Clean Coalition

San Marcos High School Solar Microgrid

Economic, Environmental, and Resilience benefits

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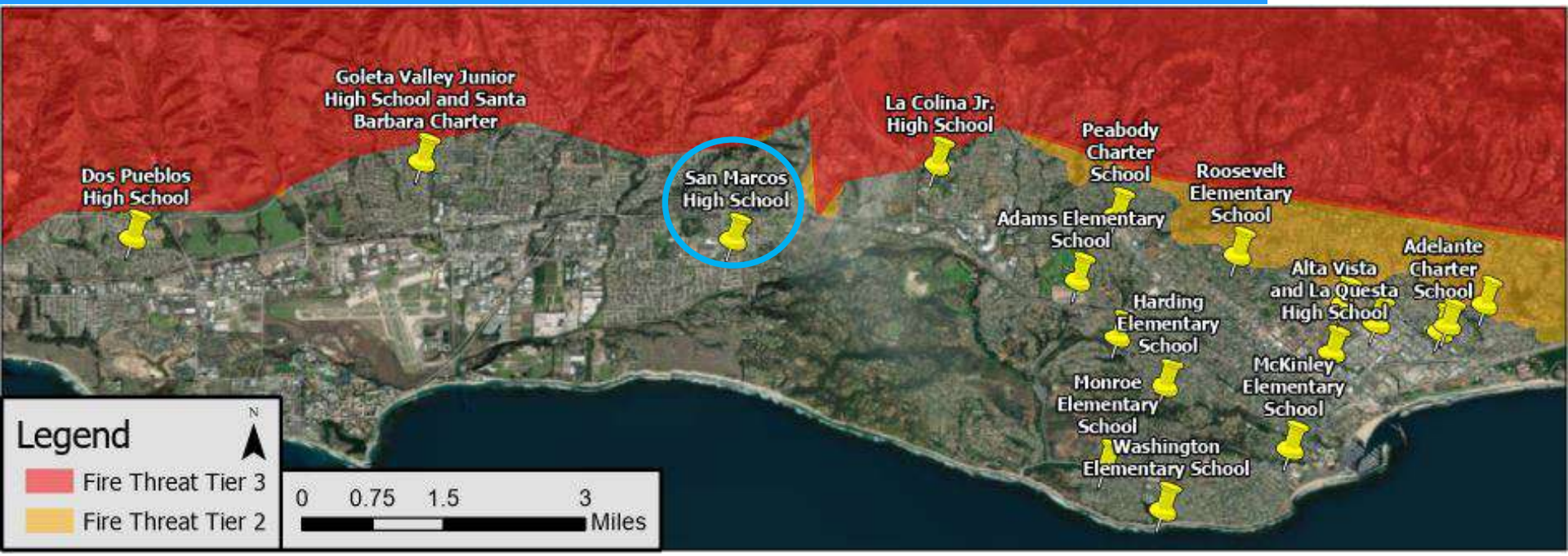
Santa Barbara Unified School District (SBUSD)

