White Paper

BurbankBus Zero Emission Rollout Plan

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List of Acronyms

AC	Alternating Current
AQMD	South Coast Air Quality Management District
BEB	Battery Electric Bus
BTM	Behind-the-Meter
BWP	Burbank Water and Power
CAISO	California Independent System Operator
CalACT	California Association for Coordinated Transportation
CARB	California Air Resources Board
CCS	Combined Charging System
CEC	California Energy Commission
CH4	Methane
CLEEN	California Lending for Energy and Environmental Needs
CMAQ	Congestion Mitigation and Air Quality
CNG	Compressed Natural Gas
CO	Carbon Monoxide
CO2	Carbon Dioxide
CPUC	California Public Utilities Commission
DAC	Disadvantaged Community
DC	Direct Current
DCFC	Direct Current Fast Charge
DER	Distributed Energy Resource
DGS	California Department of General Services
DOE	U.S. Department of Energy
EBCM	Electric Bus Corridor Model
EMFAC	Emission Factor Model
EnergIIZE	Energy Infrastructure Incentives for Zero-Emission Commercial Vehicles
EV	Electric Vehicle
EVITP	Electric Vehicle Infrastructure Training Program
EVSE	Electric Vehicle Supply Equipment
FCEB	Fuel Cell Electric Bus

ft	Feet
FTA	Federal Transit Administration
FTM	In Front-of-the-Meter
GGRF	Greenhouse Gas Reduction Fund
GHG	Greenhouse Gas
GIS	Geographic Information System
GREET	Greenhouse Gases, Regulated Emissions, and Energy use in Technologies Model
GVWR	Gross Vehicle Weight Rating
GWh	Gigawatt-hour
GWP	Glendale Water and Power
HDRSAM	Heavy-Duty Refueling Station Analysis Model
HVAC	Heating, Ventilation, and Air Conditioning
HVIP	Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project
IAAS	Infrastructure-as-a-Service
iBank	Infrastructure and Economic Development Bank
ICT	Innovative Clean Transit
ISRF	Infrastructure State Revolving Fund
IIJA	Infrastructure Investment and Jobs Act
ITC	Investment Tax Credit
JPL	Jet Propulsion Laboratory
Kg	Kilogram
kV	Kilovolt
KVA	Kilovolt-ampere
kW	Kilowatt
kWh	Kilowatt-hour
L2	AC Charging at 240V and at least 6 kW
LACTOA	Los Angeles County Transit Operators Association
LADOT	Los Angeles Department of Transportation
LADWP	Los Angeles Department of Water and Power
lbs	Pounds
LCFS	Low Carbon Fuel Standard
LCTOP	Low Carbon Transit Operations Program
Low-No	Low or No Emissions Program
MDT	Microgrid Design Toolkit
Metro	Los Angeles Metro
MW	Megawatt
MWh	Megawatt-hour
N20	Nitrous Oxide
NFPA	National Fire Protection Association
NOx	Nitrogen Oxide
NREL	National Renewable Energy Laboratory
OCPP	Open Charge Point Protocol
OEM	Original Equipment Manufacturer
OSHA	Occupational Safety and Health Administration
PEM	Proton Exchange Membrane

PM	Particulate Matter
PM10	Particulate Matter - 10 micrometers and smaller
PM2.5	Particulate Matter - 2.5 micrometers and smaller
PPA	Power Purchasing Agreement
PSPS	Public Safety Power Shutoffs
PWP	Pasadena Water and Power
PV	Photovoltaic
RAISE	Rebuilding American Infrastructure with Sustainability and Equity
RFID	Radio Frequency Identification
RFP	Request For Proposal
RNG	Renewable Natural Gas
SaaS	Software-as-a-Service
SAE	Society of Automotive Engineers
SARTA	Stark Area Regional Transit Authority
SCE	Southern California Edison
SCPPA	Southern California Public Power Authority
SCRTTC	Southern California Regional Transit Training Consortium
SMR	Steam Methane Reforming
SOC	State of Charge
SOx	Sulfur Oxides
STURAA	Surface Transportation and Uniform Relocation Assistance Act of 1987
TAP	Transit Access Pass
TIRCP	Transit and Intercity Rail Capital Program
TOU	Time-of-Use
WCCoE	West Coast Center of Excellence in Zero Emission Technology
ZEB	Zero Emission Bus

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Section I

Section I: Project Introduction and Technology Overview

Project Description

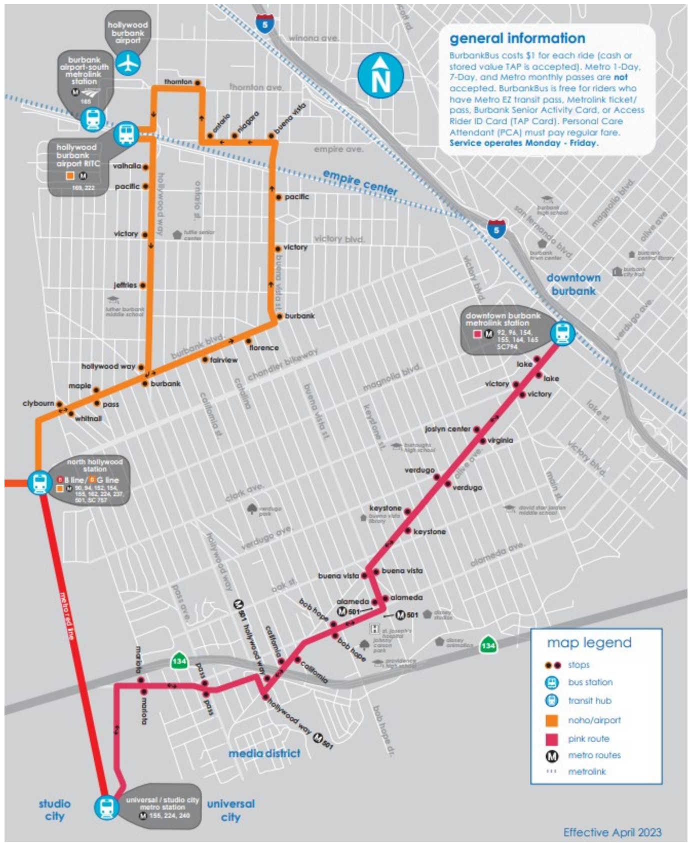
BurbankBus is a transit agency that serves Burbank, California, and provides both demand response service and fixed-route service. Fixed-route service provides transit services to key locations in Burbank including the Media District, Downtown Burbank, the Bob Hope Airport, and the Burbank Metrolink Station. Fixed-route service also connects with Metro's North Hollywood Red Line Station and Metro's Universal City Station. Fixed-route service is provided Monday through Friday. To combat climate change and improve air quality, BurbankBus aims to transition to a zero-emission bus (ZEB) fleet. Additionally, the Innovative Clean Transit (ICT) regulation issued by the California Air Resources Board (CARB) mandates that all transit agencies in California transition to ZEBs.

This report is structured in three sections: Section I provides an overview of the BurbankBus and delves into a detailed discussion of current ZEB technology, including charging infrastructure, charging cost considerations, resiliency, financing resources, and more. Section II examines the feasibility of transitioning to a fully ZEB transit fleet for BurbankBus. The feasibility study provides a techno-economic analysis of transitioning to a battery electric bus (BEB) fleet, BurbankBus, the energy needs of the fleet, a plan for phasing in ZEBs, utility analysis, an overview of infrastructure and resiliency equipment that will serve the fleet, financial analysis, a funding strategy, and an implementation plan.

BurbankBus Overview

BurbankBus is a transit agency that serves Burbank, California, and provides both demand response service and fixed-route service. Fixed-route service provides transit services to key locations in Burbank including the Media District, Downtown Burbank, the Bob Hope Airport, and the Burbank Metrolink Station. Fixed-route service also connects with Metro's North Hollywood Red Line Station and Metro's Universal City Station. Fixed-route service is provided Monday through Friday. This region, pictured in **Figure 1-1**, is located north of the City of Los Angeles. BurbankBus plays an important role in this region as it provides local transit service and helps transport people to other forms of public transit. Other transit agencies like LA Metro (Metro), Metrolink, Glendale Beeline, Pasadena Transit, LADOT Commuter Express, and Foothill Transit. BurbankBus Is not part of a joint group.

Figure 1-1: Map of BurbankBus's Service Area



The City of Burbank was incorporated in 1911. BurbankBus has been operating since the 1970s and began fixed-route service in 1995, providing local transit service and connecting Burbank to other forms of public transit (Oberstein, 2007). BurbankBus has experience utilizing zero-emission vehicles and previously hosted a hydrogen fueling station. Since 2008, BurbankBus has been running its fixed routes on 100 percent CNG buses.

For additional information on the Rollout Plan and the city's efforts towards sustainable transportation, please contact Karen Pan, the Transportation Services Manager, at 818-238-5187 or kpan@burbankca.gov,

Fixed-Route Transit Service

Fixed-route service is defined as a service where buses travel established routes at scheduled times. BurbankBus has two fixed routes; BurbankBus has 17 buses for their two routes; their service operates Monday through Friday. BurbankBus owns all buses used in transit operations. The operations and maintenance for BurbankBus's fixed-route fleet are contracted to a transit services company.

Dial-A-Ride Service

Dial-A-Ride service is defined as an on-demand, curb-to-curb transportation service for seniors and people with disabilities. BurbankBus operates dial-a-ride service. For residents in BurbankBus service area, individuals who are 60 years and older, or those under 60 years with an Access membership or a Los Angeles County Transit Operators Association (LACTOA) Disabled Reduced Fare Transit Access Pass (TAP) card, are eligible for this service. Due to the curb-to-curb nature of this service, these vehicles often traverse residential streets, have limitations in service areas due to street width or other conditions, and do not adhere to a fixed schedule. BurbankBus offers dial-a-ride service six days a week, with service not being offered on Sundays or holidays.

ZEB Overview

Benefits of ZEBs

In Southern California, most transit agencies use a fleet of buses powered by CNG. These buses have an internal combustion engine that burns CNG to create torque and propel the bus. The current CNG buses have proven to be a reliable technology capable of handling most transit bus duty cycles, but they do have several drawbacks, including noise pollution and tailpipe emissions. The combustion of CNG produces carbon dioxide ($CO2$) —a greenhouse gas (GHG) that contributes directly to climate change—and other pollutants. One of the most potent pollutants is nitrogen oxide (NOx). NOx, when combined with heat and sunlight, produces ozone, which is harmful to the respiratory system and human health. NOx emissions are regulated by the State of California.

ZEBs are buses that produce no tailpipe emissions, and therefore do not produce any GHGs or criteria emissions during bus operations. In practical terms, a ZEB cannot use an internal combustion engine and must use an electrified drivetrain. There are currently two ZEB technologies in existence: the BEB, which uses electricity from a battery to power the bus, and the FCEB, which uses hydrogen to produce electricity that propels the bus. These two technologies do not produce any tailpipe GHG or NOx emissions, which helps to improve air quality. The electricity to charge the bus and the hydrogen production process do produce GHG emissions, but since the drivetrain of a ZEB is twice as efficient as that of an internal combustion engine, ZEBs produce less GHG emissions than CNG buses. ZEBs also generate less noise than CNG buses.

The ICT Regulation

The ICT regulation issued by CARB mandates that all transit agencies in California transition to ZEBs. Fleets must be 100 percent zero-emission by 2040, and the regulation provides a timeline for phasing in ZEB procurements. Under the ICT regulation, the BurbankBus qualifies as a small transit agency— It is located in the South Coast Air Basin, and operates fewer than 65 buses in annual maximum service. Small transit agencies must submit a ZEB Rollout Plan to the Executive Officer of CARB by July 1, 2023, with the following items:

- **a.** A goal of full transition to ZEBs by 2040 with careful planning that avoids early retirement of conventional internal combustion engine buses.
- **b.** Identification of the types of ZEB technologies a transit agency is planning to deploy, such as BEB or FCEB.
- **c.** A schedule for construction of facilities and infrastructure modifications or upgrades, including charging, fueling, and maintenance facilities, to deploy and maintain ZEBs. This schedule must specify the general location of each facility, type of infrastructure, service capacity of infrastructure, and a timeline for construction.
- **d.** A schedule for zero-emission and conventional internal combustion engine bus purchases and lease options. This schedule for bus purchases must identify the bus types, fuel types, and number of buses.
- **e.** A schedule for conversion of conventional internal combustion engine buses to ZEBs, if any. This schedule for bus conversion must identify number of buses, bus types, and the propulsion systems being removed and converted.
- **f.** A description on how a transit agency plans to deploy ZEBs in Disadvantaged Communities (DACs) as listed in the latest version of CalEnviroScreen (https://oehha.ca.gov/calenviroscreen).
- **g.** A training plan and schedule for ZEB operators and maintenance and repair staff.
- **h.** Identification of potential funding sources.

The ICT timeline for phasing in ZEB procurements for a small transit agency is as follows:

- By 2026: 25 percent of new bus purchases must be zero emission.

- By 2029: 100 percent of new bus purchases must be zero emission

U.S. Federal Requirements

Altoona Bus Testing

The Surface Transportation and Uniform Relocation Assistance Act of 1987 (STURAA) created the Standardized Bus Testing program. The Standardized Bus Testing program, which is frequently referred to as Altoona Bus Testing, is a federal program that tests the maintainability, reliability, safety, performance, structural integrity and durability, fuel and/or energy economy, noise, and emissions from buses. Altoona Bus Testing is intended to serve as quality control and aims to ensure that new bus models can safely and reliably operate in real-world conditions. Under Altoona Bus Testing, buses are scored on a scale of 1 – 100 based on their performance in each of the testing categories. A bus must receive a score of 70 to pass testing. STURAA mandates that no new bus model can be acquired with federal funding without having received a passing score during Altoona Bus Testing. Since BurbankBus may use federal funding towards the purchase of transit vehicles and operations, this study only examines buses that have already passed Altoona Bus Testing or are likely to begin testing in the near future.

Buy American and Buy America

In addition to Altoona Bus Testing, the U.S. federal government has two distinct requirements related to domestic content of federal purchases: Buy American and Buy America. Buy American refers to a requirement from the 1933 Buy American Act and applies to purchases by the U.S. federal government valued at more than $10,000. To comply with this requirement, the goods must be manufactured in the United States, and at least 50 percent of the cost of their components must come from the United States. There are exceptions to this rule: waivers can be granted if it is deemed to be in the public interest, or if the cost of U.S. components is unreasonably high compared to foreign counterparts. Buy America refers to a requirement for purchases of iron, steel, and other manufactured products incorporated into infrastructure that is funded by the U.S. federal government, including if the project is undertaken by a state or municipal government in the United States. This requirement also applies to transit agencies. If a bus does not meet Buy America standards, then it cannot be purchased with federal funding.

Per Buy America, any transit vehicles purchased with the federal funds from the Federal Transit Administration (FTA) must have at least 70 percent of the cost of the vehicle be of domestic origin. This is determined by the origin of the bus components—a component is domestic if it is manufactured in the United States, and if at least 70 percent of the cost of its subcomponents are manufactured in the United States. The cost of making a battery pack is about 26 percent of the cost of a BEB. However, the FTA has not deemed the use of imported battery cells to be contrary to the Buy America rules; battery cells are considered sub-subcomponents, which are ignored, and they are substantially transformed into battery packs, with modules, coolants, and sensors added in the United States (Canis, 2018). The iron and steel components for direct current (DC) fast chargers received a waiver for the Buy America requirements from the FTA in 2016, as there were no domestic manufacturers of the required components (FTA, 2016).

BEB Overview

Battery Electric Technology

BEBs are propelled by an electrified drivetrain and use batteries to store electricity. When the bus needs to move, it draws energy from the battery to power a traction motor. The traction motor uses magnets to generate torque and propel the bus. BEBs also have a regenerative braking system that can capture some energy from the bus when it decelerates and use it to recharge the battery during braking. BEBs produce no tailpipe emissions and are very quiet when moving. BEBs do suffer from some drawbacks, mainly that their range is constrained by how much energy can be stored in the battery. Batteries are heavy and require a lot of space. This factor puts constraints on how many batteries can be placed on the bus safely and may further limit the range of the bus. The range of the bus can be decreased if ridership is high, which increases the weight of the bus, or if the bus must gain elevation on its routes. The heating, ventilation, and air conditioning (HVAC) systems are also energy intensive and, in temperature extremes, can consume more energy than the propulsion system itself. This can reduce the range of the bus on days that are very hot or cold. Lastly, driver behavior can have a large impact on the range of the bus. BEBs are designed to be driven in a certain manner, and bus operators must receive driver training to properly drive the buses. Deviations from this training will impact the bus's performance. Consequently, BEBs cannot serve as a "drop-in" or a one-to-one replacement for a CNG bus for some cycles/routes. This problem is exacerbated by battery charge time. While a CNG bus can be fully refueled in minutes, a BEB can take hours to fully recharge.

Appendix A provides an overview of some of the relevant BEBs currently on the market, and more information on charging technology can be found in the Charging Infrastructure section and Appendix B.

Transit BEBs

Classified in the FTA's 12 year/500,000 mile service-life category, transit buses are Class 7 or 8 vehicles, typically used for fixed-route service, and generally range between 30 and 40 feet in length. A transit BEB is a battery-powered bus that has a length of 30 feet or more. Transit BEBs are considered a mature technology—multiple BEB models have passed Altoona testing, and there are several original equipment manufacturers (OEMs) that produce and sell transit BEBs. Articulated 60-foot ZEB models, which have two sections connected by a joint and can be up to 60 feet in length, have also been Altoona tested.

Transit BEBs generally have a range of up to 225 miles, depending on the duty cycle. CNG buses, on the other hand, have a range of about 350 miles. The lower range of the BEB may require additional vehicles to provide the same level of service, depending on the duty cycle. Battery technology is expected to improve over time, however, and it is possible that a BEB can become a drop-in replacement for a CNG bus in the future. Please see Appendix A: Zero Emission Bus Specifications for additional details on currently available ZEBs.

Battery Electric Shuttle Bus and Transit Vans

A battery electric shuttle bus (also commonly referred to as a small bus) is classified in the FTA's 5 year/150,000 mile or 7 year/200,000-mile service-life category, and is defined as a battery-powered cutaway bus with a length of less than 30 feet and a gross vehicle weight rating (GVWR) of greater than 14,000 pounds. Shuttle buses are generally medium-duty Class 4-6 buses. These buses are typically used for demand response service and have a wheelchair lift to serve disabled passengers. Most shuttle buses can carry 19-24 passengers. OEMs also have the ability to customize configurations based on transit needs, such as changing the floorplan and adding equipment such as fareboxes and wheelchair lifts. Battery electric transit vans have recently been introduced to the market. These vehicles are smaller than shuttle buses and can typically carry fewer than 10 passengers.

Battery electric shuttle buses generally have a range of up to 150 miles, depending on the duty cycle, and cost about $275,000. Fossil fuel powered counterparts, on average, have a range of 350 miles and cost around $75,000. Again, additional vehicles may be required to provide the same level of service, depending on the duty cycle, but battery technology continues to improve. By the time BurbankBus is subject to the ICT regulation, shuttle buses will likely have a longer range. The market for transit vans is expected to grow, and there will likely be more commercial offerings in the coming years.

Charging Infrastructure

Depot Plug-in Charging

Most electric buses are charged using a plug-in charger, which consists of the dispenser and a charging cabinet. The dispenser has a plug that goes into the bus to provide energy to charge the battery, and the plug connects to the dispenser via a hose. The dispenser is then connected to the charging cabinet, which contains the power electronics and communications equipment used to control charging with the bus and to communicate with the charging provider's network The current technology requires workers to manually plug in the bus when it returns from its route. The communications protocols between vehicle and charger can vary among BEB OEMs (see Charger Interoperability section for additional details).

