Peninsula Advanced Energy Community (PAEC)

Task 5.2: Final Solar Emergency Microgrid Site Design and Deployment Plan

Solar Emergency Microgrids: An Advanced Energy Solution for Communities

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II. About the Author

The Clean Coalition is a nonprofit organization whose mission is to accelerate the transition to renewable energy and a modern grid through technical, policy, and project development expertise. The Clean Coalition drives policy innovation to remove barriers to procurement and interconnection of distributed energy resources (DER) such as local renewables, energy storage, and demand response. The Clean Coalition also establishes programs and market mechanisms that realize the full potential of integrating these solutions. In addition to being active in numerous proceedings before state and federal agencies throughout the United States, the Clean Coalition collaborates with utilities (and other Load Serving Entities) and municipalities (and other jurisdictions) to create near-term deployment opportunities that prove the technical and economic viability of local renewables and other DER.

Ultimately, the Clean Coalition envisions the United States being 100% powered by renewable energy, substantially from local sources. To make this goal a reality, the Clean Coalition is working to achieve the following objectives by 2025:

- From 2025 onward, at least 80% of all electricity from newly added generation capacity in the United States will be from renewable energy sources.
- From 2025 onward, at least 25% of all electricity from newly added generation capacity in the United States will be from local renewable energy sources.
    - Locally generated electricity does not travel over the transmission grid to get from the location it is generated to where it is consumed.
- By 2025, policies and programs are well established for ensuring successful fulfillment of the other two objectives.
    - Policies reflect the full value of local renewable energy.
    - Programs prove the superiority of local energy systems in terms of economics, environment, and resilience; and in terms of timeliness.

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III. Legal Disclaimer

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IV. Goal

The goal of this task is to create a Solar Emergency Microgrid (SEM) site design and deployment plan at one location within the core PAEC region. The SEM will provide renewables-driven power backup for critical facilities – police and fire stations, emergency operations centers, emergency shelters, and other facilities prioritized by the jurisdiction – over the agreement term. While the primary goal of the SEM is to provide renewables-driven backup power to critical facilities, boosting the environmental and resilience benefits for a site, a secondary goal is to provide economic benefits to the site through lower long-term energy costs and reduced utility charges (including demand charges) made possible using distributed energy resources (DER.)

V. Purpose

A SEM is an essential asset for communities seeking enhanced resilience of their local power grid. In the event of a power outage or natural disaster, a SEM can island from the larger grid to provide continuous power to a critical facility, such as an emergency response command center, hospital, police station or shelter. Local renewable energy, battery backup, load shedding and a monitoring, communications and control solution are key elements of a SEM.

VI. Site Selection

The selection of a SEM location depends upon several interrelated factors:

- Services to critical facilities desired and their implicit or minimum loads
    - Infrastructure, e.g. water supply, waste water treatment, road maintenance/clearance and pumps for fuel supply
    - Emergency services, e.g. fire, police, medical care, communications and information technology
    - Community shelter, often with prior agreements with Red Cross in place
- Resources
    - Availability of generation resources
    - On-site locations for Energy Storage (ES) as well as Monitoring, Communications, and Control equipment (MC^2)
    - Proximity to existing distribution feeder(s)
- Proximity to known local hazards, e.g. flood zones
- Project finance and revenue streams
    - Ownership model of the various resources
    - Revenue streams, e.g. utility bill savings from demand charge reduction during normal operation from PV, ES, or both
    - Tax incentives including Investment Tax Credit (ITC) and Self-Generation Incentive Program (SGIP)
    - Grant funding programs in many states that may influence the services offered, the location of the SEMs, or the partners in the project

a. Services

The services needed in a community during an outage will determine the types of loads that must continue operations. Typical municipal infrastructure loads might include water treatment and pumping, firefighting, police, hospitals and fuel pumping. These types of facilities typically have backup power systems in place usually powered by a mix of diesel generators and small battery backup or uninterruptable power supplies (UPS.) Shelter sites often have agreements with the Red Cross and are usually large spaces such as gymnasiums and meeting halls where cots can be set up for overnight shelter and food distribution.

Within each site, the loads that will continue operating during an extended outage must be identified and prioritized in a rank order. Building Energy Management Systems (BEMS) can be utilized to immediately manage controllable loads, e.g. HVAC and lights, and are typically a major component of an existing demand response system.

Prioritization of loads must consider criticality of function, timing, and duration. Some loads, such as computers and communications equipment, cannot afford more than a few cycles of outage and usually have a UPS system in place to bridge over brief outages of a few seconds to a few minutes. Other loads, such as water pumps, might allow an immediate outage but may need to come back later to continue their functions at a reduced load. Shelters may need some immediate short-term lighting coverage to allow safe egress, but may not need longer term load support until they are employed for shelter.

Thus, it is important to priority rank the loads for both short and long-term consideration. An excellent starting point for this process is to review the labels on breaker panels along with site maps of the facility that identify electricity usage by sub-areas. The loads can then be ordered into tiers of what must be kept on for both short and long-term outages, especially if the utility of the particular load or room changes for long-term outages.

As an example, much of coastal California enjoys a relatively benign climate. Many shelter sites in these areas already plan to have the HVAC off during an extended outage when the facility is used for shelter. Another example is water distribution system pumps that normally do most of their pumping at night due to lower time-of-use rates. The pumps can be off for the short-term, and for long-term outages could shift their loads to daylight hours to take advantage of the abundant solar resource to supply the needed energy.

b. Generation and Storage Resources

Existing backup power facilities must be inventoried and considered. Existing PV may be insufficient to support the needed effort due to limited quantity of production or incompatible equipment such as inverters. Planned expansion of PV systems must consider roof loading.

Energy storage will typically need to be sited at ground level and requires pouring a concrete pad due to the weight of the batteries. In unique situations, siting ES above ground level may be preferred which requires further engineering to design the mounting structure.

Finally, it should be noted that all site design specifications and recommendations must meet and/or exceed all local and state safety requirements. Understanding project economics is key to ensuring that the project is replicable and scalable.

VII. PAEC Region - Siting

c. Solar Siting Survey

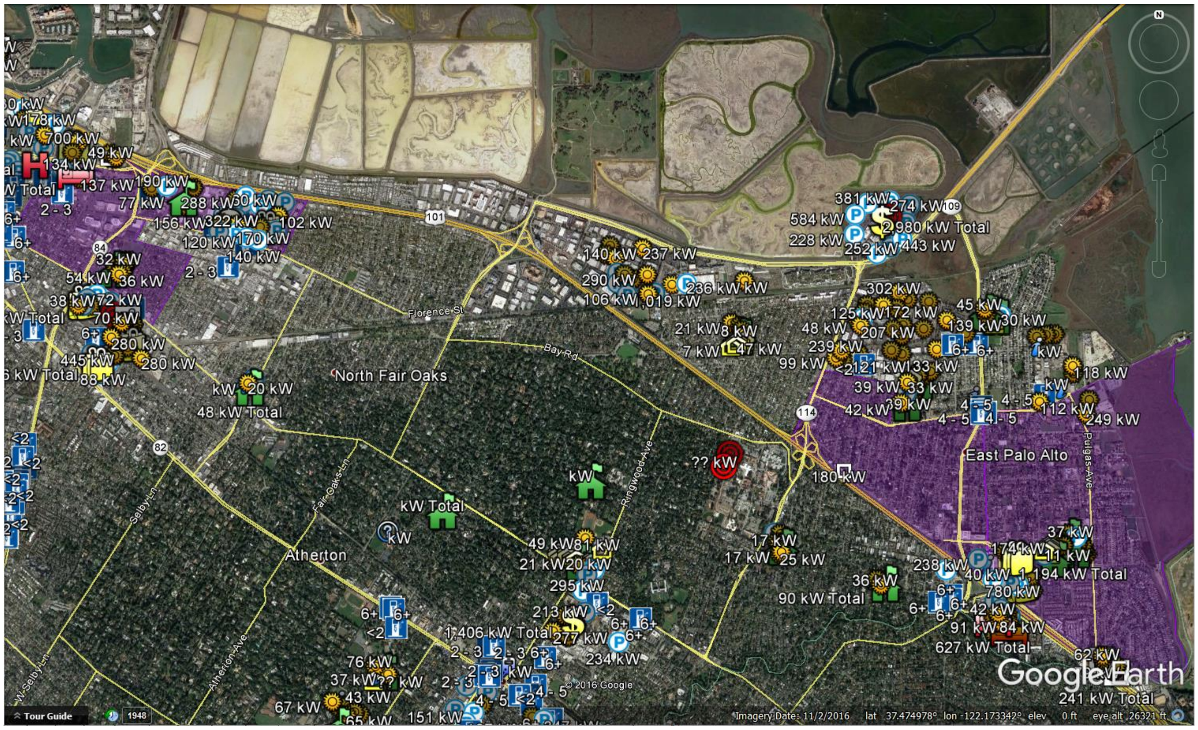
To power the SEM from solar PV, it is important to assess the best resource locations in a defined area. The coverage should include not just the potential properties but also their neighbors which can potentially provide generation that could be tapped during a long-term emergency outage. See "PAEC Task 8 - Solar Siting Survey Summary Final Report clean (31_wb, 27 Mar 2017).docx" for more details on how to perform a solar siting survey.

