Project Report

Santa Barbara Metropolitan Transit District

Santa Barbara Zero-Emission Resilient Transportation Blueprint

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List of Acronyms

Acronym	Definition
3CE	Central Coast Community Energy
3C-REN	Tri-County Regional Energy Network
ADA	Americans with Disabilities Act
AFV	Alternative Fuel Vehicle
APTA	American Public Transportation Association
APWA	American Public Works Association
ATN	Anaheim Transportation Network
BEB	Battery-Electric Bus
BEPS	Bus Exportable Power Supply
BESS	Battery Energy Storage System
BTM	Behind-the-Meter
C5	Central Coast Clean Cities Coalition
CaaS	Charging-as-a-Service
CAP	Climate Action Plan
CARB	California Air Resources Board
CBO	Community-Based Organization
CCA	Community Choice Aggregator

CEC	California Energy Commission
CO	Carbon Monoxide
CO2e	Carbon Dioxide-Equivalent
CPUC	California Public Utilities Commission
CRT	Charge Ready Transport
CSG	Carbon Solutions Group
DCFC	Direct Current Fast Charger
DER	Distributed Energy Resource
DICE	Diesel-fired Internal Combustion Engine
EPA	U.S. Environmental Protection Agency
ETB	Energy Tool Database
EV	Electric Vehicle
EVSE	Electric Vehicle Supply Equipment
FCEV	Fuel Cell Electric Vehicle
FTA	Federal Transit Administration
FTM	Front-of-the-Meter
GHG	Greenhouse Gas
GO-Biz	Governor's Office of Business and Economic Development
GVWR	Gross Vehicle Weight Rating
GWh	Gigawatt-Hours
HVIP	Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project

ICT	Innovative Clean Transit
JCMT	Job Co-benefit Modeling Tool
LCFS	Low Carbon Fuel Standard
MHD	Medium- and Heavy-Duty
MW	Megawatts
NEM	Net Energy Metering
NOx	Nitrogen Oxide
OCPP	Open Charge Point Protocol
OpenADR	Open Automated Demand Response
PM	Particulate Matter
PPA	Power Purchasing Agreement
PSPS	Public Safety Power Shutoff
PV	Photovoltaic
REopt	Renewable Energy Integration and Optimization
ROC	Reactive Organic Carbon
SAIDI	System Average Interruption Duration Index
SAIFI	System Average Interruption Frequency Index
SBCAG	Santa Barbara Association of Governments
SBCAPCD	Santa Barbara County Air Pollution Control District
SBCC	Santa Barbara Community College
SBCE	Santa Barbara Clean Energy

SBMTD	Santa Barbara Metropolitan Transit District
SBUSD	Santa Barbara Unified School District
SCE	Southern California Edison
SOC	State of Charge
SOMAH	Solar on Multifamily Affordable Housing
TCO	Total Cost of Ownership
TOU	Time-of-Use
UCSB	University of California, Santa Barbara
V2B	Vehicle-to-Building
V2X	Vehicle-to-X
VGI	Vehicle-to-Grid Integration
VMT	Vehicle Miles Traveled
ZEB	Zero-Emission Bus
ZEV	Zero-Emission Vehicle

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Executive Summary

In July 2020, the California Energy Commission (CEC) released GFO-20-601: Blueprints for Medium- and Heavy-Duty Zero-Emission Vehicle Infrastructure. This solicitation provided funding for the development of plans that identify the actions needed to encourage the transition to medium- and heavy-duty (MHD) zero-emission vehicles and the accompanying charging and/or hydrogen fueling infrastructure. Santa Barbara Metropolitan Transit District (SBMTD), along with the City of Santa Barbara and CALSTART, received funding to develop a Blueprint that will facilitate the adoption of MHD zero-emission vehicles through the development of a microgrid. Fleet resiliency is a central theme in the Blueprint.

The City of Santa Barbara aims to combat climate change by transitioning to renewable energy and adopting zero-emission vehicles (ZEVs). To support this objective, the City has enacted a series of policies and adopted action plans to reduce emissions. While there is strong interest in transitioning to ZEVs, SBMTD stands out as an early adopter. SBMTD's decision to adopt zero-emission buses (ZEBs) was encouraged by the enactment of the Innovative Clean Transit (ICT) regulation, which mandates that transit agencies transition to zero-emission by 2040, and government funding for making this transition. While SBMTD aims to transition to ZEBs, resiliency stands out as a major challenge. The entire Goleta Load Pocket is served by only one transmission line, which traverses an area that is prone to natural disasters. As a result, an extended power outage during an emergency is a very real threat. To mitigate this threat, SBMTD will need to deploy resiliency measures.

This Blueprint investigated the regulatory environment in Santa Barbara that is driving the transition to zero-emission vehicles for local fleets. This regulatory environment, which focuses on climate and energy policy, includes:

- City of Santa Barbara Resolution No. 17-043
- Municipal Green Building Policy
- Carbon Neutrality 2035 Resolution
- Natural Gas Infrastructure Prohibition Ordinance
- Santa Barbara Clean Energy

The City also developed renewable energy plans to help guide the transition to zero-emission. These plans include:

- Climate Action Plan
- Strategic Energy Plan
- City of Santa Barbara Zero Net Energy Roadmap

The City also has several transportation policies including:

- Zero-Emission Vehicle Action Plan
- Municipal Vehicle Acquisition Policy

CALSTART analyzed actions that have been taken to transition transit and municipal fleets in Santa Barbara to ZEVs. CALSTART identified several fleets in the region and their progress toward zero-emission.

- SBMTD: In accordance with the ICT Regulation, SBMTD plans to transition their fleet of transit buses and microtransit vans to zero-emission by 2040. This would include a total of 100 transit buses and 6 transit vans. SBMTD is in the process of deploying charging infrastructure to serve these vehicles. Today, SBMTD has 43 light- and heavy-duty electric vehicle (EV) chargers (with 10 more planned for installation in early 2025) at its Terminal 1 facility. The goal at Terminal 1 is to have a minimum of 83 heavy-duty electric vehicle chargers and 32 light-duty chargers. SBMTD is also in the process of recommissioning its Terminal 2 operating facility. When the multiphase project is complete, it is anticipated that the facility will have at least 30 light- and heavy-duty electric vehicle (EV) chargers.
- City of Santa Barbara: The City of Santa Barbara has about 450 vehicles. The City aims to transition all vehicles to zero-emission. To date, the City has purchased more than 20 battery-electric vehicles and more than 40 plug-in hybrid vehicles. The City has deployed 20 Level 2 chargers and has plans for additional Level 2 chargers and 4 chargers for MHD vehicles. The City has also deployed 50 public chargers and plans to install an additional 100 public chargers.
- Santa Barbara County Association of Governments: The Santa Barbara County Association of Governments (SBCAG) operates the Clean Air Express service, which provides commuter service. SBCAG has purchased one battery-electric commuter bus and plans to convert the entire 20-bus fleet to electric. SBCAG has purchased a facility in Goleta where they intend to deploy chargers for the electric buses as they are deployed.

- County of Santa Barbara: The County has a fleet of 1,598 vehicles, including light-duty trucks, passenger buses, cars, and other MHD equipment. The County has focused its efforts on transitioning the light-duty cars to zero-emission. The County has 91 EV sedans, 1 EV full size cargo van, and 36 hybrid vehicles. There are currently 13 hybrid vehicles on order and plans to acquire at least 1 EV truck.
- Santa Barbara Unified School District: Santa Barbara Unified School District (SBUSD) has a fleet of 104 vehicles but does not own any school buses (school bus service is contracted out). These vehicles include cars, pickup trucks, Ford E-series delivery trucks, and various off-road vehicles. SBUSD is currently leasing its light-duty car fleet. The leasing company is transitioning the cars to hybrid vehicles and has provided SBUSD with five plug-in hybrids with four more arriving soon. Of these light-duty vehicles, SBUSD is considering using electric vehicles (EVs) in departments such as Food Services and Warehouse as pilot projects. SBUSD is looking into this because the vehicles only drive a maximum of 80-100 miles per day. The pilot projects will begin in the next three to five years.

SBMTD worked with CALSTART to analyze resiliency measures that can be deployed. CALSTART worked with Anser Advisory to examine the techno-economic feasibility of deploying a microgrid at SBMTD's Terminal 1 depot. CALSTART also carried out initial analysis on microgrid sizing at SBMTD's Terminal 2 depot. CALSTART and Anser Advisory found that Terminal 1 would be best served by two microgrids. Microgrid 1 at Terminal 1 is designed to include 641 kW of solar panels, a 650 kW/2,610 kWh battery energy storage system (BESS), and a 1,500 kW generator. Microgrid 2 at Terminal 1 is designed to include 320 kW of solar panels, a 640/1,280 kWh BESS, and an 800 kW generator. These microgrids are designed to provide backup power for at least 24 hours but can meet load requirements as long as it has access to renewable diesel fuel. CALSTART also analyzed microgrid sizing for Terminal 2. CALSTART sized the Terminal 2 microgrid for 250 kW of solar panels, 1,749 kWh of BESS, and an 800 kW generator.

The buildout of the microgrids at Terminal 1 is expected to cost approximately $12.26 million. However, it will save approximately $488,184 per year in utility cost savings. The construction of the microgrid will also create jobs for the local community. Construction will support direct jobs, which are jobs created through the construction of the project. The microgrid is estimated to support 32 direct jobs which have a combined salary of approximately $2.98 million. The microgrid will also support indirect jobs, which are jobs related to the provision of the microgrid components. The project is expected to support 19.6 indirect jobs which have a combined salary of approximately $1.03 million.

The microgrid will also displace grid power and replace it with locally generated renewable energy. This will increase the renewable content of the energy used by the buses and reduce greenhouse gas (GHG) emissions. The increase in renewable content and the associated GHG emissions savings depend on whether SBMTD uses regular grid power from their utility or opts to purchase renewable grid power.

Vehicle-to-X (V2X) refers to the export of power from the bus to another load. V2X can be used alongside the microgrid to provide additional resiliency benefits to SBMTD and the community. A bus with V2X capability can charge from the microgrid and export power to the grid or to other loads such as buildings. This functionality is important because the buses can then be used to export power to critical facilities, such as a fire station or communications array, during an outage. This effectively turns the ZEBs into resiliency assets. There are several standards that have been developed for V2X. This includes UL1741 which governs the bi-directional inverters that are used to export power back to the grid. ISO 15118 is also an important standard that governs communication between the vehicle and the charger. It is important to note that this technology is still being developed and should be examined in the future once it is fully commercialized.

SBMTD can also use public chargers as a resiliency measure. The City of Santa Barbara has deployed multiple public chargers throughout the City. These chargers can potentially be used as a resiliency measure for SBMTD's light-duty fleet. This method is useful for cases where SBMTD experiences a localized outage at its charging facilities, but power remains intact in other places throughout the City. In such a scenario, SBMTD can charge their vehicles at public chargers in lieu of their own depot. While this is an option, public chargers in Santa Barbara are Level 2 chargers. As a result, they are only an appropriate solution for SBMTD's EVs and transit vans. SBMTD would require public MHD chargers to serve their ZEBs.

Introduction

The City of Santa Barbara is a coastal city on the California Central Coast. Santa Barbara is located in the southern part of Santa Barbara County, commonly referred to as the South Coast, and is the largest city in the region. The City serves as the main economic hub in Santa Barbara County and is a tourism destination. The region also hosts educational institutions including Santa Barbara City College and the University of California, Santa Barbara. Santa Barbara has played a major role in the environmental and sustainability movement. In 1969, there was a major offshore oil spill that caused significant ecological and environmental damage to the region. The oil spill was one of many environmental disasters that led to the enactment of environmental legislation in the United States. It also led to the establishment of one of the most iconic environmental events around the globe, Earth Day (Santa Barbara County Air Pollution Control District). Santa Barbara is also susceptible to the impacts of climate change due to its location between the Santa Ynez Mountains to the north and the Pacific Ocean to the south. Santa Barbara has recently been impacted by climate-related natural disasters such as wildfires and mudslides.

Recognizing the threat posed by climate change, the City of Santa Barbara has aggressively pursued measures to reduce its carbon footprint. As part of their sustainability efforts, the City aims to transition their fleets from internal combustion engine vehicles to zero-emission vehicle technology. The City is exploring ways to support the deployment of light-, medium-, and heavy-duty zero-emission vehicles. The Santa Barbara Metropolitan Transit District (SBMTD), which is an independent Special District that provides transit service to southern Santa Barbara County, has emerged as an early adopter of zero-emission vehicle (ZEV) technology. SBMTD began deploying electric shuttle buses in 1990, introduced new battery-electric transit buses in 2018, and has a Board-adopted goal of achieving a 100% zero-emission fleet by 2030. The City of Santa Barbara is also working on a plan to transition to zero-emission.

In July 2020, the California Energy Commission (CEC) released GFO-20-601: Blueprints for Medium- and Heavy-Duty Zero-Emission Vehicle Infrastructure. This solicitation provided funding for the development of plans that identify the actions needed to encourage the transition to medium- and heavy-duty (MHD) zero-emission vehicles and the accompanying charging and/or hydrogen fueling infrastructure. SBMTD, along with the

City of Santa Barbara and CALSTART, received funding to develop a Blueprint that will facilitate the adoption of medium- and heavy-duty vehicles through the development of a microgrid. Fleet resiliency is a central theme in the Blueprint.

This Blueprint examines the steps that entities in Santa Barbara are taking to transition their fleets to zero-emission. Since SBMTD is an early adopter of MHD zero-emission vehicles, this Blueprint gives special attention to this fleet. The Blueprint examines the local regulatory environment driving the transition to zero-emission before focusing on stakeholder outreach. It then focuses on measures that SBMTD can take to promote fleet resiliency. This includes a techno-economic analysis of microgrids and analysis of microgrid benefits and financing options. The report also investigates the feasibility of using shared chargers as a form of resiliency. This report ultimately provides an actionable Blueprint that can be implemented to support zero-emission MHD vehicle deployments in Santa Barbara.

City of Santa Barbara Regulatory Environment

The City of Santa Barbara's efforts to transition to ZEVs are occurring in the midst of major changes in City energy and climate change policy. Santa Barbara recognizes that it is extremely vulnerable to the effects of climate change. Furthermore, Santa Barbara has already experienced some of the negative impacts of climate change. As a coastal town, Santa Barbara is vulnerable to sea level rise and has historically contended with coastal erosion and infrastructure damage due to extreme tides. Santa Barbara is also located along an urban wildland interface and is therefore subject to elevated risk of wildfires. The Thomas Fire, which started in December 2017, and the resultant debris flow in January 2018, caused major disruptions and posed a threat to the City.

Climate and Energy Policy

In response to the threat that climate change poses, the Santa Barbara City Council has enacted several policies to lower the City's carbon footprint and mitigate climate change. This section outlines these policies.

City of Santa Barbara Resolution No. 17-043

On June 6, 2017, Santa Barbara City Council adopted Resolution 17-043, which established a citywide goal of 100% renewable energy. The Resolution established an intermediate goal for municipal facilities of at least 50% renewable energy by 2020 and a goal of 100% renewable energy for the City's entire electricity supply by 2030.

Municipal Green Building Policy

Santa Barbara City Council enacted the Municipal Green Building Policy in September 2020. This Policy requires green building practices in all City-owned and occupied facilities. The Policy sets environmental performance requirements for new construction and major renovations of existing buildings and leased spaces. In addition, the Policy establishes construction waste diversion objectives. The ultimate aim of this Policy is to implement zero net carbon practices for new building construction and major renovations.

Carbon Neutrality 2035 Resolution

In 2020, Santa Barbara City Council adopted the Carbon Neutrality 2035 Resolution. This

Resolution establishes a goal of achieving carbon neutrality for the entire City by 2035. It also mandates the City develop a Climate Action Plan that proposes strategies for achieving this goal. The Carbon Neutrality 2035 Resolution effectively created a de facto objective of transitioning the City's fleet to zero-emission by 2035.

Natural Gas Infrastructure Prohibition Ordinance

On July 27, 2021, Santa Barbara City Council adopted the Natural Gas Infrastructure Prohibition Ordinance to reduce the carbon emissions associated with the building sector. This ordinance prohibits the installation of new natural gas infrastructure in newly constructed buildings. The ordinance applies to all building permits submitted after December 31, 2021. Exemptions are allowed for the following: restaurants, clean rooms, laboratories, and projects where electrification is not feasible or deemed to be in the public interest by the Permitting Authority.

Santa Barbara Clean Energy

On October 22, 2019, City Council adopted Ordinance 5915, establishing the City's Community Choice Aggregation Program, Santa Barbara Clean Energy (SBCE). SBCE began serving residents in October 2021 and commercial customers in March 2022. All customers are auto-enrolled in 100% carbon-free electricity for a small premium over Southern California Edison (SCE) rates. Customers may change enrollment by opting downcharger to a smaller percentage of carbon-free electricity at the same rate as SCE or opt-out to go back to SCE's generation offering. SBCE's transition to fully renewable energy is expected to reduce the City's greenhouse gas (GHG) emissions by 20% (Martinez-Pogue, 2022). It also opens a clear pathway to decarbonizing the building and transportation sector.

City Energy Plans

The City of Santa Barbara has ambitious renewable energy and climate goals and has commissioned several studies and plans to investigate how these goals can be achieved. This section provides an overview of these plans.

Climate Action Plan

In 2012, the Santa Barbara City Council adopted its first Climate Action Plan. It was developed in response to the City General Plan, which called for a plan to mitigate climate change. In addition, several pieces of legislation from the State Legislature, including AB 32 – The Global Warming Solutions Act of 2006, SB 375 – The Sustainable Communities and Climate Protection Act of 2008, and SB 97 – The California Environmental Quality Act of 2007, require cities to develop Climate Action Plans. The Climate Action Plan provided an inventory of current GHG emissions generated by the community in Santa Barbara and projections for future GHG emissions. The Climate Action Plan identified landfill gas, electricity production within Santa Barbara, and on-road vehicle trips as large sources of emissions. The Climate Action Plan also identified strategies that can be implemented to reduce emissions and to adapt to the impacts of climate change. The Climate Action Plan recommended actions like implementing energy efficiency programs, deploying solar power, deploying electric vehicles (EVs), decreasing single-occupancy vehicle trips, and increasing vegetation. In response to the Carbon Neutrality 2035 Resolution, the City began updating the Climate Action Plan in 2020. The updated plan is expected to be published in 2024. Transportation will be a large component of the updated Climate Action Plan.

Strategic Energy Plan

In 2019, the City of Santa Barbara released its Strategic Energy Plan. This plan was developed in response to Resolution 17-043. The Strategic Energy Plan investigated several strategies, programs, and policies that can be implemented to achieve the 100% renewable energy goal. The plan also assessed the renewable energy generation potential for several projects on City-owned property and in the community. The plan found that the City needs 235-240 megawatts (MW) of solar power to meet the City's expected energy needs. It also found that the City has a maximum viable potential of 151-190 MW of solar within city limits. This means that the shortfall will need to be provided by renewable energy generated outside of city limits.

City of Santa Barbara Zero Net Energy Roadmap

In 2021, the City of Santa Barbara released its Zero Net Energy Roadmap. The study was written in partnership with TRC, a global engineering and consulting firm. It examined 36 City-owned sites and identified energy efficiency and renewable energy measures that can be implemented to achieve the Santa Barbara's 100% renewable energy goal. The plan recommended the adoption of energy efficiency measures, the deployment of solar photovoltaic (PV) technology and battery energy storage systems, and the deployment of solar water heating. The study found that the City needs to generate an additional 11 Gigawatt-Hours (GWh) of renewable energy per year to meet its zero net energy goals.

City of Santa Barbara Transportation Policy

The City of Santa Barbara does not currently have any zero-emission transportation plans. While there are no explicit plans, other policies do allude to the need for clean transportation. The Climate Action Plan aims to reduce single-occupancy vehicle trips. The Carbon Neutrality 2035 Resolution also places a de facto goal of transitioning to a fully zero-emission fleet by 2035. The City is expected to release several policies related to zero-emission transportation. The City is updating its Climate Action Plan and transportation is expected to be a major component of the plan. The City is also developing a Zero-Emission Vehicle Action Plan to support the Carbon Neutrality 2035 Resolution. The draft of this plan is expected to be available in summer 2024 The City is also developing a Fleet Decarbonization Plan to outline milestones for decarbonizing its fleet no later than 2035, and a draft is expected to be available in summer 2024.

Additionally, the City is developing a draft Municipal Vehicle Acquisition Policy to inform future procurement of City vehicles and to prioritize the deployment of ZEVs. Exceptions to the ZEV procurement requirement will be granted when such procurements are economically infeasible, not commercially available, or if ZEVs cannot meet critical functions.

Vehicle Deployment and Infrastructure Planning

The objective of this section is to identify the number of medium- and heavy-duty zero-emission vehicles that will be deployed by public fleets in the City of Santa Barbara. The Department of Energy differentiates between different classes of vehicles. A light-duty vehicle is defined as a Class 1 or 2 vehicle. These vehicles have a gross vehicle weight rating (GVWR) of less than 10,000 pounds. Medium-duty vehicles are defined as Class 3-6 vehicles. These vehicles have a GVWR of 10,001 – 26,000 pounds. Heavy-duty vehicles are defined as Class 7 and 8 vehicles. These vehicles have a GVWR of 26,001 or more pounds (US Department of Energy).

This analysis focuses on public entity fleets, including both City and County fleets, operating in the City of Santa Barbara, and excludes private fleets. The scope of this study was limited to government fleets because they have stronger regulatory factors encouraging adoption of ZEVs. Public entity fleets are subject to state regulations, like the Innovative Clean Transit regulation. In addition, the City of Santa Barbara's sustainability goals encourage and, in some cases, mandate the adoption of ZEVs. As a result, the transition to zero-emission medium- and heavy-duty vehicles is likely to occur faster in public fleets than in private fleets.

CALSTART developed projections for the number of public entity medium- and heavy-duty ZEVs that each fleet will deploy in the City of Santa Barbara. To develop these projections, CALSTART identified public fleets by using IHS Markit data. The IHS Markit dataset includes information on all vehicles registered in Santa Barbara. This information was used to identify the agencies that own these vehicles. This process identified SBMTD, the City of Santa Barbara, the County of Santa Barbara, Easy Lift Transportation, the Santa Barbara Association of Governments (SBCAG), and the Santa Barbara Unified School District (SBUSD).

Current and future ZEV deployments were determined by gathering data directly from the agencies. This data was collected through a combination of desk research, analyzing planning documents, and direct correspondence with the agencies. This information was used to create a ZEV profile for each fleet, which identifies the number of ZEVs currently in operation and planned for future procurement.

It is important to note that these projections have several limitations. The main limitation is that many of the agencies interviewed did not yet have concrete plans for transitioning to zero-emission and could only provide an estimated timeline. Furthermore, many of the agencies need funding to purchase ZEVs. As a result, their ability to adhere to their ZEV deployment plan is dependent on winning grants or other sources of funding. As a result, the actual deployment of vehicles may deviate from planned procurements.

Santa Barbara Metropolitan Transit District

SBMTD is the transit agency that serves southern Santa Barbara County. SBMTD is based in the City of Santa Barbara and also provides service to the nearby cities of Carpinteria and Goleta, and the unincorporated communities of Montecito, Summerland, Isla Vista, and the Eastern Goleta Valley. SBMTD is a Special District governed by its own Board of Directors and functions independently of the City of Santa Barbara. SBMTD directly operates fixed-route bus service, and contracts with Easy Lift Transportation to operate required Americans with Disabilities Act (ADA) complementary paratransit service. SBMTD will soon offer microtransit service. SBMTD provides service to important facilities and destinations like Downtown Santa Barbara; Santa Barbara Airport; the University of California, Santa Barbara; and Santa Barbara City College, among others. SBMTD has already begun its transition to a zero-emission fleet. Furthermore, SBMTD is likely to be the first public fleet operating in the City that will fully transition to zero-emission. As a result, SBMTD is the primary focus of this report. SBMTD's accelerated transition to a zero-emission fleet has been influenced by the regulatory environment. As a transit agency in California, SBMTD is subject to the Innovative Clean Transit (ICT) regulation. The ICT regulation issued by the California Air Resources Board (CARB) mandates that all transit agencies in California transition to zero-emission buses (ZEBs). Fleets must be 100% zero-emission by 2040, and the regulation provides a timeline for phasing in ZEB procurements. Under the ICT regulation, SBMTD is considered to be a small transit agency, since it operates fewer than 100 buses in maximum revenue service. Thus, starting in 2026, 25% of SBMTD's new bus purchases must be zero-emission. Starting in 2029, 100% of SBMTD's new bus purchases must be zero-emission. Since transit buses have a minimum "useful life" of 12 years, as defined by the Federal Transit Administration, this ensures that, in an ideal scenario, all public transit buses in the state would be zero-emission by 2040. In addition, SBMTD's Board of Directors adopted a goal of transitioning to a 100% zero-emission fleet by 2030. If SBMTD meets this goal, the fleet will transition to zero-emission well ahead of the timeline set by the ICT regulation. SBMTD also has a fleet of 28 non-revenue vehicles, of which 24 are light-duty vehicles. Of these 24 light-duty vehicles, 14 are EV sedans. The remaining four non-revenue vehicles are medium-duty trucks. SBMTD plans to transition all non-revenue vehicles to EVs by 2040.

Fixed-Route Fleet

SBMTD uses transit buses to serve its fixed-route service. SBMTD currently has a fleet of 112 transit buses. This includes 28 30-ft. buses, 81 40-ft. buses, and 3 60-ft. articulated buses. The majority, 98 buses, are fueled with renewable diesel. Of those, 17 are diesel-electric hybrid. The remaining 14 are battery electric. These buses are currently housed at SBMTD's Terminal 1 facility, located at 550 Olive Street, Santa Barbara, California 93101. SBMTD will soon begin construction on recommissioning its currently dormant Terminal 2, located at 5353 Overpass Road, Goleta, California 93111. As mentioned, SBMTD has already begun to transition its fixed-route fleet to zero-emission. In 2018, SBMTD deployed 14 battery-electric buses. SBMTD also ordered an additional nine battery-electric buses, which will be delivered during the fourth quarter of 2023. SBMTD intends to comply with the ICT regulation by transitioning to a 100% battery-electric fleet (as opposed to any other zero-emission propulsion technology).

SBMTD will deploy 100 battery-electric buses by 2040. In addition to complying with the ICT regulation, SBMTD is working to meet the 2030 zero-emission goal. To do so, SBMTD will need an accelerated fleet transition plan. However, SBMTD's ability to meet this goal depends heavily on the availability of funding. SBMTD will aggressively pursue this goal by seeking grant funding. Due to the competitive nature of grants, the 2030 goal for deploying a 100% battery-electric bus fleet is an ambitious target.

Microtransit Fleet

SBMTD will soon implement an on-demand microtransit service. This service, called The Wave, provides curb-to-curb service in the Goleta area. Riders use the Transloc app to schedule a pickup from the service, or they can call SBMTD directly to schedule a trip. SBMTD is using ADA-compliant electric Ford e-Transit vans to provide this service. SBMTD has procured three vans and deployed them in 2022. In addition, SBMTD aims to procure an additional three electric vans in 2024. These vehicles have a minimum useful life of eight years.

Paratransit Service

SBMTD also provides the required Americans with Disabilities Act (ADA) complementary paratransit service for persons who are unable to utilize the fixed-route service. SBMTD has contracted this service to Easy Lift Transportation, which is a local nonprofit organization. Easy Lift currently has 23 vehicles. Four of these vehicles are Class 3 or 4 cutaway buses. The remaining vehicles are light-duty transit vans. Easy Lift does not own or operate any ZEVs, and, at present, does not have a plan to transition to ZEVs.

Infrastructure Plans

In 2018, SBMTD deployed 14 battery-electric transit buses. To charge the buses, SBMTD installed 15 chargers at Terminal 1 located at 550 Olive Street in Santa Barbara. These chargers are proprietary chargers and can only be used to charge the battery-electric transit buses they were installed to serve. SBMTD has been taking delivery of an additional nine battery-electric transit buses and has installed an additional 14 chargers to serve those buses. SBMTD has 14 Level 2 chargers to charge their non-revenue fleet of Chevrolet Bolt electric vehicles. Lastly, SBMTD has one charger that is available to the public. SBMTD has three battery-electric microtransit vans and plans to expand to six vans in the future. The microtransit vans can charge using any of SBMTD's existing or proposed chargers, with the exception of the aforementioned proprietary chargers. While SBMTD currently houses its battery-electric transit bus fleet and associated charging infrastructure at Terminal 1 in Santa Barbara, the agency is in the process of recommissioning its Terminal 2 facility in the City of Goleta. SBMTD intends to house battery-electric buses and supporting infrastructure at Terminal 2 in the future.

City of Santa Barbara

To meet its climate objectives, the City of Santa Barbara plans to transition its fleets to ZEVs. The City has a fleet that is used to provide public services to City residents. The City owns about 450 vehicles. The fleet consists of multiple types of vehicles, including motorcycles, police cars, fire trucks, utility trucks, pickup trucks, heavy trucks, and vans.

The majority of these vehicles are fueled at the City's Corporate Yard, which is located at 630 Garden Street in Santa Barbara. These vehicles consume a large amount of fuel. Between 2017 and 2021, the fleet consumed an average of 204,059 gallons of gasoline per year, 60,410 gallons of diesel per year, and 4,274 gallons of off-road/red dye diesel. Similar to SBMTD, the City stopped using diesel and instead adopted renewable diesel. Renewable diesel significantly reduces carbon monoxide (CO), hydrocarbon emissions, and lifecycle GHG emissions. However, it does not reduce tailpipe emissions of carbon dioxide, oxides of nitrogen, or particulate matter.

The City aims to transition the entire fleet to zero-emission technology. They are open to purchasing either battery-electric or hydrogen fuel cell vehicles. The City has purchased electric and plug-in hybrid vehicles. While the City is open to purchasing fuel cell vehicles, they have not purchased any to date. The main barrier to deploying fuel cell vehicles is infrastructure requirements. Deploying a private hydrogen fueling station for the City fleet is difficult because the City would need to acquire additional land to build the station. As a result, there are currently no plans to purchase fuel cell vehicles.