Buses can be charged with Level 2 chargers or DC Fast Chargers (DCFC). A Level 2 charger delivers AC power to the bus at voltages of up to 240 volts. Level 2 chargers can deliver up to 19.2 kW and are typically used to charge electric cars, vans, and shuttle buses. Buses can also be charged with a DCFC. DCFCs deliver DC power to the bus at voltages of up to 600 volts. DCFCs are typically used to charge transit buses. They can also be used to quickly charge shuttle buses.

A plug-in charging system has a large physical footprint. Charging cabinets are responsible for much of the footprint, and they typically require concrete pads. Bollards are also required to protect the charging cabinets from being hit by buses or other vehicles. Some flexibility in the design/layout of a charging site does exist: The charging cabinet must typically be located within a few hundred feet of the dispenser and, as a result, the charging cabinets can be put in areas of the yard with more space (e.g. the edges). Most depots are designed with the dispensers and charging cabinets adjacent to parked buses. For example, a depot might have parking spots for the buses with a dispenser for each parking spot, as illustrated in **Figure 1-3**. In most cases, this design is the least expensive option for charging.

Figure 1-2: Plug-in Chargers Example

Since space is a major constraint, space-saving designs can be developed. A depot can also be designed whereby the buses are parked in lanes, and the dispensers and charging cabinets are located next to the buses in between the lanes, as seen in **Figure**

1-4 below.

Figure 1-3: Buses Parked in Lanes Example (Source: ABB)

Another possible design would be overhead plug-in charging. In this design, the buses are parked in lanes and a structure is built over the parking lanes, similar to the example shown in **Figure 1-5**.

Figure 1-4: Overhead Plug-in Charging Example (Source: Burns McDonnell Foothill Transit In-Depot Charging and Planning Study)

A retractable spool is installed on the overhead structure, which allows the plug to be pulled down for charging. This design does not require the charging cabinets to be located next to the bus, which is advantageous when there is not enough space in between parking lanes to install the charging cabinets or dispensers. The overhead structure can also be used for other purposes, such as housing a solar photovoltaic (PV) installation. While this design does save space, the construction cost for the overhead structure is higher because a foundation needs to be laid. Foothill Transit currently uses this design.

Charger Interoperability

A key factor in plug-in charging infrastructure is charger interoperability. Charger interoperability refers to a bus charger's compatibility with multiple types of buses—if a bus charger can charge buses from multiple manufacturers, it would be considered interoperable. Interoperability has multiple dimensions: the charger must be able to plug-in to, charge, and communicate with buses from multiple manufacturers. Since transit agencies tend to phase-in their fleets over time, it is possible that a fleet will consist of buses from multiple OEMs and that chargers from multiple manufacturers will be deployed. The use of a fleet with buses from multiple OEMs and multiple types of chargers increases the risk that there will be interoperability problems. To promote interoperability, charger standards have been developed. There are several different charger standards. SAE J1772 standardizes the charging plug for Level 2 charging up to 19.2 kW. The Combined Charging System (CCS) standardizes the charging plug and offers a protocol for charging communication. CHAdeMO is a competing charging standard that offers a standard for the charging plug and charging communications. The major OEMs have adopted CCS standards.

Other interoperability concerns exist, one being that the plug-in charger must be able to communicate with the onboard charger via a compatible communications protocol. Another concern is whether the charger provides alternating current (AC) or DC power. The type of power the plug-in charger operates on must be the same as that of the onboard charger. Before purchasing, buses and infrastructure should be tested to ensure interoperability. For example, charging infrastructure for the shuttle BEBs and transit vans can vary. Most shuttle buses and transit vans can charge with a Level 2 charger, though many of these vehicles can also be charged faster with a DCFC. The type of charger required for DC fast charging varies by OEM, and some buses must use a high voltage DCFC. It is important to purchase charging equipment that is compatible with the specific bus purchased.

Depot Overhead Charging

Buses can also be charged with an overhead pantograph charger, which is placed over the bus. When the bus parks, a radio frequency identification (RFID) sensor on the bus signals to the charger, the charger and the bus make contact, and charging begins. There are two types of pantograph chargers: a top-down charger, in which the pantograph lowers itself down to the bus to initiate charging, and a bottom-up charger, in which the pantograph is mounted on the bus and raises itself to the charger to begin charging. Pantograph chargers tend to charge at a higher power level than plug-in charging. Most overhead chargers charge at 150-200 kilowatt (kW), though some can charge at 450-600 kW. Most depot overhead chargers charge in the 150-200 kW range to manage utility demand chargers.

An overhead pantograph charger requires an overhead structure to be built in order to mount the charger above the bus parking spots. At a very minimum, a steel structure is required. Typically, the installation of a steel structure involves building a foundation to anchor the structure. Installing the structure itself is one of the most expensive parts of the construction process, but adding additional features to the structure can be done at a relatively low incremental cost. As a result, solar panels are often installed on the structure, which provides the benefit of providing power for the facility and sheltering the bus from sunlight (to prevent heat gain) and rain. Parking lanes are also built underneath the structure, and a curb is necessary to guide the buses to align with the charger and protect the charging cabinet from collisions.

The main advantage of depot pantograph charging is that the pantographs can automatically charge the bus without workers present to manage plugs. Smart charging software can be used to control when to start and stop charging, which means that some of the charging operations can be automated. However, overhead pantograph charging, as depicted in **Figures 1-6 and 1-7**, is more expensive than regular plug-in charging. The pantographs add about 30 percent to the cost of the charger (per correspondence with Amply Power), but this amount excludes the construction/installation costs. Since construction/installation comprise the majority of the cost, the overall incremental cost of the pantograph is relatively small. An overhead structure is expensive, but this solution, which becomes economical when installed to charge at least 30 buses, is not much more expensive than overhead plug-in charging. For example, the Los Angeles Department of Transportation (LADOT) is currently planning to deploy a depot overhead charging solution for some of their yards to charge a total of 104 buses.

Figure 1-5: In-Depot Overhead Charging Example (Source: CALSTART)

Figure 1-6: In-Depot Overhead Charging Example (Source: CALSTART)

SAE J3105 is the standard by which conductive automated connection charging devices for electric vehicles are designed. There are multiple types of chargers that are governed by this standard including overhead pantograph chargers. SAE J3105 provides standards for both top-down and bottom-up chargers. SAE J3105/1: Infrastructure-Mounted Cross Rail Connection is the portion of SAE J3105 that governs top-down chargers. SAE J3105/2: Vehicle-Mounted Pantograph Connection is the part of SAE J3105 that governs bottom-up chargers. Top-down chargers that comply with SAE J3105/1 will be interoperable with each other whereas bottom-up chargers that comply with SAE J3105/2 will be interoperable with each other. A SAE J3105/1-compliant top-down charger will not be interoperable with a SAE J3105/2-compliant bottom-up charger.

A potential variation of this setup includes in-ground inductive chargers, shown in **Figure 1-8**. Inductive chargers can charge a vehicle without plugging-in or needing an overhead charger. Instead, inductive chargers can charge vehicles wirelessly. The charger consists of a pad on the ground; the bus parks on top of the charging pad and wireless charging begins. Inductive chargers can charge at powers of up to 200 kW. If these chargers are used, the bus is parked on the inductive chargers at the end of the day's service. Smart charging software then controls the charging overnight. In-ground inductive chargers are currently produced by Momentum Dynamics and WAVE. At this point in time, few transit agencies use depot inductive chargers. However, this is a technology that agencies might begin to consider as an alternative to depot overhead pantograph charging.

Figure 1-7: Inductive Charging Example (Source: Momentum Dynamics)

On-route Charging

Most transit agencies use depot charging as the primary method of charging their buses. However, buses are sometimes deployed on routes that they cannot serve on a single charge. This issue can occur if the bus is on a lengthy or high-grade route, or alternatively, on days with extreme weather that increases the energy consumption of the bus's HVAC system. This is highly problematic, as the bus will run out of battery before it finishes the route.

Overhead on-route chargers is one way to address this problem. On-route charging occurs during a gap in service—the bus will typically drive underneath an overhead on-route charger, and the bus and the charger will interface and connect in a similar manner as depot overhead charging. Most buses have only short breaks during their schedule. To charge as much of the battery as possible during a break, these overhead chargers usually charge at high power levels. The typical on-route overhead charger will charge at power levels of 450-600 kW. These chargers are commonly built at a bus stop or a bus terminus to use when the bus is on a scheduled break.

One major issue with an overhead charger is that the driver needs to align the bus with the pantograph. To achieve this, transit agencies will add markings to the ground underneath the charger to assist the driver. See **Figure 1-9** as an example of this setup.

Figure 1-8: On-route Overhead Charging (Source: ABB)

Public Charging

A transit agency could also utilize public charging networks. The use of a public charging network could serve as a form of on-route charging. Under this charging model, the buses would be charged overnight. However, if the buses were to run low on charge during the day, they would have the option to charge at a public charging station during a break in service to refill the battery and extend the range of the bus. Public charging can be used as an emergency measure if a bus runs low on battery during its operations. It could also potentially be used to extend the range of the bus if its service is expanded. Alternatively, public charging can be used as a resiliency measure if the bus depot were to lose power. Unless there is an area-wide power outage, it is unlikely that two separate charging locations would lose power simultaneously. As a result, a public charging station could provide backup charging if the bus depot were to lose power.

Public charging would likely be most useful for shuttle buses operating demand response service (e.g. Dial-A-Ride), as they have a smaller battery capacity than transit buses and can therefore recharge a high percentage of the battery during a mid-day charge. Public charging stations can have Level 2 chargers, DCFCs, or both. DCFCs can charge the battery faster and would be the more useful type of charger. However, Level 2 chargers can be useful if the bus only needs a small amount of charge.

If a transit agency opts to use public charging, it would need to identify the specific station or stations that it plans to use in advance. Transit agencies should confirm that the chargers at those specific sites are interoperable with their specific bus OEM. Since there are multiple charging standards and different charging voltages, it would be advisable to confirm interoperability by physically charging the bus at the actual station. Public charging stations typically require that customers purchase a subscription and they also charge per kWh dispensed by the charger.

Most public charging stations are designed for light-duty electric vehicles as they have head-in parking spaces. However, bus operators do not typically backup vehicles in public spaces without using a spotter to guide them. As a result, this parking configuration would not appropriate for buses. To use a public station, the buses would need to have access to a pull-through parking configuration.

There is an Electrify America station located at 1301 N. Victory Place, Burbank, CA. The transit agencies could potentially use any sites located in their own service area. It is likely that additional public charging stations will also be deployed in the future, which would be an opportunity for coordination to occur with other transit agencies in advance in order to identify how these stations could potentially address their needs and to plan their designs accordingly.

Charging Cost Considerations

Energy and Power

The utility costs for a ZEB fleet are dependent on two main factors: energy and power. Energy represents the total amount of electrical fuel consumed by the bus. Energy is denoted in units of kilowatt-hours (kWh). The battery of a BEB has capacity limits and can only store a certain amount of kWh of energy. The energy capacity of the battery is analogous to the number of gallons that can be stored in a gas tank. Utility companies typically sell energy by the kWh. The price of the kWh can also change depending on how much demand occurs during the day. Energy is usually most expensive in the afternoon when demand is high and costs less at night when demand is lower. As a result, transit agencies typically schedule their charging to coincide with the lowest energy rates.

Power represents the rate at which energy is consumed and is typically measured in kW. Utilities care about power; if there is too much aggregate demand, it can overwhelm the grid and cause a blackout. As a result, utilities incentivize lower power demand from their customers by charging per kW. Customers are usually charged for the maximum amount of power they demand over the course of the month, regardless of how long they draw power at that level. For example, if a transit agency normally has a power demand of 50 kW but experiences a surge in demand and consumes 100 kW for 15 minutes over the course of a month, they would be charged for demanding 100 kW. Charges for power demand are typically high and can be extremely costly. These charges are typically responsible for the majority of the utility bill.

Strategies for Managing Utility Costs

Utility charges are determined by a variety of factors such as energy and power demand, which have a major impact on the utility charges that a transit agency must pay to charge their buses. However, there are strategies to reduce utility charges. This section will discuss some of the strategies that transit agencies can employ to minimize this cost.

Overnight Charging

Transit agencies are charged for the energy they consume. Transit agencies are typically charged by the kWh, and utilities usually have different rate structures that their customers can use. Most transit agencies use time-of-use (TOU) tariffs. Under a TOU tariff, energy charges vary throughout the day. Energy charges are typically lowest during times of low energy demand (off-peak rates) at night and are highest during the day in the late afternoon/evening hours—solar production decreases as the sun begins to set, and energy consumption increases as air conditioning loads come online. As a result, peak energy charges usually occur from approximately 4 to 8 pm. Some utilities also offer flat rate tariffs, where the cost per kWh is constant throughout the day.

Transit agencies aim to reduce the energy costs associated with charging, but transit agencies cannot reduce energy costs by reducing the amount of energy they consume, which would entail cutting transit service. If a transit agency is on a TOU tariff, they can reduce energy charges by shifting the times during which they charge the buses. Since off-peak rates are lower than peak rates, energy costs can be reduced by shifting the charging schedule so that the majority of buses charge at night during off-peak hours.

Sequential Charging

Utilities typically charge a fee per kW of peak power demand. As a result, transit agencies can decrease their utility costs by lowering the peak power they draw from the grid through sequential charging. In a depot with unmanaged charging, the buses start charging as soon as they are plugged in. All buses then charge at the same time, causing maximum possible power draw.

Sequential charging entails breaking the fleet into batches. The first batch of buses begins charging and continues until fully charged. Once the first batch is complete, the second batch begins charging, and so on until all batches have completed charging. This staggers the power demand on the grid throughout the night and results in lower power demand as compared to unmanaged charging.

Managed/Networked Charging

Another method of reducing utility costs and demand charges is the use of managed charging. Managed charging minimizes power demand by remotely monitoring the bus battery status, communicating with the chargers to prioritize which buses get charged, and regulating the amount of power each bus receives. Managed charging uses algorithms to control which buses should get charged and when. Managed charging software usually avoids having all buses charge at the same time and can control the power level at which they charge, thus reducing power demand. Managed charging optimizes charging and can result in even lower power demand than sequential charging.

Many smart charging systems support the use of Open Charge Point Protocol (OCPP), which is a standard for charger-to-network communication. OCPP compliant chargers allow multiple types of chargers to be integrated by a smart charging provider. While these features are not necessary for charging electric buses, they are a useful tool for larger fleets, as they can ensure all buses charge on time while also reducing maximum power demand. Reducing maximum power demand is important—demand charges and utility interconnection charges are a function of max power demand. Smart charging systems can control charging behavior to reduce maximum power, decreasing maximum power draw by up to 31 - 65 percent (Eichman, 2020) and greatly reducing demand charges and the cost to operate the buses. Sometimes the charger manufacturer (e.g., ABB and Siemens) will offer their own networked charging solution. However, there are also other companies who specialize in this space as network providers.

The most basic software solution will remotely monitor the bus battery status while charging. This usually comes in the form of a web portal or app that the fleet manager can access at any time. The web portal can integrate data from the fleet operations/dispatch control system, yard management system, and energy management/smart charging system. In addition, if a fleet purchases buses and chargers from multiple manufacturers, the web portal can integrate this data in one place. Basic analysis, such as which buses use the most energy, which buses are having range problems, which buses are having a disproportionate amount of maintenance downtime, and battery state-of-charge can be regularly reported to the manager. Some smart charging companies can also integrate telematics and real-time data from the buses into their smart charging systems. This information can be used by the smart charging software to prioritize which buses should be charged first to assure that all buses are ready for their respective duty cycles.

More advanced solutions will 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 the utility via the OpenADR (Open Automated Demand Response) 2.0b protocol, or using the OpenADR with OCPP protocol. In this case, the utility could use OpenADR with OCPP to have open communication between the electric vehicle (EV) charging stations and central management software, enabling the charging system to serve as a demand response or excess supply asset. 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. Using OCPP on its own is also an option. Several charging manufactures support the OCPP standards, which allows the end user to manage various chargers with one compatible software management system.

To provide managed charging solutions, a network provider will typically need to collaborate with the utility serving the transit agency. In most cases, managed charging companies provide turnkey infrastructure construction and installation services. In doing so, the managed charging company provides the capital expenditures for the chargers and then signs a power purchasing agreement to sell the electricity to the transit agency. Appendix D provides details for managed/networked charging providers.

Maintenance and Training

Many similarities exist between ZEBs and CNG buses, but ZEBs have unique systems such as electric drivetrains, batteries, fuel cells, and hydrogen storage tanks that require specific operational and maintenance needs. These systems have particular needs and require specialized training to service. In addition, ZEBs must be operated and driven differently than a CNG bus to obtain the maximum performance from the buses.

BurbankBus contracts with a transportation services company to operate and maintain their fixed-route fleet, but uses City of Burbank employees to maintain and operate the Senior and Disabled Fleet.

If an agency uses a transportation service contractor, the maintenance and operations is provided by the contractor. As a result, the contractors will need to provide trained bus drivers and maintenance staff. Since some of these transportation service contractors also serve other fleets with ZEBs, their drivers and mechanics might have previous experience with ZEBs. BurbankBus, however, will need to obtain training for the maintenance staff. In addition, BurbankBus will need to conduct maintenance on bus infrastructure. This section will provide an overview of the maintenance and training that is required to operate a ZEB fleet and associated infrastructure.

Bus Operator Training

Bus operators will need training to drive and operate ZEBs. ZEBs need to be driven in a certain manner to optimize performance and bus range. Typically, electric buses maximize their range when accelerated slowly. Poor driver behavior, such as rapidly accelerating from a stop, can reduce bus range by up to 25 percent. As a result, ensuring the bus operators drive the buses in the correct manner is vital to maximizing the benefits of ZEBs. Range anxiety, where the driver fears that they do not have enough charge to complete their route, has also been widely documented. This fear has resulted in operators prematurely ending their route and returning to the depot to charge the bus. To avoid this problem, bus operators need to understand the range and capabilities of the bus. Bus operators also need to learn how to correctly use technologies such as regenerative braking.

Bus Technician Training

ZEBs have different maintenance needs and operation best practices than traditional internal combustion engine buses. ZEBs replace the internal combustion engine with an electric drivetrain, which changes the maintenance needs of the bus. While maintaining a traditional bus, a maintenance technician needs to have expertise in maintaining and repairing internal combustion engines and moving parts like belts, alternators, and pumps. In addition, expertise in mechanical systems such as steering, HVAC, and suspension is vital. However, with ZEBs, the vast majority of the moving parts are replaced with electric components, such as batteries, DC-to-DC converters, and electric motors. Since there are few moving parts on a ZEB, the majority of the maintenance tasks relate to preventative maintenance. As a result, the most vital skills for maintenance technicians to become proficient in are high voltage safety and proper use of personal protective equipment to minimize the risk of electrical shocks and arc flashes. Mechanics should consider obtaining the NFPA 70E: Standards for Electrical Safety in the Workplace and High Voltage OSHA 1910.269 8 Hour Qualified Training Course certificates. Maintenance technicians will also need to become proficient in bus inspection, preventative maintenance, and how to handle removed battery systems to effectively maintain the buses. Knowledge of standard bus mechanical systems is also important. If a fleet has hydrogen FCEBs, the maintenance technicians need additional skills. Hydrogen is a highly flammable gas, meaning that it requires specialized skills. Technicians working on hydrogen buses need training in high pressure gases and hydrogen safety. Local first responders need to receive training in EV and hydrogen safety so they can effectively respond in the event of an accident.

Technicians receive their training through a variety of sources, which usually starts in an automotive program at either a community college or trade school. While at community college/trade school, technicians are introduced to automotive safety, vehicle systems, engines, and mechanical systems. Many students will also learn about electric and hybrid drivetrains. Many community colleges such as Rio Hondo College and San Bernardino Valley College have devoted EV Associate of Sciences programs.