The figures which follow show the survey results as a displayed layer on the maps.

d. Additional Constraints

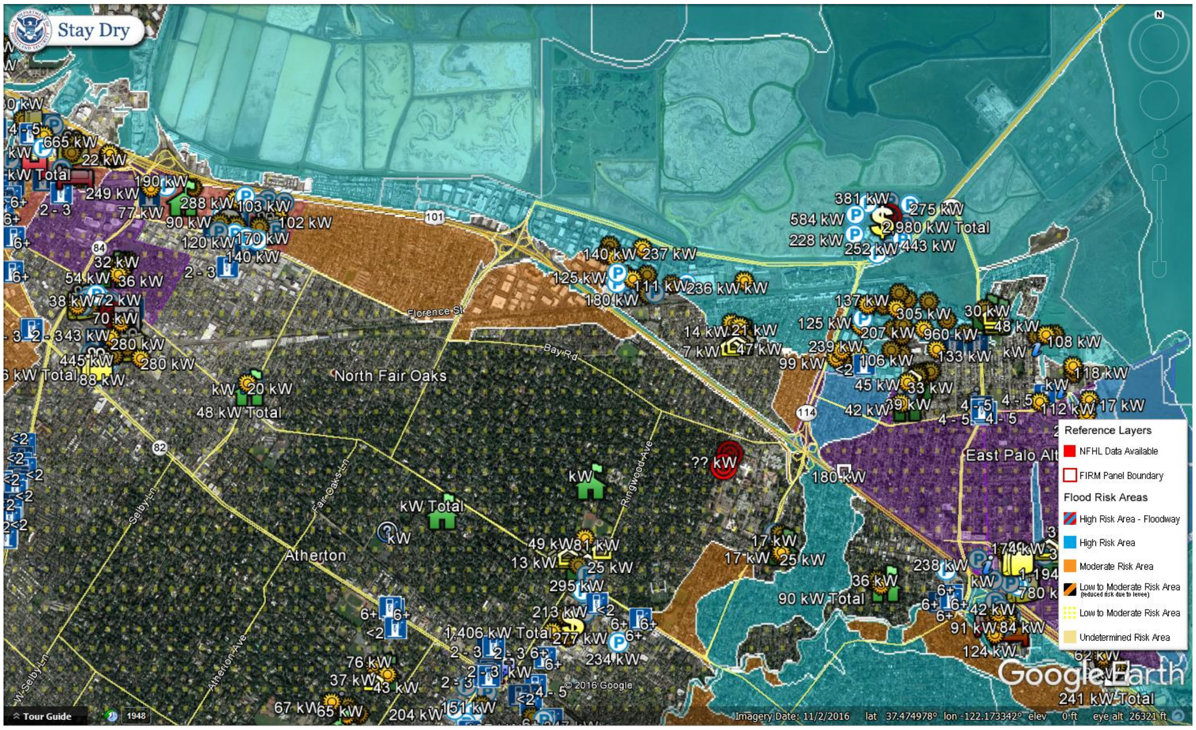
In the PAEC Region, the study has uncovered several likely candidate sites for SEMs. When the constraint of siting within the top quartile of the CalEnviroScreen 3.0 maps (indicating a disadvantaged community) is added, two regions are identified, as shown in Figure 1 one in City of Redwood City, one in East Palo Alto.

Figure 1: CalEnviroScreen 3.0 Top Quartile Zones (purple) in PAEC Region with Solar Siting Survey



When the EPA Flood Zone Risk map layer is added (blue for high risk, brown for moderate risk) the selected areas still look acceptable, as shown in Figure 2.

Figure 2: FEMA Flood Risk added to CalEnviroscreen 3.0 Map of PAEC Region



Further details regarding the sites considered and selected can be found in section *VIII. Selecting the PAEC SEM Site.*

e. SEM Resource Considerations

i. Solar PV

In urban built environments, there are usually a large number of flat commercial or industrial rooftops available for consideration for installing solar PV. Pitched roofs can additionally be used, but the rooftops tend to be smaller, and their orientations may limit PV production potential if they are not south facing. The solar siting survey identifies the best candidates.

ii. Energy Storage

In order to power the SEM when there is no sun shining, it is necessary to store the excess energy produced during daylight hours. Space allocation for the ES unit(s) needs to be discussed early in the project scoping and design phases.

iii. Property Owners

It is important that the property owner is fully committed to the project. All construction projects involve much planning and will result in much disruption during construction. Therefore, the owner will have to buy into and support all the key decisions involving system design, impact to their site, financing and approval of permitting applications.

The owner and/or operator of the property must also agree to any operational changes that must be made to support operation of the SEM during long-term outages. This could include manual procedures for load shedding that would require commitment to training on-site staff for effective operation.

f. Feeders

Distribution feeders must have sufficient capacity to support the intended resources needed in the SEM. Since islanded operation is planned, net energy metering (NEM) interconnection would be utilized. The Interconnection Capacity Analysis map (ICA) from the utility can be used to identify the desirability of a site for interconnection. It should be noted that the ICA map does not always have the most up to date information, especially if there has been recent construction or energy projects in neighboring areas (along the same feeder.)

g. ES Services

The resources of the SEM should be usable to reduce the sites electricity expenses via demand charge reduction, decrease in total energy use, and possible participation in demand response programs. Demand charge reduction is especially important for sites with Electric Vehicle Charging Infrastructure (EVCI) which implicitly increases a sites power demand, and can create huge demand charges as multiple vehicles charge simultaneously at high powers.

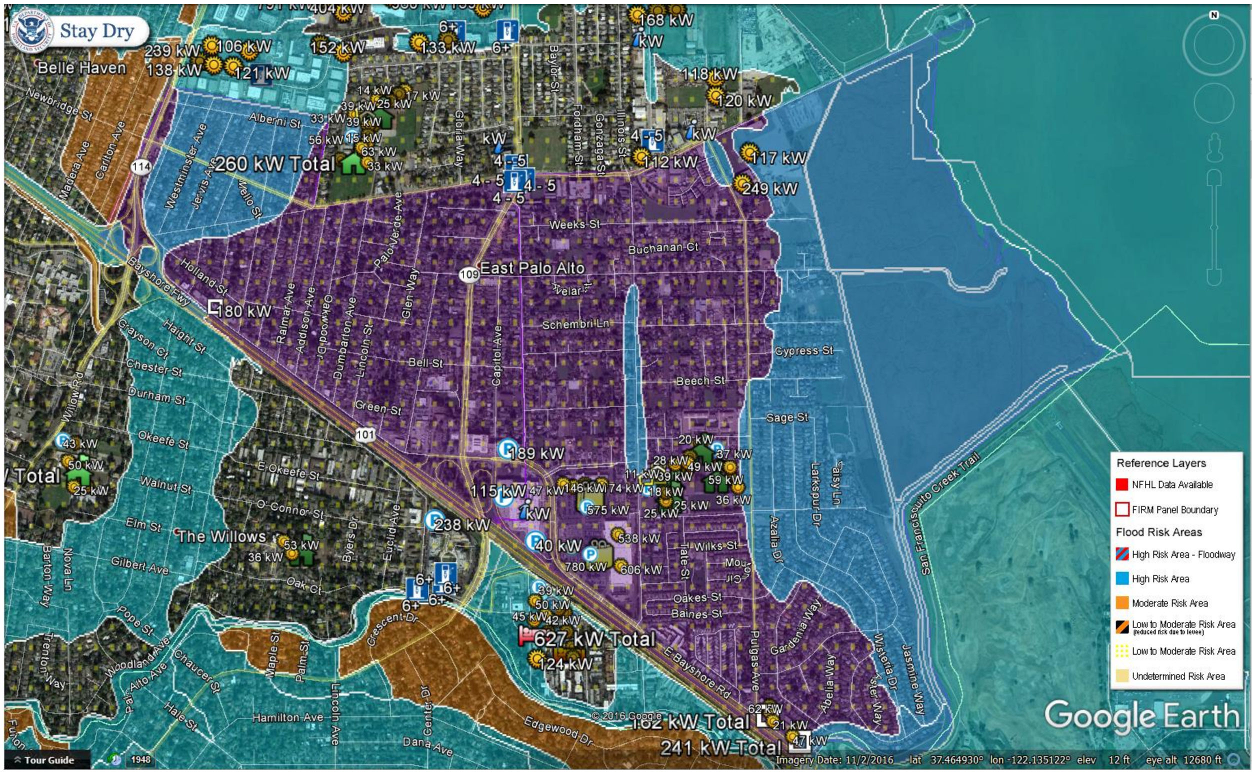
VIII. Selecting the PAEC SEM Site

Figure 2 above shows the specific areas that have been targeted. The following discussion looks at the East Palo Alto and Redwood City regions to narrow down the focus.

