Santa Ana Regional Transportation Center (SARTC) Microgrid Feasibility Study

PREPARED BY:
Stephen Brett Reno, PE
John Rossi, PE

June 2, 2022

TRC Companies
6 Executive Circle
Suite 200, Irvine, CA 92614

Table of Contents

LIST OF FIGURES

LIST OF TABLES

1 Project Summary Description

Santa Ana Regional Transportation Center (SARTC) is a main transportation hub for Orange County. This feasibility study provides preliminary analyses and site-specific findings that lay the groundwork for future microgrid development. The primary goal of the microgrid system provided in this study is to strengthen energy resiliency and enable the facility to continue providing transportation services in the face of extreme climate events and power outages. The facility is located within the Aliso Canyon gas leak impacted region. As a result, Southern California Edison (SCE) has designated this portion of its service territory as load constrained.

Key threats to the City of Santa Ana include earthquakes, storms and floods, public safety power shutoffs, power blackouts, climate events such as heat or drought, and acts of terrorism. The Santa Ana Emergency Operations Plan relies on SARTC as a key piece of critical transportation infrastructure for the City's emergency preparedness and response; keeping SARTC operational during emergencies is a key benefit to the City's emergency operations. The feasibility study focuses on a permanently installed, islandable microgrid that will help the city achieve critical emergency preparedness goals and maintain important operations and resources in the event of an emergency.

Through this study, the City of Santa Ana and SARTC will assess the feasibility of not only developing a microgrid but also incorporating additional electric vehicle (EV) charging infrastructure into SARTC. The study will also assess the feasibility of adding solar photovoltaics (PV) on SARTC parking structure and incorporating battery storage to develop SARTC into a replicable and resilient transportation hub.

Figure 1: Facade of the SARTC Facility

Special thanks to Adrian Covert and Anna Sciaruto of the Bay Area Council Foundation for funding this feasibility study through their California Resiliency Challenge grant. Additional special thanks to the City of Santa team for their valuable contributions, including, Christy Kindig, Phil Neff, Gabriela Lomeli, and Mark Shorthouse.

2 Executive Summary

TRC found that a microgrid system is a feasible solution to satisfy the SARTC facility's goals of resiliency, EV accessibility, greenhouse gas (GHG) reduction, and cost effectiveness.

The proposed microgrid system is composed of 492-kW of carport solar PV, 972-kWh of battery storage, and 10 Level-2 EV chargers. TRC estimates the system will generate 832,000 kWh of electricity annually, bringing the site to *net zero energy* consumption. The battery storage system is sized to provide backup power to the site for six hours of peak consumption. Total projected GHG reduction of 4,145.5 metric tons of CO2e is achieved over the project's 25-year effective useful life (EUL).

The size of the system summarized below is based on discussions with SARTC. TRC also analyzed alternative system sizes based on resilience and load growth sensitivity conditions. See Sections 4.3 and 4.4 for alternative cases.

Table 1: Energy Savings Summary

Annual Energy Generation (kWh)	Annual Demand Reduction (kW)	Annual GHG Reduction (MT CO2e)	Energy Generation Over 25-yr EUL (kWh)	GHG Reduction Over 25-yr EUL (MT CO2e)
832,000	63	165.6	20,800,000	4,145.5

Table 2 below details the pure financial impacts of the project, realized through utility bill savings. Utility bill savings are achieved by energy consumption reduction and Time of Use (TOU) load shifting. See Section 2.1 for credit details.

Table 2: On-Bill Economic Analysis Summary

Ownership Model	Upfront Project Cost ($)*	Year 10 Project Cost ($)	Total Annual Cost Savings ($/yr)	Credits Utilized ($)	Net Simple Payback (yr)	ROI (25-year EUL)
Cash Purchase	$4,103,000	$0	$69,000	$688,500	49.5	51%
Standard PPA	$25,000	$0	$1,000	$2,478,600	-	-
PPA with Year 10 Buyout	$25,000	$817,023	$43,400**	$2,478,600	11.8	128%

*$25,000 of the upfront project costs reflects EV charger cost.

**Cost savings represent a weighted average of 10 years with PPA and 15 years of ownership.

Table 3 below details the project's value analysis, capturing the Value of Resilience (VOR) provided by the microgrid system. See Section 2.2 for VOR details.

Table 3: Economic Analysis Summary, Including VOR

Ownership Model	Upfront Project Cost* ($)	Year 10 Project Cost ($)	Total Annual Cost Savings ($/yr)	VOR ($/yr)	Credits Utilized ($)	Net Simple Payback (yr)	ROI (25-year EUL)
Cash Purchase	$4,103,000	$0	$69,000	$230,500	$688,500	11.4	219%
Standard PPA	$25,000	$0	$1,000	$230,500	$2,478,600	-	-
PPA with Year 10 Buyout	$25,000	$817,023	$43,400	$230,500	$2,478,600	3.0	838%

*$25,000 of the upfront project costs reflects EV charger cost.

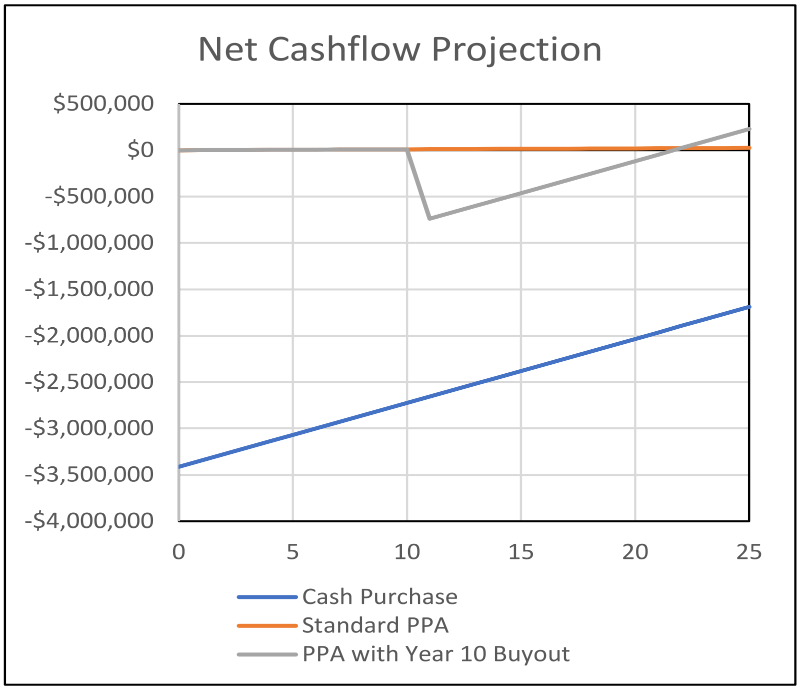

Figure 2: Net Cashflow Projection

Figure 2 illustrates the net cashflow impacts of each option. The graph captures changes in utility bills and site maintenance costs. Before accounting for VOR, Option 1 does not achieve positive payback. Options 2-3 achieve positive financial impacts by the end of the equipment life, with Option 3 realizing the greatest savings over time.

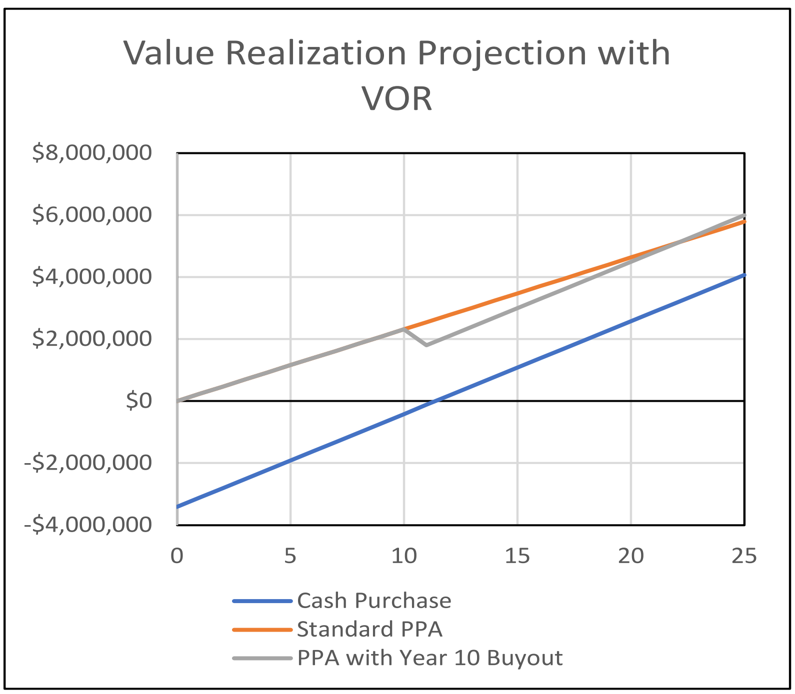

Figure 3: Value Realization Projection with VOR

Figure 3 details the value added by each option. In addition to changes in utility bills and site maintenance costs, the graph captures the value of the resilience added. Accounting for all impacts, Options 1-3 achieve lifetime positive project values of $4-6 million, with Option 3 realizing the greatest value over time.