After completing community college/trade school, technicians are then hired by a fleet or a transportation services company. Technicians usually receive on-the-job training after they are hired. Their employer often provides one-on-one training so the technician can work on real-life maintenance and repair issues. Bus OEMs also provide training to technicians. This training typically begins one week before the bus is delivered. The OEM will send a field service representative to provide bus operator training to the contractor's drivers. The field service representative provides safety, preventative maintenance, and diagnostic/troubleshooting training to the mechanics. Since this training is specific to the buses and is generally at a more advanced level, it is important that the technicians have some experience with the basics of zero-emission vehicle maintenance before attending the OEM's training.

The field service representative is also vital for training mechanics on more advanced maintenance tasks. During the warranty period, if repairs or troubleshooting beyond preventative maintenance are needed, the field service representative can be called to teach the mechanics how to fix the issue. It is important to use the warranty period to provide further training to its mechanics. If there are problems with any of the non-drivetrain components on the bus (e.g. the HVAC system), many component manufacturers offer similar services.

There are other avenues for obtaining maintenance technician training. SunLine Transit in Thousand Palms, California, is currently operating the West Coast Center of Excellence in Zero Emission Technology (WCCoE). The WCCoE offers workforce development training for transit agencies. As a part of this training, the WCCoE offers technician training in multiple formats, including on-site at the WCCoE, virtual training, and webinars. On-site training at the WCCoE includes hands-on lab work with actual buses.

The Southern California Regional Transit Training Consortium (SCRTTC) also offers training for ZEB technicians. SCRTTC is a membership-based organization that counts many Southern California transit agencies as members. SCRTTC works with OEMs to provide training in a wide range of zero-emission technologies and bus mechanical systems. This organization works with the OEMs to provide train-the-trainer programs, including classroom and hands-on training.

Workforce Development Training Plan

Each transit agency will need to provide training to their workforce to ensure that they have the skills to operate and maintain ZEBs and infrastructure. The BurbankBus does not hire their own mechanics or bus operators. Instead, they contract with a transit company to provide mechanics and bus operators. The contractor is responsible for hiring and providing training to mechanics and bus operators. When ZEBs are purchased, the contractors will need to ensure that their workers have the skills to maintain the buses. Since many traditional vehicle maintenance competencies (such as suspension, mechanical systems, HVAC systems, etc.) are transferable for maintaining ZEBs, the easiest way to develop a workforce is to upskill the existing bus operators and maintenance staff. The prerequisite knowledge required to begin ZEB maintenance training is a firm understanding of high-voltage electrical systems and safety. The contractor will need to provide high-voltage electrical training for their maintenance staff before they begin training.

To upskill the existing staff, a transit agency should purchase training packages from the OEM. OEM-provided training teaches maintenance staff how to operate and maintain a zero emission drivetrain system. The OEM-provided training begins about a week before the delivery of the buses. The OEM sends a field service representative to provide bus operator training to the contractor's drivers. The field service representative will also train the maintenance staff. Since there are few moving parts on a zero emission bus, the majority of the maintenance tasks relate to preventative maintenance. As a result, the field service representative provides safety, preventative maintenance, and diagnostic/troubleshooting training to the contractor's mechanics. The field service representative is also vital for training mechanics on more advanced maintenance tasks. During the warranty period, if repairs or troubleshooting beyond preventative maintenance are needed, the contractor may call out the field service representative to fix the issue and teach the mechanics how to fix it. Using the warranty period to provide on-the-job training to the mechanics is vital to developing the skills of the maintenance staff. Overtime the maintenance staff will accrue enough knowledge to work independently from the field service representative. This knowledge can be institutionalized by pairing more experienced maintenance staff with junior staff and new hires to teach them maintenance best practices. OEM-provided training can also be supplemented with training provided by other organizations such as the SCRTTC, the California Transit Association, American Public Transportation Association, CalACT, and the National Transit Institute.

Bus Maintenance Requirements

BEB Maintenance

BEBs have an electric drive train that is powered by electricity from an energy storage system, and consequently lack some of the components in an internal combustion engine bus, especially some of the mechanical systems in the propulsion system. The maintenance needs for the propulsion system are therefore different in BEBs than internal combustion engine buses. Despite these differences, BEBs do share many mechanical systems with internal combustion engine buses, such as brakes, suspension, door opening systems, the cab, and chassis, so some of the maintenance needs will be similar.

Those transit agencies that have already deployed BEBs, can provide lessons about the maintenance needs for these vehicles. A number of these agencies reported that BEBs have fewer moving parts and therefore fewer parts to replace. BEBs do not require oil changes and do not have belts that need to be replaced. As a result, certain aspects of preventative maintenance for BEBs is lower than for CNG buses, with the main cost being labor and time.

Transit agencies have reported some issues in regard to unscheduled maintenance for BEBs, with the earlier generation of BEBs experiencing some problems and failures with major components such as high voltage batteries and inverters. Another common issue has been the wires from the high voltage batteries. These wires are held together by connector pins. On many buses, these connector pins have corroded and come apart, preventing energy from being transferred from the battery to the drivetrain. Some BEBs have also experienced problems with the low voltage batteries. In these buses, auxiliary equipment such as the security camera system continued to draw power even after the bus was turned off. This issue depletes the battery. Despite these problems, the drivetrain itself has proven to be very reliable, and most buses only experience minor problems with the drivetrain.

Unfortunately, these problems have been costly, and the cost of unscheduled maintenance is higher for BEBs than for CNG buses. The bus availability in a fleet of BEBs has also been significantly lower than for CNGs. One transit agency reported that the availability for CNG buses is about 95 percent, while BEB availability is about 70 percent. This low rate of availability has been caused by the fact that repairs on BEBs can take time to resolve. Some parts can be difficult to obtain, and sometimes diagnosis of a problem is not quickly resolved. As a result, BEBs can be out of service for up to 20-30 days in the event of an issue. To improve bus availability, ensuring the quick delivery of parts is vital. Transit agencies can also mitigate this problem by stocking extra parts.

Since some transit agencies have already deployed BEBs, there is data available on maintenance needs and costs. Foothill Transit has a fleet of BEBs: twelve 35-foot Model year 2014 buses and two 40-foot Model year 2016 buses (Eudy, 2020). The National Renewable Energy Laboratory (NREL) has been tracking the maintenance costs for this fleet and has compared it to the costs for the CNG fleet. NREL found that the maintenance costs for the 35-foot BEB fleet is $0.84 per mile and $0.53 per mile for the 40-foot BEB fleet. CNG buses have lower maintenance costs of $0.23-$0.42 per mile. Since all three fleets are out of warranty and Foothill Transit has taken over maintenance, these figures are comparable.

Although this data indicates that the maintenance costs are higher for the BEB fleet, there are several caveats in the data to consider. First, the BEBs had lower scheduled maintenance costs than the CNG fleet. The 35-foot and 40-foot BEB fleet had scheduled maintenance costs of $0.05 and $0.04, respectively. The CNG fleet had scheduled maintenance costs of $0.10. As a result, the main difference in cost between the BEB fleets and the CNG fleet is unscheduled maintenance. Some of the unscheduled maintenance figures were also skewed by an issue with the low-voltage batteries, which had to be changed out frequently. The bus manufacturer is working to resolve these issues, and the low-voltage battery problem is not expected to emerge in future generations of their bus. When the cost of the low-voltage battery problem is excluded, the maintenance cost for the 35-foot and 40-foot BEBs are $0.72 and $0.48, respectively.

NREL also measures data on bus availability, which is defined as the percentage of days the bus is available for service. NREL issued a report analyzing BEB availability at Foothill Transit. This report found that Foothill Transit's CNG bus fleet had an availability of 95.1 percent. The fleet of 35-foot BEBs had a bus availability of 83.1 percent, and the 40-foot fleet had a bus availability of 81.6 percent. In most cases, general maintenance is the cause of bus unavailability. However, other issues such as problems with the electric drive or energy storage system can cause the buses to be unavailable. Significant variation of bus availability exists within the fleet; that is, some buses will have lower availability than others. For example, between Q3 and Q4 2019, some buses had a bus availability as high as 82 percent and others as low as 42 percent. Moreover, bus unavailability tends to increase as the buses get older, much like bus maintenance costs.

Maintenance and bus availability figures are also for older generations of buses. Since buses have continued to develop and become more technologically mature, newer generations of buses are likely to have fewer problems with unscheduled maintenance and unavailability. During interviews with CALSTART, OEMs and other transit agencies in the Southern California region reported that newer generations of buses have proven to be more reliable and have had higher bus availability.

Infrastructure Maintenance Requirements

Plug-in Charging Infrastructure

Charging infrastructure requires maintenance, though most of the components are non-moving parts with fewer maintenance needs. Most maintenance tasks focus on changing air filters in the charger and performing inspections. However, components can break from time to time. Since there is an established supply chain for these components, repairs are usually routine and completed quickly. For many chargers, the biggest threat is accidentally damaging the charger receptacle by driving over it. The use of DC fast chargers and networked chargers can increase maintenance needs; DC fast chargers have cooling equipment that can need maintenance and repair. Networked chargers also have data and communications equipment that can potentially break.

Transit agencies can rely on their charger manufacturer to provide maintenance. The chargers usually come with a warranty during which the manufacturer is responsible for maintenance and repair tasks. If the transit agency opts to pay for networked charging services, the chargers can communicate with the network and can alert the charging company to any problems the charger is experiencing. After the warranty period expires, the transit agency can opt for an extended warranty, pay for a maintenance package, or take over maintenance with their own staff. Charging companies typically plan for up to two planned outages per year to do routine maintenance. Although the actual maintenance tasks are relatively easy to carry out, the labor costs of the maintenance can be substantial, as a certified electrician is needed to perform all maintenance tasks. In addition, if the transit agency uses overhead plug-in chargers, a manlift is required to elevate maintenance worker to the chargers.

The Electric Vehicle Infrastructure Training Program (EVITP) provides training to electricians on how to install EV charging infrastructure. Electricians who complete this program can receive EVITP certification. This certification is accepted as industry-standard, and some California Energy Commission (CEC) grants even require that a certain percentage of electricians working on EV charging infrastructure have EVITP certification. EVITP also provides training on maintaining, troubleshooting, and commissioning EV chargers. It is recommended that maintenance staff who work on chargers obtain EVITP certification.

Overhead Charging Maintenance

Unlike plug-in chargers, overhead chargers have moving parts that require a prescribed set of preventative maintenance that needs to be performed regularly. Every month, the overhead charger requires an inspection to ensure that the wiring and the brushes are functioning property. Every six months, maintenance technicians measure the energy and charging capacity to make sure the charger is outputting the correct amount of power. On a yearly basis, maintenance technicians inspect the charger to ensure that the wiring and communication systems are working properly. Maintenance is typically carried out by the OEM, and the manufacturer will normally offer a maintenance service package.

Required Tools and Facility Upgrades

To adequately service the buses, the maintenance staff will need to have proper tools and facilities. Many of the tools used to maintain traditional internal combustion engine buses can also be used to service electric buses. However, some specialized equipment is needed to handle EV high-voltage components such as batteries, inverters, and traction motors. The following are examples of necessary tools and equipment:

- OEM-specific diagnostic tools to troubleshoot problems on the bus
- High impedance multimeters to monitor current in the electrical systems
- Insulated hand tools (wrenches, screwdrivers, pliers, etc.) to protect workers from shock
- Personal protective equipment including Class 0 rubber high voltage gloves (which need to be inspected and tested regularly), leather overgloves, insulated dielectric boots, face shield, insulating rubber apron, and insulated electrical rescue hook
- Overhead crane to lift batteries from the roof of the bus
- Forklift to remove inverters and HVAC systems from the roof of the bus
- Scaffolding with fall protection so technicians can access the roof of the bus
- Lifting jigs for batteries and inverters
- OEM-specific tools to fix bus mechanical systems
- Manlift (if using overhead plug-in or pantograph chargers) to perform routine maintenance and repairs

Training Costs

OEM-specific training is typically part of procurement contracts. California Department of General Services (DGS) has procurement contracts that transit agencies can use to purchase buses at a fixed price without having to issue a Request for Proposal (RFP). These DGS contracts also include pricing for bus technician and bus operator training, as well as for maintenance manuals. See **Table 1-3** for a breakdown of these costs.

Table 1-1: ZEB Maintenance and Operator Training Costs

Item	OEM 1	OEM 2	OEM 3	OEM 5
Operator Training (total of 56 hours)	$12,250.00	$11,667.04	$11,200.00	$11,667.04
Technician Training (total of 304 hours)	$66,500.00	$107,001.92	$44,797.44	$141,657.92
Maintenance Packages Manual (per manual)	$300.00	$741.00	$500.00	$815.54
Preventative Maintenance and Procedure Manual (per manual)	$300.00	$298.15	$100.00	$298.15
Parts Manual (per manual)	$200.00	$153.46	$500.00	$153.46
Operator's Manual (per manual)	$100.00	$87.69	$250.00	$87.69

Financing Strategies & Resources

Transit agencies have multiple options for funding the deployment of ZEBs. Bus OEMs offer several models for financing the procurement of buses and infrastructure. In addition, there are myriad governmental programs available to help fund vehicles and infrastructure. This section provides an overview of financing options.

Traditional Financing Models

Bus OEMs offer a variety of financing mechanisms that transit agencies can use to obtain buses. This includes capital purchases, bus/battery leasing, and infrastructure as a service.

Capital Purchases

Traditionally, buses are obtained through capital purchases. A capital purchase is a transaction in which an OEM or infrastructure provider transfers ownership of a bus or infrastructure to a transit agency in exchange for a capital payment. In a traditional capital purchase, a transit agency typically releases RFPs, in which they outline the number of buses and type of infrastructure they would like to procure and release the duty specifications the buses need to meet. OEMs and infrastructure providers are then invited to submit bids, and the transit agency selects a winning bid and awards a contract. However, several states have now issued statewide contracts for buses. Under a statewide contract, the state negotiates a contract with bus OEMs to purchase buses at a fixed price. Transit agencies can purchase buses from a statewide contract and thereby avoid the RFP process. The State of California has statewide contracts with several bus OEMs through California DGS. CalACT has also developed a statewide contract for zero-emission shuttle buses.

A capital purchase allows a transit agency to make a single payment to obtain a bus. The bus's value is then depreciated over the entire life of the bus. Capital purchases can be problematic; they require transit agencies to have access to a large amount of money. It is often difficult for transit agencies to obtain enough funding to make a lump sum payment, especially smaller transit agencies.

Battery Leasing

When compared to conventional diesel- and/or gas-powered vehicles, EVs often come at a higher upfront capital cost. In most cases, the largest cost is the battery itself, which is why some OEMs have developed battery leasing programs to lower the barrier to entry for fleets and allow the manufacturer to recoup the cost of the battery over an extended contract. In this model, the BEB can be purchased without the battery pack at a lower price that is cost competitive with conventional vehicles. The upfront cost of the battery itself is covered by a participating financial partner and enables battery warranties to be guaranteed for the duration of the lease. Under this model, the transit agency would then make monthly or annual lease payments for the battery. Battery leasing helps transit agencies because it reduces capital expenditures for the buses. This model effectively shifts a large portion of the bus cost into lease payments, which allows transit agencies to finance their purchase through operational budgets, rather than capital expenditures.

While this is a promising model for the acceleration of transit fleet electrification, it is a newer idea that is still in development at most OEMs. A price comparison between leasing and owning the battery remains uncertain; battery leasing is a nascent business model, and it is unclear which, if any, transit agencies have utilized this option. **Table 1-5** provides a brief overview of BEB OEM battery leasing options.

Table 1-2: Battery Leasing Options

Bus OEM	Battery Leasing Options
BYD	Yes
New Flyer	Unknown
Proterra	Yes
GreenPower Motor Company	No
Phoenix Motorcars	No, but considering offering battery leasing in the future

Infrastructure-as-a-Service (IAAS)

Like bus/battery leasing, IAAS is another method for reducing the capital expenditures associated with deploying ZEBs, particularly charging and resiliency infrastructure. IAAS can also be combined with battery leasing to further reduce capital expenditures. Under an IAAS model, a company will provide turnkey service, managing the construction and installation of charging infrastructure. Under this model, the infrastructure company will typically maintain ownership of the chargers and any resiliency equipment. The infrastructure company then signs a power purchase agreement (PPA) with the transit agency to sell the power produced and dispensed to the buses. IAAS companies can develop PPAs where power is sold on a per kWh basis or a per mile basis. Most IAAS companies prefer to sell power on a per kWh basis. IAAS companies typically combine the infrastructure with managed/networked charging to minimize demand charges and the cost of electricity.

The IAAS model can also provide tax benefits in some cases. Some types of infrastructure can qualify for the Investment Tax Credit (see page 46) and other tax benefits. Since a transit agency is a public agency that does not pay taxes, they cannot directly take advantage of these tax credits. However, under the IAAS model, the infrastructure provider retains ownership, and they can benefit from the tax credits. This option would allow the infrastructure provider to pass some of the tax benefits onto the transit agency in the form of lower PPA rates. In some cases, an IAAS company may also give transit agencies the option to convert the PPA to a capital purchase of the infrastructure once the tax benefits have been realized. An overview of IAAS companies can be found in Appendix D.

Funding Sources and Incentives for Buses and Infrastructure

BurbankBus does not currently receive state or federal formula funding (except for the Low Carbon Transit Operations Program). The main funding option that BurbankBus has to fund the transition to a ZEB fleet is to apply for competitive grants to pay for buses or bus facilities. Grant funding can be used to reduce the capital expenditures associated with purchasing buses or chargers. Alternatively, there are situations where grants can be combined with traditional financing models to fund the fleet. This section provides an overview of governmental funding opportunities.

State Funding Sources and Incentives

California State Budget Allocations

The California State Budget has allocated $2.7 billion for the 21-22 fiscal year and a total of $3.9 billion over the next three years. Millions of dollars of funding are specifically being earmarked for ZE transit buses and associated refueling/charging infrastructure:

- $1.3 billion over 3 years to deploy over 3,000 ZE drayage trucks, transit buses, and school buses
- $500 million for zero emission clean truck, buses, and off-road equipment
- $200 million for medium-and heavy-duty ZEV fueling and charging infrastructure
- $407 million to demonstrate and purchase or lease clean bus and rail equipment and infrastructure that increase intercity rail and intercity bus frequencies.

Clean Transportation Program - CEC

The Clean Transportation Program was created to fund projects that help transition California's fuels and vehicle types to achieve California's climate policies. The Clean Transportation Program is funded from fees levied on vehicle and vessel registrations, vehicle identification plates, and smog abatement. The Clean Transportation Program was created by Assembly Bill 118 and was extended to January 1, 2024 by Assembly Bill 8. The Clean Transportation Program funds multiple classes of vehicles. Every year the CEC develops an Investment Plan Update to identify how the program's funds will be allocated. For FY 2021-22, the CEC proposed that $30.1 million in Clean Transportation Program funding and $208 million in general funds would be used to fund medium- and heavy-duty vehicle charging and hydrogen fueling infrastructure. For FY 2022-23, the CEC proposed $30.1 million of Clean Transportation Program funding for zero emission medium- and heavy-duty vehicles and infrastructure. The amount that will be allocated from general funds in FY 2022-23 has not yet been determined (California Energy Commission, 2021).

Carl Moyer Program – CARB

The Carl Moyer Program provides grant funding for engines, equipment, and other sources of air pollution that exceed CARB's regulations for on-road heavy-duty vehicles. The Carl Moyer Program is managed by CARB in collaboration with local air pollution control districts and air quality management districts. ZEBs with a GVWR of greater than 14,000 pounds are eligible for funding under Carl Moyer. The air pollution control districts and air quality management districts are the entities that issue the grants and determine funding for the program.