h. East Palo Alto

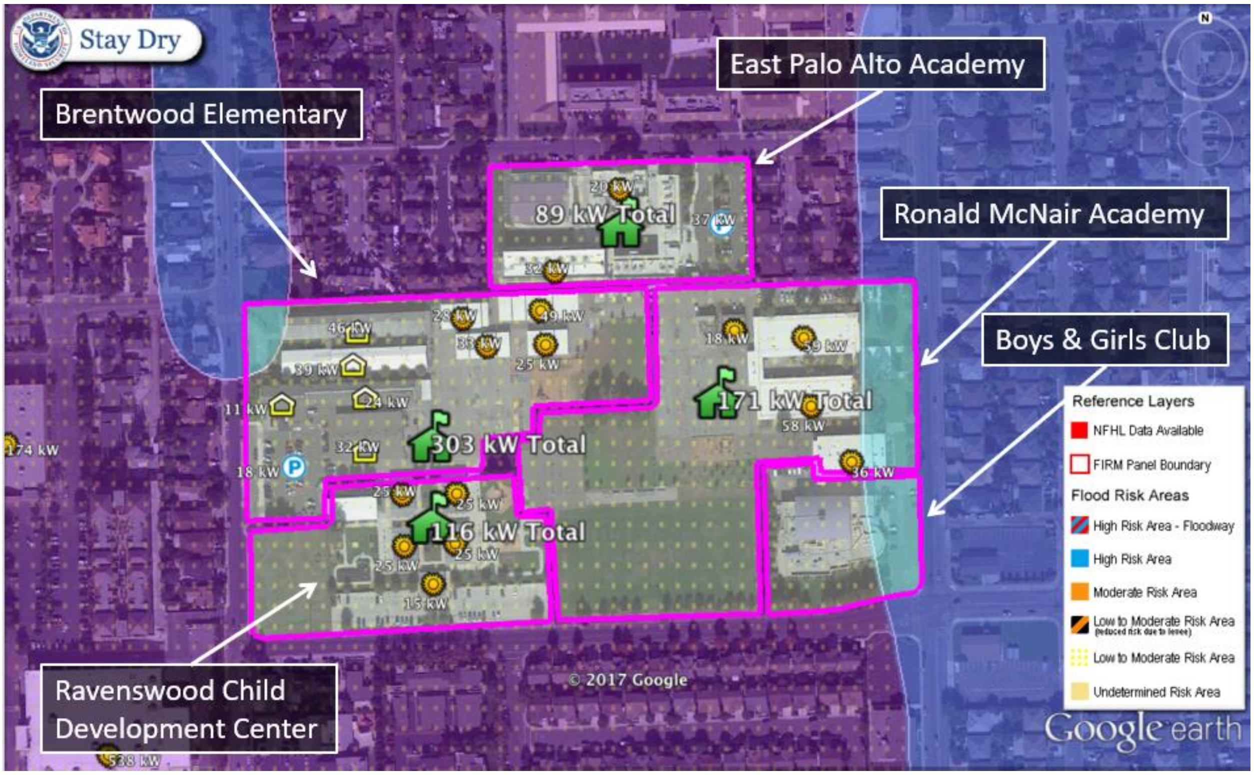
There is a very obvious choice of clustered school sites when the map in Figure 3 is examined because they cluster into one block and they are near but outside the high-risk flood zone meaning there would be high probability of need in the case of a flooding event.

Figure 3: East Palo Alto SEM Site Map Overview



A closer view of the block of schools is seen in Figure 4. The sites are all in the same block on property owned by Ravenswood School District.

Figure 4: Ravenswood SEM School Site Cluster



The sites are:

- Brentwood Elementary
- Ravenswood Child Development Center
- Ronald McNair Academy
- East Palo Academy (leased by City of Redwood City School District)
- Boys & Girls Club (leased by the organization, and affiliated with the City of Redwood City site)

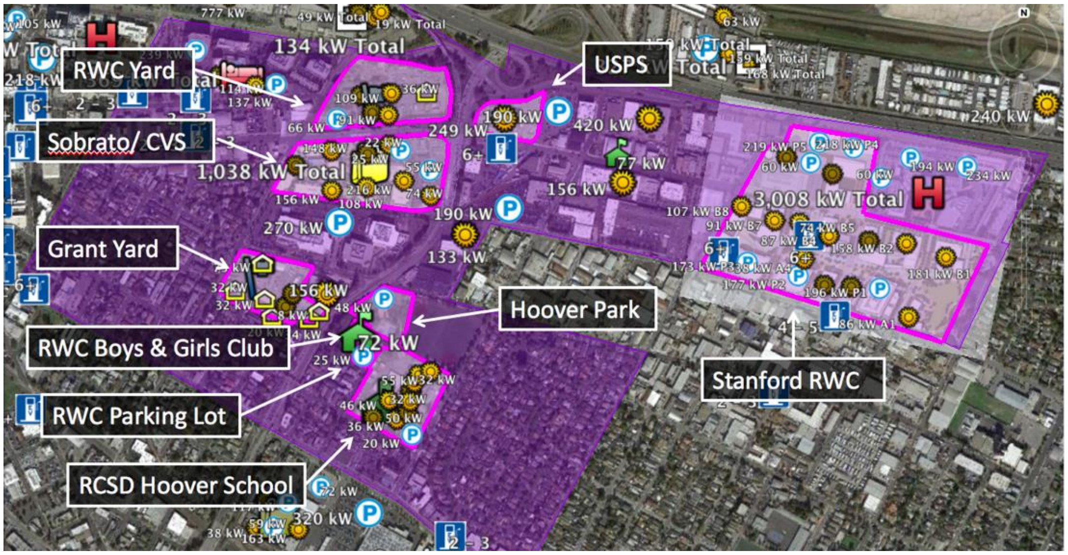
The Boys & Girls Club site would make an excellent shelter, but it does not have good solar siting potential. The three Ravenswood schools have solar potential to be good SEM sites along with adequate on-site space for batteries.

Ravenswood School District is interested in pursuing the SEM concept, but budget and staff constraints will make quick project deployment a challenge. When one or more of the schools is set up for SEM, it may allow tying in the Boys & Girls Club into the microgrid during emergency operation.

i. The City of Redwood City

The City of Redwood City also has tremendous potential to incorporate SEM sites in a disadvantaged area (Figure 5). Again, the purple zone defines the CalEnviroscreen 3.0 top quartile desired zone. The blue area at the top is the high-risk flood zone that is out of consideration because it does not meet the resilience requirements of a SEM. The orange areas (which are darker where they overlap the CalEnviroscreen 3.0 desired zone) are moderate-risk zones for flooding, but should be considered for shelter in California's common hazard of earthquakes.

Figure 5: City of Redwood City SEM Sites Overview



The potential sites include:

- The City of Redwood City Corporate Yard
- Sobrato retail and multi-family housing development
- San Mateo County Corporate Yard
- Stanford Redwood City (Stanford RWC) (new real estate development)
- Hoover School
- Boys and Girls Club of the Peninsula, Redwood City
- Hoover Park and Swimming Pool

The City of Redwood City Corporate Yard and Sobrato are both planning for major renovations in the next few years, so they are not good prospects for SEMs at this time. There will be major construction at the interchange for Woodside Road and Highway 101 that will remove some of the property at the Redwood City Yard from consideration. Sobrato, a local real estate developer, will be turning the Foodsco Shopping Center into a combined residential and commercial property, and their plans are still being developed and finalized through the permitting process.

San Mateo County Corporate Yard is a good potential SEM site. During an outage, communications and electric pumps to enable fuel pumping (to fuel the trucks needed to take crews out to clear roads and debris) are critical facilities and could greatly benefit from indefinite backup power.

Stanford RWC is a new, two-phase real estate development of more than a dozen buildings and has tremendous potential to become a SEM and/or Community Microgrid (CM). A CM is a new approach for designing and operating the electric grid, stacked with local renewables. CMs are also capable of providing all functions and services met by traditional peaker plants including energy, reliability, and resilience. The project can potentially leverage $50 million of advanced energy investments, including a $40 million Central Energy Facility (CEF), to provide clean, resilient power in a disadvantaged San Francisco Bay Area community. The microgrid can include the Central Energy Facility, a data center, one parking garage, and four office buildings and could integrate 886 kW of local solar, nearly 50 MWh of energy storage, 52 Level-2 electric vehicle charging ports, and sophisticated load management of smart buildings and Vehicle-Grid-Integration (VGI) capable electric vehicle charging infrastructure (EVCI.)