2.1 Ownership Options

TRC performed economic analysis of the proposed system under three ownership cases for the PV and battery storage system. Line-by-line costing is contained within Attachment A, and PPA analysis is located in Attachment B.

TRC recommends *Option 3: PPA with Year 10 Buyout*. This option avoids large upfront costs while maximizing long-term return on investment (ROI), as can be seen in Figure 2 illustrates the net cashflow impacts of each option, realized by utility bill savings. Before accounting for VOR, Option 1 does not achieve positive payback. Options 2-3 achieve positive financial impacts by the end of the equipment life.

Option 1: Cash Purchase: This scenario explores full ownership of the solar PV and battery storage system, purchased upfront by the City. Credits available to the City are Self-Generation Incentive Program (SGIP) battery storage rebates. Annual cost savings include maintenance costs equal to 0.5% of the system cost. Funding options are identified in Section 2.3.

Option 2: Standard Power Purchase Agreement (PPA): In this scenario, a third party installs and owns the solar PV and battery storage system, and it sells electricity to the City at a reduced rate. This strategy allows a third party to claim additional credits, including the 26% Solar PV Federal Tax Credit and the 87% Rapid Depreciation Credit, equivalent to 25% of the solar PV cost. ROI is null, because there is no cost to the City.

Option 3: PPA with Year 10 Buyout: This scenario begins with a PPA, and it includes a buyout of the system at year 10. This allows the City to own the system for the last 15 years of its life, while still taking advantage of the Federal Tax Credit and Rapid Depreciation Credit. ROI is based on the last 15 years of ownership.

2.2 VOR Analysis

VOR123 is a methodology established by the Clean Coalition to assign a quantifiable value to the resilience added by backup power systems[1]. The methodology was cited by the California Public Utilities Commission (CPUC) in a July 2020 Concept Paper as a part of their microgrid implementation plan[2].

The methodology establishes three tiers of critical loads. This tiering allows for systematic load shedding capabilities during outages that will aim to ensure onsite PV, and battery energy storage system (BESS) assets maintain the most crucial loads necessary for facility operations. The tiering approach also allows for PV and BESS assets to be optimally sized, reducing capital costs and underutilization. See Section 4.1 for critical load analysis, and Attachment C for VOR calculations.

- **Tier 1:** Mission-critical, life-sustaining loads that warrant 100% resilience.
- **Tier 2:** Priority loads that should be maintained as long as doing so does not threaten the ability to maintain Tier 1 loads.
- **Tier 3:** Discretionary loads that should be maintained only when doing so does not threaten Tier 1 and Tier 2 resilience.

The VOR123 methodology then establishes energy value multipliers to the value of the resilient power sent to the three tiers:

- **Tier 1 Energy Value:** 300% of normal utility cost
- **Tier 2 Energy Value:** 150% of normal utility cost
- **Tier 3 Energy Value:** 100% of normal utility cost

[1] https://clean-coalition.org/disaster-resilience/
[2] https://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M344/K038/344038386.PDF

Using the above energy value multipliers, the annual VOR was estimated at $230,500. Note that Tier 1 load typically make up 20% of a site's total consumption. Because 81% of site loads were deemed Tier 1 by SARTC staff, VOR may be inflated above its typical amount. TRC encourages SARTC to further examine its critical load tiering.

Table 4: VOR Summary

Load Breakout	Electrical Use (kWh)	Existing Utility Cost ($)	VOR Multiplier	Resilient Energy Value ($/yr)	Resiliency Value Added ($/yr)
Tier 1 (81.0%)	670,058	$109,400	3.0	$328,200	$218,800
Tier 2 (17.3%)	143,111	$23,400	1.5	$35,100	$11,700
Tier 3 (1.7%)	14,063	$2,300	1.0	$2,300	$0
Total (100%)	827,232	$135,061		$365,600	$230,500

2.3 Funding Source Assessment

Please note all funding sources described below reflect current conditions, but funding availability is subject to change. TRC encourages SARTC to pursue funding as soon as possible to ensure access.

2.3.1 Infrastructure Investment and Jobs Act's (IIJA)

TRC evaluated and continues to monitor potential funding avenues available through the IIJA of 2021, which is expected to be disbursed over a five-year timeframe from 2022 – 2026. This assessment incorporated competitive and formula funding opportunities, new programs and existing programs that received additional funding or modified eligibility, programs for which the City could be a direct recipient of funds, and others for which partnerships would be required. TRC prioritized relevant opportunities based on the degree of compatibility between the intended use of the program funds and the scope of this project, the anticipated timeline of funding availability, competitiveness, and other factors. Priority opportunities include:

- Department of Transportation's Promoting Resilient Operations for Transformative, Efficient, and Cost-Saving Transportation Program
- The Department of Energy's Energy Efficiency and Conservation Block Grant Program
- Department of Homeland Security's Building Resilient Infrastructure and Communities Program

Eligibility requirements and timelines for these funding opportunities vary, and TRC continues to monitor for funding and application developments. TRC will reach out with next steps regarding pursuit of IIJA funds.

A list of available IIJA funding sources, ranked by feasibility, funding amount, and timeline, is included in Attachment D.

2.3.2 Federal Solar Investment Tax Credit (ITC)

Eligible: Option 2 ◆ Option 3

The ITC allows 26% of the solar PV system's cost to be deducted from income taxes. This credit drops to 22% in 2023 and to 10% in 2024. Because SARTC does not pay income taxes, this credit cannot be claimed if SARTC purchases the system outright at Year 0.

The *Standard PPA* and *PPA with Year 10 Buyout* ownership models take advantage of this credit by utilizing a private third party, capable of claiming the credit and passing down the savings.

2.3.3 Modified Accelerated Cost Recovery System (MACRS)

Eligible: Option 2 ◆ Option 3

U.S. tax code allows the cost of depreciated tangible property to be recovered via tax deduction. Accelerated depreciation rules allow the full tax basis, minus half the ITC, to be depreciated over a five-year schedule. Solar PV systems may claim bonus depreciation of 100% in 2022. This bonus depreciation is scheduled to drop by 20% each following year, reaching 0% in 2027. The total value of the reduced tax liability is equivalent to 25% of the project cost.

See Attachment E for ITC and MACRS program details.

The *Standard PPA* and *PPA with Year 10 Buyout* ownership models take advantage of this system by utilizing a private third party, capable of claiming the depreciation and passing down the savings.

2.3.4 Self-Generation Incentive Program (SGIP)

Eligible: Option 1 ◆ Option 2 ◆ Option 3

SGIP rebates are applicable to the SARTC microgrid project under the SGIP Equity Budget for non-residential customers. SGIP offers rebates[3] for battery systems serving sites that meet the following criteria outlined in the 2021 SGIP Handbook:

- Government agencies, educational institutions, or non-profit organizations; and
- Located in a Disadvantages Community (DAC)
- Peak discharge rating of BESS based on the 12-months of 2019 SCE utility data

The program offers incentives at $850/kWh for systems sized to power a facility for four hours, and $425/kWh for hours 5-6. See Section 4.3.2 for discussion of proposed BESS sizing relative to SGIP rebates.

2.3.5 SCE Charge Ready Transport Program

Eligible: Option 1 ◆ Option 2 ◆ Option 3

SCE's Charge Ready Transport Program has $432 million allocated to supporting EV charging infrastructure, as of Q3 2021. For public EV chargers, the program will pay for up to 80% of the infrastructure cost. See Attachment F for program details.

[3] SGIP funding availability fluctuates daily. To check available funds, go to: https://www.selfgenca.com/home/program_metrics/

3 SARTC Facility Description

The SARTC facility is a five-story, 47,000 square-foot facility with two ground level parking lots and one four-story parking structure. The building operates Monday through Sunday from 5:00 AM to 12:00 AM and hosts various tenants through lease agreements on the second and third floors of the main facility. As of May 2020, there is one vacant tenant space where a restaurant resided that currently does not have any solidified plans for occupancy. Services at SARTC include train, bus, taxi, and airport transportation services. The SARTC facility also currently hosts one dual port ChargePointEV charges for public use near the northwest parking lot.