The City has already purchased more than 20 battery-electric vehicles and more than 40 plug-in hybrid vehicles. These vehicles are primarily light-duty sedans and carpool vehicles. However, one electric police car has been deployed. The City has also ordered several Ford F-150 Lightning trucks. The City has also identified several types of light-duty vehicles that they plan to transition to zero-emission in the near future. These types of vehicles were selected because they have a duty-cycle that can be served by zero-emission technology and there are zero-emission models available on the market. These vehicle types include police patrol cars, emergency sedans, utility wagons/SUVs, small trucks, half-ton trucks, and ¾ ton trucks (Class 2).

The City fleet also has medium- and heavy-duty vehicles. These include Class 3-8 vehicles. These vehicles vary in their function. Most of these vehicles are Class 3-6 trucks and vans. However, some of these vehicles are electric power take-off trucks or fire trucks. The City of Santa Barbara does not currently have any plans to electrify the medium- or heavy-duty fleet until more cost effective and commercially available models enter the market.

The City also owns and operates the Santa Barbara Airport and its fleet of vehicles. The Airport currently offers a shuttle service between the main terminal building and the economy parking lot. This service operates along a 1.6-mile route daily from 6 am – 12 pm. The service currently uses two diesel vans. These vans accumulate approximately 85,000 miles per year with a considerable amount of idling. The City is exploring the feasibility of purchasing battery-electric vans to replace these vehicles. However, there is no definitive timeline for purchasing the electric vans.

Santa Barbara is currently in the early stages of transitioning to ZEVs. As a result, the City has been actively investigating ZEV charging infrastructure. Currently, the City operates 20 Level 2 chargers (J1772 7.2 kW chargers) located at their Corporate Yard at 630 Garden Street, the Waterfront, and the Airport. The City plans to install six Level 2 chargers at their Corporate Yard for City vehicles and eight Level 2 chargers next to the Corporate Yard for employee use. Additionally, the City plans to install four DCFCs at their Corporate Yard. Two of these DCFCs will be drive-through chargers to allow MHD vehicles or vehicles with a trailer to use them. The DCFCs will be used to quickly charge City vehicles with multiple shifts/high vehicle miles traveled (VMT). This opens the door to piloting new types of electric vehicles and exploring ways to connect the DCFCs to the emergency back-up generator at the facility.

There are 50 public chargers available throughout Santa Barbara. City vehicles sometimes use these public chargers. There are plans to install 100+ additional public chargers throughout the City in the future.

Santa Barbara County Association of Governments

The Clean Air Express is a public transit service that is administered by the Santa Barbara County Association of Governments (SBCAG) and operated by a private contractor. SBCAG is a Joint Powers Authority between the County and the eight cities within the County, and functions as the Metropolitan Planning Organization for the County. The Clean Air Express provides commuter bus service on weekdays between North Santa Barbara County and South Santa Barbara County. Clean Air Express routes run from Lompoc, Santa Maria, and Buellton to Goleta and Santa Barbara. Most of the riders are workers who are commuting to their jobs in Goleta and Santa Barbara. The Clean Air Express currently owns commuter buses (over-the-road coaches). SBCAG plans to house and maintain their fleet of up to 20 buses at their recently acquired facility at 6416 Hollister Ave in Goleta. In 2022, Clean Air Express purchased one 45-foot battery-electric commuter bus. Clean Air Express plans to convert the entire fleet to electric buses. However, they do not yet have a timeline for this transition.

County of Santa Barbara

The County of Santa Barbara has several fleets that are used to provide public services. The County has started to investigate the feasibility of transitioning the fleet to zero-emission. This effort was catalyzed by the County's energy and climate change objectives. In 2015, the County published its 2015 Energy & Climate Action Report. This report called for a reduction in transportation related GHG emissions and one of the strategies the report recommended was adopting ZEVs. This section will explore the County's plans to transition to a zero-emission fleet.

The County has a fleet of 1,598 vehicles used to provide public services. The fleet consists of 334 light-duty trucks, 11 earth movers/graders, 152 medium- and heavy-duty trucks, 2 steam rollers, 5 60-passenger buses, 25 landscape vehicles, 64 police cars, 6 police motorcycles, 590 light-duty passenger cars, 20 fire brush trucks, 32 fire pumpers, and 39 tractors, among others.

To date, the County has focused on transitioning light-duty cars to zero-emission. The County currently has 91 EV sedans, 1 EV full size cargo van, and 36 hybrid vehicles. There are currently 13 hybrid vehicles on order and plans to acquire at least 1 EV truck.

If the County proceeds with transitioning to zero-emission, the five 60-foot passenger buses would be a potential candidate. These buses are used by the Sheriff's Office to transport prisoners to city courthouses, County jailhouses, and penitentiaries. The buses are primarily used to transport prisoners between the North County Jail in Santa Maria and the South

County Jail in Goleta. However, there are no plans nor funding available to transition these buses to zero-emission.

Santa Barbara County currently operates 123 Level 2 chargers. Roughly 25% of the chargers are accessible for public charging. An additional 144 charger installations are planned for 2024. Santa Barbara County has also deployed 6 DCFCs. The County is in the final stages of completing a 700 kW solar photovoltaic (PV) panels and battery microgrid at the Betteravia Campus in Santa Maria. This microgrid serves the County government offices and has the capacity to store four to eight hours of energy. The County is currently in the exploration phase of deploying a similar microgrid at the Foster Road Campus in Santa Maria.

Santa Barbara Unified School District

Santa Barbara Unified School District (SBUSD) is a public school district that manages schools in Santa Barbara and Goleta. SBUSD has about 13,000 students across 21 schools, including elementary, middle, and high schools. SBUSD has a fleet of 104 vehicles. These vehicles include cars, pickup trucks, Ford E-series delivery trucks, and various off-road vehicles.

SBUSD does not have any explicit zero-emission vehicle procurement plans. SBUSD passed Board Policy 3510 which directed the District to implement green school operational strategies. The Policy aims to reduce car trips by encouraging students to walk, bike, or use school buses or public transit. The Policy also cited the use of renewable and clean energy technologies as a possible strategy for implementing green operations. Although transitioning to ZEVs would support this strategy, the Policy does not explicitly require the adoption of ZEVs.

SBUSD is currently leasing its light-duty car fleet. The leasing company is transitioning the cars to hybrid vehicles and has provided SBUSD with five plug-in hybrids with four more arriving soon. Of these light-duty vehicles, SBUSD is considering using electric vehicles in departments such as Food Services and Warehouse as pilot projects. SBUSD is looking into this because the vehicles only drive a maximum of 80-100 miles per day. The pilot projects will begin in the next three to five years.

SBUSD does not own any school buses. Instead, school bus service has been contracted out to Student Transportation of America, which is a transportation services company. Student Transportation of America currently does not operate any electric school buses in the City of Santa Barbara.

SBUSD is currently seeking a grant from Santa Barbara County Air Pollution Control District (SBCAPCD) to fund EV chargers for one District location. In addition, SBUSD plans to install solar arrays at 14 sites across the District with 11 of the sites falling in the City of Santa

Barbara's jurisdiction. Six of the sites are proposed to have a microgrid attached. Those six sites are Dos Pueblos High, San Marcos High, La Cumbre Junior High, La Cuesta High School/District Office, District Warehouse, and Santa Barbara High. The 14 sites should supply between 70 to 80% of the District's overall energy use and 80 to 90% of each respective site's energy demands. (See Santa Barbara Unified School District Microgrid section for more details). The microgrids are proposed to provide resiliency to District buildings, not to District EVs.

Resiliency Infrastructure

One of the key themes of this project is fleet resiliency. To date, there has been little resiliency infrastructure deployed in Santa Barbara for zero-emission transportation. Santa Barbara has installed public chargers which can be used by fleets during an emergency (see Shared Public Charging section). However, there are few sources of backup power that have been deployed for ZEVs. Resiliency is also a major concern for non-transportation sectors. As a result, plans have been developed to help the City of Santa Barbara address its resiliency vulnerabilities. Clean Coalition, which is a nonprofit organization that focuses on deploying microgrids, has developed and is currently implementing plans to deploy microgrids in the Santa Barbara area. These plans are described below.

Vallecito Energy Storage Resiliency Project

Clean Coalition has developed plans to deploy a community microgrid in Carpinteria. The community microgrid is designed to serve important facilities like Carpinteria High School, which can be used as an emergency shelter. The microgrid will be powered with 15 MW of solar PV panels and 40 MWh of battery storage. The system will be located at the Carpinteria Substation (Sanchez, 2020).

Santa Barbara Unified School District Microgrid

Clean Coalition has developed plans to build microgrids to serve multiple Santa Barbara Unified School District facilities. This plan calls for the creation of microgrids that will provide resiliency to 15 District facilities. These microgrids will primarily use solar and energy storage to provide resiliency. In total, the microgrids will deploy 4,523 kW of solar PV panels and a 2,683 kW/5,986 kWh of battery storage. For most facilities, the microgrid will be sized to provide 2-4 hours of resiliency without receiving energy from solar PV (Clean Coalition (b)).

Microgrids are planned at the following locations:

- San Marcos High School
- La Cuesta High School

- Dos Pueblos High School
- La Cumbre Junior High School
- Santa Barbara High School
- District Warehouse

Direct Relief Microgrid

Direct Relief is a nonprofit organization that provides humanitarian relief to emergency-stricken areas. Direct Relief has a logistics warehouse in Goleta that is used to distribute humanitarian aid. As a result, it is vital that this facility can operate during a grid outage. To mitigate this risk, Direct Relief built a microgrid. This microgrid includes a 320 kW solar PV system, a 676 kWh battery storage system, and a 600 kW diesel generator. The facility has room to add additional generation assets and there is space to add an additional 1,013 kW of solar PV and 2,028 kWh of additional battery storage (Clean Coalition (c)).

Montecito Community Microgrid

In 2018, the unincorporated community of Montecito experienced a major mudslide. This mudslide, which was a direct result of heavy rainfall in the burn scar of the 2017 Thomas Fire, killed 23 people, destroyed 100 homes, and damaged 300 other homes. Clean Coalition is helping Montecito to develop microgrids to protect critical facilities against grid outages. Clean Coalition is planning microgrids at the Montecito Fire Protection District headquarters and fire station, Montecito Water District headquarters and water pumps, and Montecito Union School (Clean Coalition (d)).

Vehicle and Infrastructure Deployment Trends

The City of Santa Barbara has proactively worked to combat climate change. The City has implemented a coherent set of energy policies and energy plans that are intended to transition the City to carbon neutrality. One of the City's key energy policies is their ordinance requiring 100% renewable energy. The City has published several plans that detail strategies for achieving 100% renewable energy. However, these plans do not take into account energy consumed by ZEVs. Since ZEVs are very energy intensive, this represents a major limitation to these renewable energy plans.

This analysis helps to quantify the number of ZEVs that will be deployed. The report focuses on the current and projected deployments of medium- and heavy-duty vehicles in transit and municipal fleets. These figures will be useful for estimating the amount of energy and power these vehicles will consume. The date can be integrated into energy planning for the City and will be instrumental for infrastructure planning. To date, there have been few zero-emission MHD vehicles deployed. The table below displays the number of electric vehicles that each fleet has currently deployed.

Table 1. Current Battery-Electric Vehicle Deployments

Fleet	Light-Duty Vehicles	Medium-Duty Vehicles	Heavy-Duty Vehicles
SBMTD	14	3	14
City of Santa Barbara	18	0	0
Santa Barbara County Association of Governments	0	0	1
County of Santa Barbara	65	0	0
Santa Barbara Unified School District	0	0	0
Total	**97**	**3**	**15**

It is important to note that currently no fuel cell fleet vehicles have been deployed in Santa Barbara. Furthermore, no fleet has expressed an interest in deploying fuel cell vehicles. This is due to the fact that there is little hydrogen infrastructure in the region. Santa Barbara only has one public hydrogen fueling station within the city limits. This hydrogen station is located at 150 S. La Cumbre Road, about four miles away from the City's depot. The next closest station is 60 miles away.

This hydrogen fueling station is intended for use by light-duty vehicles. The station does not have enough physical space to accommodate fueling for MHD vehicles. In addition, the station has a relatively small storage capacity and cannot fuel a large number of vehicles. The City of Santa Barbara does not believe that this station would be adequate for a fuel cell fleet as the station is located too far away from the City yards and there are no other public fueling sites that can be used as a backup if this station were to be inoperable or run out of fuel. As a result, this station cannot be used to fuel MHD vehicles.

It is important to note that bus fleets, like SBMTD and Clean Air Express, are on track to be the first fleets to fully transition to zero-emission. This is likely due to policy drivers, like the ICT Regulation, and funding that has been made available for zero-emission buses through programs like the Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project (HVIP), VW Settlement, and the Federal Transit Administration's Low and No Emission Program. Furthermore, zero-emission buses are more technologically developed than other classes of medium- and heavy-duty vehicles and the market is more mature.

While Santa Barbara's municipal fleets are transitioning light-duty vehicles to zero-emission, it appears that their transition to zero-emission medium- and heavy-duty vehicles is moving slower than for bus fleets. This is due to the fact that there are fewer regulations driving the adoption of zero-emission medium- and heavy-duty vehicles. The majority of medium- and heavy-duty vehicles in a municipal fleet are trucks. The Advanced Clean Truck Rule requires that manufacturers sell an increasing number of zero-emission trucks. However, this regulation does not go into effect until 2024. The proposed Advanced Clean Fleet Rule will also require fleets with more than fifty vehicles to purchase zero-emission trucks. However, this regulation has not been enacted yet. As a result, fleets do not currently have strong regulatory pressure to transition their truck fleet to zero-emission. In addition, municipal fleets have several vehicle types for which there is no zero-emission replacement on the market. For example, there are currently no zero-emission earthmovers/graders or steamrollers on the market. Lastly, there are fewer funding programs for medium- and heavy-duty trucks. To accelerate the deployment of ZEVs in municipal fleets, more funding will need to be made available.

Microgrid Planning and Technology Analysis

Zero-emission buses are fundamentally reliant on the power grid. This is especially true for BEBs, which use electricity directly as a fuel. Any grid outage would disrupt charging operations, and sustained outages could prevent charging to the extent that the fleet would be effectively disabled. The disruption to charging operations is problematic because it would impact transit operations, hampering mobility and causing economic harm. This could also cause reputational damage to the ZEB industry.

As an early adopter of ZEBs, SBMTD is vulnerable to this threat. SBMTD is in the process of transitioning their fleet to BEBs which will require significant investment in charging infrastructure. In order to accommodate the transition to BEBs, major changes to SBMTD's depot are required. SBMTD currently houses their entire fleet at Terminal 1, located at 550 Olive Street, Santa Barbara, California 93101. SBMTD also owns Terminal 2, which is located at 5353 Overpass Road, Goleta, California 93111. Terminal 2 will be undergoing improvements in the near future that will allow SBMTD to shift some of its fleet and operations to that facility and alleviate operational capacity strain at Terminal 1.

SBMTD is currently focused on deploying charging infrastructure at Terminal 1. This requires significant construction at the site to install charging infrastructure. Since Terminal 1 is already space constrained, and charging infrastructure has a large physical footprint, the recommissioning of Terminal 2 is critical to the success of SBMTD's fleet electrification efforts. While SBMTD's charging infrastructure upgrades are concentrated at Terminal 1 now, SBMTD will begin deploying EV charging infrastructure at Terminal 2 after the first phase of facility recommissioning is complete.

SBMTD Microgrid Planning

SBMTD is served by SCE, and SCE's grid is relatively stable and has a track record of reliably delivering power. However, major environmental events like extreme weather or natural disasters can cause grid outages. This is especially relevant to California, which is seismically active and is prone to wildfires. California utilities have historically initiated Public Safety Power Shutoffs (PSPS's) in areas prone to wildfire to ensure that their equipment does not start fires, with these power shutoffs lasting an average of 30 hours. The City of Santa Barbara is located near an area that is prone to wildfire and mudslides and has previously been affected by PSPS's.

The City of Santa Barbara faces unusually high grid resiliency risks due to its geography, and the City produces very little power within its boundaries. Instead, SCE provides the vast majority of Santa Barbara's power through the Goleta Load Pocket. The Goleta Load Pocket consists of a single 220 kV transmission line that runs from Santa Clarita to Goleta. These transmission lines, which are attached to transmission towers, traverse mountainous terrain that is vulnerable to natural disasters. The City's reliance on the Goleta Load Pocket for power creates a resiliency problem. If a natural disaster occurs near the Goleta Load Pocket, it could disable the transmission lines and cause widespread and lengthy power outages in the City. This scenario is no longer hypothetical, as the area has experienced multiple natural disasters in recent years. In late 2017, the Thomas Fire burned the area near the Goleta Load Pocket. As a result of this wildfire, SCE was forced to shut off power to the Goleta Load Pocket, which left 200,000 customers without power (Clean Coalition (e)).

To protect against extended grid outages, SBMTD is interested in deploying measures, including a microgrid, to mitigate the risk of a grid outage and provide resiliency to the fleet. Since Terminal 1 will host the majority of the fleet, SBMTD aims to deploy a microgrid at this site first. SBMTD is also interested in deploying a microgrid at Terminal 2 but needs to prioritize the recommissioning of the site before any fleet electrification upgrades are performed. SBMTD collaborated with CALSTART to examine the techno-economic feasibility of deploying microgrids at Terminal 1 and Terminal 2. This analysis was then used to develop a conceptual design for the microgrid at Terminal 1.

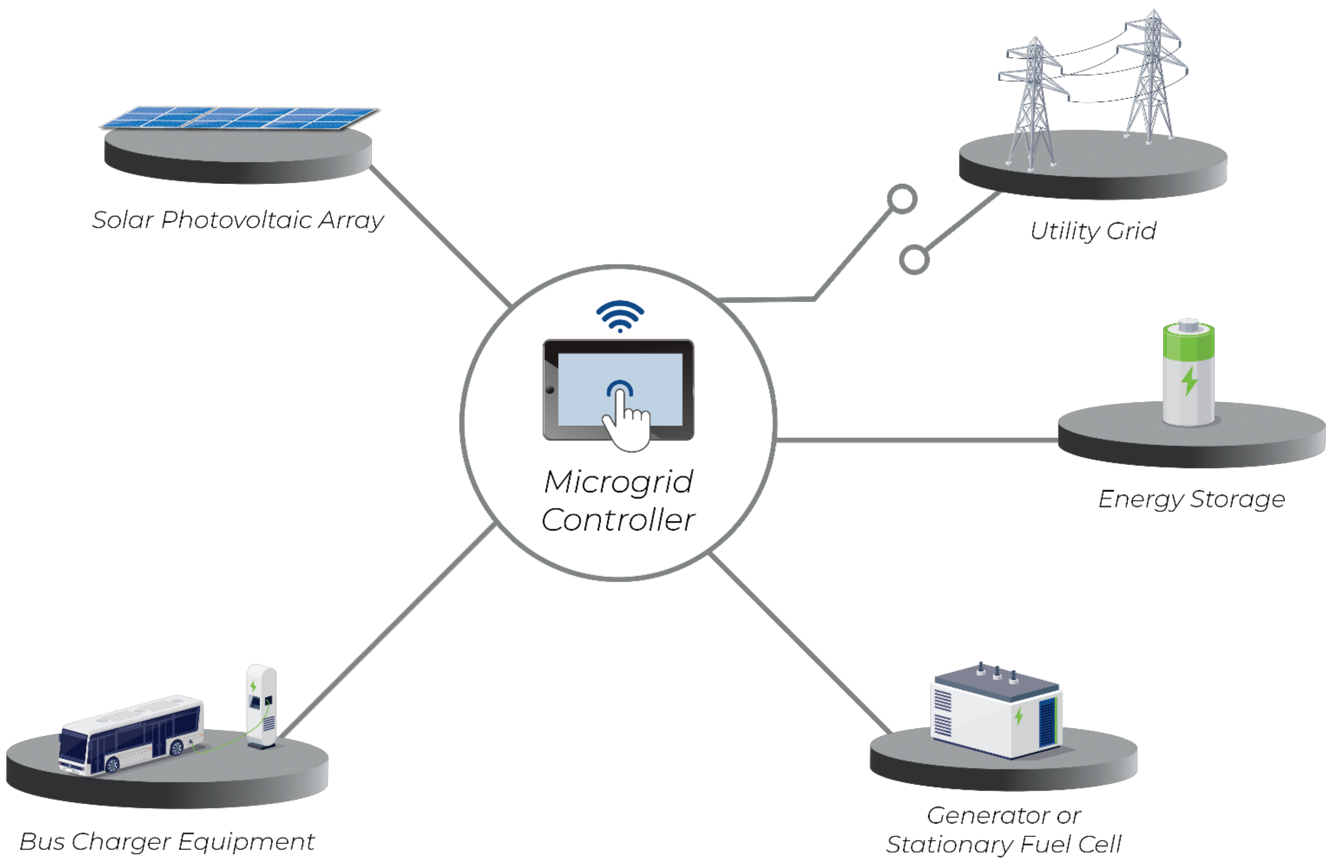
Introduction to Microgrids

ZEV fleets have historically addressed resiliency concerns in several ways. One of the strategies is maintaining access to redundant equipment. For example, a fleet can use public charging, if available, as a form of resiliency (see the Shared Public Charging section). Alternatively, a fleet might come to an agreement with another fleet to share charging infrastructure if one of their depots loses power. Lastly, a fleet might opt to have two or more charging sites so that if one site loses power, charging can continue at the other sites. While these are valuable resiliency strategies, they will not work if there is a widespread outage that takes out power at all of the backup charging sites.

Fleets also address resiliency concerns by deploying additional infrastructure to provide backup and maintain operations in the event of a grid outage. Some fleets use generators, powered by natural gas or liquid fuels like diesel, to produce electricity and mitigate the effects of grid outages. While generators can produce power in the event of a grid outage, there are some disadvantages to this technology. Generators produce GHG, nitrogen oxides (NOx), and particulate matter (PM) emissions, which are pollutants and harm air quality. As a result, many jurisdictions have air quality regulations that limit the use of generators to emergencies. Since generators are only used during emergencies, the levelized cost of energy is high. One option to reduce the cost of using a generator is to rent a mobile generator during an extended outage. However, it can be difficult to obtain one during an emergency, and the turnaround time to acquire and install the generator is an additional downside. Furthermore, generators can potentially fail to start up due to poor maintenance, fuel degradation, or generator component failure (Ericson and Olis, 2019). The foregoing is particularly problematic if the generator is the sole source of backup power.

A microgrid is a local grid that uses DER and energy storage assets to provide power to a specific campus or facility. A key feature of microgrids is their ability to disconnect from the grid and generate their own power. This is managed by a switch at the point of connection with the utility grid and a controller that decides when to connect and disconnect from the main grid. Essentially, microgrids must be able to function as an island, operating even when isolated from outside power sources. This is why solar power systems and standalone generators, by themselves, cannot be described as microgrids.

Figure 1. Microgrid Diagram



A microgrid is superior to a standalone generator for several reasons. The benefits of a microgrid include:

- Instantaneous Power: Most backup generators take time to start up. A microgrid, however, can use an uninterruptible power supply to instantaneously start providing power when an outage occurs.
- Flexibility: Backup generators are usually tied to an individual load and can only provide power to that load. Microgrids are more flexible because the generation assets are not tied directly to an individual load and can power multiple loads.
- Asset Diversification: Microgrids can provide multiple generation sources. If one source fails, there are other power generation sources to fall back on.
- Peak Shaving and Load Shifting: Microgrids can be used to manage power demand. A microgrid can allow agencies to reduce demand by storing self-generated energy during times of low power demand and then deploying it when the EVs are charging. This can help to reduce demand charges for the fleet. This is known as peak shaving.

Likewise, a microgrid can use DERs to provide power during times of the day when electricity rates are higher. This can help to reduce energy charges for the fleet. This is known as load shifting.

Microgrid Design Parameters

CALSTART conducted analysis to develop a design for a microgrid to serve SBMTD. The microgrid must be able to provide enough energy to power SBMTD's fleet, meet resiliency goals for the fleet, and incorporate an energy portfolio that is acceptable to SBMTD. CALSTART quantified the required energy load, selected the grid outage scenarios that the microgrid is intended to protect against (design-threat basis), and defined the DER assets that can be included in the microgrid. This section details these design parameters.

Loads

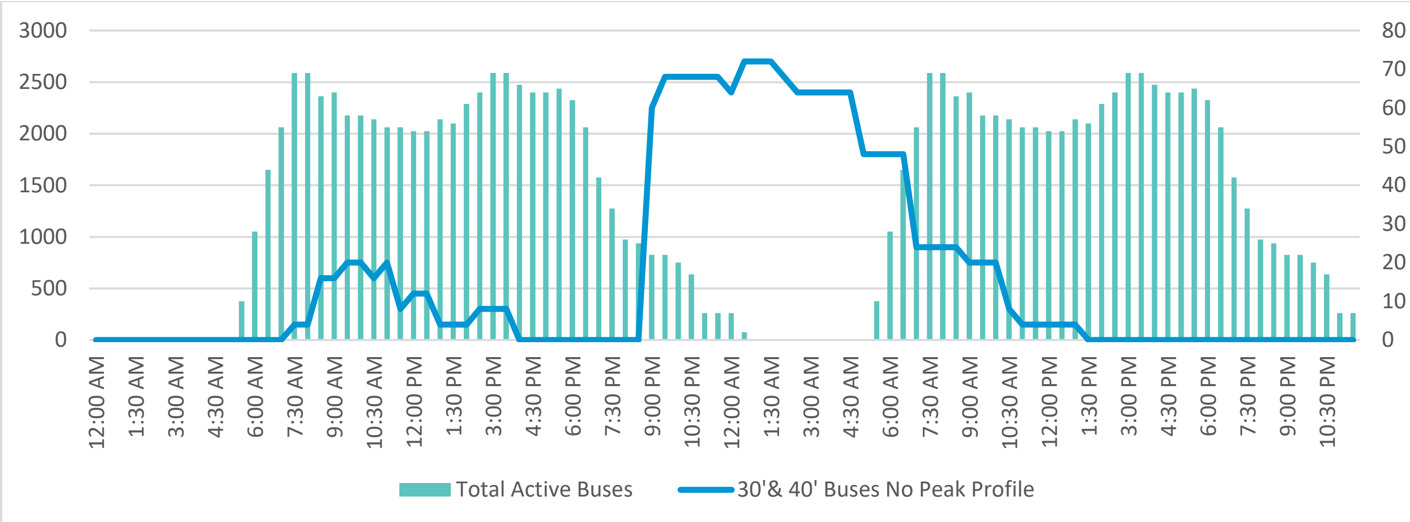
Microgrids are designed to serve specific loads. As a result, estimating the load that the microgrid will serve is a vital task. CALSTART estimated the loads that need to be served at Terminal 1 and Terminal 2.

Terminal 1

Terminal 1 will host several loads and will house approximately 80 buses. About 10 of these buses will be spare buses, which will not need to be charged on a daily basis. As a result, SBMTD expects that 70 buses will be charged per day at this site. SBMTD also hosts 14 light-duty EVs that are used by road supervisors and also to transport drivers to the bus at the route terminus. Terminal 1 has an Administration Building with staff that serve various functions within the organization and maintenance facilities that include offices, repair bays, canopies, and other purpose-built structures to support fleet fueling, cleaning, maintenance, and repair.

CALSTART quantified each of these loads. SBMTD's engineering consultant, Stantec, developed estimates for power demand at Terminal 1, including a charging profile for charging all BEBs. These estimates were used to develop a load profile, which expresses power demand throughout the course of a 24-hour period. The load profile was then modified to avoid charging BEBs at peak utility rate hours (4-9pm) and spread out as much as possible to avoid new demand peaks and still make bus pull out in the morning. This resulted in a peak power demand of about 2.7 MW. CALSTART used these estimates as the basis for the BEB charging load. The BEB charging profile developed and used in the analysis is displayed below.

Figure 2. Terminal 1 BEB Charging Profile



Other charging loads, such as the administration building and the maintenance bays, were originally considered to be tied into the BEB charging microgrids. However, due to metering arrangements, SCE Charge Ready Restrictions (see Utility Microgrid Regulations section), and the presence of existing generators to serve these buildings, the scope of the new microgrid(s) was limited to bus charging only.

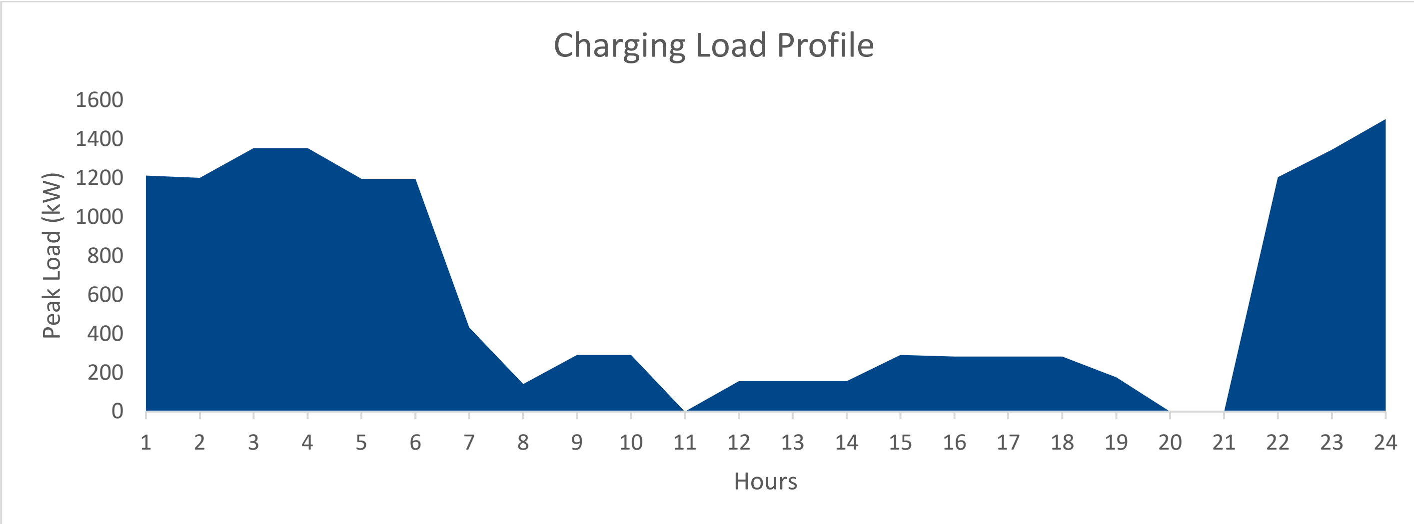
Terminal 2

CALSTART used a similar methodology to estimate the loads for Terminal 2. As discussed, SBMTD is in the process of recommissioning the site, with the first phase of construction to begin in 2024. Once fully recommissioned, which is planned to take place in multiple phases, the site will host approximately 20 BEBs. Stantec provided a load profile for the BEBs.

