage structure is composed of Tesla lithium-ion outdoor-rated Powerpack modules. These batteries have an expected lifetime of 10 years, reflected in SRJC's performance guarantee agreement, ensuring that SRJC remains whole if the battery does not meet expectations over those 10 years. A specified degradation rate is included within the contract calculations and it is the contractor's responsibility to maintain the system.

SRJC is a participant in the Self-Generation Incentive Program, which provides rebates for demonstrating peak demand reduction (if the consumer pays the Public Purpose charge). The cost of peak demand for the campus is estimated to be $125,000. With the peak shaving capabilities of the Powerpacks, campus demand has fallen to $90,000. The project also received a large grant from the California Energy Commission to turn the campus into a microgrid, for which they are performing a full energy and power analysis. Currently, it is possible to operate the entire campus in isolation from the electric grid (known as islanding) for up to a few hours.

SRJC also takes advantage of a Stem-sourced software (https://www.stem.com/) that uses battery storage meters and meters located at interconnection points to optimize discharging. SRJC found the interconnection process to be challenging to navigate, requiring that they install additional meters, place money into an escrow account, provide telemetry to improve PG&E's grid communication system (for systems over 1 MW), and initiate several other upgrades.

[9] California Energy Commission. December 31, 2019 (to be released). "Demonstrate Emerging Energy Storage Technologies that Can Support the Future Clean Energy Needs of the California Grid." https://www.energy.ca.gov/solicitations/2019-12/demonstrate-emerging-energy-storage-technologies-can-support-future-clean; California Energy Commission. January 31, 2020 (to be released). "Assessing the Priorities for Long-Duration Energy Storage to Meet California's 2030 and 2045 Energy Policy Goals." https://www.energy.ca.gov/solicitations/2020-01/assessing-priorities-long-duration-energy-storage-meet-californias-2030-and

commercial and industrial businesses.[10] While transit agencies would not likely qualified during their initial phase of transit electrification, a similar program could be valuable to the agencies due to lower upfront costs and guaranteed savings once the fleets are fully electrified.

Several financing options and value streams were researched and are synthesized in *Appendix C.* On-bill financing for energy storage and related technologies is not presently available through PG&E, whose on-bill financing programs focus on energy efficiency efforts through lighting, refrigeration, HVAC, food services equipment, and business computing. However, agencies may look to collaborate with SCP as a well-positioned partner as they explore this financing option. The financing matrix in the appendix also details demand response programs. Demand response programs, which are offered through PG&E and various third parties, can provide financial incentives for energy systems. While it is unlikely that the transit agencies would enroll their buses in demand response without further advances in smart charging technologies, this option should be kept in mind for future clean energy endeavors. As Property Assessed Clean Energy program (PACE) financing relies on participating property owners paying lenders back through real estate taxes, this opportunity may not apply to municipal transit facilities. However, it could be an option for any agency or entity that is leasing their property.

Storage at San Joaquin Regional Transit District (SJRTD)

As of December 2019, SJRTD is in the process of procuring on-site battery energy storage in tandem with introducing electric buses into its fleet. SJRTD is installing a 508 kWh capacity Li-ion battery system that discharges at 250 kW for two hours, with the intent of using energy in 15-minute increments to top-off bus charge levels during peak grid prices. SJRTD has worked closely with PG&E and their selected installer and operator, Engie. PG&E helped SJRTD with the battery specification and selection from four battery providers. Engie provides a 10-year warranty with specifications on degradation and performance expectations and will be responsible for any ongoing maintenance to keep up with performance standards.

The infrastructure for this custom-designed system will not exceed 10 feet by 20 feet, including all battery, coolant, AC unit, and cabinet components. Engie predicts that permitting and installation will take four to six months, while the interconnection process will only take about two months. As part of the contract, the battery will not be able to flow back onto the grid and will be used to address peak-shaving and load-shifting concerns. The entire project is expected to cost around $400,000 and is financed by PG&E through their pilot Transportation Electrification program. SJRTD is also planning on pairing this storage with a solar PV system within the next six to eight months.

There are many parallels between the storage and electrification objectives of SJRTD and those of the SCP transit agencies. The agencies should closely monitor the SJRTD's system process as the battery is installed and becomes operational.

10 Sonoma Clean Power Authority. Last updated 2019. "Battery Storage to Help Large Businesses Save Big." https://sonomacleanpower.org/news/battery-storage-from-stem-inc

Battery Electric Buses

This report reviews several vendors that offer BEB solutions that would be applicable to the Petaluma Transit, Santa Rosa CityBus, Sonoma County Transit, and Mendocino County Transit agencies. A summary of key decision factors is presented here, while a complete survey of potential vehicle models is provided in *Appendix H*. A description of the key BEB characteristics suitable for each agency is provided in the *Recommendation: Short-Term Battery Electric Bus Procurements* section.

With a multitude of BEBs on the market, the right buses for each agency will be based on the expected overall bus performance on each route. Both the cost and the weight of the battery will affect the bus performance and should be considered in the overall decision-making process. For buses with lower daily mileage and opportunity charging options, an agency can use a smaller bus with better cost efficiency in order to meet its needs. Buses that drive longer routes work best with a bigger battery or well-managed recharging cycles to serve their higher energy requirements. Weather and terrain are also important—a bus with routes that contain more hills and more extreme temperatures will benefit from a bigger battery for the performance and energy efficiency benefits. The more often that auxiliary systems like HVAC are used, the shorter the projected range, which is particularly an issue in summer and winter months.

Another important factor in the BEB market stems from a provision in the National Defense Authorization Act that was signed into law on December 20, 2019.[11] After a two-year implementation grace period, this rule would bar Chinese companies (like BYD) from supplying BEBs to U.S. transit agencies (Wehrman 2019). For agencies that already initiated fleet transitions and have selected BYD for preliminary procurements, the rule may result in a lack of interoperability within the fleet, or even stranded assets. This is because BYD buses can only be served by BYD charging infrastructure, and BYD charging infrastructure is only configured for BYD buses. Additionally, reduced competition in the BEB market could translate to fewer market-ready options for transit agencies and slower price declines.

Charging Equipment

This report reviews several vendors that offer charging station solutions that would be applicable to the Petaluma Transit, Santa Rosa CityBus, Sonoma County Transit, and Mendocino County bus yards. After a review of hardware components, the report presents software solutions and funding sources. A brief description of the charging solution most suitable for each agency is provided in the *Recommendation: Short-Term Infrastructure Upgrades* section.

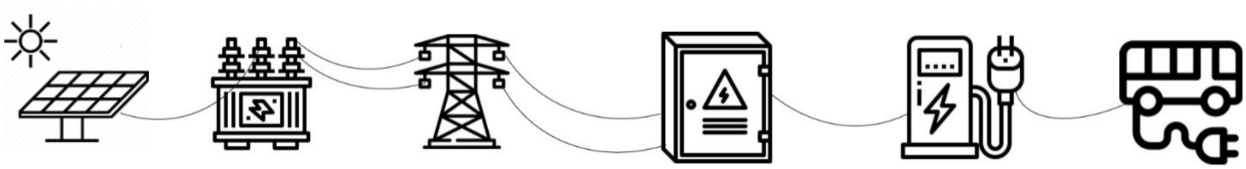
To fairly compare the different vendors, only depot chargers were investigated. Many charging stations vendors offer alternative, custom-built solutions that do not allow for easy comparison, such as on-route chargers, wireless charging, or overhead charging. In general, almost any qualified vendor will be able to design and build a charging station, but they may not understand the niche applications of a transit agency. This report is intended to help the four transit agencies understand the basic depot

[11] AFP. December 26, 2019. "China Slams US Defense Act Over Trade Restrictions." *East Asia Pacific.* https://www.voanews.com/east-asia-pacific/china-slams-us-defense-act-over-trade-restrictions

charger layout, clarify issues associated with this design, and ensure they have the tools to effectively communicate their needs to vendors.

Figure 11 depicts the power delivery, from the power plant and distribution substations to the power lines that transmit power from the grid, then to the stepdown transformer at the bus yard. This transformer will power the EVSE that will convert AC power to DC power.

Figure 11. Basic Design of Charging Equipment



Electricity generated by SCP and delivered by the local utility (in this case, PG&E) will enter the bus yard, where a stepdown transformer will lower the voltage and connect to a main switchboard that contains the utility meter and main circuit breaker. EVSE connects to the switchboard and can be individually metered and placed on a separate circuit. Most electric buses use the combined charging standard that uses bus chargers with power electronics that convert AC power to DC power, which is directly fed into the battery in the vehicle.

The EVSE operates similarly to any other charging station for a light-duty electric car, and primarily serves as an on-the-ground interface for the charging system. It will have a screen interface that can be used to input instructions and a large electrical cord that can be inserted into the bus charging port. The connector plug that is inserted into the bus can be one of several types. This report reviews products built by a variety of EVSE manufacturers, such as ABB, Broadband Telcom Power, Inc. (BTC Power), Proterra, and Siemens (see *Appendix E* for a comparison of the electrical cabinets and EVSE units).

Charge Management Solutions

A charge management system is an optional component to charging infrastructure design, providing the fleet manager with additional possibilities. These include tracking buses' charging, commanding the EVSE to increase or decrease power levels, prioritizing certain buses for charging, and other functions. These features are commonly called smart charging capabilities, and services can come with a wide variety of options.

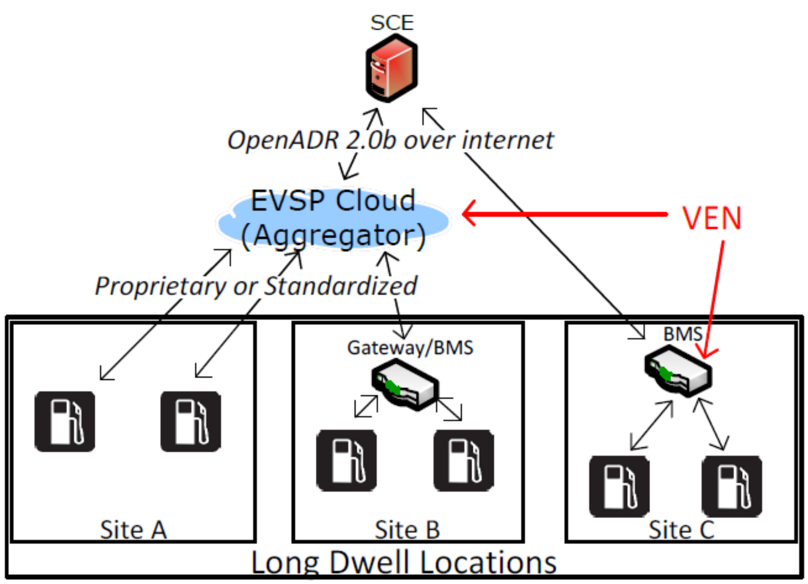
Smart charging is often treated as a separate service from the physical hardware of an electrical cabinet and EVSE. However, with larger or more completely electrified fleets, smart charging can become a crucial element of bus yard design. These charge management solutions include features like remote monitoring of bus battery status, prioritizing which buses get charged, and regulating the amount of power each bus receives at any point in time to reduce or mitigate demand charges or subscription fees. While these features are not always critical, they are useful tools for agencies looking to manage the power level, time of day, and coincidence of their fleet's charging profile.

Sometimes the EVSE product manufacturer (such as ABB or Proterra) will offer their own charge management service. There are also electric vehicle (EV) service providers, or simply network providers, that specialize in offering charge management systems (detailed in *Appendix F*).

Smart Charging Features

The most basic software solution will allow the agencies to remotely monitor the bus battery status (state of charge) while charging. This usually comes in the form of a web portal or application that the fleet manager can access at any time, similar to that shown in Figure 12. Basic analysis, such as which buses use the most energy, can be regularly reported to the manager.

Figure 12. Examples of How Southern California Edison Allows Data to be Reported to Utility



Note: A virtual end node (VEN) is the mechanism that allows communication between Southern California Edison and the individual EVSE.

More advanced solutions allow the charger to communicate with the utility grid. The data could be passed through in several ways, including aggregated at a network provider's cloud service or individually sent to SCP via the Open Automated Demand Response (OpenADR) 2.0b protocol or using the OpenADR with Open Charge Point Protocol (OCPP). In this case, SCP could use OpenADR with OCPP in order to have open communication between the EV charging stations and central management software, enabling the charging system to serve as a demand response or excess supply asset.[12] Using OCPP on its own is also an option. Several charging manufacturers support the OCPP standards, which allow the end user to manage various chargers with one compatible software management system. If

[12] Demand response and excess supply programs incentivize customers to shift electricity load to different times of day to facilitate grid operations and system-wide cost savings.

agencies procure more than one type of charger, then having the OCPP feature enables interoperability because they can all be managed by a single centralized system.

Fleet managers can use smart charging software to dynamically regulate electricity demand in response to signals from the grid, which will help mitigate demand charges or subscription fees. Decisions about what to do under certain circumstances or the use of specific time-of-use rates can be made ahead of time, with smart charging software allowing a fleet manager to seamlessly apply those decisions to all EVSEs. Some buses can be prioritized for charging regardless of the utility signal, while others can be reduced or entirely curtailed during a specified event.

The most advanced charge management solutions can even account for on-site energy storage and solar generation. Smart charging software can intelligently integrate energy from on-site generation resources and the grid to meet a specific price threshold. These capabilities can be extremely helpful if agencies pursue net energy metering or participate in other electricity market programs.

