California Energy Commission

Clean Transportation Program

FINAL PROJECT REPORT

Santa Barbara Zero-Emission Resilient Transportation Blueprint

A Microgrid Design for Santa Barbara Metropolitan Transit District

Prepared for: California Energy Commission

Prepared by: CALSTART on behalf of Santa Barbara Metropolitan Transit District (SBMTD)

January 2025 | CEC-600-2025-001

California Energy Commission

Bryan Lee
Aditya Kushwah
Mike Hynes
Brian Ballschmidt
Primary Author(s)

CALSTART, Inc.
48 South Chester Ave.
Pasadena, CA 91106
Calstart.org

Ryan Gripp
Steve Maas

Project Manager(s)

Santa Barbara Metropolitan Transit District
550 Olive Street
Santa Barbara, CA 93101

Agreement Number: ARV-21-020

Esther Odufuwa
Commission Agreement Manager

Elizabeth John
Branch Manager
COMMERCIAL AND INDUSTRIAL ZEV TECHNOLOGIES AND INFRASTRUCTURE BRANCH

Hannon Rasool
Director
FUELS AND TRANSPORTATION

Drew Bohan
Executive Director

DISCLAIMER

This report was prepared as the result of work sponsored by the California Energy Commission (CEC). It does not necessarily represent the views of the CEC, its employees, or the State of California. The CEC, the State of California, its employees, contractors, and subcontractors make no warrant, express or implied, and assume no legal liability for the information in this report; nor does any party represent that the use of this information will not infringe upon privately owned rights. This report has not been approved or disapproved by the CEC nor has the CEC passed upon the accuracy or adequacy of the information in this report.

ACKNOWLEDGEMENTS

The authors would like to thank the following individuals from various organizations for their contributions to this study.

<u>Santa Barbara Metropolitan Transit District</u>

Jerry Estrada

Hillary Blackerby

<u>Anser Advisory</u>

Steven Clark

David Lazerwitz

Danielle Nelson

<u>City of Santa Barbara</u>

Alelia Parenteau

Kristian Hoffland

<u>Stantec</u>

Will Todd

Analy Castillo

<u>CALSTART</u>

Justin Slosky

Susan Cavan

PREFACE

Assembly Bill 118 (Núñez, Chapter 750, Statutes of 2007) created the Clean Transportation Program. The statute authorizes the California Energy Commission (CEC) to develop and deploy alternative and renewable fuels and advanced transportation technologies to help attain the state's climate change policies. Assembly Bill 8 (Perea, Chapter 401, Statutes of 2013) reauthorizes the Clean Transportation Program through January 1, 2024, and specifies that the CEC allocate up to $20 million per year (or up to 20 percent of each fiscal year's funds) in funding for hydrogen station development until at least 100 stations are operational.

The Clean Transportation Program has an annual budget of about $100 million and provides financial support for projects that:

- Reduce California's use and dependence on petroleum transportation fuels and increase the use of alternative and renewable fuels and advanced vehicle technologies.
- Produce sustainable alternative and renewable low-carbon fuels in California.
- Expand alternative fueling infrastructure and fueling stations.
- Improve the efficiency, performance, and market viability of alternative light-, medium-, and heavy-duty vehicle technologies.
- Expand the alternative fueling infrastructure available to existing fleets, public transit, and transportation corridors.
- Establish workforce-training programs and conduct public outreach on the benefits of alternative transportation fuels and vehicle technologies.

To be eligible for funding under the Clean Transportation Program, a project must be consistent with the CEC's annual Clean Transportation Program Investment Plan Update. The CEC issued GFO-20-601 to accelerate the deployment of medium- and heavy-duty vehicle (MDHD) zero-emission vehicles (ZEVs) and ZEV infrastructure with a holistic and futuristic view of transportation planning. In response to GFO-20-601, the recipient submitted an application which the CEC proposed for funding in their notice of proposed awards on April 8, 2021 and executed the agreement as ARV-21-020 on August 11, 2021.

ABSTRACT

Santa Barbara Metropolitan Transit District is an early adopter of electric buses and has a Board of Directors goal to convert its fleet to 100% zero-emission by 2030, and a State of California mandate to do so by 2040. However, electric buses are dependent on the utility grid because they use electricity directly as a fuel. If there is a lengthy grid outage, the buses cannot charge, which effectively disables the fleet. This would be a major problem for Santa Barbara Metropolitan Transit District, because the Santa Barbara area is vulnerable to grid outages due to its reliance on a single set of transmission lines that traverse terrain that has high natural disaster risk. To mitigate this threat, Santa Barbara Metropolitan Transit District aims to deploy a microgrid. A microgrid is a local grid that uses DERs including 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. 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 manages this feature. 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, are not microgrids. Microgrids can play a key role in electric vehicle fleet resiliency by supplying power to charging assets during grid power outages. This project investigated the techno-economic feasibility of a microgrid and other resiliency measures to support Santa Barbara Metropolitan Transit District's electric bus deployments. This study found that microgrids are technologically and economically feasible.

Keywords: Microgrid, Distributed Energy Resource, Resiliency, Electric Bus, Transit

Please use the following citation for this report:

Lee, Bryan, Aditya Kushwah, Mike Hynes, and Brian Ballschmidt. 2023. *Santa Barbara Zero-Emission Resilient Transportation Blueprint*. California Energy Commission. Publication Number: CEC-600-2025-001.

TABLE OF CONTENTS

Page

LIST OF FIGURES

LIST OF TABLES

EXECUTIVE SUMMARY

Santa Barbara Metropolitan Transit District (SBMTD) is an early adopter of electric buses and has a Board goal to convert its fleet to 100% zero-emission by 2030, and a State of California mandate to do so by 2040. However, electric buses are dependent on the utility grid because they use electricity directly as a fuel. If there is a lengthy grid outage, the buses cannot charge, which effectively disables the fleet. This would be a major problem for SBMTD because the Santa Barbara area is vulnerable to grid outages. To respond to this risk, SBMTD aims to deploy a microgrid to protect against a grid outage. SBMTD received funding from the California Energy Commission under solicitation GFO-20-601 to investigate the techno-economic feasibility of deploying a microgrid at their Terminal 1 depot near downtown Santa Barbara. SBMTD partnered with CALSTART and the City of Santa Barbara for this project.

Technology and System Analysis

CALSTART collaborated with SBMTD to develop a microgrid design for the Terminal 1 depot. CALSTART evaluated the charging load for the electric buses and gathered historical data on grid outages at the site. CALSTART and SBMTD then developed operational parameters that the microgrid must meet. CALSTART also investigated regulatory constraints on the microgrid from the government and the utility, as well as space and site constraints. Based on these inputs, the project team collaborated with Anser Advisory to size the microgrid components and develop a conceptual design. Anser Advisory identified site constraints that could affect the microgrid design. One factor is that there are multiple meters onsite. Anser Advisory also aimed to minimize trenching to avoid disturbing known contaminated soils at the site. Because SBMTD plans to transition their fleet to zero-emission over time, phasing in the microgrid as the electric bus fleet grows was an important consideration.

Anser Advisory determined that SBMTD should deploy two separate microgrids, attached to separate meters. Anser Advisory conducted energy modeling to identify how to best meet the charging load with distributed energy resources. Based on this modeling, Anser Advisory determined that Microgrid 1 should incorporate 641 kW of solar panels, a 650 kW/2,610 kWh battery energy storage system (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. SBMTD plans to deploy the two microgrids in three phases.

Replicability White Paper

CALSTART developed a microgrid replicability white paper that outlined the lessons learned and steps for deploying resiliency assets. The objective of this white paper is to share these lessons with other transit agencies that would like to deploy resiliency assets.

During the study, CALSTART investigated the possibility of using public charging infrastructure as a resiliency asset during a localized grid outage at the Terminal 1 depot. CALSTART held interviews with the City of Santa Barbara, which owns multiple public chargers in the city. Santa Barbara contracts the operations and maintenance of public chargers to a third-party company and negotiated access to the chargers during emergencies. Since SBMTD is a separate entity from the City, they would have to negotiate separate emergency access to the chargers. A key consideration for using public chargers as a resiliency resource is physical access. Most public charger designs are for use with light-duty electric vehicles and cannot accommodate medium- or heavy-duty (MDHD) vehicles. As a result, to be useful, public chargers need to have a large enough parking spot and a parking configuration that is compatible with MDHDs. Furthermore, most public chargers are Level 2 chargers. While they can charge medium-duty transit vans and cutaway buses, transit buses use direct current (DC) fast chargers. Until the deployment of more DC fast chargers, public chargers will be of limited use to transit agencies.

CALSTART also outlined the steps required to develop a design for a microgrid and the role that each stakeholder plays in this process.

Economic Analysis

CALSTART investigated the economic benefits of the microgrid. This report estimates that the microgrids will have a capital cost of approximately $12.26 million. During normal operations, the microgrids can produce electricity and offset power drawn from the grid. This displacement of grid power will reduce utility costs. SBMTD expects to save approximately $488,000 per year in utility bills, which is a 21% reduction. The report estimates that the microgrids will support jobs, primarily during their construction. The jobs include 32 direct jobs, 19.6 indirect jobs, and 34.8 induced jobs. The resiliency provided by the microgrid also has an economic value, as it prevents disruptions to public transit service. The estimated value of the resiliency is approximately $229,399 for each 24-hour grid outage.

Emissions Reductions

The microgrids at Terminal 1 will produce significant greenhouse gas (GHG) emissions reductions. The microgrids will produce emissions reductions under both blue sky and black sky conditions. Under blue sky conditions, the microgrids will reduce GHG emissions by replacing grid power with fully renewable energy. The report estimates that the microgrids will displace about 24.2% of grid power. The GHG emissions displaced by the microgrid depends on the carbon intensity of the grid power used. SBMTD has several options for purchasing power:

- Southern California Edison (SCE) Option: 31.4% renewable content
- Santa Barbara Clean Energy (SBCE) Green Start: 65.7% renewable content
- SBCE 100% Green: 100% renewable content

If SBMTD uses the SCE Option 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. If SBMTD uses the 100% Green Option, there will be no further GHG emissions reductions since the grid power is already fully renewable. These reductions are separate from the GHG emissions savings that occur by switching from diesel-powered buses to electric buses.

Public transit reduces emissions by decreasing the number of car trips and associated vehicle miles traveled (VMT). In the absence of the microgrids, black sky conditions will effectively disable SBMTD's electric buses. Under this scenario, SBMTD's riders will likely use alternative forms of transportation, such as passenger cars or rideshare services, which will increase VMT and cause an increase in emissions. By preventing disruptions to public transit, the microgrid will effectively eliminate these emissions. CALSTART estimates that the net GHG emissions reductions during black sky events will be 24.15 metric tonnes per 24-hour grid outage.

Community Outreach and Engagement

The City of Santa Barbara conducted outreach with local stakeholders to support this project. This outreach informed the stakeholders about the project, helped stakeholders to understand how the project will affect the community, and identified possible opportunities for collaboration.

The City conducted outreach with the City permitting department, regional workplaces, and business owners. SBMTD conducted outreach with utilities, governmental stakeholders in the Central Coast region, and workforce and educational institutions. The City also conducted outreach directly to the public. The public outreach activities included engagement with community-based organizations, and public workshops. CALSTART also presented about the microgrid design at industry conferences.