3.1 Lighting and Heating, Ventilation, and Air Conditioning (HVAC)

A large portion of building interior and exterior lighting fixtures have been retrofitted to light emitting diode (LED) technology to reduce building energy consumption; however, some fluorescent lighting fixtures remain. The building's space conditioning needs are served by a series of 26 fan coils, served by 1 air-cooled screw chiller and 1 gas-fired boiler. Two chilled water pumps equipped with variable frequency drives (VFDs) serve the chilled water loop from the chiller unit, while two hot water pumps provide flow to the hot water loop. The domestic hot water is served by a newer hot water boiler.

3.2 Energy Efficiency Measures

The SARTC facility over the last five years has implemented a series of energy efficiency measure projects, as shown in Figure 4. Most impactful to reducing the building annual load were a retrofit of approximately 80% of the facility's interior lighting to LED with occupancy-based controls, full retrofit of exterior lighting to LED with photocells, replacement of fan coils that thermally condition the building's numerous spaces, and the addition of variable frequency drives to the chilled water pumps.

Figure 4: Energy Efficiency Measure Timeline

With these efficiency projects, building load has reduced, which directly reduces the size of renewable assets needed for a microgrid. However, there is still opportunity to retrofit the remaining non-LED interior lighting and potentially explore other energy efficiency opportunities such as implementing an energy management system or replacement of low-efficiency HVAC equipment that may be reaching its end of useful life.

3.3 Backup Generators

Two backup diesel generators, one 1983 Kohler Fast Response II 50 kW and a newer 2011 Generac 30 kW, located in the same mechanical yard as the chiller provide standby power to the following loads:

- Fire alarm system
- Security system
- Emergency lighting
- Smoke detectors
- Control panels
- Servers
- Motor Control Center (MCC) and Amtrak loads
- Panels EH and HS

Both generators have their own automatic-transfer-switches (ATS) and associated control panels. These backup generators and their control panels/ATS will need to be integrated into any proposed sequence of operations associated with a potential microgrid and microgrid controller. The project team determined the existing generators can integrate with the microgrid controller for the proposed microgrid system.

Additionally, one small uninterruptable power supply (UPS) for the building's main IT/server room was found on the second floor of the SARTC facility.

3.4 2019 Annual Building Load Summary

SARTC is served by four main electrical service meters under SCE's GS-2-TOU Option D rate tariff. This is a three-phase service type for less than 2 kV. Table 5 below provides a summary of the four meters composing the load used to estimate the total facility annual load and other metrics presented in the following figures.

Table 5: Electric Meter Summary

Facility	Meter #	SCE Rate Tariff	2019 Usage (kWh)
SARTC Main Building	V349N-016729	TOU-GS2D	637,607
SARTC Parking Structure	256000-104069	TOU-GS2D	95,644
SARTC Unit C	256000-036728	TOU-GS1D	71,152
SARTC Unit B	256000-036730	TOU-GS1D	22,829
		Total	**827,232**

Based on SCE monthly data provided by the client, during 2019[4] the SARTC facility consumed 827,232 kWh of energy with an annual peak demand of 162 kW. The following plots, shown in Figure 6, highlight the annual building load shapes for the SARTC facility on a seasonal demand basis.

Figure 5 below details the rate periods the site's energy consumption falls under across each month. The figure illustrates costs rising in the summer months as on-peak periods take effect. It is important to note

[4] 2019 SCE utility data was used due to the building load impact resulting from the onset of the COVID-19 pandemic in early 2020. More information provided in the COVID-19 Building Energy Consumption Impacts section of this report.

that SARTCs flat building load paired with the GS-2-TOU rate tariff's 4:00 PM – 9:00 PM peak demand pricing, makes this facility a prime candidate for BESS peak demand reduction bill savings through BESS peak shaving strategies.

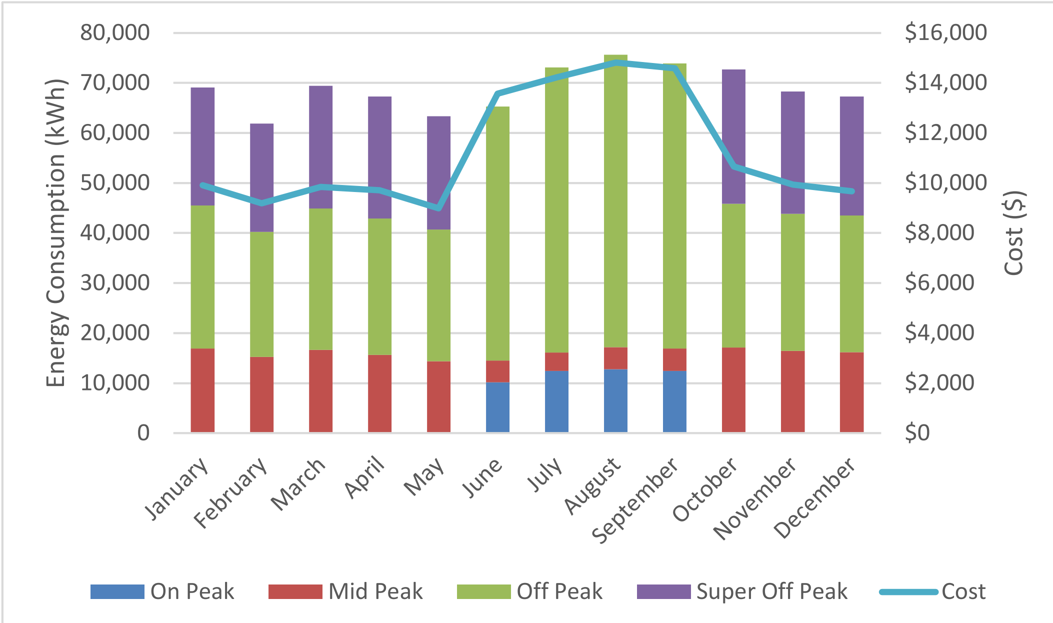

Figure 5: Seasonal Building Load Shape

Overall, the average daily energy consumption is flat and consistent throughout the year as expected, with August having the highest peak demand of 162 kW, as shown in Figure 6. Demand peaking alongside cost in the summer months demonstrates the large savings potential solar PV provides. Utility bill costs amounted to $117,950 for 2019.

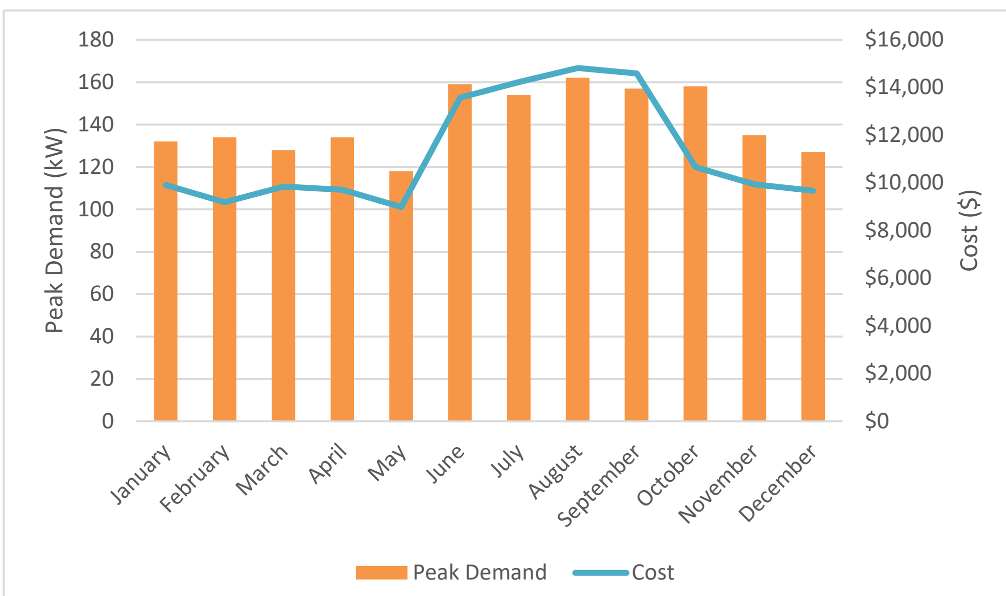

Figure 6: Average Daily Energy Consumption and Peak Demand

3.4.1 COVID-19 Building Energy Consumption Impacts

Based on SCE-provided 2019 and 2020 utility data, TRC analyzed a comparison of annual building energy consumption to estimate the potential impacts to building load due to the COVID-19 pandemic and respective shelter-in-place mandates. These closures of public facilities drastically reduced building occupancies across the nation, as many employees transitioned to a work from home schedule. Exploring and estimating load impact from COVID-19 is important because it informs the estimates for the capacities of the PV and BESS assets composing the microgrid.