Selecting a Suitable Charging System

To select a suitable charging system, an agency must consider bus battery size, charging equipment, and charge management solutions, and should weigh four key concepts in their EVSE selection processes:

- The system must meet the fleet's energy needs in terms of **total kilowatt-hours needed for daily operation**. This threshold is determined by the number of electric buses, the initial state of charge when charging begins, and the final state of charge (typically 100%) after charging is complete.
- The **power demand** is a function of the total kilowatt-hours spread over the amount of time available to charge. It is optimal to smoothly allocate energy supply over the entire available charging window to achieve the lowest peak power draw from the grid. The more time the agency has available to charge (such as 12 hours instead of eight hours), the lower the average power demand. Lower, slower power charging systems are generally cheaper than faster, higher power charging systems. It is also often cheaper and easier for the local utility to upgrade the grid connection to the bus yard when the average power demand is lower.
- Another key aspect is the **charger-to-bus ratio** (such as 1:1). Because chargers can have a different number of nozzles and varying power levels, certain chargers lend themselves to certain charger-to-bus ratios. The lower the charger-to-bus ratio (such as 1:3 compared to 1:1), the lower the up-front capital and installation costs are likely to be; however, fleet managers should expect these up-front savings to be accompanied by higher staff costs if sequencing of bus charging is accomplished manually. In this case power demand might also be slightly higher due to losing some of the available charging time when an operator moves one bus off the charger and connects the next bus.
- **Operational constraints** may also be a factor. These include details like the availability of maintenance staff to manually move charger nozzles between buses after one has completed its charging cycle. Another factor might be the ability of the bus battery to accept a given level of power from the EVSE. Some of these inefficiencies can be mitigated with smart charging software.

Smart charging software can regulate the power demanded by each EVSE and among multiple EVSE nozzles. The ABB 150 E-Bus Charger, for example, can automatically switch power from one bus to another in mere seconds. Higher power chargers, like the BTC Power 200 – 475 kW High Performance DC Charging System, may be justified when there is limited time or space for chargers. The considerations detailed above informed the agency-specific suggestions provided in the *Recommendation: Short-Term Infrastructure Upgrades* section.

Funding Sources for Electric Vehicle Supply Equipment

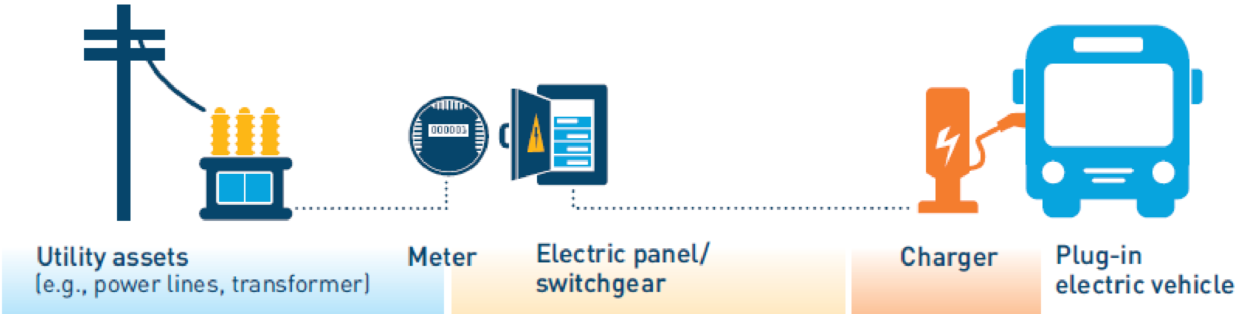
There are several EVSE funding opportunities available to public transit agencies on the local, state, and federal levels; a full list can be found in *Appendix G*. The most prevalent form of funding for EVSE comes from grants. The California Air Resources Board, and its local Bay Area Air Quality Management District, have become leaders in EV grants. Agencies should consider applying to one or more funding opportunities: the Low-Carbon Transit Operations program, the Carl Moyer program, the Transportation Fund for Clean Air, or the Transit and Intercity Rail Capital program.

There are also cooperative purchasing opportunities that can help reduce the upfront costs of EVSE. The State of California offers two contracts that provide lower prices to state and local governmental agencies. Other co-op purchasing contracts may become available in the future (and the agencies should monitor the market for these opportunities). For example, medium- and heavy-duty trucks are increasingly considered for electrification; while these vehicles are not the same as transit buses, the charging infrastructure can be similar. Agencies may benefit from coordinating their EVSE procurements with other public agencies looking to electrify their heavy-duty fleets and may find additional funding in the pipeline to support these efforts. Similarly, a few programs are listed as “other useful programs” in *Appendix G* because, while not currently feasible for the transit agencies’ purposes, the funding mechanisms of these opportunities may change over time. On-bill financing for EVSE is not presently available through PG&E, whose programs focus on energy efficiency efforts through lighting, refrigeration, HVAC, food services equipment, and business computing.

PG&E EV Fleet Program

PG&E created its EV Fleet program, outlined in Figure 13, to support state efforts to eliminate tailpipe emissions and increase EV operations. The program is also an opportunity for PG&E to demonstrate leadership in successful EV operations. Through this program, PG&E offers dedicated electrical infrastructure design and construction services, significant cost offsets for electrical infrastructure work, and additional EV charger rebates for eligible equipment, following a five-year plan that can be designed according to a customer’s needs. Transit agencies are natural partners for this program because as they transition to increasing electric fleets, they will have consistently high utilization of this infrastructure and will consume predictable and large volumes of electricity.

Figure 13. PG&E EV Fleet Program Overview



Source: Pacific Gas and Electric Company. 2019. "Boost Sales with PG&E's EV Fleet Program." https://pgemarketing.app.box.com/s/7yc6xh96fs0wbzlbm7088eqhnlscamnm

To-the-Meter Infrastructure	Behind-the-Meter Infrastructure	EV Supply Equipment
PG&E coordinates engineering, procurement, construction and also owns and maintains infrastructure up to meter panel	Customer pays for, constructs, owns and maintains infrastructure from meter to charger	Customer owns and maintains; PG&E provides $9 k/bus

Customers eligible for this program must be within the PG&E territory, though they can receive power from SCP. The applicant needs to have the authority to install charging infrastructure on their site, meaning they either own or rent the property. Additionally, the applicant needs to show commitment to EVs by obtaining at least two EVs over the span of the program. The infrastructure can be designed to accommodate future procurement plans over the five-year program. Applicants must agree to provide PG&E with their EV usage data for at least five years after the chargers are installed and they must make a 10-year commitment to use the chargers after installation.

When applying to PG&E's EV Fleet program, applicants need to provide several pieces of information:

- Proof of EVs: a paid invoice, grant approval, or letter from a board member or owner on future procurement schedule
- Site location: to verify that the charger locations examined are sufficient
- Site plan: to aid in charging infrastructure design and configuration
- Charging infrastructure type: to select the charger company, model, and size (kilowatts) so that the design and electrical planning can begin immediately

Applicants must use a qualified, network-connected smart charger to qualify for the EV Fleet program rebate; this allows the charger to be programmed to charge when cheaper energy is available. But, up to a point, the exact charger details can be adjusted as the planning and design process proceeds. Finally, the CEV rate requires that EVSE be metered separately from other loads. The EVSE recommendations provided in this report include consideration of PG&E's approved vendor list and should be sufficient for applicants to initiate the process with PG&E.

Short-Term Recommendations

Short- and long-term fleet electrification plans will require transit agencies to make notable shifts in their physical assets and operational practices. Key determinants of the scale and nature of these adjustments include the amount of energy required to operate each fleet's electrified buses, planned BTM resources, anticipated electricity rates, and more. This final report section integrates modeling and analysis across these variables to inform transit agencies' short-term plans. It includes recommendations designed to meet agencies' short-term needs while preserving flexibility and alignment with long-term BEB deployment plans.

Route Energy Requirements

CALSTART, in partnership with the Utah State University Sustainable Electrified Transportation Center, developed a modeling tool to analyze and predict the performance of a BEB on a predetermined route. Environmental factors like terrain and climate can have a significant impact on the range of BEBs. A bus in Petaluma, California, will perform differently than an identical bus in Chicago, Illinois, or in Miami, Florida. The Battery Electric Bus Corridor Model (BEBCM) attempts to address these differences and highlight factors that will impact bus operation.

The BEBCM estimates the amount of energy each system on the bus consumes while completing one service lap on the route. This breakdown of energy consumption can be expanded to a typical day in the summer and winter, with results tailored to the specific climate zone of the agency—in this case mild Sonoma winters and very hot summers. The output from this tool can inform estimates of optimal battery pack sizes, suitable charging infrastructure, and necessary upgrades to site electrical infrastructure. The BEBCM presents estimates of bus energy needs on an extreme temperature day in each season to illustrate performance in the worst-case scenario.

Approach to Short-Term Fleet Energy Needs

In collaboration with Petaluma Transit, four routes were selected for analysis using the BEBCM tool. The initial analysis examined the performance a 40-foot New Flyer bus with a 388 kWh battery and found that these could meet the energy needs for routes 3 and 24. This means these routes are likely well-suited for service by the first wave of BEBs procured. According to Petaluma Transit, generally no more than two buses are assigned to these routes at one time, so once it moves beyond its four initial bus procurements, the agency will need to consider other routes.

Following discussion with stakeholders, a second iteration of the modeling focused on adjustments to route 11 that would increase its viability for BEBs. The route schedule was adjusted to allow for two mid-day 30-minute recharges of 150 kW at the Copeland/Petaluma Transit Mall. This does not affect daily route energy requirements but illustrates whether the operational change enables the battery to maintain a sufficient level of charge to complete the full day's assignment. Additionally, this second modeling round compared a 40-foot Proterra with a 660 kWh battery and a 40-foot New Flyer with a 466 kWh battery with the performance of the New Flyer with a 388 kWh battery (see gray rows in Table 7).

As best practice to support battery longevity, most major bus manufacturers recommend ensuring that the state of charge does not dip to lower than 20% to 30% of the battery's full energy capacity. For New Flyer's 388 kWh bus model, adhering to the 20% state of charge standard means a route can require no more than 310 kWh of energy for the bus to cover it on a single charge, while New Flyer's 466 kWh model would be limited to routes requiring no more than 373 kWh of energy and Proterra's 660 kWh model can serve routes that require up to 528 kWh.

Table 7. Results of Route Energy Requirements: Petaluma Transit

Route	Bus Make/Model	Battery Capacity	Daily Energy Requirement[a]		
			Minimum (winter)	Maximum (summer)	Shoulder Season[b]
2	New Flyer 40'	388 kWh	451	521	446-467
3	New Flyer 40'	388 kWh	232	270	233-243
11	New Flyer 40'	388 kWh	398	456	406-420
11	New Flyer 40'	466 kWh	405	463	413-427
11	Proterra 40'	660 kWh	401	500	410-423
24	New Flyer 40'	388 kWh	247	267	249-253

[a] There are typically significant cool-weather impacts from the HVAC system present when temperatures fall below 40°F during the hours buses are in operation; on the other hand, buses run through the hottest part of the day in the summer.
[b] This shoulder season column summarizes model results for fall and spring; energy requirements are presented as a range encompassing typical results.

The results of the BEBCM reveal several key insights that can inform Petaluma Transit's selection and prioritization of vehicle characteristics for its initial bus procurements. There are commercially available BEB models that can meet Petaluma's energy needs throughout the year for routes 3 and 24. This is illustrated by the energy needs modeled for the 40-foot New Flyer bus with the 388 kWh battery on those routes being lower than the 310 kWh maximum for that model (see light green rows in Table 7).

Other routes appear to require significantly higher levels of energy but could be feasible if the agency introduced recharge in the schedule or procured buses with larger batteries. Proterra's 660 kWh 40-foot bus can manage route 11 even under the most extreme conditions, as the peak energy requirement is 500 kWh and the vehicle's state of charge threshold is 528 kWh. The variation across routes depicted in the results suggests that the agency would likely benefit from procuring a variety of vehicles with a mix of battery sizes and operating capabilities. Likewise, Petaluma Transit could adjust route assignments to better align with the capabilities of BEBs. In the scenario where route 11 is served by a 388 kWh New Flyer and receives two 30-minute recharges of 150 kW, the bus would be able to endure much longer on the route than in the initial run. Matching the capabilities of each bus model with the energy needs of routes could help the agency integrate electric buses efficiently and cost-effectively.

BEB models that can meet Petaluma Transit's energy needs for routes 3 and 24 are commercially available; for its remaining routes, energy needs are much higher, but strategic mapping between BEBs and route energy needs could facilitate electrification.

Recommendation: Short-Term Battery Electric Bus Procurements

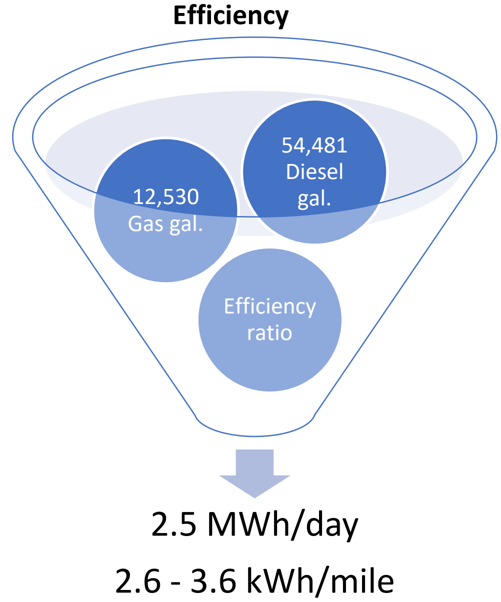
Petaluma Transit plans to procure four BEBs in the next five years. The BEBCM results presented here suggest that the agency is well-positioned to run the 388 kWh New Flyers on two routes in the near term. To electrify route 11, one option is for the agency to select higher capacity vehicle models, such as the Proterra 660 kWh modeled here or New Flyer's 545 kWh 40-foot bus. Further, Petaluma Transit could investigate how operational adjustments could pair with specific bus models to meet the energy requirements of a particular route. Among the characteristics covered in this study's BEB technology survey, which is provided in *Appendix H*, battery capacity is likely to be Petaluma Transit's principal concern. The agency will also want to consider eligibility for the Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project, which can increase cost-effectiveness; luckily, nearly all the bus models surveyed for this study qualify for that grant.