Blueprint Report

CALSTART developed a Blueprint Report summarizing the results from this project. The Blueprint Report provided an overview of the local municipal regulatory environment that is driving the transition to zero-emission vehicles. The Blueprint Report also outlined the methodology and results for the microgrid analysis. Additionally, the Blueprint Report discussed other resiliency technologies such as vehicle-to-X (V2X).

Lessons Learned and Next Steps

This study uncovered several lessons for deploying resiliency assets to support zero-emission MDHD deployments. These lessons include:

- The regulatory environment has incentivized transit fleets to adopt zero-emission vehicles faster than municipal fleets.
- Southern California Edison’s Charge Ready Transport Program (CRT) can be a useful tool for deploying charging infrastructure. However, some of the pathways under this program prohibit the deployment of distributed energy resources, which effectively precludes a microgrid. To avoid this problem, fleets who wish to deploy a microgrid should use the Customer-Built Pathway under the CRT program. Fleets interested in deploying a microgrid should begin planning for it as part of their zero-emission transition planning.
- Microgrids have high capital costs. Deploying microgrids in phases can help to mitigate this challenge as it allows fleets to deploy parts of the microgrid while they accumulate funds for future phases.
- Due to high power demand from bus charging, providing full resiliency for the fleet with 100% renewable energy is very difficult. Emergency backup generators, using renewable diesel, are a critical asset to provide full resiliency for the fleet. These generators will only operate during grid outages and will not have any long-term impacts on local air quality.
- Microgrids can be damaged or destroyed by unexpected events. Microgrid survivability is of paramount importance to ensure that it can provide resiliency during an emergency. As a result, microgrid designs must survive a wide range of scenarios.

The project team ultimately found that the SBMTD microgrids are a viable project and would provide great value if deployed. As a result, SBMTD plans to pursue funding to implement this project and deploy the microgrids.

CHAPTER 1: Project Purpose and Background

Security of fuel supply is important because zero-emission buses (ZEBs), like any other propulsion type, cannot operate without access to fuel. For battery-electric buses (BEBs), the fuel supply is electricity. BEBs are fundamentally reliant on electricity because they use it directly as a fuel. As a result, if there is a loss of power, transit agencies are unable to charge their BEBs. California has a relatively stable grid, and the average customer can expect to experience few outages per year. While customers can expect to have relatively few outages, extreme events such as storms, natural disasters, terrorism, or cyberattacks can cause the grid to go offline for longer periods of time. For example, in 2017, the American Northeast experienced extreme winter storms, which caused disruptions to power service to the region. Likewise, in 2017, states such as Florida and Georgia experienced outages from hurricanes; in the aftermath of Hurricane Maria, Puerto Rico experienced the worst blackouts in American history (U.S. Energy Information Administration, 2018). More recently, in February 2021, Texas experienced a lengthy grid outage following a polar vortex (The University of Texas at Austin, 2021). Lengthy outages such as these could prevent transit agencies from engaging in routine charging of their buses, which would then disrupt normal service and core transit operations. Since many members of the community use public transport to get to and from work or school, access to shopping centers, and travel to medical appointments, such disruptions would have major economic implications.

Santa Barbara Metropolitan Transit District Background

Santa Barbara Metropolitan Transit District (SBMTD) is the transit agency that serves southern Santa Barbara County, referred to as the South Coast. 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 ADA complementary paratransit service. SBMTD will also provide microtransit service in the near future. SBMTD provides service to important facilities and destinations such as 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 Santa Barbara that will fully transition to zero-emission. As a result, SBMTD is the primary focus of this report.

The regulatory environment influences SBMTD's accelerated transition to a zero-emission fleet. 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 ZEBs. Fleets must be 100 percent zero-emission by 2040, and the regulation provides a timeline for phasing in ZEB procurements. Under the ICT regulation, SBMTD is a small transit agency as 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.

Barriers to Fleet Electrification

Southern California Edison (SCE) serves SBMTD, and SCE's grid is relatively stable and has a track record of reliably delivering power. However, the city of Santa Barbara faces unusually high grid resiliency risks due to its geography. The region has elevated risks of natural disasters and has experienced mudslides and wildfires in recent years that have cut power. The city also 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 set of 220 kV transmission lines that run from Santa Clarita to Goleta. These transmission lines, attached to transmission towers, traverse mountainous terrain that is vulnerable to natural disasters. The city of Santa Barbara'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 shut off power to the Goleta Load Pocket, which left 200,000 customers without power (Clean Coalition). To protect against extended grid outages, SBMTD is interested in deploying measures, including a microgrid, to mitigate the risk of an outage and provide resiliency to the fleet. They are also interested in deploying other resiliency solutions.

Project Background

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 (MDHD) zero-emission vehicles (ZEVs) 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 MDHD vehicles in Santa Barbara's transit and municipal fleets through the development of a microgrid.

SBMTD has two depots where they can house buses: Terminal 1 and Terminal 2. Since Terminal 1 will host most of the fleet, the Blueprint primarily focuses on that depot. SBMTD collaborated with CALSTART to examine the techno-economic feasibility of deploying a microgrid. The analysis led to the development of a conceptual design for the microgrid at Terminal 1. CALSTART also examined the feasibility of other resiliency methods such as utilizing public charging stations during grid outages.

CHAPTER 2: Technology and System Analysis

Microgrid Design and Analysis

As an early adopter of ZEBs, SBMTD is vulnerable to loss of grid power. SBMTD is in the process of transitioning their fleet to BEBs which will require significant investment in charging infrastructure. The transition to BEBs requires major changes to SBMTD's depot. 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 is undergoing improvements that will allow SBMTD to shift some of its fleet and operations to that facility and alleviate operational capacity strain at Terminal 1.

To protect against extended grid outages, SBMTD is interested in deploying resiliency measures, including a microgrid, to mitigate the risk of a grid outage. Since Terminal 1 will host most of the fleet, SBMTD will likely deploy a microgrid at this site first. SBMTD is also interested in deploying a microgrid at Terminal 2 but first needs to prioritize the recommissioning of the site prior to any fleet electrification upgrades. SBMTD collaborated with CALSTART to examine the techno-economic feasibility of deploying a microgrid at Terminal 1 and Terminal 2. That effort was followed by the development of a conceptual design for the microgrid at Terminal 1.

Microgrid Design Parameters

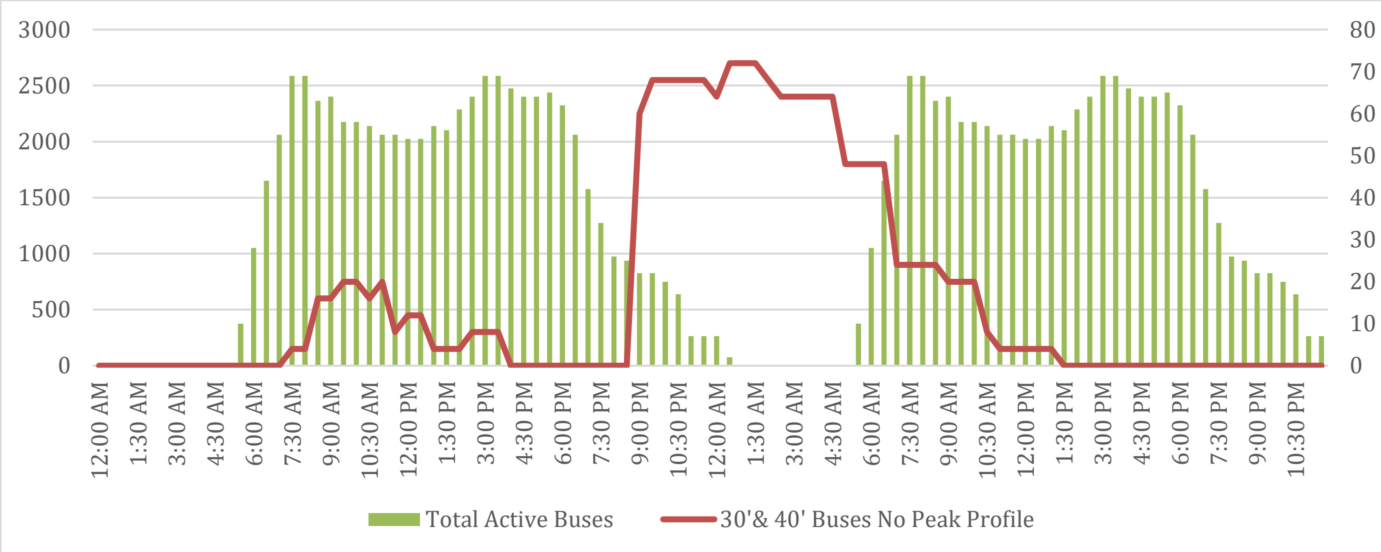
CALSTART conducted an analysis to develop a design for a microgrid to serve SBMTD. The microgrid must be able to provide enough energy to power SBMTD's fleet, meet resiliency goals for the fleet, and incorporate an energy portfolio that is acceptable to SBMTD. CALSTART quantified the required energy load, selected the grid outage scenarios that the microgrid will protect against (design-threat basis), and determined the composition of distributed energy resources (DER).

Loads

SBMTD's engineering consultant, Stantec, developed estimates for power demand at Terminal 1. Terminal 1 will host several loads. Terminal 1 will house approximately 80 buses. About 10 of these buses will be spare buses, which will not require charging on a daily basis. As a result, SBMTD expects to charge 70 buses per day at this site. SBMTD also hosts 14 light-duty electric vehicles (EVs) that road supervisors and bus operators utilize. The analysis originally considered tying other charging loads, such as the administration building and the maintenance bays, into the BEB charging microgrids. However, due to metering arrangements, SCE Charge Ready Restrictions (see Utility Regulations section), and the presence of existing generators to serve these buildings, the analysis limited the scope of the new microgrid(s) to bus charging only.

These load estimates resulted in a load profile, which expresses power demand throughout the course of a 24-hour period. The modified load profile avoids charging BEBs at peak utility rate hours (4 pm-9 pm) and is spread out as much as possible to avoid new demand peaks but still meet operational needs. This resulted in a peak power demand of about 2.7 MW. CALSTART used these estimates as the basis for the BEB charging load. Figure 1 below displays the BEB charging profile.

Figure 1: SBMTD Terminal 1 Load Profile



Source: Stantec

Energy Portfolio

CALSTART analyzed the feasibility of deploying each type of DER. The feasibility of deploying a DER depends on several factors. These factors include, among others, capital and operating costs, space availability at the depot, utility interconnection rules, and compatibility with the microgrid's expected load.

The analysis deemed solar panels and battery storage to be the most desirable DERs 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, the operating costs of these resources 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 supplement other DERs. SBMTD is open to using generators to supplement power from solar and batteries. If SBMTD utilizes generators, the agency 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 supplies fuel to the existing fleet of diesel and diesel-hybrid buses. The tank carries an average of 14,000 gallons of renewable diesel, and SBMTD orders additional renewable diesel when the tank level falls to 10,000 gallons. As a result, there is a significant amount of renewable diesel onsite that can fuel a diesel generator. It is important to note that Terminal 1 already hosts three diesel generators. These generators provide backup power to the administration building, maintenance facilities, some of the existing BEB chargers, and the fueling island. These generators combined have a nameplate capacity of approximately 600 kW.