Based on the utility data, the SARTC facility saw, on average, a 5% reduction in annual building energy consumption for 2020 compared to 2019. Figure 7 below provides a percent difference comparison of SARTC's monthly energy consumption in 2020 to that of 2019. Quantification of this change was important in determining if building load reduced significantly enough during 2020 from COVID-19 impacts to support the usage of 2019 utility data when sizing renewable assets and other associated electrical system components.

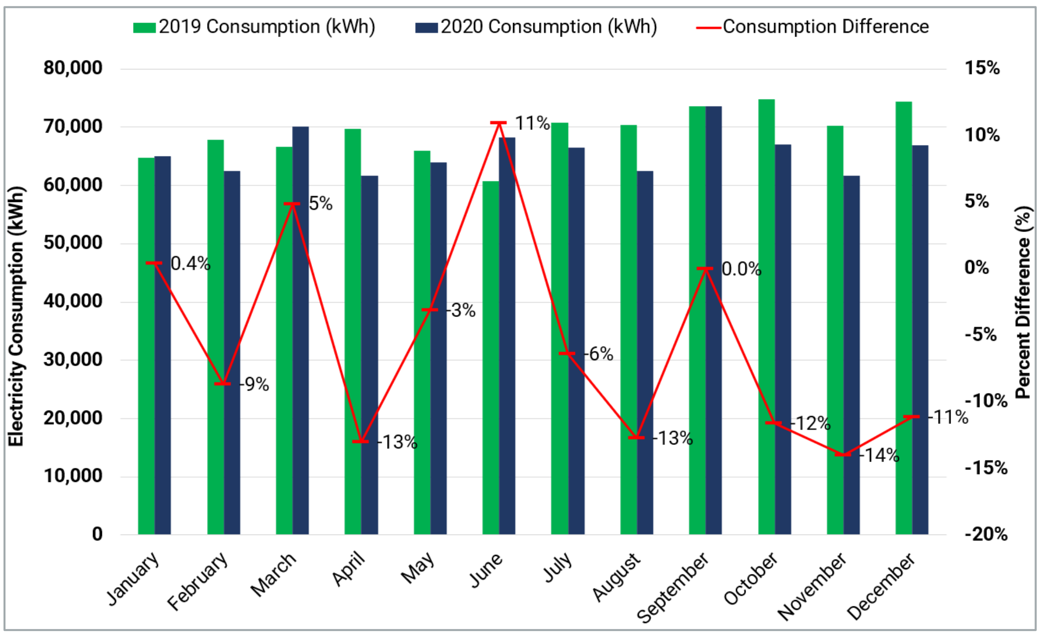

Figure 7: 2020 and 2019 SARTC Monthly Electricity Consumption Comparison

As seen in Figure 7, after April 2020, all months except for June saw monthly energy consumption lower than that of 2019. This timeline of reduced load corresponds with the end of March 2020 mandates from the California governor to shelter-in-place. With this observation of the confirmed impacts to building load resulting from COVID-19, our team opted to utilize the 2019 SCE utility data to ensure that PV and BESS assets are sized for more "business as usual" facility load operations.

3.5 Electrical Infrastructure Assessment Findings

During the site visit on February 24th, 2021, electrical panels were identified to be in fair to good condition; however, most of the subpanels have been modified over the years to accommodate new and changing electrical loads. Specifically, a new 30 kW diesel generator was recently added to pick up additional critical load during outages beyond the original diesel generator, and portions of the building are vacant—thus requiring low electrical demand (restaurant space and various unoccupied office areas). The diesel generators are used during outages to serve critical loads (fire alarm system, security system, lighting, smoke detectors, control panels, servers, MCC, and Amtrak loads) and serve panels EH and HS. The other floor's electrical load consists of lighting, HVAC, outlets, and emergency circuits for office space, including critical computer loads on the second floor.

The two electrical rooms for the pedestrian bridge serve the two elevators, UPS, sump pumps, Capacitor Coupled Voltage Transformer (CCVT), lighting, HVAC, ticket booth, gate opener, and alarms for the structure. Similarly, the parking structure electrical system serves lights, elevators, rollup doors, fire booster pump, elevator sump, security, entry gate, east and west cashiers booths, elevator machine room, pit and elevator main control, a high current unit.

Additional space on the existing electrical panels is limited, especially if the vacant restaurant and office and spaces are intended to be used in the future. However, most of the critical load is already sectionalized into certain panels, like panel EH and HS on 1st floor of the main building.

3.6 Structural Infrastructure Summary

TRC conducted a visual structural assessment of the SARTC parking structure to determine its condition. Following the site audit, the team's structural engineer determined the site was in fair condition; however, a complete engineering-grade assessment of the structure would be required. After discussion with the city, the parking structure was removed as a PV siting candidate due to added costs required for detailed structural analysis.

4 Microgrid Analysis

This section presents the specific analyses findings and stakeholder engagement outcomes, to date, required to inform the renewable asset sizing, locations, and required electrical infrastructure upgrades needed to accommodate a microgrid. The following items include but are not limited to:

- Identification and quantification of the facility's critical loads and stakeholder consensus on tiering of critical loads as it applies to load shedding capabilities.
- Sizing of the PV and BESS assets to serve as onsite renewable generation.
- Viable siting locations for both PV and BESS assets.
- Analysis of future load growth.
- Proposed modification to existing electrical infrastructure.
- EV charger assessment and sizing.

4.1 Critical Load Analysis

This section provides a high-level summary table of the preliminary critical loads tier list for the SARTC facility based on the site audit findings, electrical drawings, and Single Line Diagrams (SLDs) provided by the city. Tier 1 indicates a mission critical load that is life-sustaining or crucial to maintaining operations during the event of an outage; Tier 2 indicates a priority load that is important but not crucial to maintaining operations during an outage; Tier 3 indicates a discretionary load and is typically the remainder of the building loads to be served[5]. This tiering allows for systematic load shedding capabilities during outages that will aim to ensure onsite PV and BESS assets maintain the most crucial loads necessary for facility operations. The tiering approach also allows for PV and BESS assets to be optimally sized, reducing capital costs and underutilization.

During a client meeting on July 22, 2021, the team received client and stakeholder feedback on the initial tiering of critical loads so to ensure consensus was reached on what the Tier 1 (critical), Tier 2 (priority), and Tier 3 (discretionary) loads were at the SARTC facility. Table 6 provides a high-level summary of the tiering summary of loads as decided on by the city:

[5] Critical load tiering methodologies were adopted from Clean Coalition and can be referenced here: https://clean-coalition.org/news/value-of-resilience-to-proliferate-community-microgrids/

Table 6: Critical Load Analysis Summary.

Site	Tier 1 – Mission Critical Loads	Tier 2 – Priority Loads	Tier 3 – Discretionary Loads
SARTC	1. Loads presently served by two generators: a. (1) Main Building Elevator[6] b. Emergency Lighting Circuits (All Floors) c. Fire System/Alarm d. Security System e. Generac Control/Battery Charger 2. MCC, and Boiler Controls Panels 3. Amtrak Loads 4. 2nd Floor Server Room 5. 1st Floor Lighting and Plug Loads 6. 1st Floor AC Equipment (Ventilation and Cooling) 7. Pedestrian Bridge Lighting 8. Parking Structure Emergency Lighting 9. (2) Pedestrian Bridge Elevators[6] 10. AC Systems for Tenant Server Rooms	1. 2nd, 3rd, Floor Plug Loads (Receptacles) 2. 2nd and 3rd AC Equipment (Ventilation and Cooling)	1. 2nd, 3rd, 4th, and 5th Floor Lighting 2. 4th and 5th AC Equipment (Ventilation and Cooling) 3. All Other Remaining Building loads 4. Vacant Offices and Restaurant Space
Total NC[7] Peak kW	131.3 (81%)	28 kW (17.3%)	2.7 kW (1.7%)

The table above details the loads assigned to each tier of criticality, based on discussion with SARTC staff. It is important to note that the Tier 1 load consensus accounts for much of the building load, which will reduce the number of hours the facility can operate solely off the BESS when solar resource is absent. The percentages of noncoincident (NC) peak demand represent the percentage of total building load for which each of the three-tiered critical loads accounts. By using the NC peak demand to model BESS consumption during an outage, a worst-case scenario, typical of summer in this climate zone, is captured. Meaning, all other months of the year, the NC peak demand will be less—therefore, the facility will be able to run solely off the battery for a longer duration of time.