In addition to battery capacity and Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project eligibility, there are several operational factors that can support improved BEB performance. Petaluma may find that optimizing these operational factors for the unique features of BEBs will enhance the agency's ability to fully integrate the new technology into its regular service. One such area is driver training for efficient operation of BEBs, which can induce energy savings that enable a bus to cover a longer block or more challenging route on a given level of charge. Likewise, the agency could make changes to its temperature sets to reduce HVAC load on the engine. As modeled in the 30-minute recharge scenario, another promising approach would be to build in some recharge opportunities along the higher-energy routes. The agency could also attempt to adjust route assignments so that BEBs can run on routes that favor their regenerative braking abilities. Lastly, Petaluma can hold buses out of retirement and use these spares to complete remaining runs on routes that are infeasible for a single BEB under certain conditions.

Approach to Long-Term Fleet Energy Needs

While the focus of this study is the short term, transit agencies operate under very long-term planning horizons. Transit yard locations, site infrastructure, and vehicle lifetimes are such that decisions made now will have enduring effects on the agency for decades into the future. Pinpointing the long-term energy needs for Petaluma Transit when its fleet is fully electrified is an inexact science. Nevertheless, this effort provides valuable order-of-magnitude guidance that can inform current investment and upgrade decisions.

Figure 14. Long-Term Site Energy Needs and Vehicle Efficiency



Here, the goal is to prioritize the efficient deployment of infrastructure and capital to mitigate the risk of stranded assets. The approach is based on interviews, data provided by the agency, and National Transportation Database statistics on the agency's fleet characteristics including annual fuel usage (in diesel and gasoline gallons), the number of vehicles operating at the agency's service maximum, and daily vehicle miles.[13] Energy needs were then calculated under the high-level assumption that, after accounting for the differing efficiency factors of combustion and electric motors, total fleet energy consumption will not change substantially under the BEB paradigm. Figure 14 presents the long-term electric fuel economy of 2.6 kWh to 3.6 kWh per mile, which generally aligns with the 1.5 kWh to 2.4 kWh range estimated by the BEBCM for the four routes analyzed here. Our calculations show that the fleet would consume approximately 2.5 MWh per day under a full electrification scenario and would require an average of 315 kW of power if charged for eight hours overnight at the depot. This power would come from the grid or a combination of grid and BTM resources. This estimate appears low, which may be because the annual fuel consumption reported in the National Transit Database was out-of-date or does not include the full suite of vehicles in the agency's fleet.

Electric Vehicle Supply Equipment

EVSE procurements in the near term will require an integrated consideration of many factors, including charging approach (on-route versus depot), route energy needs, scale of BEB deployment, and operational flexibility. This section briefly discusses the limited potential of on-route charging to serve agency needs in the short term, then provides EVSE recommendations to match Petaluma Transit's depot charging context.

On-Route Chargers

High-power on-route opportunity chargers require high utilization levels in order to be cost-effective. Due to the low penetration of BEBs in the Petaluma fleet, the upfront costs of the infrastructure, and the challenges of sharing operations and costs among agencies—along with reliability challenges peer agencies have faced charging through these means—this technology is recommended for only a secondary role in the near term, while the focus remains on depot charging at the main yard facility.

In the mid to long term, it is possible that on-route charging at the Santa Rosa Transit Mall and the Copeland/Petaluma Transit Mall could bring valuable flexibility and cost savings to agencies that navigate through those points. First, the transit malls are visited by several agencies who can share the up-front cost of new infrastructure. Second, high-traffic times of day at the transit malls coincide with the super-off-peak period of the proposed CEV rate, meaning charging costs would be lower during these hours. Third, on-route EVSE at the transit malls would bolster the agencies' resilience by diversifying the locations where a bus can obtain charge and by providing high-powered service for deploying charge rapidly, if necessary. The interoperability of charging infrastructure across the agencies is central to realizing these potential benefits.

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[13] Florida Department of Transportation. Accessed September 14, 2019. "Integrated National Transit Database." http://www.ftis.org/iNTD-Urban/Reports.aspx
Florida Department of Transportation. Last updated 2019. "Rural Integrated National Transit Database." http://www.ftis.org/rural_iNTD.aspx

Depot Chargers

Depot chargers located at the Petaluma Transit Yard are the appropriate technology for the fleet's short-term infrastructure needs. As discussed in *Selecting a Suitable Charging System*, the suitability of a given depot charging technology will depend on the agency's available charging window and the number of chargers it procures. In Table 8, charging windows indicate the hours each day that vehicles are available to charge (regardless of specific charging pattern or profile). Charging windows are paired with different numbers of chargers to illustrate how various combinations of these factors would affect the minimum charger rating that could meet the agency's needs.

Table 8. Potential Minimum Charger Ratings

Daily Site Energy	Number of Chargers	6-Hour Charge	8-Hour Charge	10-Hour Charge
388 kWh battery (291 kWh recharged per day)		**Minimum Charger Rating** (kW)		
1,164 kWh across four buses	4	49	36	29
	3	65	49	39
	2	97	73	58
660 kWh battery (495 kWh recharged per day)		**Minimum Charger Rating** (kW)		
1,980 kWh across four buses	4	83	62	50
	3	110	83	66
	2	165	124	99

Although the power needs over a given charging window are higher for vehicles with larger battery capacities, there are many EVSE options (summarized in *Appendix E*) that would suit Petaluma Transit in the short term. While Petaluma Transit could technically meet its short-term energy needs with as few as two chargers, this approach would be risky because operations would be constrained if even one charger needed maintenance or was otherwise out of service. Three chargers, which will be sufficient to meet the energy needs of the fleet given a constrained eight-hour charging window, would provide extra capacity in the case of a charger being out of commission. In pursuing a charging solution comprised of less than a 1:1 charger-to-bus ratio, a system's charge management capabilities are of increased importance. Petaluma faces tradeoffs between automated and manual systems. An automated system that complies with the OCPP standard and is capable of managing power loads across multiple chargers and nozzles will be more costly up-front than a simpler manual system, while a manual system would likely require increased staff involvement and introduces greater risk of human error.

Recommendation: Electric Vehicle Supply Equipment

To support its initial bus acquisition plans, the agency should prioritize several characteristics in its EVSE procurements:

- Depot charging
- OCPP v1.6 enabled
- If determine to participate in PG&E EV Fleet program, should select a model that is eligible for $25,000 rebate per charger

- Chargers with power ratings sufficient to meet vehicle energy needs for a given combination of charging window to bus charger ratio, as displayed in Table 8

Short-Term Infrastructure Upgrades

As discussed earlier in the *Approach to Distribution System Capacity* section, readiness for BEB infrastructure is not just a question of adequate space; the electrical capacity of the infrastructure serving the site is critical. Infrastructure must be appropriately sized on both the utility and customer sides of the meter to accommodate the agency's specific power requirements, which are based on its anticipated charging patterns and equipment selection.

Infrastructure Electrical Capacity

The existing service at the Petaluma Transit Yard is 208V. This is enough to supply a few low-powered EVSEs providing charge to electric shuttles or other vehicles with relatively shorter ranges and smaller battery capacities. However, a new 480V service would be necessary to meet the charging needs of full-sized transit buses. Luckily, the eastern side of the property has a good location for such an installation, at the corner of McDowell Boulevard and Rainier Avenue (directly below the 12 kV utility distribution line). A new primary underground service would cost $45,000, but it is possible that a lower cost alternative, such as overhead delivery, would also suffice. For this new service, the transformer, switchgear, pad, meter, and panel can be in the northeast corner of the yard parking area, where a dumpster is currently kept because the corner is too tight for parking buses. From this hub, conduit and wiring can be laid for the EVSEs along the perimeter of the yard. It would likely be cost-effective and efficient for the agency to oversize these upgrades in order to accommodate future expansion of the fleet beyond its initial four buses.

The daily site energy requirements described in Table 9 detail the potential for four buses requiring a total daily charge of between 1 MWh and 2 MWh. This is relatively close to the estimated long-term daily energy need (2.5 MWh per day), but only represents electrification of one quarter of the fleet. Given this uncertainty, it would behoove the agency to put greater weight on results of the near-term analysis. As illustrated in the table, under shorter charging protocols, the site's power needs are higher than when charging is spread across a longer window. The upgrades would also include installing a new transformer to step down the power for the charging infrastructure. While in most cases a 300 kVA ($47,000) transformer could meet the agency's EVSE power needs in the short term, the agency may choose to procure a 750 kVA ($58,000) transformer in order to provide additional capacity for near-term growth.

Table 9. Potential Levels of Site Power Needs

Bus Model	New Flyer 40' (291 kWh energy/bus/day)	Proterra 40' (495 kWh energy/bus/day)
Daily energy for four buses (kWh)	1,164	1,980
Average power (kW) if spread over six hours	194	330
Average power (kW)if spread over eight hours	146	248
Average power (kW) if spread over 10 hours	116	198

Note: A 300 kVA transformer has sufficient capacity in every case except the highest power scenario, when a 750 kVA transformer is required.

Given the thermal limitations on the nearest line sections (as discussed in the *Electrical Service, Backup Generation, PV, and Storage* section), these calculations suggest that the site may face a power limitation in the near term. However, this limitation on load hosting capacity is based on the system's peak loading, whereas the agency's increased consumption is likely to occur during nighttime hours that tend to experience lower distribution system loads. Infrastructure limitations can be further managed by strategically sequencing yard operations to maximize the amount of time available for buses to charge. The PG&E engineers involved in the site's infrastructure upgrades will weigh these factors as part of their load analysis activities.

Furthermore, considering the long-term energy requirements of the agency as calculated above, it is estimated that the agency could regularly demand around 315 kW when charging buses (assuming an eight-hour charging window). This level of consumption is likely to trigger upgrades to the local distribution grid.

Recommendation: Short-Term Infrastructure Upgrades

Table 10 provides a summary of likely infrastructure upgrades and associated costs that will be necessary at the Petaluma Transit Yard for its fleet to integrate the initial four BEBs it plans to procure in the short term.

Table 10. Potential Site Infrastructure Upgrades

Upgrade	Cost
Drop new 480V service (primary overhead to underground)	Up to $45,000
To-the-meter infrastructure (design, switchboard, concrete pad, other)	$50,000 - $100,000
Secondary service metering to qualify for CEV rate	$5,000
300 kVA to 750 kVA transformer	$47,000 – 58,000
Customer-side infrastructure (design, permitting, bollards, pavement, other)	$100,000 - $200,000

Notes: To-the-meter cost estimates from PG&E "Boost Sales with PG&E's EV Fleet Program" report. Costs are meant to provide only order-of-magnitude guidance.

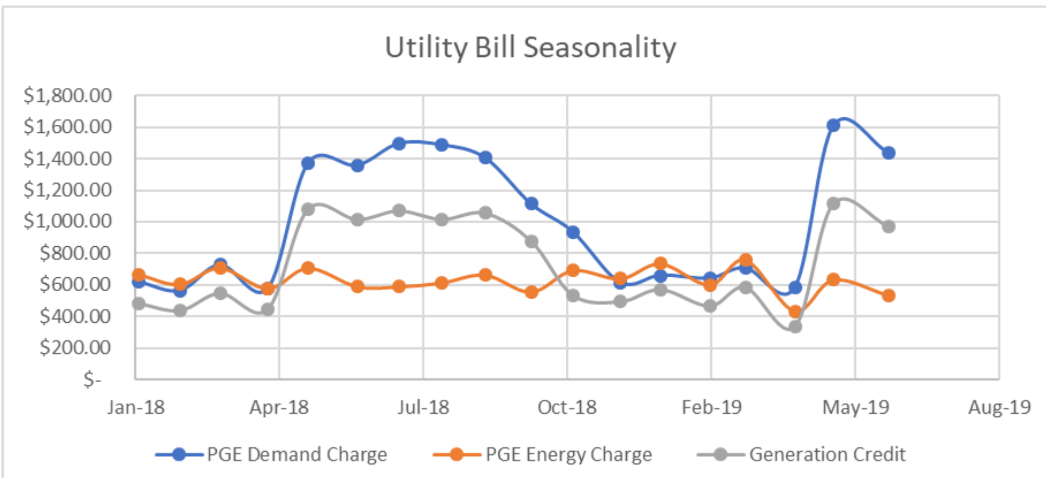
Charging Patterns and Policies

SCP supplies power to Petaluma's Transit Yard and provided about two years of utility bills to allow for a better understanding of their current expenses. A baseline of costs was established from this data, as well as an assessment of seasonal variation and a description of demand charges at the site prior to the addition of BEBs. The utility bills have two parts, one from PG&E and one from SCP. The PG&E bill has three core components: the energy charge, the demand charge, and the generation credit. The energy charge is billed per kilowatt-hour, the demand charge is billed per kilowatt of maximum demand, and the generation credit is a portion of the bill credited back for being a customer of SCP.