Terminal 2 will also host an office/maintenance building. Since the site is currently decommissioned, there is no utility data for this building. CALSTART estimated power demand for this load. The power demand was assumed to be equal to the maintenance bays at Terminal 1.

After developing these load profiles, CALSTART added them together to develop a load profile for the entire facility.

Figure 3. Terminal 2 Load Profile



Microgrid Energy Portfolio

Microgrids consist of multiple DERs that are used as energy assets. DERs will need to be deployed to power the microgrid's loads. CALSTART considered several types of DERs to include in the energy portfolio for the microgrid.

- Solar Panels: Solar panels produce renewable power from the sun. Solar panels are not energy dense and produce relatively low kW per unit of area. As a result, space is oftentimes a constraint on how much solar can be deployed on a site. However, solar panels are flexible in that they can be placed on rooftops or on top of carports or canopies to be space-efficient and maximize the amount of solar that can fit onto a site. Solar panels are an intermittent power source and can only produce power when there is sunlight. They do not produce power at night and electricity production decreases significantly when the weather is not sunny. As a result, they need to be supplemented with grid power, energy storage, or other generation assets to produce power when the panels cannot.
- Battery Storage: Lithium-ion batteries are used to provide energy storage in microgrids. Batteries are valuable in microgrids because they can store energy from the grid or excess energy that is produced by DERs. Battery storage assets can then be deployed to provide power when other power sources are not available. As a result, batteries are vital for providing power during a grid outage. Batteries are also advantageous because they can provide power instantly in the event of an outage. Batteries can also help to reduce costs by engaging in peak shaving. This occurs when a battery is used to store self-generated energy during times of low power demand and then deploying this energy when charging occurs. This approach can

lower power demand which helps to reduce demand charges for the fleet. Batteries can also be used to displace grid electricity during times of the day when energy is most expensive, thereby reducing utility costs.

- Generators: A natural gas or diesel generator can be used to produce power for a microgrid. Generators are used as a backup source of power when the grid goes down. Generators are advantageous because they are energy dense and can produce large amounts of power with a small physical footprint. Generators are discussed in more detail in the Introduction to Microgrids section.
- Stationary Fuel Cells: Stationary fuel cells are fuel cells that are used to produce power for a facility, rather than for powering a vehicle. Currently available stationary fuel cells use hydrogen or natural gas. The fuel cells use an oxidation reaction to convert the fuel to electricity. Typically, there are no source emissions from using a fuel cell.

CALSTART analyzed the feasibility of deploying each type of DER. The feasibility of deploying a DER depends on several factors, including, but not limited to, capital and operating costs, space availability at the depot, utility interconnection rules, and compatibility with the microgrid's expected load.

Solar panels and battery storage were deemed to be the most desirable DERs. This determination was made because solar panels are a renewable resource. Pairing the solar panels with batteries is also desirable because the batteries can store excess energy produced, which helps to address the intermittency issue that solar panels face. These resources also do not have any point-source emissions. As a result, they are compatible with SBMTD's environmental objectives. Furthermore, once these resources are deployed, operating costs are low and there are no restrictions on their use.

One of the drawbacks of solar and battery storage is that they have a relatively low power density compared to other types of DERs. Since the depot is space constrained and the microgrid must serve a significant power demand, solar and battery storage will need to be supplemented with other DERs. This can include generators or stationary fuel cells. Stationary fuel cells were ruled out because they require a source of fuel that is not readily available to provide power. Many stationary fuel cells use hydrogen. The Santa Barbara region does not currently have an established hydrogen supply chain. This is problematic because hydrogen must be delivered to the region. If there is an emergency, the main freeways into Santa Barbara might get cutoff, which would prevent the delivery of hydrogen. Due to this supply chain risk, stationary fuel cells were ruled out.

SBMTD is open to using generators to supplement power from solar and batteries. If generators are required, SBMTD will need to decide between using diesel or natural gas generators. SBMTD has the capacity to use a diesel generator. Terminal 1 currently has a 20,000-gallon tank of renewable diesel that is used to supply fuel to the existing fleet of diesel and hybrid buses. The tank carries an average of 14,000 gallons of renewable diesel and additional renewable diesel is ordered when the tank level falls to 10,000 gallons. As a result, there is a significant amount of renewable diesel onsite that can be used by a diesel generator. It is important to note that Terminal 1 is already hosting three diesel generators. These generators are currently used to provide backup power to the administration building, maintenance facilities, existing BEB chargers, and the fueling island. These generators combined have a nameplate capacity of approximately 600 kW.

Selecting a natural gas generator would require SBMTD to install a new service for natural gas. It is important to note that in 2021, the City of Santa Barbara adopted the Natural Gas Infrastructure Prohibition Ordinance. This ordinance prohibits the installation of new natural gas infrastructure in newly constructed buildings. The ordinance applies to all building permits submitted after December 31, 2021. Exemptions are allowed for restaurants, clean rooms, laboratories, and projects where electrification is not feasible or deemed to be in the public interest by the Permitting Authority. As such, SBMTD could potentially obtain an exemption to the ordinance through the public interest exemption. SBMTD already has the infrastructure to use a diesel generator that is fueled by renewable diesel. In addition, installing a natural gas generator would violate the spirit of the ordinance. As a result, natural gas generators were eliminated from the energy portfolio.

Based on this analysis, SBMTD aims to power the microgrid with solar panels, batteries, and diesel generators powered with renewable diesel.

Desired Use Case

SBMTD plans to use the microgrid for multiple purposes. The primary purpose of the microgrid is to provide resiliency to their fleet to protect against a grid outage. This objective is consistent with the City of Santa Barbara's Strategic Energy Plan. The Strategic Energy Plan calls for the provision of resiliency infrastructure and Strategy 4.1 specifically calls for the deployment of microgrids at critical municipal facilities. To provide resiliency and meet this objective, the microgrid needs to provide power so fleet operations can continue. The exact resiliency requirements are described in the Design-Threat Basis section.

The City of Santa Barbara also hopes that localized microgrids like the one SBMTD plans to develop can serve as a resource for regional resiliency. Strategy 4.1 of the Strategic Energy Plan also calls for the deployment of a network of DERs and microgrids that can support each other and island or disconnect from the grid during grid outages. The SBMTD microgrid can potentially be a node within this network. One of the key functionalities required to achieve this is the ability to export power to support other facilities.

SBMTD also aims to use the microgrid to offset utility costs and/or generate revenue. This can be achieved by using the microgrid to offset energy sourced from the grid, to reduce energy costs and demand charges. The microgrid may also generate revenue by providing grid services, such as demand response or voltage regulation.

SBMTD also aims to use this microgrid to support the city-wide deployment of renewable energy. Strategy 4.3 of the Strategic Energy Plan calls for the creation of a Smart Energy Zone. This zone will allow the City to deploy renewable energy pilot projects, address barriers to renewable energy development, and encourage investment. The Smart Energy Zone can be a "living lab" where policies, new technology, and novel technology applications can be developed and evaluated. The proposed Smart Energy Zone is 1.5 square miles and is located in downtown Santa Barbara. The physical area of this zone would include the main City facilities, SBMTD's Terminal 1 depot, the water treatment and desalination plants, two school campuses, and multiple shopping centers. Development of a microgrid by SBMTD to serve transportation needs would fit well with the objectives of the Strategic Energy Plan.

Design-Threat Basis

Santa Barbara is served by SCE, which has historically been reliable. The reliability of the grid is measured through several metrics, called reliability indices. Common reliability indices include System Average Interruption Frequency Index (SAIFI) and System Average Interruption Duration Index (SAIDI). SAIFI measures the number of grid interruptions the average customer experiences over one year. SAIDI measures the length of the grid interruption (in minutes) that the average customer experiences over one year. In the City of Santa Barbara, SCE has a SAIFI of 1.5 and a SAIDI of 154 minutes (SCE, 2022), indicating that the grid is stable under normal conditions. SCE provided data for grid outages that occurred at SBMTD's Terminal 1 depot. These outages were minor because they lasted less than a minute and were corrected by automated equipment without needing repairs. These outages occurred during the two-year period between November 15, 2020, and November 15, 2022.[1]

[1] Data obtained through correspondence with SCE

Table 2. Minor Unplanned Grid Outages at Terminal 1

Outage Date	Duration (minutes)	Cause
7/21/2021	0.4	Mylar balloons
5/13/2022	0.5	Bird made contact with substation equipment
5/14/2022	0.5	Bird made contact with substation equipment

While the grid can experience outages lasting less than a minute, it is also possible for more serious outages to occur. These outages are more severe because they can last for hours (or even longer than a day) and cannot be corrected by automatic equipment and typically require repairs. SCE provided data for these lengthy grid outages that occurred at SBMTD's Terminal 1 depot. These outages occurred during the two-year period between November 15, 2020, and November 15, 2022.[2]

Table 3. Major Unplanned Grid Outages at Terminal 1

Outage Date	Duration (minutes)	Cause
4/20/2021	212	Automatic equipment detected a fault and automatically de-energized the circuit
8/1/2021	1781	Replaced failed underground cable

The outages reported in Table 2 and Table 3 are examples of outages that are captured by SCE's reliability indices. However, it is important to note that SCE's reliability indices exclude "major event days." Major event days are outlier events, like extreme weather events or natural disasters, that cause extended outages. An example of a major event day would be if an earthquake damaged a substation and caused a grid outage lasting for a week. As a result, while SCE's reliability indices are helpful for measuring typical outages, they do not fully capture the consequences of an outage caused by an emergency.

The microgrid must be able to respond to a wide range of grid outage types. Since the biggest threat to SBMTD is an emergency that causes a major event day, the microgrid

[2] Data obtained through correspondence with SCE

should be designed to maximize the duration of grid resiliency. However, given the demanding load the microgrid must serve and that the primary assets in the energy portfolio are solar and battery storage, there are limits on how much resiliency can be provided. Based upon these constraints, SBMTD aims to obtain a minimum of 24 hours of resiliency from the microgrid. This level of resiliency would provide backup for most grid outages. This resiliency objective is consistent with other microgrids that have been deployed at transit agencies. However, SBMTD also aims to maximize the resiliency that can be provided. As a result, if techno-economically feasible, SBMTD would aim to pursue additional resiliency beyond 24 hours.

Microgrid Regulatory Environment

While the design parameters are driven by the microgrid user, the regulatory environment for microgrids is imposed on the user by other entities. Microgrids are subject to multiple rules and regulations, which vary depending on the regulatory environment of the jurisdiction. Since microgrids are a relatively new technology, many states do not have a fully developed regulatory environment. However, the state of California regulates microgrids through the California Public Utilities Commission (CPUC). Furthermore, utilities also enforce rules on microgrid deployments. The regulatory environment that is enforced by the state and utilities is important because it places constraints on the microgrid. These constraints have a deep impact on its design, implementation, and operation. This section details the regulatory environment that this microgrid faces and the impacts that it will have on the microgrid.

Microgrid Operational Models

There are multiple models under which a microgrid can be owned and operated. These operating models are classified based on ownership of the microgrid and where the microgrid is located in relation to the meter.

Behind-the-Meter (BTM) operating models refer to situations where the microgrid is located on the customer's side of the meter. In most cases, the microgrid is located directly on the customer's property. There are two main ownership models that can be implemented BTM. The first model is the customer-owned model. Under this model, the microgrid user finances and builds the microgrid. Once the microgrid is built, the user owns the microgrid and is responsible for operating and maintaining it. Alternatively, the microgrid user may benefit from the microgrid through a third-party power purchasing agreement (PPA). Under a third-party PPA, a third-party company finances, builds, and operates the microgrid. Oftentimes, the third-party company bundles the microgrid with the charging infrastructure. The third-party company then signs a PPA with the user where they provide electricity in return for payment. These PPAs are usually for a defined period and are structured so the user pays per kWh. One advantage of PPAs is that the microgrid user can deploy the microgrid without the upfront capital costs.

Microgrid users can also opt to use a Front-of-the-Meter (FTM) operating model. Under FTM, the microgrid is located on the utility's side of the meter. Usually this means that the microgrid is attached to the utility's distribution system. The microgrid is typically located on utility property but can be located on the user's property. In most cases, the utility will own and operate the microgrid for the benefit of customers. Customers downstream of the microgrid will receive power if there is a grid outage. Utilities typically charge a recurring fee or a higher per kWh rate for the energy to recover the costs of the microgrid.

CPUC Microgrid Regulatory Environment

The main basis of California's regulatory environment is SB 1339 (2017-2018). SB 1339, which was enacted in 2018, requires CPUC to work with the California Energy Commission and the California Independent System Operator to develop policies to support the commercialization of microgrid technology.[3] In response to SB 1339, CPUC initiated rulemaking for microgrids under R.19-09-009 in September 2019. The CPUC later issued a Scoping Memo on December 20, 2019 that established a framework for a rulemaking proceeding for microgrids. The objective of the rulemaking proceeding was to accelerate the deployment of microgrids with battery storage to mitigate against grid outages. The Scoping Memo also established three tracks for the rulemaking proceeding (CPUC, 2019). Track 1 addressed resiliency in areas prone to outages and wildfires with the objective of deploying resiliency measures by summer 2020. Track 2 addressed the development of standards, protocols, rates, and tariffs to reduce barriers to deploying microgrids across the entirety of California. Track 3 addressed other topics such as codifying standards and protocols for microgrids. Tracks 1 – 3 were completed by July 2021.

In August 2021, an Amended Scoping Memo was issued which initiated Track 4 proceedings. Track 4 is broken into two phases. Phase 1 is an expedited track that addresses plans for deploying more clean energy and storage projects. The intent of Phase 1 is to mitigate grid capacity shortages and reduce the strain on the grid. Phase 2 is a non-expedited phase that addresses multi-property tariffs for microgrids and the Microgrid Incentive Program which provides funding for microgrid deployments (CPUC, 2021). Another revised Scoping Memo was issued in December 2021 which initiated Track 5 proceedings. Track 5 addresses economic and equity impacts of grid outages, metrics for evaluating resiliency, and how these metrics should guide environmental and social justice

[3] The text of SB 1339 can be found at: https://legiscan.com/CA/text/SB1339/2017

(CPUC, 2021a). Track 4 is currently on hold and Track 5 is in progress. As a result, there is still uncertainty about the regulatory framework for microgrids.

BTM Regulatory Environment

CALSTART analyzed the feasibility of deploying the SBMTD microgrid BTM. CPUC has developed a regulatory framework for BTM microgrids. The microgrid can be operated by either the microgrid user or by a third-party. The microgrid must go through SCE's interconnection process and there are multiple ways that the microgrid can be interconnected, depending on how the microgrid will be operated. Most of these pathways involve Rule 21, which governs interconnections for generating facilities/DERs. Rule 21 is designed to streamline interconnections by establishing requirements that each installation must meet before being connected to the grid.

- Rule 21 – Non-Export: The microgrid normally operates in parallel with the SCE grid and does not continuously export power back to the grid.
- Rule 21 – Isolated Operations: The microgrid is used solely for backup generation. The microgrid only operates in "isolated operation mode" and is not connected to the SCE grid.
- Rule 21 – Momentary Parallel Operations: The microgrid is used for backup generation and the backup generation is not normally operational. When the backup generation is started up, it may connect in parallel with the grid for less than one second before it must disconnect to provide backup service to the facility.
- Net Energy Metering (NEM) Interconnection with Eligible Paired Storage: The microgrid includes paired energy storage. The microgrid operates in parallel with the SCE grid and provides energy to power the microgrid or to export energy to the grid (SCE, n.d.).

Rule 21 also imposes some constraints on the microgrid, and the main constraint is that Rule 21 is designed for smaller DER installations. Rule 21 provides an easy-to-navigate pathway to interconnection for installations with DERs of up to 1 MW AC. However, Rule 21 imposes additional requirements for DER installations that exceed 1 MW AC. For installations 1 MW AC and larger, the utility will require the installation of telemetry equipment to monitor the microgrid's impact on the utility grid. The utility can also require engineering studies to analyze the impact that the microgrid will have on the grid and to ensure that proper grid protections are in place. These requirements can greatly increase the timeline of the project and impose additional customer costs.

It is important to note that the 1 MW limit applies to both the solar panels and the nameplate capacity of the battery storage inverter. For SBMTD's Terminal 1 microgrid, the solar panel and battery storage inverter nameplate capacity will exceed the 1 MW limit (see Microgrid Design section). As a result, it is expected that this microgrid will be required to install telemetry equipment.

While microgrids typically provide power to a particular facility, the City of Santa Barbara is investigating ways to maximize the value of microgrids and design them so they can provide resiliency to multiple facilities. One way would be to create a microgrid that can export power to other facilities. This option was explored in the Strategic Energy Plan. However, there are some regulatory barriers to this model. The main barrier to this is the "over-the-fence" rule. The "over-the-fence" rule is California Public Utilities Code Section 218 Rule 18 and 19. The requirement stipulates that any entity that sells energy to more than two contiguous properties or an adjacent property across a public street must become a regulated electrical corporation, which is regulated as a utility. This rule disincentivizes the export of power from microgrids since doing so would trigger a host of prohibitively burdensome regulatory hurdles.

As discussed above, CPUC was directed by SB 1339 to open rulemaking proceedings for microgrids. Thus, CPUC opened rulemaking proceedings R.19-09-009. In Track 2, CPUC recognized that Rule 18 and Rule 19 limit the benefits that microgrids can provide to adjacent properties. The CPUC stated that microgrids should be allowed to provide electricity to adjacent properties for emergencies and critical operations during grid outages. As a result, the CPUC recommended allowing some municipal customers to be exempted from Rule 18 and Rule 19 so they can export power to adjacent properties during grid outages. Under this proposal, a device would be installed to prevent the export of power to adjacent premises during normal operation.

It is important to note that the CPUC is placing limitations on the scope of this exemption. Only microgrids that are owned by a public agency (state, county, local, or tribal government) or a third-party microgrid that serves a public agency will be exempted from Rule 18 and Rule 19 during a grid outage. Furthermore, the number of microgrids that will be exempted from Rule 18 and Rule 19 is limited so data can be gathered on how this affects operations. Each investor-owned utility can only exempt up to 10 microgrids in its service territory from Rule 18 and Rule 19.

FTM Regulatory Environment

CALSTART analyzed the feasibility of deploying an FTM microgrid. CALSTART held discussions with SCE to understand the regulatory environment for FTM microgrids. During discussions, SCE stated that they are unwilling to deploy an FTM microgrid for SBMTD at this time. SCE's reasoning is that the regulations and tariffs for FTM microgrids are not fully developed. As noted, the CPUC is in the process of developing these regulations and tariffs. While SCE is pursuing FTM microgrid pilot projects (CPUC, 2023a), SCE cannot pursue regular commercial projects until they have clarity on the regulatory environment. As a result, outside of pilot projects, there is currently no avenue for deploying FTM microgrids until the regulations are finalized.

Utility Microgrid Regulations

Microgrids are also constrained by regulations imposed by the utility. Some of these regulations are related to SCE's Charge Ready Transport Program (CRT). CRT is a "make-ready program" that provides funding to install charging infrastructure for medium- and heavy-duty vehicles. This program is intended to streamline the installation of charging infrastructure for SCE customers. It is also designed to reduce, or in some cases eliminate, the cost of installing charging infrastructure. CRT achieves this by displacing the capital costs associated with deploying charging infrastructure.

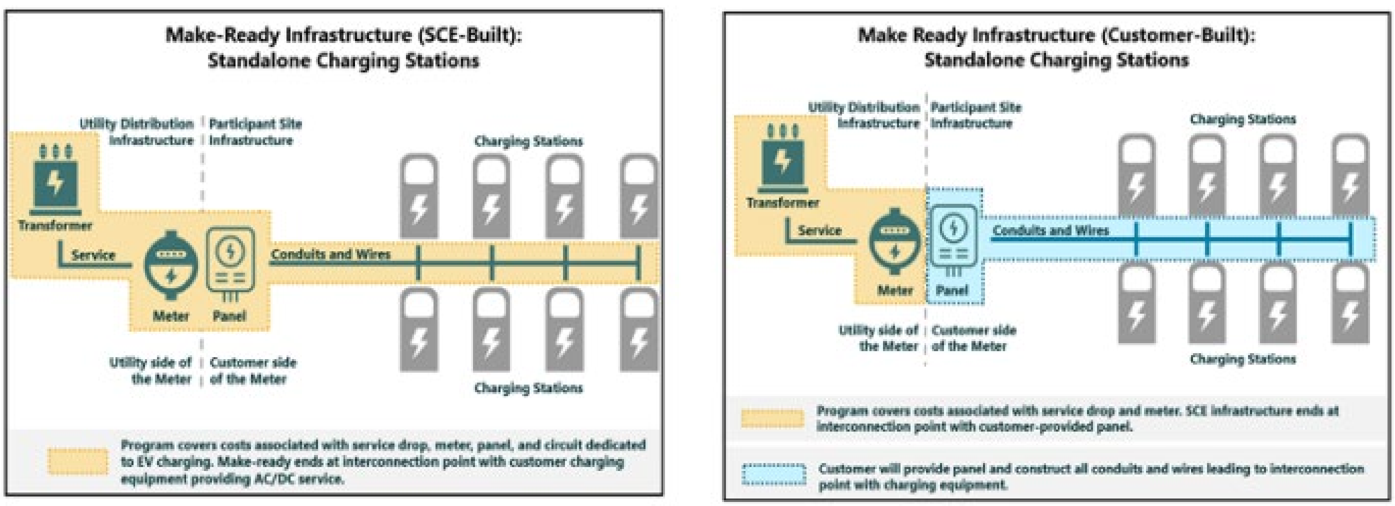
CRT offers substantial support to fleets that are deploying electric medium- and heavy-duty vehicles. However, there are several eligibility requirements for the program. These requirements include:

- Lease, purchase, or convert at least two medium- or heavy-duty battery-powered EVs.
- Own or lease the property where chargers are installed and operate and maintain chargers for a minimum of 10 years.
- Select, purchase, and install SCE-approved charging equipment.
- Provide data related to charging equipment usage for a minimum of five years (on-road vehicles only).
- Provide a property easement for the SCE infrastructure.
- Agree to program terms and conditions.

Fleets that are accepted into the program can receive funding to deploy their charging infrastructure and this funding can be distributed through one of two pathways. The first pathway is the SCE-Built Pathway. Under the SCE-Built pathway, SCE will finance and install FTM and BTM infrastructure. This includes components such as transformers, the service drop, meters, and panels. SCE will also install conduit all the way up until the disconnect switch that the chargers connect to. The fleet is responsible for purchasing the actual chargers. Once the chargers are purchased, they are interconnected at the disconnect switch. Under the SCE-Built pathway, SCE will fund the entire cost of the infrastructure and the installation. This pathway allows fleets to deploy infrastructure at no cost.

Alternatively, fleets can opt to use the Customer-Built pathway. Under this pathway, SCE will cover the cost of deploying FTM infrastructure, up until the point of service interconnection. This includes the transformer, service drop, and meter. The customer is then responsible for deploying infrastructure on their side of the service interconnection. This includes the panel and all conduits and wires leading up to the chargers. SCE then provides a partial reimbursement for the BTM installation costs. SCE can reimburse up to 80% of what it would have cost them to install the infrastructure. It is important to note that this does not necessarily equate to 80% of the actual installation cost. If the fleet's installation costs are higher than SCE's, they will be reimbursed for less than 80% of their actual cost.

Figure 4. Charge Ready Transport Program Pathways (SCE, 2022)



The CRT pathway that a fleet chooses has implications for deploying microgrids. The SCE-Built pathway does not allow DERs to be attached to the circuits. Since DERs are critical components of a microgrid, this effectively prevents the deployment of a microgrid using this pathway. However, there are no restrictions on deploying DERs if the customer opts to use the Customer-Built pathway (SCE, 2022).

This restriction on DERs is problematic for SBTMD because some of the existing charging infrastructure at Terminal 1 was funded through the CRT SCE-Built pathway. CALSTART investigated potential avenues for deploying a microgrid despite this restriction. One option that was considered was waiting until the end of the 10-year CRT commitment period and then building the microgrid after this period ends. Another option considered is converting the SCE-Built project to a Customer-Built project after the 10-year CRT commitment. This conversion would require SBMTD to purchase the infrastructure back from SCE. Through discussions with SCE, CALSTART found that neither of these options for deploying a microgrid are viable. As a result, there is no way to attach DERs or a microgrid to the existing charging infrastructure for 14 buses at Terminal 1 funded through the CRT SCE-Built Pathway. The only way to deploy a microgrid connected to the infrastructure provided through SCE's CRT Program is to utilize the Customer-Built pathway.

Air District Regulations

As discussed, SBMTD is considering including generators in the microgrid energy portfolio. However, generators are subject to air quality regulations. These regulations are imposed by air districts. Any generator deployed at SBMTD will be regulated by the Santa Barbara County Air Pollution Control District. SBCAPCD requires that all diesel engines over 50 brake-horsepower obtain a permit. This requirement also applies to emergency standby generators. Emergency standby generators are defined as engines that are intended to be used for emergency use and are not the primary source of power. Emergency use is defined as the failure or loss of normal electrical service or the internal power distribution system. This loss of power cannot be the result of contract enforcement by a third party and the outage must be beyond the control of the owner of the facility. As a result, the emergency standby generator can be used to provide backup power during most unplanned grid outages. Emergency standby generators can also be used for maintenance and testing, emissions testing, and initial start-up testing (SBCAPCD, n.d.). Emergency standby generators can also be used to respond to PSPS events. SBCAPCD allows emergency standby generators to be used if the facility is within the outage area. In addition, it can only be used after the outage has started and for the duration of the outage. Based on these regulations, SBMTD could only use generators during an emergency or during a grid outage to provide backup power.

Microgrid Design

CALSTART worked with Anser Advisory and Stantec to develop the design for the microgrid. Stantec serves as SBMTD's engineering firm and is heavily involved in SBMTD's bus charging infrastructure planning. Stantec developed SBMTD's ZEB transition plan that outlines the pathway to deploying a 100% zero-emission fleet. Anser Advisory was a subcontractor to CALSTART and worked with CALSTART to size the microgrid system and develop a conceptual design and single-line diagram for the microgrid.

The project team developed a design that fulfills SBMTD's requirements, ensuring compliance with the regulatory environment and all necessary design parameters, while also providing resiliency. Among the critical considerations in the microgrid design are the regulatory environment and the interconnection process, as these directly impact the microgrid architecture. Considering the regulatory environment set by CPUC, there is a clear regulatory framework for deploying and interconnecting a BTM microgrid. Rule 21 provides a clear path for building a BTM microgrid. However, the CPUC regulatory environment for FTM microgrids is less clear. Until the regulatory framework for FTM microgrids is more developed, the utility is hesitant to build an FTM microgrid. As a result, the only microgrid operating model that is currently viable is BTM. The SBMTD microgrid needs to be interconnected using one of the Rule 21 pathways, which includes Non-Export, Isolated Operations, Momentary Parallel Operations and NEM Interconnection with Eligible Paired Storage (see BTM Regulatory Environment section).

As mentioned earlier, the microgrid has the dual objectives of providing resiliency and reducing costs through the displacement of grid power. To achieve this, it is necessary for the microgrid to operate in parallel with the grid. Consequently, the Isolated Operations and Momentary Parallel Operations interconnection pathways can be ruled out. Considering the microgrid operational dynamics, there is a mismatch between power production and consumption due to solar panels generating energy during the day while vehicle charging predominantly occurs at night. As a result, there will be instances when the microgrid produces more energy than is needed. Although the batteries can absorb some of this surplus energy, they have limitations and cannot guarantee storage of all excess solar production.

Hence, it is essential for the microgrid to have the capability to export power to the grid, ensuring that the excess energy can be transferred and utilized effectively. This will help optimize the microgrid's operation, allowing it to balance power generation and consumption efficiently while supporting the objectives of resiliency and cost reduction. Based on this required functionality, the NEM Interconnection with Eligible Paired Storage is the most appropriate interconnection pathway. The microgrid was designed to comply with the Rule 21 requirements for the NEM Interconnection pathway. After determining the interconnection pathway, the project team then worked to size the microgrid components.

Microgrid System Sizing Methodology

The project team collaborated to size the microgrid components. Based on their infrastructure planning, Stantec identified the areas at Terminal 1 and Terminal 2 that can host solar panels and batteries. Stantec also designated areas that can host other DERs such as batteries or generators based on the amount of resiliency required. Since the sites are space constrained, the addition of DERs can displace buses from the sites and Stantec took this factor into account when designating areas that can host DERs. This analysis helped to identify the physical constraints of the sites.

CALSTART and Anser Advisory utilized the HelioScope tool to analyze the solar potential of Terminal 1. This tool played a pivotal role in the conceptualization of the photovoltaic (PV) design and the assessment of the depot's solar potential. By leveraging HelioScope, CALSTART and Anser Advisory were able to evaluate the feasibility of solar energy generation while considering the specific constraints outlined by SBMTD and achieving the microgrid’s energy objectives and resiliency goals.

Anser Advisory utilized the tool Energy Toolbase (ETB) to conduct an in-depth analysis of the microgrid's requirements and optimize the sizing of the DERs. With ETB, users can define a load profile for the site and specify parameters, including desired resiliency levels. The ETB tool conducts a comprehensive techno-economic analysis to determine the optimal energy portfolio for the microgrid and the sizing of DERs by considering factors such as utility rate structure, energy consumption of the site, and demand data.

During the optimization process, CALSTART and Anser Advisory prioritized the integration of solar panels and batteries to maximize the amount of load served by these renewable energy sources. This approach not only promotes sustainability but also helps reduce reliance on the grid and associated utility costs. In the event of a grid outage, the system is designed to prioritize the use of solar power and battery storage first. If additional power is required, generators are employed as a backup option. Generators were sized to handle the maximum microgrid loads with help from the on-site batteries, thereby achieving a more economical installation.

The use of the ETB tool enabled Anser Advisory to optimize the sizing of DERs, such as solar panels, batteries, and generators, to support the load requirements of SBMTD while ensuring resiliency.