Energy Infrastructure Incentives for Zero-Emission Commercial Vehicles (EnergIIZE) – CEC, CALSTART

EnergIIZE is a program that was launched by the CEC and is being managed by CALSTART. EnergIIZE will provide $50 million of funding to entities to help finance the purchase of charging and hydrogen infrastructure. EnergIIZE will fund medium- and heavy-duty infrastructure and is intended to primarily benefit communities with disproportionately high levels of air pollution. EnergIIZE program will only cover a part of the infrastructure hardware and software costs. For EV projects, charging equipment eligible for funding includes Level 2 electric vehicle supply equipment, DCFC electric vehicle supply equipment, charge management software, switchgear, electrical panel upgrades, wiring and conduit, and meters. For hydrogen projects, equipment that is eligible for funding includes compressors, liquid and gaseous pumps, piping and pipelines, hydrogen dispensers with hoses and nozzles, high-pressure storage, on-site production equipment, chillers, switchgear, electrical panel upgrades, wiring and conduit, and meters. Construction, labor, and utility upgrade costs are not eligible for funding under this program.

The EnergIIZE program offers four pathways to fund infrastructure. Each of these pathways has different eligibility criteria:

- EV Fast Track – for fleets that own or have a purchase order for a vehicle registered in the State of California as a result of State or Federal vehicle incentive funded projects (such as HVIP, Volkswagen Settlement, Carly Moyer, TIRCP, etc.)
- EV Jump Start – for transit agencies in a designated Disadvantaged Community (according to CalEnviroScreen 3.0)
- EV Public Charging Stations – for public charging station developers

The pathway that a transit agency qualifies for determines the amount of funding that they can receive. Under the EV Fast Track pathway, applications are evaluated on a first-come, first-served basis. EV Fast Track will fund 50% of hardware and software costs incurred, up to a maximum of $500,000. EV Jump Start funding is awarded on a competitive basis. EV Jump Start will fund 75% of hardware and software costs incurred, up to a maximum of $750,000. Hydrogen pathway funding is awarded on a competitive basis. The Hydrogen pathway will finance 50% of hardware and software costs incurred, up to a maximum of $2,000,000.

At the time of writing, CALSTART plans to open funding for the first round of the EV Fast Track pathway in Q1 2022. A second round of funding is planned to open in Q3 2022. The first round for EV Jump Start is planned to open in Q2 and close in Q3 2022. A second round of EV Jump Start is scheduled to open in Q4 2023. The hydrogen pathway is scheduled to open in Q2 2022. A second round is scheduled to open in Q4 2022. 70% of funding will be allocated to EV projects and 30% will be allocated to hydrogen (CALSTART, 2021).

Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project (HVIP) – CARB, CALSTART

California HVIP is a program that was launched by CARB and is managed by CALSTART. HVIP provides vouchers that are used to finance the purchase of clean transportation vehicles. HVIP's vouchers are applied at the point-of-purchase, which reduces the purchase price of the vehicle when it is purchased. ZEBs are eligible to receive vouchers under HVIP. Vouchers are allocated on a first-come, first-serve basis.

Table 1-3: HVIP Voucher Funding Amounts

Vehicle Weight Class	Base Vehicle Incentive
Class 3	$45,000
Class 4-5	$60,000
Class 6-7	$85,000
Class 8	$120,000

California Infrastructure and Economic Development Bank (IBank)

The IBank was created in 1994 to fund infrastructure and economic development projects in California. The IBank was started by the Bergeson-Peace Infrastructure and Economic Development Bank Act and is operated by GO-Biz. IBank can issue low-interest bonds that can be used to finance projects for public agencies or nonprofits. The IBank has programs that can be used to finance the transition to a zero emission fleet. The Infrastructure State Revolving Fund (ISRF) program provides low-Interest financing for infrastructure projects. ISRF provides loans of $50,000 to $25 million over a term of up to 30 years at a fixed interest rate. These loans are funded through the sale of Infrastructure State Revolving Fund Revenue Bonds. Public transit projects, which includes but is not limited to, vehicles and maintenance and storage yards, are eligible for funding through ISRF. ISRF applicants must be a public agency, joint power authority, or nonprofit corporation formed by an eligible entity. ISRF accepts applications on an ongoing basis (California Infrastructure and Economic Development Bank, 2016).

The IBank also offers the California Lending for Energy and Environmental Needs (CLEEN) program. CLEEN provides loans from

$500,000 to $30 million over a team of up to 30 years. These loans can be used to fund projects that use a commercially proven technology to reduce greenhouse gas emissions or pursue other environmental objectives. Eligible projects include energy storage, renewable energy generation assets, stationary fuel cells, electric vehicles, alternative fuel vehicles, and alternative fuel vehicles refueling stations (California Infrastructure and Economic Development Bank, n.d.).

Low Carbon Fuel Standard (LCFS) Program – CARB

The LCFS Program is run by CARB and creates a mechanism for the users and producers of low-carbon fuels (including electricity) to generate credits for the use of these low-carbon fuels. These credits can then be sold in the LCFS market. The LCFS program sets standards for the maximum carbon intensity that a fuel can have. If an entity uses fuels that are below the carbon intensity standards, they generate LCFS credits. However, if an entity uses fuels that exceed the carbon intensity standards, they generate deficits and must purchase LCFS credits to negate their deficits.

To earn LCFS credits, transit agencies must comply with CARB reporting requirements and register their chargers with CARB. These credits are generated based on the fuel type, fuel quantity, and carbon intensity of the fuel used, such as electricity. However, the standards for carbon intensity are becoming more stringent over time, which makes it more challenging to earn LCFS credits. It's important to note that LCFS credits are subject to change every week based on the reduction of carbon intensity, and the latest information can be found on the CARB website[1]. LCFS credits can be sold to polluters that need to negate their deficits based on the going market rate.

Transit and Intercity Rail Capital Program (TIRCP) – Caltrans

TIRCP provides grants to fund capital improvements that will modernize California's rail, bus, and ferry public transit facilities. The objective of the program is to reduce GHG emissions, expand transit service, increase transit ridership, and improve transit safety. Funded projects are expected to reduce GHG emissions, vehicle miles traveled, and congestion. TIRCP is funded through the Greenhouse Gas Reduction Fund (GGRF) and the Cap and Trade program. TIRCP funds can be used to finance site upgrades and the deployment of zero-emission infrastructure at bus depots and facilities.

Low Carbon Transit Operations Program (LCTOP) – Caltrans

The LCTOP is one of several programs that is funded by the GGRF, which is funded by revenues from the state's cap-and-trade system. State law requires continual appropriation of 5 percent of the revenue from the GGRF to be allocated to the LCTOP. State law requires the program's funds to provide transit operating or capital assistance that meets any of the following criteria:

1. The funding can directly enhance or expand transit service by enabling new or expanded bus or rail services, water-borne transit, or expanded intermodal transit facilities, and may include equipment acquisition, fueling, and maintenance, and other costs to operate those services or facilities.
2. The funding can fund operational expenditures that increase transit mode share.
3. The funding can fund the purchase of ZEBs, including electric buses, and the installation of the necessary equipment and infrastructure to operate these ZEBs.

VW Mitigation Trust – CARB

The purpose of the VW Environmental Mitigation Trust is to fully mitigate the excess NOx emissions released during the Volkswagen emission scandal. This program was established as a part of the settlement that VW reached with the EPA. The VW Mitigation Trust has allocated $423 million to the State of California to fund the deployment of clean transportation vehicles. $130 million of these funds is devoted to replacing older, high emission buses with BEBs or FCEBs. Transit, school, and shuttle buses are eligible for funding.

[1] https://ww2.arb.ca.gov/resources/documents/weekly-lcfs-credit-transfer-activity-reports

Clean Mobility Options Vouchers Program

The Clean Mobility Options (CMO) Voucher Pilot Program is a statewide initiative that provides zero-emission shared mobility options to under-resourced communities in California. The CMO Voucher Pilot is available throughout California to eligible disadvantaged communities, as well as low-income communities and eligible tribal governments, to increase access to safe, reliable, convenient, and affordable transportation options.

Clean Mobility Options is part of California Climate Investments, a statewide initiative that puts billions of Cap-and-Trade dollars to work reducing greenhouse gas emissions, strengthening the economy, and improving public health and the environment — particularly in under-served communities, and California Energy Commission's Clean Transportation Program, which is investing more than $1 billion to accelerate the deployment of zero-emission transportation infrastructure and support in-state manufacturing and workforce training and development.

State of Good Repair - Caltrans

The Road Repair and Accountability Act of 2017, Senate Bill (SB) 1 (Chapter 5, Statues of 2017), signed by the Governor on April 28, 2017, includes a program that will provide additional revenues for transit infrastructure repair and service improvements. This investment in public transit will be referred to as the State of Good Repair (SGR) Program. This program receives funding of approximately $105 million annually. SGR funds are to be made available for eligible transit maintenance, rehabilitation and capital projects. SB 1 emphasizes the importance of accountability and transparency in the delivery of California's transportation programs.

Transportation Development Act (TDA)

The Mills-Alquist-Deddeh Act (SB 325) was enacted by the California Legislature to improve existing public transportation services and encourage regional transportation coordination. Known as the Transportation Development Act (TDA) of 1971, this law provides funding to be allocated to transit and non-transit related purposes that comply with regional transportation plans. TDA established two funding sources; the Local Transportation Fund (LTF), and the State Transit Assistance (STA) fund. Providing certain conditions are met, counties with a population under 500,000 (according to the 1970 federal census) may also use the LTF for local streets and roads, construction and maintenance. The STA funding can only be used for transportation planning and mass transportation purposes.

LTF- Local Transportation Fund (LTF), is derived from a ¼ cent of the general sales tax collected statewide. The State Board of Equalization, based on sales tax collected in each county, returns the general sales tax revenues to each county's LTF. Each county then apportions the LTF funds within the country based on population.

STA- The STA funds are appropriated by the legislature to the State Controller's Office (SCO). The SCO then allocates the tax revenue, by formula, to planning agencies and other selected agencies. Statue requires that 50% of STA funds be allocated according to population and 50% be allocated according to transit operator revenues from the prior fiscal year.

Federal Funding Sources and Incentives

Bus & Bus Facilities (5339) – USDOT/Caltrans

The Bus & Bus Facilities program is managed by the FTA. This program provides capital funding to replace, rehabilitate, and purchase transit vehicles and construct bus-related facilities. The FTA allocates funding to states to administer these grants. In California, Caltrans has been delegated the responsibility of managing these grants. Public agencies and nonprofit organizations that are involved in public transit may apply for these grants.

Section 5307 – FTA/Caltrans

The Urbanized Area Formula Funding program (49 U.S.C. 5307) makes federal resources available to urbanized areas and to governors for transit capital and operating assistance in urbanized areas and for transportation-related planning. An urbanized area is an incorporated area with a population of 50,000 or more that is designated as such by the U.S. Department of Commerce, Bureau of the Census.

Funding is made available to designated recipients that are public bodies with the legal authority to receive and dispense federal funds. Governors, responsible local officials and publicly owned operators of transit services shall designate a recipient to apply for, receive, and dispense funds for urbanized areas pursuant to 49 USC A5307(a)(2). The governor or governor's designee acts as the designated recipient for urbanized areas between 50,000 and 200,000.

For urbanized areas with 200,000 in population and over, funds are apportioned and flow directly to a designated recipient selected locally to apply for and receive Federal funds. For urbanized areas under 200,000 in population, the funds are apportioned to the governor of each state for distribution.

Eligible activities include: planning, engineering, design and evaluation of transit projects and other technical transportation-related studies; capital investments in bus and bus-related activities such as replacement, overhaul and rebuilding of buses, crime prevention and security equipment and construction of maintenance and passenger facilities; and capital investments in new and existing fixed guideway systems including rolling stock, overhaul and rebuilding of vehicles, track, signals, communications, and computer hardware and software. In addition, associated transit improvements and certain expenses associated with mobility management programs are eligible under the program. All preventive maintenance and some Americans with Disabilities Act complementary paratransit service costs are considered capital costs.

Section 5310 – FTA/Caltrans

FTA Section 5310 – Enhanced Mobility of Seniors and Individuals with Disabilities Program is authorized by 49 United States Code (U.S.C.) 5310. The goal of the FTA 5310 Program is to improve the mobility of seniors and individuals with disabilities by removing barriers to transportation services and expanding the transportation mobility options available. This program provides grant funds for capital, mobility management, and operating expenses for:

- Public transportation projects planned, designed, and carried out to meet the special needs of seniors and individuals with disabilities when public transportation is insufficient, inappropriate, or unavailable;
- Public transportation projects that exceed the requirements of the Americans with Disabilities Act (ADA);
- Public transportation projects that improve access to fixed-route service and decrease reliance on complementary paratransit; and
- Alternatives to public transportation projects that assist seniors and individuals with disabilities and with transportation.

Section 5311 – FTA/Caltrans

The Formula Grants for Rural Areas program provides capital, planning, and operating assistance to states to support public transportation in rural areas with populations of less than 50,000, where many residents often rely on public transit to reach their destinations. The program also provides funding for state and national training and technical assistance through the Rural Transportation Assistance Program. Eligible activities include planning, capital, operating, job access and reverse commute projects, and the acquisition of public transportation services. The federal share is 80 percent for capital projects. Section 5311 funds are available to the States during the fiscal year of apportionment plus two additional years (total of three years). Funds are apportioned to States based on a formula that includes land area, population, revenue vehicle miles, and low-income individuals in rural areas.

Rural Surface Transportation Grant Program – Federal Highways Administration (FHWA)

The Rural Surface Transportation Grant Program supports projects that improve and expand the surface transportation infrastructure in rural areas to increase connectivity, improve the safety and reliability of the movement of people and freight, and generate regional economic growth and improve quality of life. Rural Surface Transportation grant program funding will be made available under the MPDG combined Notice of Funding Opportunity (NOFO). Eligible projects:

- A highway, bridge, or tunnel project eligible under National Highway Performance Program
- A highway, bridge, or tunnel project eligible under Surface Transportation Block Grant
- A highway, bridge, or tunnel project eligible under Tribal Transportation Program
- A highway freight project eligible under National Highway Freight Program
- A highway safety improvement project, including a project to improve a high-risk rural road as defined by the Highway Safety Improvement Program
- A project on a publicly owned highway or bridge that provides or increases access to an agricultural, commercial, energy, or intermodal facility that supports the economy of a rural area
- A project to develop, establish, or maintain an integrated mobility management system, a transportation demand management system, or on-demand mobility services.

Carbon Reduction Program – (FHWA)

The IIJA establishes the Carbon Reduction Program (CRP), which provides funds for projects designed to reduce transportation emissions, defined as carbon dioxide (CO_2) emissions from on-road highway sources .A State may transfer up to 50% of CRP funds made available each fiscal year to any other apportionment of the State, including the National Highway Performance Program, Surface Transportation Block Grant Program, Highway Safety Improvement Program, Congestion Mitigation and Air Quality Improvement (CMAQ) Program, National Highway Freight Program, and Promoting Resilient Operations for Transformative, Efficient, and Cost-saving Transportation (PROTECT) Formula Program. CRP funds may be obligated for projects that support the reduction of transportation emissions, including, but not limited to– [except as noted, § 11403; 23 U.S.C. 175(c)(1)]

- a project described in 23 U.S.C. 149(b)(4) to establish or operate a traffic monitoring, management, and control facility or program, including advanced truck stop electrification systems;
- a public transportation project eligible under 23 U.S.C. 142;
- a transportation alternative (as defined under the Moving Ahead for Progress under the 21st Century Act [23 U.S.C. 101(a)(29), as in effect on July 5, 2012]), including, but not limited to, the construction, planning, and design of on-road and off-road trail facilities for pedestrians, bicyclists, and other nonmotorized forms of transportation;
- a project described in 23 U.S.C. 503(c)(4)(E) for advanced transportation and congestion management technologies;
- deployment of infrastructure-based intelligent transportation systems capital improvements and the installation of vehicle-to-infrastructure communications equipment;
- a project to replace street lighting and traffic control devices with energy-efficient alternatives;
- development of a carbon reduction strategy developed by a State per requirements in 23 U.S.C. 175(d);
- a project or strategy designed to support congestion pricing, shifting transportation demand to nonpeak hours or other transportation modes, increasing vehicle occupancy rates, or otherwise reducing demand for roads, including electronic toll collection, and travel demand management strategies and programs;
- efforts to reduce the environmental and community impacts of freight movement;
- a project that supports deployment of alternative fuel vehicles, including–
    - acquisition, installation, or operation of publicly accessible electric vehicle charging infrastructure or hydrogen,

- natural gas, or propane vehicle fueling infrastructure; and
    - purchase or lease of zero-emission construction equipment and vehicles, including the acquisition, construction, or leasing of required supporting facilities;
- a project described in 23 U.S.C. 149(b)(8) for a diesel engine retrofit;
- certain types of projects to improve traffic flow that are eligible under the CMAQ program, and that do not involve construction of new capacity; [§ 11403; 23 U.S.C. 149(b)(5); and 175(c)(1)(L)]
- a project that reduces transportation emissions at port facilities, including through the advancement of port electrification; and
- any other STBG-eligible project, if the Secretary certifies that the State has demonstrated a reduction in transportation emissions, as estimated on a per capita and per unit of economic output basis. (Note: FHWA will issue guidance on how the Secretary will make such certifications.) [§ 11403; 23 U.S.C. 133(b) and 175(c)(2)]

Congestion Mitigation and Air Quality (CMAQ) Improvement Plan – USDOT

CMAQ provides funds directly to states. These funds may be used to finance projects that reduce traffic congestion and improve air quality. The main objective of this program is to reduce CO, ozone, and PM emissions. This program is primarily intended to fund projects in areas that do not meet national air quality standards. The Infrastructure Investment and Jobs Act (IIJA) provides $13.2 billion of funding over five years. Under IIJA, there are new project types that are eligible for funding under CMAQ. The purchase of medium- or heavy-duty zero emission vehicles and supporting infrastructure is eligible for funding under CMAQ. Shared micromobility projects are also eligible for funding. CMAQ funds can also be used to provide operating assistance for public transportation projects.

Investment Tax Credit (ITC) - IRS

Internal Revenue Code Section 48 provides a tax credit for investments in certain types of energy projects. Section 48 provides tax credits for a wide range of renewable energy investments. Renewable energy technologies such as solar PV, fuel cells, small wind microturbines, and combined heat and power are eligible for tax credits. Solar PV projects are eligible for a tax credit equal to 10 percent of the cost of system for projects that begin construction in 2022 or after. Only the owner of the system can claim the ITC. Small wind power (100 kW of capacity or less) is eligible for the same tax credits as solar. Fuel cells are eligible for the ITC and are limited to $1500 per 0.5 kW in capacity. Lastly, combined heat and power equipment qualifies for an ITC of 10 percent (Congressional Research Service, 2018).

It is important to note that the ITC for some technologies will phase out over time. The solar ITC is permanent and will remain at 10 percent beyond 2022. However, the ITC for wind, fuel cells, and CHP has been approved until 2024. It is unclear whether the ITC for these technologies will be enacted beyond this date. Since transit agencies are tax-exempt entities, they would not be able to directly take advantage of these tax credits. However, if a separate entity, such as an IAAS company, owned and operated the energy assets, they would be able to benefit from these tax credits and pass these benefits on to BurbankBus.

Low or No Emissions Program (Low-No) – USDOT/FTA

Low-No provides funding to state and local governmental authorities for the purchase or lease of zero-emission and low-emission transit buses. Low-No funding can also be used to acquire charging or fueling infrastructure for the buses, pay for construction costs, or obtain or lease facilities to house a fleet. In FY2021, $182 million was allocated for the Low-No program. However, the enactment of IIJA will expand funding for the Low-No program. IIJA allocates an additional $5.25 billion for the Low-No program over five years. To be eligible for this funding, a transit agency will need to submit a plan for transitioning to zero emission buses. This plan must demonstrate a long-term fleet management plan that addresses how the transit agency will meet the costs of transitioning to zero emission, the facilities and infrastructure that will be needed to be deployed to serve a zero emission fleet, the transit agency's relationship with their utility or fuel provider, and the impact that the transition will have on the transit agency's current workforce. Under IIJA, transit agencies may apply for Low-No funding with other entities, such as an OEM, that will participate in the implementation of the project. IIJA also requires that 5% of grant funds awarded be used to fund workforce training to prepare their current workforce to maintain and operate the buses.