[6] Required to maintain ADA compliance.

[7] Non-coincident (NC) peak demand refers to the customers maximum energy demand during nay stated period of an annual billing cycle.

4.1.1 Load Shedding

By characterizing the critical load tiers, this priority list serves as the priority circuit inputs to programming a microgrid controller that will, during an outage, isolate the microgrid system from the grid and subsequently begin to shed the Tier 2 and 3 loads. In that time, it is also recommended that the Tier 1 loads be operated conservatively by building staff, so to optimize the available PV and BESS energy usage during the outage. The high level microgrid controller sequence of operations is included in Appendix A: Sequence of Operations.

4.2 Outage Simulation Sensitivity Findings

By pairing the City's designated 81% Tier 1 critical load with the proposed 492 kW_{DC} Carport PV array and 648 kWh/162 kW BESS (4-hour) assets, a simulation was developed to determine how the proposed system would respond during a simulated 32-hour outage. Given that the majority of building load was deemed critical load, this simulation does include the generator as a backup asset, connected to the microgrid, that the building can fall back on when PV and BESS are no longer available. Subsequently, a sensitivity analysis was conducted to explore how required generator run time during the 32-hour simulated outage varied as a function of Tier 1 critical load reduction. The findings from the outage below reflect a summer August day during which Southern California cooling and building loads are typically high. The grid outage runs from 8:00 AM in the morning on day one through 4:00 PM the next day (day two). The findings of the baseline and sensitivity analysis are provided in Figure 8 for this simulation.

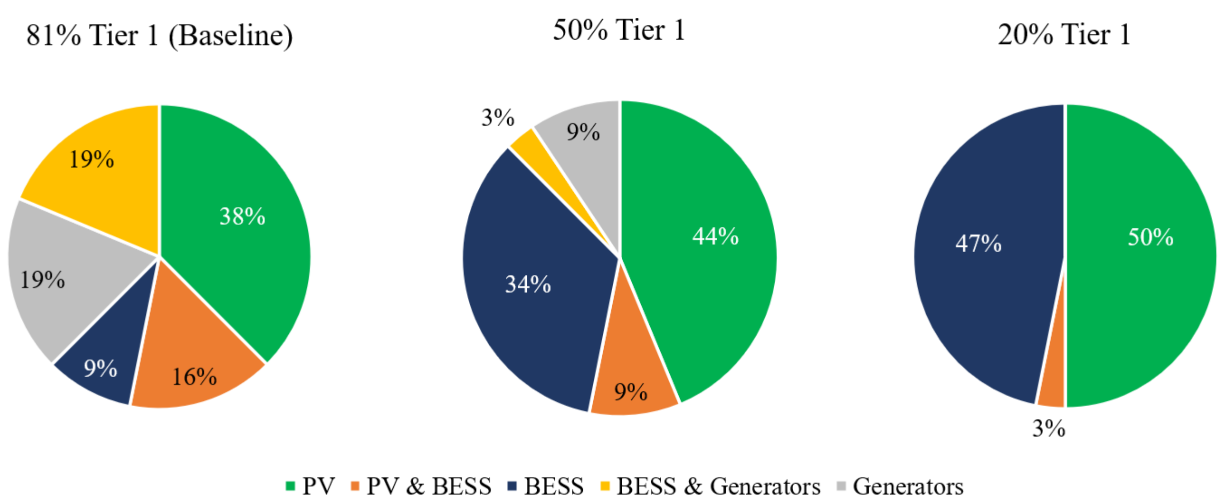

Figure 8: Required Tier 1 Generator Runtime

This sensitivity analysis aims to highlight the importance of the facility shedding as much non-critical load as possible during an outage to prolong the duration for which their renewable energy assets can support the load. The sensitivity analysis identifies that the baseline scenario requires the generator to support the building load for approximately 12 hours in order to maintain 81% of the building load, once PV and BESS are no longer available. By reducing the critical load by 31%, the generator would only need to run for 3.5 hours; finally, reducing the Tier 1 critical load to 20% of normal building load would allow the building to run entirely off renewable energy assets. TRC recommends that Tier 1 load reduction be re-assessed during the project design stage.

4.3 Onsite Renewable Asset Sizing

This section outlines the sizing approach for both PV and BESS assets, along with major assumptions and constraints used during the sizing and siting analysis.

4.3.1 Carport PV Approach

It was determined, following client engagement, that preferred siting for PV assets were throughout the east and west parking lots adjacent to the SARTC facility through deployment of carport PV. The following key criteria were used for sizing the carport PV assets to ensure system resiliency, while minimizing footprint and capital costs:

- Size PV capacity to meet 2019 annual building energy consumption
- Utilize market available 400-Watt PV modules
- Carport PV design assumes a tilt of 5° and a canopy height of 15 ft. (at lowest point)
- Design for panel shading less than 5% per module and system-wide
- Target inverter load ratio between 1.20 and 1.30
- Employees and visitor parking were assumed to be a potential area for carport PV
- If possible, locate carports in one parking lot to reduce wire runs and trenching requirements on site
- Assume tree removal/relocation is acceptable

4.3.2 BESS Sizing Approach

The BESS sizing was conducted based on adhering to the CPUC-provided SGIP requirements for sizing an energy storage system with backup capability.

The system was sized to maximize the utility bill savings associated with the energy and demand charges realized by the BESS deployment on an annual basis. This was done by maximizing the amount of BESS peak shaving utilization to reduce building load during the SCE designated peak demand period during the hours of 4:00 PM and 9:00 PM.

Finally, two BESS capacity options were analyzed:

1. Minimal project cost 4-hour discharge BESS
2. Maximum resiliency 6-hour discharge BESS

Option 2 above only receives the 100% of rebate amount ($850/kWh) for the first 4 hours of rates discharge duration, while hours 5-6 only receive 50% of the rebated ($425/kWh). Option 2 is provided with the intent to allow the facility to operate longer solely from the BESS; however, this option will have a higher capital cost and a larger footprint. Lastly, it is important to note that for any BESS durations greater than 6 hours, no SGIP incentive is provided—given the project team's goals to minimize projects costs, battery durations greater than 6 hours were not explored. The BESS duration comparison was deemed valuable to present to the client for the purpose of comparing the minimal cost Option 1 to that of a more resiliency focused BESS (Option 2).

Based on discussions with SARTC, Option 2 was identified as the most desirable option, and it was the subject of all energy savings and financial analysis.

BESS Siting Constraints

The following siting constraints were used to identify potential location options for the BESS asset at the SARTC facility:

- Assume BESS is placed outdoors, not in a walk-in housing unit
- Adhere to California Fire Code 2019 Chapter 12 Section 6
  - Areas within 10 feet on each side of energy storage system (ESS) shall be cleared of combustible vegetation and other combustible growth
  - ESS located outdoors shall be separated from any means of egress as required by fire code officials to ensure safe egress under fire conditions, but in no case, less than 10 feet (CA Fire Code 1206.8)
  - Adhere to Table 1206.8 of California Fire Code 2019 for outdoor ESS installations
- Aim to minimize distance from main electrical room, if possible, to reduce trenching and wiring runs

4.3.3 Asset Siting and Sizing Overview

Figure 9 below provides an overview of the PV and BESS siting and sizing to meet the criteria and sizing requirement outlined in the previous two sections. The project team and modeled and provided two layouts to present the 4-hour and 6-hour system capacities, siting, and associated estimated bill savings. Based on discussions with the City, final energy and financial analysis was performed on the 6-hour system.

The proposed system will necessitate the removal of 37 parking lot trees. Tree removal is built into costing calculations.