Desired Use Case

SBMTD aims to deploy the microgrid to serve several purposes:

1. Fleet Resiliency: The primary purpose of the microgrid is to provide resiliency and protect SBMTD's fleet against a grid outage.
2. Reduce utility costs and/or generate revenue: SBMTD hopes to use the microgrid to generate electricity. This electricity will offset grid power, which will reduce energy costs and demand charges.
3. Local Resiliency: The City of Santa Barbara hopes to deploy localized microgrids, like the one SBMTD plans to develop, for use as a resource for regional resiliency. The City envisions that a multi-nodal network of localized microgrids can support each other during a grid outage. The City hopes that the SBMTD microgrid can serve as one node in this network of microgrids.

Design-Threat Basis

SCE's grid has historically been stable. In Santa Barbara, SCE customers can expect to have 1.5 grid outages per year that last for an average of 154 minutes (SCE, 2022). SBMTD's Terminal 1 has only experienced a few minor unplanned grid outages over the period between November 15, 2020, and November 15, 2022. These grid outages resolved automatically.

Table 1: Minor Unplanned Grid Outages

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

Source: SCE

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 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.

Table 2: Major Unplanned Grid Outages

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

Source: SCE

The outages reported in Table 1 and Table 2 are examples of outages that SCE's reliability indices capture. 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 design should 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 resiliency. 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 microgrids that other transit agencies have deployed. However, SBMTD also aims to maximize the resiliency. As a result, if techno-economically feasible, SBMTD would aim to pursue additional resiliency beyond 24 hours.

Microgrid Regulatory Environment

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 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 SBMTD's microgrid faces and the impacts of such regulations on the microgrid.

CPUC Regulations

CPUC regulates microgrids in the state of California. The CPUC regulates multiple aspects of microgrids:

- Operating Modes: A microgrid deployment is either behind-the-meter (BTM) or front-of-the-meter (FTM). BTM refers to situations where the microgrid is located on the customer's side of the meter. FTM refers to situations where the microgrid is located on the utility's side of the meter, usually attached to the utility's distribution system. CPUC Rule 21 regulates BTM microgrids , which governs DER interconnections. At the time of writing, the regulations and tariffs for FTM microgrids are under development. Outside of pilot projects, SCE will not pursue commercial FTM microgrids until the regulations are more defined. As a result, SBMTD plans a BTM microgrid deployment.

- Microgrid Sizing: 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, SBMTD expects that this microgrid will require installation of telemetry equipment.
- Power Export: 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 option would be to create a microgrid that can export power to other facilities. However, there are some regulatory barriers to this model. The main barrier is the "over-the-fence" rule, which is in California Public Utilities Code 218 Rule 18 and 19. The rule 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 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 a result, this microgrid could not be part of a multi-nodal microgrid, as envisioned by the City.

Utility Regulations

Regulations imposed by the utility also constrain microgrids. 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 MDHDs. The program streamlines the installation of charging infrastructure for SCE customers.

Fleets accepted into the program can receive funding to deploy their charging infrastructure and the funding is distributed through one of two pathways:

- SCE-Built Pathway: SCE finances and installs FTM and BTM infrastructure, including components such as transformers, the service drop, meters, and panels. SCE will also install conduit all the way up to the disconnect switch that the chargers connect to. The fleet is responsible for purchasing and installing the actual chargers. The interconnections of the chargers are 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 minimal cost.
- Customer-Built Pathway: SCE covers 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 reimburses 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, the reimbursement would be less than 80% of their actual cost.

The CRT pathway that a fleet chooses has implications for deploying microgrids. The SCE-Built Pathway does not allow attachment of DERs to the circuits. Since DERs are critical components of a microgrid, this effectively prevents the deployment of a microgrid under 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 the CRT SCE-Built Pathway funded some of the existing charging infrastructure at Terminal 1. As a result, there is no way to attach DERs or a microgrid to 14 existing DCFC ports and 14 Level 2 ports at Terminal 1 funded through the CRT SCE-Built Pathway. Due to the foregoing, SBMTD will pursue the Customer-Built Pathway for future CRT projects.

Santa Barbara County Air Pollution Control District Regulations

SBMTD is considering including generators in the microgrid energy portfolio. However, generators are subject to air quality regulations. Air districts impose these regulations. The Santa Barbara County Air Pollution Control District (SBCAPCD) will regulate any generator deployed at SBMTD. SBCAPCD requires that all diesel engines over 50 brake-horsepower obtain a permit. This requirement also applies to emergency standby generators. Emergency generators can only operate during a grid outage, including Public Safety Power Shutoffs, and for maintenance and testing, emissions testing, and initial start-up testing. This regulation effectively means that the generators can only provide backup power.

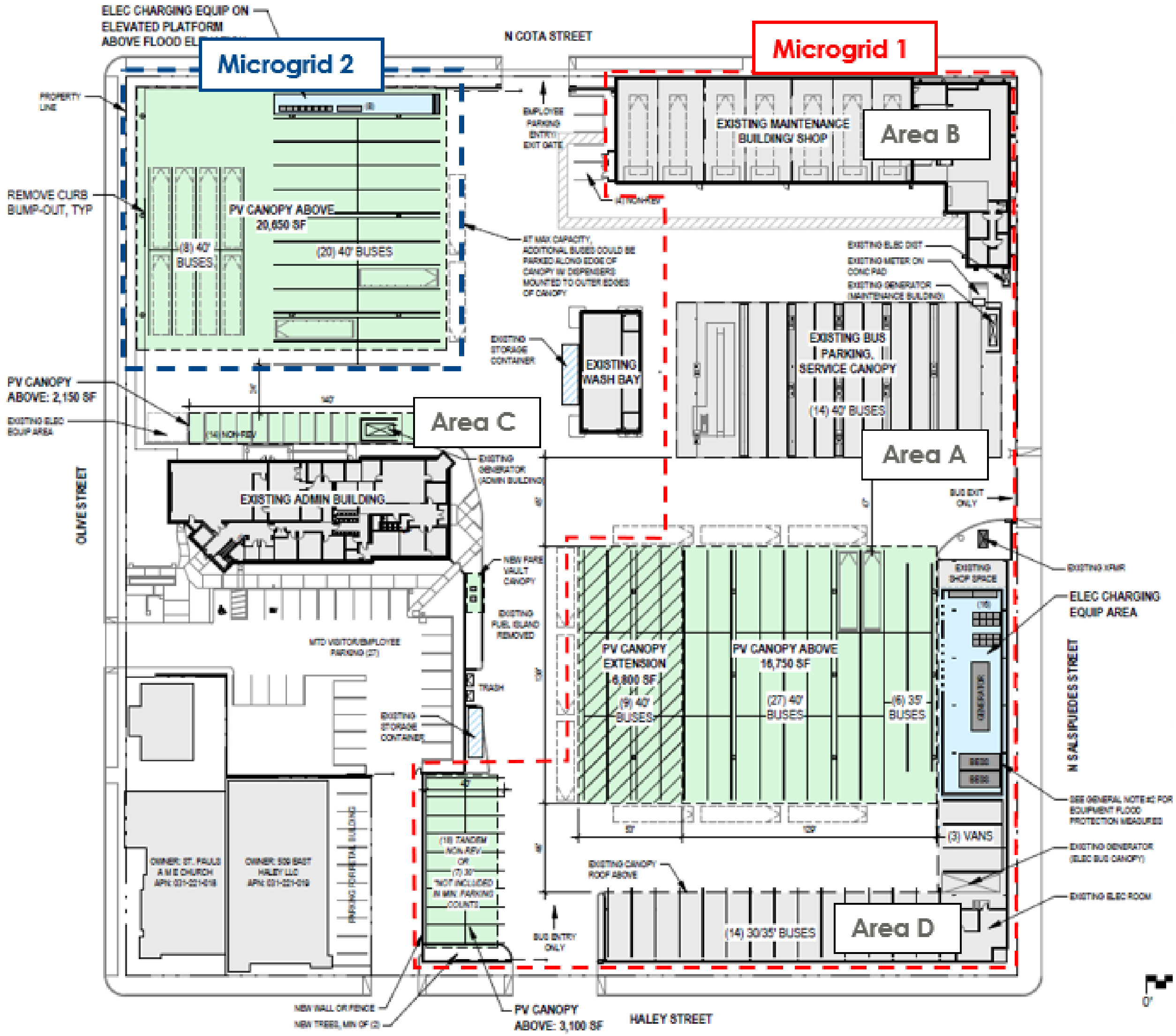
Microgrid Design

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.

Terminal 1 Microgrid Design

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, displayed in Figure 2 below.

Figure 2: Terminal 1 Site Layout and Microgrid Component Siting



Source: Stantec

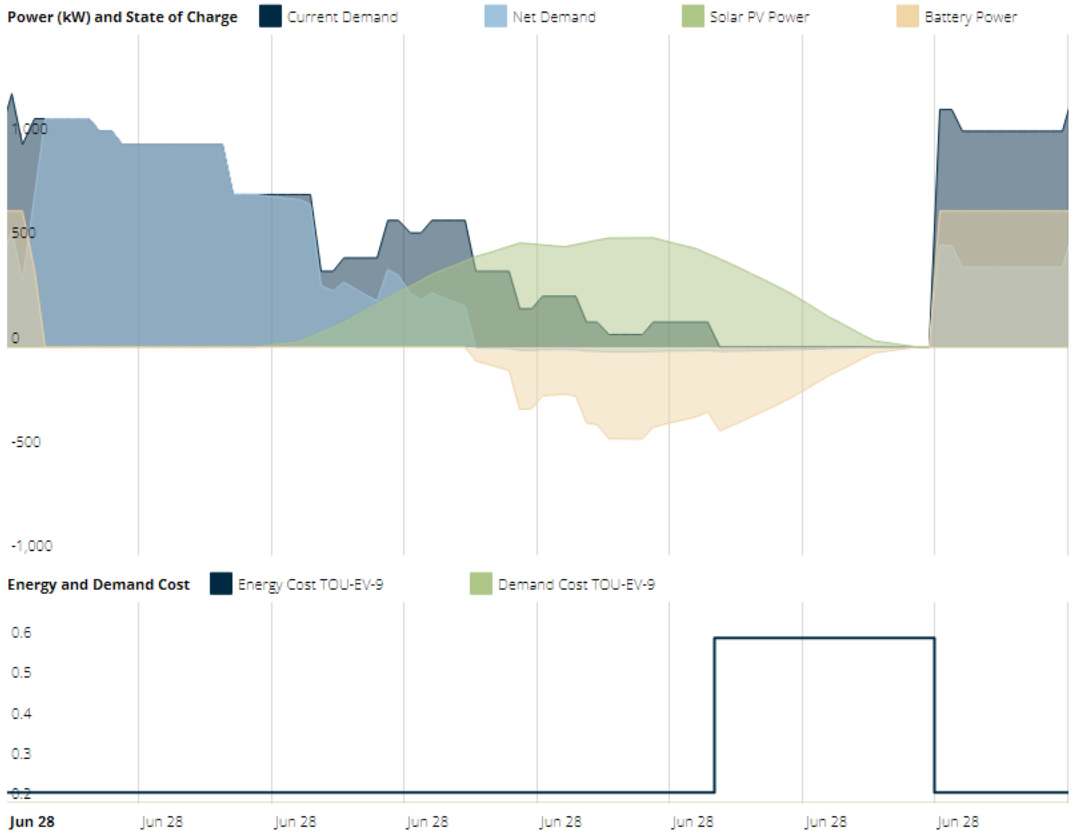
The areas shaded in green above are good candidates for the installation of solar carports under which vehicles could park. Even though Stantec's original plan designated the parking spaces next to the Administration Building (Area C) as an area that can potentially host solar panels, the output of Area C will 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.

