Peninsula Advanced Energy Community (PAEC)

Task 10.2: Final Master Community Design

Redwood City Community Microgrid: Innovation and Resilience

<u>Prepared for</u>

California Energy Commission
1516 Ninth St., MS-51
Sacramento, CA 95814

Prepared by
Clean Coalition
16 Palm Court
Menlo Park, CA 94025
www.clean-coalition.org

May 2018

Table of Contents

Table of Figures

Table of Tables

I. 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.

Visit us online at www.clean-coalition.org.

II. Legal Disclaimer

This document was prepared as a result of work sponsored by the California Energy Commission. It does not necessarily represent the views of the Energy Commission, its employees, or the State of California. Neither the Commission, the State of California, nor the Commission's employees, contractors, nor subcontractors makes any warranty, express or implied, or assumes any legal liability for the information in this document; nor does any party represent that the use of this information will not infringe upon privately owned rights. This document has not been approved or disapproved by the Commission, nor has the Commission passed upon the accuracy of the information in this document.

III. Executive Summary

The Clean Coalition's Peninsula Advanced Energy Community (PAEC) initiative was funded by a grant through the California Energy Commission's Electric Program Investment Charge (EPIC) program, which offered "The EPIC Challenge: Accelerating the Deployment of Advanced Energy Communities." The Clean Coalition has worked with a broad range of collaborators including the local utility, Pacific Gas & Electric (PG&E) and local governments to accelerate the planning, permitting and deployment of an Advanced Energy Community (AEC) in southern San Mateo County.

PAEC provides an opportunity for the Clean Coalition to develop innovative and replicable approaches for accelerating the deployment of AECs. It is anticipated that, based on 25 megawatts (MW) of peak demand reduction, the initiative will save energy consumers over $25 million, generate over $100 million in regional economic output, create $35 million in local wages, and reduce greenhouse gas (GHG) emissions by nearly 800 million pounds over 20 years. These findings have paved the way to enable streamlined planning, permitting and deployment of advanced energy technologies including solar PV, energy storage and electric vehicle charging infrastructure (EVCI).

The Clean Coalition developed the following Master Community Design for a disadvantaged community within the PAEC region in southern San Mateo County. The report identifies the locations of the proposed distributed energy resources (DER) and other PAEC elements including Solar Emergency Microgrids (SEMs), Community Microgrids (CMs), EVCI and a description of how these elements are combined in a systems approach to form a synergistic AEC. The design will include a site map with the proposed DER deployments, describe the interconnection type and location for each component, and will include the quantity, type, and size of units to be built. Ultimately, the Master Community Design develops a shovel-ready pilot project that can be deployed during PAEC Phase 2. The Master Community Design calls for developing a Redwood City Community Microgrid that will be an asset for the local community by reducing energy costs and emissions, improving local air quality and providing energy resilience during grid outages. Lessons learned from this project will inform and streamline future deployments, allowing for large-scale DER and Community Microgrid proliferation.

The Final Master Community Design contains single line drawing block diagrams, engineering drawings, cost estimates and financial models for all Phase 1 proposed sites which include Stanford Redwood City, Hoover Cluster, Redwood City Corporation Yard, and San Mateo County Corporation Yard. Initially there was a possibility of using the existing distribution grid to connect all sites of the Redwood City Community Microgrid; however, due to concerns from the utility, Pacific Gas and Electric (PG&E), and an excessive number of reclosers and other switching equipment required for this design, a single line diagram describing the utility connection between all sites of the Redwood City Community Microgrid was not produced.