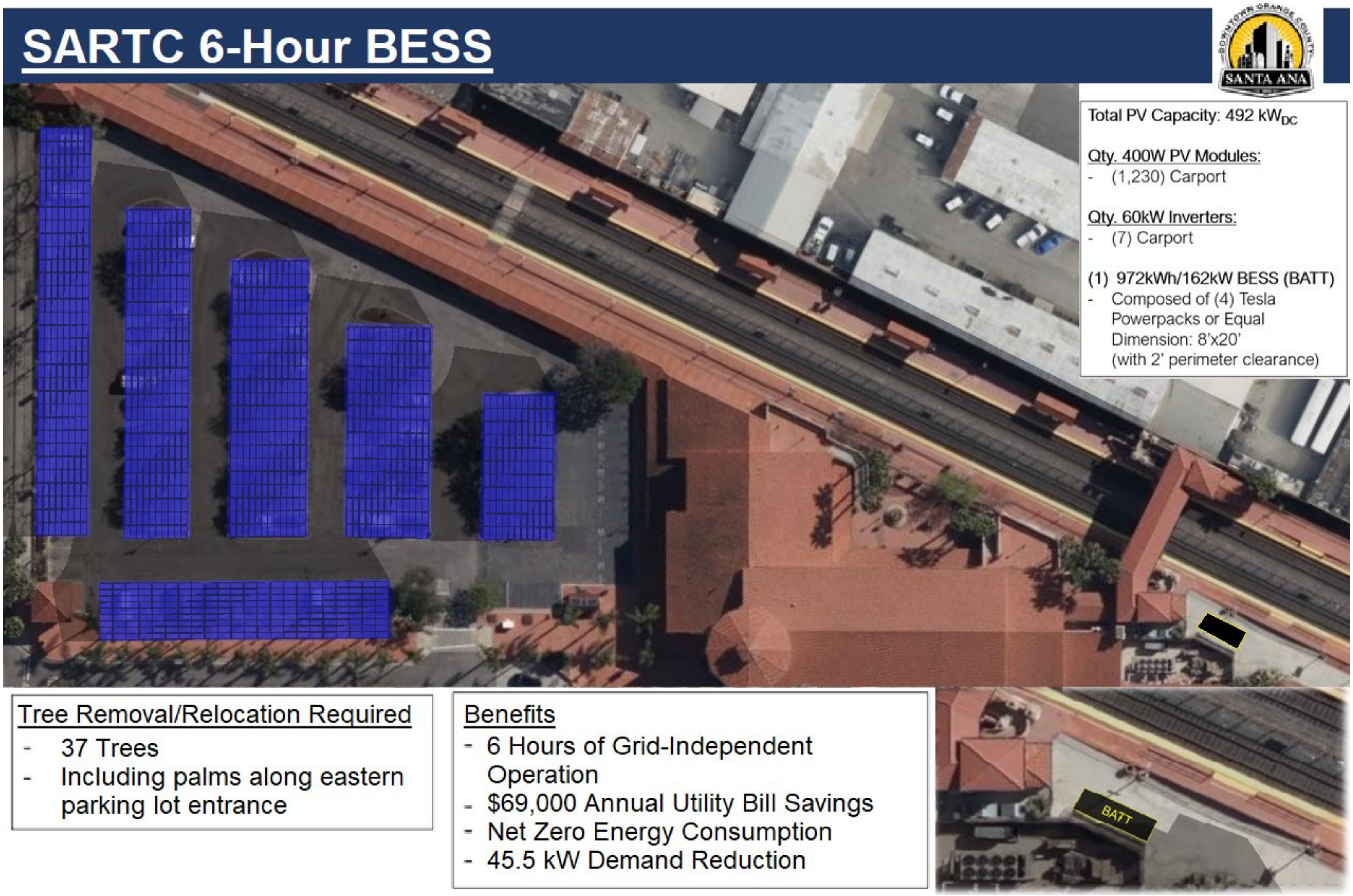

Figure 9: Renewable Asset Summary with 4-Hour BESS (Option 1).

Battery Storage Siting Viability

The proposed BESS location, shown in the figures above, was selected based its proximity to the main electrical room, ability to be sited at least 10 feet from enclosed buildings, and location (away from any vegetation). Other locations considered for BESS sizing are provided in Figure 10 below.

Figure 10: Potential Alternative (alt) Locations for Battery Siting

It is important to note that Alternative 2 (Alt 2) and Alternative 3 (Alt 3) locations in Figure 10 would require tree and vegetation removal to be compliant with California fire code. All the proposed alternative locations would require a concrete pad mount be poured to install the BESS modules and intercomponent, along with a recommended enclosure around the perimeters of the pad mount to stop tampering and vandalism. The BESS location would also need to be surrounded by bollard posts to protect the system from passing vehicles and buses. A final alternative is to place the system on the enclosed ground level floor of the parking structure; however, many more fire code compliances must be met for this installation location.

4.4 Load Growth Asset Sizing Analysis

Energy usage at SARTC is projected to increase in future years. TRC performed high level analysis of solar PV and BESS system sizing that would be necessary to accommodate load increases of 2.5% - 15%, presented in Table 7 below. The 0% growth case represents the size used for energy and financial analysis.

Table 7: Load Growth Projection Summary

Growth Rate	0.0%	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
Battery System Size	972 kWh	997 kWh	1,021 kWh	1,045 kWh	1,070 kWh	1,094 kWh	1,118 kWh
Solar PV System Size	492 kW	504 kW	517 kW	529 kW	541 kW	554 kW	566 kW
Net Project Cost ($)	$4,103,000	$4,162,000	$4,221,000	$4,280,000	$4,339,000	$4,398,000	$4,457,000

At the greatest load case analyzed (+15%), the required carport footprint increases from 30,200 square feet to 35,280 square feet at 566 kW. Spatial analysis of the front SARTC parking lot reveals it is capable of accommodating a system up to 615 kW.

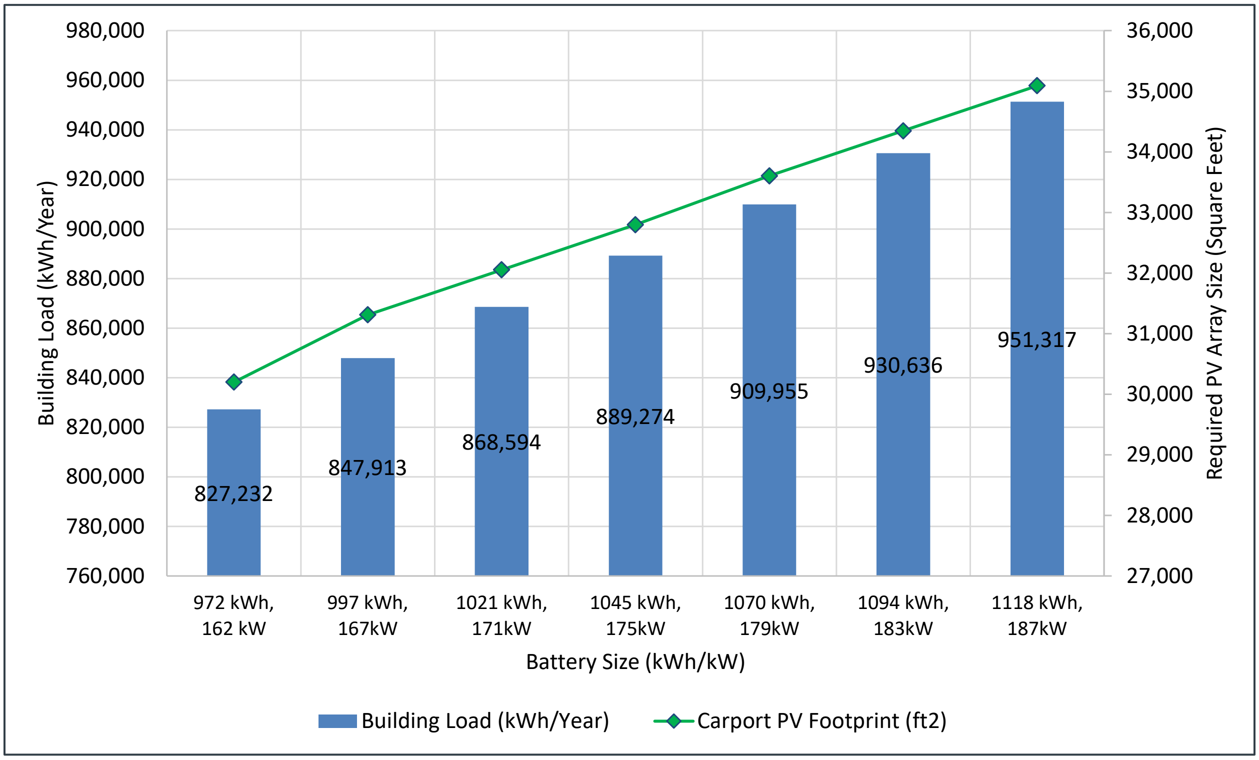

Figure 11: Load Growth Siting Projection

The proposed BESS will not increase in footprint across any growth cases—calculations assume a BESS equivalent to a Tesla MegaPack, which is stored inside a shipping container with storage potential of 3,000 kWh, far greater than the maximum analyzed size of 1,118 kWh.