The analysis considered solar 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 buses 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 following retrofits 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, this analysis assumed that this is possible. As stated before, the analysis divided the site into two separate microgrids, with Microgrid 1 serving the "right half" of the above diagram and Microgrid 2 serving the "left half."

CALSTART used the HelioScope commercial solar software design tool to determine the maximum solar capacity of the site. This model expects the solar photovoltaics (PV) capacity to be 641 kW 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 installation on the site. Appendix A displays the assumptions behind the HelioScope model.

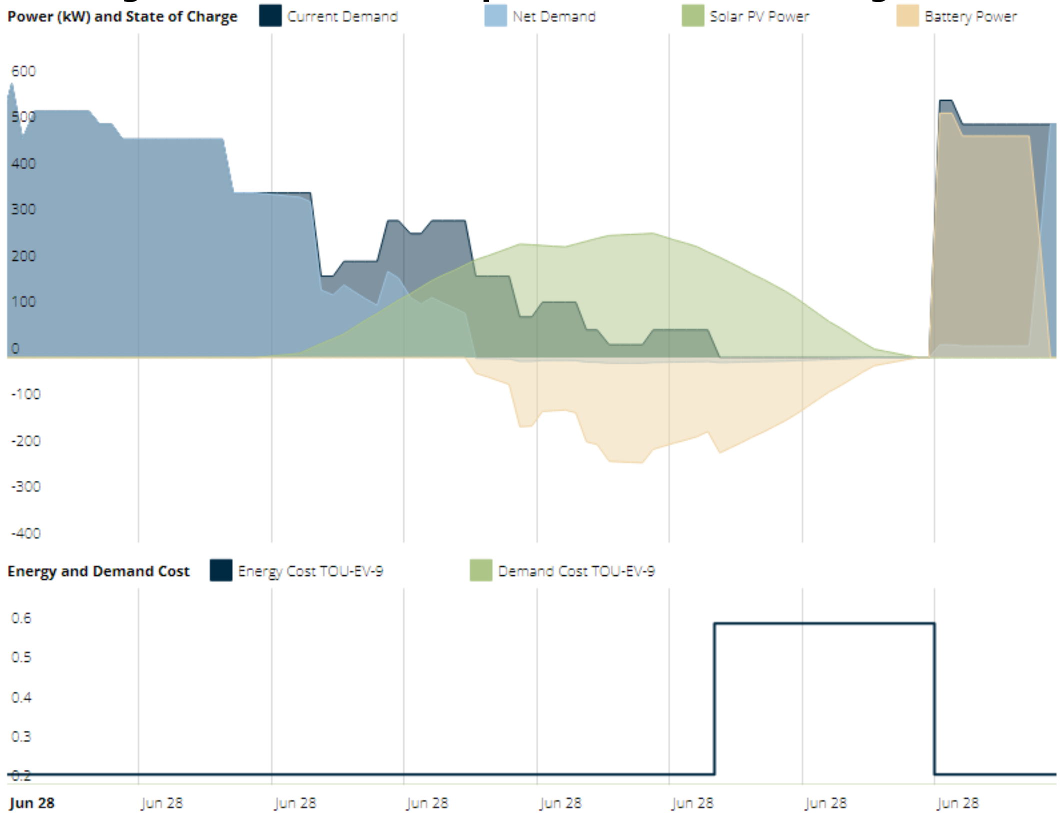
The Anser Advisory team then employed the Energy Toolbase (ETB) model to optimize the design specifications of the battery and generators to work with the solar limitations and meet the resiliency goals of the microgrid, given the above constraints. Based on the analysis conducted using ETB, it was determined that Microgrid 1 should incorporate 641 kW of solar panels, a 650 kW/2,610 kWh battery energy storage system (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. Figure 3 & Figure 4 below show the outputs for the microgrids. In the event of a grid outage, the solar, batteries and generator could handle the load as long as there was available renewable diesel fuel to power the generators.

Figure 3: ETB Model Output for Terminal 1 Microgrid 1



Source: Anser Advisory

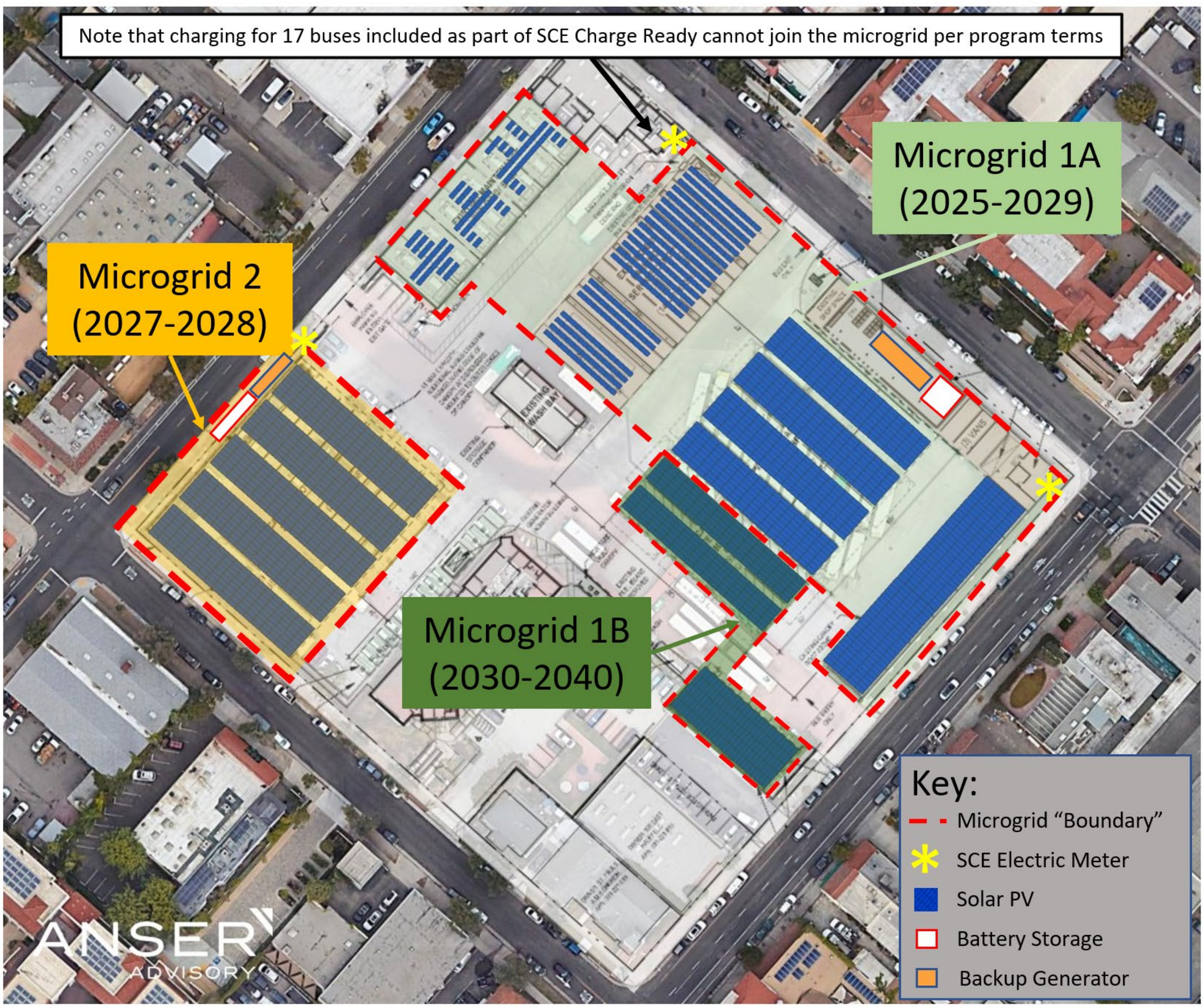
Figure 4: ETB Model Output for Terminal 1 Microgrid 2



Source: Anser Advisory

Anser Advisory also took additional factors into account when developing the conceptual design for the Terminal 1 microgrid shown in Figure 5 below. The first factor is grid connection considerations. The analysis considers the technical requirements and interconnection standards set by the utility company for grid integration, including voltage levels and power quality criteria 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 site. Since Terminal 1 has contaminated soils, minimizing trenching is important to prevent exposure to these contaminants. This has regulatory implications as construction or modifications that disturb these soils triggers California Environmental Quality Act (CEQA) regulations, which can entail a lengthy environmental review. Finally, Microgrid 1 will tie into the existing BYD bus charging meter which is located in the southeastern corner of the site to avoid significant trenching.