IV. Community Design Overview

a. Collaborators

The collaborators involved in the PAEC Master Community Design include a variety of local municipalities, community groups, private companies, technical experts, and the local utility PG&E. Municipal partners include the City of Redwood City, San Mateo County government, and the Redwood City School District. Each of these municipal groups are committing at least one property to serve as a deployment site for the advanced energy technologies discussed in this report. In addition, the City of Redwood City has been a great resource in determining challenges and solutions to implementing technologies such as EVCI and has also supported the PAEC project by detailing their internal review processes for permitting new energy and sustainability projects. Community group partners include the Boys and Girls Club of the Peninsula, Redwood City, which will serve as a deployment site. The PAEC project also has the support of Redwood City 2020, a community organization dedicated to building healthy and vibrant communities, as well as the Red Cross which would run emergency operations out of the Hoover School's emergency shelter if the need arose.

The Sobrato Organization and Stanford University are two private companies that are involved with the Master Community Design as deployment sites for advanced energy technologies. The Sobrato Organization is a for-profit building developer in the Bay Area and is dedicated to the PAEC project to support the deployment of clean energy and advanced energy technology; they are also interested to learn and understand how to streamline the design of energy components in new construction, and to understand that long-term financials of buildings that incorporate advanced energy technologies. Stanford University is a top-tier research university that is a global innovator and leader in district thermal energy systems; they've deployed a large scale thermal energy system on their main campus and are investigating the possibility of including a smaller-scale version of the system at their new Redwood City development. In addition to being a deployment site, Stanford University will provide technical expertise on integrating a district thermal system with PV and energy storage for a Zero Net Energy facility.

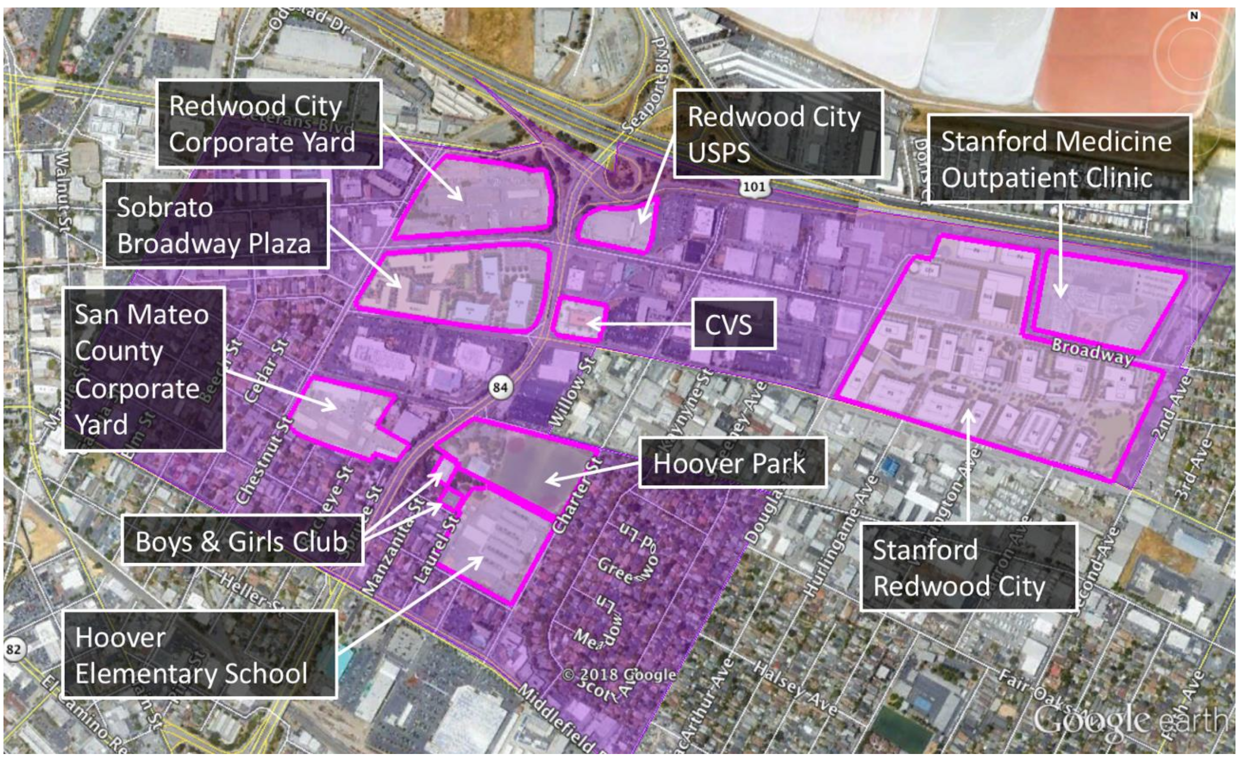
Technical expertise for the Master Community Design is provided by West Hills Construction (WHC). WHC is developing the detailed engineering designs including rooftop and carport solar layouts, onsite trenching plans, and individual site single line diagrams, some of which utilize the existing distribution grid. WHC will also review the detailed economic models which will account for asset ownership structure, state and federal incentives for solar and energy storage. During the deployment phase, WHC will serve as the main technology partner and EPC for the solar and battery as well as engineering support for developing the microgrid controller. Prior to deployment, the proposed designs will need to undergo a permit level engineering design and review. Without funding in place to develop the project, producing permit level designs is cost prohibitive.