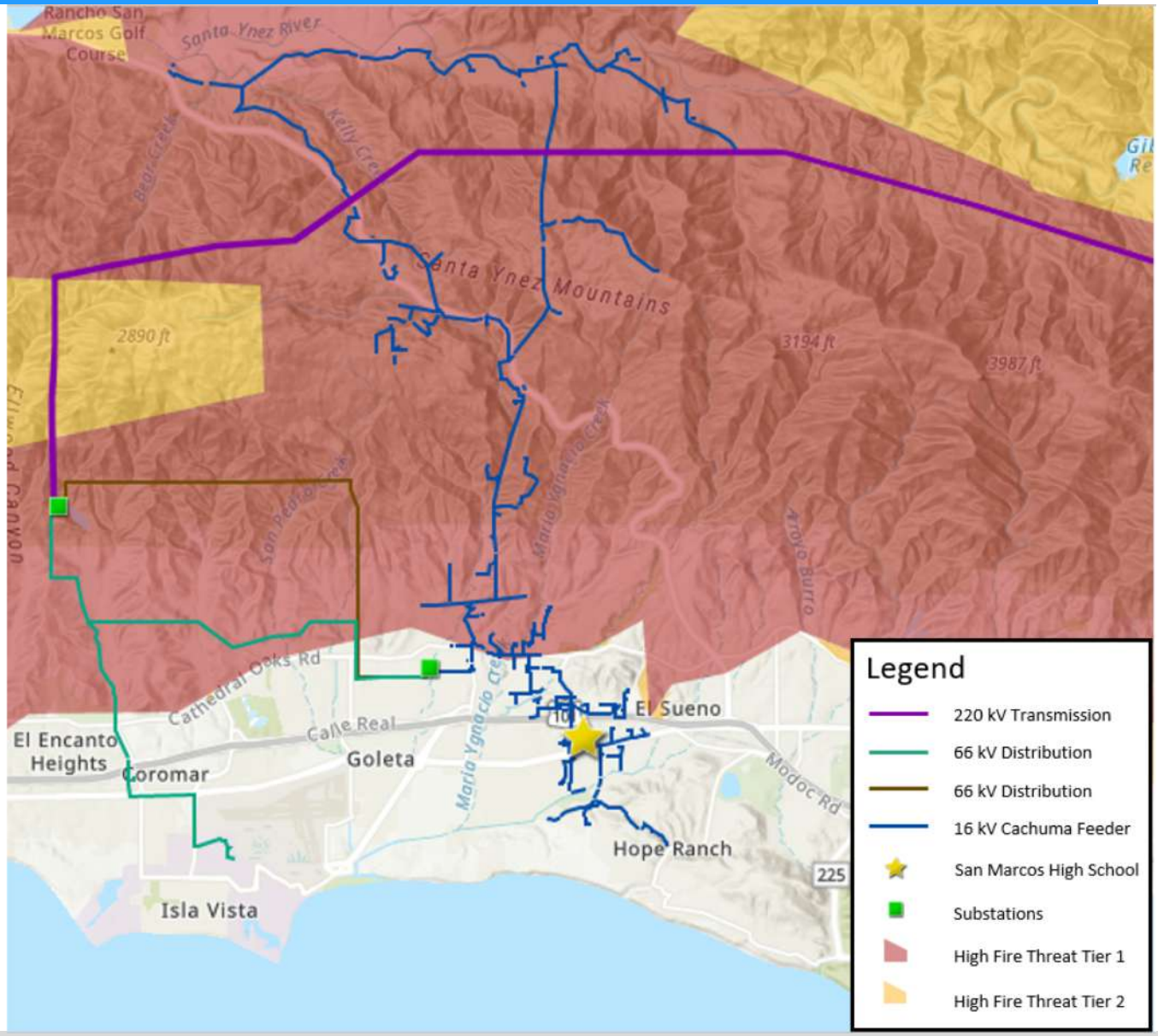


- The entire Santa Barbara region is surrounded by extreme fire risk (earthquake & landslide risk too) and is extremely vulnerable to electricity grid outages.
- The SBUSD is a major school district that increasingly recognizes the value-of-resilience (VOR) and has embraced the Clean Coalition's vision to implement Solar Microgrids at a number of its key schools and other critical facilities.
- SMHS is in the middle of the extensive SBUSD service area.