The following assumptions were utilized during the ETB optimization:

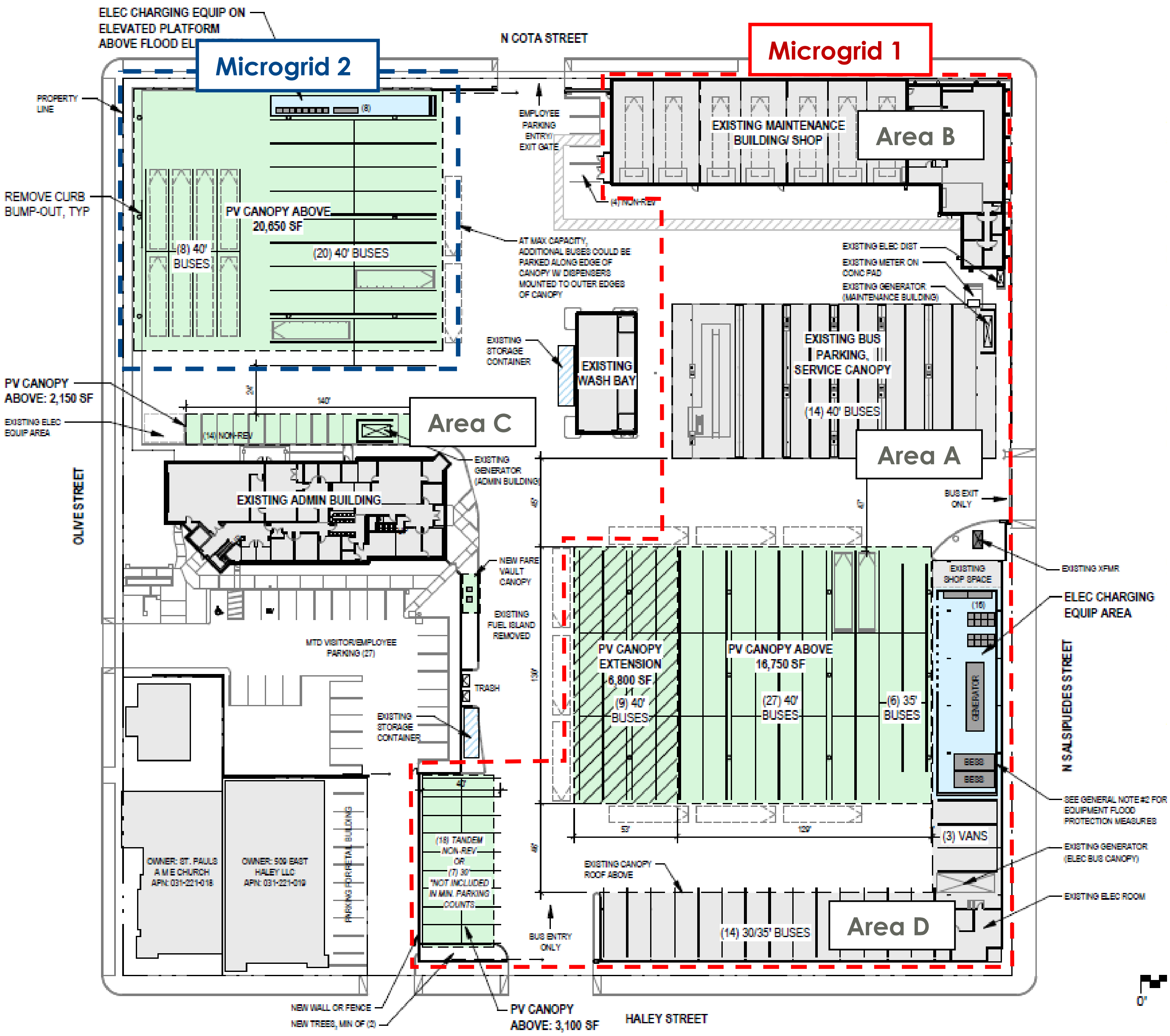
- DER technologies include solar panels, batteries, and generators.
- In order to further boost site resiliency, two microgrids will be constructed at Terminal 1. Microgrid 1 will be broken up into phases 1A and 1B with a maximum PV capacity set to 641 kW. Microgrid 2 maximum PV capacity is set at 320 kW. Solar PV sizing is restricted by the physical constraints of how much solar could fit on the site’s existing building roofs and proposed carports/canopies.
- Battery capacities are capped at 650kW / 2,610kWh for Microgrid 1 and 640kW / 1,280 kWh for Microgrid 2. The generator capacities are capped at 1500kW for Microgrid 1 and 800kW for Microgrid 2, respectively, to account for backup loads and space constraints.

- The outage duration considered for optimization is 24 hours, with the outage starting at noon. With the diesel generators on site, as long as there is fuel, backup power can be maintained.
- In order to support peak charging loads, both the battery and generators will need to operate in tandem.
- Solar and battery storage are utilized up to 80% state of charge (SOC) to meet the load before relying on the generator.
- The maximum generator fuel capacity at the site is assumed to be 10,000 gallons. The site has an underground tank that can store up to 20,000 gallons of renewable diesel. However, the tank is not always full as fuel is dispensed to buses. SBMTD typically orders fuel when the tanks reach 14,000 gallons and the tanks almost never fall below 10,000 gallons. As a result, 10,000 gallons is considered to be the worst-case scenario for fuel availability.

System Sizing for Terminal 1

CALSTART and Anser Advisory produced a microgrid design for Terminal 1. The microgrid design process started by identifying the areas at Terminal 1 that can host microgrid components. Stantec developed a site map identifying these areas, which are displayed below.

Figure 5. Terminal 1 Site Layout and Microgrid Component Siting



The areas shaded in green above were considered as good candidates for the installation of solar carports under which vehicles could park. Even though Stantec's original plan designated the parking spaces next to the Administration Building (Area C) as an area that can potentially host solar panels, the output of Area C is expected to be low due to its small size and shading from the buildings. Installing solar panels in Area C would require the construction of a carport structure, which is expensive. Based on the expected output of Area C, installing solar panels in Area C would not be effective from a cost-benefit perspective.

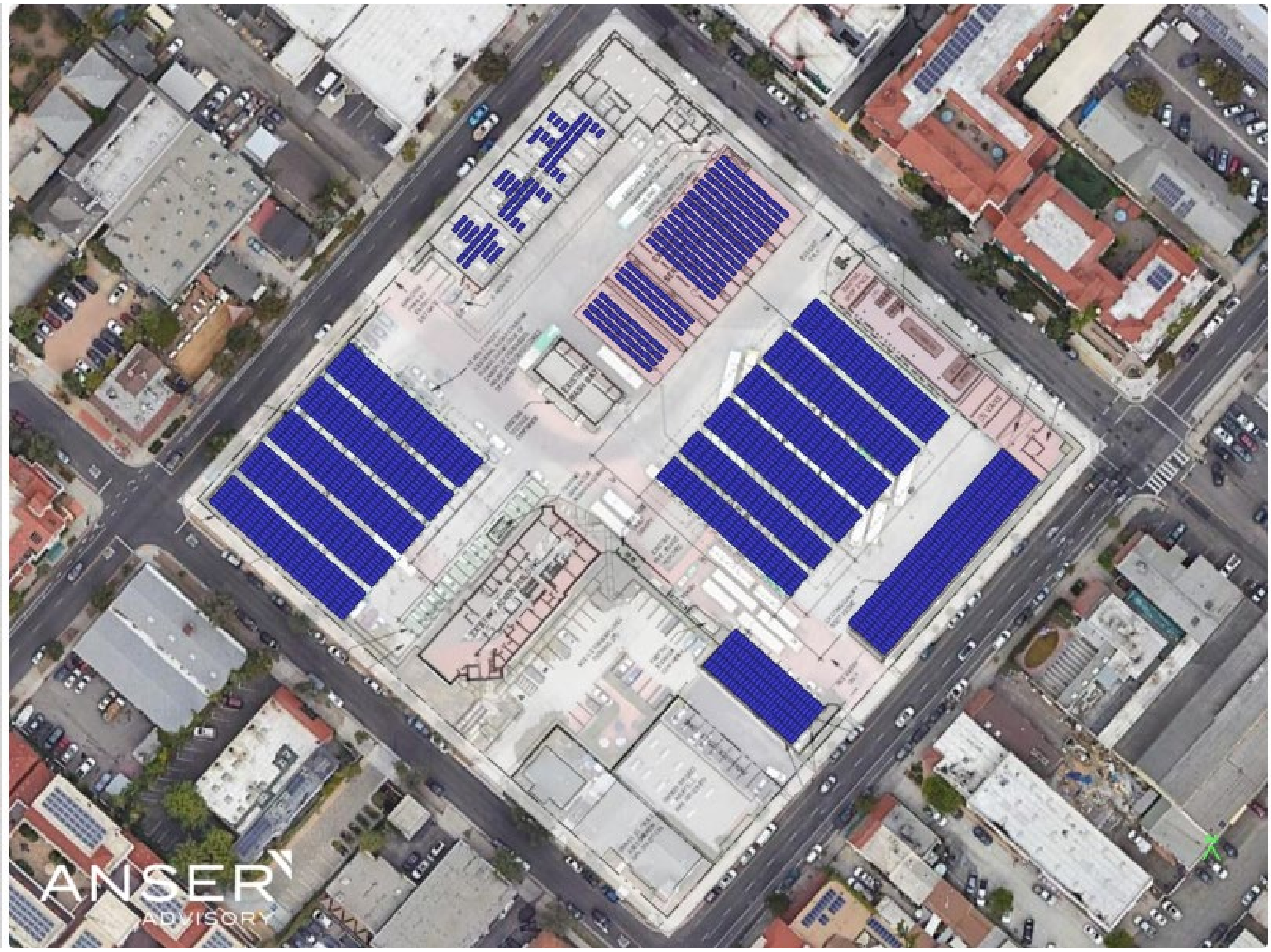
Solar was also considered on existing rooftops, the "Existing Bus Parking Service Canopy" in Area A, the "Existing Maintenance Building Shop" in Area B, and the roof over where the current BYD BEBs park in Area D. The Area A canopy underwent structural upgrades to accommodate solar panels. Furthermore, the Maintenance Building (Area B) is capable of hosting rooftop solar if retrofits are done to improve the structural capacity of the roof. Since SBMTD is planning to carry out these retrofits, this analysis assumes that the roof will host solar panels. Further study of the existing roofs over Area D will be necessary to confirm whether they can support the estimated solar panel load; however, for the purposes of this analysis, it is assumed that this is possible. As stated before, the site was then divided into two separate microgrids, with Microgrid 1, serving the "right half" of the above diagram, and Microgrid 2 serving the "left half."

Before the ETB model was developed, the solar system design was created utilizing HelioScope. This step was taken to identify the solar capacity for the site. The following assumptions were used in the design:

- Solar Panel Efficiency: A standard solar panel efficiency of 95% was assumed.
- Solar Irradiance: Average solar irradiance levels were considered based on historical data or regional solar resource databases.
- Solar Panel Orientation and Tilt: The optimal panel orientation of 5 to 7 degrees for carport-type structures and 7 degrees for fixed roof mount structures was assumed to maximize solar energy capture.
- Shading Analysis: Minimal shading of the solar panels was assumed by considering nearby objects, buildings, or trees that may potentially obstruct sunlight.
- Inverter Efficiency: An inverter efficiency level of 95% was assumed to convert DC power from the solar panels to AC power for grid integration.
- Losses and Degradation: Losses and degradation over time were taken into account, typically considering degradation rates provided by solar panel manufacturers.

Based on these assumptions, the solar PV design is projected to have a DC nameplate capacity of 641kW for Microgrid 1 and 320 kW for Microgrid 2. This means that Terminal 1 has enough space for solar PV to offset about 25% of the overall bus charging consumption. While more solar would be advantageous to offset a greater percentage of the bus charging load, physical constraints limit the amount of solar PV that can be installed on the site. However, modeling in ETB allowed the Anser Advisory team to optimize the design specifications of the battery and generators to work with the solar limitations and meet the resiliency goals of the microgrid, given the above solar constraints (see ETB analysis below). The conceptual design of solar PV at Terminal 1 is shown in Figure 6.

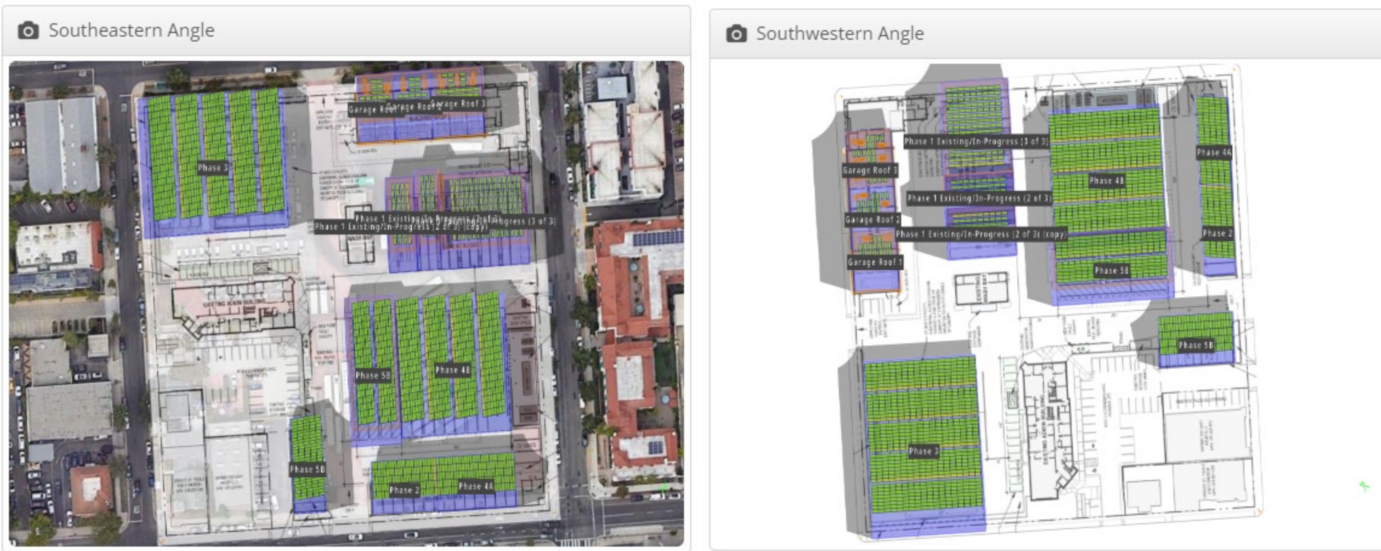
Figure 6. Terminal 1 HelioScope Model



Shading losses can significantly impact the overall output of a microgrid. When solar panels are obstructed or shaded by nearby objects, buildings, or trees, their efficiency is greatly reduced, resulting in a decrease in energy generation. To address these shading losses and optimize the microgrid's performance, the design takes careful consideration of the placement and orientation of the solar panels. The aim is to strategically position the panels in areas with minimal shading potential, maximizing solar energy capture and minimizing disruptions caused by shading. The design process includes a meticulous evaluation of potential shading impacts from surrounding structures, trees, and other sources of obstruction.

The HelioScope tool plays a vital role in assessing shading losses. This tool enables the design team to analyze and predict shading scenarios, providing valuable insights into potential obstructions and their impact on the microgrid system. By utilizing HelioScope, it has been determined that the designed microgrid structure will not be significantly affected by shading, ensuring optimal performance. The shading analysis is displayed in Figure 7 below.

Figure 7. Terminal 1 HelioScope Shading Analysis



The table below outlines the essential components of the solar design, including inverter sizing, wiring considerations, optimizer type, and type of solar modules. All the sizing decisions are based on physical constraints and are further refined in accordance with the phased approach discussed earlier. The conceptual design plays a crucial role in analyzing the solar potential that can be harnessed from the terminal. By considering these design elements, the microgrid system is thoughtfully configured to optimize energy generation while adhering to physical limitations and project requirements.

Table 4. Terminal 1 Balance of System Components

Component	Name	Count
Inverters	PVI 60TL (Solectria)	13 (780.0 kW)
Inverters	SE100KUS (SolarEdge)	2 (200.0 kW)
Inverters	SE33.3K (2020) (Solar Edge)	1 (33.3 kW)
Strings	10 AWG (Copper)	127 (12,108.3 feet)
Optimizers	P950 (2020) (Solar Edge)	133 (126.4 kW)
Module	JA Solar, JAM78S10-445MR (445 W)	2,160 (961.2 kW)

Anser Advisory then utilized the ETB model to determine the appropriate sizing of the microgrid components and to assess how the distributed energy resources (DERs) would be utilized to meet the load requirements. Based on the analysis conducted using ETB, it was determined that Microgrid 1 should incorporate 641 kW of solar panels, a 650 kW/2,610 kWh BESS, and a 1,500 kW generator. Microgrid 2 should incorporate 320 kW of solar panels, a 640 kW/1,280 kWh BESS, and an 800 kW generator. Subsequently, ETB performed simulations to demonstrate the operation of these DERs in serving the load under various conditions. The simulations showcased the coordinated operation of solar panels, batteries, and the grid to supply power to the load during normal operation, and in the event of a grid outage, the solar, batteries, and generator could handle the load as long as there was available diesel fuel. The results of these simulations are presented in Figure 8 and 9 below, which illustrates the system's performance and behavior during normal operation. The graph provides insights into the utilization of solar assets to charge the batteries and indicates the battery state of charge over time. This simulation graph effectively represents the dynamic operation of the microgrid system, showcasing its capability to sustain power supply during normal conditions.

Figure 8. ETB Model Output for Terminal 1 Microgrid 1

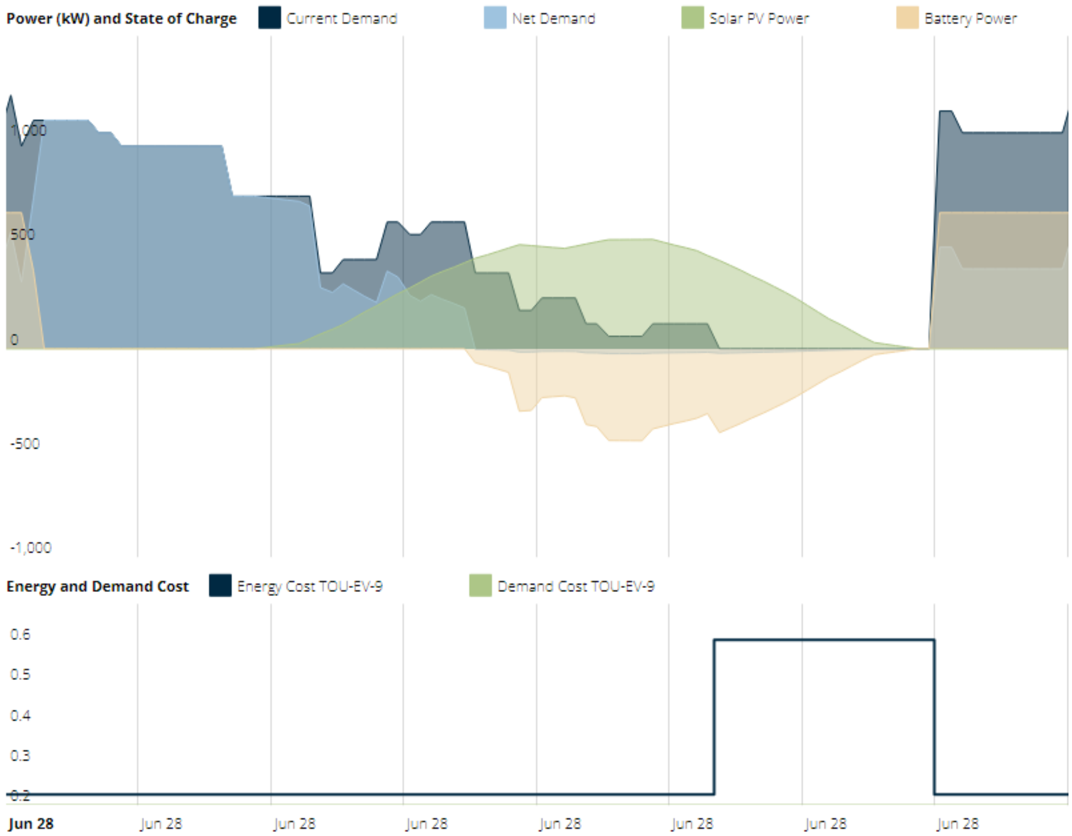
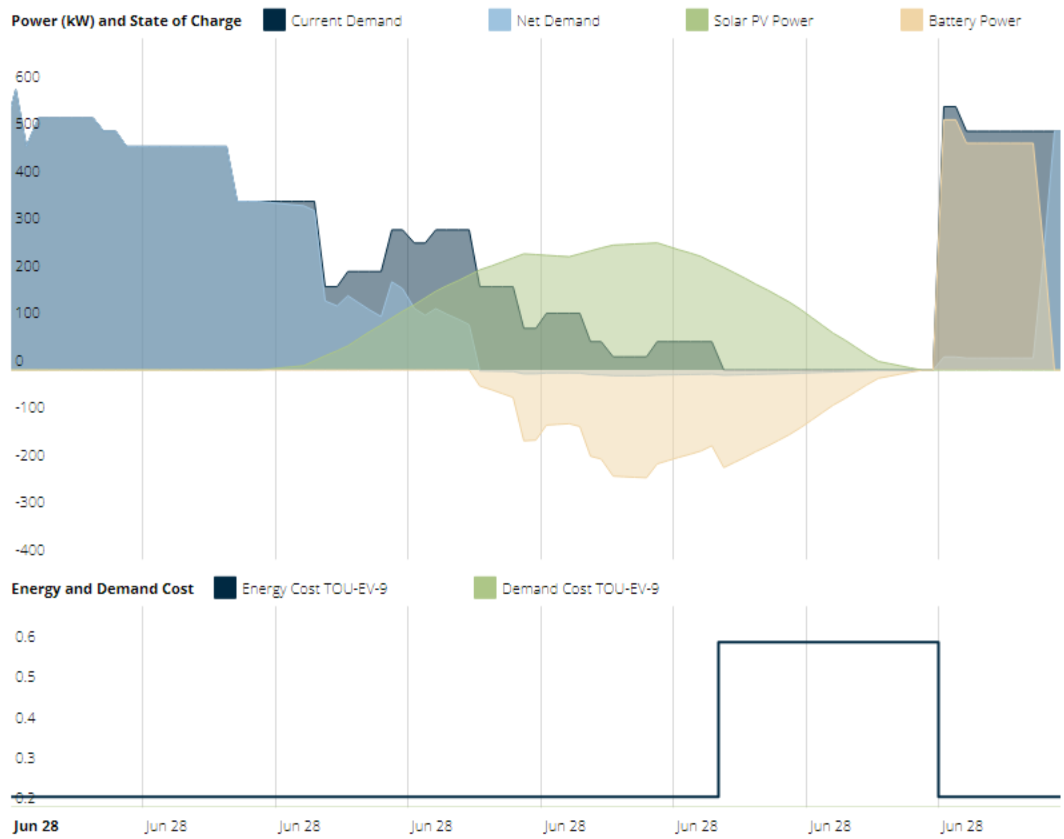


Figure 9. ETB Model Output for Terminal 1 Microgrid 2



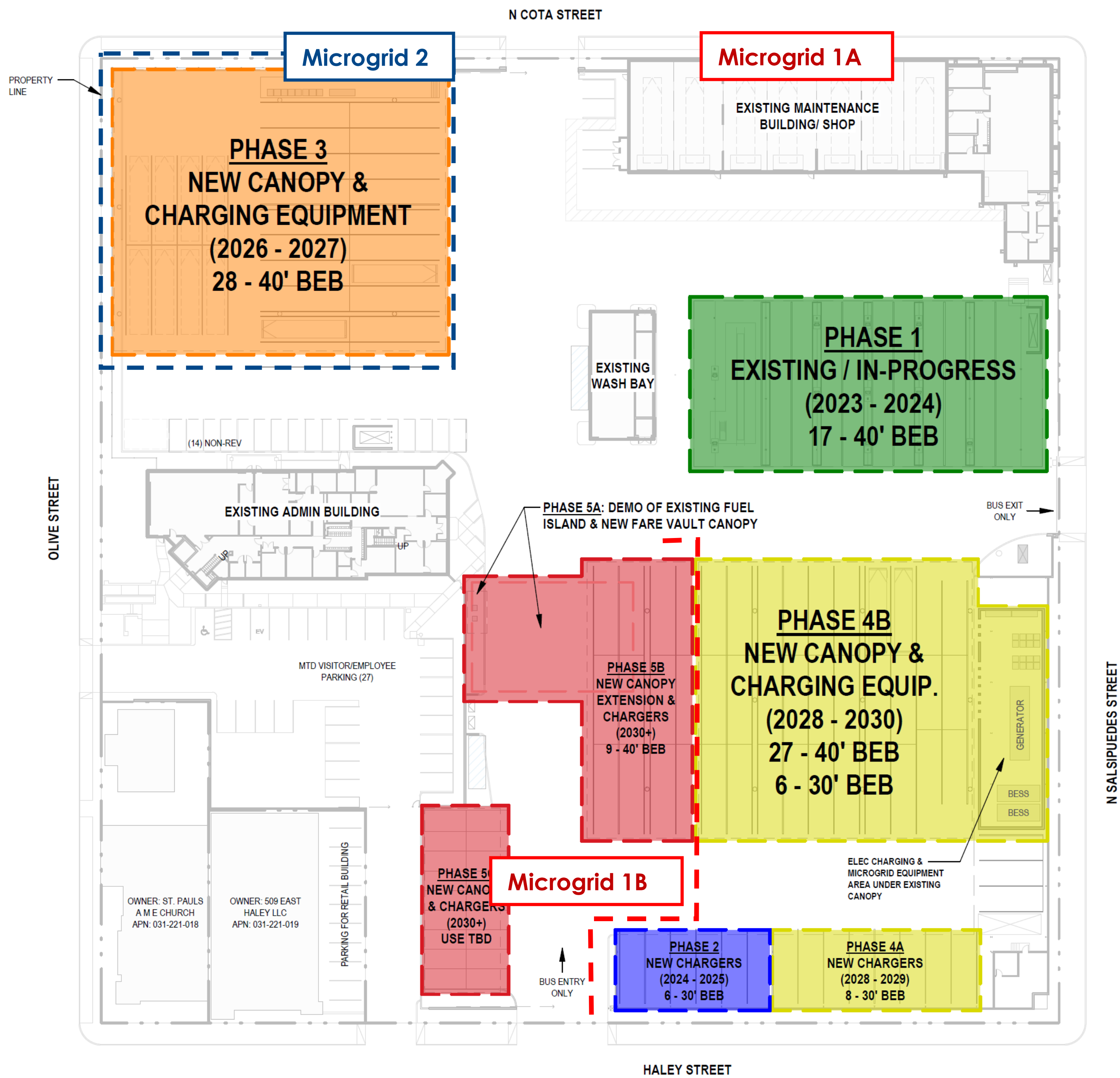
Anser Advisory also took additional factors into account when developing the conceptual design for the Terminal 1 microgrids. The first factor is grid connection considerations. The technical requirements and interconnection standards set by the utility company for grid integration, including voltage levels and power quality criteria, were considered. Furthermore, it was determined that adding a separate meter in the northwest corner for Microgrid 2 equipment would create the least amount of trenching which is both more financially feasible and would cause less overall disruption to the Terminal. Since Terminal 1 has contaminated soils at the site, minimizing trenching is important to limit the amount of soil remediation required. This has regulatory implications as construction or modifications that disturb these soils triggers California Environmental Quality Act regulations, which can entail a lengthy environmental review. Finally, Microgrid 1 will be tied into the existing BYD bus charging meter which is located in the Southeastern corner of the Terminal as to avoid significant trenching.

The design also took into account how the load profile will change over time. The load profiles for bus charging were created based on a total estimated demand for charging all 80 buses at Terminal 1. Because SBMTD is not buying all buses at once, the total charging demand profile was scaled down accordingly based on the number of buses each microgrid would have to charge in a given year, which then dictated the overall demand profile. Additionally, the provided charging demand profile was shifted to avoid charging buses during peak times, ultimately creating a higher peak demand during off peak times, and a more conservative sizing of microgrid components to handle the higher peak loads.

It is important to note that the microgrid will not be deployed all at once, for two reasons. First, Terminal 1 will be renovated in phases, as shown in Figure 10 below. Second, since the fleet will transition to zero-emission technology over time, the microgrid will need to be phased in as charging load increases. The phasing plan for Terminal 1 assumes that the microgrid will be developed in three phases (1A, 2, 1B) as displayed below.

Due to the timing of the phases of the solar PV installations and their locations in the bus yard, creating two microgrids on site made the most sense. Microgrid 1 includes existing BYD chargers (that will eventually be converted into other DCFC chargers), Phase 2 chargers, Phase 4A chargers, Phase 4B chargers and solar PV canopy, and Phases 5B and 5C chargers and solar PV canopies. Microgrid 2 will include only Phase 3 chargers and the solar PV canopy due to the equipment's distance away from the rest of the microgrid infrastructure.

Figure 10. Terminal 1 Phasing Plan



When determining Microgrid 1 sizing, solar PV output, as modeled in HelioScope, was compared to BEB charging profiles for the buses to be charged by Microgrid 1. Because Microgrid 1 would ultimately serve buses purchased in two distinct tranches (with Microgrid 2 built in between), it was determined that Microgrid 1 should be split into two phases, 1A and 1B. For Microgrid 1A, all components of resiliency for Microgrid 1 in its entirety will be added to help both offset grid usage for bus charging and to serve as a backup in case of an outage. Microgrid 1A will include backup for the existing BYD chargers (that will eventually be converted to standard DCFCs), Phase 2 chargers, and Phase 4A chargers, which should all be installed by 2029. Microgrid 1B will include Phase 4B chargers and Phases 5B and 5C chargers which will occur from 2030-2040. These phases were chosen based on the timing of the implementation of the microgrid elements.

As mentioned above, the system sizing in ETB was conducted in three phases to facilitate the transition to ZEBs and account for the future expansion of SBMTD's fleet. This phased approach allows for the scalable increase in system capacity as SBMTD introduces new BEBs. The sizing details for each phase are provided in the table below. In each phase, the solar PV capacity is sized at 487 kW, 641 kW and 320 kW, the battery capacity at 650 kW/2,610 kWh and 640 kW/1,280 kWh, and the generator capacity at 1,500 kW and 800 kW respectively. This output across all phases reflects the consideration of SBMTD's load requirements, desired resiliency, and future expansion plans for ZEBs.