Current Electricity Baseline

The Transit Yard is currently on the E19S rate schedule, which is a time-of-use rate with a seasonal component. The rate favors consumption during the off-peak periods of the day, which encompass the hours between 9:30 p.m. and 8:30 a.m. throughout the year. The seasonal component of the E19S rate contributes to higher bills in the summer and lower bills in the winter. Peak hours occur from 12 noon to 6 p.m. during the summer period. Partial-peak hours are from 8:30 a.m. to 12 noon and 6 p.m. to 9:30 p.m. during the summer and from 8:30 a.m. to 9:30 p.m. during the winter. All three components of the PG&E bill exhibit similar seasonal variation, as shown Figure 15. The energy charge under this rate schedule has a less pronounced seasonality pattern. Collectively, costs are consistently higher in the summer months and lower in the winter months.

Figure 15. Seasonality in Petaluma Transit Yard's PG&E Bill



Future Commercial Electric Vehicle Rate

The new CEV rate that was approved in October 2019 operates differently than PG&E's typical time-of-use rates. It requires customers to pay a subscription fee in lieu of demand charges. The subscription fee is determined based on a customer's projected maximum demand per month and is sold in blocks of 10 kW for small customers and 50 kW for large customers.[14] The Petaluma Transit Yard is likely to select the CEV rate tailored to large customers using a secondary service.

The second component of the new rate schedule is a time-of-use energy charge. The peak period is from 4 p.m. and 9 p.m., while off-peak is from 2 p.m. to 4 p.m. and 9 p.m. and 9 a.m. and super-off-peak is from 9 a.m. to 2 p.m. (summarized in Table 11). This charge incentivizes consumption during off-peak

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[14] Customers with a peak demand of less than 100 kW are considered small, while those with peak demand greater than 100 kW are considered large.

and super-off-peak hours. It also shifts the bulk of the bill away from demand charges and toward energy charges, which provides greater certainty of costs (particularly for agencies using on-route charging) and affords an opportunity for the agency to manage its electricity expenses by scheduling charging during off-peak times.

Table 11. Commercial Electric Vehicle Rate Schedule for Large Customers, Secondary Service

Charge Type	Time of Use	Rate per Kilowatt-Hour (except where noted)
Subscription Demand Charge	N/A	$167.75/50 kW block
Super-Off-Peak Energy Charge	9 a.m. to 2 p.m.	$0.09760
Peak Energy Charge	4 p.m. to 9 p.m.	$0.33410
Off-Peak Energy Charge	2 p.m. to 4 p.m.; 9 p.m. to 9 a.m.	$0.12086

To analyze the advantages of the new CEV rate and to estimate an annual bill, the agency's estimated short-term fleet energy needs were mapped across different charging scenarios. Scenario A assumes buses will charge for eight hours a day during off-peak hours overnight. Scenario B assumes buses will charge for six hours a day during off-peak hours overnight. Scenario C assumes buses will charge for seven hours a day total: five hours during off-peak hours overnight and two hours during super-off-peak hours in the middle of the day.

Table 12 summarizes the results of these hypothetical scenarios when charged on the CEV rate and on the E19S rate. It is clear from this analysis that the CEV rate will be more economical for the Transit Yard than their current rate schedule, primarily because the demand portion of the bill will be lower and be fixed every month. Actual bills may be slightly lower than that shown in the table, which were modeled based on PG&E's generation prices (SCP's generation prices are lower, usually generating bill savings of about 2%).

Table 12. Hypothetical Annual Bills for Petaluma Transit Yard

Rate Schedule	Scenario A (8 hours overnight)	Scenario B (6 hours overnight)	Scenario C (5 hours overnight, 2 hours midday)
CEV Rate	$54,000	$55,800	$55,800
E19S Rate	$67,800	$77,900	$96,800

Another important lesson from this analysis is that a transit agency's electricity bills are going to increase significantly regardless of which rate it chooses. Petaluma's current annual electricity bill of roughly $14,000 will increase by 400% under the CEV rate but it will increase by 480% to 700% if the agency remains on E19S. **These charging scenarios are hypothetical and meant to demonstrate the potential impact of different rates and charging schedules on the total annual bill.** Petaluma must also consider charger power and infrastructure upgrades that will influence its charging patterns.

Recommendation: Charging Patterns and Rates

The new CEV rate is the most cost-effective way for transit agencies to meet their fleet electricity needs. Agencies should subscribe to the CEV rate when it is made available, then should ensure that EVSE is separately metered from other site loads in order to qualify for that rate.

Optimal charging patterns on the CEV rate will take full advantage of daytime charging during the super-off-peak rate to the extent feasible; however, in many cases agencies do not have spares or vehicles returning to the yard during this midday period to benefit from the low prices. As long as the vehicle is charging outside of the 4 p.m. to 9 p.m. peak times, Petaluma Transit can avoid the most costly energy prices. For vehicles charging overnight, agencies that can accommodate longer charging windows can select a lower demand level for the subscription portion of the bill. There are several best practices the agency should heed when choosing charging patterns:

- Charge during the midday super-off-peak period if feasible.
- Plan the charging window to reduce energy demand during the peak period.
- Extend the charging window to reduce power demand, thus lowering the subscription level.

Behind-the-Meter Energy Resources

As utilities shift toward time-of-use pricing models, such as that exhibited in PG&E's recently approved CEV rate, it is becoming increasingly advantageous to shift electricity demand to specific times of the day. Since the transit fleet is in service and unavailable for charging during many hours of the day, another way to shift energy load is by integrating BTM battery storage. As discussed in the *Energy Storage* section above, batteries can also help support the fleet in the event of a power outage. To similar ends, BTM solar generation can be added to a system to reduce the net energy drawn from the grid and can increase a site's resilience by providing on-site generation.

Agencies are interested in understanding the economics of installing generation and storage resources on their site. As discussed in the *Charging Patterns and Policies s*ection, the CEV rate offered by PG&E is likely to provide significant bill savings for transit agencies. Thus, the value proposition of BTM resources lies in securing low-cost energy, either from the grid or from on-site generation, and moving the use of that energy to a cost-effective time of day. The price of grid electricity is essentially the breakeven point that the levelized cost of the BTM energy system must be below in order to be a cost-effective alternative.

The case for on-site solar is challenging because the CEV rate was designed to encourage grid consumption during the most productive solar generation hours. Direct, instantaneous consumption of on-site solar is a poor fit for transit agencies whose fleets are in service during these hours. Solar net energy metering would likely be less cost-effective, as most on-site generation would be compensated at a low super-off-peak rate, but energy would be consumed during higher cost periods.

A battery could capture and store this energy until buses return to the yard at day end. However, because the off-peak price is only $0.02 per kilowatt-hour more expensive than the super-off-peak price, the incremental cost of the battery would need to be less than $0.02 per kilowatt-hour, which is not the case at this time. On the other hand, the peak period price is more than triple the super-off-peak rate, and more than $0.20 higher than the off-peak rate. For agencies with inflexible charging patterns that must consume energy during the CEV peak period (4-9 p.m.), BTM energy systems with a levelized cost of energy lower than the $0.20 increment could be cost-effective.

Approach to REopt Model

The National Renewable Energy Laboratory's REopt model was used to derive recommendations for the optimal mix of energy resources to support the Petaluma Transit fleet. This techno-economic decision support platform combines "renewable energy, conventional generation, and energy storage technologies to meet cost savings, resilience, and energy performance goals."[15] The tool is used in a variety of contexts including buildings, campuses, communities, and microgrids; only more recently has it been applied to systems supporting vehicle electrification.

Source: National Renewable Energy Laboratory

REopt includes both financial and resilience modules:

- The financial optimization module is a maximization model that finds the mix of storage, solar, and grid power that would provide the maximum financial return given the specified electricity load at the site over an entire year.
- The resilience module is a minimization model that finds the minimum mix of storage, solar, and generators that could supply the specified critical load during a specified outage.

Other key modeling assumptions are related to the up-front and ongoing costs of storage, solar, diesel, electricity rates, and charging patterns, described below. These assumptions were informed by agency contexts and vetted by SCP.

Li-ion battery storage cost assumptions were obtained by reviewing data from government reports, publicly available market analyses, and proprietary research with project developers. These entities included the U.S. Energy Information Administration, the National Renewable Energy Laboratory, BloombergNEF, and project implementors in both Northern California and other parts of the country. Insight from these reports and resources was combined with existing knowledge of energy markets and trends to establish these cost estimates. There is significant variation in storage cost estimates, as project prices are driven by both power and energy components. After reviewing with stakeholders, $200 per kilowatt-hour and $1,000 per kilowatt were found to be reasonable cost estimates given the expected scale of projects at the agency sites. These costs are "all-in" estimates for the entirety of the installation but may underestimate permitting costs and the higher labor costs for California projects relative to other areas of the country.

Cost inputs to the REopt analysis for solar are discussed in the *Approach to Solar Potential* section.

Diesel costs assumptions were obtained by reviewing and comparing the U.S. Energy information Administration reports to the National Renewable Energy Laboratory's recommended diesel price, leading to a reasonable wholesale price estimate of $3 per gallon. The per-kilowatt cost of the diesel

[15] National Renewable Energy Laboratory. "REopt: Renewable Energy Integration & Optimization." https://reopt.nrel.gov/

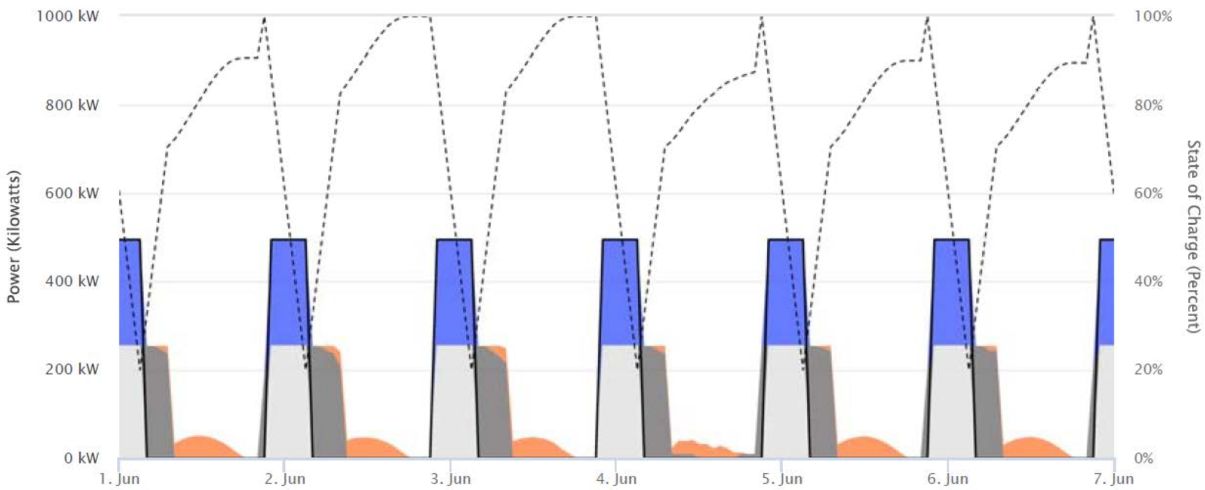
generators was determined by adding the expected installation costs to the retail price, then dividing the combined cost by the kilowatt rating of the generators. It was assumed that each site already has at least one small on-site diesel storage system to service the current fleet, and that this equipment could be made available to help meet fleet resilience targets as the fleet is electrified.

The National Renewable Energy Laboratory's database of electric service rates was leveraged to input the Petaluma Transit's current A-10S time-of-use rate. PG&E's approved CEV rate (U39E) was used to illustrate how resource recommendations might differ if sites subscribe to this alternative rate. The projected load was used to determine which of the primary and secondary services and which of the large or small tariff options of the CEV rate best fit each site.

The three charging patterns described in the *Future Commercial Electric Vehicle Rate* section (Scenario A, Scenario B, and Scenario C) were initially tested for what would best suit the needs of each site. These charging patterns were extrapolated to build hourly profiles of the agency's energy demand for one year at the end of its five-year electrification plans and of the energy requirements if the fleet were fully electrified. The Scenario C mixed charging profile (two hours in the daytime and five hours at night) was only relevant for the CEV rate scenarios because on the current site electricity tariffs, midday is the most expensive time of day to charge. After several modeling configurations it was determined that there were no differences in results between the three scenarios when subscribed to the CEV rate, so only the two overnight approaches (Scenario A and Scenario B) warranted further consideration.

For each run of the financial module, REopt first calculates a business as usual cost, which is the net present value of the site's energy costs under the specified rate structure and load profile over 25 years without any additional BTM resources. The model then iterates through combinations of BTM resources to find the financially optimal mix of resources and their capacities for this same charging profile and electricity rate. Figure 16 illustrates how the model integrates various resources to meet load at the site in the most economical way. Once the model identifies the optimal mix of BTM resources, it calculates the associated net present value of the system, including costs for BTM resources and for supplemental grid energy over the 25 years. In cases where the most cost-effective option is the business as usual scenario, the model recommends zero BTM resources. While CEV is expected to be the most cost-effective rate for transit agencies, REopt modeling was conducted on the current E19S rate as well.

Figure 16. Illustrative Example of Optimized Dispatch Strategy for Distributed Energy Resources at a Transit Yard with Overnight Depot Charging



The solid line indicates electric load at the site, while the dotted line is the battery state of charge. Blue shading is the battery discharging to serve the load, while light gray is the grid serving load, medium gray is the grid charging the battery, and orange is PV charging the battery.