Figure 5: Conceptual Design for Terminal 1 Microgrids



Source: Anser Advisory

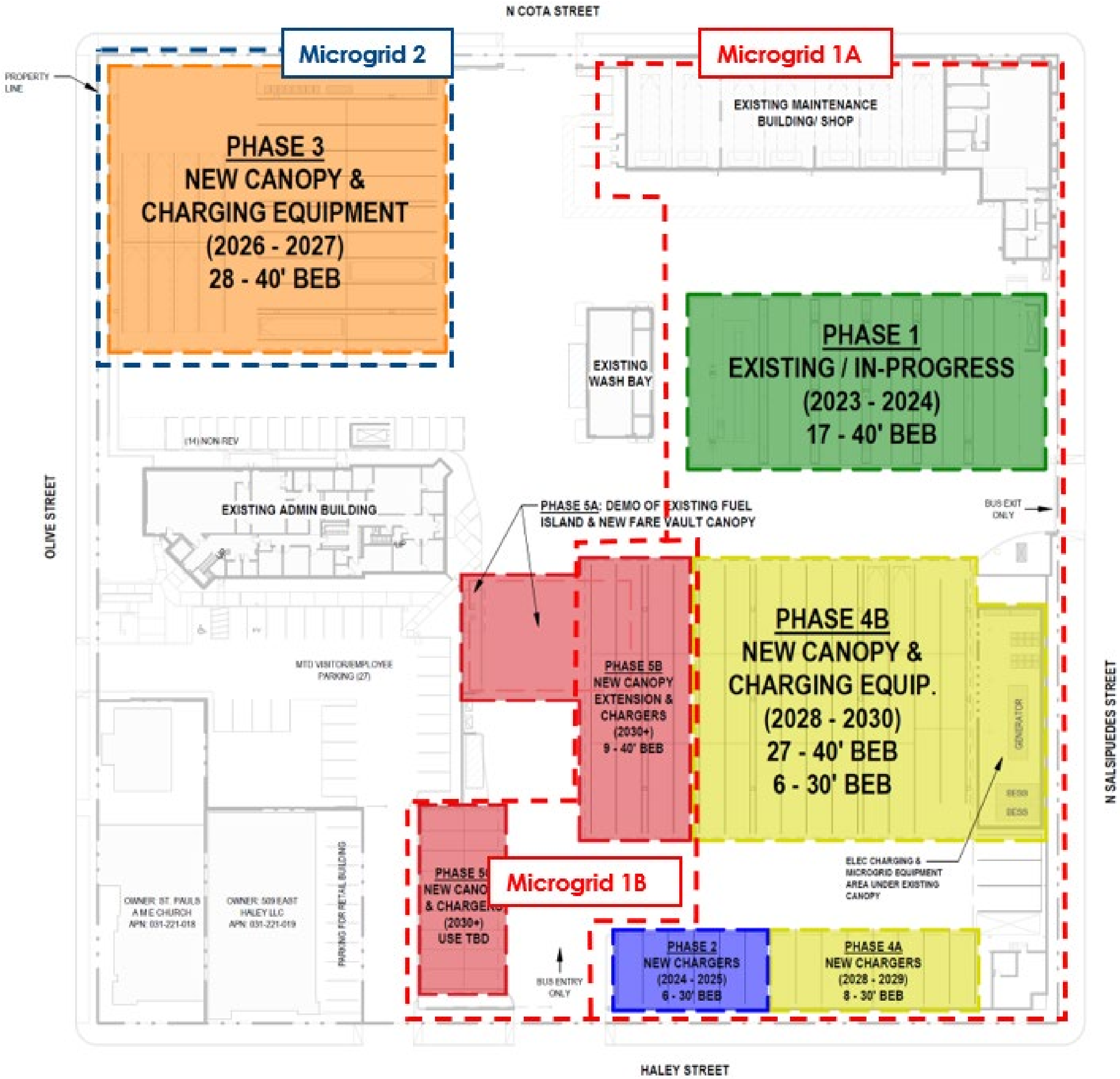
Microgrid Implementation Strategy

The microgrid will phase in over time, because the BEB deliveries will also phase 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 prior to BEB delivery. To avoid this problem, the analysis includes a phasing plan for the microgrids.

Anser Advisory determined that there were significant savings by charging buses on an EV-only rate tariff, like SCE's TOU-EV-9. Using that rate tariff dictates that loads on the meters responsible for charging buses are bus charging only, and excludes other site loads such as building loads. This was determined to be an acceptable solution, as buildings onsite already have backup generation. Additionally, loads from existing onsite buildings were insignificant in comparison to simulated bus charging loads.

It was also determined that building two microgrids to serve different banks of chargers would best serve resiliency at Terminal 1, as shown in Figure 6 below. In the event of equipment failure at one microgrid, SBMTD would have the ability to use the other microgrid to continue to charge BEBs. Microgrid 1 includes existing BYD chargers (for eventual conversion to standard DC fast 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 only includes Phase 3 chargers and the solar PV canopy due to the equipment's distance away from the rest of the microgrid infrastructure.

Figure 6: Terminal 1 Phasing Plan



Source: Anser Advisory

As mentioned above, the phasing of system sizing in ETB facilitates the transition to zero-emission buses 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. Table 3 below provides the sizing details for each phase. Each phase sizes the solar PV capacity 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 BEBs.

Table 3: Study Participant Recruitment Pools

Phase	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

Source: Anser Advisory

The sizing of the generators in conjunction with the batteries will provide the maximum amount of charging to the buses. In an ideal scenario, the battery will solely store energy created from the solar PV to minimize loss of value from solar exports under net energy metering (NEM) 3.0, and will offset the grid electricity needed to charge the buses. 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 downsizing of the batteries ensures they can reach an 80% state of charge.

CHAPTER 3: Replicability White Paper

CALSTART developed the Microgrid Replicability White Paper which discusses best practices for increasing grid resiliency and deploying a microgrid for transit agencies. This white paper specifically focuses on best practices for using public chargers as a resiliency asset and the steps for deploying a microgrid.

Public Charging

Public chargers are a resiliency asset. Many cities deploy public chargers. Other fleets, such as transit agencies, can potentially use these chargers if there is an outage at their depot. City governments often contract the operations and maintenance of public chargers to third-party companies. Cities typically negotiate with the third-party company for exclusive access to the chargers during emergencies. If a transit agency is a part of the municipality, these negotiations include their access to the chargers. However, transit agencies that are independent from the city government, such as SBMTD, will need to negotiate access to the chargers separately.

A key consideration for using public chargers as a resiliency resource is physical access. The design of most public chargers for light-duty electric vehicles cannot accommodate MDHD vehicles. Parking stalls for light-duty vehicles are often too small for MDHDs. Furthermore, many public chargers are located in parking garages which have clearances that are not compatible with buses and trucks. This is problematic because transit agencies typically deploy electric transit vans and full-sized electric transit buses. As a result, for public chargers to be a viable resiliency asset, the design of charging stations and parking spaces must accommodate transit vehicles. The design of charging stations must consider factors such as the size and turning radius of the vehicles. An outdoor parking lot with larger parking stalls or a pull-through parking configuration is an example of a parking layout that would be most useful for transit agencies.

Furthermore, most public chargers are Level 2 chargers. While these chargers can charge EVs and electric transit vans, Class 8 transit buses provide most public transit service, and these require direct current (DC) fast chargers. This mismatch in charger type means that only medium-duty transit vehicles will be able to use public chargers. As a result, deployment of public DC fast chargers is a requirement before public charging will be a useful resiliency asset for electric transit buses.

Microgrid Deployment

This report also provides an overview of best practices for designing a microgrid. There are several key responsibilities and tasks for designing a microgrid. These include:

1. Identify microgrid loads
    - 1.1 Quantify Loads
    - 1.2 Develop Load Profile
2. Determine microgrid parameters
    - 2.1 Energy Portfolio

- 2.2 Microgrid Functionality
- 2.3 Design-threat basis

3. Determine site constraints
    - 3.1 Identify flood zones and other site constraints
    - 3.2 Determine solar capacity for the site
    - 3.3 Determine utility constraints
4. Understand the microgrid regulatory framework
    - 4.1 Understand government regulatory environment
    - 4.2 Understand utility regulatory environment
5. Prioritize loads
    - 5.1 Determine which loads the microgrid will include
6. Size microgrid components
7. Develop a microgrid conceptual design

The Stakeholder Responsibilities section below explains these steps in more detail.

There are several types of tools that can be helpful for designing a microgrid. This includes solar potential software, which determines the amount of solar capacity that can be deployed at the site. HelioScope was the solar potential software used in designing the SBMTD microgrids. Microgrid sizing software determines the optimal sizing of microgrid assets. ETB was the microgrid sizing software used in this project. Utility provided maps and tools were used to determine the need for utility infrastructure upgrades at the depot.

Stakeholder Responsibilities

During the microgrid design process, transit agencies collaborate with a variety of partners. These partners typically include a microgrid consultant/engineering firm and the utility. Each entity has a different role to play in the microgrid design process. Table 4 illustrates the division of labor between each entity.

Table 4: Microgrid Stakeholder Responsibilities

Task #	Task	Transit Agency	Microgrid Consultant/ Engineering Consultant	Utility
1.1	Quantify Loads	Provide information on charging schedule and charging windows	N/A	Provide data on power draw and charging for any existing EVs (if available) and buildings onsite

Task #	Task	Transit Agency	Microgrid Consultant/ Engineering Consultant	Utility
1.2	Develop Load Profile	N/A	Use the information provided by the transit agency and utility to develop a load profile	N/A
2.1	Energy Portfolio	Identify unacceptable DERs	Understand restrictions on DERs (e.g., air quality regulations, city ordinances, etc.)	Understand restrictions on DERs (e.g., air quality regulations, city ordinances, etc.)
2.2	Microgrid Functionality	Identify the grid services (e.g., resiliency, peak shaving, load shifting, etc.) that they wish to obtain from the microgrid	Provide guidance on the feasibility of the transit agency's desired functionality	N/A
2.3	Design-threat basis	Identify the grid outage scenarios that the microgrid will protect against	Identify the grid outage scenarios that the microgrid will protect against Use historical grid outage data to determine how much resiliency will protect against grid outages	Provide historical data on grid outages Provide forecasts for future severity and frequency of grid outages, if available
3.1	Identify flood zones and other site constraints	N/A	Determine areas that are subject to flooding and other disasters	N/A
3.2	Determine solar capacity for the site	N/A	Use solar potential software to determine solar capacity for the site	N/A
3.3	Determine utility constraints	Initiate discussions with the utility about utility constraints at the site	Determine space constraints such as easements and rights-of-way	Determine remaining distribution

Task #	Task	Transit Agency	Microgrid Consultant/ Engineering Consultant	Utility
				capacity at the charging site Identify required utility upgrades
4.1	Understand government regulatory environment	N/A	Understand how the government will regulate the microgrid Determine how government regulations will impact the viability of operating modes	N/A
4.2	Understand utility regulatory environment	Initiate discussions with the utility to understand utility interconnection requirements for microgrids and other rules and regulations	Initiate discussions with the utility to understand utility interconnection requirements for microgrids and other rules and regulations	Work with the transit agency and the microgrid designer to share utility rules and regulations
5.1	Determine which loads the microgrid will include	Determine which loads the microgrid will include and which loads the microgrid will prioritize in the event of a grid outage	Determine which loads the microgrid will include and which loads the microgrid will prioritize in the event of a grid outage	N/A
6	Size Microgrid Components	N/A	Use microgrid sizing software to determine the optimal sizing for DERs and microgrid components	N/A
7	Develop conceptual design	N/A	Develop a high-level conceptual design and single-line diagram	N/A

Source: CALSTART

CHAPTER 4: Economic Analysis

The microgrids at Terminal 1 will provide resiliency. They will also provide a host of economic benefits. For example, the solar panels and BESS will engage in load shifting to reduce SBMTD's utility bills. The microgrids will also provide other benefits beyond utility savings. Jobs supported through the construction of the microgrids will provide benefits. The direct jobs will benefit local workers in Santa Barbara and the indirect jobs will benefit workers in other areas. This section quantifies the economic benefits provided by the microgrid.

Microgrid Costs

Microgrids have a significant amount of equipment and high capital costs. Anser Advisory estimated the capital costs associated with the Terminal 1 microgrids, along with a breakdown of the required equipment as shown in Table 5 below. The table also breaks down these estimates for each microgrid segment deployed at Terminal 1.

Table 5: Microgrid 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**

Source: Anser Advisory

The costs presented are inclusive of equipment and labor for the installation of the microgrid components. The analysis assumes that the 20% contingency covers soft costs like design and permit fees.

Microgrid Financial Benefits

The Terminal 1 microgrids can also provide financial benefits. The main financial benefit the microgrid can provide is lower utility bills. Anser Advisory analyzed utility costs for each of the microgrids in ETB, assuming normal (non-backup) operation. Anser Advisory assumed Santa Barbara Clean Energy (SBCE) 100% Green rate paired with SCE's TOU-EV-9 rate tariff to model bus charging loads. Currently, the preceding does not have demand charges. This rate tariff would cost SBMTD roughly $0.23/kWh. Solar PV generation added to the model under NEM 3.0 rules significantly devalues any solar exports. BESS added to the model assumed it would charge from onsite solar and used for self-consumption (bus charging). Table 6 below shows the results of this financial analysis.