Table 5. Deployment Phases for Terminal 1 Microgrids

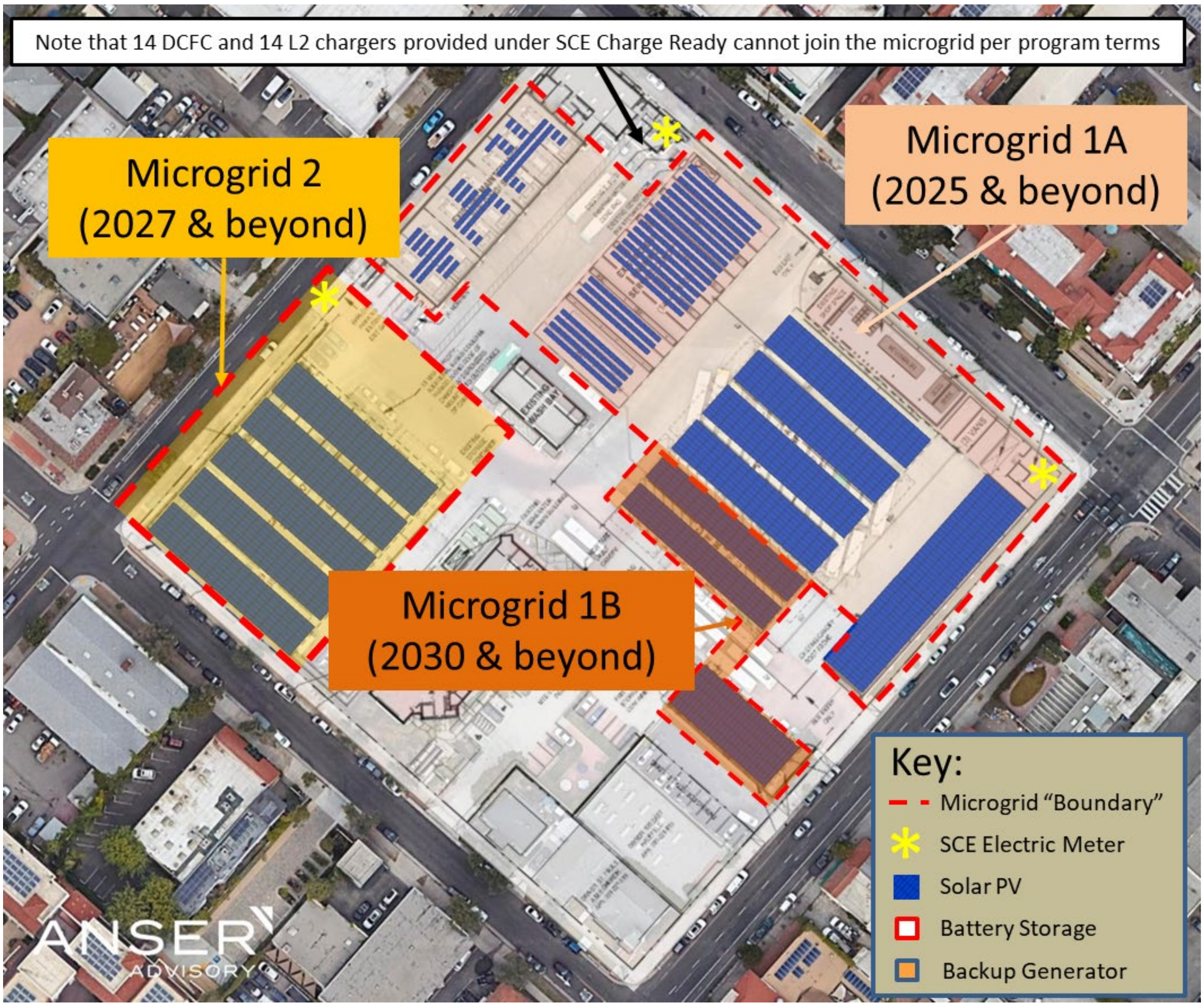
Type	Base Load (Active BEBs)	Components
Microgrid 1A (2025 and beyond)	19 BEBs (Existing BYD + 4 New BEBs) (2025-2028) 23 BEBs (2029)	487 kW Solar PV 650 kW/2,610 kWh Battery Storage 1,500 kW Generator
Microgrid 1B (2030 and beyond)	29 BEBs (2030-2031) 35 BEBs (2032-2040)	154 Additional Solar PV (641 kW Total)
Microgrid 2 (2027 and beyond)	17 BEBs (2027-2040)	320 kW Solar PV 640 kW/1,280 kWh Battery Storage 800 kW Generator

The generators were sized to be utilized in conjunction with the batteries to provide the maximum amount of charging to the buses. In an ideal scenario, the battery will be used solely to store energy created from the solar PV (to minimize loss of value from solar exports under NEM 3.0) and will be used to offset the grid electricity needed to charge the buses. The generator would then only be used in a worst-case resiliency scenario to keep Terminal 1 using a maximum amount of clean, renewable energy. It is also important to note that the limiting factor in the microgrid battery sizing was the amount of solar the site could produce. Since the site cannot accommodate much solar, the batteries needed to be downsized to ensure they can reach an 80% state of charge.

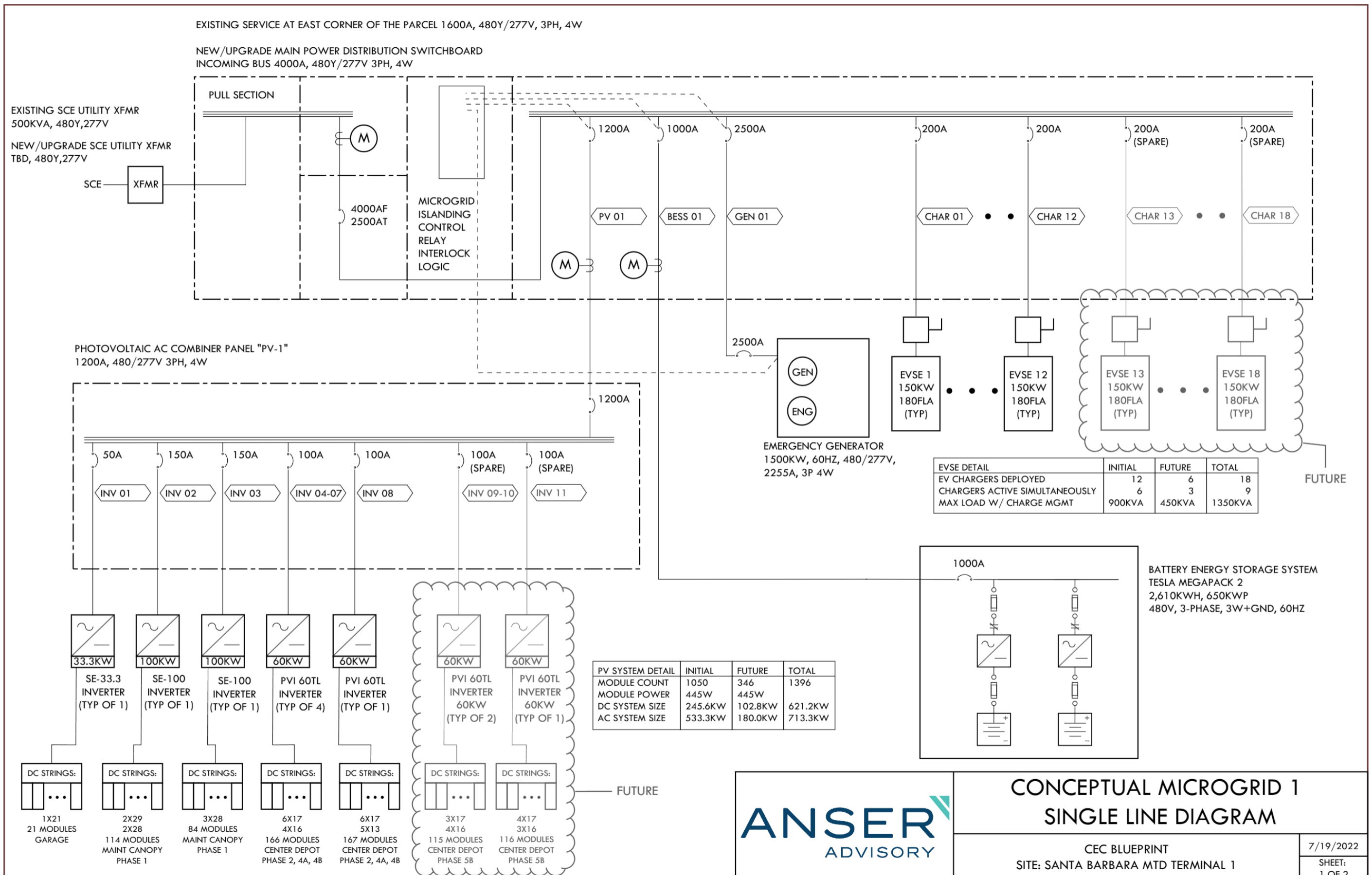
Conceptual Design for Terminal 1

The conceptual design for the Terminal 1 microgrids is included below.

Figure 11. Conceptual Design for Terminal 1 Microgrids

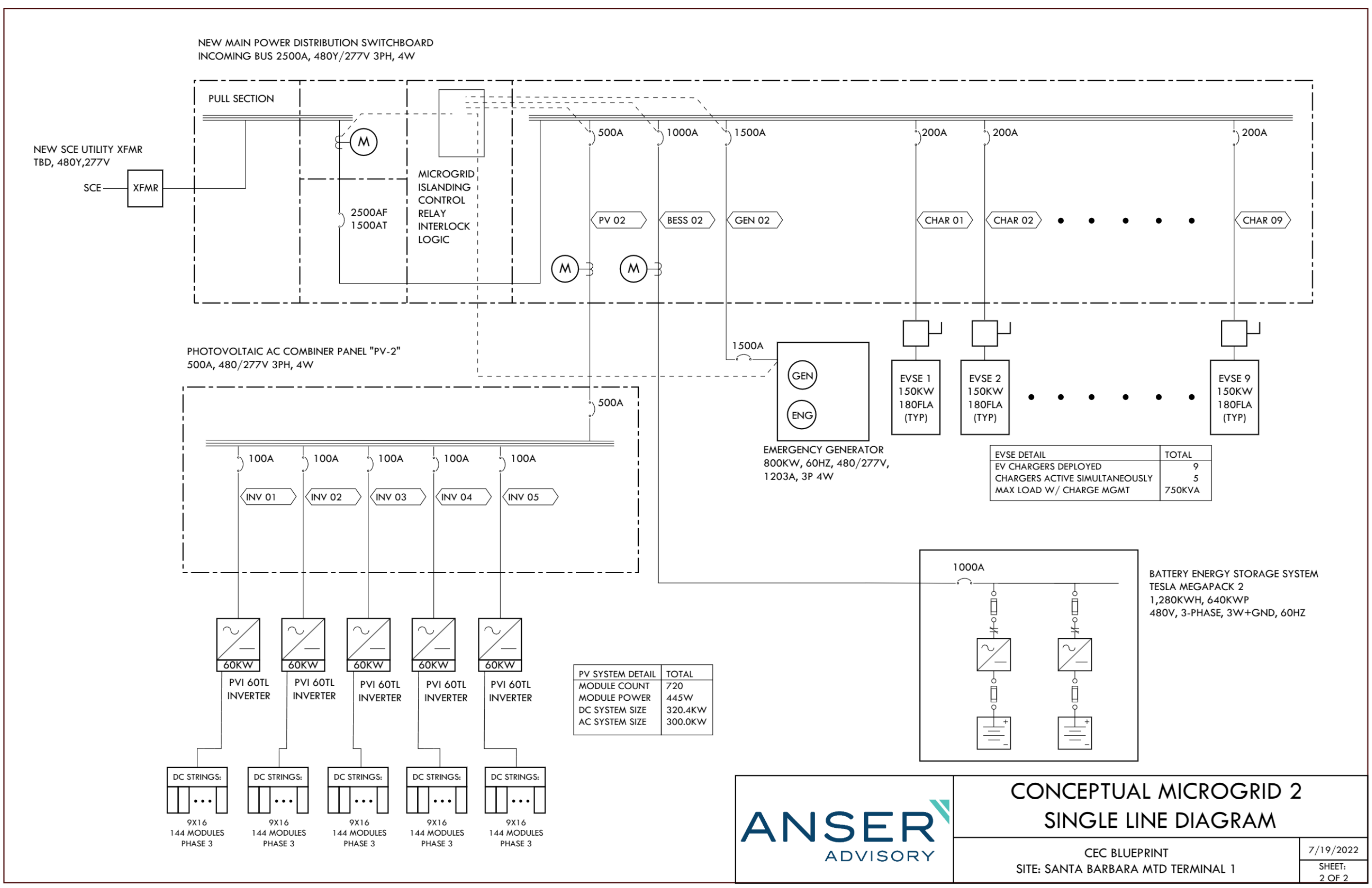


A single line diagram of the above microgrids can be seen in the figures below.



EVSE DETAIL	INITIAL	FUTURE	TOTAL
EV CHARGERS DEPLOYED	12	6	18
CHARGERS ACTIVE SIMULTANEOUSLY	6	3	9
MAX LOAD W/ CHARGE MGMT	900KVA	450KVA	1350KVA

PV SYSTEM DETAIL	INITIAL	FUTURE	TOTAL
MODULE COUNT	1050	346	1396
MODULE POWER	445W	445W	
DC SYSTEM SIZE	245.6KW	102.8KW	621.2KW
AC SYSTEM SIZE	533.3KW	180.0KW	713.3KW



EVSE DETAIL	TOTAL
EV CHARGERS DEPLOYED	9
CHARGERS ACTIVE SIMULTANEOUSLY	5
MAX LOAD W/ CHARGE MGMT	750KVA

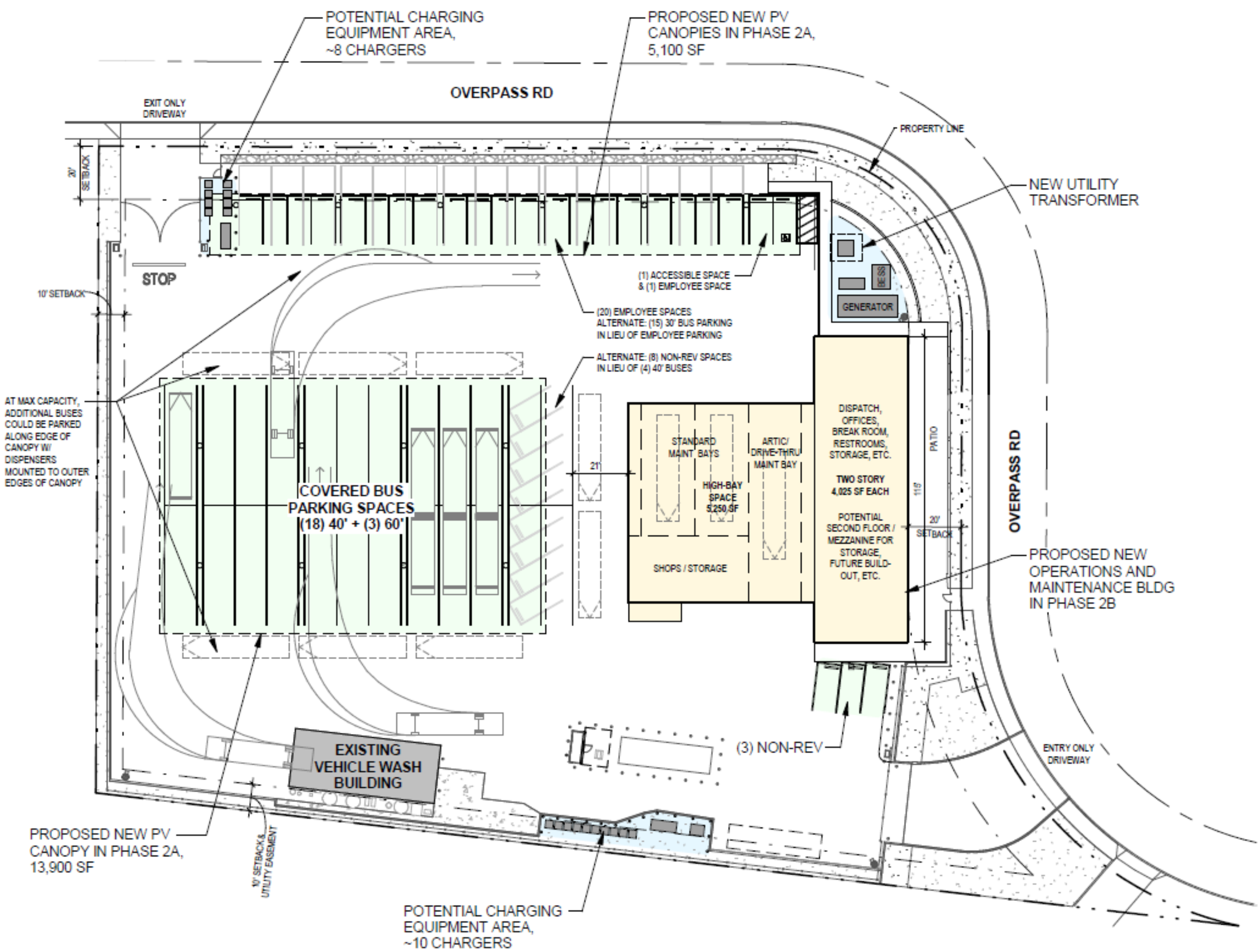
PV SYSTEM DETAIL	TOTAL
MODULE COUNT	720
MODULE POWER	445W
DC SYSTEM SIZE	320.4KW
AC SYSTEM SIZE	300.0KW

System Sizing for Terminal 2

This study also analyzed the techno-economic feasibility of deploying a microgrid at Terminal 2. As discussed above, SBMTD is in the process of recommissioning that depot. Once Terminal 2 is operational, it will also host SBMTD's BEBs and charging equipment.

As a result of the foregoing, SBMTD is also planning to deploy a microgrid at Terminal 2. Stantec developed a site plan for Terminal 2 that identified areas that can host microgrid components. These areas are displayed below.

Figure 12. Terminal 2 Site Layout and Microgrid Component Siting



The areas shaded in light blue represent places where equipment such as generators, batteries, and power electronics can be hosted. The areas shaded in light green represent areas that are physically capable of hosting solar panels. The design that CALSTART pursued differed from the above site layout. Since the maintenance bay will need to be rebuilt, it is assumed that the roof of that building can host solar panels. The other major difference is that there is a utility easement on the southern edge of the property. This easement precludes any further construction on the southern edge of Terminal 2.

The solar system was designed using HelioScope based on the same assumptions used to design the Terminal 1 microgrids. The HelioScope model for the Terminal 2 site is displayed below. Based on this design, Terminal 2 can host solar panels with a DC nameplate capacity of 250 kW.

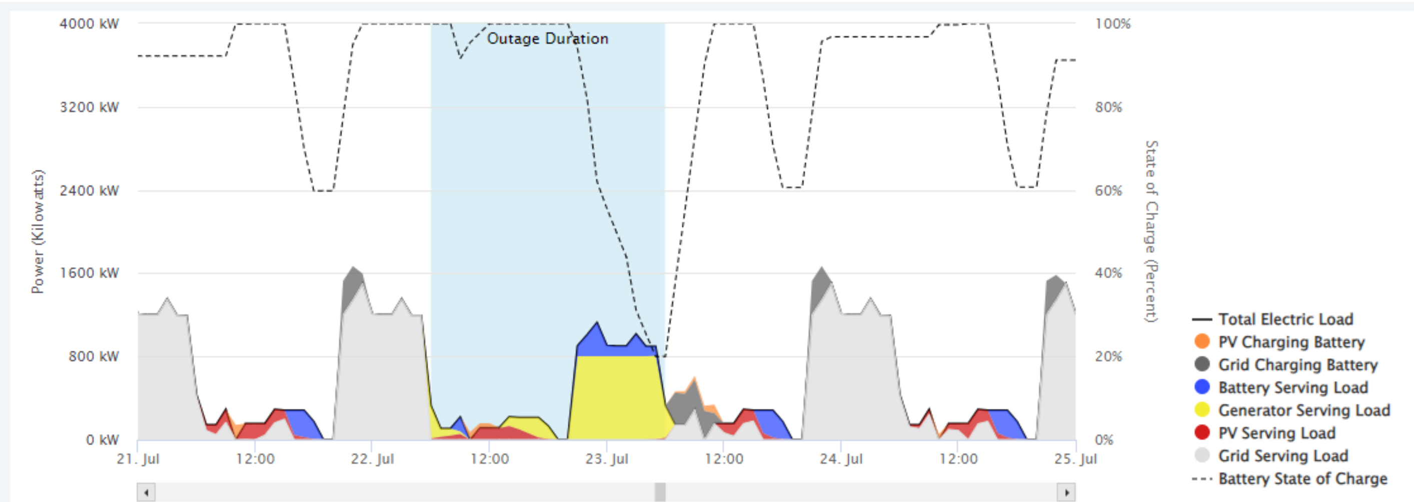
Figure 13. Terminal 2 HelioScope Model

CALSTART then used HelioScope to assess possible shading losses for the solar PV system. CALSTART determined that the designed microgrid structure will not be significantly affected by shading.

Figure 14. Terminal 2 HelioScope Shading Analysis

CALSTART used the Renewable Energy Integration and Optimization (REopt) model to size the DERs for the microgrid. The Terminal 2 site was restricted to 250 kW of solar, 2,000 kWh of battery storage, and 1,000 kW of generators as a result of space constraints on the site. In addition to serving the bus charging load, the microgrid will also provide resiliency for the maintenance bays and office space. Currently, Terminal 2 does not have an active maintenance facility. CALSTART used the utility data for the maintenance facilities at Terminal 1 to approximate the load for future maintenance facilities at Terminal 2. The microgrid was also designed to provide up to 24 hours of resiliency. Based on these parameters, REopt calculated that the microgrid will require 250 kW of solar panels, 1,749 kWh of battery storage, and an 803 kW generator. Due to the physical constraints of the site, the microgrid cannot provide resiliency for the entire load over a 24-hour period. However, CALSTART found that the microgrid can provide resiliency for 75% of the load for 24 hours.

Figure 15. Terminal 2 REopt Model



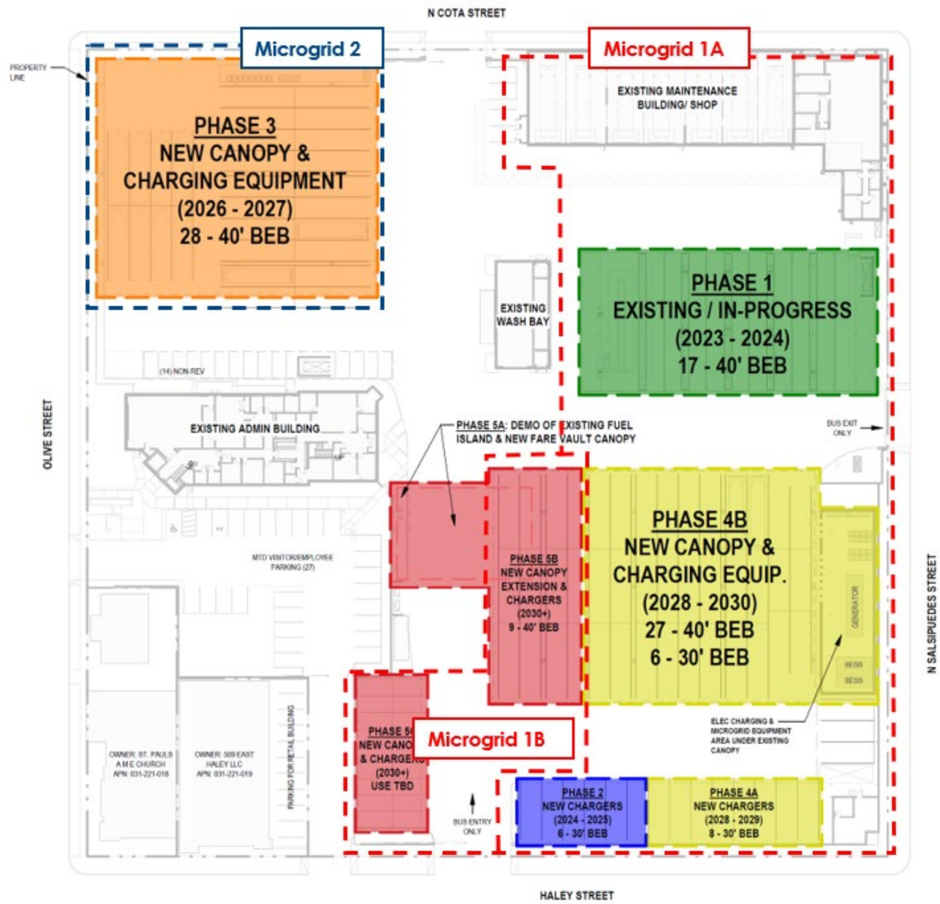
Terminal 1 is the first site to host BEBs. As a result, SBMTD is focusing its fleet electrification infrastructure upgrades on Terminal 1. Since Terminal 2 is in the early stages of recommissioning, there is more uncertainty about the final design for the site. Due to this uncertainty, a conceptual microgrid design was not developed for Terminal 2.

Microgrid Implementation Strategy

The project team developed an implementation plan for a microgrid at Terminal 1 that outlines the most optimal way to deploy the microgrid. This is important because other factors, such as SBMTD's operations and the utility, impact how the microgrid can be deployed. The project team developed a plan for navigating these constraints. This section addresses the feasibility of incorporating the Terminal 1 microgrid into a citywide multimodal microgrid.

The microgrid will need to be phased in over time. This requirement is driven by the fact that the BEBs will not be delivered all at once and will also be phased in over time. As a result, building the entire microgrid all at once would not be a good strategy because many chargers and microgrid assets would be unused until the BEBs are delivered. To avoid this problem, a phasing plan for the microgrid was developed.

As a first step in scoping the microgrid, Anser determined that there were significant savings to be had charging buses on an EV-only rate tariff, like SCE's TOU-EV-9. Using that rate tariff dictated that loads on the meters responsible for charging buses were limited to bus charging only, and other site loads such as building loads would need to be excluded from backup. This was determined to be an acceptable solution, as buildings on site already had backup generation. Additionally, loads from existing on-site buildings were insignificant in comparison to simulated bus charging loads.



It was also determined that resiliency at Terminal 1 would be best served by building two microgrids to serve different banks of chargers. In the event of equipment failure at one Microgrid, SBMTD would have the ability to use the other microgrid to continue to charge BEBs. This concept was also supported by the fact that the different areas of the yard would be modified at different times. Microgrid 1 includes existing BYD chargers (that will eventually be converted into standard DCFCs), Phase 2 chargers, Phase 4A chargers, Phase 4B chargers and solar PV canopy, and Phases 5B and 5C chargers and solar PV canopies. Microgrid 2 will include only Phase 3 chargers and the solar PV canopy, due to the equipment's distance away from the rest of the microgrid infrastructure. These phases were designed to coincide with BEB deployments. This was done to match the charging loads with microgrid power production.

The CRT program's restriction on DERs through the SCE-Built pathway poses serious limitations on Terminal 1's ability to fully backup it's vehicles. DERs cannot be added to the existing chargers that were funded through the SCE-Built pathway, which precludes the addition of a microgrid to that charging infrastructure. The Terminal 1 microgrids were designed to partially avoid this problem by attaching the microgrids to future charging infrastructure. As SBMTD deploys their BEB fleet, they will need to install additional charging infrastructure. The restrictions on DERs does not apply if this additional charging infrastructure is funded through the Customer-Built pathway or directly by SBMTD. This approach is the only feasible pathway for deploying the microgrids.

Multinodal Microgrid

Strategy 4.1 of Santa Barbara's Strategic Energy Plan calls for a network of multiple connected microgrids across the City that can provide mutual support to each other. This effectively calls for a multimodal microgrid where each microgrid is a node within a larger microgrid that provides power to the City. The key value that a multimodal microgrid provides is that each node can export power to support other nodes. CALSTART carried out initial research into the feasibility of a multimodal microgrid and whether the proposed microgrid at Terminal 1 can integrate into it.

CALSTART found that, based on the current regulatory environment, there are limited options for incorporating the Terminal 1 microgrid into a larger multimodal microgrid. Microgrids must be interconnected BTM or FTM. An individual microgrid can be interconnected BTM. However, there are limited regulatory options for connecting multiple microgrids BTM and allowing them to export power to each other. As discussed in the BTM Regulatory Environment section, the over-the-fence rule as outlined in Rule 18 and Rule 19 prohibits the export of power to non-adjacent facilities. This is problematic because power export is a key functionality of a multimodal microgrid. As a result, currently, there is no BTM pathway to deploying a multimodal microgrid.

FTM pathways are a potential pathway for deploying multimodal microgrids. This would effectively be an FTM community microgrid. However, FTM pathways are challenging because the FTM regulatory pathway is not fully formed. This uncertainty in the regulatory environment has historically discouraged utilities from deploying FTM microgrids. Despite this, utilities have previously participated in pilot projects to deploy FTM microgrids. In addition, the CPUC has approved the Microgrid Incentive Program that was discussed in the Track 4, Phase 1 proceedings. This program allocates $200 million, to be split between the California investor-owned utilities, to support FTM community microgrids in disadvantaged and tribal communities who are vulnerable to grid outages. SCE will be allocated $83.3 million of this funding. Each project can receive up to $15 million in funding (CPUC, 2023). The Microgrid Incentive Program might be an avenue for implementing a multimodal microgrid. However, at the time of writing, the selection criteria for the Microgrid Incentive Program have not been released. As a result, it is not possible to determine how competitive this project will be.

The best prospect for implementing a multimodal microgrid would be the development of a multi-property microgrid tariff. CPUC is working on developing this tariff during Track 4, Phase 2 proceedings. This tariff has not been released yet and it is unclear whether it will allow for BTM or FTM multi-property microgrids. Until this tariff is finalized, there will be few options for deploying a multimodal microgrid outside of a pilot project. The feasibility of a multimodal microgrid should be revisited once the multi-property microgrid tariff is finalized.

Microgrid Financial Analysis and Financing Options

Microgrids require significant investment to deploy. They have sizable capital costs but can also provide financial benefits by reducing utility bills. This analysis is important because the financial benefits of a microgrid can help to displace some of the capital costs. Anser Advisory provided financial analysis that quantifies the costs and financial benefits of the microgrid.