4.5 Electrical Infrastructure Modifications

A TRC senior electrical engineer audited the site to determine modifications to the electrical infrastructure that will be required to accommodate the proposed microgrid system.

To implement the microgrid according to the SGIP operational requirements, it will be necessary to install power controls to isolate or connect the various load tiers to the main distribution panel. Furthermore, the PV and BESS systems will require similar power controls.

The existing distribution switchboard is located at ground level, adjacent to the Mechanical Room. The switchboard is comprised of feeder circuit breakers that feed other MCCs and distribution panels throughout the complex. This panelboard was manufactured for the purpose of providing a centralized main power distribution in the enclosure without requiring space for power controls, and the electrical room has no additional space for new equipment. Therefore, new infrastructure solutions must be located outside of the electrical room.

TRC evaluated several electrical infrastructure solutions, including the possibility of mounting individual power contactors, one for each existing feeder circuit breaker, in the existing panelboard. This was not further explored due to the inherent cost of material and labor to mount contactors and extend circuits. Another drawback would be the electrical system downtime installing the equipment.

TRC recommends the following electrical infrastructure upgrades:

- Install a new outdoor switchboard, complete with main bus, feeder circuit breakers, and power contactors. The available space is outdoors in a protected electrical area, adjacent to the electrical room.
- Connect the PV and BESS systems, with their own DC/AC inverters, to the main 480V distribution panel.

The estimated installed cost of the recommended infrastructure improvements is $892,500 – 22% of the proposed project cost. Engineering drawings, as well as a list of materials of the proposed system are provided in the Attachments section.

4.6 Energy Generation & Cost Savings Analysis

TRC modeled the proposed solar PV system using HelioScope, a meteorologically and location-dependent solar resource, to estimate its annual monthly generation profile.

The generation profile of the proposed solar PV system can be viewed in Figure 12 below. Meteorological PV generation data was sourced from the National Solar Radiation Database; the solar intensity map is visible in . As expected, the system generates the majority of energy when sunlight is most intense. This causes most generation to occur during the most expensive summer months, but also fall predominantly within *off peak* and *super off peak* periods. This profile demonstrates the large utility savings benefit that can be achieved via BESS load shifting.

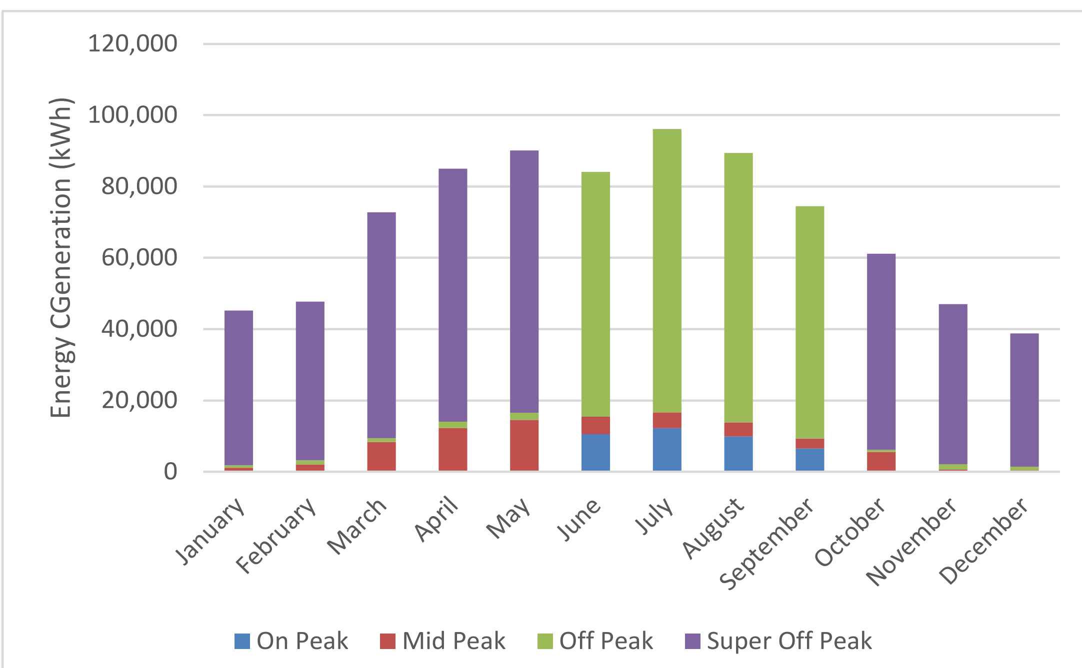

Figure 12: Energy Generation Profile

The solar PV generation profile was fed into Energy Toolbase® (ETB), a TOU BESS and utility cost analysis tool that compared the generation profile vs the building's hourly consumption interval data.

The ETB analysis was used to simulate BESS operation throughout the year and to calculate utility cost savings with hourly utility rate sensitivity. The ETB generated plot below indicates a typical day of the following performance metrics for the proposed solar + battery storage assets as well as the utility grid and building power:

- **Current Demand (Dark Blue):** Instantaneous building power demand before solar + storage.
- ***Net Demand (Light Blue):*** Instantaneous building power demand after solar + storage:
  - This metric can also be viewed as the energy required to be sourced from the utility
- **Solar Power (Green):** Energy generated from the existing solar assets
- **Battery Power (Yellow):** Instantaneous power delivered to meet building demand (positive value) or instantaneous power sent to the battery from excess solar power (negative value):
  - This metric can also be interpreted as storage discharging (positive values) or charging (negative values)
- **Battery SOC (Red):** Instantaneous storage state of charge throughout the day (referenced to the second y-axis on the right side of the plot)

The difference between Current Demand and proposed Net Demand in Figure 13 below represents the savings provided by the microgrid. Notice the BESS minimizes utility costs by bringing Net Demand to zero from 4:00 PM to 9:00 PM, avoiding any electricity purchase from the grid when it is most expensive.

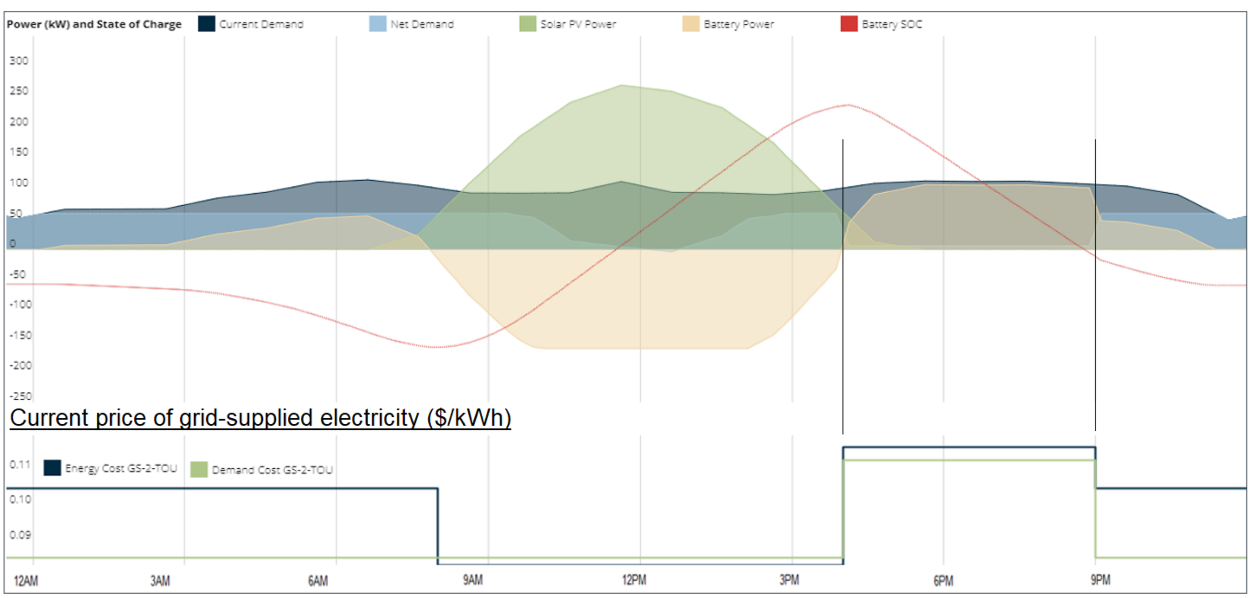

Figure 13: BESS Representative Daily Discharge Behavior

4.7 EV Chargers

Title 24, Part 11, "CALGreen", established minimum EV charger infrastructure requirements for new parking lot construction or major alteration as of 2020. The parking lots being modified contain 178 parking spots—at this quantity, CALGreen code requires infrastructure for 10 EV chargers on the premises. TRC recommends construction of both the infrastructure and chargers.