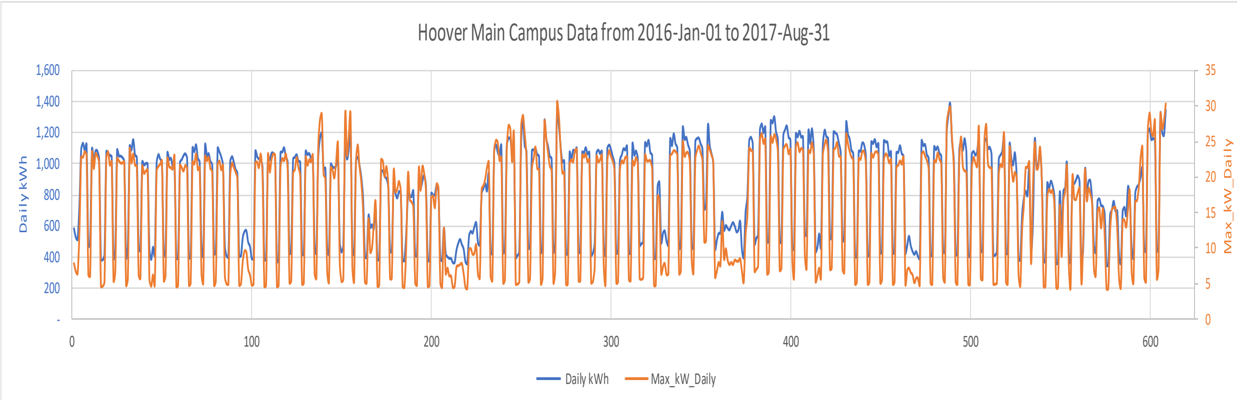
While many potential SEM sites in the disadvantaged community in Redwood City have been investigated, the best site uncovered so far is the Hoover School shown in Figure 6. The school has already done energy efficiency upgrades and is in process of planning other bond-funded projects. It is particularly advantageous to site at SEM at Hoover School because they are already a Red Cross designated emergency shelter, and they have already incorporated several advanced energy community elements (i.e. energy efficiency) that allow a properly sized system to be designed and installed, without risk that the system may be oversized.

Figure 6: Overview of Hoover Elementary School Site

IX. Designing the System

The SEM must provide backup power to well defined loads. Figure 7 shows that this facility is in use year-round with only brief shutdowns for major holidays.

Figure 7: Hoover Main Campus Energy and Peak Power Needs



The goal of this SEM is first to continue immediate operations in the event of a short-term outage (minutes). A medium length outage (hours) must also be handled so that the students can be kept at the school safely until their parents can pick them up. For a long-term outage (days), restricted set of rooms and buildings will be kept operating for shelter per an agreement with the Red Cross.

In addition, the resources of the SEM should be usable to help lower the school's expenses via demand charge reduction, decrease in total energy use, and possible participation in demand response programs. Demand charge reduction is especially important for Electric Vehicle Charging Infrastructure (EVCI) which can create huge charges as multiple vehicles charge simultaneously.

j. Site Overview

Figure 6 shows the mix of potential resources for the Hoover Elementary School site. The PV opportunities have three basic structure types: flat roofs, pitched roofs, and parking lots.

The red region with the large rectangle (planned gymnasium) and offshoot (covered walkway) are flat roof sites. The many pitched roof sites have good south facing exposure for PV. Additionally, there are two parking lots at the corners that can support both PV and EVCI equipment. It should be noted that all site design specifications and considerations will be compliant under the Americans with Disabilities Act (ADA).

Potential locations for SEM components are shown as well. Very near the electrical room (HES Elec Pnl) room is another storage room that could house the batteries indoors (HES ES). Also nearby is the equipment room for IT and communications (HES IT) that would be desirable to keep operating in the event of a long-term outage. The adjacent locations of these rooms in the same building would simplify installation and cabling.

k. Solar Resource

There is currently no solar power on the Hoover Elementary School site. The Solar Siting Survey identified the potential locations for placing solar panels. The best spots are the flat-roof and parking lot locations already mentioned, which mesh well with planned construction projects.

The pitched roofs create a potential issue for timing in moving a project forward. The Division of the State Architect (DSA) must approve any PV on these roofs, and their processes can take many months. The Hoover SEM design and analysis will consider both options of just flat roof and parking lots (275.8 kW PV AC) and all potential sources (566.3 kW PV AC).

l. Feeder Access

Figure 8 shows the distribution feeder map for Hoover. The main campus is fed from the feeder on Charter Street.

Figure 8: ICA Feeder Map for Hoover School

m. ICA

Figure 9 shows that as of the date of inquiry, there is little issue in adding PV up to 304 kW and that major impacts should not occur at up to 874 kW (PV only) or 965 kW (PV with storage).

Figure 9: ICA Data for Feeder 409 at Hoover

1 of 1

Asset Info | DER Capacity

Feeder name: REDWOOD CITY 0409   Zone Id:24160409.001

DER	Zone DER Capacities (kW) Minimal Impacts	Zone DER Capacities (kW) Possible Impacts	Substation DER Capacities (kW) Feeder Limit	Substation DER Capacities (kW) Substation Bank Limit
Uniform Generation (Inverter)	304	501	501	2,414
Uniform Generation (Machine)	103	390	390	1,866
Uniform Load	304	624	624	3,797
PV	304	874	874	4,044
PV with Storage	304	965	965	4,463
PV with Tracker	304	663	663	3,116
Storage - Peak Shaving	304	698	698	3,235
EV - Residential (EV Rate)	304	1,062	1,450	8,296
EV - Residential (TOU Rate)	304	753	753	4,417
EV - Workplace	304	786	786	5,111

n. Electrical Loads

The electrical loads for the existing campus are graphed in Figure 7.

Billing data for 2016 through August of 2017 was obtained showing the following selected statistics. The facility uses the A-10 Time-of-Use tariff:

- Annual load (2016): 292,176 kWh
- Maximum hourly load: 116 kWh
- Average hourly load: 33 kWh
- Minimum hourly load: 13 kWh

X. Benefits Cost Analysis

The Benefits Cost Analysis examines three scenarios:

- The first is a standard Demand Charge Management case using the existing load profile, with the battery sized only for that task.
- The second case adds proposed EV charging to the existing profile to see the impact on battery sizing and economics.
- The third case examines the requirements to use the school for a long-term shelter in an off-grid scenario, sizing the solar and battery for continuous operation with no other generation sources.

These scenarios represent a good sampling of current and planned usage of energy storage combined with renewable generation that are currently in use or can be easily implemented with current technology.

o. General Background

The major benefits of a SEM from an economic perspective are a result of energy usage reduction and demand charge reduction on a customer's utility bills.

It is important to understand how the battery resource can be used year-round to save the school money. This constant utilization also means that there is no uncertainty about the battery's operation when an emergency occurs, because it is in constant use and does not require dedicated periodic testing. With diesel generator backup, one hopes that it will work when needed, and ensures that is possible by undertaking periodic testing which results in higher operational costs and local air pollution.

The school serves a student population of almost 700 students with approximately 100 staff employees. The school is in use year-round and has after-school programs for students to help working parents. As such, it is an important community resource.

The school has a full-service cafeteria with large walk-in refrigerators and freezers. A large percentage of the students depend upon the school for proper nutrition with both breakfast and lunch programs. During the summer months, summer programs for students are offered at the school and the cafeteria is used to prepare lunches (for both on-site and off-site programs. During a grid outage, the cafeteria serves as a critical load to help prepare meals for community members in need.

p. Modeling and Modeling Tools

For the technical and financial analysis, two cases are evaluated. One is normal operation with ES being used for Demand Charge Management (DCM). In this mode the battery is an asset that is in continuous use so that there is no concern regarding its fitness for use during an extended outage. The second case is one of continuous grid outage in which the school would be used as an emergency shelter, running at a much-reduced load.

Modeling of the system is hampered by a lack of tools currently available on the retail market. Many project developers use proprietary modeling tools.

StorageVET is a microgrid modeling that is still in development. Several attempts were made to use it, but a major shortcoming has yet to be fixed as of this writing. It is possible to upload user files for loads and generation, but they are not accessible when running the models, rendering the tool unusable for running user defined cases.

Geli's modeling tool is designed as a sales tool for configuring the lowest cost battery or battery plus solar system to provide DCM. It does not have resilience component but was chosen because it does show what a minimal energy storage system can do to lower utility bills when DCM is important. For many potential sites, this application is the key to getting

ES installed that can pay for itself and then later be expanded in capacity for extended outage operation.

HOMER is probably the best-known modeling tool for microgrids. It has evolved to include many different energy sources. HOMER is an analytical tool that lets the user quickly evaluate different configurations and guide the tool toward an optimal solution. HOMER does not yet include a module for DCM (currently starting beta testing); its strength is off-grid and is the tool used for modeling an extended outage in this report.

q. Demand Charge Management Model

iv. Baseline Model with Existing Load adding PV and ES

A DCM modeling run for Hoover baseline load was performed using Geli ESyst. Figure 10 shows the utility bill analysis with a breakdown of energy and demand charges. Figure 11 shows heat maps for the existing load and the reduction in net energy drawn from the grid with the addition of the PV.