Microgrid Construction and Implementation Costs

Microgrids have a significant amount of equipment and have high capital costs. Anser Advisory estimated the capital costs associated with the Terminal 1 microgrids. These estimates provide a breakdown of the required equipment and a cost estimate. These estimates are also broken down for each microgrid segment that will be deployed at Terminal 1.

Table 6. Terminal 1 Microgrids Cost Estimates

Category	Item	UOM	Cost/UOM	Qty.	Cost	Subtotal
Microgrid 1a	Interconnection/ Telemetry	Unit	$ 300,000	1	$ 300,000	
	Utility Infrastructure - Structures, New Ducts, Service Plan	Unit	$ 158,630	1	$ 158,630	
	PV System (excludes canopy steel)	kW	$ 2,650	486.8	$ 1,290,020	
	BESS - Site Controller Metering, Installation	kWh	$ 1,000	2610	$ 2,610,000	
	Switchboard	Unit	$ 324,880	1	$ 324,880	
	1500kW Generator, Install, & Cx	Unit	$ 1,351,000	1	$ 1,351,000	
	20% Contingency	%	$ 1,206,906	1	$ 1,206,906	**$ 7,241,436**
Microgrid 1b	PV System (excludes canopy steel)	kW	$ 3,100	154.0	$ 477,400	
	20% Contingency	%	$ 95,480	1	$ 95,480	**$ 572,880**
Microgrid 2	Interconnection/ Telemetry	Unit	$ 300,000	1	$ 300,000	
	Utility Infrastructure - Structures, New Ducts, Service Plan	Unit	$ 158,630	1	$ 158,630	
	PV System (excludes canopy steel)	kW	$ 2,750	320.4	$ 881,100	
	BESS - Site Controller Metering, Installation	kWh	$ 1,000	1280	$ 1,280,000	
	Switchboard	Unit	$ 259,904	1	$ 259,904	
	800kW Generator, Install, & Cx	Unit	$ 824,413	1	$ 824,413	
	20% Contingency	%	$ 740,809	1	$ 740,809	**$ 4,444,856**
	ROM FULL BUILD 2030+ (excludes site prep, demo, & remediation)					**$ 12,259,172**

The costs presented are inclusive of potential costs which SBMTD may incur to construct the multiple microgrids presented above.

Microgrid Utility Cost Analysis

The Terminal 1 microgrids can also provide financial benefits. The main financial benefit the microgrid can provide is lowering utility bills. Anser Advisory analyzed utility costs for each of the microgrids in ETB, assuming normal (non-backup) operation. Bus charging loads were modeled using SBCE 100% Green as the CCA rate paired with SCE's TOU-EV-9 rate tariff, which does not currently have demand charges. Currently, this rate tariff would cost SBMTD roughly $0.23/kWh. Solar PV generation was then added to the model under NEM 3.0 rules, which significantly devalues any solar exports. BESS was also added to the model, assuming it would charge from on-site solar and be primarily used for self-consumption (bus charging). The results of this financial analysis can be seen in the table below.

Table 7. Terminal 1 Microgrids Utility Cost Savings Analysis

Meter Name	Utility Rate Tariff	Annual Usage (kWh)				Electric Bill Cost		Demand Cost		Blended Savings $/kWh		PV Generation	
		Site Usage	Solar Generation	BESS	Offset	Before / After	Savings	Before / After	Savings	PV	BESS	kWh / kW	Exports
Microgrid 1A	SBCE 100% Green/SCE TOU-EV-9	3,009,240	821,120	-22,820	27%	$683,080 / $518,283	$164,798	$0 / $0	$0	$0.17	$8.40	1,687	3%
Microgrid 1B	SBCE 100% Green/SCE TOU-EV-9	4,577,630	1,084,087	-29,075	23%	$1,036,964 / $820,850	$216,113	$0 / $0	$0	$0.18	$9.34	1,692	3%
Microgrid 2	SBCE 100% Green/SCE TOU-EV-9	2,226,270	542,554	-20,304	23%	$506,430 / $399,157	$107,273	$0 / $0	$0	$0.18	$8.73	1,693	3%

The savings in the table above assume solar PV will be stored in the batteries for self-consumption, as resiliency was the main objective of this project. However, should SBMTD want to explore other battery operating strategies, such as load shifting or peak shaving, savings may be different. Load shifting was already modeled in the assumed load profiles and can be accomplished with charge management software preventing any buses from charging on peak. Peak shaving was not selected as the optimal way to operate batteries, as current SBCE 100% Green/SCE TOU-EV-9 rate tariffs do not currently have demand charges. As demand charges are reintroduced by the utility again in the near future, it is worth reevaluation.

Financing Options

Microgrids have significant upfront capital costs. These capital costs can pose a major barrier to deployment. This is an especially prevalent barrier for transit agencies. As a result, transit agencies oftentimes have to seek other sources of funding, like state or federal grants. However, there are also options for obtaining funding through other types of financial institutions. This section provides an overview of possible financing options. Please note that this list is into intended to be exhaustive.

California Infrastructure and Economic Development Bank (California iBank)

CALSTART conducted research with financial institutions to better understand financing options for the SBMTD microgrid. CALSTART conducted outreach with the California iBank to understand options for mobilizing funding for the microgrid. California iBank is a part of the California Governor's Office of Business and Economic Development (GO-Biz). California iBank finances public infrastructure in California and has the authority to provide funding to public agencies, acquire or lease facilities, issue tax-exempt and taxable revenue bonds, and leverage state and federal funds.

California iBank has programs that can be used to finance infrastructure. The Climate Catalyst Fund is a program that funds climate solutions. This fund offers low-cost financing and credit support. It is intended to provide financing to projects that are too risky for traditional financiers. The main objective is to mobilize public and private financing for shovel-ready projects. As a result, applicants for funding should have written expressions of interest from other financing partners. The Climate Catalyst Fund allocates funding on a first-come, first-served basis. This fund is a revolving fund meaning that as previous loans are paid back, the fund can make new loans. As a result, they prefer to make shorter-term loans so the funding can be revolved. California iBank has flexible financing terms. Projects can be financed through a wide range of financing mechanisms, from traditional loans to loan guarantees (to reduce the interest on private loans).

California iBank's ability to provide financing depends on the technology involved. The Climate Catalyst Fund is currently funding projects related to climate-smart agriculture and forest biomass management. Currently, there is no funding available for transportation-related projects or microgrids. However, California iBank can fund transportation-related projects or microgrids in the future if they receive dedicated funding for these projects. California iBank will be receiving funding from the Inflation Reduction Act. At the time of writing, it is unclear what types of projects this funding will be used for. California iBank supports the Justice 40 Initiative. As a result, any federal funding they receive will support this initiative by targeting financing for projects that help disadvantaged communities.

BP subsidiary bp pulse

bp pulse is an EV charging business, rolling out fast, reliable charging assets to consumers and commercial fleets around the world. Entering the Americas, bp pulse focuses on providing EV charging and energy management to fleets that operate heavy-, medium- and light-duty vehicles. Globally, bp pulse is one of the United Kingdom's leading rapid and ultra-fast public EV charging networks. It also operates the largest number of sites with ultra-fast charging in Germany, with a growing footprint in China and the Netherlands. The company aims to increase its network of public EV charging assets by 2030 to over 100,000 worldwide.

bp pulse can provide Charging-as-a-Service (CaaS) to remove the burden of high capital investment and stakeholder engagement with comprehensive project management and amortized costs. bp pulse believes that the CaaS model generates the best total cost of ownership (TCO) for customers, as this ensures the customer has no upfront capital expense. The amortized capital expenses, operating expenses, and energy expenses are rolled into one monthly usage fee. CaaS terms can be between three and 15 years in length, although longer periods/extensions can be considered. In bp pulse's innovative charging and energy services agreement with Anaheim Transportation Network (ATN), the term is twenty years. This guarantees a service level of recharging vehicles for an upfront, known price per kilowatt hour (price-per-kWh).

bp pulse previously won funding from the California Energy Commission to build a microgrid for ATN. This microgrid will power 46 of ATN's electric buses. This $5 million grant will be used to deploy charging stations, battery energy storage systems, and microgrid controller units at ATN's to-be constructed depot to boost the resilience and flexibility of their zero-emission operations.

Electrada

Electrada is a 360 CaaS + Electric Fuel company that builds, owns, and operates EV charging infrastructure for fleet customers. Electrada offers a complete turnkey solution for deploying EV infrastructure. Electrada funds 100% of the capital costs of the EV charging infrastructure project, and then owns and operates this infrastructure during the contract term. Electrada can also integrate renewable energy, energy storage, and microgrids into the project. This allows customers to avoid having to pay a large upfront payment for the equipment, as would occur under more traditional financing mechanisms. Electrada also pays for the operation and maintenance costs of the equipment during the contract term. Electrada then bundles these expenses and charges customers for the electricity that is dispensed to their vehicles. Customers are charged a flat rate per kWh. This per-kWh rate is fixed and does not change over the length of the contract. This financing model effectively spreads the cost of the infrastructure over time, but also shifts the responsibility for the operation and maintenance of the infrastructure during the term of the contract. This financing model is appropriate for customers who are unable to finance the upfront cost of the infrastructure and would prefer to finance the infrastructure from their operational budget, as well as shift the responsibility of maintaining that infrastructure to Electrada. Electrada guarantees 99% uptime for their infrastructure.

Electrada works with all fleet types and all on-road vehicle types. Electrada begins projects by conducting a feasibility study for the project to understand the fleet's operations and any vehicle and infrastructure needs. They also investigate the performance parameters for the charging infrastructure and any microgrid additions. This information is used to evaluate the costs of the project and to develop an implementation plan. If the customer decides to move forward with the project, Electrada will then build the project and sign an "Electrification Services Agreement" with the fleet, that typically spans a 5-to-10-year term.

Electrada offers flexible financing terms. Electrada's contracts can last from as little as five years to as high as 20 years. Electrada can also build out the infrastructure in phases as fleets scale up EV deployments over time. Contracts can be structured with different terms based on the number of vehicles deployed and the location of the depot. Electrada can secure governmental grant funding to support projects. If grant funding is used, Electrada bundles the grant funding into the per-kWh price to reduce that cost, thus passing the savings on to the customer.

AlphaStruxure

AlphaStruxure is an Energy-as-a Service provider that specializes in renewable energy and microgrids. AlphaStruxure is a joint venture between the Carlyle Group and Schneider Electric. AlphaStruxure provides a turnkey solution and designs, finances, builds, owns, operates, and maintains energy assets. The expenses from these operations are then bundled together into a power purchase agreement with their customer. Under this financing model, the customer is charged a flat rate per kWh provided. AlphaStruxure offers power purchase agreements that last 15 – 25 years. The power purchase agreement model also effectively spreads the cost of the infrastructure over time.

AlphaStruxure built the Brookville Smart Energy Bus Depot for Montgomery County Transit in Maryland. This microgrid integrates solar panels, battery energy storage, and natural gas turbines. The microgrid serves 70 electric buses and is designed to provide resiliency to the buses in the event of a grid outage. AlphaStruxure also offers other energy services. AlphaStruxure can incorporate hydrogen production into their microgrids. AlphaStruxure can also build community microgrids.

AlphaStruxure is also able to work with government grant funding to support projects. AlphaStruxure is open to pursuing funding from programs like the Federal Transit Administration's Bus and Bus Facilities Grant Program and the Low and No Emission Program.

Microgrid Benefits

SBMTD is planning to deploy a microgrid at their Terminal 1 depot. The microgrid is intended to provide resiliency to their fleet of electric buses. However, in addition to resiliency, they will also provide a host of other benefits. These benefits include job creation, economic/financial benefits, and GHG emission reductions. This section identifies and quantifies these benefits.

Jobs and Economic Benefits

The Terminal 1 microgrids are expected to generate job creation and economic benefits for the local community. For example, the solar panels and BESS can be used to engage in load shifting to reduce SBMTD's utility bills. The microgrids will also provide other benefits beyond utility savings. The construction of the microgrids will create jobs and these jobs will benefit both local workers in Santa Barbara and workers in other parts of the United States. The resiliency provided by the microgrid also has an economic value.

To help Santa Barbara capture the economic benefits of the microgrid construction, CALSTART provided an overview of the types of direct and indirect jobs that will be created, wages for these jobs, and the qualifications that workers need to attain these jobs. This information can be used to develop appropriate workforce development programs to prepare the labor pool for these jobs. CALSTART also conducted an economic analysis to quantify the benefits that accrue directly to SBMTD, as well as positive externalities that benefit the local community and beyond. Using this information, CALSTART conducted a simple cost-benefit analysis of the microgrids.

Summary of Jobs

The microgrids will provide job benefits to Santa Barbara and the state of California. CALSTART used the Job Co-benefit Modeling Tool (JCMT) of the California Air Resources Board to calculate the number of jobs created. JCMT is used to estimate the number of jobs created by projects that are funded by the state of California. JCMT is designed to carry out these calculations for specific state funding programs. This model accepts several inputs, including the year when the project starts, the amount of funding for the project, and what the funding is spent on (e.g., procurement of electric vehicle supporting infrastructure or procurement of solar photovoltaic equipment).

JCMT uses these inputs to calculate job creation for three classes of jobs. The first class is "direct" jobs. These include jobs that are created to complete the project itself. This typically includes jobs in the construction or production of the project deliverables. In the context of the microgrids, direct jobs would include those created by the construction of the microgrids. The second class is "indirect" jobs. Indirect jobs are those related to the supply chain associated with the project. For the microgrid project, this would include jobs created by the manufacturing of microgrid components. The last class is "induced" jobs. Induced jobs are those generated by the spending of income from the direct and indirect jobs that were created.

CALSTART programmed JCMT with several assumptions and parameters. This model assumes that the construction of the microgrids will begin in 2024. CALSTART also assumed that the total capital costs of both microgrids will be $12,259,172. This assumption is based on the estimate that Anser Advisory provided in the Microgrid Financial Analysis and Financing Options section.

Table 8. JCMT Project Information Inputs

Input	Value
Project Start Year	2024
Total Project Budget	$12,259,172

JCMT requires that the project budget be broken down by "activity." CALSTART broke down the project into three activities: procurement of electric vehicle supporting infrastructure, procurement of solar photovoltaic equipment, and other. A percentage of the total budget was allocated to each activity. The microgrid project cost estimate provides a budget for each microgrid component. This includes interconnection/telemetry, utility infrastructure, PV system, BESS, switchboard, EV infrastructure, EV chargers and installation, generators, and a 20% contingency.

Each line item in the cost estimate was assigned to an activity. These assignments are displayed below. As indicated, the cost estimate includes a 20% contingency. The 20% contingency was split up proportionally between each of the activities.

Table 9. JCMT Activity Breakdown

Activity	Project Components	Percentage of Budget
Procurement of solar photovoltaic equipment	PV system BESS	50%
Procurement of electric vehicle supporting equipment	Interconnection/Telemetry Utility infrastructure EV infrastructure EV charger and installation	37%
Other	Generator	13%

Based on these inputs, JCMT estimated the number of jobs that will be created by these microgrids. JCMT found that the microgrids will support 86.4 full-time equivalent jobs. This includes direct, indirect, and induced jobs. The breakdown between these categories is displayed below.

Table 10. JCMT Results

Job Type	Number of Full-time Equivalent Jobs Supported
Direct	32.0
Indirect	19.6
Induced	34.8

The direct jobs figure represents the jobs that will be created from the construction of the microgrids. Since construction work typically must be completed in-person, it is expected that the vast majority of these jobs will be filled by local labor. The types of direct jobs that are expected to be created by this project and the median wage for these occupations (California wages) are displayed below. This data was gathered from the Bureau of Labor Statistics.

Table 11. Direct Jobs

Job Type	Annual Wages (California)	Credentials Required
Occupations in solar power plant construction		
Construction Managers	$125,530	Bachelor's degree
Civil Engineers	$113,290	Bachelor's degree
Construction Equipment Operators	$83,600	High school diploma or equivalent
Electricians	$104,680	High school diploma or equivalent
Structural Iron and Steel Workers	$69,400	High school diploma or equivalent
Welders	$55,290	High school diploma or equivalent
Solar PV Installers	$53,690	High school diploma or equivalent
Construction Laborers	$56,210	No formal credential
Occupations involved in charging network development		
Electrical Engineers	$150,940	Bachelor's degree
Urban and Regional Planners	$100,630	Bachelor's degree
Electrical Power-Line Installers and Repairers	$104,680	High school diploma or equivalent
Electricians	$78,140	High school diploma or equivalent
Construction Laborers	$56,210	No formal credential

CALSTART also gathered data on indirect jobs. These are jobs that are created in the supply chain for the microgrids. Many of these jobs will be related to manufacturing for microgrid equipment. Since Santa Barbara does not have a major manufacturing facility that produces microgrid equipment, it is unlikely that the indirect jobs will be filled by local labor. The types of indirect jobs that are expected to be created by this project and the median wage for these occupations (California wages) are displayed below. This data was gathered from the Bureau of Labor Statistics.

Table 12. Indirect Jobs

Job Type	Annual Wages (California)	Credentials Required
Occupations in manufacturing for solar power		
Industrial Production Managers	$134,500	Bachelor's degree
Glaziers	$67,580	High school diploma or equivalent
Semiconductor Processing Technicians	$55,790	High school diploma or equivalent
Welding, Soldering, and Brazing Workers	$55,290	High school diploma or equivalent
Coating and Painting Machine Setters, Operators, and Tenders	$49,010	High school diploma or equivalent
Computer-controlled Machine Tool Operators	$48,600	High school diploma or equivalent
Occupations in battery manufacturing		
Electric and Electronic Equipment Assemblers	$46,750	High school diploma or equivalent
Miscellaneous Assemblers and Fabricators	$42,680	High school diploma or equivalent

Economic Benefits

The Terminal 1 microgrids are expected to provide multiple economic benefits for Santa Barbara. The microgrids will provide these benefits through several mechanisms. The most frequently used mechanism will likely be using the battery to engage in peak shaving and load shifting to reduce utility bills. However, the construction of the microgrids will also provide economic benefits by providing resiliency. Public transit service provides benefits to the local economy and if a grid outage prevents SBMTD from providing service, there will be consequential economic damage. As a result, the resiliency provided by the microgrids has economic value. This section aims to quantify the economic benefits of the microgrids.

Utility Cost Reductions

The microgrids are expected to provide economic benefits in the form of reduced utility costs. The microgrids will have solar panels and battery energy storage systems, and the microgrids were designed to employ these systems to generate power for electric bus charging. As discussed in the Microgrid Design section, the battery energy storage system will charge from the onsite solar panels. This energy will then be used to charge the electric buses. The Terminal 1 microgrids will be deployed in phases with two separate microgrids being deployed onsite. As described in the Microgrid Utility Cost Analysis section, once both microgrids are deployed at Terminal 1, SBMTD will be able to reduce their utility bills by $488,184 per year. This equates to a 21.9% reduction in their utility bills. Assuming that the microgrids have a life of 25 years, this equates to $12,204,600 in utility bill savings over the life of the microgrids.

Microgrid Construction

The buildout of the microgrids will provide economic benefits for the surrounding community in the form of jobs. As discussed above, direct jobs are the class of jobs that are most likely to be filled by local labor. As a result, these jobs will directly benefit Santa Barbara.

CALSTART quantified the economic value of these jobs. CALSTART started this analysis by estimating the number of each type of direct job (e.g., construction manager, civil engineer, etc.) that will be supported by the project. While JCMT can calculate the total number of direct jobs, it does not estimate the quantity of each type of direct job that will be created. Using data from the Bureau of Labor Statistics, CALSTART determined the number of people employed for each type of direct job in the United States. CALSTART used this data to estimate the proportion of people employed in each direct job type. Since JCMT estimated that 32 direct jobs would be supported, CALSTART multiplied these proportions by 32 to estimate the number of each direct job type that will be supported. The estimated number of direct jobs was then multiplied by the corresponding median salary for that job type. These values were then added to estimate the total annual wage that will be earned by these workers. Based on this calculation, CALSTART estimates that, collectively, the workers employed in the direct jobs will earn approximately $2,976,115 per year.

Table 13. Economic Value of Direct Jobs

Job Type	Annual Wages (California)	Estimated Jobs	Estimated Wages
Construction Managers	$125,530	2.72	$341,668.11
Civil Engineers	$113,290	3.55	$402,282.29
Construction Equipment Operators	$83,600	2.97	$248,237.89
Electricians	$104,680	5.98	$626,346.56
Structural Iron and Steel Workers	$69,400	0.75	$51,725.37
Welders	$55,290	1.20	$66,294.41
Solar PV Installers	$53,690	0.19	$10,242.18
Construction Laborers	$56,210	9.45	$531,159.96
Electrical Engineers	$150,940	3.39	$511,557.92
Urban and Regional Planners	$100,630	0.47	$47,037.50
Electrical Power Line Installers and Repairers	$104,680	1.33	$139,563.12
Total	**-**	**32**	**$2,976,115.29**

Indirect jobs will also generate economic benefits. CALSTART quantified these benefits by determining the value of the wages earned by the workers in the indirect jobs. CALSTART used the same methodology that was used to calculate the value of the direct jobs. Based on this analysis, workers in the indirect jobs will earn wages of $1,034,460. It is unlikely that these indirect jobs will be in Santa Barbara. As a result, it is likely that most of these economic benefits will not accrue to Santa Barbara. However, they do represent a positive economic benefit for the nation.

Table 14. Economic Value of Indirect Jobs

Job Type	Annual Wages (California)	Estimated Jobs	Estimated Wages
Industrial Production Managers	$134,500	1.68	$225,374.84
Glaziers	$67,580	0.47	$31,616.18
Semiconductor Processing Technicians	$55,790	0.26	$14,256.61
Welding, Soldering, and Brazing Workers	$55,290	0.25	$14,065.20
Coating and Painting Machine Setters, Operators, and Tenders	$49,010	1.25	$61,298.52
Computer-controlled Machine Tool Operators	$48,600	1.47	$71,670.57
Electric and Electronic Equipment Assemblers	$46,750	2.27	$105,900.49
Miscellaneous Assemblers and Fabricators	$42,680	11.96	$510,277.73
Total	**-**	**19.61**	**$1,034,460.13**

Microgrid construction will also create induced jobs. However, based on the information available, it is not clear what type of induced jobs will be supported by the microgrids. As a result, while induced jobs will be supported, CALSTART is not able to quantify the economic benefits of these jobs. It is likely that many of these induced jobs will be lower wage service industry jobs, and that the economic benefits of these jobs will be relatively low.

Resiliency

The primary benefit of the microgrids is to provide resiliency, or backup power, in the event of a grid outage. Resiliency measures are difficult to value because they typically entail high upfront costs and are used on an infrequent and unpredictable basis. Despite this challenge, there are various methodologies that have been developed to value resiliency. One methodology is to determine the marginal cost of increasing power availability. Under this approach, the costs that an entity incurs to increase power availability is considered to be the economic value of resiliency. These costs can then be spread out over the total power that is expected to be provided by the resiliency asset to determine a levelized cost of resiliency (typically expressed in dollars per kWh). An alternative method is to determine the value of damages that occur in the event of an outage. It is then assumed that the value of resiliency services is equivalent to the damages from an outage (Thomas and Henning, 2017).

This approach faces challenges in the context of these microgrids. The microgrids provide resiliency for SBMTD's fleet of electric buses. However, SBMTD is not a business, and its primary objective is not to maximize profits. As a result, traditional methodologies for valuing its output are not applicable. Since the microgrids are ultimately intended to allow electric buses to operate in the event of an outage, the value of resiliency is fundamentally tied to the economic benefits of public transit.

CALSTART assumed that the economic value of resiliency is equivalent to the value of the damages that occur during an outage. As a result, CALSTART aimed to quantify the benefits that public transit provides to the Santa Barbara region. According to a study conducted by the American Public Transportation Association (APTA), there are several benefits that public transit provides. These include reducing transportation costs (i.e., reducing gas and parking costs), reducing congestion on roads, and decreasing travel time by reducing car accidents. Public transit can also increase accessibility to transportation, which can allow people to make trips that would not ordinarily have been made. This is important because it allows people to get to work and increases the public's access to businesses.

APTA quantified the economic value of these benefits. According to APTA (2020), a $2.9 billion per year increase in spending on public transit will yield $9.1 billion of gross domestic product equivalent. This suggests that $1 of investment yields approximately $3.14 in benefits from public transportation. For FY21-22, SBMTD's audited operating expenses were $26,519,751.5 This implies that SBMTD's transit service produces $83,272,018 of economic benefits per year. This equates to approximately $229,399 of economic benefits per day (based on SBMTD's 363 days of transit service per year).

Based on this analysis, any grid outage that disrupts transit service for one day will inflict $229,399 of economic damages. It is important to note that a 24-hour grid outage is not necessarily required to disable the fleet for an entire day. If, for example, a 6-hour grid outage occurs when the buses are normally charging, it can delay charging long enough to where the buses are not ready for service at their normal time. As a result, even shorter grid outages can potentially disrupt public transit for an entire day.

Cost-Benefit Analysis

CALSTART found that the microgrids are favorable from a cost-benefit perspective over a 25-year period. The microgrids are expected to cost $12,259,172. However, they will provide many benefits to SBMTD, the residents of Santa Barbara, and the United States. The microgrids are projected to provide SBMTD with $12,204,600 in utility bill savings over their entire lifetime. The microgrid construction will also support employment in Santa Barbara. Construction is estimated to directly support 32 full-time equivalent jobs in the local market. CALSTART assumes that construction will take one year. As a result, these jobs will provide wages of $2,976,115 to Santa Barbara. Construction is also projected to support 19.6 indirect jobs, providing wages of $1,034,460. The microgrids also provide resiliency benefits. Without any resiliency measures, SBMTD's fleet of electric buses will not be able to provide transit service if there is a grid outage. CALSTART valued the economic damage resulting from a grid outage at $229,399 per day that transit service is disrupted.

CALSTART compared the costs of the microgrids to all economic benefits that accrue to SBMTD, the City of Santa Barbara, and the United States over a 25-year life of the microgrids. The utility savings and the wages from direct and indirect jobs supported through microgrid construction are worth $16,215,175. In addition, for each day that the microgrids provide resiliency and prevent disruption to public transit, Santa Barbara accrues an additional $229,399 of economic benefits. As a result, the benefits of the microgrids exceed the costs.

There are some limitations to this analysis. One limitation is that this analysis does not take into account operating costs for the microgrids. Another limitation is that the microgrids are going to be built in phases as the electric buses are purchased. However, this analysis assumes that the microgrids will be deployed at once. This assumption was made to simplify the financial analysis. It is also important to note that there are some benefits that are not included in this analysis. The benefits of induced jobs, while likely to be low, were not included because they could not be quantified with the available information. Furthermore, this analysis does not quantify the economic value of environmental benefits, such as reduced greenhouse gas emissions or improved air quality. As a result, the benefits in this analysis are likely to be an underestimate.

GHG Emissions Benefits

The microgrids at Terminal 1 are expected to provide many benefits to SBMTD, including utility cost savings and increased resiliency. The microgrids will also provide environmental benefits, including reductions in GHG emissions. Microgrids can operate under blue sky conditions and black sky conditions. Blue sky conditions refer to a situation where the utility grid is operational. Under blue sky conditions, the microgrid will only deploy the solar panels and BESS. Black sky conditions refer to a situation where the utility grid experiences an outage and the microgrid must act as an island. Under black sky conditions, the solar panels and BESS will be deployed. In addition, the backup generators will also likely be in use. The Terminal 1 microgrids can provide GHG emissions reductions under both blue sky and black sky conditions. CALSTART quantified the emissions reductions that the microgrids will provide under both conditions.

Microgrid GHG Emission Reductions Under Blue Sky Conditions

The Terminal 1 microgrids will operate under blue sky conditions for the vast majority of the time. SBMTD currently charges their electric buses with power drawn from the utility grid. However, once the microgrids are completed, they will be able to provide a portion of SBMTD's energy needs with renewable energy. The microgrids will be used to generate energy from the solar panels, which will either be consumed immediately or stored in the BESS. This energy can be deployed to displace electricity drawn from the utility grid. The microgrids will reduce GHG emissions because the energy they produce will have a higher renewable content than the energy displaced from the utility grid.

SBMTD currently receives their energy from SBCE, which as mentioned above, is the local community choice aggregator for Santa Barbara. SBCE offers multiple options for providing renewable energy to Santa Barbara and they collaborate with SCE to deliver power to their customers. SBCE's customers have multiple options for their power portfolio. The first option is to receive normal grid power that is equivalent to SCE's energy portfolio. The second option is Green Start, under which at least 50% of the energy provided comes from carbon-free sources. The last option is 100% Green under which all energy comes from carbon-free sources. Solar energy can be paired with either the Green Start or 100% Green options. CALSTART conducted an analysis on the impacts that the Terminal 1 microgrids will have on GHG emissions for each SBCE power option. This analysis is included below.

SCE Option

Based on the analysis provided in the Microgrid Design section, the charging load for SBMTD's buses at Terminal 1 will be 9,813,140 kWh per year. This analysis also projected that the Terminal 1 microgrids will displace 2,375,562 kWh per year, or about 24.2% of the load. According to SCE (2021), their energy portfolio includes 31.4% renewable content which has a carbon intensity of 580 pounds of carbon dioxide equivalent (CO2e) emissions per MWh of electricity produced.1 Based on this carbon intensity, if SBMTD's electric bus fleet that is based at Terminal 1 was charged using SCE's energy portfolio, the electricity would produce 5,691,621.2 pounds or 2,587.1 metric tonnes of CO2e emissions per year.

The Terminal 1 microgrids will displace energy drawn from the grid and replace it with fully renewable energy. The renewable energy provided by the microgrid will produce zero pounds of CO2e emissions per MWh. This means that 7,437,578 kWh will be drawn from the utility grid and 2,375,562 kWh will be provided by the microgrid. This figure is the net energy provided by the microgrid, taking into account efficiency losses resulting from charging and discharging the battery.

Table 15. SCE Option Assumptions

Parameter	Value
kWh from Grid	7,437,578
Renewable Content from Grid	31.4%
SCE Grid Carbon Intensity	580 pounds of CO2e per MWh
kWh from Microgrids	2,375,562
Renewable Content from Microgrid	100%
Microgrid Carbon Intensity	0 pounds of CO2e per MWh

Based on these assumptions, the emissions from charging the electric buses with the microgrids will be 4,313,795.24 pounds or 1,960.82 metric tonnes of CO2e per year. This will result in annual reductions of 626.28 metric tonnes or 15,657 metric tonnes over the 25-year life of the microgrid. This represents a 24.2% decrease in GHG emissions. CALSTART also calculated the effective renewable content that will result from using the microgrids. This was calculated as a weighted average of the renewable content for electricity provided by the grid and by the microgrids. CALSTART found that the microgrids increase the effective renewable content to 48.01%, as compared to renewable content of 31.4% for SCE's grid.