b. Locations

This area of Redwood City is a great location for deployment of an Advanced Energy Community project because it is representative of many growing suburban neighborhoods throughout California. The excellent solar resource paired with common suburban features such as relatively short buildings (up to four stories) and reliance on a personal vehicle for transportation mean that the Redwood City Community Microgrid can serve as a model project for other California communities interested in deploying solar, energy storage and EVCI to lower their energy footprint and reduce GHG emissions. The proposed locations for development are shown in Figure 1 below, which is an overview map of the deployment project area. Deployment sites include:

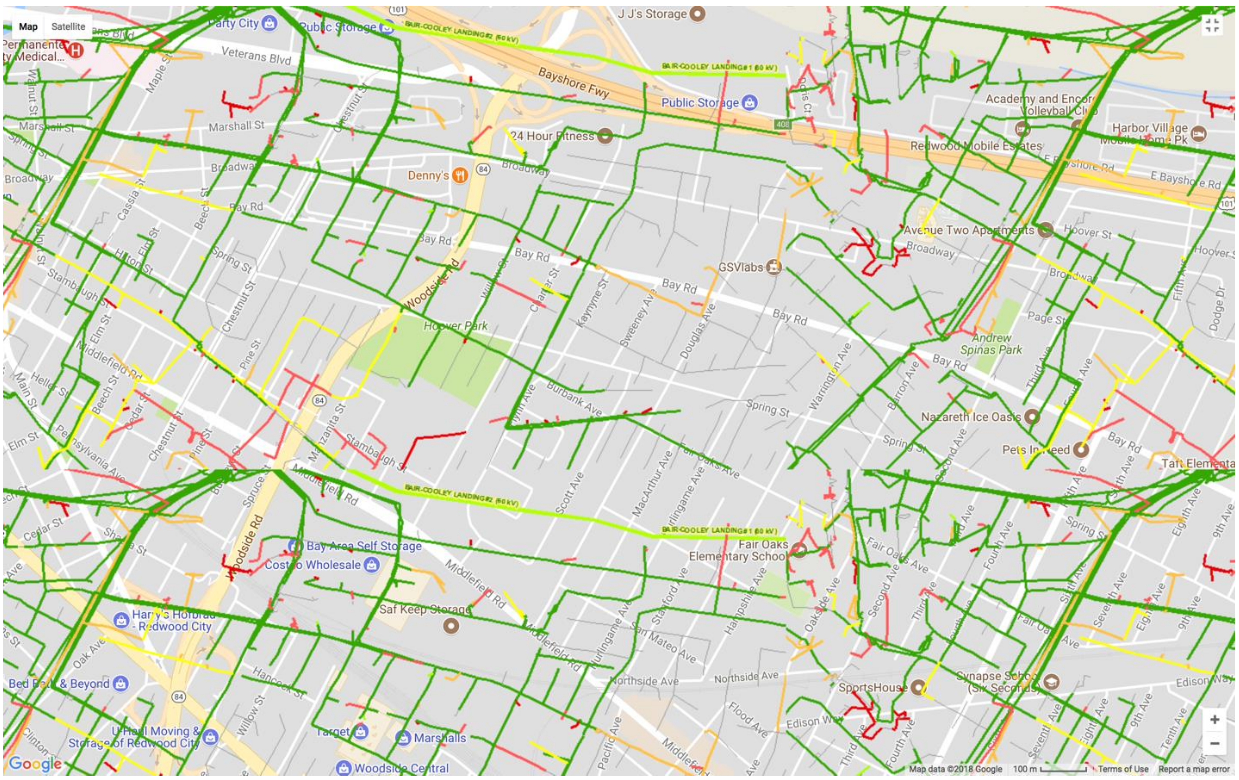
- Hoover Cluster
    - Hoover Elementary School
    - Boys & Girls Club of the Peninsula, Redwood City
    - Hoover Park (Redwood City public park)
- Stanford Redwood City real estate development
- Stanford Medicine Outpatient Clinic
- Sobrato Broadway Plaza, a new retail and affordable housing development
- Redwood City USPS
- Redwood City Corporate Yard
- San Mateo County Corporate Yard