Rebuilding American Infrastructure with Sustainability and Equity (RAISE) grants – USDOT

The RAISE grant is the latest iteration of the BUILD and TIGER grant program. This program is intended to invest in road, rail, transit, and port projects. The objective of this program is to fund projects that are difficult to support through traditional USDOT programs. Public entities, such as municipalities, are eligible to apply for this program. RAISE is a competitive grant program.

Prospective Financing Mechanisms

IBank Climate Catalyst Fund

The state's IBank is poised to create a new low-interest loan program for public fleets. The Climate Catalyst Fund was created in June 2020 and received its first funds in September 2021. The objective of this fund is to provide a financing mechanism to support the State of California's climate and sustainability infrastructure. The Climate Catalyst Fund's goal is to provide low-interest loans for projects that support the state's climate objectives. The IBank is in the process of developing the criteria that will be used to award projects. The Climate Catalyst Fund will initially prioritize projects that advance forest biomass management. However, the Climate Catalyst Fund's scope is expected to increase over time. From discussions with the Governor's Office of Business Development as well as the Director of the IBank, Scott Wu, CALSTART understands that the Fund's scope will eventually encompass zero emission fleets. These low interest loans could be used to fund vehicle purchases, as well as charging infrastructure projects.

Medium- and Heavy-Duty Zero-Emission Vehicle Fleet Purchasing Assistance Program - CARB

Under existing California law, CARB administers an Air Quality Improvement Program which promotes the use of zero-emissions vehicles by providing rebates for their purchase. There is a bill in the state legislature, SB-372, which would establish a Medium- and Heavy-Duty Zero-Emission Vehicle Fleet Purchasing Assistance Program, within the Air Quality Improvement Program, and make financing tools and nonfinancial support available for the operators of medium- and heavy-duty vehicle fleets to help them transition to zero-emissions vehicles. This bill has passed State Senate with broad support, by a margin of 37-2, and for that reason appears likely to pass the Assembly and be approved by the Governor. If enacted, the bill would require that the financial tools offered by this program be available to fleets by January 1, 2023.

Zero Emissions Truck, Bus, and Infrastructure Finance Program – Southern California Edison (SCE)

SCE has filed with the California Public Utilities Commission to establish a Zero Emissions Truck, Bus, and Infrastructure Finance Program, by funding zero-emissions trucks, buses, and associated infrastructure with $20 million.

Shasta County Air Quality Management District

AB 617 Community Air Protection Program Grant Projects

The Community Air Protection Program (CAPP) is a multi-faceted program that provides funds for air districts to operate community outreach and incentive-based programs to reduce air pollution in local communities. The grants help owners of older high-polluting vehicles and equipment, make replacements with newer models that have much lower emissions -- or zero emissions. Grant funds may also be used for changes at local industrial facilities that reduce emissions of toxic or smog-forming pollutants, to build zero-emission charging stations, or to support local measures that air districts and communities identify through AB 617 Community Emissions Reduction Programs. The Shasta County Air Quality Management District is currently participating in implementation of AB 617 through development of a Best Available Retrofit Control Technology (BARCT) implementation plan.

Shasta County Air Quality Management District has obtained California Climate Investments grant funds that will be used as implementation incentives for emission reductions. Eligible projects include: Mobile Equipment Emissions Reductions through the Carl Moyer Diesel Exhaust Reduction Program, Air Filtration Systems for Schools or other Community Environments, Zero Emission Vehicle Charging Stations, and Zero Emission Commercial and Residential Landscaping Equipment Replacements.

Section II: Executive Summary

Section II: BurbankBus Executive Summary

BurbankBus is a transit agency that serves Burbank, California, and provides both demand response service and fixed-route service. Bus route modeling showed the current daily transit energy needs can be served with a 1:1 drop-in replacement using either BEBs or FCEBs for the fixed-route and dial-a-ride service. Based on the current cost of ZE buses, fueling Infrastructure, and BurbankBus's needs, BEBs are recommended.

To assess the required infrastructure for the transition, CALSTART utilized internally developed tools such as the Route Energy Model (REM) and Total Cost of Ownership (TCO) calculations. Based on the REM results, the fuel economy of the buses was estimated to be around 0.62 kWh/mi for Senior and Disabled services, and 3.00 kWh/mi for Fixed Route services. These estimates considered the city's topography and climate conditions, as well as historical trip patterns.

BurbankBus will need to acquire the appropriate charging Infrastructure to transition their fleet to ZEBs. Two types of chargers were considered: 19.2 kW (5 chargers) and 100 kW (17 chargers) to accommodate the fleet of 26 buses. The Senior and Disabled Fleet is expected to make their first ZE vehicle purchase in 2027. This will lead to a full ZE Senior and Disabled fleet conversion by 2032. For the fixed-route fleet, BurbankBus should plan to begin purchasing ZE buses in 2027, leading to 100 percent ZE fleet by 2039. BurbankBus is planning to house their Senior and Disabled Fleet and fixed-route fleet housed at the same location and the predicted peak utility load for the facility is estimated to be 1,520 kW.

To accommodate the increased load, it is anticipated that the location may require infrastructure modifications. However, due to time limitations and the heavy workload on GWP, it is currently challenging to determine the exact type of modifications needed. In this rollout plan, it is recommended that BurbankBus engage in detailed discussions with the utility company to assess the requirements for infrastructure upgrades. The cost of these upgrades could range from no cost to potentially up to $1 million for the county, depending on the current power availability at the depot.

BurbankBus is planning to house their fleet at Glendale's facility which falls within the GWP territory. GWP’s PC-1-B electric utility rate structure was utilized to calculate the running costs. This rate structure is specifically designed for large commercial businesses with power demands that exceed 500 kW, and the details can be found in **Table 2-1** below.

Table 2-1: PC-1-B Rate Structure

Fee Type	High Season	Low Season
Energy Charge - Base Period	$0.0714/kWh	$0.0714/kWh
Energy Charge - Peak Period	$0.2008/kWh	$0.1163/kWh
Relative Power Charge	$0.0040/kVar	$0.0040/kVar
Demand Charge	$0.8200/kW	$0.5800/kW

The cost of transitioning to a fully BEB fleet is projected to cost $21,698,357 between 2023 and 2040. When this amount is discounted at a rate of 5 percent per year (discounted to 2023 dollars), this amounts to a net present value of $12,640,501. Capital cost estimates include incentives like HVIP. The operating cost encompasses expenses such as bus maintenance, Electric Vehicle Supply Equipment (EVSE) infrastructure, and the running cost of the buses, as outlined in the table below. This analysis does not include utility Infrastructure upgrade costs, cost of acquiring land, or labor associated with operating the buses. With this transition, the levelized cost of energy (LCOE) is projected to be 98 cents per kilowatt-hour (kWh). Burbank's fleet transition plan, required Infrastructure, and costs are summarized below In **Table 2-2**.

Table 2-2: BurbankBus Fleet Transition Summary

Type	Vehicles	Charger Type & Qty		Utility Upgrade	Peak Daily kWh	Capital Costs	Operational Costs	Total Costs
Replacement	26 buses	19.2	5	TBD	1,520	$18,137,562	$3,560,795	$21,698,357
		5	17					

*Subject to change based on potential utility upgrade cost.

*Operating/ Running cost is calculated until 2040.

BurbankBus can successfully transition their conventional bus fleet to BEBs, accommodate future growth, and effectively manage their charging requirements by considering the drivers for ZE operations and the selection of appropriate charging infrastructure. This will contribute to the city's sustainable transportation goals while optimizing operational and economic efficiency.

Section III

Section III: BurbankBus

BurbankBus Overview

BurbankBus is a transit agency that serves Burbank, California, and provides both demand response service and fixed-route service. BurbankBus's demand response service provides curb-to-curb transit services for senior and disabled residents of Burbank. Prior to the COVID-19 pandemic, demand response service was provided all seven days of the week. On Mondays and Tuesdays, the service area for demand response extends into parts of North Hollywood and Glendale for medical-related travel. Since the COVID-19 pandemic started, Sunday demand response service has been suspended. Fixed-route service provides transit services to key locations in Burbank including the Media District, Downtown Burbank, the Bob Hope Airport, and the Burbank Metrolink Station. Fixed-route service also connects with Metro's North Hollywood Red Line Station and Metro's Universal City Station. Fixed-route service is provided Monday through Friday.

BurbankBus Senior and Disabled Transit demand response service provides curb-to-curb service for seniors and disabled residents of Burbank. Eligible riders can call BurbankBus dispatch to schedule their ride and are then picked up at their location and transported to their destination. Prior to the COVID-19 pandemic, BurbankBus demand response service was typically provided by six to seven shuttle buses. However, due to reduced Senior & Disabled ridership during the pandemic, one to three shuttle buses are currently being used for weekday service and only bus is being used for Saturday operations. This service is provided every day except on Sundays, with the service expanded on Mondays and Tuesdays to include parts of North Hollywood and Glendale for medical-related travel. Since this is a dial-a-ride service, the buses do not adhere to a fixed route. The buses normally drive between 50 and 100 miles per day and are driven on residential streets, arterial streets, and freeways. The buses also typically drive in hilly areas with high grade.

BurbankBus operates two fixed routes on weekdays. The Orange Route serves North Hollywood and the Bob Hope Airport. This route operates continuously between 5:30 am and 11 pm, and there are no gaps in service hours. The Pink Route is a bidirectional route that runs between termini at Universal City Walk and the Downtown Burbank Metrolink Station. This route operates continuously between 6 am and 11 pm.

BurbankBus Fleet and Bus Depots

BurbankBus owns all the buses that are used in transit operation. The operations and maintenance for BurbankBus's fixed-route fleet are contracted to a transit services company. The Senior and Disabled fleet is operated and maintained by BurbankBus's staff. Currently, the fixed-route buses in the fleet have internal combustion engines and are fueled with CNG. The Senior and Disabled fleet is fueled with gasoline and consists of nine Allstar 25-foot shuttle buses. Four of these buses are due to be replaced in 2020, two are due to be replaced in 2029, and the remaining three are due to be replaced in 2032. Prior to the COVID-19 pandemic, six to seven buses were put into service each day to provide demand response service, with each bus driving approximately 50 to 100 miles per day. Due to reduced Senior & Disabled ridership during the pandemic, one to three shuttle buses are being used for weekday service and only bus is being used for Saturday operations.

The Senior and Disabled fleet is currently housed at 124 South Lake Street, Burbank, California, which is a property owned by the City of Burbank. This property houses Burbank Public Works facilities and the City of Burbank's municipal fleet. This facility has a gasoline fueling station to fuel municipal vehicles. In addition, it houses a hydrogen station that will be managed by a third-party fueling company. This hydrogen station can fill vehicles at 700 bar and is designed to fill light-duty vehicles. The site also houses maintenance bays for the vehicles, ventilation equipment, and a server/data room. This depot is space constrained because it also houses the City of Burbank's municipal fleet. This problem is expected to worsen as the municipal fleet grows. As a result, it is not possible to store additional buses at this depot.

The fixed-route fleet consists of seventeen transit buses, including one President 30-foot bus, ten Bluebird L4RE 35-foot buses, and six additional ElDorado Axess 35-foot buses. Six buses are due to be replaced in 2023, five are due to be replaced in 2027, and six are due to be replaced in 2035. Fourteen of the buses are put into transit service each day. The fixed-route fleet is housed at a facility located at 1242 Los Angeles Street, Glendale, CA 91204. This property is not owned by the City of Burbank and is leased. BurbankBus contracts its maintenance to a transit services contractor. As of June 2021, the fixed-route fleet is maintained and repaired at a depot that is located at 1242 Los Angeles Street, Glendale, California 91204.

The analysis provided in this study assumes that BurbankBus will resume pre-pandemic operation levels after the COVID-19 pandemic ends. This analysis also assumes BurbankBus Is going to collocate their entire fleet at Glendale Beeline's facility at 1759 Gardena Avenue, Glendale, CA 91204.

Energy Analysis

The CALSTART-developed Route Energy Model (REM) was utilized to assess the performance of Battery Electric Buses (BEB) and estimate the average daily energy consumption for the fixed-route buses. The REM, a physics-based model, considers various factors such as topography, ambient temperature, HVAC usage, passenger weight, and route characteristics to estimate energy consumption per mile and per trip. For fixed routes, the analysis utilized GTFS files to extract location and topography data, which are crucial for accurate energy consumption estimation. The assumptions used to determine the energy requirements for BurbankBus are summarized below.

Assumptions for Route Energy Calculation:

- GTFS files and daily mileage data were used to estimate energy consumption.
- Battery electric 40-foot transit bus (Class 8) and shuttle buses (Class 5) were considered as replacement vehicles for the fixed routes.
- The maximum number of reported trips per route was considered for route energy modelling. The Pink route was assumed to travel a maximum of 106 miles per day and the Orange route was assumed to travel a maximum of 130 miles per day.
- Burbank's topography was considered for energy calculations.
- To meet the daily demand, only 80% of the total battery capacity was considered as useful energy.

A route energy model (REM) analysis was performed to determine the daily average energy consumed by the buses by considering Class 8, 40 foot buses. The analysis returned an average of 3 kWh/mile and 2.97 kWh/mile for Pink route and Orange route respectively. These energy consumptions are used to calculate the total daily energy requirement for buses to be able to meet expected levels of operation. These findings, listed in **Table 3-1** below, are vital for understanding the daily energy demands of the buses and for appropriately sizing the required infrastructure equipment.

The route modeling results demonstrate that the current daily transit energy needs can be served with a 1:1 drop-in replacement using BEBs for the fixed-route and dial-a-ride service. Based on the current cost of ZE buses, fueling Infrastructure, and BurbankBus's needs, BEBs are recommended.

Table 3-1: BurbankBus Fixed Route Energy Consumption

Route	Pink Route	Orange Route
Number of Buses	9	8
Average Daily miles per bus (miles)	106	130
Energy Consumption (kWh/mile)	3.00	2.97
Energy required per day per bus (kWh/day)	318	386

Senior and Disabled Fleet

BurbankBus's Senior and Disabled Fleet provides a dial-a-ride service. The energy demand requirements for the Senior and Disabled fleet were estimated from a bus demonstration hosted by CALSTART. The demonstration covered an approximate route that the Senior and Disabled Fleet bus would drive on a typical day. During the demonstration, a shuttle bus deployed the wheelchair lift to ensure that energy consumption from this equipment was included in the energy consumption figures. To represent a worst-case scenario, the wheelchair lift was used on twenty-five stops during the demonstration. The bus drove 99 miles in the city limits for more than seven hours and consumed approximately 61 kWh for the duration of the demonstration. Key variables from the demonstration are outlined below in **Table 3-2**.

Table 3-2: BurbankBus Senior and Disabled Fleet Demonstration Parameters

Variable	Value
Average number of people on the bus	2
Average Driving Speed	15 miles per hour
Average Temperature	66° F

Based on the results of the demonstration, the energy needs estimates for an electric shuttle bus are provided in **Table 3-3**.

Table 3-3: BurbankBus Daily Energy Needs Analysis for Senior and Disabled Fleet Service

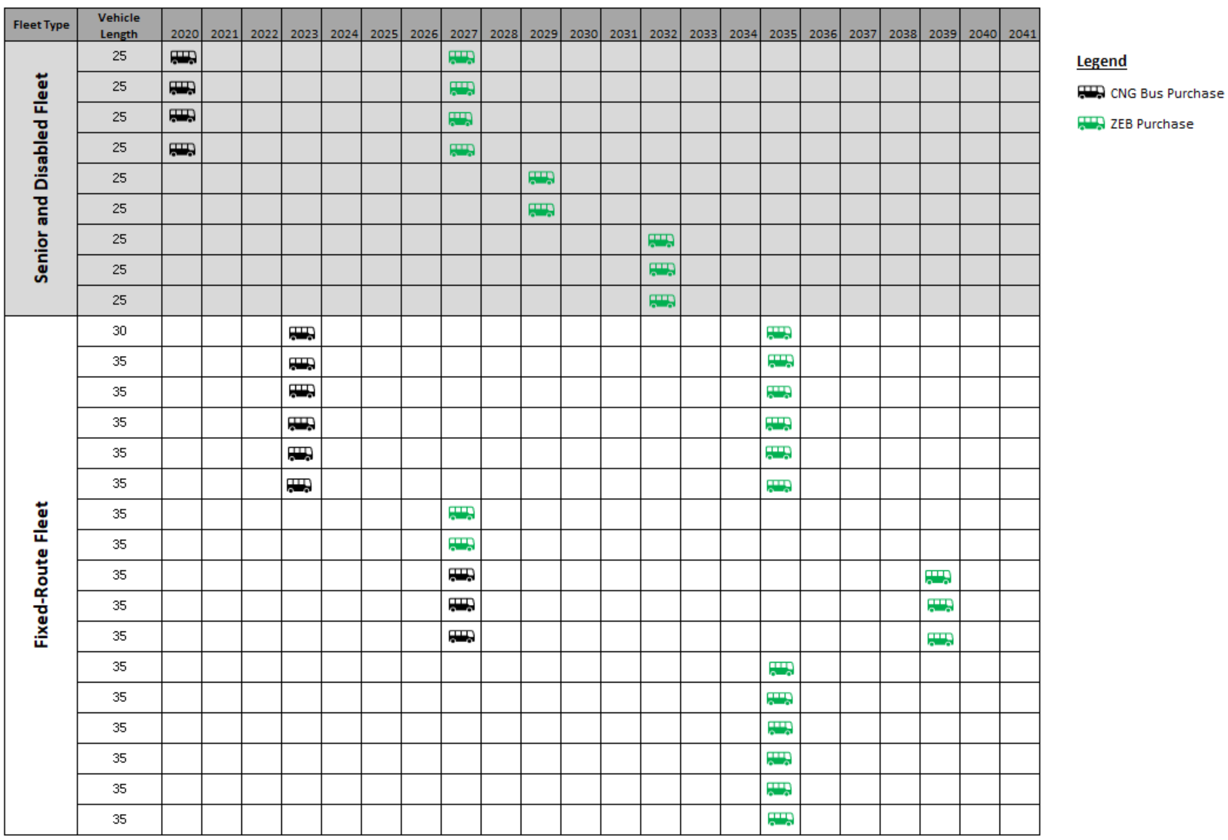
Demonstration Metric	OEM 4
Mileage	99
Energy (kWh/day)	61
Energy Economy (kWh per mile)	0.616

These figures estimate the amount of energy that one Senior and Disabled Fleet bus will consume over the course of a typical service day. Based on these results, the buses are considered a drop-in replacement for BurbankBus's duty cycle because it requires less than 80% of the battery's storage capacity to complete service. The daily energy needs per bus for the Senior and Disabled Fleet Is estimated to be approximately 61 kWh per day. It is important to note that the majority of the driving during the demonstration took place on surface streets, with a few trips on the freeway. As a result, this estimate should be valid for service that is primarily driven at low speeds.

Fleet Replacement Plan

BurbankBus will replace their current fleet with ZEBs over multiple years. BurbankBus plans to replace the current fleet as the buses reach the end of their useful life. CALSTART developed a fleet replacement plan based on BurbankBus's fleet replacement schedule. This fleet replacement plan assumes that BurbankBus will begin purchasing buses after 2026, when the ICT regulation comes into effect for small transit agencies. The plan also assumes minimum compliance with the ICT regulation's purchasing requirements. The fleet replacement plan is displayed below in **Figure 3-4**.