Green Start Option

SBCE's Green Start option increases the renewable content of grid electricity to at least 50%. The SCE 2021 power content label states that SCE's renewable content for their 50% option is actually higher than the 50% requirement. This option has 65.7% renewable content, which produces 290 pounds of CO2e emissions per MWh of electricity produced (SCE, 2021). Based on this carbon intensity, if SBMTD's electric bus fleet was charged using SCE's 50% option (with an actual renewable content of 65.7%), the electricity would produce 2,845,810.6 pounds or 1,293.55 metric tonnes of CO2e emissions per year.

The Terminal 1 microgrids will displace energy drawn from the grid and replace it with renewable energy. The renewable energy provided by the microgrids will produce zero pounds of CO2e emissions per MWh. This means that 7,437,578 kWh will be drawn from the utility grid and 2,375,562 kWh will be provided by the microgrids.

Table 16. Green Start Option Assumptions

Parameter	Value
kWh from Grid	7,437,578
Renewable Content from Grid	65.7%
SCE Grid Carbon Intensity	290 pounds of CO2e per MWh
kWh from Microgrids	2,375,562
Renewable Content from Microgrid	100%
Microgrid Carbon Intensity	0 pounds of CO2e per MWh

Based on these assumptions, the emissions from charging the electric buses with the microgrids under the Green Start option will be 2,156,897.62 pounds or 980.41 metric tonnes of CO2e per year. This will result in annual reductions of 313.14 metric tonnes or 7,828.5 metric tonnes over the 25-year life of the microgrid. This represents a 24.2% decrease in GHG emissions. CALSTART found that the microgrids increase the effective renewable content to 74.0%, as compared to renewable content of 65.7% for SCE's 50% option.

100% Green Option

The energy provided by SBCE under the 100% Green option is already fully renewable. Thus, the microgrids will not provide any further increases to renewable content.

Microgrid GHG Emission Reductions Under Black Sky Conditions

In addition to the financial benefits, resiliency can also reduce GHG emissions reductions by preventing disruptions to public transit. The Terminal 1 microgrids will be used during black sky conditions to act as an island from the utility grid and provide resiliency to SBMTD's fleet. Public transit reduces emissions by decreasing the number of car trips and associated VMT. In the absence of the microgrids, SBMTD's electric buses will effectively be disabled under black sky conditions. Under this scenario, SBMTD's riders will likely use alternative forms of transportation, including gas- or diesel-powered vehicles, which will increase VMT and cause an increase in emissions. As a result, the Terminal 1 microgrids can reduce these VMT-related GHG emissions by preventing disruptions to public transit service.

VMT-Related GHG Emissions Reductions

CALSTART quantified these GHG emission reductions by using the Federal Transit Administration's Transit Greenhouse Gas Emissions Estimator (Version 3).[4] This tool contains a "Displaced Emissions" module that calculates GHG emissions associated with passenger VMT. The module accepts vehicle type, fuel source, and annual VMT as inputs into the model. CALSTART programmed the GHG Emissions Estimator with the following assumptions:

Table 17. Displaced Emissions Assumptions

Parameter	Value
Vehicle Type	Sedan/Auto
Fuel Source	Gas
Annual VMT Displaced	26,307,657

CALSTART assumed that under black sky conditions, all riders would switch to private cars, taxis, or ridesharing services to complete their trips. It is probable that this assumption overstates the total, as some riders may choose to walk or bicycle instead. CALSTART

[4] The Transit GHG Emissions Estimator can be found at: https://www.transit.dot.gov/regulations-and-guidance/environmental-programs/ftas-transit-greenhouse-gas-emissions-estimator

calculated annual VMT by multiplying SBMTD's ridership by the average trip length. According to SBMTD's data, there were 6,432,190 passenger trips during FY2019. The average trip length on SBMTD's transit system is 4.09 miles. This data was obtained from the lookup tables in the CARB Benefits Calculator Tool for the Transit and Intercity Rail Capital Program.

Based on these inputs the GHG Emissions Estimator found that SBMTD's transit service displaces up to 10,734 metric tonnes of CO2e emissions per year. This equates to 29.57 metric tonnes of CO2e emissions per day (assuming 363 days of SBMTD service per year). As a result, for each day that the Terminal 1 microgrids prevent disruption to transit service, they are projected to prevent up to 29.57 metric tonnes of CO2e emissions. It is important to note that these figures only include the emissions associated with the actual trips. If riders switch to taxi or rideshare services, there are typically deadhead miles involved in these trips. These potential deadhead miles are not included in this analysis. If the deadhead miles are significant, this figure will likely underestimate actual VMT-related emissions.

Generator GHG Emissions

While the microgrids will reduce emissions from VMT during black sky conditions, the microgrid will likely need to deploy its backup generator to provide full resiliency for the fleet. The backup generators will be using renewable diesel. While renewable diesel is more environmentally friendly than petroleum diesel, it still produces GHG emissions. As a result, these GHG emissions need to be subtracted from the GHG emissions saved from reducing VMT to calculate net GHG emissions reductions. Furthermore, the combustion of renewable diesel will still produce criteria pollutants.

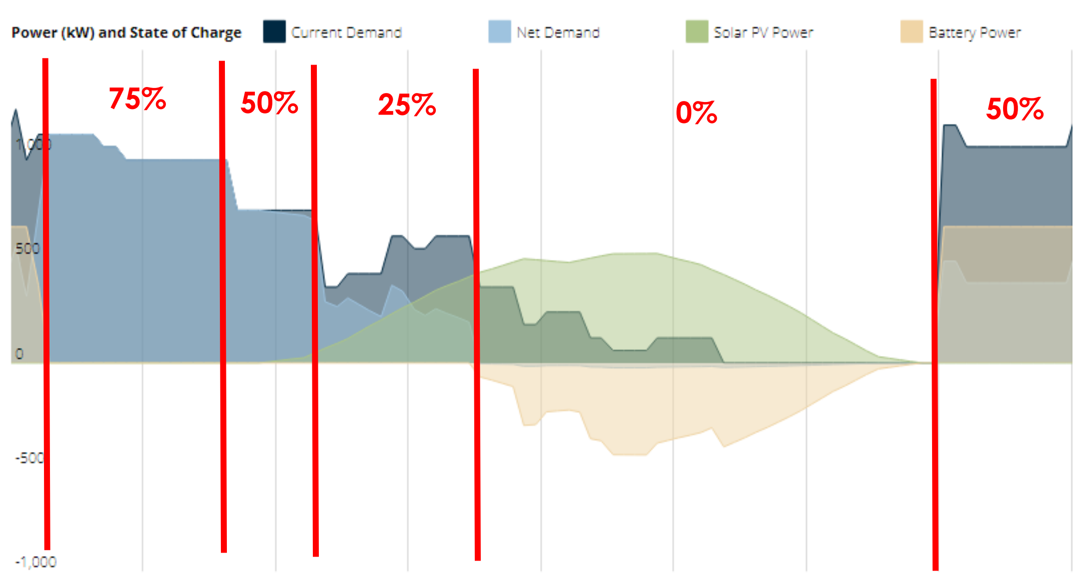
CALSTART calculated the GHG emissions that will be produced by the backup generators. CALSTART's calculations assumed that the backup generators will operate for up to 24 hours during black sky operations to prevent one day's worth of disruptions to public transit. CALSTART began by calculating the diesel that will be consumed by each generator. The generator in Microgrid 1 is a 1,500 kW generator. This generator is expected to consume diesel at the following rates:

Table 18. Microgrid 1 Generator Diesel Consumption (1,500 kW)[5]

Generator Capacity (Percent Load)	Fuel Consumption (Gallons per Hour)
25%	36.5
50%	66.0
75%	97.3
100%	133.0

The generator will not operate at the same rate throughout the entire day. The generator will ramp up and down based on the load that it must serve. Since the microgrid will also use solar panels and batteries, the generator will not need to power the entire load. As displayed in Figure 16, the generators will only need to supply power for the portion of the load profile labeled as "Net Demand". The figure below shows the generator capacity over the course of a day.

Figure 16. Terminal 1 Microgrid 1 Load Profile



Based on these assumptions, the generator in Microgrid 1 will consume 894.7 gallons of diesel during a 24-hour outage. CALSTART also calculated the diesel consumption for

[5] Fuel consumption rates are based on the Generac SD1500 generator

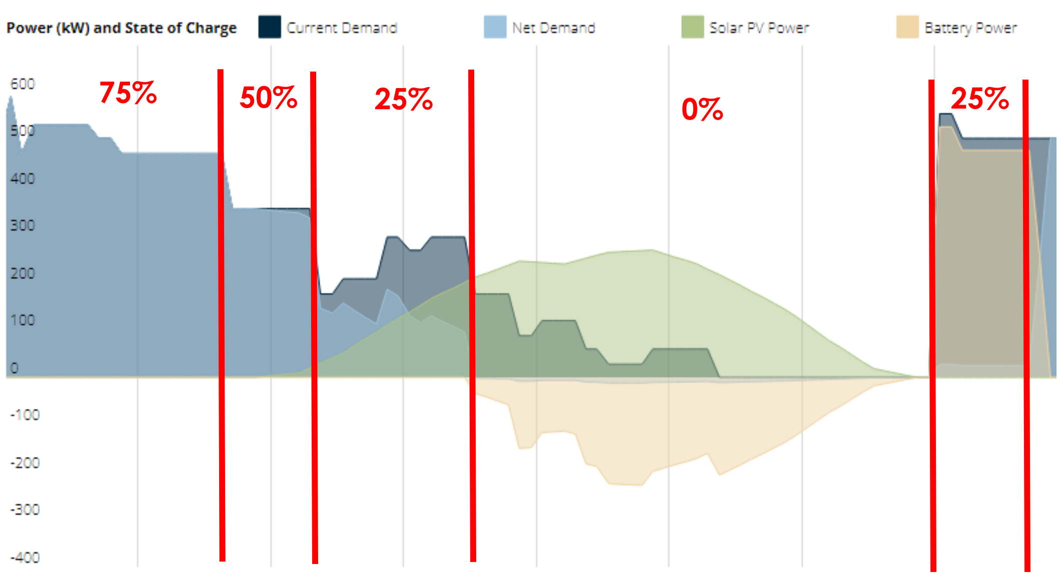
Microgrid 2, which will use an 800 kW generator. This generator is expected to consume diesel at the following rates:

Table 19. Microgrid 2 Generator Diesel Consumption (800 kW)[6]

Generator Capacity (Percent Load)	Fuel Consumption (Gallons per Hour)
25%	19.5
50%	34.6
75%	50.9
100%	74.4

This generator is also expected to ramp up and down over the course of the day. The generator capacity used throughout the day is displayed below:

Figure 17. Terminal 1 Microgrid 2 Load Profile



Based on these assumptions, the generator in Microgrid 2 will consume 511.1 gallons of diesel during a 24-hour outage.

[6] Fuel consumption rates are based on the Generac SD800 generator

CALSTART then calculated the GHG emissions produced by the diesel. Petroleum diesel has a carbon intensity of 10.19 kg of CO2e per gallon of diesel (Energy Information Administration, 2022). Since renewable diesel has a lower carbon intensity than petroleum diesel, CALSTART also calculated the carbon intensity of renewable diesel. This calculation was used to adjust the calculations to reflect the lower carbon intensity of renewable diesel. CALSTART used the following assumptions for this calculation:

Table 20. Renewable Diesel GHG Reductions (Source: California Air Resources Board, n.d.)

Fuel	Carbon Intensity (g CO2e per MJ)
Petroleum Diesel	100.45[7]
Renewable Diesel	37.93[8]
Renewable Diesel GHG Emissions Reduction	62.2%

Using carbon intensity data from the CARB Low Carbon Fuel Standard website, CALSTART found that renewable diesel reduces GHG emissions by approximately 62.2%. CALSTART then multiplied diesel consumption by the carbon intensity to determine the emissions associated with petroleum diesel. This figure was decreased by 62.2% to reflect the GHG emissions reduced by using renewable diesel.

Based on these parameters, the generators are expected to produce 5.42 metric tonnes of GHG emissions during a 24-hour outage. The emissions are broken down as follows:

Table 21. Generator GHG Emissions

Fuel	Renewable Diesel Consumption (Gallons)	GHG Emissions (Metric Tonnes)
Microgrid 1	894.7	3.45
Microgrid 2	511.1	1.97
Total	**1,405.8**	**5.42**

[7] Based on CARB Low Carbon Fuel Standards data. Average petroleum diesel carbon intensity as listed on the Current Fuel Pathways spreadsheet.

[8] CARB Low Carbon Fuel Standards data. Renewable diesel carbon intensity as listed on the Substitute Pathways for Reporting Fuels with Unknown CI for 2023 table.

Net GHG Emission Reductions

The microgrids at the Terminal 1 depot are expected to reduce emissions by preventing disruptions to transit service. This is expected to produce a reduction of 29.57 metric tonnes of CO2e emissions for every 24-hour disruption in transit service. However, the generators used in the microgrids will produce GHG emissions. These generators are expected to produce 5.42 metric tonnes of CO2e emissions over a 24-hour grid outage. As a result, the net GHG emission reduction from the microgrid under black sky conditions is expected to be 24.15 metric tonnes of CO2e for each 24-hour grid outage.

Criteria Pollutant Emissions

The Terminal 1 microgrids will include generators in the energy portfolio. While these generators will use diesel, many of the GHG emissions will be reduced due to the use of renewable diesel. However, the generators will still produce criteria pollutants, such as NOx, reactive organic carbon (ROC), PM, and CO. CALSTART used Santa Barbara Air Pollution Control District's Diesel-fired Internal Combustion Engine (DICE) Emergency Standby Emissions Calculator to estimate emissions from the generators. The DICE Calculator accepts inputs including the engine rating (in brake horsepower) and daily hours of usage. The amount of emissions also depends on the type of generator that is used. The U.S. Environmental Protection Agency (EPA) has established emissions standards for generators. The EPA has established tiers to rate generators by how many emissions they produce. Tier 1 has the highest emissions, whereas Tier 4 has the lowest emissions. The DICE Calculator also accepts EPA Tier as an input.

CALSTART calculated emissions for the generators integrated into Microgrid 1 and Microgrid 2 at Terminal 1. Microgrid 1 will contain a 1,500 kW generator and Microgrid 2 will contain an 800 kW generator. The output of the generator was converted from kW to brake horsepower. CALSTART used the following inputs in the model.

Table 22. DICE Model Inputs

Parameter	Microgrid 1 (1,500 kW)	Microgrid 2 (800 kW)
Brake Horsepower	2,011.53	1,072.82
Maximum Daily Hours	24	24

These inputs were used to calculate the emissions produced during a 24-hour outage. CALSTART calculated emissions for Tier 1, Tier 2, and Tier 4 engines.

Table 23. DICE Model Results for a 24-Hour Outage (Tier 1 Engines)

Microgrid	NOx (lbs)	ROC (lbs)	CO (lbs)	PM (lbs)
Microgrid 1 (1,500 kW)	734.37	106.32	904.66	42.57
Microgrid 2 (800 kW)	391.66	56.71	482.49	22.71
Total	**1,126.03**	**163.03**	**1,387.15**	**65.28**

Table 24. DICE Model Results for a 24-Hour Outage (Tier 2 Engines)

Microgrid	NOx (lbs)	ROC (lbs)	CO (lbs)	PM (lbs)
Microgrid 1 (1,500 kW)	478.94	31.90	276.72	15.96
Microgrid 2 (800 kW)	255.43	17.01	147.58	8.51
Total	**734.37**	**48.91**	**424.30**	**24.47**

Table 25. DICE Model Results for a 24-Hour Outage (Tier 4 Engines)

Microgrid	NOx (lbs)	ROC (lbs)	CO (lbs)	PM (lbs)
Microgrid 1 (1,500 kW)	53.22	14.89	276.72	2.13
Microgrid 2 (800 kW)	28.38	7.94	147.58	1.14
Total	**81.60**	**22.83**	**424.30**	**3.27**

It is important to note that these figures assume that the generators operate at full capacity during the outage. As a result, they represent a worst-case scenario for criteria pollutants over a 24-hour period. It is very likely that the generators connected to the Terminal 1 microgrids would run at less than full capacity during an outage. Thus, these figures are likely to be an overestimate. While these generators will produce criteria pollutants, they will not have a long-term impact on air quality. These generators will only be used during a grid outage, which occur very infrequently. Therefore, the generators will not be regularly producing emissions.

Total GHG Emissions Benefits

The microgrids at Terminal 1 will produce significant GHG emissions reductions under both blue sky and black sky conditions. Under blue sky conditions, the microgrid will displace a portion of the grid electricity and replace it with fully renewable energy, thereby increasing the renewable content of the power. If SBMTD uses normal grid electricity to power their buses, the microgrid will increase the renewable content from 31.4% to 48.01%. This will reduce GHG emissions by 626.28 metric tonnes per year. If SBMTD uses the Green Start Option, they will increase the renewable content of their power from 65.7% to 74.0%. This will reduce GHG emissions by 313.14 metric tonnes per year. These reductions are separate from the GHG emission savings that occur by switching from diesel-powered buses to electric buses.

The microgrid will also produce emissions savings during black sky events. It will achieve this by preventing emissions from disruptions to public transit. Emissions can increase if public transit is disrupted because people will find alternative forms of transportation. CALSTART calculated that the microgrid, by allowing public transit to continue operating during a grid outage, will prevent 29.57 metric tonnes of CO2e emissions per day. However, to continue providing power to the SBMTD fleet, the microgrid will need to employ generators consuming renewable diesel. These generators will produce 5.42 metric tonnes of CO2e emissions over a 24-hour grid outage. Thus, the net GHG emissions reductions will be 24.15 metric tonnes of CO2e for each 24-our grid outage.

The generators will also produce criteria pollutant emissions. The amount of criteria pollutants will vary depending on the type of diesel engine used. If SBMTD uses Tier 1 engines, the generators will produce 1,126.03 pounds of NOx, 163.03 pounds of ROCs, 1,387.15 pounds of CO, and 65.28 pounds of PM over a 24-hour period. These emissions are greatly reduced if SBMTD uses Tier 4 engines. Using a Tier 4 engine, the generators will produce 81.60 pounds of NOX, 22.83 pounds of ROCs, 424.30 pounds of CO, and 3.27 pounds of PM over a 24-hour period. It is important to note that these figures assume that the generators will run at full capacity at all times. As a result, these figures likely overestimate the actual emissions. The generators will only be used during grid outages and emergencies meaning that they will not have a long-term impact on air quality. Furthermore, the generators are not located in a disadvantaged community.

Vehicle-to-X Integration

V2X refers to the ability to export power from the vehicle back to the grid, a building, or other load. The main premise of V2X is that the vehicle's battery is an additional source of energy storage. As a result, if the vehicle exports power, it essentially becomes a DER. This feature offers multiple opportunities to provide grid services and additional resiliency. This section will provide an overview of V2X and its potential use cases. It will then provide an overview of the current state of the technology and relevant standards before examining the viability of implementing V2X.

V2X Definition and Use Cases

V2X is an application of vehicle-to-grid integration (VGI). CPUC defines V2G as "the facilitation of flexible charging (and discharging) of an increasing number of EVs in a way that benefits rather than negatively impacts the transmission, generation, and distribution systems (CPUC, n.d.)." EVs can be used as an asset to benefit the grid and provide other benefits to the owner of the vehicle. VGI is split into further subcategories such as V1G, V2G and V2X which are discussed below.

- V1G refers to managed charging, or the use of software to control how and when vehicles are charged. Managed charging is typically used to minimize peak power demand, reduce utility charges, and schedule vehicle charging. Managed charging is widely used by fleets in the EV industry.
- V2G refers to interactions between EVs and the grid. A key functionality of V2G is bi-directional flow of electricity. This feature allows the EV to import electricity while it charges or to discharge the battery and export power to the grid. Typically, a fleet would sell the power it exports to the grid. This feature can be useful for maintaining grid stability during times when demand for power is beginning to outstrip power supply (Norris *et al.*, 2020). There are pathways to implementing V2G in California. As discussed, Rule 21 is the interconnection standard that investor-owned utilities in California use to connect DERs, such as generating or energy storage systems, to the grid. California investor-owned utilities effectively treat V2G as a DER and bi-directional DC chargers that are compliant with Rule 21 are allowed to connect to

and export power to the grid (Vehicle Grid Integration Council, 2021).

- V2X is also another application of VGI. V2X refers to interactions between EVs and other loads. Under V2X, the EV will typically export power to loads such as buildings. This specific use case of V2X is known as vehicle-to-building integration (V2B) and is valuable because the vehicle can be used to offset the electricity that the building draws from the grid. V2X can also be used to facilitate interactions between the EV and DERs or a microgrid. In theory, V2X can even be used to export power to charge other vehicles (Norris *et al*., 2020).

V2X opens new possibilities for providing resiliency. Bi-directional electrical flow effectively allows EVs to be used as backup generators. This is especially true for BEBs and fuel cell electric vehicles (FCEVs), which have large batteries or onboard power generation. V2X is valuable because the BEBs can be used to provide resiliency for their depot. However, since they are mobile, they can also be driven to other sites to export power. This can increase resiliency as the BEBs can be used to provide backup power during grid outages. This is particularly valuable during emergencies as BEBs can be used to export power to critical infrastructure, such as fire stations, emergency shelters, and first responder staging areas. The microgrid can also play a role as it allows the BEBs to be recharged during an emergency. This feature allows BEBs to provide backup power to critical sites during a long-term grid outage or emergency. Figure 18 shows the typical power demand for different critical facilities.

Figure 18. Critical Facility Power Demand (Hanlin *et al.*, 2019)

Type of Facility	Typical Demand*
Emergency shelters/evacuation centers	250 kW**
Emergency operations center	15–25 kW
Police/fire emergency call centers	15–25 kW
Communication infrastructure	35–75 kW
Nursing home	100–200 kW
Transit depots	100–300 kW

*Source: USACE, unless otherwise noted.
**Source: NYCEM.

The government recognizes the potential value that V2X offers. In 2021, the CEC released GFO-21-303. This solicitation funds demonstrations of V2B technologies that allow plug-in electric vehicles to power homes or buildings during grid outages or islanding events.[9] The technology developed and demonstrated under this solicitation could potentially be

[9] More information about this solicitation can be found at: https://www.energy.ca.gov/solicitations/2021-10/gfo-21-303-vehicle-building-technologies-resilient-backup-power

applied to buses and other medium- and heavy-duty vehicles in the future. In 2013, the Federal Transit Administration (FTA) started the Bus Exportable Power Supply (BEPS) program and began to allocate funding to develop and demonstrate a BEPS system. BEPS refers to the export of power from a bus's battery and would be classified as a form of V2X. In 2019, the Center for Transportation and the Environment published a study that was funded through the BEPS program. This report examined the use cases and feasibility of using transit buses to export power and serve as emergency generators (Hanlin *et al*., 2019). In 2021, the FTA issued Notice of Funding Opportunity FTA-2022-005-TRI-SDBEPS Standard Development for Bus Exportable Power Systems.[10] This solicitation was meant for developing BEPS standards and demonstrating a plug-and-play BEPS system. The FTA awarded funding for this program in 2022.[11] The project is still in progress.

The Department of Energy and U.S. Army Corps of Engineers also conducted research on a similar concept. In 2020, the Department of Energy released a solicitation for H2@Rescue Program. This program was used to develop a fuel cell-powered emergency vehicle to provide power to critical facilities during an emergency. The vehicle has a driving range of 180 miles round trip. During an emergency, the vehicle can be driven to a site that needs power. Once on site, the emergency vehicle can export up to 25 kW of power for up to 72 hours. The system has the ability to load follow. The system is installed on a Class 7 box truck and has 176 kg of storage for gaseous hydrogen at a pressure of 700 bar. The H2@Rescue vehicle was tested in West Sacramento in May 2023 (Skaggs, 2023). This project validates the concept and demonstrates the viability of vehicle export systems.

V2X Technology Overview

V2X and BEPS systems require specialized equipment to establish a bi-directional connection and facilitate power export. Charging infrastructure is the base equipment that facilitates VGI and V2X as it connects vehicles to a load or to the grid. However, charging infrastructure, by itself, cannot facilitate VGI or V2X. Implementing this functionality requires additional hardware and software and currently in the United States V2G technology is governed by the Federal Energy Regulatory Commission under Order No. 841.

V1G, or managed charging, is the type of VGI with the least hardware and software needs. V1G requires an EV, EV chargers, advanced metering, and communications technology hardware. However, to effectively implement V1G, software will be needed to control how the hardware is used to charge the vehicles. This software includes telematics systems, route

[10] More information about this funding opportunity can be found at: https://www.transit.dot.gov/notices-funding/standard-development-bus-exportable-power-systems-fy-2021-notice-funding

[11] More information about BEPS can be found here: https://www.transit.dot.gov/funding/grants/BEPS

scheduling software, charging management software, and maintenance tracking software. Telematics systems are useful because they allow fleets to track performance data for the buses. Route scheduling software is required because it allows fleets to know where each individual vehicle is, how much more service it has before its shift ends and predict when each vehicle needs to be charged so it is ready for service. Charging management software is used to coordinate charging so each vehicle has enough charge to complete service and to control when vehicles charge to manage peak power demand. Maintenance tracking is also important, so fleets know when vehicles are not available because of maintenance and when they are likely to be available again. This software ensures that the fleet has the data required to manage charging. Ideally, all of this software will be integrated so it can be easily accessed from one platform and interpreted (Norris *et al*., 2020).

V2G requires additional hardware and software. In addition to the hardware requirements for V1G, V2G and V2X requires a bi-directional inverter. Normal chargers operate in one direction, converting AC current from the grid to DC current. However, this only allows electricity to move from the grid to the vehicle. Bi-directional inverters also allow DC current to be converted back to AC current. This functionality allows electricity to flow from the bus back to the grid and facilitates bi-directional power flow. V2G also requires communications between the vehicle and the grid (Norris *et al*., 2020).

V2X and BEPS have similar requirements as V2G. V2X and BEPS both require an inverter to convert power from DC to AC and allow power to be exported from the bus. However, the architecture for the system might differ from V2G. Under V2G, power export occurs through the charger. V2X generally facilitates power export through the charger. As a result, many V2X systems will have a similar or identical hardware architecture as V2G. The main difference would be the communications software. However, BEPS systems could potentially operate and export power without the use of a charger. Under this architecture, the bus needs to be connected to the facility's electrical room with a cable. The system would also require an inverter to convert DC power to AC power and a transformer to convert the voltage to the facility's voltage. The BEPS system, as tested in the Hanlin *et al.* (2019) study, consists of an external inverter and transformer. However, an onboard BEPS system could potentially be developed (Hanlin *et al.*, 2019).

V2X Standards

V2X requires additional technology beyond that required for regular charging. This additional technology has developed rapidly. As this technology has developed, standards have been established to ensure interoperability. It is important to note that standards for some of this technology are still under development. This section will provide an overview of the standards that have been adopted by industry and standards that still need to be developed.

A key technology for V2X is a bi-directional charger, which requires a bi-directional inverter. This technology facilitates the export of power from the charger to a load or back to the grid. There are two main standards that govern the bi-directional inverter. UL 1741 governs the grid connection of inverters that export to the grid. UL 1741 is typically used for stationary inverters to facilitate the export of power from a DER. UL 9741 is also relevant to V2X. While UL 1741 focuses on the export of power from a stationary inverter, UL 9741 is more specific to bi-directional EV chargers. UL 9741 also differs from UL 1741 in that it governs both export and import of power. These standards are important to ensure that power can be safely exported to the grid (Mafazy, 2022).

Communication with the grid and the charger is also a key aspect of V2X. Communications requires both hardware and software. Standards have been developed to facilitate this. ISO 15118 is a hardware standard for J1772 or CCS charger connectors. The most relevant provision of ISO 15118 is that the charger is equipped with a powerline carrier transceiver to support digital communication between the vehicle and the charger. This functionality is required to support communication with the grid (CEC, 2022).

In addition to hardware standards, communications protocols are also a vital aspect for V2X. Smart charging is a prerequisite for V2X. Smart charging requires communication between the charger and a smart charging network. The industry standard that has emerged for charger-to-network communication is Open Charge Point Protocol (OCPP). The use of OCPP compliant chargers allows multiple types of chargers to be integrated by a smart charging provider. This allows chargers to communicate with each other and the smart charging provider. The use of this standard ensures interoperability between different smart charging providers and chargers (Mafazy, 2022).

There are standards that also facilitate communication between the charger and the utility/grid. This functionality is vital for V2G capability. These standards govern how information is shared between these entities. Open Automated Demand Response (OpenADR) protocol governs communications related to demand response programs. Demand response communications allow utilities to signal when the grid is stressed and when customers can shift load or export power to the grid. To achieve this, OpenADR provides a standard for exchanging information between utilities, demand response aggregators, and the fleet (Mafazy, 2022).

The CEC has played a de facto role in promoting V2X standards. The CEC has made recommendations for which standards should be adopted by industry. The CEC recommended that charging equipment providers manufacture their equipment to comply with ISO 15118 (CEC, 2022). The CEC has also encouraged the adoption of UL 1741. The CEC maintains the Vehicle-to-Grid Equipment List, which contains a list of bi-directional DC charger equipment that is certified to UL 1741.[12] The Vehicle-to-Grid Equipment List is analogous to the Solar Equipment Lists, which includes solar equipment that meets established safety and performance standards. The Solar Equipment Lists are publicly available and are influential as many solar incentive programs prefer to fund equipment that is included on these lists. As a result, by developing the Vehicle-to-Grid Equipment List, the CEC has incentivized industry to adopt UL 1741.

It is important to note that there are some gaps in V2X standards. There are currently no standards for BEPS. However, the FTA aims to fill this gap. The FTA funding opportunity, FTA-2022-005-TRI-SDBEPS, is a solicitation that funds the development of BEPS standards and specifications for BEPS technologies. This project is currently in progress. At the conclusion of this project, it is expected that there will be a fully developed standard for BEPS. The development of standards will help to advance the commercialization of this technology.

In the future SBMTD should look into the V2X and V2G technologies as they become more developed. They can serve as a valuable tool for resiliency, emergency power needs, and financial offset for energy costs.