Figure 10: Baseline Utility Bill Including Demand Charges

Baseline Utility Bill: Pacific Gas & Electric Co - A-10-TOU

Billing Period		Energy Usage (kWh)			Max Demand (kW)	Charges *			
Date	Season	On Peak	Partial Peak	Off Peak	Monthly Max	Energy	Demand	Fixed	Total
September 2016	summer	10,964	8,822	9,571	122	$5,116	$2,436	$144	$7,696
October 2016	summer	9,564	8,485	9,920	95	$4,803	$1,911	$148	$6,862
November 2016	winter	0	16,353	10,397	95	$3,424	$1,136	$144	$4,704
December 2016	winter	0	15,757	12,546	99	$3,597	$1,190	$148	$4,935
January 2017	winter	0	15,960	12,212	104	$3,585	$1,251	$148	$4,984
February 2017	winter	0	16,952	10,961	100	$3,571	$1,205	$134	$4,910
March 2017	winter	0	20,723	10,650	104	$4,042	$1,243	$148	$5,434
April 2017	winter	0	14,660	9,660	94	$3,110	$1,128	$144	$4,381
May 2017	summer	11,152	9,458	9,780	119	$5,288	$2,385	$148	$7,822
June 2017	summer	8,907	7,775	9,159	103	$4,442	$2,064	$144	$6,649
July 2017	summer	6,718	6,536	9,227	85	$3,772	$1,705	$148	$5,625
August 2017	summer	9,625	7,736	9,629	121	$4,655	$2,423	$148	$7,227
Total		56,931	149,218	123,712		$49,404	$20,078	$1,746	$71,228

* Includes taxes and escalators.
** Contains extrapolated data.

Figure 11: Heat Maps of Baseline Bill, PV, and Baseline Netted with PV

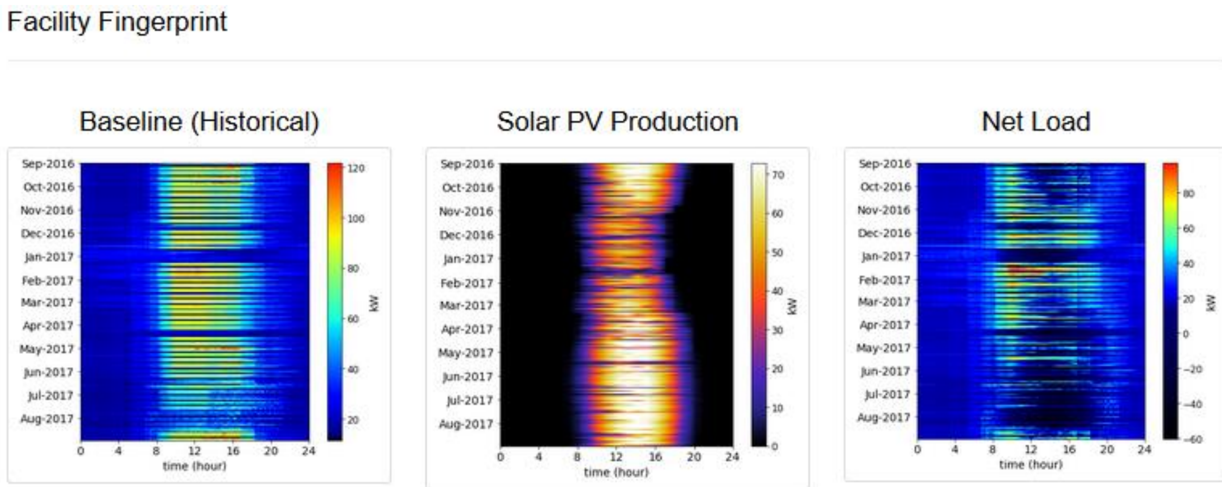
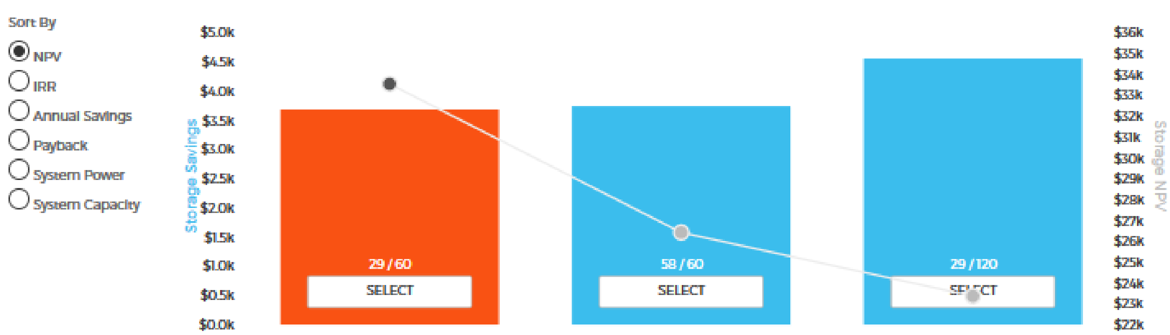


Figure 12 shows the three best ES configurations from the chosen ES vendor and the best choice (29 kW/ 60 kWh) based upon NPV.

Figure 12: Financial Summary of Best ES Choices

Based on the energy data that you uploaded, your incentive & financial inputs, and available OEM system configurations, Geli ESyst determined that the following systems provide the best financial performance. Select a system configuration and progress to the next page to download the Geli ESyst analysis and financial model.



\+ Solar + Storage Financial Performance

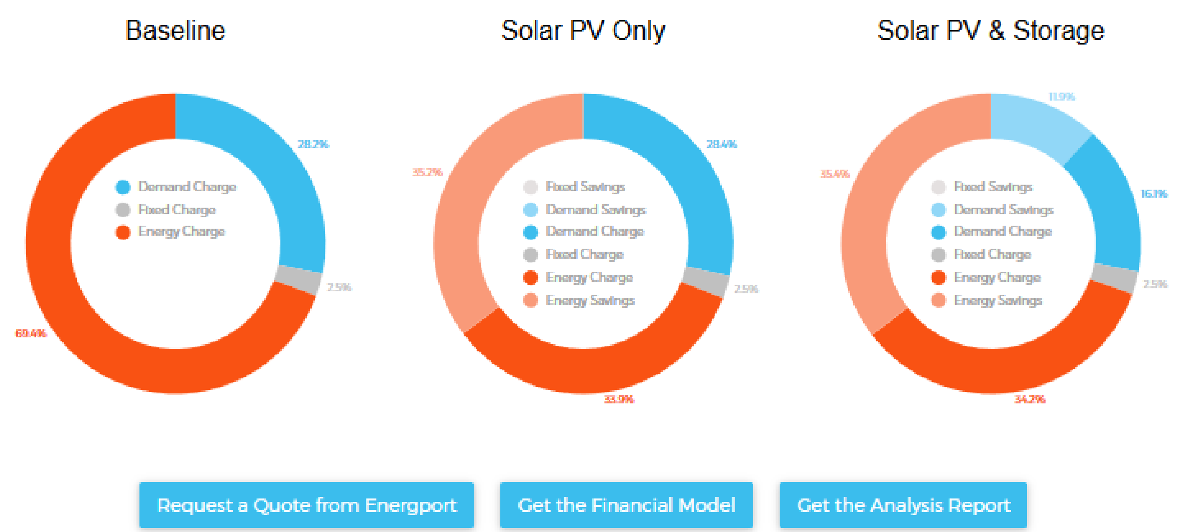
Solar + Storage Payback (Yrs)	4.2	4.3	4.7
Solar + Storage NPV	$242,713	$235,580	$232,515
Solar + Storage IRR (%)	20.6	20.0	18.2

\+ Energy Storage Financial Performance (Post-Solar PV)

For the selected system, Geli recommends ES of 29 kW / 60 kWh. It has the highest NPV and IRR among the 3 best configurations.

For the selected system, Figure 1Figure 13, provides a more detailed breakdown of the finances of the scenarios before and after PV and ES are added. The existing electrical bill of $71k annually drops to $45k with PV and down to $37K when the ES is added to PV. The payback period for the combined PV plus ES system is a little over 4 years.

Figure 13: Financial Summary of Selected System



	Baseline	Solar PV Only	Solar PV & Storage
Tariff:	A-10-TOU	A-10-TOU	A-10-TOU
Energy Charges:	$ 49,403	$ 23,924	$ 23,963
Demand Charges:	$ 20,078	$ 20,078	$ 11,299
Fixed Charges:	$ 1,746	$ 1,746	$ 1,746
Total Utility Bill:	$ 71,228	$ 45,748	$ 37,008
Energy Savings:		$ 24,861	$ 24,823
Demand Savings:		$ 0	$ 8,322
Energy Assets:		$ 0	$ 8,322
Tariff Switch:		$ 0	$ 0
Fixed Savings:		$ 0	$ 0
Total Savings:		$ 24,861	$ 33,145
Payback:		4.83 years	4.24 years
NPV:		$ 148,471	$ 242,713
IRR:		17.32 %	20.62 %

The summary shows how the PV dramatically reduces the energy charges by $25,480 (50%) and the additional ES reduces both energy and demand charges by a total of %33,145 (67% total), resulting in the highest NPV and IRR.

iv. Baseline Model adding EV load to Existing Load plus PV and ES

When EV load is added to the model, the results change. For EV, it was assumed that 5 out 10 potential EV charging stations would be occupied on work days from 8 a.m. to 3 p.m.