Figure 3-1: BurbankBus Fleet Replacement Plan



According to this plan, the first zero-emission shuttle buses in the Senior and Disabled Fleet will be purchased in 2027, and the first purchases of ZEBs in the Fixed-route Fleet will begin in 2027. The Senior and Disabled Fleet will be fully zero-emission by 2032, and the Fixed-route Fleet will be fully zero-emission by 2039.

BurbankBus has the option to purchase BEBs or FCEBs. There are multiple factors that need to be considered when selecting a technology. The main factors that need to be considered are the capability of the technology, capital costs and total cost of ownership, and infrastructure viability. Based on the energy analysis, both technologies can serve as a drop-in replacement for a CNG bus and are capable of handling BurbankBus's duty cycle. The capital expenditures and total cost of ownership are also a major factor. BEBs have a lower capital cost and are projected to have a lower total cost of ownership. Lastly, due to space constraints, installing hydrogen fueling infrastructure would be challenging. As a result, CALSTART recommends that BurbankBus transitions their fleets to BEBs.

BEB Charging Cost Analysis

Glendale Water & Power (GWP) Overview

BurbankBus's proposed bus depot location is served by Glendale Water & Power (GWP), which is a municipal utility that serves the City of Glendale. GWP is owned by the City of Glendale and is also a member of the Southern California Public Power Authority (SCPPA). GWP manages multiple assets including fourteen substations, 503 miles of distribution lines, and 14,768 utility poles. In FY2019-20, GWP provided a total of 1,540,033 MWH with a system peak power demand of 288 MW. GWP uses a variety of resources to provide power to Glendale. GWP owns the Grayson Power Plant, which is a local natural gas power plant located in the City of Glendale used produce electricity. This power plant produced 119,213 MWH during FY2019-20 (GWP, 2020). The Grayson Power Plant is undergoing several upgrades to modernize the facility.

Figure 3-2: GWP Electric Utility Operating Statistics (GWP, 2020)

SYSTEM SUPPLY (MWH)	FY2019-20	FY2018-19	FY2017-18	FY2016-17	FY2015-16
Owned Generation					
Glendale Owned Generating Facilities					
Natural Gas Units (Grayson)	119,213	79,210	158,353	160,396	179,028
Jointly Governed Organizations / Remote Ownership					
Intermountain Power Project (IPA)	233,619	243,520	250,391	240,123	242,105
PV Nuclear Generating Station (SCPPA)	82,196	81,767	83,928	83,317	84,190
San Juan Unit 3 (SCPPA)	-	-	57,026	136,669	112,255
Magnolia Power Project (SCPPA)	211,566	244,479	250,177	225,603	270,975
Tieton Hydropower Project (SCPPA)	19,072	18,499	26,955	29,954	26,003
Total Owned Generation	**665,666**	**667,475**	**826,830**	**876,062**	**914,556**
Purchased Power					
Purchased Power Contracts	453,634	451,655	412,286	453,419	349,826
Market Purchases	420,733	490,888	327,594	381,013	418,806
Total Purchased Power	**874,367**	**942,543**	**739,880**	**834,432**	**768,632**
Total System Supply	**1,540,033**	**1,610,018**	**1,566,710**	**1,710,494**	**1,683,188**
System Peak (MW)	**288**	**332**	**344**	**293**	**332**

GWP also imports power. GWP obtains power from several power plants that they jointly own through SCPPA or that are remotely owned. The power from these sites is transported through the transmission system to GWP. GWP also obtains electricity through purchased power contracts and market purchases. The vast majority of GWP's power does not originate from local sources.

GWP is also obtaining power from renewable sources and aims to obtain 100 percent of its power from clean sources. GWP owns a 12.5 percent share of the Eland 1 Solar and Storage Center in Kern County. GWP also receives power from the Whitegrass and Star Peak Geothermal projects and owns a 4.166 percent share of the Intermountain Power Plant in Utah. GWP also uses local solar and battery storage to provide power. The City of Glendale also recently signed an agreement to deploy solar and storage at multiple municipal facilities throughout the city.

BurbankBus Electric Utility Tariffs

When the City of Burbank transitions to BEBs, they will incur utility costs as the fleet electrifies. The City of Burbank will be purchasing power from GWP and would qualify for the PC-1-B tariff. The PC-1-B tariff is a TOU rate for large customers that have a power demand of greater than 500 kW. As a TOU tariff, PC-1-B has different rates for energy depending on the time of day. The day is divided into the base period and the peak period. From July to October, or the High Season, the peak period occurs between 2 pm – 7:59 pm on weekdays. From November to June, or the Low Season, the peak period occurs between 12 pm – 8:59 pm. All other times are in the base period. In this analysis, the buses are assumed to charge only during base hours.

The PC-1-B tariff also has demand charges. Demand charges are assessed based on the maximum kW consumed over the course of a year. There is also a separate demand charge based on reactive power. This demand charge is assessed based on the maximum kVAR that occurs over the course of a year. For estimating Burbank's utility costs, CALSTART assumed a power factor of 90% to estimate the kVar demand charges. A summary of the administrative, demand/ energy charges, and peak period timing under the PC-1-B rate structure Is provided In **Table 3-4**.

Table 3-4: PC-1-B Rate Structure

Fee Type	High Season	Low Season
Energy Charge - Base Period	$0.0714/kWh	$0.0714/kWh
Energy Charge - Peak Period	$0.2008/kWh	$0.1163/kWh
Relative Power Charge	$0.0040/kVar	$0.0040/kVar
Demand Charge	$0.8200/kW	$0.5800/kW

Table 3-5: PC-1-B Rate Structure - Peak Period Timing

Peak Period Timing		
High Season Peak Period	**2PM - 7:59PM**	**Monday to Friday (excluding holidays)**
Low Season Peak Period	**12:00 PM to 8:59 PM**	**Monday to Friday (excluding holidays)**

Facility and infrastructure Modifications

BurbankBus Facility Planning

BurbankBus is planning to co-locate their fleet of 26 vehicles at Glendale's transit facility, which is located within the GWP service territory. Based on a load analysis, the peak energy required for charging the replacement buses is approximately 1,520 kW as shown in the figure below. Due to this large power demand, GWP will likely need to Install additional utility Infrastructure to serve a fully electric fleet for BurbankBus. The City of Burbank will need to coordinate the GWP and any other transit agencies, such as Glendale's Beeline service, to plan for the future utility upgrades that are necessary to support Burbank's fleet conversion to electric vehicles.

Figure 3-3: Depot Charging Load Profile

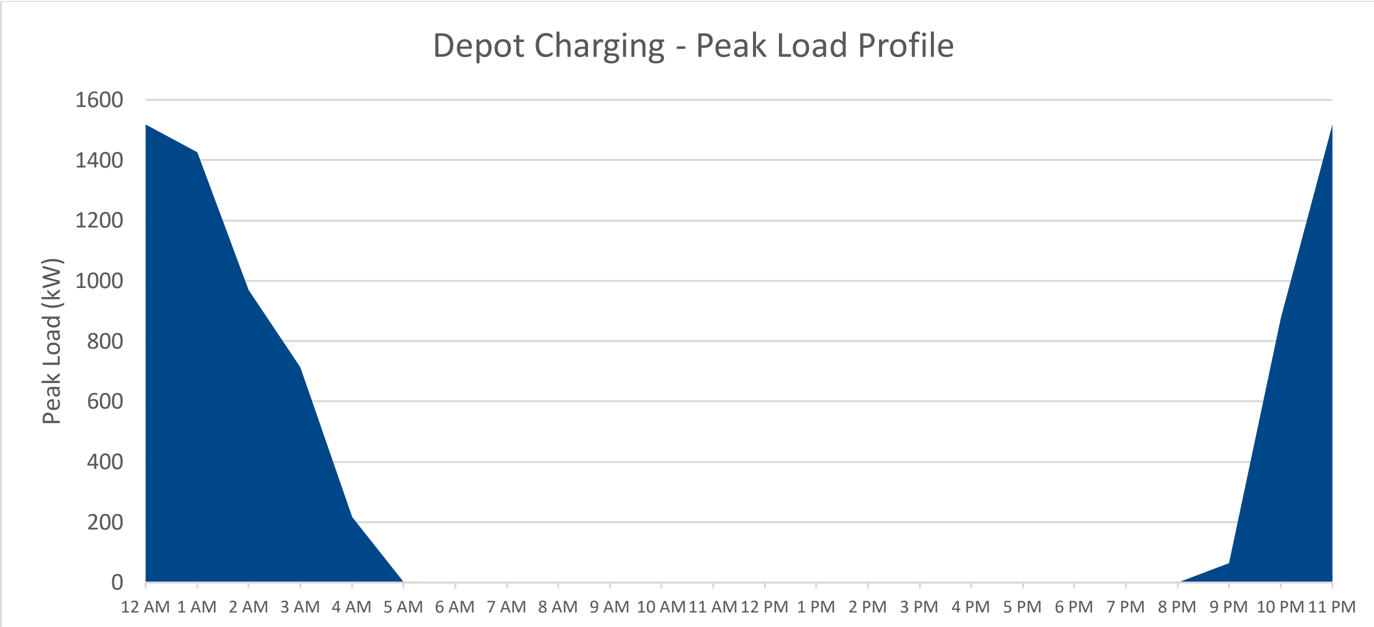


Table 3-6: BurbankBus Depot Summary

Facility Name	Address	Main Function(S)	Utility Service Capacity	Utility Upgrade (Yes/No)	Infrastructure Need		
					Type	Port Type	Qty
Glendale Beeline Maintenance Facility	1759 Gardena Av., Glendale, CA 91204	Vehicle Maintenance/ Storage Bus Parking	TBD	Yes	19.2 KW	Dual-Port	5
					100 KW	Single-Port	17

To meet the electricity needs required for the 26 planned battery electric vehicles, two different chargers were considered for depot charging: 19.2 kW and 100 kW chargers. Five dual port 19.2 kW chargers are sufficient to charge all nine paratransit cutaway shuttle buses at the depot. Seventeen 100-kW chargers are required to charge the seventeen transit buses used for the fixed routes.

Overall, BurbankBus is taking a proactive approach to ensuring that its transit operations are energy-efficient and sustainable. By carefully analyzing its energy needs and exploring the most efficient charging options, the city can reduce its carbon footprint and provide reliable transportation services to its residents.

Alternative Facility Planning

While the City of Burbank will be working with the City of Glendale on co-locating BurbankBus in Glendale, there may be a possibility of not having enough space to house all vehicles, accommodate the chargers, driving lanes, utility equipment, employee parking, maintenance facilities, and office space in Glendale. The City of Burbank has identified opportunity sites if there is a need for additional space:

- Downtown Burbank Metrolink Station;

- Burbank Zones: Burbank Center Commercial Manufacturing (BCCM); and
- Other San Fernando Valley cities such as Sun Valley and other parts of Glendale.

If co-locating buses at Glendale is not feasible, a BEB transit operations facility for BurbankBus will require the installation of a utility transformer, a main disconnect, a switchboard, power cabinets, and up to 26 chargers. The BurbankBus ZEB Rollout Plan outlines types of charging stations the City would consider for BEBs such as overhead, inductive, and plug-in charging.

All financial analysis, cost estimates, route energy modelling, and load demand analysis assumed that BurbankBus will house their vehicles at Glendale’s facility. If this is unfeasible, the cost estimates provided below may no longer be accurate. Additional cost analysis is recommended once BurbankBus has confirmed the depot location for their fleet.

Financial Analysis & Cost Estimates

Transitioning to a ZEB fleet from an ICE fleet requires high upfront capital investments. However, the ZEB implementation makes up for this cost due to their low operations costs including energy/fuel charges and maintenance cost. CALSTART has calculated the capital cost associated with this transition based on the ICT rollout mandate and BurbankBus' proposed plans for transitioning their fleet to zero emission vehicles. In addition to the initial investment, CALSTART has also calculated the levelized cost of converting Burbank's fleet to battery electric vehicles until 2040, considering the lifetime of the vehicles. Capital costs for all vehicles and equipment are listed in **Table 3-8** and **Table 3-9** and later summarized with references in **Table 3-12**.

Table 3-7: BurbankBus Infrastructure Costs

Equipment	Amount	Unit Cost ($)
19.2 kW Charger (Port-2)	5	$5,068
100 kW Charger (Port-1)	17	$58,366

Table 3-8: BurbankBus Vehicle Capital Costs

Vehicle Type	Number of Vehicles	Unit Cost ($)*
Battery Electric Cutaway Bus	9	$240,000
Battery Electric Transit Bus (40 feet)	17	$880,000

*The capital cost of the buses include HVIP incentives: $120,000 for Class 8 vehicles and $60,000 for Class 5 vehicles. See State Funding Sources and Incentives for additional details.

Table 3-8 and Table 3-9 outline the initial capital costs associated with the replacement schedule of Burbank's fleet, which involves transitioning to 26 ZEVs. These cost calculations are based on the following assumptions:

- The Burbank will house all of their vehicles at Glendale's transit depot, which falls under the GWP's Utility territory. The current electric utility costs for GWP are summarized in **Table 3-6**.
- To calculate the relative power for utility demand charges, a 90% power factor was assumed.
- This analysis assumes a vehicle charging efficiency of 95%.
- All capital costs associated with vehicle charging/fueling infrastructure and vehicle purchasing are industry averages obtained from various OEM catalogs.
- Maintenance costs for electric vehicles are estimated from Argonne National Laboratory’s Alternative Fuel Life-Cycle Environmental and Economic Transportation tool.
- Levelized costs were calculated using a 5% discount rate and costs were calculated from 2023 to 2040.

- No utility upgrade costs were Included In this analysis. Burbank should coordinate with Glendale to determine the plan for financing the required utility Infrastructure upgrades at the Beeline bus maintenance facility.
- LCFS credit costs are not Included In the capital, operational, or total financial estimates; however, CALSTART has performed an Initial estimation of the total revenue from LCFS credits. It is estimated that a total of $1,300,000 In LCFS credit revenue will be generated from 2023 to 2040 assuming a $0.08/kWh price. This revenue was estimated assuming a total credit price of $80 and carbon Intensities from CARB's LCFS compliance schedule for 2024. However, the LCFS credits are subjected to change over time.

Table 3-9: BurbankBus Financial Costs

Year	Capital Expenditures	Operational Expenditures	Total
2027	$2,846,868	$81,433	$2,928,301
2028	$0	$81,433	$81,433
2029	$485,068	$94,150	$579,218
2030	$0	$94,150	$94,150
2031	$0	$94,150	$94,150
2032	$730,136	$113,277	$843,413
2033	$0	$113,277	$113,277
2034	$0	$113,277	$113,277
2035	$11,260,392	$436,517	$11,696,909
2036	$0	$436,517	$436,517
2037	$0	$436,517	$436,517
2038	$0	$436,517	$436,517
2039	$2,815,098	$514,791	$3,329,889
2040	$0	$514,791	$514,791
Total	$18,137,562	$3,560,795	$21,698,357
Levelized Cost	$0.98/kWh		

Table 3-10: BurbankBus Financial Costs Summary (2027 to 2040)

Transit Agency	Capital Expenditures	Operational Expenditures	Total
BurbankBus	$18,137,562	$3,560,795	$21,698,357

Using the capital, operational, and utility costs presented in above, the levelized cost of ownership was estimated for the battery electric fleet conversions. The approximate levelized cost for the fleet transition to battery electric vehicles is $0.98/kWh. However, it is important to note that the financial calculations are only for transitioning of ICE vehicles to zero emission vehicles and the cost of replacing vehicles at the end of their useful life (after the initial purchase is made) is not considered in the calculation. The capital and operational expenditures considered in the financial calculations are shown in **Table 3-12**.

Table 3-11: BurbankBus Financial Assumptions Summary

	Type	Details	Category	Cost
Capital Expenditures (One Time Costs)	**Vehicle Cost**	The upfront cost of purchasing the battery electric vehicles, including approximate incentives.	Class 5 Cutaway/Shuttle - Electric	$240,000*
			Class 8 Transit Bus - Electric	$880,000*
	Charger Cost	The upfront cost of purchasing the electric chargers.	19.2 kW (Dual Port)	$5,068
			100 kW (Single Port)	$58,366
Operational Expenditures (Reoccurring Costs)	**Bus Maintenance Cost**	The average maintenance cost per mile.	Cutaway/Shuttle - Electric	$0.13/mile
			Transit Bus - Electric	$0.60/mile
	Infrastructure Maintenance Cost	2% of the capital cost of charger or fueling equipment.	19.2 kW	$101/Charger/Year
			100 kW	$1,167/Charger/Year
	Running/Charging Cost	Includes utility costs.	Paratransit - Electric	$4,400/Bus/Year
			Transit Bus - Electric	$9,500/Bus/Year

*The capital cost is assumed to be $1,000,000 but the cost of the buses include HVIP incentives: $120,000 for Class 8 vehicles and $60,000 for Class 5 vehicles. See **State Funding Sources and Incentives** for additional details.

Previous work for BurbankBus completed by CALSTART and funded by CalTrans was completed in 2022. The analysis has been added as an appendix to this document: **Appendix E: Financial Analysis & Cost Estimates (February 2022).**

Financing Strategy

BurbankBus will need a financing strategy to transition to a zero-emission fleet. Please see Financing Strategies & Resources for ZEB deployment funding options.

Once a transit property has been acquired and the infrastructure upgrades have been completed, the operational costs are expected to be covered by BurbankBus's operating budget. However, the purchase of the buses needs to be financed. Bus purchases can be financed with various grant and funding sources (see Financing Strategies & Resources). Most of these grant and finance programs will only partially finance the cost of the buses. To maximize funding for bus purchases, it would be advisable to apply for multiple grants so they can be stacked. It is unlikely that grants will pay for the entire transition to a zero-emission fleet. The main objective when pursuing grants should be to cover the incremental cost of zero emission buses, or the difference between the cost of a ZEB and a CNG bus. Using grants to cover the incremental cost of the buses would allow BurbankBus to purchase ZEBs with the funding sources they normally employ to purchase buses.

BurbankBus should also consider which finance methods would be most appropriate for their agency. If BurbankBus is amenable to capital expenditures, then traditional financing models would be the most appropriate. However, if BurbankBus prefers to avoid or reduce capital expenditures, then financing models like bus/battery leasing or IAAS would be more appropriate. These financing models would effectively allow BurbankBus to pay for capital expenditures from their operational budget.

Implementation Plan

BurbankBus has many options for deploying a ZEB fleet. The most practical option would be to deploy a BEB fleet. As discussed under Financial Analysis and Cost Estimates, a fully BEB fleet would be a cheaper option than deploying a fully FCEB fleet. Furthermore, since BEBs can serve as a drop-in replacement for all of BurbankBus's shifts, there would not be any bus performance benefits to deploying an FCEB fleet.

BurbankBus will be moving the fixed route and DAR fleet to Glendale Beeline's depot. Together, they will complete a transit route analysis for 2024 and consider branding as a regional transit service. The goal of this analysis is to provide a comprehensive vision of how Glendale Beeline and BurbankBus can adapt and reorient transit services to better meet the travel needs of future and current residents/visitors. This analysis would take into consideration the mobility network in Los Angeles (e.g. Metro, LADOT, and La Canada Flintridge) and future changes such as the Metro Bus Rapid Transit, Golden State Specific Plan, Media District Specific Plan, and Downtown Burbank Transit Oriented Development Specific Plan. Part of this analysis would also include public outreach component to understand the community's travel needs and preferences between both cities.

It is vital that the utility upgrades occur before the buses arrive. If this is not completed, then the buses will not be able to charge. In addition, during the construction process, the site can be unusable, especially during trenching. BurbankBus should coordinate with GWP to ensure that the utility upgrades are coordinated with the delivery of the buses. If the buses arrive before the utility upgrades and/or site construction is completed, BurbankBus can use temporary chargers until the permanent charging infrastructure is ready for use.