V2X Limitations

As mentioned earlier, V2G is a relatively new concept that is still evolving, and it will require more time to reach maturity. While V2G integration shows promise, it does come with certain limitations that need to be considered.

Some of these limitations are constraints on V2G equipment and hardware. Battery degradation is one such constraint. The process of discharging and recharging the EV battery for V2G can cause significant wear and tear on the battery, ultimately impacting the overall lifetime of the battery. Utility infrastructure is another constraint. Existing charging infrastructure consists mostly of unidirectional chargers. However, unidirectional chargers cannot support V2G. Instead, bidirectional chargers are required. However, bidirectional chargers have different infrastructure needs. Utility infrastructure adjustments such as the installation of smart meters, advanced meters, bidirectional inverters, and telematics are also necessary to implement V2G technology effectively. Another constraint on V2G is the

[12] The Vehicle-to-Grid Equipment List can be found at: https://v2gel.energy.ca.gov/Home/

capacity of the battery on an EV. Since EVs will presumably be used for transportation, the amount of the battery that can be devoted to exporting power and providing V2G services is limited. Stationary batteries do not face this same constraint and might be a more appropriate solution for exporting larger quantities of energy.

There are also other V2G constraints that are not related to equipment. One constraint is utility rate structures. Utility rate structures have a large impact on the economic viability of V2G because they affect the price that fleets can receive for excess energy. If the utility does not have time-of-use pricing and there are no onsite DERs, the V2G technology might not be economically viable because there would not be an opportunity for energy arbitrage. Furthermore, the utility might introduce a new rate structure in the future, which may reduce the economic viability of this technology. Cybersecurity is also a major concern because V2G is highly dependent on software. Strong measures need to be taken to eliminate cyber vulnerabilities, which can potentially compromise the local V2G system, as well as the wider grid's security. This can potentially result in adverse impacts, such as grid outages.

Shared Public Charging

The City of Santa Barbara has deployed public Level 2 EV chargers to support the growing number of EVs on the road. The City has deployed the chargers in public places such as City-owned parking lots and parking garages. Other public agencies, including SBMTD, have also deployed Level 2 chargers. The public may use these chargers to power their EVs. These public chargers, however, can serve a dual purpose. Public chargers can be called upon as assets by municipal fleets including the City, SBMTD, SBUSD, Santa Barbara County, and SBCAG. The City has occasionally used the public charging stations for midday charging of their vehicles.

Public chargers can also be used as a resiliency measure to protect against grid outages and other disruptions. Since fleets are becoming more reliant on electricity as a fuel, they need a way to charge even if the grid goes down. One resiliency strategy is to use chargers located at a different site than the fleet's depot. This strategy can include using off-site chargers such as public charging stations. This strategy is used to protect against a localized grid outage that only affects a small number of sites within a city. The logic behind this strategy is that multiple sites are unlikely to experience a local grid outage at the same time.

As a result, public charging stations are assets that can be used by municipal fleets. Since there are many Level 2 public charging stations in Santa Barbara, there are potential opportunities for the City, SBMTD, SBUSD, Santa Barbara County, and SBCAG to use these assets for their light- and medium-duty EV fleets. This section will examine the feasibility of using public charging stations as a resiliency measure. In particular, this section will focus on use cases for public charging and potential barriers and limitations.

Public Charging Assets

Multiple public charging assets have been deployed in the City of Santa Barbara. The City of Santa Barbara has installed 50 public Level 2 chargers. The majority of these public chargers are located at various parking lots in the Downtown area, including City Lot 6, City Lot 7, City Lot 11, the Helena Lot, and the Harbor Main Lot. The City sometimes uses these chargers to charge their vehicles. Charging costs $0.20 per kWh from 9:00 pm to 3:59 pm and $0.35 per kWh from 4:00 pm to 8:59 pm. It is important to note that these public stations are Level 2 chargers. As a result, they are not a suitable charging solution for medium- or heavy-duty vehicles.

The City has contracted with a company called Carbon Solutions Group (CSG) to procure, install, operate, and maintain the chargers. The City's agreement with CSG provides the City with priority access to the chargers, particularly in the event of an emergency. The City is undertaking ongoing efforts to identify suitable sites to deploy additional public chargers in the future.

SBMTD has also deployed one public Level 2 charging station in their staff parking lot and intends to install others in the future.

Potential for Shared Public Charging

Public chargers are a potential asset that fleets can use as a resiliency measure to protect against a grid outage. Public chargers have proven to be useful during charging disruptions. For example, during rainstorms in January 2023, SBMTD experienced moderate flooding at their depot near downtown Santa Barbara. This flooding inundated a part of the depot in about 22 inches of water. As a precaution, SBMTD staff deenergized all of its charging assets in that portion of the depot until the equipment could be inspected by the electric utility. SBMTD was able to mitigate this risk by using the public Level 2 charger in its staff parking lot, as well as Level 2 chargers in some of the City's public parking areas. This example demonstrates that public chargers can play a role in addressing grid resiliency challenges.

The City of Santa Barbara is well positioned to use public charging as a resiliency asset during a localized grid outage. The City controls 50 Level 2 public chargers in Santa Barbara. These chargers are intended to help EV owners charge when they are in Downtown Santa Barbara and are located in public parking lots and parking garages. The City's contract with CSG stipulates that the chargers be open access. However, there are provisions in the contract that provides avenues through which the City's municipal fleet can use the assets. In the event of an emergency, the City can take over the chargers.

After the flooding on their depot, SBMTD is also interested in using shared public charging to protect against localized grid outages or other disruptions to their charging operations. However, SBMTD faces more barriers to using public chargers than the City. While SBMTD desires to use Level 3 (DCFC) public charging assets as a resiliency measure for its battery-electric bus fleet, such chargers are not included in the City's current inventory of public charging assets. Thus, SBMTD would only be able to use the existing Level 2 public chargers for its fleet of electric cars and passenger vans. Ideally, 25 publicly-available DCFC ports would likely be sufficient for this element of SBMTD's resiliency measures.

SBMTD is constrained because it only owns one public Level 2 charger. Given that SBMTD has 14 electric cars and plans to deploy up to six electric passenger vans, this one public charger is not sufficient for SBMTD's needs. Furthermore, since they control so few public chargers, they cannot offer much charging capacity to other fleets that need power during an outage. As a result, SBMTD will need access to other public chargers.

SBMTD's best prospect for accessing public charging would be to negotiate an agreement to use the City's public charging network. The City's contract with CSG allows the City to take control of the chargers during an emergency. However, in conversations with the City, it was found that this power is exclusive to the City and does not extend to other public entities like SBMTD. SBMTD would need to negotiate access to the public chargers through the City's existing contract or a standalone contract with CSG.

There are several factors that would need to be taken into consideration in such an agreement. The first factor is the open access requirements in the City's contract with CSG. This clause guarantees public access to the chargers. This clause, however, can come into conflict with SBMTD's access to chargers during an emergency. If an emergency occurs, it is likely that some of the public chargers will be occupied by private vehicles. This is problematic because this would prevent SBMTD from using the chargers during the emergency. Attempts to address this, such as stopping charging for these vehicles during an emergency, may be difficult as prioritizing SBMTD fleet vehicles might violate the open access requirements of the current contract.

Charger reliability is also a potential hurdle to using public charging. Recent studies indicate that charger reliability is a major problem for public charging in general (Zukowski, 2023). This is a major challenge because if a charger is experiencing downtime during an emergency, it cannot be used to mitigate this risk. The owner of the chargers might try to negotiate uptime requirements in their charger maintenance service contracts; however, due to supply chain problems with replacement parts for chargers, contractors are oftentimes unwilling to agree to such terms. Despite this, the City's public chargers have historically been reliable, with 97-98% uptime. The main charger downtime has been caused by broken charging heads, which have to be replaced every few years. There were some reliability problems that resulted from switching the charger from operating on the 4G network to the 5G network. However, these issues were quickly resolved and are not expected to occur again.

The last barrier to shared charging is physical access to the charger. Public charging stations are generally designed for EVs. However, many public charging stations are not compatible with other types of vehicles like medium- or heavy-duty vehicles. This is problematic because in addition to charging their EV car fleet, SBMTD would also like to have the option of charging their electric transit vans at public charging stations. There are several factors that can cause this incompatibility. One factor is the parking layout. EV cars are smaller than medium- and heavy-duty vehicles and typically have smaller parking spaces. Thus, it would be difficult or in some cases infeasible to park a medium- or heavy-duty vehicle in a traditional EV stall because it is physically too small to accommodate the larger vehicle. A related factor is accessibility to the EV charging station. Many EV charging stations are located in parking garages. Unlike cars, which can easily enter and exit the parking garage, many medium- and heavy-duty vehicles cannot physically fit into the entrance of the parking garage, which would prevent access to the charger. The foregoing factors would prevent SBMTD from charging their electric transit vans at public charging stations.

SBMTD estimates that they would need access to a minimum of four or five public charging stations to provide resiliency in the event of an emergency. To get access to these chargers, SBMTD will need to negotiate emergency access to public charging stations with CSG directly or through the City. SBMTD will need to negotiate access to specific charging stations to ensure that they have access to stations that are physically compatible with their vehicles. While this is not a problem for their light-duty EVs, it is a critical consideration for their electric transit vans. The stations to which they negotiate access should be located in an outdoor parking lot to ensure that they can physically access them. SBMTD should also negotiate access to stations with larger parking spaces to accommodate the electric transit vans.

Next Steps

Public charging stations are a valuable resource that can be used by municipal fleets to provide resiliency. Despite the value that public charging stations can offer, there are only a couple of municipal fleets that can use them in the Santa Barbara area. The City has many light-duty EVs that can potentially use the chargers in the event of an outage. SBMTD also has light-duty EVs and transit vans that can use the chargers.

It is important to note that, at the time of writing, there are only about 50 Level 2 public charging stations that are controlled by the City. As the City and SBMTD continue to electrify their fleets, these public charging stations will become even more critical resiliency assets. Moreover, as the aforementioned public agencies deploy more medium- and heavy-duty electric vehicles, it will be essential to have back-up DCFCs in the area. As private operators begin to electrify their medium- and heavy-duty fleets, demand for public DCFCs will increase. The preceding will improve the business case for adding such chargers to the City's portfolio of public charging assets. Efforts should be taken to increase the number of public chargers to meet potential demand from the City and SBMTD. Doing so will help both agencies achieve their respective resiliency goals.

Stakeholder Outreach

To support this project, the City of Santa Barbara conducted outreach with local stakeholders. This outreach was intended to inform the stakeholders about the project, understand how the project will affect the community, and identify possible opportunities for collaboration. Outreach was also conducted with utilities and local governmental agencies to understand how EV infrastructure will be regulated. The results of this outreach are described in this section.

Utilities

Santa Barbara Metropolitan Transit District (SBMTD) staff met with three local utilities, SCE, SBCE, and Central Coast Community Energy (3CE). The purpose of the meetings was to discuss SBMTD's ongoing fleet electrification projects, potential programs and tariff structures offered by the utilities related to transportation electrification, and opportunities for partnership between SBMTD and the utilities so each may help to advance the others' electrification goals. The meeting with each utility lasted for approximately one hour and the representatives from SBMTD and the utilities agreed to maintain an open line of communication to provide relevant updates as each entity advances its transportation electrification initiatives. The following sections summarize the key discussion points, takeaways, and implications of these discussions.

Southern California Edison

The City of Santa Barbara conducted outreach with SCE to learn more about the CRT program. SBMTD's first foray into Charge Ready was in 2018 with the CRT pilot. SBMTD was one of a handful of transit properties considered because of its long track record of successfully operating and maintaining EV technology. While SBMTD's proposed project was ultimately deemed ineligible because the electric vehicle supply equipment (EVSE) did not meet program requirements at the time, it galvanized SBMTD's focus on pursuing Charge Ready to advance SBMTD's EV charging infrastructure. SBMTD continued to work with SCE staff to develop viable Charge Ready projects, resulting in one that enabled the installation of 14 light-duty EV chargers at SBMTD's Terminal 1 facility (Figure 32) and another that enabled the installation of 14 heavy-duty EV chargers at the same facility.

The heavy-duty Charge Ready project, provided under the Charge Ready Transport program, resulted in infrastructure for 14 battery-electric buses (BEBs). The project included the replacement of an existing transformer with a significantly larger one, new switchgear and metering, above and below ground conduit and associated trenching, and disconnect switches at each charger location. The work also included flood mitigation measures to meet FEMA flood plain requirements at MTD's site.

While SBMTD has previous experience with deploying chargers through CRT, it was unclear how this would affect the integration of solar PV, BESS, and a back-up generator with the charging infrastructure previously funded by CRT. The results of this engagement are detailed in the Utility Microgrid Regulations section.

Key takeaways include:

- SCE's CRT program offers rebates for charging infrastructure and equipment.
- The CRT program offers two options, SCE-Built or Customer-Built.
- For future CRT projects, SBMTD should pursue the Customer-Built option because it does not restrict the addition of DERs.
- While the Charge Ready Program is advantageous, SBMTD needs to be aware of potential risks like clawbacks if the number of vehicles agreed upon are not deployed within the 10-year agreement, as well as granting property easements to SCE.

Santa Barbara Clean Energy

The recently started SBCE Program is a Community Choice Aggregator (CCA), which allows the City to choose an energy portfolio and set rates. This tool gives authority to the City to set rates and power content while the investor-owned utility, SCE, continues to own and operate the electrical grid. As a new utility provider, the SBCE Program will continue to build reserves for the next couple of years but began service in winter/spring 2022.

Customers in Santa Barbara are automatically enrolled (opted-in) with 100% clean energy and must opt out if they do not wish to participate. Electrical rates have the same structure as SCE rates, including demand charges and time-of-use (TOU) rates. However, they are generally less expensive than SCE rates. Clean energy rates are more expensive than regular grid power and 100% clean energy is about 1.4 cents more expensive than standard SCE rates.

Discussions with SBCE indicated that opting down from the 100% clean energy portfolio does not bring many advantages except for a less expensive rate. If SBMTD opted-down, it would need to wait a year to 'opt-up.' Moreover, unlike SCE with the CRT program, SBCE indicated that they are unlikely to offer similar incentive programs.

Key takeaways include:

- SBCE is the CCA for the City of Santa Barbara and is the electric utility for SBMTD at Terminal 1.
- SBMTD is currently a customer of SBCE.
- SBMTD could explore using the 100% clean energy rate together with low carbon fuel standard (LCFS) credits to reduce the cost of electricity as fuel.
- SBCE has TOU EV rate structures similar to SCE.
- SBCE is unlikely to offer infrastructure rebates and incentives; SBMTD will need to continue leveraging grants, funding, and programs like SCE's Charge Ready program for infrastructure and equipment.
- SBCE indicated a willingness to work with SBMTD to discuss rates and rate structure to better accommodate transit operations.

Central Coast Community Energy

The Central Coast Community Energy (3CE or CCCE), formerly known as Monterey Bay Community Power, is the CCA for local communities to source clean and renewable electricity for Monterey, San Benito, and Santa Cruz counties and now parts of San Luis Obispo and Santa Barbara counties. 3CE has taken over SCE's role of delivering power and maintaining electric infrastructure as well as billing. 3CE is SBMTD's electric utility at its Terminal 2 yard in Goleta.

Similar to Santa Barbara Clean Energy, 3CE offers two key products—3Cchoice, which is electricity from ~30% renewable sources, and 3Cprime, which is electricity from 100% renewable sources. Rate structures again are similar to SCE with TOU EV structures, but 3CE rates are generally less expensive than SCE rates.

Due to 3CE being a CCA and using rate payer dollars for programs, 3CE has a large degree of discretion for developing programs and incentives to help agencies and residents in the transition to EVs. For example, 3CE currently operates the "Electrify Your Ride" program for incentives for chargers and installing chargers with up to $8,000 per project. In the past, 3CE offered school bus rebates of $200,000 per bus or up to 50%, which was stackable with other programs like HVIP to further incentivize conversion to electric school buses.

Key takeaways include:

- 3CE is the CCA for parts of Santa Barbara County, including Goleta where SBMTD's Terminal 2 is located.

- 3CE offers lower electricity rates than SCE as well as different products with different power content, including 100% renewable energy.
- 3CE is interested in working with SBMTD to develop programs that would financially aid SBMTD's conversion to ZEBs, including rebates for equipment and infrastructure, as well as vehicles.
- SBMTD should work with 3CE and monitor 3CE's website for programs that could be leveraged to reduce capital expenditures and that could be stackable with grants and other programs like Charge Ready. Indeed, EV infrastructure at Terminal 2 could potentially benefit not only from Charge Ready, but potential programs from 3CE as well.

Local Jurisdictions and Planning Organizations

The City of Santa Barbara permitting passes through Planning review for discretionary and zoning review and then Building and Safety for building code review. Solar PV generations systems, including associated battery energy storage systems (BESS), and electric vehicle supply equipment (EVSE), otherwise known as EV chargers, pass through this same permitting process. Common permitting barriers to project development can be:

- Lengthy design review process and approvals, delaying project deployment
- Lengthy building code permitting approvals, delaying project deployment
- Extensive design review changes/requirements, adding significant expense to project
- Expensive permitting fees
- Lengthy interconnection and final electrical plan approvals and final energization waits from IOU's, delaying project deployment

Solar

Previous California legislation helped the permitting process for solar systems, such as the Solar Rights Act (1978 and 2015 revision) and SB 226 (2011). California's Renewable Portfolio Standard has helped California become the nation's largest solar producer, with millions of distributed small-scale solar generation systems installed over the past 20 years. The City of Santa Barbara developed and published Solar Energy Design Guidelines and Solar Recognition Program in 2006 to aid in the adoption and permitting process of solar systems and encourage local generation. AB 2188 (2014) required streamlined permitting for small systems (<10kW), which the City complied with in 2015 with a streamlined solar checklist and permit process and added municipal code 22.91 outlining the streamlined process.

Neighboring jurisdictions, including Santa Barbara County and Goleta, instituted similar measures. The Building Permit office further reduced permitting barriers by instituting On-Demand-Permitting for small scale solar systems, solar and BESS, and added BESS to an existing system in 2021 and 2022 reducing permit wait times from two to three weeks to five minutes.

Despite the extensive legislation from 2006 to 2019, larger systems in Santa Barbara still required a lengthy Planning permit process, including discretionary review, hampering cost-effective deployment of larger systems within the City. In 2019, the City started a process to install a microgrid with a one-megawatt solar system with associated BESS on top of a parking garage but spent over two years attempting to comply with extensive aesthetic comments from a discretionary review board. This included requirements to add aesthetic columns and trellis details causing significant delays and considerable added design and construction expense, jeopardizing the viability of the project.

After implementing the On-Demand-Permitting for solar and battery systems, City inspections saw an increase in install errors, due to no formal plan review of initial designs, which also resulted in more staff time and re-inspections, frustrating both installers and taxing City staff. In the summer of 2022 (June 15), the City hosted a regional Solar PV and battery storage design and install training webinar in combination with the County and the Tri-County Regional Energy Network (3C-REN) to alleviate common mistakes in the process. The webinar is available on-demand at 3C-REN.

AB 1124 (2021) has all but removed expanded solar system definitions and restricted discretionary review. This legislation, taking effect in 2022, greatly reduced these barriers to solar and microgrid development in the City for large and smaller systems alike. City staff had several internal workgroup meetings and memos to plan on how best to revise the planning and zoning approval process to incorporate these changes. Since the City's municipal codes have aesthetic and safety elements intermixed, there were many discussions around what should be excluded from discretionary review. The legislation also further limited solar permitting fees allowed, removing additional potential barriers to the permitting process, although the City had not previously imposed restrictive solar permitting fees.

EV Charger

Electric vehicle charger (or EVSE) installation has seen similar permitting challenges. AB 1236 (2015) and AB 970 (2021), like AB 2188 for solar, required a streamlined permitting process for EVSE. Similar to solar, the City developed a streamlined EVSE checklist and permit process, and added municipal code sections for one and two family residential EVSE installs. The streamlined process allows small residential chargers to be permitted quickly and easily, and a new On-Demand-Permitting process went into effect in November 2023, further reducing barriers to EV adoption. However, like solar systems, larger scale and commercial EVSE have encountered delays and cost increases primarily due to discretionary review.

Like solar, AB 970 (2021) expanded the definition of EVSE, prohibited discretionary review and mandated specific timeframes for expedited reviews. This has greatly reduced the remaining barriers to the permitting process for commercial EVSE.

The City has permitted and installed over 50 public EV chargers over the past 10 years, including 20 in 2022 at the downtown Granada Garage, and instituted EV commuter and EV 24/7 parking permit pilots to encourage EV adoption and use.

Ongoing Efforts

While solar PV, BESS, and EVSE permitting barriers in the City of Santa Barbara have all but been eliminated at the local level, there are still areas of opportunity to reduce planning and permitting processes. The City is in the process of revising its outdated solar design guidelines and creating new EVSE guidelines. Additional opportunities exist to reduce the interconnection and energizing process timelines by the California Public Utilities Commission (CPUC) and local investor-owned utility, Southern California Edison.

CBOs, Community Leaders, and Residents

The update to the City of Santa Barbara's Climate Action Plan (CAP) included staff development of an outreach campaign called "Together to Zero." The campaign included targeted brainstorming sessions with regional community-based organizations (CBOs), community leaders, and residents to share information on planning efforts and gather feedback on key issues. Transportation decarbonization, one of the three pillars of the CAP, was a key focus, and ZEV adoption and use was a central component of these efforts. Information and data from this effort was used in developing and evaluating potential measures to be included in the City's draft and final CAP.

In parallel to the CAP planning, the City's Fleet and Energy and Climate divisions developed a Zero-Emission Vehicle Acquisition Policy to help the City formalize its role in leading the effort for vehicle decarbonization. This effort included an extensive planning partnership analyzing City fleet data as well as developing best practices to decarbonize the City's fleet swiftly and economically, while still providing a high level of service. In late fall 2022, a proposal was presented to the City's Fleet Advisory Committee and Budget Steering Committee and overview of the proposed policy and planned support mechanisms.

- CAP Brainstorming sessions
- CAP development outreach
- Vehicle Acquisition Policy development

Regional Workplaces, Business Owners, and Operators

One particularly difficult sector to encourage installation of EV charging has been the small- to medium-sized multifamily sectors due to the owners' lack of payback for the investment and limited capacity to plan capital improvement projects. City staff engaged the Santa Barbara Rental Property Association to write an article describing the benefits of multifamily building owners to offer EV charging as well as leverage available incentives. This education and outreach were also intended to support the subsequent local training presentation describing SCE's multifamily Charge Ready program. For this subsequent training, the City partnered and co-hosted a webinar with Electric Drive 805 and Community Environmental Council, two regional advocacy groups, as well as Ventura County Regional Energy Alliance and SCE to promote multifamily EV charger deployment and SCE's Charger Ready Multifamily EVSE incentive program which specifically addressed these barriers all along the central coast. Additional information was provided for the California Solar on Multifamily Affordable Housing (SOMAH) program for subsidizing solar on low-income properties, including multifamily and the multifamily program of 3C-REN.

The City Sustainability Committee provides updates on citywide sustainability efforts, as well as feedback and direction from council members and the public on these efforts. A presentation was provided by City staff in October 2021 with updates on City fleet electrification and EV market. Feedback was overwhelmingly in support of expanding public access to EV charging to support citywide and regional transportation decarbonization efforts. There was also feedback on how to consider equity in the location of public EV chargers, and direction to further consider curbside charging as a potential solution.

SBMTD Employees

MTD conducted a brief survey of employees about EVs to gauge interest in personal EV ownership, and to learn whether access to charging on MTD's light-duty EV chargers would influence the likelihood of EV adoption for their personal vehicles. This survey was conducted from August 27, 2020 to September 18, 2020 electronically and in hard copy format. Sixty of MTD's 197 employees responded to the survey. Only four respondents currently own or lease an electric vehicle and all of these employees say that the single public EV charger in MTD's public parking lot is "sometimes" available when they want to charge. 100% of EV owners said it would make charging easier if they could use the bank of 14 light duty chargers in MTD's Terminal 1 yard, paying to charge through their own personal ChargePoint accounts.

MTD acquired a fleet of electric 2020 Chevy Bolt vehicles to be used for light-duty nonrevenue service. Of the employees surveyed who had driven the new Bolts, when asked if having driven the new Bolts made them more or less likely to want to own or lease an EV for personal use, 57% said that it made them very likely (34%) or likely (23%) to want to own or lease one in the future. Only 5% were unlikely or very unlikely. The rest of respondents said they were neither likely nor unlikely.

42% of respondents without an EV today said they are likely or very likely to own or lease an electric vehicle in the next five years. 28% were unlikely or very unlikely, while 30% were neutral. This means that 72% of non-EV owning employees are open to EV adoption in the next five years. When asked if being able to charge their personal EV on MTD's light-duty chargers with their own ChargePoint account would make them more likely to acquire an EV, 63% said that it would.

The results of this survey demonstrate an openness among a majority of the MTD employees who completed the survey to adopt EV technology for their own personal transportation. When offered the convenience of charging at MTD's Terminal 1, even at their own expense, a supermajority of those employees said they would be more likely to own or lease an EV, or for those who already own or lease, it would make it easier for them to charge their vehicle.

Public Workshops

The City hosted a CAP stakeholder outreach as part of a broader 'Together to Zero' campaign to bring together the community to reach the goal of carbon neutrality by 2035 as Santa Barbara City Council has set. Information was hosted on the City website and advertised in the City's 'News in Brief' weekly newsletter to engage residents and stakeholders as well as gather feedback. Engagement activities included a survey to gather information about climate action planning from the public, listening sessions, and climate chats.

- Stakeholder workshops
- Listening sessions
- Climate chats

Theme-based Stakeholder Workshops

During summer 2021, the City presented at the regional Gold Coast Fleet annual meeting, comprised of fleet directors and managers of local governments all along the central coast. The presentation described current trends, traditional barriers to adoption, and special considerations for municipal fleet electrification. The meeting also gathered feedback from local fleet managers on best practices and barriers to ZEV procurement, vehicle selection, cost, and behavioral change needed for an effective ZEV transition.

In spring 2022, the City presented at the regional chapter of the American Public Works Association (APWA), comprised of directors and managers of publics works departments of local governments all along the Central Coast on municipal fleet electrification. The presentation described current trends, traditional barriers to adoption, and special considerations and similarly sparked a regional discussion on best practices.

- Gold Coast presentation
- APWA presentation

Workforce and Educational Outreach

The Santa Barbara County Workforce Development Board and a broad range of educational institutions have expressed interest in engaging with the Blueprint project and any projects that result from it in the future. The region is home to Santa Barbara City College (SBCC) and the University of California, Santa Barbara (UCSB), a world-class research university. Academics and staff at both institutions have committed to participating in various ways, to provide real-world, hands-on learning and research opportunities for students. These entities include: UCSB Office of Sustainability, UCSB Bren School of Environmental Management, UCSB Electrical and Computer Engineering Department, UCSB Geography Department, and SBCC Environmental Studies Program.

Conferences

The blueprint was also presented at conferences. These conferences include the International Conference on Transportation and Development 2022 and the Battery Show North America.

Conclusion

The City of Santa Barbara aims to combat climate change by transitioning to renewable energy and adopting ZEVs. To support this objective, the City has enacted a series of policies and adopted action plans to reduce emissions. While there is strong interest in transitioning to ZEVs, SBMTD stands out as an early adopter. SBMTD's decision to adopt ZEBs was encouraged by the enactment of the ICT regulation, which mandates that transit agencies transition to zero-emission by 2040, and government funding for making this transition. While SBMTD aims to transition to ZEBs, resiliency stands out as a major challenge. The entire Goleta Load Pocket is served by only one transmission line, which traverses an area that is prone to natural disasters. As a result, an extended power outage during an emergency is a very real threat. To mitigate this threat, SBMTD will need to deploy resiliency measures.

SBMTD worked with CALSTART to analyze resiliency measures that can be deployed. CALSTART worked with Anser Advisory to examine the techno-economic feasibility of deploying a microgrid at SBMTD's Terminal 1 depot. CALSTART also carried out initial analysis on microgrid sizing at SBMTD's Terminal 2 depot. CALSTART and Anser Advisory found that Terminal 1 would be best served by two microgrids. Microgrid 1 at Terminal 1 is designed to include 641 kW of solar panels, a 650 kW/2,610 kWh BESS, and a 1,500 kW generator. Microgrid 2 at Terminal 1 is designed to include 320 kW of solar panels, a 640/1,280 kWh BESS, and an 800 kW generator. These microgrids are designed to provide backup power for at least 24 hours but can meet load requirements as long as it has access to renewable diesel fuel. CALSTART also analyzed microgrid sizing for Terminal 2. CALSTART sized the Terminal 2 microgrid for 250 kW of solar panels, 1,749 kWh of BESS, and an 800 kW generator.

The buildout of the microgrids at Terminal 1 is expected to cost approximately $12.26 million. However, it will save approximately $488,184 per year in utility cost savings. The construction of the microgrid will also create jobs for the local community. The microgrid will also displace grid power and replace it with locally generated renewable energy. This will increase the renewable content of the energy used by the buses and reduce GHG emissions.

In addition to the microgrid, there are other resiliency measures that can be taken. V2X refers to the export of power from the bus to another load. A bus with V2X capability can charge from the microgrid and export power to critical facilities during an outage, thereby turning the ZEBs into resiliency assets. It is important to note that this technology is still being developed. Public chargers can also be used as a resiliency measure. The City of Santa Barbara has deployed multiple public chargers throughout the City. These chargers can potentially be used as a resiliency measure. This method is useful for cases where SBMTD experiences a localized outage at its charging facilities, but power remains intact in other places throughout the City. In such a scenario, SBMTD can charge their vehicles at public chargers in lieu of their own depot. While this is an option, public chargers in Santa Barbara are Level 2 chargers. As a result, they are only an appropriate solution for SBMTD's EVs and transit vans. SBMTD would require public MHD chargers to serve their ZEBs.

SBMTD has multiple resiliency measures that they can deploy. The microgrid would be the most valuable resiliency asset because it will protect their fleet even in the event of a lengthy regional grid outage. It can also provide financial, economic, and environmental benefits. CALSTART found that the microgrid is technologically feasible. SBMTD can pursue grant funding opportunities to build the microgrid. SBMTD can also use other funding programs, such as EnergIIZE and Low Carbon Fuel Standard credits, to offset some of the costs.

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