In the resilience module, the user specifies a particular outage date, time, and duration. The timing of the outage defined in this REopt modeling corresponds to the Public Safety Power Shutoffs experienced in the North Bay starting on October 9, 2019, just after midnight.[16] The BTM resources were then sized to the minimum combination that could cover the critical load over that time; in this case, following consultation with the transit agencies, critical load was defined as meeting the charging needs of 25% of the fleet over 48 hours. After identifying the set of BTM resources sufficient to meet the specified outage, REopt also iterates through all possible outages of the same length that could occur over the year and assesses whether, with the specified BTM resources, the site would survive each outage. This information was compiled and expressed as the percentage of time the system sustains the critical load for all potential 48-hour outages throughout the year.

Recommendation: Behind-the-Meter Energy Resources

The results of the REopt modeling in Table 13 suggest that the most economical way to meet the fleet's short-term energy needs is to select the CEV rate and forgo installing any BTM resources. In fact, in the eight-hour charging scenario, BTM resources are also not cost-effective on the agency's current rate. This is likely driven by the need for on-site solar to be constructed as solar parking arrays, which drives up the dollar-per-watt installation costs. According to the model results, switching to the CEV rate could save the agency more than $800,000 (in 2019 dollars) over the next 25 years relative to the next best

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16 Pacific Gas and Electric Company. October 25, 2019. "PG&E Public Safety Power Shutoff Report to the CPUC." https://www.pge.com/pge_global/common/pdfs/safety/emergency-preparedness/natural-disaster/wildfires/PSPS-Report-Letter-10.09.19.pdf

option. Given that the CEV rate is quite favorable and easy to execute, cost savings alone are not a compelling rationale for Petaluma Transit to procure BTM energy resources in the near term.

Table 13. Petaluma Transit Yard REopt Results: Financial Module, Short-Term Energy Needs

Utility Rate	Battery Capacity (kW)	Battery Duration (hrs.)	Solar Size (kW)	Business As Usual Cost ($) (25-year NPV)[a]	Cost with BTM Resources ($) (25-year NPV)[a]	Should the Agency Pursue BTM Resources?
6-Hour Charging Scenario						
CEV Rate	0	0	0	$1,140,903	Same as BAU (no BTM recommended)	No
A-10S Time of Use	105	8	35	$2,183,495	$2,071,310	Yes
8-Hour Charging Scenario						
CEV Rate	0	0	0	$1,144,824	Same as BAU (no BTM recommended)	No
A-10S Time of Use	75	11	115	$1,977,893	$1,953,133	Yes

[a] NPV stands for net present value.

In the long term, on-site storage and generation are appealing for their reliability and resilience characteristics. Resilience resonates with agencies because of their emergency response duties and because the North Bay is increasingly subject to Public Safety Power Shutoffs. To understand the potential for BTM resources to support transit agencies' resilience, the fully electrified fleet energy needs of Petaluma's peer agency Santa Rosa CityBus were run through REopt's resilience module as a representative example.

The model suggests that without an impractically large and financially restrictive battery, solar and batteries alone cannot support the agency's critical load. Table 13 illustrates that, for a resilient fleet capable of limited operation during an outage, the agency likely needs a backup generator. REopt suggests a reasonably sized (200 kW to 350 kW), long-duration battery along with a 100 kW generator. Interestingly, no solar is recommended, which could be because the prescribed outage occurs over more nighttime than daytime hours or, more likely, is due to a limitation of the model. On-site solar is not expected to be cost-effective during the remainder of the year because the CEV rate is so favorable.

Even this qualified level of resilience will come at significant cost—the present value of the BTM system designed to survive outages similar to the specified October 9 outage is about $1 million more expensive than the business as usual scenario over a 25-year lifetime (see Table 14). While BTM resources that are installed to provide resilience may not have a positive payoff, the agency may still consider these hard-to-quantify resilience benefits to be worth the additional investment. Furthermore, to the extent that the agency can obtain grant funding to lower the cost for BTM resources, they may become cost-effective due to a change in internal benefit/cost calculations.

Table 14. Illustrative REopt Results: Resilience Module, Long-Term Energy Needs

Battery Size (kW)	Battery Duration (hours)	Generator (kW)	Solar Size (kW)	Business as Usual Cost ($) (25-year NPV)[a]	Cost with BTM Resources ($) (25-year NPV)[a]
6-Hour Charging Scenario					
322	8	100	0	$9,861,602	$10,931,386
8-Hour Charging Scenario					
216	11	100	0	$9,861,602	$10,768,094

[a] NPV stands for net present value.

As agencies consider procuring BTM energy resources, there are several factors to consider about the results of the REopt modeling:

1. First, the REopt optimization does not constrain battery recommendations to commercially available sizes. This is particularly important in the resilience module, as the battery size can become so large that it either becomes commercially unavailable or takes up so much space as to be impractical. To address this, certain runs were repeated with adjustments to the input constraints on maximum generator sizes to bring battery size within reasonable bounds.
2. Second, while the treatment of resilience in the REopt model centers on technological solutions, operational workarounds can also support resilience.
   a. In the near term, agencies can meet their resilience needs by deploying their conventionally fueled buses for longer-haul evacuation services or as warming and Wi-Fi centers.
   b. Agencies can also collaborate across the region to procure interoperable bus and charging systems, so during an outage, an agency can obtain charge from the yards or auxiliary charging sites of neighboring agencies that are not experiencing outages (provided that the charging infrastructure is specified with a sufficiently high rate of charge and number of ports to serve more than the needs of that agency's fleet).

These are just two examples of creative approaches agencies can take to meet their resilience needs for electrified transportation.

Low Carbon Fuel Standard Credits

Additionally, REopt does not integrate incentives that sunset prior to the end of the broader project lifetime. Credits under the LCFS are one such type of incentive. Available to transit agencies that power buses with electricity, the LCFS could provide transit agencies with a lucrative additional value stream through 2030, when its authorization will expire. Credits are allocated based on the carbon intensity of the electricity used to power the bus and *are available to the agency regardless of whether BTM resources are installed*.

Because solar generation has a carbon intensity of 0 gCO2e/MJ (grams of carbon dioxide equivalent per megajoule), whereas the California electric grid has a carbon intensity of 81 gCO2e/MJ, sites can generate more LCFS credits by powering their buses with solar. On the other hand, because the carbon intensity of the energy supplied by SCP is just 16 gCO2e/MJ, the delta between the value of an LCFS credit from SCP electricity relative to that from solar electricity is about $0.01 per kilowatt-hour. Thus, BTM energy system recommendations would likely be the same if optimization included values from LCFS credits.

The estimated LCFS credit values the agency could receive are calculated under an assumed carbon intensity of 16 gCO2e/MJ per the SCP generation mix and a gradual decline of available credits through 2030. The credit calculations were conducted from 2020 through 2030, at market price points of $80, $120, and $200, to account for market volatility over the next decade (see Table 15). The energy use metric represents the projected energy to be supplied to the Petaluma Transit Yard from the grid annually using a six-hour charging window; an eight-hour charging window was also examined and could deliver similar value in LCFS credits. Under these assumptions, Petaluma could earn up to $700,000 from LCFS credits over the next 10 years, based on the energy needs of the agency's short-term BEB procurements.

Table 15. Potential Revenue from Low Carbon Fuel Standard Credits for Petaluma Transit Using Sonoma Clean Power Electricity

Year	kWh	Market Price Point		
		$80	$120	$200
2020	424,860	$55,232	$80,723	$135,955
2021	424,860	$55,232	$80,723	$135,955
2022	424,860	$55,232	$80,723	$131,707
2023	424,860	$50,983	$80,723	$131,707
2024	424,860	$50,983	$76,475	$127,458
2025	424,860	$50,983	$76,475	$127,458
2026	424,860	$50,983	$76,475	$127,458
2027	424,860	$50,983	$72,226	$123,209
2028	424,860	$46,735	$72,226	$123,209
2029	424,860	$46,735	$72,226	$118,961
2030	424,860	$46,735	$72,226	$118,961
Net Present Value		**$408,254**	**$474,259**	**$710,544**
Discount Rate		**3%**	**3%**	**3%**

Next Steps

This report presents guidance for Petaluma Transit's near-term BEB transition. There are several ongoing processes, outstanding opportunities, and unanswered questions that could benefit from further examination:

- ***Route modeling:*** The route modeling conducted as part of this report is just a portion of the total opportunity. Petaluma would benefit from continued engagement with the project team to explore additional route and BEB model combinations in order to be strategic in its bus procurements.
- ***Site engineering and design:*** The site energy needs, distribution system capacity, and potential electrical infrastructure upgrades discussed in this report are a starting point for more technical site work once the agency has settled its procurement plans. The agency should look to contract with an experienced partner for the engineering, design, and construction stages of its BEB

transition. Additionally, the agency should continue to engage with PG&E to determine what is feasible and to ensure that the utility considers how the agency's long-term ambitions might inform short-term plans.

- ***Innovative financing:*** A principal challenge for Petaluma Transit will be securing the up-front capital to cover the incremental cost of a BEB over a diesel (hybrid) bus. City of Petaluma should explore innovative financing solutions, such as tariffed on-bill financing, and should consider collaboration with SCP, PG&E, or other authorities.
- ***Regional collaboration:*** SCP is committed to facilitating Petaluma Transit's BEB transition. SCP can serve as a resource to provide avenues of communication with the Bay Area Air Quality Management District, letters of support for grant applications, or potentially contribute technical expertise as *ad hoc* advisors. As described in the report, agencies can also benefit from collaboration via cooperative purchasing, selection of interoperable BEB technologies, and creative approaches to meeting resilience needs.

Appendices. Research Tables and Background Details

The following appendices outline technology options and funding sources available to transit agencies looking to electrify their fleets and install BTM resources to support these efforts.

Appendix A. PV Funding/Finance Options

The financing table below was created through desk research and builds on a literature review and interviews. The table is focused on local and state resources and programs, as well as any opportunities provided through PG&E and SCP. Some of the options listed may not be viable directly for the transit agencies, such as tax incentives or PACE financing, but are included to provide a holistic depiction of the funding available for energy storage and BTM resources.

Category	Incentive	Administrator	Contact	Notes and Link
Self-Generation Incentive Program				
State	Rebates	California Public Utilities Commission (through local utilities)	SelfGenCA.com; selfgen@pge.com; 1-877-743-4112, ext. 4, then ext. 3	Available funds from PG&E: $16,033,266.15; Solar can be eligible for renewable generation or general generation. https://www.cpuc.ca.gov/General.aspx?id=11430 Application: https://www.pge.com/en_US/small-medium-business/energy-alternatives/private-solar/understand-the-solar-process.page
Low or No Emission Competitive Program				
Federal	Grant	Federal Transit Administration	202-366-2053	The Low or No Emission Competitive program provides funding to state and local governmental authorities for the purchase or lease of zero- and low-emission transit buses as well as for the acquisition, construction, and leasing of required supporting facilities. Under the Fixing America's Surface Transportation Act, $55 million per year is available until September 30, 2020. **Funds cannot be used to retrofit an existing facility with solar panels unless those panels are necessary for the operation of EVs**. An agency can use Low or No Emission Competitive program funds to build a maintenance facility that uses solar panels if that facility is incidental to the operation of EVs. https://www.transit.dot.gov/funding/grants/lowno
The Grants for Buses and Bus Facilities Program (49 U.S.C. 5339)				
Federal	Grant	Federal Transit Administration	202-366-2053	Capital projects to replace, rehabilitate, and purchase buses, vans, and related equipment and to construct bus-related facilities including technological changes or innovations to modify low- or no-emission vehicles or facilities. https://www.transit.dot.gov/bus-program

Category	Incentive	Administrator	Contact	Notes and Link
Electric Program Investment Charge Program				
State	Ratepayer Benefits	California Energy Commission, PG&E, San Diego Gas & Electric, Southern California Edison	ERDD@energy.ca.gov	$162 million annually for the development, deployment, and commercialization of next generation clean energy technologies. https://www.energy.ca.gov/programs-and-topics/programs/electric-program-investment-charge-epic-program Application: https://ww2.energy.ca.gov/research/epic/faq.html
Reimagining Affordable Mixed-Use Development in a Carbon-Constrained Future				
State	Grant	Electric Program Investment Charge	916-327-2388; fernando.pina@energy.ca.gov	Estimated Funding Amount: $48 million https://www.energy.ca.gov/solicitations/2019-09/next-epic-challenge-reimagining-affordable-mixed-use-development-carbon Application: Being released September 30, 2019
Title 17 Loan Program				
Federal	Loan	U.S. Department of Energy	--	Finances the first deployments of a new technology to bridge the gap for commercial lenders; up to $4.5 billion in loan guarantee authority for innovative energy and efficient energy projects. https://www.energy.gov/lpo/title-xvii
California Net Metering Program (Net Energy Metering Aggregation)				
State	Financial Credit	California Public Utilities Commission (through local utilities)	Kerry.Fleisher@cpuc.ca.gov (general net energy metering inquiries); Brian.Korpics@cpuc.ca.gov (net energy metering revisit inquiries and general net energy metering inquiries); Brian.Korpics@cpuc.ca.gov (net energy metering revisit inquiries)	Participating customers receive a bill credit for excess generation that is exported to the electric grid. https://www.cpuc.ca.gov/general.aspx?id=3800
Sales and Use Tax Exemption for Electrical Power Generation and Storage Equipment (AB 398)				
State	Sales Tax Incentive	California Department of Tax and Fee Administration	800-400-7115	Incentive Amount: 100% https://programs.dsireusa.org/system/program/detail/22048 https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201720180AB398