Table 6: Microgrid Utility Cost Savings

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%

Source: Anser Advisory

CALSTART found that following deployment of both microgrids at Terminal 1, SBMTD's reduction in electric utility bill costs is estimated to be $488,184 per year. That equates to a 21.9% decrease. This estimate assumes the solar energy stored in the batteries would be used for self-consumption, as resiliency was the main objective of the project. However, should SBMTD want to explore other battery operating strategies, such as load shifting or peak shaving, savings may be different. The modeling of load shifting in the assumed load profiles accomplished with charge management software will prevent any buses from charging on peak. The analysis does not select peak shaving 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 reevaluating.

Jobs Supported by the Microgrid

Microgrid construction will provide economic benefits for the surrounding community in the form of jobs. Microgrid construction will support several classes of jobs in Santa Barbara and in other areas. These include direct jobs, which are jobs supported by the construction of the microgrid. It will also create indirect jobs, which are jobs supported by the supply chain associated with the microgrid. Many of these indirect jobs are related to manufacturing. Lastly, it will create induced jobs, which are jobs supported by spending from workers employed in the direct and indirect jobs. CALSTART used CARB's Job Co-benefit Modeling Tool to calculate the number of jobs supported through microgrid construction. This model estimates that the microgrids will support 32 direct jobs, 19.6 indirect jobs, and 34.8 induced jobs. Using data from the Bureau of Labor Statistics, CALSTART determined the types of job creation, and the median wage earned. Using this data, CALSTART calculated the total wages earned by workers in these jobs. Collectively, the analysis projected that laborers in the 47 direct jobs will earn wages of $2,976,115 per year and laborers in indirect jobs will earn wages of $1,034,460 per year.

Value of 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. One resiliency valuation method is to determine the value of damages that occur in the event of an outage. The analysis then assumes 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 would 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 intent of the microgrids is to allow electric buses to operate in the event of an outage, the value of resiliency fundamentally ties to the economic benefits of public transit. The American Public Transportation Association (APTA) (2020) produced a study that identifies the 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 allows people to make additional trips. This is important because it enables 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 implies 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. 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 an estimated $229,399 of economic damages. It is important to note that a grid outage less than 24-hours may 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.

CHAPTER 5: Emissions Reductions

The microgrids at Terminal 1 will result in significant GHG emissions reductions under both blue sky and black sky conditions.

Under blue sky conditions, the microgrid will displace grid electricity and replace it with fully renewable energy, thereby increasing the renewable content of the power (unless the grid electricity is already 100% renewable). Anser Advisory's microgrid modelling indicates the buses will consume 9,813,140 kWh per year. The microgrids can displace 2,375,562 kWh per year or about 24.2% of the load.

The GHG emissions displaced by the microgrid depends on the carbon intensity of the grid power used. SBMTD plans to purchase power from SBCE, their local community choice aggregator. SBCE provides multiple options for power, each with a different level of renewable content (SCE, 2021):

- SCE Option: 31.4% renewable content (580 pounds of carbon dioxide-equivalent (CDE) per MWh)
- SBCE Green Start: 65.7% renewable content (290 pounds of CDE per MWh)
- SBCE 100% Green: 100% renewable content (0 pounds of CDE per MWh)

If SBMTD uses the SCE Option 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. If SBMTD uses the 100% Green Option, there will be no further GHG emissions reductions since the grid power is already fully renewable. 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 under black sky conditions. Public transit reduces emissions by decreasing the number of car trips and associated VMTs. In the absence of the microgrids, black sky conditions can effectively disable SBMTD's electric buses. Under this scenario, SBMTD's riders will likely use alternative forms of transportation, such as passenger cars or rideshare services, which will increase VMT and cause an increase in emissions. By preventing disruptions to public transit, the microgrid will effectively eliminate these emissions. Using the Federal Transit Administration's Transit Greenhouse Gas Emissions Estimator (Version 3),[1] CALSTART estimated that a 24-hour disruption to public transit could increase VMT-related emissions by 29.57 metric tonnes of CDE. However, the use of generators in the microgrids will consume renewable diesel, negating some of these emissions reductions. The analysis estimates the production from the generators of 5.42 metric tonnes of CDE during a 24-hour outage. As a result, the estimate of net GHG emissions reductions during black sky events is 24.15 metric tonnes of CDE per 24-hour grid outage.

[1] The Federal Transit Administration's Transit Greenhouse Gas Emissions Estimator is available at https://www.transit.dot.gov/regulations-and-guidance/environmental-programs/ftas-transit-greenhouse-gas-emissions-estimator

Since the microgrid will include generators in the energy portfolio, it will produce criteria pollutant emissions. The amount of criteria pollutants will vary depending on the type of engine used. CALSTART used Santa Barbara Air Pollution Control District's Diesel-fired Internal Combustion Engine Emergency Standby Emissions Calculator[2] to estimate emissions from the generators. If SBMTD uses Tier 1 engines, the generators will produce 1,126.03 pounds of NOx, 163.03 pounds of reactive organic gases (ROGs), 1,387.15 pounds of CO, and 65.28 pounds of PM over a 24-hour period. SBMTD's use of Tier 4 engines would greatly reduce these emissions. Using a Tier 4 engine, the generators will produce 81.60 pounds of NOx, 22.83 pounds of ROGs, 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 estimates likely overestimate the actual emissions. Usage of the generators only during grid outages and emergencies means they will not have a long-term impact on air quality.

[2] The Diesel-fired Internal Combustion Engine Emergency Standby Emissions Calculator is available at https://www.ourair.org/tech/

CHAPTER 6: Community Outreach and Engagement

The City of Santa Barbara and SBMTD conducted outreach with stakeholders to inform them about the project, explain how the project will affect the community, and identify possible opportunities for collaboration.

The City and SBMTD conducted outreach with the following entities:

- Utilities: SBMTD and Stantec conducted outreach with utilities to discuss fleet electrification efforts, potential programs and tariffs for fleet electrification, and opportunities for partnership.
    - Southern California Edison
    - Santa Barbara Clean Energy
    - Central Coast Community Energy
- Local Jurisdictions and Planning Organizations: The City's permitting department conducted outreach to understand the permitting and regulatory requirements for solar arrays, BESS, and EV charging infrastructure.
- Regional Workplaces, Business Owners, and Operators: The City conducted outreach with workplaces, business owners, and operators to understand their interest in transitioning to zero-emission vehicles.
    - Santa Barbara Rental Property Association
    - Electric Drive 805
    - Community Environmental Council
    - Ventura County Regional Energy Alliance
    - City Sustainability Committee
    - Central Coast Clean Cities Coalition
- Stakeholder Workshops: The City conducted outreach to other fleets along California's Central Coast to understand their plans for transitioning to zero-emission vehicles.
    - Gold Coast Fleet Annual Meeting
    - American Public Works Association
- Workforce and Educational Outreach: SBMTD conducted outreach with local workforce and educational institutions to establish partnerships with entities that wish to engage with vehicle electrification projects.
    - Santa Barbara City College
        - Environmental Studies Program
    - University of California, Santa Barbara
        - Office of Sustainability
        - Bren School of Environmental Management
        - Electrical and Computer Engineering Department

        - Geography Department

The City and SBMTD also conducted outreach directly to the public. The public outreach activities included:

- Community Based Organizations, Community Leaders, and Residents: The City conducted outreach 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 Climate Action Plan (CAP), was a key focus, and ZEV adoption and use was a central component of these efforts.
- Public Workshops: As part of the CAP, the City surveyed the public to gather feedback about the City's goal of carbon neutrality by 2035.
    - Surveys and workshops about the CAP
    - Listening Sessions
    - Climate Chats
- SBMTD Employees: A survey of SBMTD employees was conducted to understand their interest in personal EV ownership and whether access to SBMTD chargers would influence their decision to purchase or lease an EV.
- Conferences: Conferences included the results of the Blueprint project. These presentations featured the design and techno-economic analysis about the microgrids.
    - Battery Show North America 2022
    - International Conference on Transportation and Development 2022
    - International Conference on Transportation and Development 2023

CHAPTER 7: Blueprint Report

CALSTART developed a Blueprint Report summarizing the results of this project. The Blueprint Report provided an overview of the local municipal regulatory environment that is driving the transition to zero-emission vehicles. This regulatory environment focuses heavily on environmental, energy, and transportation policy. These regulations include:

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

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 Blueprint Report analyzed actions 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 developing a plan to deploy 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. The multiphase project anticipates that the facility will have at least 30 light- and heavy-duty electric vehicle (EV) chargers once the work is complete.
- City of Santa Barbara: The City 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 four chargers for MDHD vehicles. The City has also deployed 50 public chargers and plans to install an additional 100 public chargers.
- Santa Barbara County Association of Governments (SBCAG): SBCAG operates the Clean Air Express commuter transit 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 electric buses.

- County of Santa Barbara: The County has a fleet of 1,598 vehicles, including light-duty trucks, passenger buses, cars, and other MDHD equipment. The County has focused its efforts on transitioning the light-duty cars to zero-emission. The County has 91 EV sedans, one EV full size cargo van, and 36 hybrid vehicles. There are currently 13 hybrid vehicles on order and plans to acquire at least one 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 (they contract out their school bus service). 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 more arriving in the future.

The Blueprint Report summarized the technology and system analysis for the microgrid, the microgrid economic analysis, and the emissions analysis. Additionally, the Blueprint examined the possibility of using public charging as a resiliency asset. The sections above describe the details of these items.

The Blueprint Report also provided an overview for using V2X as a resiliency asset. V2X refers to the export of power from the bus to another load. V2X used alongside the microgrid can provide resiliency benefits to 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 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 developed for V2X. This includes UL1741, which governs the bi-directional inverters used to export power back to the grid (Mafazy, 2022). ISO 15118 is also an important standard that governs communication between the vehicle and the charger (CEC, 2022). Development of this technology is underway, and examination of the technology should remain in the future once it is fully commercialized.

CHAPTER 8: Lessons Learned and Next Steps

The project team developed an actionable microgrid design. This process uncovered multiple lessons for supporting MDHD vehicle electrification, designing microgrids, and promoting grid resiliency. One of the lessons learned was that the regulatory environment has pushed electrification for transit fleets before that of municipal fleets. The ICT Regulation requires California transit agencies to adopt zero-emission MDHD vehicles. However, municipal fleets have not been as quick to adopt zero-emission technology. The Advanced Clean Trucks and Advanced Clean Fleets rules will accelerate this adoption. This demonstrates the impact that regulatory mandates have on driving zero-emission adoption.

This project also provided analysis about the microgrid regulatory environment. At the beginning of the project, the City of Santa Barbara was interested in deploying a multimodal microgrid, where multiple microgrids across the city can export power to support each other during an outage. However, California's current regulatory environment is not conducive to this functionality. Utility restrictions on microgrids are also an important regulatory factor. SCE's CRT program places restrictions on DERs. The SCE-Built Pathway prohibits attachment of DERs to charging infrastructure, which effectively precludes the construction of a microgrid. Fleets that plan to deploy a microgrid should avoid utilizing the SCE-Built Pathway and should instead use the Customer-Built Pathway if they wish to use the CRT program. Since it is not possible to change programs following deployment of the infrastructure, if a fleet is interested in deploying a microgrid, they should begin planning for the microgrid as a part of their zero-emission fleet transition planning process.