Figure 1 Redwood City Master Community Design overview map



The locations included above were selected for several reasons. First, each site demonstrates a unique use-case for a Community Microgrid as it relates to the ownership model and energy cost savings and resilience. This is significant because demonstrating microgrids for a variety of use-cases is essential to ensuring widespread adoption of microgrid technology and renewable distributed energy resources (DER). The sections below discuss the unique use-case of each site in more detail, and this information is also summarized in the Deployment Summary. Second, each of the facilities contains critical loads that could greatly benefit from indefinite renewables-driven backup power during a grid outage, especially long-term outages caused by a disaster event. Some facilities benefit the entire community such as the Hoover School emergency shelter and the corporation yards which will assist in disaster recovery, while other sites such as Stanford Redwood City will benefit from emergency backup power so they may carry out their own disaster response activities. Finally, all sites included in the Master Community Design are located in the top 85th percentile of disadvantaged communities per the CalEnviroscreen 3.0, a tool developed by CalEPA to identify communities that are disproportionately affected by environmental burdens.

Figure 2 PG&E ICA map for Redwood City



The map in Figure 2 above is from the PG&E Integrated Capacity Assessment (ICA) tool[1] which is available online with a PG&E login. The map illustrates the approximate location of distribution grid feeders (typically run along roads, either above or underground). The color scale gives a relative idea of the capacity of the feeders to accept new renewable generation; green indicates that a feeder can accept more renewables while red indicates the feeder is already congested and would require a grid upgrade such as a transformer upgrade to accommodate more load or generation. While the ICA map is a great tool for evaluating the initial feasibility of a renewable energy project, there are a few challenges. First, the exact location of the feeder is difficult to determine; utility maps that are to-scale must be requested from PG&E directly, and the expected turnaround time for this information is 2 weeks. Furthermore, even the utility map may not be enough information; prior to beginning construction on a site, construction contractors must call PG&E to ensure that there are no underground utilities that may be damaged by the proposed