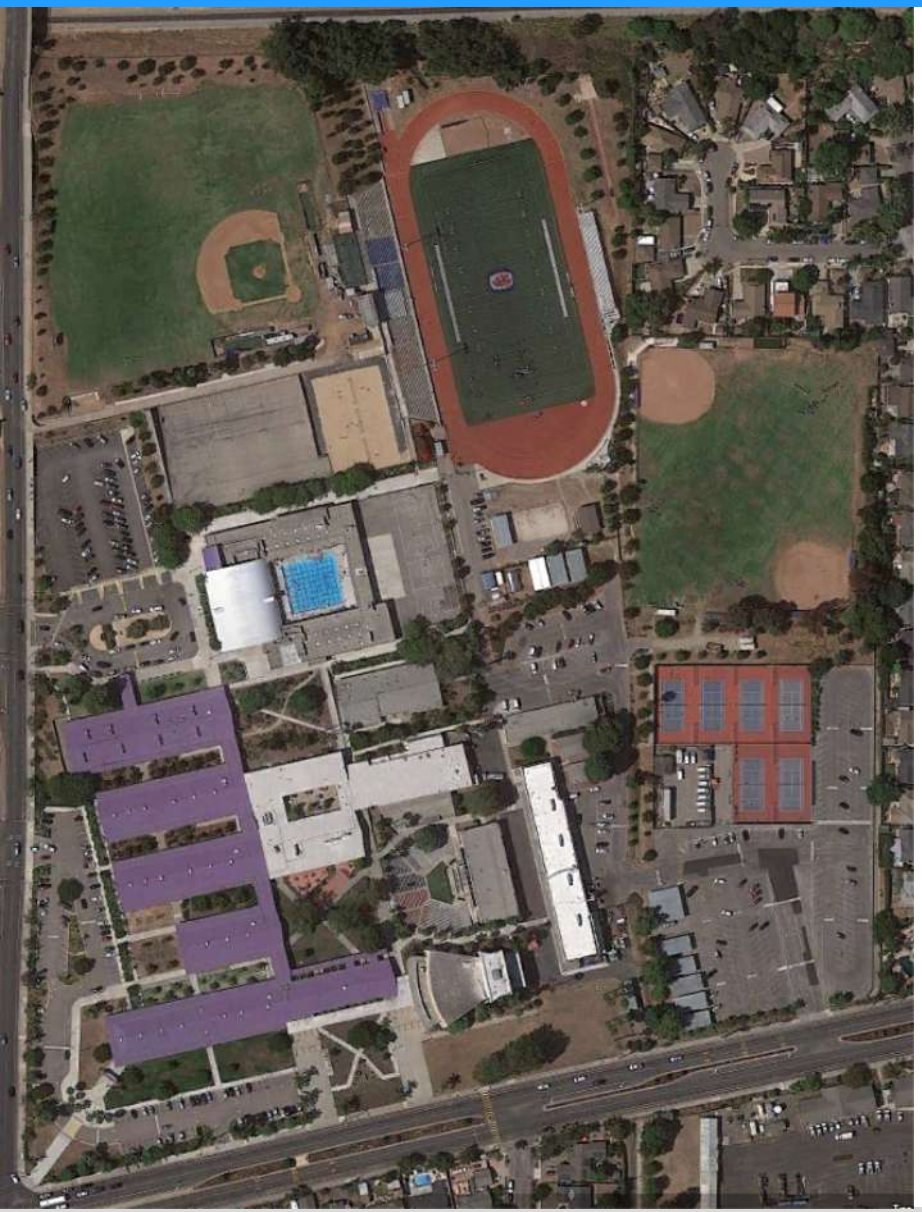
SMHS is vulnerable to long transmission outages

- SMHS is located in the middle of one of the most grid vulnerable regions in California: the **Goleta Load Pocket (GLP).**
- The GLP spans 70 miles of California coastline, from Point Conception to Lake Casitas, and encompassing the cities of Goleta, Santa Barbara (including Montecito), and Carpinteria.
- The GLP is served by a single 40-mile transmission line routed through mountainous and disaster-prone terrain.
- Southern California Edison (SCE) has identified the GLP's transmission path as being **vulnerable to catastrophic failure from fire, earthquake, and/or landslides that could cause a crippling, extended blackouts of weeks or even months in duration.**

SMHS is vulnerable to distribution outages



San Marcos High School (SMHS)



- SMHS is a large public high school serving just over 2,000 grade 9-12 students.
- Red Cross emergency sheltering facility.
- School features include:
  - Array of classroom buildings
  - Large Pool
  - Gymnasium
  - Football stadium
  - Multiple baseball fields
  - Cafeteria
  - Outdoor Greek theater
  - Auditorium
  - Numerous tennis & basketball courts
- Craig Lewis in the Class of 1981.

SMHS Solar Microgrid overview

The SMHS Solar Microgrid is intended to enable the school to operate independently during grid outages of any duration with **indefinite resilience for the most critical loads** and **resilience for all loads for significant percentages of time**.