Category	Incentive	Administrator	Contact	Notes and Link
Sonoma County Energy Independence Program				
Local	Financing (PACE)	Sonoma Energy and Sustainability Division	707-565-6470; SCEIP@sonoma-county.org	Minimum amount of financing is $2,500, which becomes an assessment of the property and is paid back through the property tax system over a term of 10 years or 20 years with a 7% interest rate. https://sonomacountyenergy.force.com/financing/s/ Application: https://sonomacountyenergy.force.com/financing/login?inst=t&startURL=%2Ffinancing%2Fs%2Fstart-an-application%3Ft%3D1534203847992 *(requires registration)*
CaliforniaFIRST				
Organization	Financing (PACE)	Renew Financial	844-736-3934	PACE allows commercial property owners to finance projects, then financing is repaid on property taxes over 30 years or less. https://renewfinancial.com/commercial Application: https://www.getfeedback.com/r/2BaBBq8j/q/1
Ygrene Works for California				
Organization	Financing (PACE)	Ygrene Energy Fund	866-634-1358	100% financing, zero capital outlay, and no payments for up to 12 or more months. https://ygrene.com/commercial Application: https://prequalification.ygrene.com/prequal
CleanFund Commercial PACE Capitol				
Organization	Financing (PACE)	CleanFund	415-256-800; info@cleanfund.com	100% financing for vital building improvements, with no payments for up to two years and payments spread over 20 years to 30 years at fixed rates. https://www.cleanfund.com Application: https://quote.cleanfund.com/
Petros PACE Finance				
Organization	Financing (PACE)	Petros Finance	512-599-9038; info@petrospartners.com	For projects ranging from $500,000 to $50,000,000. https://www.petros-pace.com/about-petros/overview/ Application: https://www.petros-pace.com/contact/
Financing for Energy Efficiency and Renewable Energy Generation Projects				
State	Financing (PACE)	California Energy Commission	916-651-3747	Interest rate 1% loans. https://www.energy.ca.gov/solicitations/2019-04/pon-17-401-financing-energy-efficiency-and-renewable-energy-generation Application: https://www.energy.ca.gov/sites/default/files/2019-05/00_PON-17-401_Notice_and_Application_0.docx

Appendix B. Energy Storage Technology Options

The table below is the product of research into the energy storage market conducted specifically for the transit agency context. This appendix conveys information regarding certain key characteristics for a variety of storage technologies. This is not an exhaustive exercise but rather is meant to highlight features of typical specimens of a giver technology in order to illuminate each technology's relative tradeoffs.

Technology	Lithium-Ion Batteries[a]	Lead-Acid Batteries[b]	Sodium-Sulfur Batteries[c]	Vanadium Redox Batteries (Flow Batteries)[d]	Solid Oxide Fuel Cells[e]
Energy Density (Wh/kg)	120 - 180	25 - 35	206	10 Wh/L - 25 Wh/L	--
Energy Range (MWh)	≤10	≤10	1.2 - 400	A few megawatt-hours	--
Efficiency (%)	90% - 98%	75% - 85%	70% - 80%	70% - 75%	53% - 65%
Cost $/kW	$1,500	$1,300	--	--	--
Cost $/kWh	$176 (2018); Could drop below $100 in 2024	$250	$300	$300 (expected to drop to $100 in coming years)	$0.10
Cell Potential (volts per cell)	3.7	2	2	1.15 - 1.55	--
Discharge Time	10 minutes to 4 hours	Minutes to over 20 hours	6 hours	2 hours - 10 hours	12 hours
Max Cycles or Lifetime	**10,000** cycles; **5 years** (regardless if used)	**3,000** cycles	**4,500+** cycles; **15 years - 20 years**	**20,000** cycles; **20 years - 30 years**	**5,000** cycles; **~ 5 years**
Common Applications	Emergency power backup, EV power, solar storage, surveillance, mobile tech, portable power packs	Large backup power supplies for telephone and computer centers, grid energy storage, off-grid electric systems; used as a cheap transition to the next low-cost generation of batteries	Commercial energy storage technology; to distribute supplementary energy during peak periods	Large-scale non-mobile energy storage applications, peak shaving, energy time shifting	Auxiliary power, electric utility, distributed generation

Technology	Lithium-Ion Batteries[a]	Lead-Acid Batteries[b]	Sodium-Sulfur Batteries[c]	Vanadium Redox Batteries (Flow Batteries)[d]	Solid Oxide Fuel Cells[e]
Commercial Options	Tesla Powerpack, Guoxuan High-Tech, CALB, American Lithium Energy Corp, Lithium Energy Japan	Gridential, FIAMM Tripp Lite, Mouser Electric, Power - Sonic Corporation, Scott's Emergency Lighting & Power Generation, bisco industries, Positive Battery Co	NGK Insulators, KEMET, Electronics Corporation, GE Energy Storage, Eagle Picher Technologies, Ceramatec, Sieyan Electric, FIAMM Group, POSCO	Vionx Energy, Sumitomo Electric, VRB Energy, Enerox, UniEnergy	Bloom Energy

[a] If lithium-ion battery cells become fully discharged, they **no longer accept a charge. Safety issue**: these batteries can catch **fire** if they come into contact with atmospheric moisture. These batteries usually require a **battery management system (increased costs).**

[b] Lead-acid batteries are not the most cost-effective grid storage option **(low energy densities**); they must be **replaced every few years**. They are toxic but 97% recyclable in the United States.

[c] Sodium-sulfur batteries are **expensive. Safety Issue:** these batteries have a high operating **temperature**, with current research on altering the shape to improve efficiency, temperature, and costs. These batteries have one of the **fastest response times**.

[d] Vanadium redox battery (flow battery) have **safety issues**, as documented online: Smart Energy International. August 8, 2019. "The Vanadium Redox Flow Battery – A Game Changer for Energy Storage Safety." https://www.smart-energy.com/industry-sectors/storage/the-vanadium-redox-flow-battery-a-game-changer-for-energy-storage-safety/ These batteries do not degrade for **20 years**; see the **San Diego case study**: Mai, H. J. May 14, 2019. "California ISO Tests Flow Battery Tech That Could Decrease Bulk Storage Costs." *Utility Dive* (Brief). https://www.utilitydive.com/news/california-iso-tests-flow-battery-tech-that-could-decrease-bulk-storage-cos/554682/

[e] Solid oxide fuel cells can be approximately 50,000% more power dense than 1 MW of solar. These fuel cells have a solid oxide or ceramic electrolyte. The largest disadvantage is their high operating temperature, which results in longer start-up times and mechanical and chemical compatibility issues; however, high-temperature operation removes the need for a precious metal catalyst, thereby reducing costs.

Appendix C. Energy Storage Funding/Finance Options

The financing table below was created through desk research and builds on a literature review and interviews. The table is focused on local and state resources and programs, as well as any opportunities provided through PG&E and SCP. Some of the options listed may not be viable directly for the transit agencies, such as tax incentives or PACE financing, but are included to provide a holistic depiction of the funding available for energy storage and BTM resources.

Category	Incentive	Administrator	Contact	Notes and Link(s)
Self-Generation Incentive Program				
State	Rebates	California Public Utilities Commission (through local utilities)	SelfGenCA.com; selfgen@pge.com; 1-877-743-4112 ext. 4, then ext. 3	Available funds: $11,051,184.57; Large-scale storage: $0.40/kWh https://www.cpuc.ca.gov/sgip/ https://www.selfgenca.com/documents/handbook/2017 https://www.selfgenca.com/home/program_metrics/
Low Carbon Transit Operations Program				
State	Grant Funding	Caltrans Division of Rail and Mass Transportation	Amar Azucena Cid amar.cid@dot.ca.gov	Provides operating and capital assistance to transit agencies with the goal of reducing greenhouse gas emissions and improving mobility, including expenditures related to the purchase of zero-emission buses, including electric buses, and the installation of the necessary equipment and infrastructure to operate and support zero-emission buses. https://ww2.arb.ca.gov/sites/default/files/2019-10/Caltrans%20presentation.pdf
The Grants for Buses and Bus Facilities Program (49 U.S.C. 5339)				
Federal	Grant Funding	Federal Transit Administration	202-366-2053	Capital projects to replace, rehabilitate, and purchase buses, vans, and related equipment and to construct bus-related facilities, including technological changes or innovations to modify low- or no-emission vehicles or facilities. https://www.transit.dot.gov/bus-program
Low or No Emission Vehicle Program				
Federal	Grant Funding	Federal Transit Administration	202-366-2053	Provides funding to state and local governmental authorities for the purchase or lease of zero- and low-emission transit buses as well as for the acquisition, construction, and leasing of required supporting facilities, including on-site energy storage. Under the Fixing America's Surface Transportation Act, $55 million per year is available until September 30, 2020. Funds cannot be used to retrofit an existing facility with solar panels unless those panels are necessary for the operation of EVs. An agency can use program funds to build a maintenance facility that uses solar panels if that facility is incidental to the operation of EVs. https://www.transit.dot.gov/funding/grants/lowno

Category	Incentive	Administrator	Contact	Notes and Link(s)
Demonstrate Emerging Energy Storage Technologies that Can Support the Future Clean Energy Needs of the California Grid				
R&D	Grant Funding	Electric Program Investment Charge Program	--	This solicitation will develop customer-side-of-the-meter energy storage solutions that address increased energy density and critical system energy needs such as resiliency, reliability, improved safety, better long-term or lifecycle performance, and lower costs than currently fielded systems. Released Date: October 30, 2019 Estimated Funding Amount: $11 million https://www.energy.ca.gov/solicitations/2019-10/demonstrate-emerging-energy-storage-technologies-can-support-future-clean
Demonstrating Innovative Energy Storage Technologies in Pressing California Applications				
R&D	Grant Funding	Electric Program Investment Charge Program	--	This solicitation will focus on demonstrating long-duration energy storage (10 hours or greater), residential energy storage compliance options, energy storage technologies that can provide clear value to support critical operations, community facilities and other relevant services in disadvantaged and low-income communities, and energy storage technologies that can provide clear value to support critical operations, community facilities, and other relevant services in Native American tribal communities. Released Date: October 30, 2019 Estimated Funding Amount: $20 million https://www.energy.ca.gov/solicitations/2019-10/energy-storage-demonstration-support-distributed-energy-resources-and-carbon
Climate Tech Finance				
State	Loans	Bay Area Air Quality Management District	415-749-4937 climatetech@baaqmd.gov	Public-sector facilities can apply for loans ranging from $500,000 to $30 million, with terms of up to 30 years. The Air Quality Management District also provides engineering evaluation and technical assistance to borrowers to evaluate proposed projects. The program supports emerging technologies that reduce greenhouse gas emissions and have been successfully demonstrated at the pilot, demonstration, or early commercial scale, but have not reached full commercial scale. Greenhouse gas emissions reductions include either direct reductions on the site (such as process improvements or electrification) or indirect reductions (via reduced energy consumption). http://www.baaqmd.gov/funding-and-incentives/businesses-and-fleets/climate-tech-finance

Appendix D. Electric Vehicle Supply Equipment Survey

Product	Output Power (kW)	Connector Type[a]	Software/ Communication Protocol	System Weight (lbs)	Dimensions (Depot - W x D)	Connectors per Depot	Output Voltage Range	Approved for PG&E Fleet Program (as of August 8, 2019)	Pantograph compatible?
ABB									
HVC 150C E-Bus Charger (NAM)	150	CCS-1 or 2	OCPP 1.6	143	24” x 8”	3	200-920 VDC	Yes	Yes
Terra HP	175	CCS-1/SAE J1772	OCPP 1.6	550	24.4” x 17”	2	150-950 VDC	Yes	Yes
Terra 54 DC	50	CCS-1/SAE J1772	Data Unavailable	775	22” x 31”	2	150-950 VDC	Yes	No
BTC Power									
350 kW Modular High Power DC Fast Charger	100-350	J1772-CCS	OCPP 1.6	Data Unavailable	22” x 12”	2	50-950 VDC	Yes	No
475 kW Modular High Power DC Fast Charger	200-475	J1772-CCS	OCPP 1.6	Data Unavailable	12” x 12”	1	50-950 VDC	Yes	No
ChargePoint									
Express Plus Double Stacked Power Block	156	J1772-CCS	OCPP 1.6	250	26” x 16”	2	300-460 VDC	Yes	No
CPE100/200/250	24/50/62	J1772-CCS	OCPP 1.7	150	19” x 12”	2	300-460 VDC	Yes	No
Proterra									
60kW Power Control System	60	J1772-CCS	OCPP 1.6	1400	30” x 13”	1	270-875 VDC	No	Yes
125kW Power Control System	125	J1772-CCS	OCPP 1.7	2500	30” x 13”	1	400-920 VDC	No	Yes
500kW (Overhead)	500	J1772-CCS	OCPP 1.8	3500	129” x 23.6”	1	270-920 VDC	No	Yes
Siemen									
RAVE US 750V 150kW CCS Cascade DC	150-600	J1772-CCS	OCPP 1.6	5291 (charging station)	79” x 47”	Up to 4	750V	Yes	Yes

Product	Output Power (kW)	Connector Type[a]	Software/ Communication Protocol	System Weight (lbs)	Dimensions (Depot - W x D)	Connectors per Depot	Output Voltage Range	Approved for PG&E Fleet Program (as of August 8, 2019)	Pantograph compatible?
Heliox									
Fast DC	150	J1772-CCS	Data Unavailable	3086	47" x 32"	1	400-800 VDC	No	Yes
BYD									
EVA100KS/02	100	CCS1	Data Unavailable	397	20" x 16" (L x W)	2	AC189V-228V	No	No
EVA200KS/01	100	CCS1	Data Unavailable	397	20" x 16" (L x W)	2	AC342-440V	No	No
Blink									
DC Fast Charger	60	Yazaki - CHA de MO compliant 120A rated	Data Unavailable	450	52" x 15"	1 or 2	200 VDC-450 VDC	No	No
Efacec									
HV350	322	CCS1	OCPP 1.5	573	23,62" x 11,81"	2	Up to 920V	No	No
Tritium									
Veefil RT	50	CCS	OCPP 1.5 & 1.6J	364	30" x 13"	2	Data Unavailable	Yes	
Veefil PK	175-600	J1772-CCS	OPP1.6J	551	20" x 39"	1 or 2	Up to 920 VDC	Yes	Yes
Power Electronics									
NB 50	50	J1772-CCS	OCPP 1.6	Data Unavailable	24" x 28"	1 or 2	50-500	No	No
NB Station HV	100, 175, 350, 460, 700, 920	J1772-CCS	OCPP 1.6		12" x 20"	1 or 2	150-1,000	No	Yes

[a] CCS stands for combined charging standard.