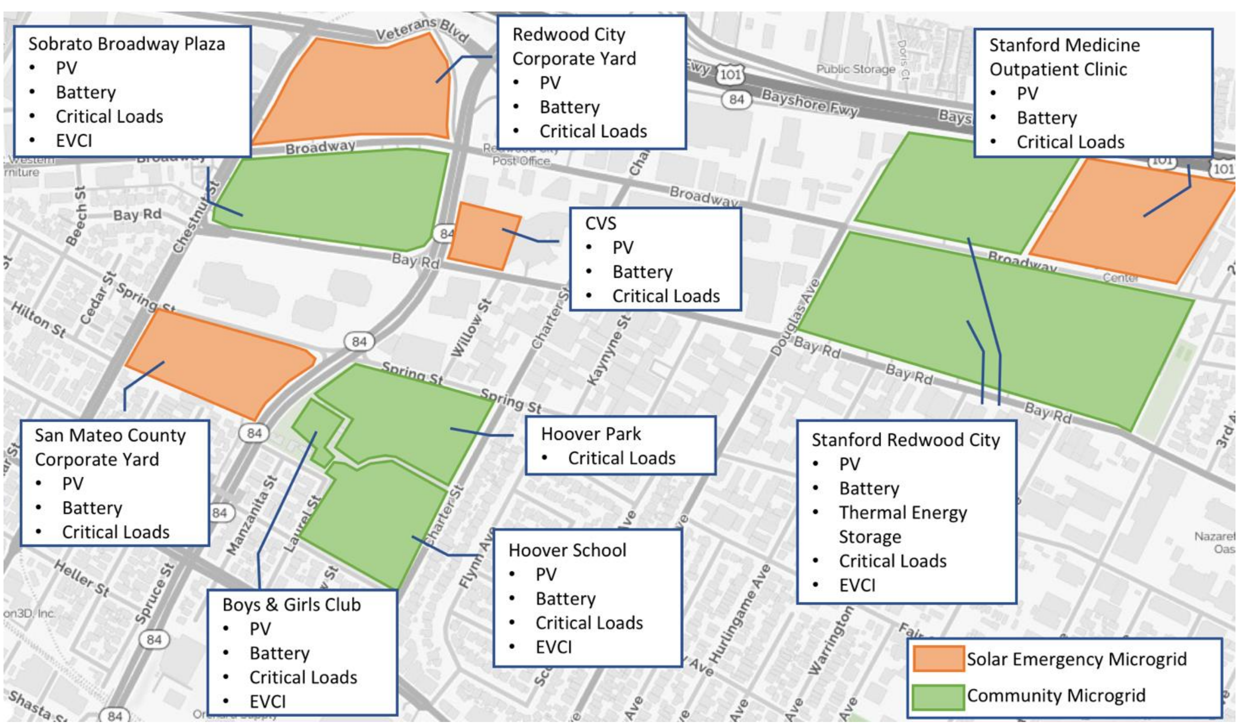
[1] The ICA tool can be found at this link: https://www.pge.com/eum/login

trenching path. Discovery of an unexpected underground utility can change the agreed-upon design and can potentially have cost impacts to the project. More details on how to obtain utility map information is provided in the Appendix. Another challenge is that information in the ICA map is not always up to date. For the feeders of interest, the ICA map was last updated in July 2015. Since this particular area of Redwood City is undergoing huge growth with several large development projects initiated in the last year, a more detailed look at the utility maps is required. Fortunately, ongoing proceedings at the California Public Utilities Commission (CPUC) indicate that California investor-owned utilities (IOUs) will be required to update the ICA maps on a monthly basis. The final challenge with the ICA maps as a resource for designing Community Microgrids is that the capacity calculations used to produce the map are based on one-way power flows; from the distribution substation to each feeder. If the Community Microgrid design proposes using the existing distribution grid to connect individual sites during a grid outage, additional power flow studies must be completed.