- **Solar**
  - 723 kWp
  - Solar is entirely in the form of solar parking canopies
  - Net Zero Energy (NZE) is exceeded at 101%
- **Battery Energy Storage System (BESS)**
  - 710 kWh energy capacity
  - 355 kW power capacity
- **Critical (Tier 1) loads**
  - Food service refrigerators & freezers, maintained indefinitely
  - 4.36 kW of average load
  - 3.44% of total average load
- **Priority (Tier 2) loads**
  - Gym lights and Main Distribution Frame, maintained at least 80% of the time
  - 4.32 kW of average load
  - 3.41% of total average load

Load tiering and valuing resilience ("VOR123" methodology)

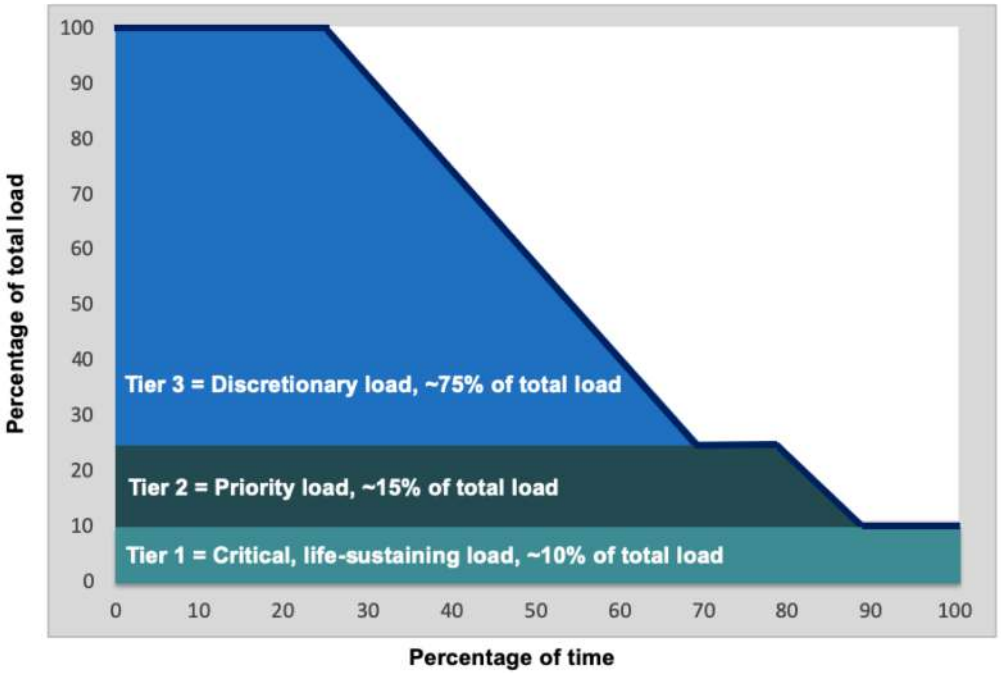
Load Tiers

- **Tier 1** are mission-critical and life-sustaining loads that are necessary to keep operational at all times, including during grid outages. Tier 1 loads usually represent about 10% of the total load.
- **Tier 2** are priority loads that should be maintained as long as long as doing so does not threaten the ability to maintain Tier 1 loads. Tier 2 loads are usually about 15% of the total load.
- **Tier 3** are discretionary loads that make up the remaining load, usually about 75% of the total load, and can be maintained when doing so does not threaten the ability to maintain Tier 1 & Tier 2 loads.

In the case of the **SBUSD sites, the following loads have been deemed to be Tier 1 & Tier 2:**

- **Tier 1: Freezers & refrigerators.** Only main foodservice units are considered to be critical and no special considerations have been made for small refrigerator units in teacher lounges and/or nursing offices etc.
- **Tier 2: Main Distribution Frame (MDF)** facilities for communications services and primary **Multi-Purpose Room (MPR) type facilities** for emergency response. The MPR at a particular site could be a cafeteria, gym, auditorium, or an officially specified MPR.
- **Tier 3:** All other loads.

Resilience levels by load tier for a Solar Microgrid evaluated at UCSB with a net zero level of solar and storage energy capacity equal to 2 hours of solar production (1 MW of solar and 2 MWh of storage for example).