Appendix E. Electric Vehicle Supply Equipment Product Review

This appendix provides a summary of the electrical cabinets and EVSE units evaluated by CALSTART. The models are DC fast chargers ranging from 60 kW to 500 kW of electrical output. The critical attributes of each charger model—including power output, system weight, exterior dimensions, connectors, output range voltage, and status of approval for PG&E's EV Fleet program—are provided in *Appendix D*.

Proterra
60 kW Power Control System

Proterra is a United States–based electric bus manufacturer that builds chargers to support its heavy-duty EV product line. Proterra's 60 kW Power Control System is one of the most straightforward charging station solutions specifically designed for electric buses. The cabinet module (shown left) provides up to 60 kW of power to a single EVSE unit to charge a single electric bus. The ground-level EVSE can be swapped out for an overhead pantograph connector for a more compact bus yard design. Depending on the available capacity of its battery, the bus can be completely recharged in approximately six hours. Manual labor is limited to plugging the EVSE into the bus in the evening after returning to the bus yard, then unplugging it in the morning prior to beginning daily revenue service. Existing examples can be seen at Greensboro Transit Authority.

Proterra
125 kW Power Control System

Just like the 60 kW version, the 125 kW Power Control System is a simple solution, but with over twice the power. The electrical cabinet (shown left) provides up to 125 kW of power to a single EVSE unit to charge a single electric bus. The bus battery can be recharged in approximately three hours, giving the fleet manager the flexibility to park two electric buses next to each other and manually transfer the plug halfway through the night.

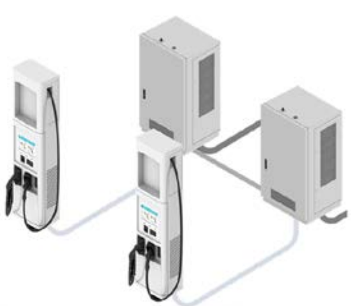
BTC Power

100 kW DC Fast Charger and 100 kW to 200 kW Modular High-Power DC Fast Chargers

BTC Power manufactures both 50 kW and 100 kW DC fast chargers, though it is unlikely that the 50 kW charger would be suitable for the agency's needs. The 100 kW DC fast charger provides superior efficiency at over 92%. BTC Power also manufactures modular high-power DC charging systems that can be sized in 50 kW increments for flexibility and expandability. BTC Power's highest power DC fast chargers consist of an electrical cabinet, called the "Power Engine" coupled with one or two separate dispensers. Two Power Engines can also be interconnected to deliver up to 350 kW of power to one EVSE. The EVSE itself offers two dispenser units that can power two electric buses sequentially on a first-come, first-served basis. When the first bus has completed charging, the second bus will begin charging without needing manual intervention. BTC Power also adds a small amount of smart charging software to their EVSE with the goal of making it very easy for a network provider to integrate a data management solution into the charging station. Existing examples include the Los Angeles International Airport and Porterville Transit.

BTC Power

350 kW High Performance DC Charging System



Based in Santa Ana, California, BTC Power manufactures a High-Performance DC Charging System that is capable of delivering up to 475 kW. This design uses two cabinet modules: one to convert energy from AC power to DC power (called a power box) and one to provide liquid cooling to the EVSE units (called a cooling box). These cabinets connect to two EVSE and can charge both simultaneously. Additional EVSE can be added with the inclusion of another power box. Generally, one cooling box can support up to three power boxes and charge six buses simultaneously at whatever power level is desired.

Like BTC Power's other chargers, the High-Performance DC Charging System has a small amount of smart charging software, which makes it very easy to integrate a data management solution. There are no existing examples of installations currently operational at any transit agency.

ABB
HVC 150 E-Bus Charger (NAM)

ABB is a leading EV charger manufacturer that has been building electric bus chargers in Europe for several years, and is expanding operations to the United States. Manufactured in Portland, Oregon, the HVC 150 E-Bus Charger can deliver 150 kW of electricity. The system uses one electrical cabinet to support up to three EVSE, and charges each on a first-come, first-serve basis. The chargers are smart enough to smoothly transfer power from one EVSE to the next when the bus is fully charged, and ABB offers additional services like remote diagnostic and management through the ABB Ability data management program. Several transit agencies, including TriMet in Portland, Oregon and the Utah Transit Authority, are using these chargers.

Heliox
Fast DC 150 Charger

Heliox is a Netherlands-based EV charging infrastructure company operating the world's largest opportunity and depot charge network including pantograph style chargers. Manufactured in the Netherlands, this 150 kW charger charges one vehicle on a first-come, first-serve basis. It can charge any J1772 or J3105 compatible truck, bus, or heavy-duty vehicle. Most Heliox customers are transit agencies in Europe, but the company is expanding into the United States market, having recently opened a headquarters in Portland, Oregon.

ChargePoint
Express Plus Double Stacked Power Block

ChargePoint is a San Francisco Bay Area–based EV charging network. Founded in 2007, it operates over 57,000 charging stations worldwide. ChargePoint has multiple models of chargers that are available for passenger vehicles, buses, and trucks. The Express Plus model is designed for ultra-fast DC charging. Thanks to its flexible modular architecture, it can expand to high charging capacity without any stranded investment by adding power modules, stations, and power blocks, per demand. Speed and dynamic power sharing are some of the many benefits of the Express Plus model.

Siemens
RAVE US 750V 150 kW Combined Charging Standard Cascade DC

Siemens is a German-based industrial giant with a major footprint in the bus charging infrastructure industry, with multiple models of depot and on-route charging to choose from. The RAVE brand charger can provide an EV with fast and efficient charging for both depot and on-route charging whenever necessary. Examples of usage of Siemens chargers include Metro Transit in Minneapolis, Minnesota and TriMet in Portland, Oregon.

BYD
EVA100KS/02 and EVA200KS/01

BYD is a Chinese automotive company known for building electric buses (transit and coach), vans, cars, and trucks. BYD also has a variety of chargers that it markets with its vehicles. All BYD EVs come with standard AC-DC quick charge inverters, creating simplified fleet integration. BYD chargers are available in 40 kW, 80 kW, 100 kW, 200 kW, 150 kW DC, and 300 kW DC configurations. As a requirement, BYD buses can only be paired with BYD chargers. Examples of usage are at the Antelope Valley Transit Authority in Lancaster-Palmdale, California.

Blink Charging
DC Fast Charger

Blink Charging is a Florida-based charging company that produces multiples lines of charging infrastructure. Blink has a variety of business models that can work for all different types of fleets. Blink's DC Fast Charger has a simplified two-piece design that connects with an advanced metering infrastructure interface and smart meter capability for demand response and energy management. This charger can provide an 80% charge in 30 minutes (pending battery size).

Efacec
HV350

Efacec is a Portugal-based charging company with a variety of high-power chargers that include 160 kW, 175 kW, and 350 kW models that can charge in both a stand-alone mode or be integrated in any network with any central system. These chargers can charge both cars and buses and have a DC output of up to 920V. Efacec chargers can be customized with graphic, logos, and colors to cater to each specific entity brand.

Tritium
Veefil PK

Tritium is an Australian DC fast charger manufacturer with a large global market that is partially owned by fueling infrastructure giant Gilbarco Veeder-Root. Tritium's sophisticated modular, scalable architecture consists of three main free-standing components: a user unit that holds one or two connectors, a power unit, and a control unit. Depending on the number of power units and user units, the system output can be scaled from 175 kW to 475 kW of power.

Power Electronics
NB Station HV

Power Electronics is a Spanish manufacturer of advanced power conversion products such as utility-scale solar inverters, energy storage systems, and EV chargers. Power Electronics' NB Station is the only vehicle charging station on the market to integrate the transformer and medium-voltage cells into the same set of equipment. By using medium-voltage rather than requiring step-down transformers, the NB Station greatly simplifies the installation design of charging infrastructure, resulting in considerable cost savings in terms of both capital and operating expenses. The modular, flexible NB Station can supply a range of charging post output powers including 50 kW, 100 kW, 175 kW, and 350 kW configurations. The NB Station also has pantograph support up to 600 kW depending on the capacity of the central power station, which also provides backup power for grid resiliency and to prevent demand charges.

Appendix F. Summary of Network Providers

As mentioned in the *Charge Management Solutions* section, data management is typically a separate service from the physical hardware of the EVSE and electrical cabinets. Companies that specialize in this space are called EV service providers or simply network providers. However, unlike with EVSEs, there are only a small handful of companies that focus on heavy-duty charging for machines like electric buses.

I/O Control Corporations offers a basic solution that includes remote monitoring and analytics and provides the ability to prioritize charging on specific buses. Their Health Alert Management System, which is an onboard telemetry system that interfaces all the electrical sub-systems, is currently being used by the Antelope Valley Transit Authority in Lancaster, California for its electric buses. This system monitors and provides data on bus aspects throughout its route, such as regenerative braking operations, average fuel economy, inter-lock system, HVAC system operations, and state of charge.

Viriciti is well-known for their telematic monitoring system for buses on the road and they offer a solution for managing chargers. Their data management solution can track EVSE performance and enable smart charging capabilities.

Greenlots (Shell Group) is another well-known network provider that specializes in transit buses. Acquired by Shell Group in June 2019, they offer similar services to Viriciti and can assist with any troubleshooting EVSE hardware. Greenlots is currently working with Foothill Transit on their electric buses.

Electriphi is known for its products and technology in electric fleet management. Their tools are designed for fleet managers, energy utilities, and planning teams to provide a variety of analysis unique to each fleet. Based on algorithms, Electriphi's tools create a variety of "what if" scenarios to analyze an agency's fleet and give insight into the energy costs, infrastructure, and the environmental impact of its vehicles.

Appendix G. Electric Vehicle Infrastructure Funding/Finance Options

Type	Administrator	Contact	Notes and Link(s)
Grants for Buses and Bus Facilities Formula Program - 5339(a)			
Grant Funding	Federal Transit Administration	202-366-2053	Eligible activities include capital projects to update or purchase buses and related equipment and to construct bus-related facilities including technological changes or innovations to modify low- or no-emission vehicles. https://www.transit.dot.gov/funding/grants/busprogram
Low-Carbon Transit Operations Program			
Grant Funding	Caltrans Division of Rail and Mass Transportation, in coordination with Air Resource Board and State Controller's Office	916-654-5266; Amar Azucena Cid Amar.Cid@dot.ca.gov 916-651-6114	Approved projects will support new or expanded bus or rail services or expanded intermodal transit facilities and may include equipment acquisition, fueling, maintenance, and other costs to operate those services or facilities, with each project reducing greenhouse gas emissions. ***There are about 200 eligible recipients for these funds, from regional transportation planning agencies to transit operators. These funds are non-competitive; however, agencies must submit an allocation request meeting all program requirements for an awarded project. The State Controller's Office will announce the amount of funding available in January of each year, and the due date for the allocation is usually in March with award by the end of June.*** https://dot.ca.gov/programs/rail-and-mass-transportation/low-carbon-transit-operations-program-lctop https://dot.ca.gov/-/media/dot-media/programs/rail-mass-transportation/documents/f0009682-lctopeligibilitylist-1819-a11y.pdf
Carl Moyer Memorial Air Quality Standards Attainment Program			
Grant Funding	California Air Resources Board	Diesel Hotline 866-634-3735 8666diesel@arb.ca.gov	Since 1998, this program has cost-effectively reduced smog-forming and toxic emissions. Almost $1 billion has been granted to date to equipment owners and the program continues to provide over $60 million in grant funding each year to clean up older polluting engines throughout California. The 15% applicant cost share is waived if the fleet is public; infrastructure grants are not popular, but are strongly encouraged. https://ww2.arb.ca.gov/our-work/programs/carl-moyer-memorial-air-quality-standards-attainment-program
Zero Emission Vehicle Fueling Infrastructure Crediting			
Credits	California Air Resources Board	Firas Abu-Seneh 916-323-1009	These credits aim to support the deployment of hydrogen refueling infrastructure and DC fast charging infrastructure. Credits are calculated based on station capacity and use. Stations must also have valid fuel pathways for electricity or hydrogen, and must report fuel dispensed quarterly. https://ww3.arb.ca.gov/fuels/lcfs/electricity/zev_infrastructure/zev_infrastructure.htm