The charging rate was assumed to 3.3 kW (low Level 2) during this time. Figure 14 and Figure 15 show the analyses of the inputs.

Figure 14: Baseline Utility Bill with 5 EVs Charging Including Demand Charges

Baseline Utility Bill: Pacific Gas & Electric Co - A-10-TOU

Billing Period		Energy Usage (kWh)			Max Demand (kW)	Charges *			
Date	Season	On Peak	Partial Peak	Off Peak	Monthly Max	Energy	Demand	Fixed	Total
January 2016	winter	0	18,431	11,061	111	$3,782	$1,326	$148	$5,257
February 2016 **	winter	0	17,945	9,652	112	$3,551	$1,342	$139	$5,031
March 2016	winter	0	21,580	9,784	109	$4,056	$1,311	$148	$5,515
April 2016	winter	0	17,436	8,874	109	$3,391	$1,311	$144	$4,845
May 2016	summer	11,925	9,084	9,725	132	$5,388	$2,639	$148	$8,176
June 2016	summer	10,328	7,336	8,738	132	$4,623	$2,639	$144	$7,405
July 2016	summer	7,554	5,932	8,711	102	$3,786	$2,049	$148	$5,983
August 2016	summer	9,028	6,952	9,022	125	$4,315	$2,511	$148	$6,974
September 2016	summer	12,822	9,566	9,571	138	$5,642	$2,767	$144	$8,553
October 2016	summer	11,334	9,193	9,920	112	$5,304	$2,242	$148	$7,694
November 2016	winter	0	18,459	10,521	111	$3,722	$1,334	$144	$5,200
December 2016	winter	0	17,719	12,941	116	$3,907	$1,388	$148	$5,443
Total		62,990	159,631	118,520		$51,468	$22,859	$1,751	$76,077

* Includes taxes and escalators.
** Contains extrapolated data.

Figure 15: Heat Maps of Baseline Bill+EV, PV, and Baseline+EV Netted with PV

Facility Fingerprint

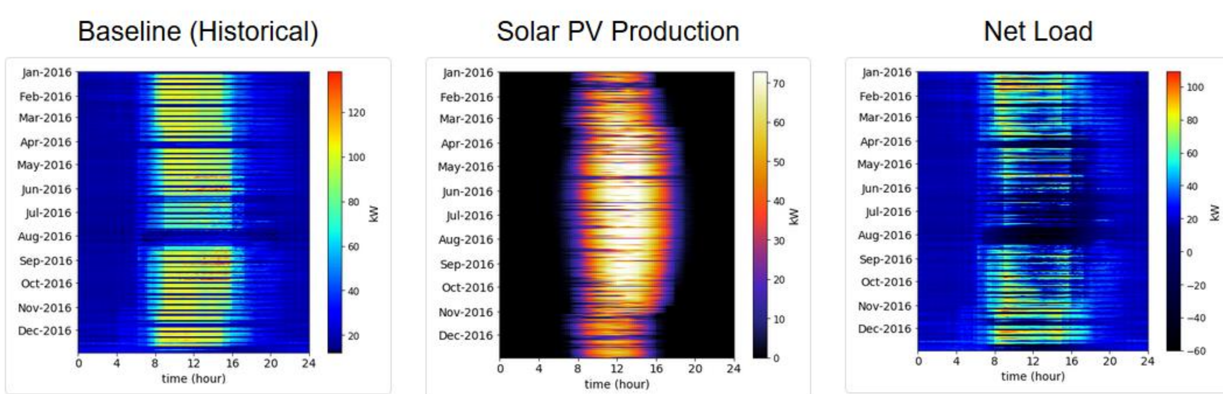


Figure 16 shows how the addition of the EV charging load doubles the preferred ES sizing in order to compensate for the additional peak and off-peak charging load.

Figure 16: Financial Summary of Best ES Choices when EV is Added

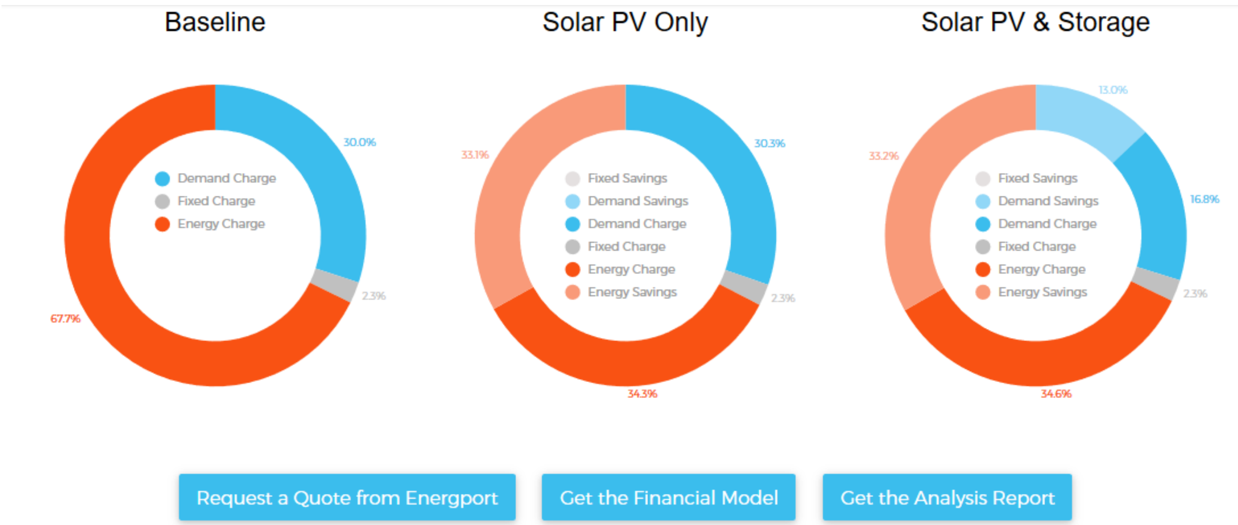
Based on the energy data that you uploaded, your incentive & financial inputs, and available OEM system configurations, Geli ESyst determined that the following systems provide the best financial performance. Select a system configuration and progress to the next page to download the Geli ESyst analysis and financial model.

\+ Solar + Storage Financial Performance

Solar + Storage Payback (Yrs)	3.3	3.1	3.3
Solar + Storage NPV	$261,207	$257,636	$252,153
Solar + Storage IRR (%)	22.5	24.3	23.7

Figure 17 shows the financial impact of the EV charging. The annual electrical bill increases to $76k if no action is taken. The addition of PV drops the bill to $50k, and ES further drops it to $40k, with a shorter payback period of a little over 3 years.

Figure 17: Financial Summary of Selected System



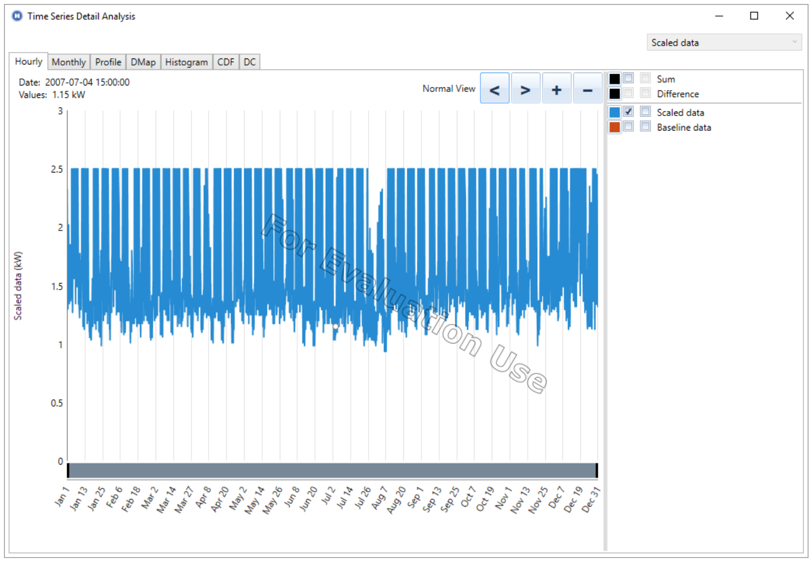
	Baseline	Solar PV Only	Solar PV & Storage
Tariff:	A-10-TOU	A-10-TOU	A-10-TOU
Energy Charges:	$ 51,501	$ 25,902	$ 25,961
Demand Charges:	$ 22,859	$ 22,859	$ 12,614
Fixed Charges:	$ 1,751	$ 1,751	$ 1,751
Total Utility Bill:	$ 76,111	$ 50,511	$ 40,326
Energy Savings:		$ 24,978	$ 24,921
Demand Savings:		$ 0	$ 9,711
Energy Assets:		$ 0	$ 9,711
Tariff Switch:		$ 0	$ 0
Fixed Savings:		$ 0	$ 0
Total Savings:		$ 24,978	$ 34,631
Payback:		3.93 years	3.34 years
NPV:		$ 152,029	$ 261,207
IRR:		19.54 %	22.51 %

r. Off Grid Model

Modeling the requirements for an extended outage requires a different approach and tool. A demonstration of HOMER was used for the modeling. HOMER assists in the design of off-grid microgrids by trying various combinations defined by the user and guiding the user toward optimum solutions among the constraints defined in the model.