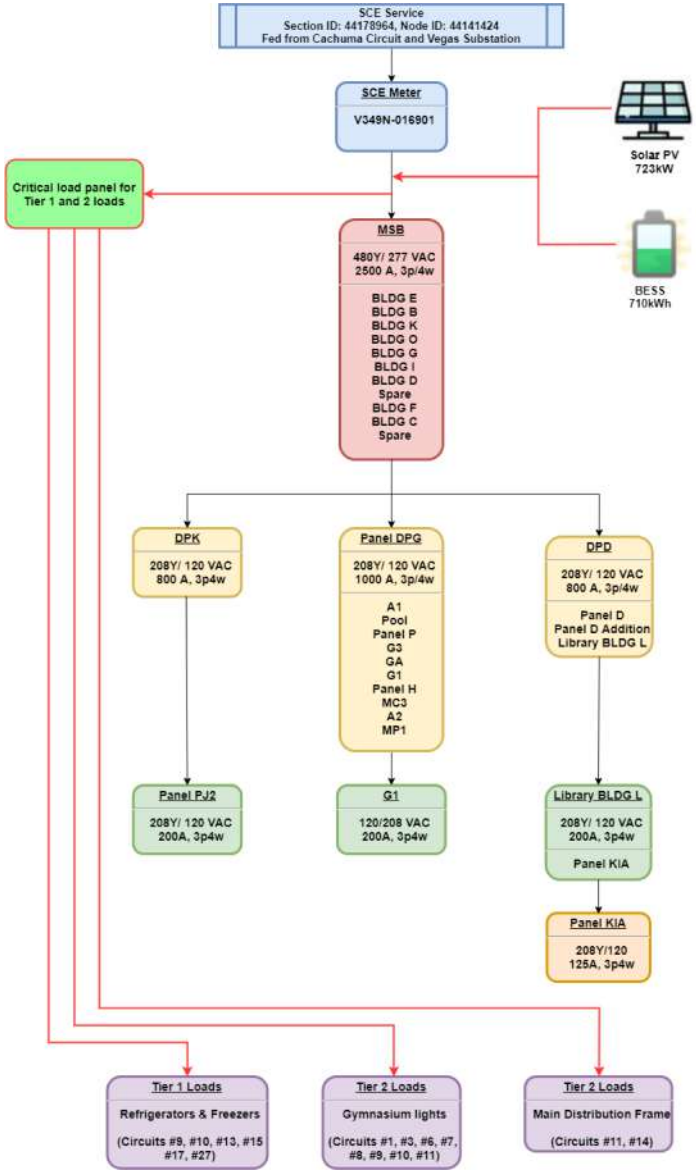
Average anticipated resilience, in terms of percentage of time online:

- Tier 1: 100%
- Tier 2: 80% (at least)
- Tier 3: 25% (at least)

Load Management configuration

Although there are multiple potential Load Management configurations, the minimal functionality anticipated to be cost-effectively implemented is referred to as **the Critical Load Panel (CLP) approach**.

The CLP name reflects the requirement for a smart critical load panel that maintains Tier 1 loads indefinitely and toggles Tier 2 loads. In the CLP approach, Tier 3 loads will be toggled as a group by toggling power to the Main Service Board (MSB). Figure 9 illustrates the CLP approach for SMHS, with Tier 1 and Tier 2 loads being served by new dedicated wire runs that connect to a new smart critical load panel.



Valuing resilience ("VOR123" methodology)

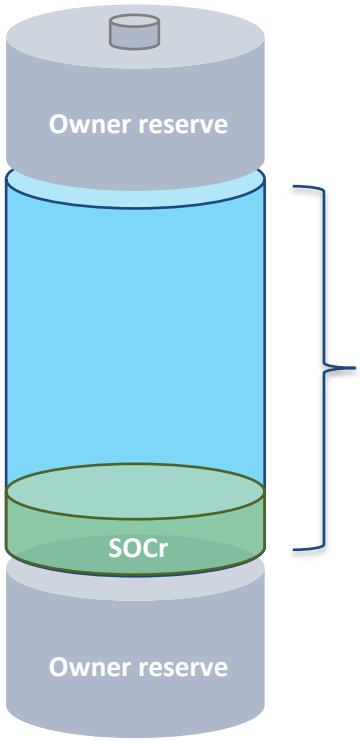
With respect to valuing resilience, there are different VOR levels for each of the three load tiers. The following valuation ranges are typical for most sites:

- **Tier 1**: 100% resilience is worth approximately 3 to 5 times the normal price paid for electricity. In other words, indefinite energy resilience for critical loads is worth 3 to 4 times the normal price paid for electricity. Given that the typical facility has a Tier 1 load that is about 10% of the total load, applying the low side of the Tier 1 VOR multiplier typically yields a 20% adder to the pre-resilience electricity rate.
- **Tier 2**: 80% resilience is worth approximately 1.5 to 3 times the normal price paid for electricity. In other words, energy resilience that is provisioned at least 80% of the time for priority loads is worth 1.5 to 2.5 times the total, so applying the low side of the Tier 2 VOR multiplier yields a 7.5% adder on top of the pre-resilience electricity rate.
- **Tier 3**: Although a standard-size solar microgrid can provide backup power to Tier 3 loads a substantial percentage of the time, Tier 3 loads are by definition discretionary, and therefore, a Tier 3 VOR multiplier is negligible and assumed to be zero.