c. Conceptual Drawing

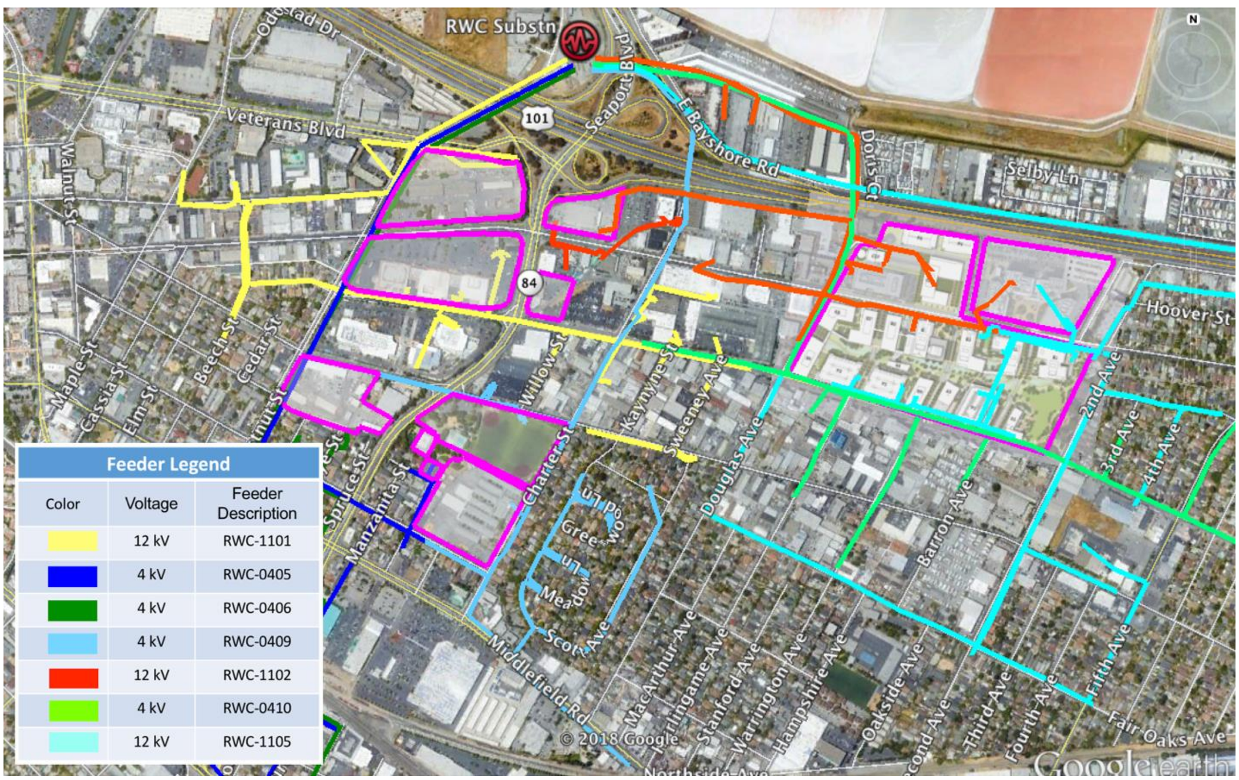
The overall conceptual drawing representing the scope, scale, and relationships of advanced energy equipment design elements to each other and to a proposed development site and buildings is included below. The drawing below represents the full-scale Redwood City Community Microgrid, which has undergone an iterative engineering and design process.