Type	Administrator	Contact	Notes and Link(s)
Transportation Fund for Clean Air			
Grant Funding	Bay Area Air Quality Management District	415-749-5000	Eligible project categories include clean air vehicles and infrastructure (for all entities), as well as the purchase or lease of new alternative fuel vehicles and the installation or construction of alternative fuel infrastructure. Public agencies are eligible to apply to all Transportation Fund for Clean Air grant programs. http://www.baaqmd.gov/funding-and-incentives/funding-sources/regional-fund
Transit and Intercity Rail Capital Program			
Grant Funding	Caltrans Division of Rail and Mass Transportation	916-654-5266	Provides grants from the Greenhouse Gas Reduction Fund for transformative capital improvements that will modernize California's intercity, commuter, and urban rail systems, as well as the bus and ferry transit systems, to significantly reduce emissions of greenhouse gases, vehicle miles traveled, and congestion. ***CalSTA published the 2020 Cycle 4 Guidelines and Call for Projects on October 18, 2019, had optional meetings with applicants from November 4 through 12, 2019, and project applications are due on January 16, 2020.*** https://dot.ca.gov/programs/rail-and-mass-transportation/transit-and-intercity-rail-capital-programhttps://calsta.ca.gov/subject-areas/transit-intercity-rail-capital-prog https://www.ca-ilg.org/post/transit-intercity-rail-capital-program-tircp
Community Health Protection Fund			
Grant Funding	Bay Area Air Quality Management District	415-749-4994 grants@baaqmd.gov	Eligible activities include those that increase interest in local air quality issues and broaden a community's ability to partner with the Air District to develop future emission reduction or air monitoring plans. Agencies may need to wait until spring 2020 to apply. http://www.baaqmd.gov/community-health/community-health-protection-program/grant-program
Electric Vehicle Supply Equipment, DC Fast Charger High Power (Contract: 1-18-61-15C)			
Cooperative Purchasing	State of California	Rita Seale 916-375-4804 Rita.Seale@dgs.ca.gov	The State of California's contract with EVStructure (contractor) provides Group 8 DC fast charging and smart EVSE with high power and a range of over 100 kW, at contracted pricing to the State and local governmental agencies in accordance with the requirements of Contract #1-18-61-15C. The contractor will supply the entire portfolio of products as identified in the contract and will be the primary point of contact for data collection, reporting, and distribution of EVSE to the State. https://www.coprocure.us/contract.html?contractId=4fc247d9-5e0d-433f-8119-394f68bb9897 https://s3.amazonaws.com/docs.coprocure.us/state-of-california/files/1-18-61-15C/User_Instruction_1-18-61-15C.pdf

Type	Administrator	Contact	Notes and Link(s)
Electric Vehicle Supply Equipment, Basic Level 2, Smart Level 2 Low Power, Smart Level 2 High Power, DC Fast Charging Low Power, DC Fast Charging Medium Power (Contract: 1-18-61-15B)			
Cooperative Purchasing	BTC Power	Rita Seale 916-375-4804 Rita.Seale@dgs.ca.gov	The State of California's contract with BTC Power (contractor) provides EVSE at contracted pricing to the State and local governmental agencies in accordance with the requirements of Contract #1-18-61-15B. The contractor will supply the entire portfolio of products as identified in the contract and will be the primary point of contact for data collection, reporting, and distribution of EVSE to the State. https://s3.amazonaws.com/docs.coprocure.us/state-of-california/files/1-18-61-15B/User_Instructions_1-18-61-15B.pdf
Other Useful Programs			
Electrify America			
Grant Funding	Electrify America	833-632-2778	Electrify America will work with transit agencies and bus fleet operators to identify opportunities to install charging infrastructure, thus promoting zero-emission vehicle adoption in this transportation arena while developing a long-term business (revenue) model for Electrify America of between $4 million and $6 million. ***This expansion into transit agency work is expected within the 2020 year.*** https://www.electrifyamerica.com/about-ev-charging https://ww3.arb.ca.gov/msprog/vw_info/vsi/vw-zevinvest/documents/cycle_2_staff_analysis_110918.pdf
Volkswagen Environmental Mitigation Trust			
Funding	California Air Resources Board	800-242-4450	The Volkswagen Environmental Mitigation Trust provides funding opportunities for specified eligible actions that are focused mostly on "scrap and replace" projects for the heavy-duty sector, including on-road freight trucks, transit and shuttle buses, school buses, forklifts and port cargo handling equipment, commercial marine vessels, and freight switcher locomotives. In all cases except ocean-going vessel shore power and light-duty zero-emission vehicle infrastructure, funding can only be provided to replace existing internal combustion engines or vehicles. The existing vehicle, equipment, or engine in the owner's fleet must be scrapped. This program offers incentives for heavy-duty EVs; however, infrastructure funding is limited to light-duty infrastructure. This could change as the program develops. https://ww2.arb.ca.gov/our-work/programs/volkswagen-environmental-mitigation-trust-california/about https://ww2.arb.ca.gov/our-work/programs/volkswagen-environmental-mitigation-trust-california/how-apply-vw-environmental

Type	Administrator	Contact	Notes and Link(s)
Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project			
Funding	California Air Resources Board	916-322-6369; stella.lingtaylor@arb.ca.gov	Fleets with Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project vouchers for EVs are eligible to receive infrastructure voucher enhancements of up to $30,000 per vehicle for EVSE hardware costs (including the pedestal if integral to the EVSE). The infrastructure voucher enhancement can also cover load management software and energy storage costs. Labor and utility upgrade costs, as well as shipping and tax, are not covered. Infrastructure vouchers must be requested separately. ***EVSE vouchers must be approved before the qualifying EVSE is ordered.*** The EVSE must be installed at locations owned or controlled by the fleet. ***The board ruled that EVSE will no longer be funded as of October 24, 2019.*** https://ww2.arb.ca.gov/our-work/programs/low-carbon-transportation-investments-and-air-quality-improvement-program/about
Air Quality Improvement Program			
Funding	California Air Resources Board	916-322-6369; stella.lingtaylor@arb.ca.gov	This program is primarily responsible for reducing air pollutants from the transportation sector. Since 2009, the program has provided deployment incentives for light-duty EVs through the California Vehicle Rebate program, and has provided deployment incentives for alternative medium- and heavy-duty vehicles and funding for other advanced emission reduction technologies for vehicles. https://ww2.arb.ca.gov/our-work/programs/low-carbon-transportation-investments-and-air-quality-improvement-program/about
Clean Transportation Program			
Investment	California Energy Commission	FTD@energy.ca.gov	Previously Alternative and Renewable Fuel and Vehicle Technology, this program supports innovations in a broad portfolio of transportation and fuel technologies that help California meet its energy, clean air, and climate change goals, investing up to $100 million annually. While there are not currently funds available for EVSE, agencies should monitor these offering for relevant solicitations that may arise in the future. https://www.energy.ca.gov/programs-and-topics/programs/clean-transportation-program

Appendix H. Battery Electric Bus Technology Survey

Bus Model	Battery Size/Capacity (Max)	OEM[a]-Rated Range	Bus Size	HVIP Eligible?[b]	Passenger Capacity (Seating)	Altoona Tested?
BYD						
K7	180 kWh	137 miles	30 feet	Yes	22	Yes
K9S	266 kWh	145 miles	35 feet	Yes	32	No
K9	324 kWh	156 miles	40 feet	Yes	37	No
K11	578 kWh	220 miles	60 feet	Yes	47 - 55	No
New Flyer						
XE35	100 - 454 kWh	260 miles	35 feet	Yes	32	No
XE40	100 - 545 kWh	260 miles	40 feet	Yes	38	Yes
XE60	250 - 818 kWh	260 miles	60 feet	Yes	50	Yes
Proterra						
Catalyst 35 ft XR	220 kWh	114 miles	35 feet	Yes	29	No
Catalyst 35 ft E2	440 kWh	212 miles	35 feet	Yes	29	Yes
Catalyst 40 ft XR	220 kWh	118 miles	40 feet	Yes	40	No
Catalyst 40 ft E2	440 kWh	230 miles	40 feet	Yes	40	Yes
Catalyst 40 ft E2 Max	660 kWh	328 miles	40 feet	Yes	40	Yes
GILLIG (+ Cummins)						
GILLIG Battery Electric Bus	444 kWh	150 miles	40 feet	TBD	TBD	No

[a] OEM stands for original equipment manufacturer.

[b] HVIP stands for the Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project.

Attachment 2

EXHIBIT ____

ACKNOWLEDGEMENT AND CERTIFICATION PURSUANT TO CITY OF PETALUMA LIVING WAGE ORDINANCE PETALUMA MUNICIPAL CODE CHAPTER 8.36

The City of Petaluma Living Wage Ordinance ("Ordinance"), Petaluma Municipal Code Chapter 8.36, applies to certain service contracts, leases, franchises and other agreements or funding mechanisms providing financial assistance (referred to hereafter as an "Agreement") between the City of Petaluma ("City") and/or the Petaluma Community Development Commission ("PCDC") and contractors, lessees, franchisees, and/or recipients of City and/or PCDC funding or financial benefits ("covered entities").

Pursuant to Petaluma Municipal Code Section 8.36.120, as part of any bid, application or proposal for any Agreement subject to the Ordinance, the covered entity shall:

- Acknowledge that the covered entity is aware of the Ordinance and intends to comply with its provisions.

- Complete the Report of Charges, Complaints, Citations and/or Findings contained in this Acknowledgement and Certification by providing information, including the date, subject matter and manner of resolution, if any, of all wage, hour, collective bargaining, workplace safety, environmental or consumer protection charges, complaints, citations, and/or findings of violation of law or regulation by any regulatory agency or court including but not limited to the California Department of Fair Employment and Housing, Division of Occupational Safety and Health (OSHA), California Department of Industrial Relations (Labor Commissioner), Environmental Protection Agency and/or National Labor Relations Board, which have been filed or presented to the covered entity within the ten years immediately prior to the bid, proposal, submission or request.

Pursuant to Petaluma Municipal Code Section 8.36.120, before the beginning of the term of any covered Agreement, or prior to the execution of said Agreement by the City or the PCDC, each covered entity shall certify that its employees are paid a living wage that is consistent with Petaluma Municipal Code Chapter 8.36.

By executing this Acknowledgement and Certification, the covered entity (i) acknowledges that it is aware of the Ordinance and intends to comply with its provisions, (ii) attests to the accuracy and completeness of information provided in the Report of Charges, Complaints, Citations and/or Findings contained herein, (iii) certifies that it pays its covered employees a Living Wage as defined in Petaluma Municipal Code Chapter 8.36 and (iv) attests that the person executing this Acknowledgement and Certification is authorized to bind the covered entity as to the matters covered in this Acknowledgment and Certification.

SO ACKNOWLEDGED and CERTIFIED:

Project or Contract I.D: _____

____ Date: _______________________
(Print Name of Covered Entity/Business Capacity)

By ____
(Print Name)

/s/____
(Signature)

Its ____
(Title /Capacity of Authorized Signer)

REPORT OF CHARGES, COMPLAINTS, CITATIONS AND/OR FINDINGS PURSUANT TO PETALUMA MUNICIPAL CODE SECTION 8.36.120

FOR EACH WAGE, HOUR, COLLECTIVE BARGAINING, WORKPLACE SAFETY, ENVIRONMENTAL OR CONSUMER PROTECTION CHARGE, COMPLAINT, CITATION, AND/OR FINDING OF VIOLATION OF LAW OR REGULATION BY ANY REGULATORY AGENCY OR COURT, INCLUDING BUT NOT LIMITED TO THE CALIFORNIA DEPARTMENT OF FAIR EMPLOYMENT AND HOUSING, DIVISION OF OCCUPATIONAL SAFETY AND HEALTH (OSHA), CALIFORNIA DEPARTMENT OF INDUSTRIAL RELATIONS (LABOR COMMISSIONER), ENVIRONMENTAL PROTECTION AGENCY AND/OR NATIONAL LABOR RELATIONS BOARD, WHICH:

- AFFECTS YOU AS A PROSPECTIVE CONTRACTOR, SUBCONTRACTOR, LESSEE, FRANCHISEE AND/OR PARTY TO ANY CITY OF PETALUMA AND/OR PETALUMA COMMUNITY DEVELOPMENT COMMISSION-FUNDED AGREEMENT OR BENEFIT SUBJECT TO PETALUMA MUNICIPAL CODE CHAPTER 8.36 (LIVING WAGE ORDINANCE), AND
- HAS BEEN FILED OR PRESENTED TO YOU WITHIN THE TEN YEARS IMMEDIATELY PRIOR TO THE BID, PROPOSAL, SUBMISSION OR REQUEST FOR WHICH THIS ACKNOWLEDGEMENT AND CERTIFICATION IS MADE.

PLEASE PROVIDE THE DATE, THE REGULATORY AGENCY OR COURT MAKING THE CHARGE COMPLAINT, CITATION OR FINDING, THE SUBJECT MATTER AND THE MANNER OF RESOLUTION, IF ANY, FOR EACH SUCH CHARGE COMPLAINT, CITATION OR FINDING.

IF NONE, PLEASE STATE “NONE”:____

ATTACH ADDITIONAL PAGES IF NEEDED.

Date: ____________________________

Regulatory Agency or Court: ____

Subject Matter: ____

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Resolution, if any: ____

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Expected resolution, if known: ____

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