This project also revealed that microgrids have high capital costs. As a result, it can be difficult for fleets to raise the required capital. There are some strategies for dealing with this challenge. One strategy is to deploy the microgrid in phases. SBMTD plans to deploy two separate microgrids in three phases. This phased approach provides several advantages. One advantage is that it spreads the capital costs out over time. It allows fleets to begin deploying parts of the microgrid while they obtain funding for future phases. It also allows scaling of the microgrid as the fleet of electric buses grows. Deployment of the full microgrid before the fleet fully transitions to zero-emission would result in oversized DERs in the microgrid until the transition is complete. Utilities will generally be hesitant to approve projects with oversized DERs. Deploying the microgrid in phases helps to address this problem.

The design process highlighted the challenges of transitioning to 100% renewable energy. The design of the microgrids will maximize the use of renewable energy in the energy portfolio. However, the load from bus charging is high and replacing this amount of grid power during a grid outage is challenging. Furthermore, SBMTD needs to have full resiliency for the fleet in the event of a grid outage. Given this desired use case and the limited space for solar panels and batteries at the depot, it is not possible to provide full resiliency for a fleet of BEBs by only using renewable energy. As a result, emergency backup generators using renewable diesel as a fuel was included in the energy portfolio to respond to lengthy grid outages. Since use of the generators will occur only during grid outages, they will not have long-term impacts on local air quality.

During the project, the depot experienced flooding due to unusually high levels of rainfall. This event threatened to inundate the charging cabinets with floodwater. Although the flooding ultimately spared the chargers, this incident demonstrated that unexpected events can threaten microgrids. This incident highlighted that microgrid survivability is of paramount importance to ensure that the microgrid is capable of providing resiliency when needed. This is a particularly salient issue because experts expect climate change to drive increasingly erratic and extreme weather events. As a result, it is vital that the design of microgrids can survive a wide range of scenarios. During this event, inspection of the chargers required deenergizing. While the chargers were offline, SBMTD used a public charger to charge their light-duty electric vehicles. This incident also demonstrated the feasibility of using public chargers as a resiliency measure.

The project team ultimately found that the SBMTD microgrids are a viable project and will provide great value if deployed. As a result, SBMTD plans to pursue funding to implement this project and deploy the microgrids.

Finally, it is important to acknowledge that this project focuses on resiliency measures for an electric fleet but does not detail the process for transitioning a medium- and/or heavy-duty fleet equipped with internal combustion engine (ICE) propulsion systems to zero-emission. The practical benefits for deploying resiliency measures for a 100% electric fleet, particularly a microgrid, are numerous as articulated in this report. But the transition to zero-emission, even beyond resiliency planning and implementation, is complicated, costly, and takes time. Fleets must be thoughtful and deliberate about their transition. While operation of a 100% electric fleet will no doubt lead to innumerable environmental and public health benefits and has the potential for marked operating cost reductions when coupled with the right mix of DERs (see Microgrid Financial Benefits section), the path to fleet electrification may obscure such benefits in the short term. The transition will be capital intensive and likely provide little relief to operating budgets. It may necessitate maintaining larger fleets resulting from a greater number of contingency or back-up vehicles comprised of ICE propulsion types to prevent interruption or compromising of business operations. While the transition to zero-emission will introduce new challenges, the results of such efforts will likely yield significant benefits for fleet operators and the customers they serve.

References

American Public Transportation Association. 2020. Economic Impact of Public Transportation Investment: 2020 Update. Available at https://www.apta.com/wp-content/uploads/APTA-Economic-Impact-Public-Transit-2020.pdf

CEC. 2022. CEC Recommendation for Deployment of ISO 15118-Ready Chargers (TN#241955). Available at https://www.energy.ca.gov/event/workshop/2021-11/iso-15118-charger-communications-and-interoperability-workshop

Clean Coalition. Goleta Load Pocket Community Microgrid. Available at https://clean-coalition.org/community-microgrids/goleta-load-pocket/

Mafazy, Midhat. 2022. Paving The Way: Vehicle-to-Grid (V2G) Standards for Electric Vehicles. Available at https://irecusa.org/wp-content/uploads/2022/01/Paving_the_Way_V2G-Standards_Jan.2022_FINAL.pdf. Interstate Renewable Energy Council.

SCE. 2021. 2021 Power Content Label. Available at https://www.sce.com/sites/default/files/custom-files/Web%20files/2021%20Power%20Content%20Label.pdf

SCE. 2022. Circuit Reliability Review – City of Santa Barbara 2022. Available at https://edisonintl.sharepoint.com/teams/Public/Misc/Shared%20Documents/Forms/PublicView.aspx?id=%2Fteams%2FPublic%2FMisc%2FShared%20Documents%2Fdocuments%2FReliability%2FSanta%20Barbra%2FSantaBarbara%2Epdf&parent=%2Fteams%2FPublic%2FMisc%2FShared%20Documents%2Fdocuments%2FReliability%2FSanta%20Barbra&p=true&ga=1

The University of Texas at Austin. 2021. The Timeline and Events of the February 2021 Texas Electric Grid Blackouts. Available at https://energy.utexas.edu/sites/default/files/UTAustin%20%282021%29%20EventsFebruary2021TexasBlackout%2020210714.pdf. Energy Institute.

Thomas, Andrew and Henning, Mark. 2017. Valuing Resiliency from Microgrids: How End Users Can Estimate the Marginal Value of Resilient Power. Urban Publications. Available at https://engagedscholarship.csuohio.edu/urban_facpub/1516. Cleveland State University Maxine Goodman Levin College of Urban Affairs.

U.S. Energy Information Administration. 2018. Average U.S. electricity customer interruptions totaled nearly 8 hours in 2017. Available at https://www.eia.gov/todayinenergy/detail.php?id=37652.

GLOSSARY

AMERICAN PUBLIC TRANSIT ASSOCIATION (APTA)—The American Public Transportation Association is a nonprofit group of approximately 1,500 public and private sector member organizations that promotes and advocates for the interests of the public transportation industry in the United States. APTA represents all modes of public transportation, including bus, paratransit, light rail, commuter rail, subways, waterborne services, and intercity and high-speed passenger rail.

BATTERY ELECTRIC BUS (BEB)—Also known as an "all-electric" bus, BEBs utilize energy stored in rechargeable battery packs. BEBs sustain their power through the batteries and therefore require an external electricity source in order to recharge.

BATTERY ENERGY STORAGE SYSTEM—(BESS) A device that stores energy and produces electric current by chemical action.

BEHIND-THE-METER (BTM)—Refers to distributed energy resources (DERs) deployed on the customer's side of the meter. BTM assets are typically located directly on the customer's property.

CALIFORNIA AIR RESOURCES BOARD (ARB)—The "clean air agency" in the government of California, whose main goals include attaining and maintaining healthy air quality; protecting the public from exposure to toxic air contaminants; and providing innovative approaches for complying with air pollution rules and regulations.

CALIFORNIA ENERGY COMMISSION (CEC)—The state agency established by the Warren-Alquist State Energy Resources Conservation and Development Act in 1974 (Public Resources Code, Sections 25000 et seq.) responsible for energy policy. The Energy Commission's five major areas of responsibilities are:

1. Forecasting future statewide energy needs
2. Licensing power plants sufficient to meet those needs
3. Promoting energy conservation and efficiency measures
4. Developing renewable and alternative energy resources, including providing assistance to develop clean transportation fuels
5. Planning for and directing the state response to energy emergencies.

CALIFORNIA PUBLIC UTILITIES COMMISSION (CPUC)—A state agency created by constitutional amendment in 1911 to regulate the rates and services of more than 1,500 privately owned utilities and 20,000 transportation companies. The CPUC is an administrative agency that exercises both legislative and judicial powers; only the California Supreme Court may consider an appeal of its decisions and orders. The major duties of the CPUC are to regulate privately owned utilities, securing adequate service to the public at rates that are just and reasonable both to customers and shareholders of the utilities; including rates, electricity transmission lines and natural gas pipelines. The CPUC also provides electricity and natural gas forecasting, and analysis and planning of energy supply and resources. Its main headquarters are in San Francisco.

CARBON DIOXIDE (CO_2)—A colorless, odorless, non-poisonous gas that is a normal part of the air. Green growing things and the sea absorb carbon dioxide exhaled by humans and animals. CO_2 is the greenhouse gas whose concentration is being most affected directly by human activities. CO_2 also serves as the reference to compare all other greenhouse gases (see carbon dioxide equivalent). The major source of CO_2 emissions is fossil fuel combustion. CO_2 emissions are also a product of forest clearing, biomass burning, and non-energy production processes such as cement production. Atmospheric concentrations of CO_2 have been increasing at a rate of about 0.5% per year and are now about 30% above preindustrial levels.

CARBON DIOXIDE-EQUIVALENT (CDE)—A metric measure used to compare the emissions from various greenhouse gases based upon their global warming potential (GWP). The typical expression of carbon dioxide equivalents is "million metric tons of carbon dioxide equivalents (MMTCDE)" or "million short tons of carbon dioxide equivalents (MSTCDE)." The derivation of carbon dioxide equivalent for a gas by multiplying the tons of the gas by the associated GWP is typical. MMTCDE= (million metric tons of a gas) * (GWP of the gas) For example, the GWP for methane is 24.5. This means that emissions of one million metric tons of methane is equivalent to emissions of 24.5 million metric tons of carbon dioxide. It is typical to use carbon as the reference and to convert other greenhouse gases to carbon equivalents. To convert carbon to carbon dioxide, multiply the carbon by 44/12 (the ratio of the molecular weight of carbon dioxide to carbon).

CALIFORNIA ENVIRONMENTAL QUALITY ACT (CEQA - pronounced See' quah)—Enacted in 1970 and amended through 1983, established state policy to maintain a high-quality environment in California and set up regulations to inhibit degradation of the environment.

CARBON MONOXIDE (CO)—A colorless, odorless, highly poisonous gas made up of carbon and oxygen molecules formed by the incomplete combustion of carbon or carbonaceous material, including gasoline. It is a major air pollutant on the basis of weight.

CHARGE READY TRANSPORT (CRT)—A “make-ready” program administered by Southern California Edison (SCE). Under CRT, SCE installs charging infrastructure for medium- and heavy-duty (MDHD) vehicles at little to no cost for the customer.

DISTRIBUTED ENERGY RESOURCE (DER)—small-scale power generation technologies (typically in the range of 3 to 10,000 kilowatts) located close to the uses of electricity (for example, a home or business) to provide an alternative to or an enhancement of the traditional electric power system.

DIRECT CURRENT (DC)—A charge of electricity that flows in one direction and is the type of power that comes from a battery.

FRONT-OF-THE-METER (FTM)—Refers to distributed energy resources (DER) deployed on the utility’s side of the meter and typically connected to the utility’s distribution system.

GREENHOUSE GAS (GHG)—Any gas that absorbs infra-red radiation in the atmosphere. Greenhouse gases include water vapor, carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), halogenated fluorocarbons (HCFCs), ozone (O_3), perfluorinated carbons (PFCs), and hydrofluorocarbons (HFCs).