Taken together, the Tier 1 and Tier 2 premiums for a standard load tiering allocation yields an effective VOR of between 25% and 30%. Hence, the **Clean Coalition uses 25% as the typical premium that a site should be willing to pay for indefinite renewables-driven backup power to critical loads** — along with renewables-driven backup for the rest of the loads for significant percentages of time.

State of Charge for resilience (SOCr)

Top owner reserve is often in place to absorb BESS degradation over time, while still delivering the contracted daily cycling energy capacity.

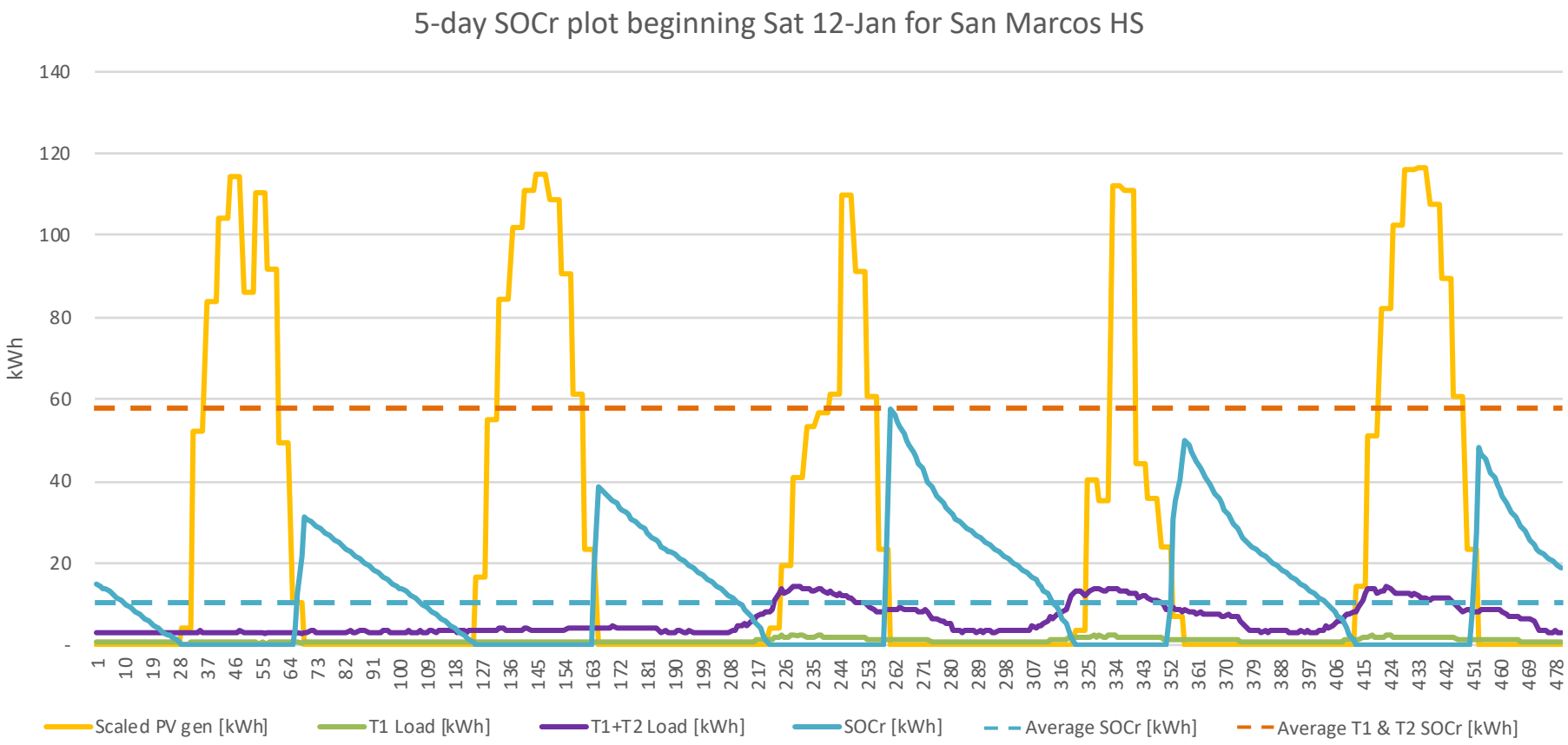


SOCr = the minimum state-of-charge (SOC) that is reserved for provisioning resilience. The SOCr can be dynamic and/or resized to between 0% and 100% of the contracted BESS energy capacity. A lower SOCr facilitates BESS operations that optimize daily economic performance while a larger SOCr facilitates the provisioning of higher resilience.

Contracted BESS energy capacity (kWh) that must be available for daily cycling over the contract duration for achieving specified economic & resilience performance.

Bottom owner reserve is often required to meet BESS warranty requirements that are imposed by BESS vendors.

SOCr dynamically minimized to maximize economics



SBUSD 2019 electricity costs & breakeven values

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Site Name	2019 Cost & Values (¢/kWh)			
	Annual Cost/kWh	PV Value	PV+BESS Value	PV+BESS+ Resilience Value
Adams ES	17.8	12.7	14.5	19.0
Cleveland ES	18	12.2	13.4	17.9
Facilities & Maintenance Warehouse	15.8	11.6	16.4	20.4
SBUSD Office & La Cuesta HS	17.7	13.7	13.8	18.2
Dos Pueblos HS	14.9	10	12.2	15.9
Franklin ES (& Adelante Charter)	16.8	12	13.7	17.9