Disadvantaged Communities

BurbankBus's service area includes disadvantaged communities (DAC). DACs can be identified by using the CalEnviroScreen 4.0 tool. The CalEnviroScreen tool assigns a score to each California census tract based on pollution levels and population vulnerability to pollution. This score is used to rank each census tract, where higher scores indicate worse pollution. Census tracts with worse scores typically have higher levels of pollution. They also tend to have a higher proportion of children or elderly who are more vulnerable to the health effects of pollution. As a result, DACs are at higher risk of adverse health effects from pollution, including elevated levels of asthma, respiratory disease, and cardiovascular disease.

Census tracts that are in the top 25 percentile are considered to be DACs. BurbankBus's service area overlaps with 11 DACs. The table below lists the census track and percentile.

Table 3-12: BurbankBus Census Track DAC Summary

Census Track	Percentile
6037125320	87
6037125310	83
6037124300	83
6037124203	82
6037124201	91
6037124103	93
6037123206	95
6037123103	94

6037310501	92
6037311802	85
6037311801	78

Appendix A

Appendix A: Zero Emission Bus Specifications

Battery Electric Transit Buses (BEBs)

Proterra – ZX5

This transit bus features faster acceleration, industry-leading gradeability, and a range of more than 125 miles per charge. The ZX5 has a capacity of up to 29 passengers.

PROTERRA

SPECIFICATIONS	SPECIFICTION VALUE(S)
Passenger Capacity	29
Lift Capable	Yes
Battery Size	225 kWh
Approximate nameplate single-charge range	95-125 miles
Length	35 Ft
Source	*https://www.proterra.com/wp-content/uploads/2021/01/Proterra-ZX5-Spec-Sheet-35-Foot-Bus-U.S..pdf*

Proterra – ZX5 MAX

This transit bus is approximately five feet longer than the standard Proterra ZX5 bus model, which can accommodate 40 passengers and run up to 329 miles on a single charge.

PROTERRA

SPECIFICATIONS	SPECIFICTION VALUE(S)
Passenger Capacity	40
Lift Capable	Yes
Battery Size	675 kWh
Approximate nameplate single-charge range	221-329 miles
Length	40 Ft
Source	*https://www.proterra.com/wp-*

	content/uploads/2021/01/Proterra-ZX5-Spec-Sheet-40-Foot-Bus-U.S..pdf

Proterra – ZX5+

A 35-foot bus that can run up to 240 miles on a single charge and has a capacity of up to 29 passengers.

PROTERRA

SPECIFICATIONS	SPECIFICTION VALUE(S)
Passenger Capacity	29
Lift Capable	Yes
Battery Size	450 kWh
Approximate nameplate single-charge range	172-240 miles
Length	35 Ft
Source	*https://www.proterra.com/wp-content/uploads/2021/01/Proterra-ZX5-Spec-Sheet-35-Foot-Bus-U.S..pdf*

New Flyer – XCELSIOR XE

A 35-foot bus that can be configured to carry up to 35 passengers standing and 32 seating. The XCELSIOR has two battery options at 350 kWh and 440 kWh.

NEW FLYER

SPECIFICATIONS	SPECIFICTION VALUE(S)
Passenger Capacity	Up to 32 seats, up to 35 standees
Lift Capable	Yes
Battery Size	350 kWh, 440 kWh
Approximate nameplate single-charge range	179, 220 miles
Length	35 Ft
Source	*https://www.newflyer.com/site-content/uploads/2021/03/Xcelsior-CHARGE-NG-Brochure-1.pdf*

New Flyer – XCELSIOR XE

A more extended version of its 35-foot counterpart, is capable of operating with three different battery sizes (350 kWh, 440 kWh, and 525 kWh). Each battery size gives varies in range, going up to 251 miles on a single charge.

NEW FLYER

SPECIFICATIONS	SPECIFICTION VALUE(S)
Passenger Capacity	Up to 40 seats, up to 44 standees
Lift Capable	Yes
Battery Size	350 kWh, 440 kWh, 525 kWh
Approximate nameplate single-charge range	174, 213, 251 miles
Length	40 Ft

Source	*https://www.newflyer.com/site-content/uploads/2021/03/Xcelsior-CHARGE-NG-Brochure-1.pdf*

BYD – K9S

A 35.8-foot bus with a maximum load of 33 passengers, including the driver. The K9S can travel up to 157 miles on a single charge.

SPECIFICATIONS	SPECIFICTION VALUE(S)
Passenger Capacity	32 + 1
Lift Capable	Yes
Battery Size	266 kWh
Approximate nameplate single-charge range	Up to 157 miles
Length	35.8 ft
Source	*https://en.byd.com/bus/35-electric-transit-bus/*

BYD – K9M

A 40-foot plus bus with two battery sizes, 313 kWh and 352 kWh. The passenger load varies on configuration and can comfortably sit between 38 and 43 passengers depending on the battery size. This Altoona-tested model can run up to 160 miles contingent on the battery size selected.

SPECIFICATIONS	SPECIFICTION VALUE(S)
Passenger Capacity	Up to 37+1 / Up to 42+1 MD
Lift Capable	Yes
Battery Size	313 kWh / 352 kWh MD
Approximate nameplate single-charge range	Up to 156 miles / Up to 160 miles MD
Length	40.2 ft / 40.9 ft MD
Source	*https://en.byd.com/bus/40-foot-electric-transit-bus/#specs*

Shuttle Buses/Vans

Lightning eMotors — Electric Zero-Emission Transit Passenger Van

A shuttle bus equipped with an electric drivetrain that delivers efficiency. The Lightning Electric Transit passenger van carries up to 15 passengers and can run up to 260 miles on a single charge.

SPECIFICATIONS	SPECIFICTION VALUE(S)
Passenger Capacity	15 passengers (including driver)
Lift Capable	Yes
Battery Size	80 kWh/120 kWh
Approximate nameplate	Up to 260 miles

single-charge range	
Source	*https://lightningemotors.com/wp-content/uploads/2021/05/LeM_G4_Transit_passenger_van_sheet_May2020_v1.0_online.pdf*

Lightning eMotors – Ford E-Transit

SPECIFICATIONS	SPECIFICTION VALUE(S)
Approximate nameplate single-charge range	126 miles estimated
Availability	2022
Source	*https://lightningemotors.com/transit-vans-ford-vs-lightning/*

Lightning eMotors — Electric Zero Emission F-550 Bus

This bus has an estimated range of over 100 miles while producing zero emissions on the road. The F-550 Bus's charging capabilities are flexible, with Level 2 AC charging as standard and DC Fast Charging also being available, providing up to 80 kW.

SPECIFICATIONS	SPECIFICTION VALUE(S)
Battery Size	128 kWh
Approximate nameplate single-charge range	100 miles estimated
Length	About 18 ft
Source	*https://lightningemotors.com/lightningelectric-f550/*

Phoenix Motorcars — Ford E-450 Cutaway Bus

The Starcraft Allstar is powered by Phoenix Motorcars, designed to offer sustainable transportation for shared mobility and commuter transporter. The bus features seating configurations accommodating 12-20 (14 with two-seat ADA option available). Phoenix provides a five-year/60,000 drive system and provides an extended battery warranty of 8 years/300,000 miles.

SPECIFICATIONS	SPECIFICTION VALUE(S)
Passenger Capacity	12-20 Passengers (14 with 2 seat ADA option)
Lift Capable	Yes
Battery Size	86-129 kWh
Approximate nameplate single-charge range	80-110 miles
Source	*https://www.creativebussales.com/featured-product--Phoenix-Motorcars*

Phoenix Motorcars – ZEUS 400 Shuttle Bus

A fully customizable with a battery capacity of 140 kWh and a single-charge range of up to 150 miles. The ZEUS 400 is eligible for the Phoenix Motorcar's PMC Battery Warranty of 5 Years/150,000 Miles, the PMC Drive System Warranty of 5 Years/60,000 Miles, the Bumper-to-Bumper Warranty of 3 Years/36,000 Miles, and the Body Structure Warranty of 5 Years / 100,000 Miles.

SPECIFICATIONS	SPECIFICTION VALUE(S)
Passenger Capacity	Up to 23 passengers forward seating, 12/2, 14/2, 16/2 ADA
Lift Capable	Yes
Battery Size	140 kWh
Approximate nameplate single-charge range	150 miles
Length	22 ft
Source	*https://www.phoenixmotorcars.com/products/#shuttles*

GreenPower — EV Star

A multi-purpose, zero-emission, min-E Bus with a range of up to 150 miles and offers dual charging capabilities as a standard feature. The EV Star can be used for paratransit, employee shuttles, micro-transit, and vanpool service. The EV Star is the only Buy America compliant and Altoona-tested vehicle in its class.

SPECIFICATIONS	SPECIFICTION VALUE(S)
Passenger Capacity	19 FF / 21 Perimeter
Lift Capable	Yes
Battery Size	118 kWh
Approximate nameplate single-charge range	Up to 150 miles
Length	25'
Source	*https://greenpowermotor.com/gp-products/ev-star/*

GreenPower – EV Star+

A cutaway bus with a broader body to utilize the interior space. It is designed for paratransit fleet operations—a larger seating capacity and wheelchair position options are available. The bus is ideal for hospitals, carpooling services, airport shuttles, and campus transportation.

SPECIFICATIONS		SPECIFICTION VALUE(S)
Passenger Capacity		24
Lift Capable		Yes
Battery Size		118 kWh
Approximate nameplate single-charge range		Up to 150 miles
Length		25'
Availability		Yes

Source		*https://greenpowermotor.com/gp-products/ev-star-plus/*

Appendix B

Appendix B: Charging Infrastructure Specifications

The following electrical cabinets and electric vehicle supply equipment (EVSE) units were evaluated by CALSTART. A side-by-side comparison between these products, including prices, is included. The cost of the plug-in charging equipment varies depending on the manufacturer. Most plug-in chargers cost approximately $40,000 to $60,000 per bus depending on the power level. This amount includes only the cost of the charging equipment and does not include construction and installation costs, nor the cost of an overhead structure if overhead plug-in charging is deployed.

Proterra 60 kW Power Control System

PROTERRA

Proterra 60 kW Power Control System
Proterra is a U.S. 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 bus, the battery can be completely recharged in approximately 6 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

PROTERRA

Proterra 125 kW Power Control System

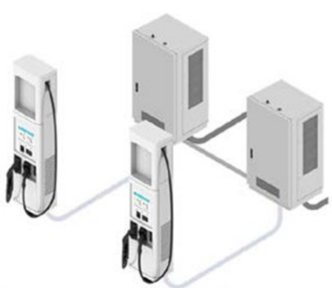
The 125 kW Power Control System is a simple solution with twice the power of the 60 kW version. The electrical cabinet (shown left) provides up to 125 kW of power to a single EVSE unit to charge a single electric bus. The bus's battery can be recharged in approximately three hours, which gives the fleet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

BTC Power 100 – 350 kW Modular High Power DC Fast Chargers

BTC POWER

BTC Power
100 – 350 kW Modular High Power DC Fast Chargers

Based in Santa Ana, California, BTC Power manufactures High-Performance DC Charging Systems. The electrical cabinet (which BTC calls the "Power Engine") can provide power at 100, 150, or 200 kW. 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 smart charging software to their EVSEs 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 Los Angeles International Airport and Porterville Transit.



BTC Power 200 – 475 kW High Performance DC Charging System

BTC POWER

BTC Power
200 – 475 kW High Performance DC Charging System

BTC Power was selected to be the sole North American provider of Porsche's High Performance DC Charging System. Capable of delivering up to 475 kW, this design utilizes two cabinet modules: one to convert the energy from AC to DC (called a "Power Box") and the other to provide liquid cooling to the EVSE units (called a "Cooling Box"). These cabinets connect to two EVSEs 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's other chargers, the High Performance DC Charging System is smart charging software capable, which makes it very easy to integrate a data management solution. At the time of this writing, there are no existing examples at a transit agency.

ABB
HVC 150 E-Bus
Charger (NAM)

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, which uses CCS1 or CCS2 connectors, can deliver 150 kW to the bus. The system utilizes one electrical cabinet to support up to three EVSE, and charges each one 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 their ABB Ability data management program. Several transit agencies, including TriMet in Portland, Oregon and Utah Transit Authority, are utilizing their chargers.

HVC150C:

- HVC150C charger with one remote depot box, 7m cables:
- HVC150C charger with two remote depot boxes, 7m cables:
- HVC150C charger with three remote depot boxes, 7m cables:
- OPTION: Pedestal for one depot box:
- OPTION: Cable management for one depot box:
- OPTION: Long distance support package:
    - Extends distance between power cabinet and remote depot box to 150M
- OPTION: Robustness package:
    - Required for systems installed in harsh climates

HVC-C Depot Plug-In
HVC100C (100 kW)

- 1:1 Charger: Depot with 7M cable
- 1:2 Charger: Depot, 7M cables, sequential charging package
- 1:3 Charger: Depot, 7M cables, sequential charging package

HVC100C Buy America

- 1:1 Charger: Depot with 7M cable, BAA
- 1:2 Charger: Depot, 7M cables, sequential charging package, BAA
- 1:3 Charger: Depot, 7M cables, sequential charging package, BAA

HVC150C (150 kW)

- 1:1 Charger: Depot with 7M cable
- 1:2 Charger: Depot, 7M cables, sequential charging package
- 1:3 Charger: Depot, 7M cables, sequential charging package

HVC150C Buy America

- 1:1 Charger: Depot with 7M cable, BAA
- 1:2 Charger: Depot, 7M cables, sequential charging package, BAA
- 1:3 Charger: Depot, 7M cables, sequential charging package, BAA

Options Robustness Package

- For installation in very cold / hot climates
- Long Distance Package
- Extends distance between power cabinet and depot to 150 M
- Standard without LD Package is 20 M
- Power Cabinet Metal Frame Foundation

- Depot Box Pedestal
- Cable Management
- Standard installation is mounted on Depot Box Pedestal
- Commissioning — Variable dependent on site

HVC-PD Overhead Pantograph

HVC150PD (150 kW)

- Charger with pantograph mounted on ABB mast
- Charger with pantograph mountable on existing structure

HVC150PD Buy America

- Charger with pantograph mounted on ABB mast, BAA
- Charger with pantograph mountable on existing structure, BAA

HVC300PD (300 kW)

- Charger with pantograph mounted on ABB mast
- Charger with pantograph mountable on existing structure

HVC300PD Buy America

- Charger with pantograph mounted on ABB mast, BAA
- Charger with pantograph mountable on existing structure, BAA

HVC450PD (450 kW)

- Charger with pantograph mounted on ABB mast
- Charger with pantograph mountable on existing structure

HVC450PD Buy America

- Charger with pantograph mounted on ABB mast, BAA
- Charger with pantograph mountable on existing structure, BAA

Options

- Robustness Package
- For installation in very cold / hot climates
- Long Distance Package
- Extends distance between power cabinet and depot to 150 M
- Standard without LD Package is 20 M
- Power Cabinet Metal Frame Foundation
- RFID Antenna Kit
- For installing pantographs in close proximity
- Commissioning — Variable dependent on site

Web Tools

ABB Connected Services

- Charger Connect
- Covers costs associated with cellular network connectivity, software upgrade support, data connection to ABB
- Operator Pro / EVE Platform
- Data management, reporting, charger status visibility

Terra - Terra HP and Terra 54HV:

Terra Terra HP and Terra 54HV

Terra
Budgetary numbers on Terra HP and Terra 54HV:
 	
Terra HP 175 kW unit w 1 power cabinet and dispenser:
Terra HP 350 kW unit w 2 power cabinets and dispenser:
 	
Terra 54HV 50 kW unit:
OPTION: Terra 54HV Cable Management
 	
Quick budgetary numbers for our HVC150C:
• HVC150C charger with one remote depot box, 7m cables:
• Same as above, BAA:
• HVC150C charger with two remote depot boxes, 7m cables:
• Same as above, BAA:
• HVC150C charger with three remote depot boxes, 7m cables:
• Same as above, BAA
 	
• OPTION: Pedestal for one depot box:
• OPTION: Cable management for one depot box
• OPTION: Long distance support package:
  ○ Extends distance between power cabinet and remote depot box to 150M
• OPTION: Robustness package:
  ○ Required for systems installed in harsh climates
 	
Included in above:
Project management, Engineering, Transport and packaging in continental US, on-site commissioning and start up, Charger connection fees for 2 years. 2 year warranty.
 	
Excluded in above:
Interconnection DC cables, installation and civil works, options as listed below

Heliox – Fast DC 150 Charger

Heliox Fast DC 150 Charger

Heliox is a Netherlands-based EV charging infrastructure company that develops charging infrastructure for electric vehicles. Manufactured in the Netherlands, this 150 kW charger charges one vehicle on a first-come, first serve basis. Heliox also has the world's largest opportunity and depot charge network. This charger can charge any J1772 and/or J3105 compatible truck, bus, or heavy-duty vehicle. Most of Heliox's customers are transit agencies in Europe, but the company is expanding into the U.S. market, having recently opened a headquarters in Portland, Oregon.

ChargePoint -
Express Plus Double Stacked Power Block

ChargePoint
Express Plus Double Stacked Power Block

ChargePoint is a San Francisco Bay Area-based electrical vehicle charging company. Founded in 2007, it operates over 57,000 charging stations worldwide. ChargePoint has multiple models of chargers and 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.

BYD -
EVA100KS/02 and EVA200KS/01

BYD
EVA100KS/02 and EVA200KS/01

BYD is a Chinese automotive company known for building EVs. Their market consists of 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. This makes for simplified fleet integration. BYD chargers are available in configurations from 40kW to 100kW per charging connector. Due to the proprietary design of the BYD charging connector and architecture, BYD buses can only be paired with BYD chargers. Each BYD bus comes with its own charger. Examples of usage are Antelope Valley Transit Authority (AVTA) in Lancaster-Palmdale, California.

Blink -
DC Fast Charger

Blink
DC Fast Charger

Blink Charging is a Florida-based charging company that produces multiple 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 2-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 percent charge in 30 minutes (pending battery size).

Blink Charging Station Highlights:

- Blink Level 2 charging stations are currently the fastest Level 2 networked chargers on the market.
- Blink Level 2 charging stations can add up to 80 miles of charge to EVs in one hour.
- Blink charging stations are equipped with an easy-to-use payment processing system that can be accessed via the Blink Mobile app.
- The Blink Network offers real-time online access to revenue and usage reports.
- Every Blink unit comes with a 1 year manufacturer's warranty.
- The Blink Network offers remote maintenance, software upgrade, and support capability.

Delta -
EVHU503 and EVHU104

Delta
EVHU503 and EVHU104

Delta is a Taiwan-based company that provides power and thermal solutions. Delta provides DC fast chargers and has 50 kW and 100 kW models. Their chargers are compatible with CHAdeMO and CCS-1 protocols. Delta chargers have two charging receptacles and can charge buses simultaneously. Delta also offers energy management software.

Efacec - HV350

efacec

Efacec HV350
Efacec is a Portugal-based charging company that has a variety of high-power chargers, which includes 160, 175, and 350 kW models. The high-power models can charge both in a standalone mode or integrated in any network with any central system. These chargers can charge both cars and buses and has a DC output of up to 920 V. Efacec chargers can be customized with graphic, logos, and colors to cater to each specific entity brand.

TRITIUM

Tritium - Veefil PK

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.

WAVE – Inductive Charger

WAVE by Ideanomics

WAVE Inductive Charger
WAVE delivers fast, safe, high-power charging within seconds of scheduled stops and natural dwell times. Medium- and heavy-duty EVs gain substantial range and operation time without manual plug-in operations or mechanical contact. With power ranging from 125kW to 500kW and higher, WAVE's high-power systems are ideal for powering EVs for mass transit, warehouse and distribution centers, shuttle services, seaports, and more.