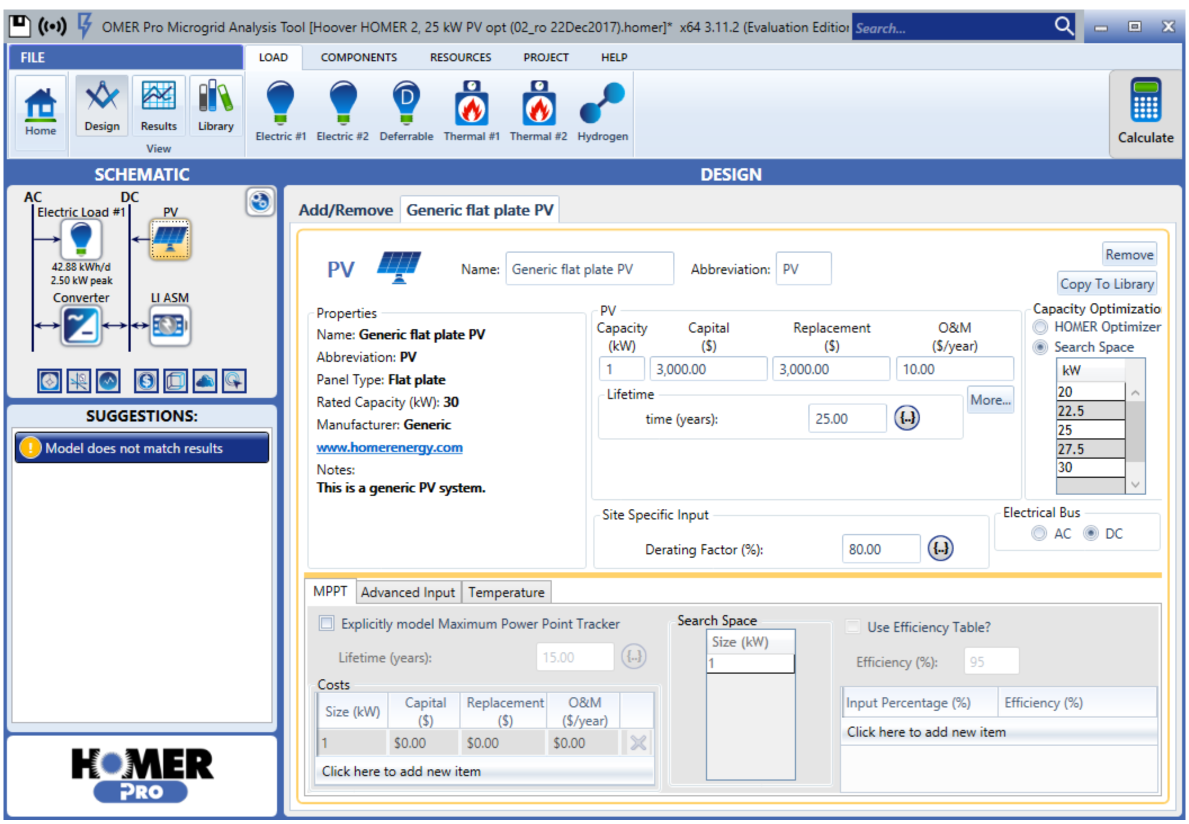
During an extended outage, the site would be used as a shelter with load drastically reduced. With the Bay Area's relatively benign climate, most shelters plan on no HVAC operation in order to conserve power needs. An estimate of about 20% of normal load (without EV charging) was used to drive the model. In order to drive the model with some natural variation, a modification to the existing load profile was used. A reduction factor was multiplied times the original reading and the annual average reading, with the smaller of the two values being used. With the reduction factor at 30%, the overall load totaled 21% of the original, as shown in Figure 18.

Figure 18: Reduce Load Profile for Off-Grid Model



A range of PV sizes was entered. First runs used a range of 25-50-75 kW. The results favored the 25 kW size, so the range of sizes shown in Figure 19 under Search Space was used in the next run for evaluation. Note that Search Space is selected in order to drive HOMER to use all the values given.

Figure 19: Range of PV Sizes for Off-Grid Operation Design



A generic 1 kWh energy storage cell was chosen for the model, and HOMER was set to try to find an optimum size package to work with the given load profile and PV sources. Figure 20 shows the choice of the generic cell and the selection to use the Optimizer for sizing. The Converter was set up similarly to have its size determined by the system.

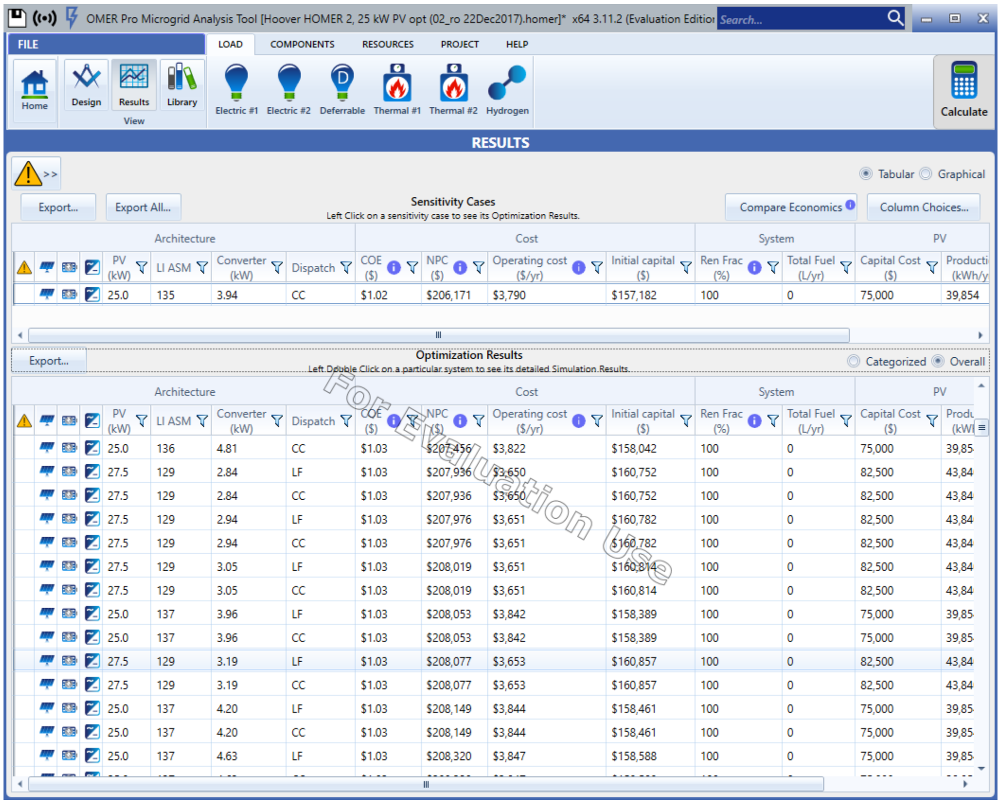
Figure 20: ES Battery Set to Generic 1 kWh Cell

The evaluation of configurations is shown in Figure 21. The Sensitivity Case is the one that had the lowest cost. The Optimization Results section has the <u>Overall</u> results selected (vs Categorized which would have only shown the best results for each combination run) in order to show some of the many combinations that were considered.