Goleta Valley JHS	16	11.5	12.5	16.5
La Colina JHS	16.2	12.1	13.1	17.2
La Cumbre JHS (& SB Community Academy)	15.6	12.2	12.9	16.8
Monroe ES	16.8	12.7	14.7	18.9
Roosevelt ES	17.8	12.6	16.1	20.6
Santa Barbara HS	14.5	11.9	14.6	18.2
Santa Barbara JHS	16.1	12.5	15.7	19.7
San Marcos HS	15.3	11.7	12.9	16.7
Washington ES	17.5	12.6	14.1	18.5
Weighted Average Total	16.1	11.6	13.5	17.5

SBUSD 2020 costs & PPA estimates

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Site Name	Year-1 PPA pricing, 3% escalator (¢/kWh)					
	Annual Cost/kWh	PV	PV+BESS	PV+BESS+ MLM	PV+BESS+ CLP	PV+BESS+FAM
Adams ES	17.8	13.0	15.5	18.5	22.5	23.5
Cleveland ES	18	14.0	15.5	22.0	29.0	31.0
Facilities & Maintenance Warehouse	14.9	13.5	13.5	13.5	19.0	20.5
SBUSD Office & La Cuesta HS	15.8	13.0	13.0	15.0	21.0	24.0
Dos Pueblos HS	16.8	10.5	11.5	12.0	12.5	13.0
Franklin ES (& Adelante Charter)	16	12.5	12.5	13.5	15.5	16.0
Goleta Valley JHS	16.2	12.0	13.5	15.0	17.5	18.5
La Colina JHS	17.7	12.0	13.5	15.5	18.5	20.0
La Cumbre JHS (& SB Community Academy)	15.6	12.0	12.0	13.0	15.0	16.5
Monroe ES	16.8	13.5	15.0	18.5	22.5	24.0
Roosevelt ES	17.8	13.0	16.0	18.5	22.5	23.5
Santa Barbara HS	15.3	11.5	12.5	13.5	14.5	15.5
Santa Barbara JHS	14.5	12.5	14.0	16.0	19.0	21.0
San Marcos HS	16.1	11.5	12.5	13.5	14.5	15.0
Washington ES	17.5	13.5	15.0	19.0	23.5	24.5
Weighted Average Total	16.1	11.7	12.8	14.1	16.0	17.0

Notes

- Analyses calculates estimated Power Purchase Agreement (PPA) pricing for each configuration, assuming 25-year PPAs starting in 2020 with 3% SCE electricity cost escalators.
- Solar Microgrid PPA prices in green are less than breakeven values, including 25% VOR adder.
- SCE raised its electricity costs by about 7% in 2019 and is proposing similar increases in each of the next three years.