What is commercially available today is a 250-kW charger that can supply power in various configurations; where power is split down to two (2) 125 kW chargers and soon split to four (4) 62.5 kW plates with smart charging for the depot.

Clipper Creek – CS-100, 70/80 Amp (Selectable) EVSE, 240V, with 25 ft cable

ClipperCreek RELIABLE. POWERFUL. MADE IN AMERICA.

Clipper Creek CS-100, 70/80 Amp (Selectable) EVSE, 240V, with 25 ft cable

The CS 100 is the world's first UL listed EV charging station manufactured in the United States. The CS-100 is a UL Listed Level 2 EVSE offering 19.2 kW for EV charging. The CS-100 works with all SAEJ1772 compliant vehicles. This charger is ideal for vehicles that can accept high power charging, and future proofing installations.

This is the recommended charger for charger for the GreenPower and Phoenix Motorcars buses.

- 208V to 240V - 100 Amp Branch Circuit (70/80 Selectable Amps continuous)
- 25 foot charging cable
- Rugged, fully sealed NEMA 4 for installation indoors or outdoors
- Automatic circuit reclosure after minor power faults
- Cold Load Pickup: Time-delayed and randomized to allow seamless re-energizing of unit following power outages
- External Control Input: Allows external control from smart meter (AMI), billing or load management device
- UL Listed
- ETL LISTED

Compatible Accessories:
• The Wall Mount Retractor from ClipperCreek is the ideal solution for sites that need cable management, keeping charging cables off the ground and vehicle connectors protected.

Compatible Mounting Solutions:
• CS Pedestal (0300-00-015)
• EVSE Size Comparison Chart (click to view larger)

Charging Power
- 70/80 Amp Selectable (19.2kW max)

Product Dimensions
- 17” W x 22” H x 12” (mounting holes 16” on center)

Product Weight
- 36 lbs

Installation
- Hardwired

Supply Circuit
- 208/240V, 100A

Warranty
- 1 year

Charge Cable Length
- 25 feet (22 feet usable)

Vehicle Connector Type
- SAE J1772

Accessories Included
- Connector Lock & Keys

Enclosure
- Fully Sealed NEMA 4

Environment Rating

- Indoor and Outdoor

Operating Temperature

- -22°F to 122°F (-30°C to +50°C)

Certifications

- UL, cULus, ETL, cETLus

Appendix C

Appendix C: Managed Charging Solutions

Networked or managed charging is helpful as it allows transit agencies to minimize their peak power demand. This helps to lower utility costs for transit agencies and helps utilities manage the grid. Networked and managed charging is typically a separate service from the physical hardware of the EVSE and electrical cabinets. Companies that specialize in this space call themselves "Electric Vehicle Service Providers" or simply "network providers." However, unlike the EVSEs, there are a small, but growing, number of companies that focus on charging heavy-duty vehicles, like electric buses. This section provides an overview of networked charging companies.

I/O Control Corporations offers software to inform smart systems, including remote monitoring, analytics, and prioritizing charging on specific buses. Their Electrical Load Management System (ELMS) product offering is a cloud-based application that enables remote electric bus charging management across multiple depot locations. It allows transit operators to set up their preferred parameters so that buses can be charged automatically according to specific schedules and vehicle limits. I/O Controls supplies a charging control gateway for each charging station. The pricing for the gateway includes a monthly fee for the first year with a 1 year warranty, and the transit entity is charged a yearly fee for the hardware for subsequent years of use. Currently, the ELMS and charging gateway combination is only offered for charging of BYD buses but I/O Controls can work with other vehicle manufacturers to make their hardware and software compatible with other bus technologies. I/O Controls also offers a Health Alert Management System (HAMS) which is currently being used by Antelope Valley Transit Authority in Lancaster, California. This operating system functions as a control for how much power a particular bus draws from the grid. The HAMS features AIMS (Alert, Inquire, Manage, Store) functionality. The Alert function sends a text or email message when there is an issue with the vehicle's charge cycle or during regular route service. The Inquire feature monitors the health status of the vehicle such as SOC, mileage, battery voltage, and other parameters and is updated once per minute. The Manage feature uses cloud-based software to maintain and edit information provided by the HAMS module. The Store feature allows for unlimited data uploads to the cloud for future use and analytics.

ViriCiti is a trusted solution for over 350+ operators worldwide and offers a system that is integrated with over 50 OEMs. The company is known for its telematic data logging system for buses on the road, but also offers solutions for managing electric bus chargers through their Charger Monitoring and Smart Charging packages. Both of these systems are OCPP compliant and OEM agnostic, meaning they support open standards and can communicate with a variety of charging station and vehicle types. No additional hardware is needed to monitor the chargers if they are OCPP1.6 compliant or higher. The first package offers a single dashboard view for easy visualization of vital Key Performance Indicators (KPIs) (e.g., charger status and location, connected vehicle ID and SOC, energy consumption, etc.) which serves to quickly identify and troubleshoot bugs, increase EVSE uptime, and reduce maintenance time and costs. Their new Depot View product provides a visual overview of the vehicle and chargers in the fleet's depot. It shows which vehicles are connected to which chargers and their remaining SOC. Depot View also shows the status of the chargers (available, busy, faulted). ViriCiti's data management solution can track EVSE performance and enable smart charging capabilities. Viriciti's smart charging systems allow for fleet-wide management of charging through scheduled load balancing and can provide benefits like peak shaving, demand response, and renewables integration. Their system can also be used to track fleet data like battery SOC, bus energy efficiency, and bus downtime. ViriCiti offers modular based license subscriptions which allows customers to customize and only pay for the features they need. Licensing is offered per charger socket on a yearly subscription basis. The average cost of charger monitoring is $18 per socket/month and the average cost for smart charging is $25 per socket/month (as of Summer 2021). The ViriCiti team offers 24/7 customer support. ViriCiti was purchased by ChargePoint, which is a charging infrastructure provider, in August 2021.

Greenlots (a member of the Shell Group) is another network provider that specializes in smart charging and fleet scheduling services. Greenlots provides a turnkey solution for EV charging, which includes a site evaluation, hardware procurement and validation, engineering and construction services, and operation and maintenance services. Greenlots works closely with Shell's Solutions Development team to provide battery systems that integrate with charging stations to provide additional microgrid and energy management solutions. Their Greenlots SKY EV Charging Network Software offers real-time network management and status of EV chargers, a variable pricing engine which can set pricing based on usage, time intervals, or sessions, and a billing and payment management system through the Greenlots mobile app or charging station. Additionally, the SKY EV system provides access to advanced analytics and customizable reporting with alerts to improve EVSE uptime and access to data such as revenue, energy delivered, and avoided CO_2 emissions. The SKY EV system utilizes the OCPP standard and features a multi-layer security system to protect sensitive data. In addition to EVSE manufacturer hardware warranties, Greenlots offers a quality assurance program called "Greenlots Care" which provides trained technicians to make on-site repairs within 24-48 hours as well as a supplemental parts warranty to ensure a charger uptime guarantee of 95 percent. Other included services are preventative and corrective maintenance, warranty management, reporting, and performance SLAs. Finally, Greenlots offers a Charging-as-a-Service package, which is based on a recurring annual fee which aims to reduce steep upfront costs for the fleet customer. Greenlots is currently working with Foothill Transit on their electric buses.

Electriphi is a wholly owned subsidiary of Ford Motor Company that offers end-to-end fleet electrification solutions including charging management and infrastructure deployment. Electriphi works alongside fleets to simplify EV management and ease the transition from conventional to electric fleets through planning, deployment assistance, and ongoing operational services. On the implementation side, Electriphi offers testing and integration services for vehicle telematics systems prior to service deployment at the customer site. Their monthly software-as-a-service (SaaS) monitoring and management system tracks charging station status, network connectivity, and equipment fault detection, as well as offers sophisticated smart charging algorithms that ensures that vehicles are charged on time at the most optimal energy cost (while taking into account vehicle dispatch schedules, route information, TOU energy rates, demand charge windows, and more). Customers may purchase a baseline operational charging system for remote fleet control and data access and may add on managed/smart charging features which can be accessed from the same online dashboard. Electriphi also offers advanced energy services such as ESS system integration, active demand response, and V2G management. Electriphi's software compatibility is constantly evaluated based on current market offerings and is suitable for use with most major EV charging equipment manufacturers for both Level 2 and Level 3/DCFC stations. Pricing is available as an upfront, non-recurring cost or a yearly SaaS fee.

The Mobility House is a network provider that serves over 350 fleets and offers charging system management software called ChargePilot. Their software helps transit agencies engage in peak shaving and schedule charging to reduce demand charges. While their system does not connect to onboard vehicle telematics, it is compliant with multiple EVSEs at once, yielding high interoperability. To keep the fleet charged when vehicles need to be deployed and to optimize costs, the system monitors the bus SOC while plugged into the charger and calculates charge times and duration based on site-specific electricity rates. The fleet only has to supply the desired departure time and desired SOC per vehicle, and the system coordinates the rest via a local controller that is installed on-site and is connected to all the chargers. Mobility House is able to assist fleets with the charger procurement process to ensure that they are OCPP compliant, and therefore ChargePilot compliant, before purchase and installation. ChargePilot can also take solar resources and distributed generation assets into account when managing charging by integrating the data from renewables on-site into the system operations. Mobility House offers a hybrid business model with a one time setup cost per site which includes hardware installation and commissioning, and then operates its software service on a monthly, yearly, or multi-year subscription basis according to the customer’s business needs and plans. The pricing is project and volume-dependent with flexibility to operate on a Charging-as-a-Service (per mile) system. As part of this package, Mobility House provides 24/7 monitoring on all sites with quick alerts and remote fixes in the case that there is a system failure. Mobility House offers a complimentary demonstration workshop for interested customers to help calculate an individual fleet’s cost savings with their managed charging solution.

Amply (owned by BP) offers smart charging services for transit fleets and beyond through power demand services, telematics, scheduled maintenance, and battery SOC monitoring. They work with the existing infrastructure to add charging capacity by analyzing the electrical capacity and redesigning the depot layout. Amply’s system integrates with onboard vehicle telematics to coordinate and manage the charging stations on schedules based on available electricity and bus SOC. They offer various payment mechanisms based on the customer’s need, such as a monthly licensing fees per charger or an energy-as-a-service per kWh model. Amply also offers charging infrastructure installation with the necessary electrical equipment to connect the systems and capital expenditures can be bundled into their Charging-as-a-Service (CaaS) solution. Their Pantograph In-Depot Equipment, or PIDE Canopy Mount, allows for overhead DC fast chargers to be installed to solar canopies, which can greatly optimize depot space and the use of solar energy. Pricing is customized to each fleet’s needs and varies based on numerous factors such as combined grants to offset costs, utility partnerships, and energy rates per utility. Amply works with EVSE OEMs to develop hardware agnostic warranties and the software includes a triage system to alert fleet operators of any potential issues before a contracted service technician is deployed to repair the system.

Proterra provides electric buses but also provides fleet planning and EV charging services. Through a turnkey solution, Proterra can provide an “energy delivery system” that offers a comprehensive solution for establishing EV infrastructure. This includes smart energy management, and electrical utility make-ready.

AmpUp is a software company and network provider for smart charge scheduling, dynamic access control, and energy optimization built into one platform. Their mobile app software was originally founded to offer peer-to-peer shared charging to increase charger access in residential areas and decrease the cost to EV owners. They have since expanded their product to include a solution for commercial entities and various customer types. All the charge management is facilitated through OCPP which allows the software to communicate with the hardware and means that the AmpUp solution is brand agnostic. The software determines when a charging station is on or offline, when it will become available, and when the plugged-in vehicle will charge based on customized pricing preferences. AmpUp's service is offered on a monthly or yearly software subscription basis with an additional per vehicle cost for an added telematics bundle, which offers an integration with their partner's (Smartcar) system. In California, AmpUp will also assist with fleet financing ROI by redeeming carbon credits on behalf of the customer and passing it along to them. The AmpUp system will pass on station data to the third-party carbon credit processor who will prepare and submit the required paperwork in order to receive the credit payment. These credits can be returned to the customer via check or can be directly put back into their AmpUp portal towards vehicle charge management expenses.

Appendix D

Appendix D: Stakeholder Engagement & Outreach Summary

The Transit Fleet Electrification Feasibility Study for the Arroyo Verdugo Region Transit Operators study was presented to the Burbank Transportation Commission and Burbank City Council. The main objective of these presentations was to solicit feedback on the study from city stakeholders. During these meetings, the City of Burbank Community Development Department, which manages BurbankBus, presented the results of the study. CALSTART served as a subject-matter expert and provided answers to technical questions.

The study was presented to the Burbank Transportation Commission on December 20, 2021. The Transportation Commission had several questions about the study. The Commission expressed concerns about the costs associated with acquiring a new transit facility. As a result, the Commission asked why a city-owned depot is required. Burbank Community Development stated that a city-owned depot is required because they are currently using leased depots that are provided by the transit company they have contracted with. Since these contracts tend to be short-term, it would not be financially viable to invest millions of dollars to build charging infrastructure unless they would control the property for the life of the equipment. The Community Development Department recognizes that they are a small transit agency and as a result, it will be difficult to achieve economies of scale. To start achieving economies of scale, the Community Development Department is exploring options for collaboration with other transit agencies. One possibility being explored is to work with Glendale Beeline on joint contracts with transit companies for both cities. The Community Development Department is aware that once charging infrastructure is installed, Glendale Beeline will likely not have enough room to accommodate BurbankBus's vehicles on their depot.

The Commission stated that over the years, there have been discussions about eliminating city-operated transit service. This topic has been raised due to concerns about decreasing ridership, the high cost of operating transit, and citizen complaints about fixed-route transit service not meeting the transportation needs of the city. The Commission expressed concerns about the unknowns about the range and reliability of ZEBs. Since the projected cost of a ZEB fleet is projected to be higher than the status quo, some of the commissioners stated that eliminating city-operated transit services might be the most viable option. They argued that bidding transit services to a contractor or switching to a demand response transportation system might be a more cost-effective option. However, other commissioners disagreed arguing that this model would leave the city at the mercy of contractors, who might charge high rates to provide these services.

Some of the commissioners also proposed purchasing used/second-hand buses as a way to reduce the costs associated with transitioning to ZEBs. Lastly, some of the commissioners stated that FCEBs should continue to be considered as an option.

Appendix E

Appendix E: Financial Analysis & Cost Estimates (February 2022)

CALSTART developed cost estimates for BurbankBus's transition to a zero-emission fleet. CALSTART developed cost estimates for the status quo with a CNG fleet. CALSTART also provided estimates for the cost of transitioning to both a BEB fleet and an FCEB fleet. This financial analysis assumes that the buses are deployed according to the Fleet Replacement Plan (see page 446). **Table 4-12** outlines the expected cost of purchasing and operating a CNG fleet. This scenario represents a continuation of the status quo between 2021 until 2040. Under this scenario, BurbankBus is projected to spend $16,847,735 between 2021 and 2040. When this amount is discounted at a rate of 4 percent per year (discounted to 2021 dollars), this amounts to a net present value of $9,714,672. Since BurbankBus already has access to CNG fueling infrastructure, this figure includes the capital expenditures associated with purchasing buses. In addition, this analysis takes into account operational costs like maintenance costs, midlife bus repairs, and the cost of fuel. This analysis does not include the cost of acquiring land or labor associated with operating the buses.

Table 4-12: CNG Fleet Financial Analysis

	Capital Expenditures		Operational Expenditures			Total Costs	
Year	Transit Buses	Shuttle Buses	Bus Maintenance	Midlife Repairs	CNG Fuel Costs	Total Cost	Net Present Value (2021 dollars)
2021							
2022							
2023							
2024							
2025							
2026							
2027	$1,300,000	$720,000	$28,005	$144,400	$64,615	$2,257,021	$1,715,150
2028			$28,005		$64,615	$92,621	$67,677
2029		$360,000	$37,772	$25,200	$86,154	$509,126	$357,705
2030			$37,772		$86,154	$123,926	$83,720
2031			$37,772		$86,154	$123,926	$80,500
2032		$540,000	$52,423	$37,800	$118,462	$748,685	$467,626
2033			$52,423		$118,462	$170,885	$102,629
2034			$52,423		$118,462	$170,885	$98,682
2035	$7,800,000		$103,246	$564,000	$247,692	$8,714,939	$4,839,096
2036			$103,246		$247,692	$350,939	$187,369
2037			$103,246		$247,692	$350,939	$180,163
2038			$103,246		$247,692	$350,939	$173,233
2039	$1,950,000		$115,952	$141,000	$280,000	$2,486,952	$1,180,413
2040			$115,952		$280,000	$395,952	$180,707
Total	**$11,050,000**	**$1,620,000**	**$971,489**	**$912,400**	**$2,293,846**	**$16,847,735**	**$9,714,672**

The cost of transitioning to a fully BEB fleet, as detailed in **Table 4-13,** is projected to cost $30,229,373 between 2021 and 2040. When this amount is discounted at a rate of 4 percent per year (discounted to 2021 dollars), this amounts to a net present value of $19,629,301. This figure includes the capital expenditures associated with utility upgrades, building a depot (purchasing and installing chargers), and the cost of the buses. In addition, this analysis takes into account operational costs like maintenance costs, the cost of electricity from the utility, and the cost of maintaining charging infrastructure.

There are a few caveats in the figures for BEBs. First, the utility upgrades are projected to be $1 million. However, this figure is based on other EV charger installations that took place in BWP territory. The cost of utility upgrades is site-specific and can vary greatly depending on the location. If BurbankBus selects a site that requires substantial upgrades to the utility distribution system, the cost of utility upgrades can be substantially higher. In addition, since the cost of building the depot and installing the chargers is expected to cost about $3 million (see Appendix N for more information about the cost assumptions). This figure does not include the construction of maintenance bays or office space. Since further investigation needs to be taken to understand the most best resiliency option, the cost of resiliency was not included in the capital expenditures section. Lastly, this analysis does not include the cost of acquiring land or labor associated with operating the buses.

Table 4-13: BEB Fleet Financial Analysis

	Capital Expenditures					Operational Expenditures				Total Costs	
Year	Transit Buses	Shuttle Buses	Driver and Maintenance Training	Charging Infrastructure	Utility Infrastructure	Bus Maintenance	Midlife Repairs	Infrastructure Maintenance	Utility Costs (fueling costs)	Total Cost	Net Present Value (2021 dollars)
2021											
2022											
2023											
2024					$5,000,000					$5,000,000	$4,274,021
2025				$3,000,000						$3,000,000	$2,465,781
2026											
2027	$1,600,396	$1,120,000	$78,750			$58,446	$192,652	$9,000	$77,782	$3,137,026	$2,383,882
2028						$58,446		$9,000	$77,782	$145,228	$106,116
2029		$560,000				$78,830	$42,000	$9,000	$103,709	$793,539	$557,530
2030						$78,830		$9,000	$103,709	$191,539	$129,397
2031						$78,830		$9,000	$103,709	$191,539	$124,420
2032		$840,000				$109,406	$63,000	$9,000	$142,600	$1,164,006	$727,035
2033						$109,406		$9,000	$142,600	$261,006	$156,753
2034						$109,406		$9,000	$142,600	$261,006	$150,724
2035	$9,602,376					$215,471	$651,912	$9,000	$298,164	$10,776,923	$5,984,043
2036						$215,471		$9,000	$298,164	$522,635	$279,039
2037						$215,471		$9,000	$298,164	$522,635	$268,307
2038						$215,471		$9,000	$298,164	$522,635	$257,987
2039	$2,400,594					$241,987	$162,978	$9,000	$337,055	$3,151,615	$1,495,890
2040						$241,987		$9,000	$337,055	$588,043	$268,375
Total	**$13,603,366**	**$2,520,000**	**$78,750**	**$3,000,000**	**$5,000,000**	**$2,027,454**	**$1,112,542**	**$126,000**	**$2,761,261**	**$30,229,373**	**$19,629,301**

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