TRC assessed the northeast and west parking lots for carport PV siting. Figure 14 below provides an aerial view of the two potential carport PV siting locations relative to the main transit station. Images were captured from the vantage point of the main building's fifth floor. The parking structure was not preferred by the client for siting of carport PV; therefore, no future exploration was made into this option.

Figure 14: Aerial View of EV Charger Locations Assessed

Figure 15 provides a top-down view of the two EV Charger siting options. The two placements minimize required trenching and additional ADA accommodations.

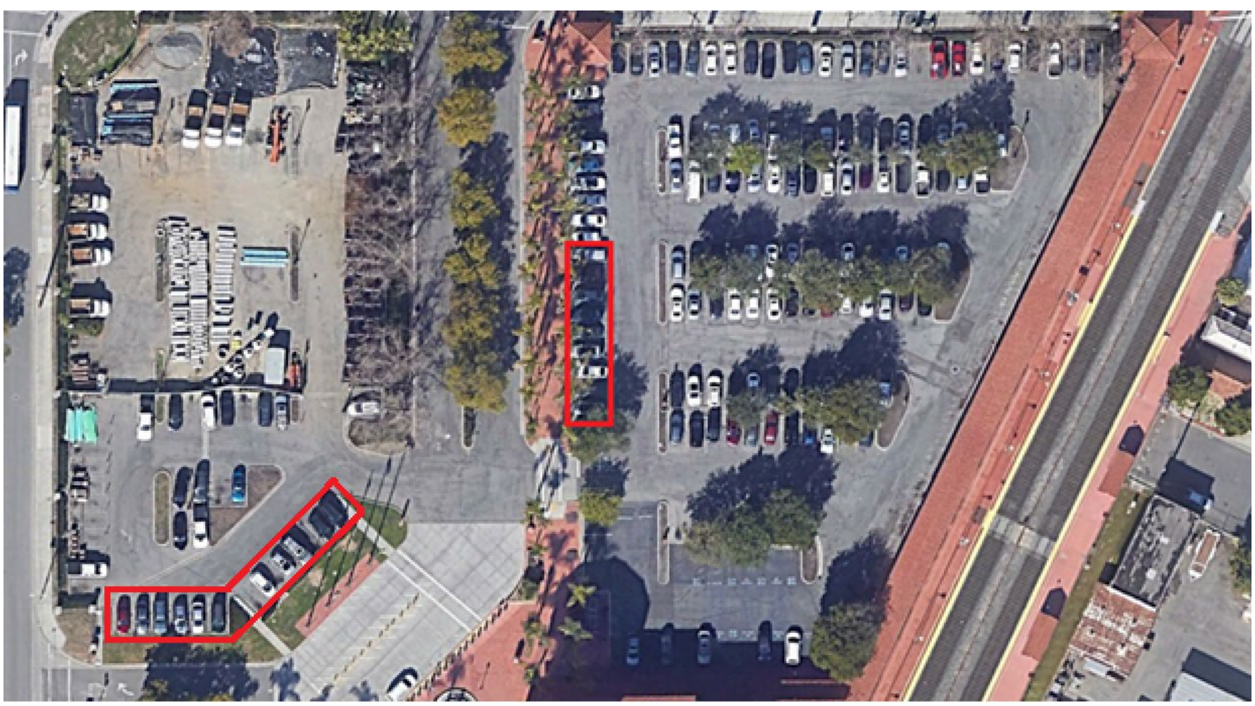

Figure 15: Proposed EV Charger Location

TRC recommends installation of Level-2 chargers, sized at 6-kW output. Transportation powered by the EV chargers is estimated to output 5.5 annual metric tons of CO_2e less than conventional gasoline transportation.

EV charging stations may be metered separately on a reduced utility rate structure (TOU-EV-7). Charging stations will require an internet connection for usage tracking. Financial calculations assume the chargers offer electricity at a rate equal to the site's utility rate, thereby incurring zero net operating cost to SARTC.

Funding for EV charger infrastructure installation and maintenance is available through the SCE Charge Ready program. See Section 2.3.1 for details.

5 Appendices

5.1 Appendix A: Sequence of Operations

SARTC, located at 1000 E Santa Ana Blvd, Santa Ana, CA 92701, will have the following generation assets:

- 492 kWDC of solar PV panels located on carports in the north-east parking lot
- One (1) 162kW / 648 kWh BESS
- Existing: One (1) 1983 Kohler Fast Response II 50 kW and one (1) 2011 Generac 30 kW

The facility currently has a maximum electric demand (as determined by 15-minute interval data) of 162 kW and an average demand of 94 kW. No energy efficiency measures are proposed at the SARTC facility, so these values are expected to remain unchanged.

5.1.1 Blue Sky Operation

Under ordinary conditions, the facility will be grid-tied and net metered. Any PV production in excess of the facility's current demand may be used to charge the BESS or, if not needed for this purpose, exported to the grid. When the facility's demand exceeds PV production, power will be drawn from the grid and/or from the BESS to make up the difference.

The BESS will, as determined by the system operator, be intermittently used to shave the facility's demand peaks (reducing the associated demand charges on the city's utility bill) or to provide excess power to the market when available.

The BESS will not be charged from grid power except as required to support ancillary services, and the diesel generator will be physically disconnected via an ATS and not in use.

5.1.2 Microgrid Operation

Upon a loss of grid power, contactors on the facility's main feed, on the solar PV inverters, on the BESS, and on the facility's individual electrical panels will all automatically open—isolating the entire facility from the grid and isolating all generation sources and loads from each other.

The microgrid controller will then, via UPS power, switch into island mode and begin to bring things back online. First, the BESS contactor will be closed, and the BESS will begin discharging in grid-forming mode. Once a stable AC waveform from the BESS is established, the contactor on the facility's critical loads panel will be closed, bringing it back online. Contactors at the PV inverters will then begin to be closed in sequence, bringing them online following the waveform generated by the BESS and stepping up available generation capacity. As additional PV inverters are brought online, contactors at additional electrical panels will be closed, bringing loads online as generation capacity is made available to support them.

If/when PV production exceeds the facility's demand, it will be used to begin recharging the BESS. If/when PV production exceeds the facility's demand and what the BESS can absorb combined, contactors at individual PV inverters will be opened as needed to curtail production.

If/when the building's demand approaches the available power from the BESS + PV, but the BESS itself still has stored energy available, contactors on some of the facility's non-critical electrical panels will be reopened to manage the load and keep it within what the microgrid is able to provide.

If/when the BESS nears depletion, and PV production alone is not sufficient to support the facility's critical loads, the microgrid controller will command the ATS to switch the facility's critical loads over to diesel generator power. The existing diesel generators are assumed to not be able to accept commands from the microgrid controller directly, but it will automatically start up when the ATS connects it. The contactors at all other electrical panels will be opened and all non-critical loads taken offline.

While the facility's critical loads are operating on diesel power, any available generation from the PV will be used to recharge the BESS, up to the BESS' maximum power rating. If/when the BESS reaches full charge, or PV production alone exceeds the facility's current demand, the microgrid controller will command the ATS to switch the facility back to PV+BESS power, which will cause the generator to automatically shut down. This process of switching back and forth between PV+BESS and generator power may be done as many times as needed, but the generator and the PV+BESS will never power any part of the facility simultaneously, as the configuration of the ATS is designed to physically prevent an electrical connection between them from ever existing.

When the microgrid controller detects a return of grid power, it will wait a minimum of five minutes to ensure grid power is stable per standard reconnect delay requirements. It will then command the contactor on the facility's main feed to close and return to blue sky operation. Any open contactors at PV inverters and/or the facility's electrical panels will be closed. If the generator is running, the ATS will switch the facility back to grid-tied mode and the generator will automatically shut down. The PV inverters and/or BESS, if active, will synchronize to the grid.

6 Attachments

Attachment A - Primary Calculations

Attachment B - PPA Analysis

Attachment C - VOR Analysis

Attachment D - Funding Analysis

Attachment E - ITC Details

Attachment F - Charge Ready Details

Attachment G - Microgrid SLD