INNOVATIVE CLEAN TRANSIT (ICT) REGULATION—The ICT regulation adopted in December 2018 requires all public transit agencies to gradually transition to a 100 percent zero-emission bus (ZEB) fleet. Beginning in 2029, 100% of new purchases by transit agencies must be ZEBs, with a goal for full transition by 2040. It applies to all transit agencies that own, operate, or lease buses with a gross vehicle weight rating (GVWR) greater than 14,000 lbs. It includes standard, articulated, over-the-road, double-decker, and cutaway buses.

MEDIUM- AND HEAVY-DUTY (MDHD)—A vehicle with a gross vehicle weight rating of more than 10,000 pounds, including vans, buses, and trucks.

NET ENERGY METERING (NEM)—A utility tariff structure where customers receive bill credits for excess generation exported to the electric grid during times when it is not serving onsite load.

NITROGEN OXIDES (NOx)—A general term pertaining to compounds of nitric oxide (NO), nitrogen dioxide (NO2) and other oxides of nitrogen. The creation of nitrogen oxides typically occurs during combustion processes and are major contributors to smog formation and acid deposition. NO2 is a criteria air pollutant and may result in numerous adverse health effects.

PARTICULATE MATTER (PM)—Unburned fuel particles that form smoke or soot and stick to lung tissue when inhaled. A chief component of exhaust emissions from heavy-duty diesel engines.

REACTIVE ORGANIC GAS (ROG)—A photochemically reactive chemical gas, composed of non-methane hydrocarbons, that may contribute to the formation of smog. Also sometimes referred to as Non-Methane Organic Gases (NMOGs).

SANTA BARBARA CLEAN ENERGY (SBCE)—SBCE is a clean choice aggregator operated by the City of Santa Barbara. SBCE procures power for customers within the City and offers customers the option to consume renewable energy.

SANTA BARBARA COUNTY AIR POLLUTION CONTROL DISTRICT (SBCAPCD)—The agency that regulates air pollution in Santa Barbara County.

SANTA BARBARA METROPOLITAN TRANSIT DISTRICT (SBMTD)— The Santa Barbara Metropolitan Transit District (MTD) is a public transit agency providing bus service in the southern portion of Santa Barbara County, California. It serves the cities of Santa Barbara, Carpinteria, and Goleta as well as the unincorporated areas of Montecito, Summerland, Isla Vista, and the Eastern Goleta Valley.

SOUTHERN CALIFORNIA EDISON (SCE)—One of the nation's largest electric utilities, which delivers power to 15 million people in 50,000 square-miles across central, coastal and Southern California, excluding the City of Los Angeles and some other cities.

VEHICLE MILES TRAVELED (VMT)—The miles traveled by motor vehicles over a specified length of time (e.g., daily, monthly, or yearly) or over a specified road or transportation corridor.

VEHICLE-TO-X (V2X)—The export of power from a bus to another load, such as a building.

ZERO-EMISSION (ZE)—An engine, motor, process, or other energy source, that emits no waste products that pollute the environment or disrupt the climate.

ZERO-EMISSION BUS (ZEB)—A bus that does not produce any tailpipe emissions. Currently, the two types of ZEBs are battery electric buses (BEB) and fuel cell electric buses (FCEB).

ZERO-EMISSION VEHICLE (ZEV)—Vehicles which produce no emissions from the on-board source of power (e.g., an electric vehicle).

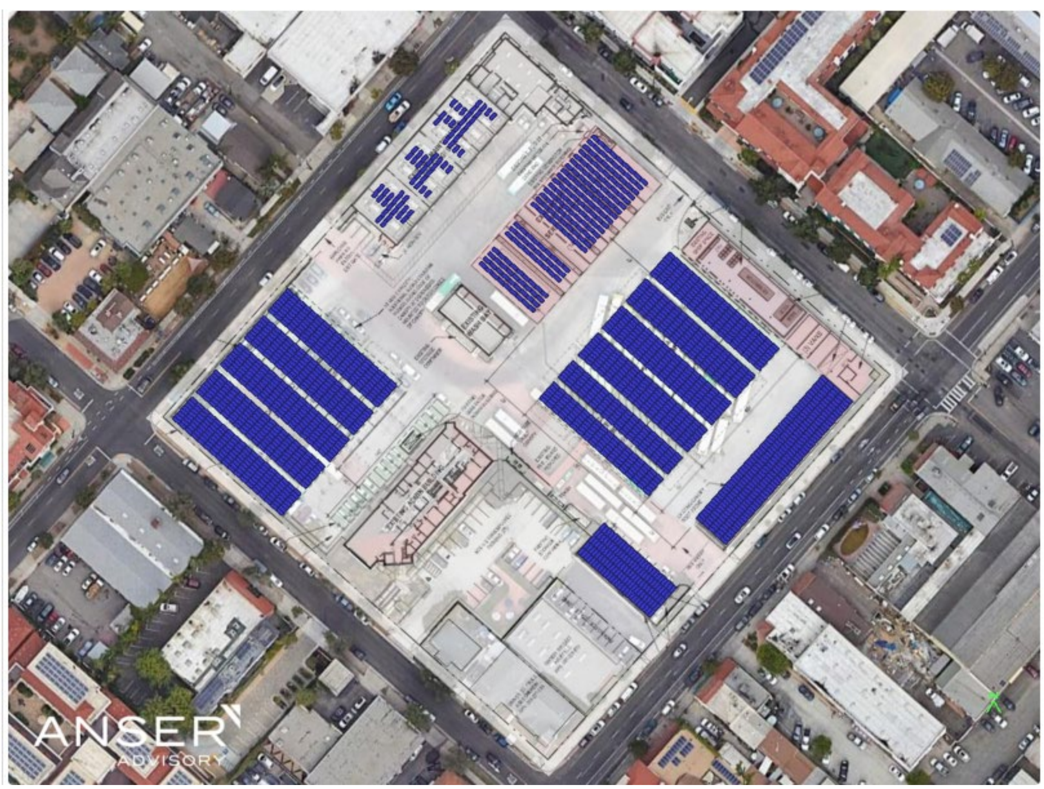
APPENDIX A:
HelioScope Assumptions and Output

HelioScope programmed the following assumptions to develop a solar design for Terminal 1:

- Solar Panel Efficiency: Assumed standard solar panel efficiency of 95%.
- Solar Irradiance: Considered average solar irradiance levels based on historical data or regional solar resource databases.
- Solar Panel Orientation and Tilt: Assumed the optimal panel orientation of 5 to 7 degrees for carport-type structures and 7 degrees for fixed roof mount structures to maximize solar energy capture.
- Shading Analysis: Assumed minimal shading of the solar panels after consideration of nearby objects, buildings, or trees that may potentially obstruct sunlight.
- Inverter Efficiency: Assumed an inverter efficiency level of 95% to convert DC power from the solar panels to AC power for grid integration.
- Losses and Degradation: Accounted for losses and degradation over time, typically considering degradation rates provided by solar panel manufacturers.

Based on these assumptions, the project team developed a design for the solar system, as displayed in Figure A-1.

Figure A-1: Terminal 1 Solar Design

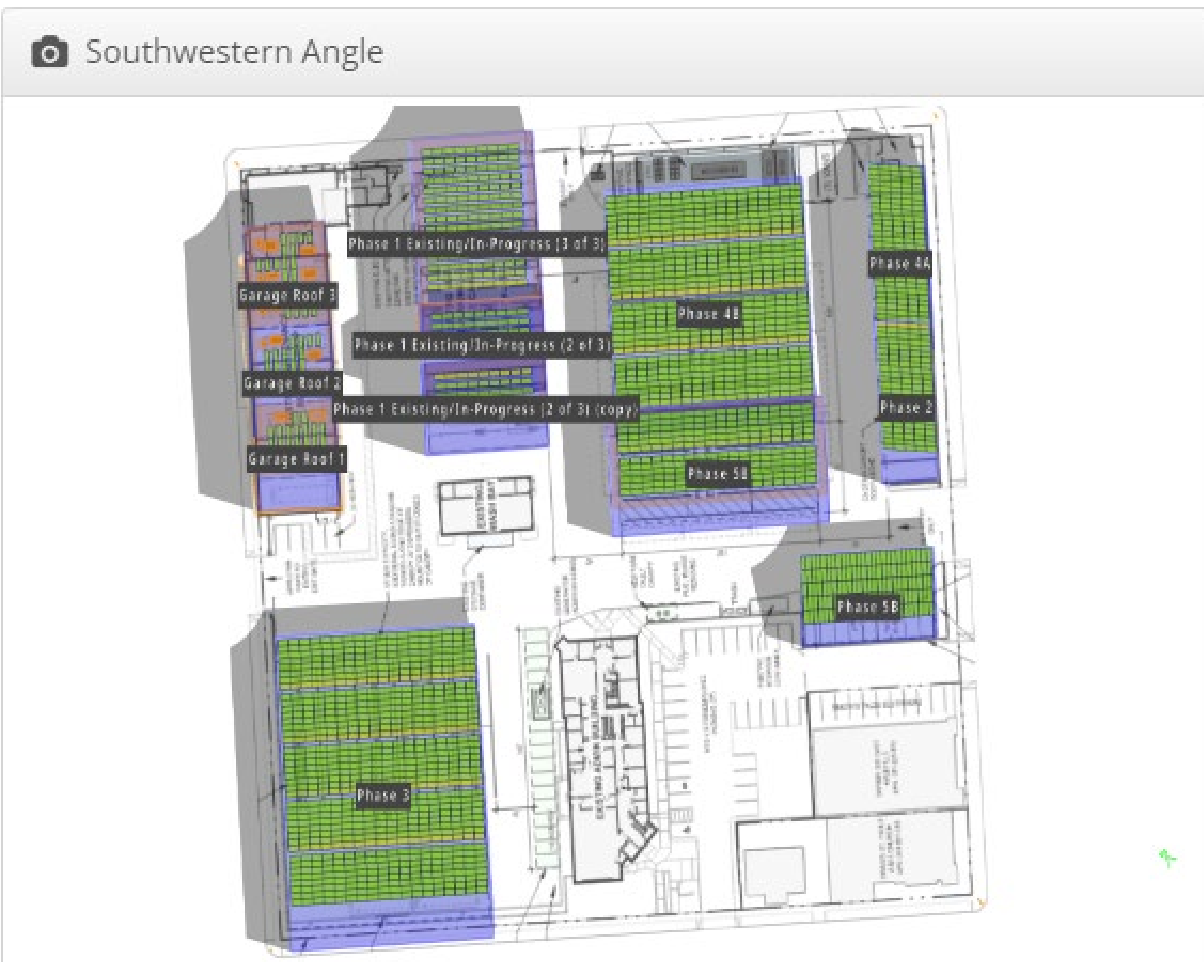


Source: Anser Advisory

Shading losses can significantly impact the overall output of a microgrid. The obstruction or shading by nearby objects, buildings, or trees of solar panels greatly reduces their efficiency, 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. The utilization of HelioScope determined that minimal shading of the designed microgrid structure will not significantly affect the structure, ensuring optimal performance. Figure A-2 below displays the shading analysis.

Figure A-2: Terminal 1 Shading Analysis



Source: Anser Advisory