The recommended configuration selected by this set of inputs is:

- PV: 25 kW
- ES: 135 kWh
- Converter: 4 kW

Figure 21: Design Run Results with Samples of Configurations Considered



PV (kW)	LI ASM	Converter (kW)	Dispatch	COE ($)	NPC ($)	Operating cost ($/yr)	Initial capital ($)	Ren Frac (%)	Total Fuel (L/yr)	Capital Cost ($)	Production (kWh/yr)
25.0	135	3.94	CC	$1.02	$206,171	$3,790	$157,182	100	0	75,000	39,854

PV (kW)	LI ASM	Converter (kW)	Dispatch	COE ($)	NPC ($)	Operating cost ($/yr)	Initial capital ($)	Ren Frac (%)	Total Fuel (L/yr)	Capital Cost ($)	Production (kWh/yr)
25.0	136	4.81	CC	$1.03	$207,456	$3,822	$158,042	100	0	75,000	39,85
27.5	129	2.84	LF	$1.03	$207,936	$3,650	$160,752	100	0	82,500	43,84
27.5	129	2.84	CC	$1.03	$207,936	$3,650	$160,752	100	0	82,500	43,84
27.5	129	2.94	LF	$1.03	$207,976	$3,651	$160,782	100	0	82,500	43,84
27.5	129	2.94	CC	$1.03	$207,976	$3,651	$160,782	100	0	82,500	43,84
27.5	129	3.05	LF	$1.03	$208,019	$3,651	$160,814	100	0	82,500	43,84
27.5	129	3.05	CC	$1.03	$208,019	$3,651	$160,814	100	0	82,500	43,84
25.0	137	3.96	LF	$1.03	$208,053	$3,842	$158,389	100	0	75,000	39,85
25.0	137	3.96	CC	$1.03	$208,053	$3,842	$158,389	100	0	75,000	39,85
27.5	129	3.19	LF	$1.03	$208,077	$3,653	$160,857	100	0	82,500	43,84
27.5	129	3.19	CC	$1.03	$208,077	$3,653	$160,857	100	0	82,500	43,84
25.0	137	4.20	LF	$1.03	$208,149	$3,844	$158,461	100	0	75,000	39,85
25.0	137	4.20	CC	$1.03	$208,149	$3,844	$158,461	100	0	75,000	39,85
25.0	137	4.63	LF	$1.03	$208,320	$3,847	$158,588	100	0	75,000	39,85

Figure 22 shows how State of Charge (SoC) of the batteries is managed in this configuration. The results show that for the given load profile, the system could run with only PV as the charging source for a year. The lower right hand "stock chart" plot with range limits shows how December and January have the most difficult SoC management needs, driving the system component sizes.

Figure 22: ES State of Charge Plots

s. Comparison of Designs for Demand Charge Management vs Off-Grid

Table 1 compares the results of the different configuration scenarios using the relevant tools.

Table 1: Comparison of Design Scenario Results

Scenario	PV	ES	Tool
Baseline Load	87.4 kW DC/ 72.8 kW AC	29 kW/ 60 kWh	Geli
Baseline + EV (5x @ 3.3 kW, low Level 2)	87.4 kW DC/ 72.8 kW AC	29 kW/ 120 kWh	Geli
Off-Grid (21% of kWh Baseline with no EV)	25 kW DC	4 kW/ 135 kWh	HOMER
Notes:	1	2	3

Table 1 notes:

1. Baseline PV for Geli runs is sized by survey estimate for flat roofs and parking lots, not pitched roofs.
2. ES size is best recommendation from the tool used.
3. Geli sizes battery for DCM and energy offset. HOMER sizes battery for off-grid operation.

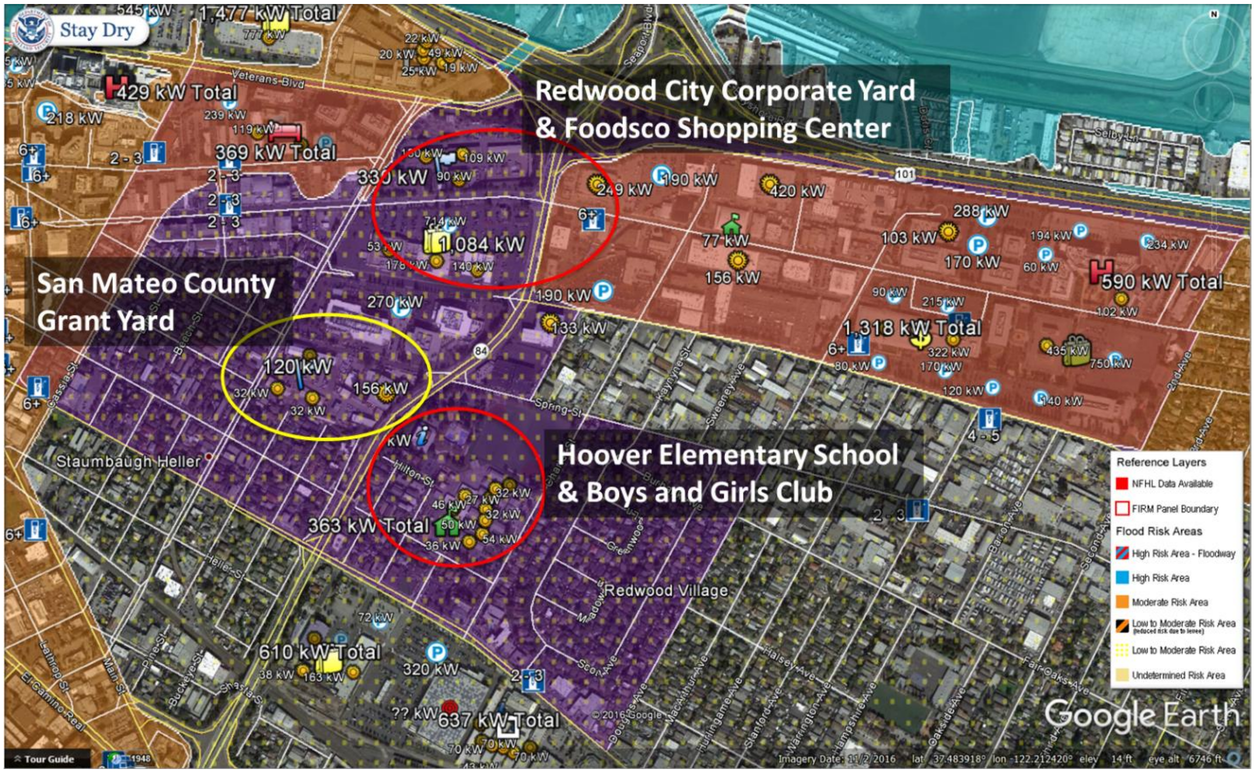
Note that when the EV load was added to the school, the ES capacity needed for DCM doubled. This larger capacity ES capacity blends well with the potential for off-grid operation. The off-grid mode can function with less PV and a slightly larger ES capacity.

This analysis shows that ES used for DCM can provide a good starting point for building a sustainable SEM. Energy efficiency improvements were implemented at Hoover Elementary several years ago which decreased their baseline load, and this is an important step that must be implemented before sizing an SEM.

XI. Deployment

The Hoover Elementary School site is part of a deployment planned for PAEC phase 2. It is in the Redwood City CalEnviroscreen 3.0 top quartile “horseshoe” that includes the Stanford Redwood City campus, corporate yards for the city and county, a new development by Sobrato near the city yard, and a Boys and Girls Club. Figure 23 below shows the area with more detail than was shown in Figure 1. Since the school is outside the moderate risk flood zone, it is an ideal location for a long-term shelter during a regional disaster. Purple is the original zone and becomes brown where it coincides with the FEMA moderate risk area.

Figure 23: Redwood City CalEnviroscreen 3.0 Top Quartile Map (purple) Overlayed with FEMA Moderate Risk Flood Zone Map



As shown in Figure 6, the school has a mix of both pitched roof and flat roof/canopy sites. Because the pitched roof buildings are older, there is concern about time delays in getting approval from The Division of the State Architect (DSA) to add PV load to the older structures. All the modeling was done with the assumption that the needed PV could be built on the newer planned structures (gymnasium, walkway, parking lots) with probable faster time for DSA review and approval.

At the time of designing and deploying the actual SEM system, more detailed studies will be performed to assess the real power needs of the school site for both short and long-term outages. The PAEC phase 2 deployment plan will include the following: (1) Deployment goals (2) Critical success factors (3) Deployment tasks, resources, and tools (4) Task and resource dependencies (5) Budget for resources needed to meet deployment goals (6) Task responsibilities and timelines for completion and (7) Significant risks and contingency plans.

XII. Conclusion

As EV charging becomes more prevalent, the need to offset the daytime charging load impacts on energy bills will create more opportunities to implement cost-effective storage that can be utilized to form an SEM during an emergency, if the emergency operating load can be reduced to minimum level.

Taking the largest component capacities from Table 1, the following system could provide economic benefits for both energy and demand charge offsets, as well as to provide an indefinitely sustainable shelter for the community during a long-term power outage disaster:

- PV: 87.4 kW DC/ 72.8 kW AC
- ES: 29 kW/ 135 kWh

The PV can be sited on newer structures which should have a faster track through DSA approval. The school already has funding and plans in progress for these newer structures.

The impact of demand charges on utility bills may come as a shock to many businesses that install EVCI so that their employees can charge their cars while at work. However, there appears to be a hidden benefit in that the demand charges can create an economic incentive to install energy storage. The ES then becomes an enabling technology for higher renewable penetration into the distribution grid as well a starting point for creating SEMs that supply indefinite renewables-driven backup power to critical loads.