Figure 3 Redwood City Master Community Design Conceptual Drawing



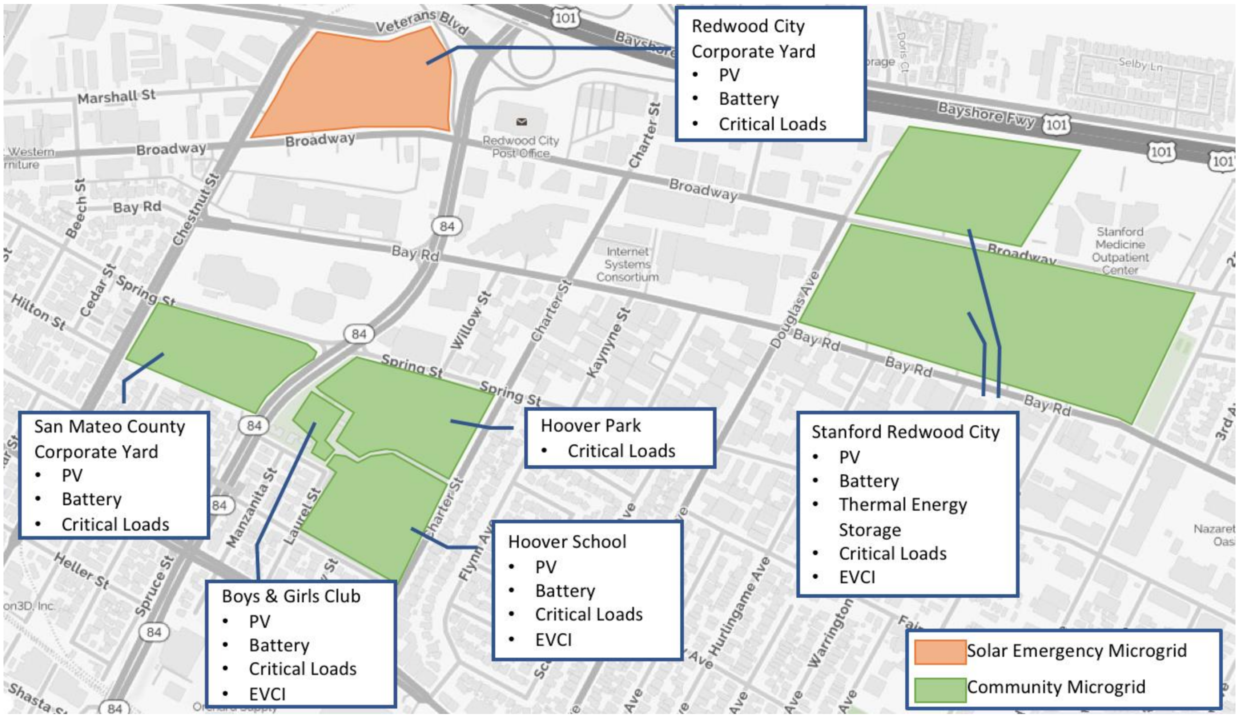
The conceptual drawing above shows each of the proposed locations for advanced energy technology deployment for the Redwood City Community Microgrid. The sites shown in orange are candidates for a SEM which is a behind the meter microgrid which includes loads behind a single meter powered by solar generation and energy storage. The sites shown in green are candidates for a Community Microgrid which includes critical loads behind multiple utility meters which will be connected via a dedicated underground or overhead line and used during grid outages only, or in the case on Stanford Redwood City may utilize the existing distribution feeders to connects the sites to each other. Initially, the vision for the Redwood City Community Microgrid was that each of the above sites be connected into a large-scale community microgrid; the relevant distribution feeders would be isolated from the larger grid during an outage, the feeders would be ties together using a combination of existing and new grid-tie points and switching equipment, and non-critical facilities along the route would be isolated to remain powered off during a grid-outage. Figure 4 below shows the approximate locations of distribution feeders in the area of the Redwood City Community Microgrid, with sites highlighted in fuchsia.

Figure 4 Redwood City Substation Feeders



Unfortunately, an experienced EPC confirmed that the cost of switching alone to isolate non-critical facilities along the islanded distribution line would be too expensive to implement. The sites are also quite far from each other, with the approximate total area of the microgrid spanning more than 220 acres of 1/3 of a square mile; if the project used a dedicated distribution line to ties the sites together, it would also be cost prohibitive. The primary advantage of connecting the sites together, is to have more operational flexibility during a grid outage; however, with so many variables involved in the successful development of a microgrid project, this vision was replaced with the more conservative Phase 1 design shown below. The sites shown above are at different stages of development; some are shovel ready while others need more engineering and design work to develop shovel-ready designs. The shovel-ready projects make up Phase 1 and are explored in detail in this Master Community Design. Phase 1 includes the Hoover Cluster, Stanford Redwood City, Redwood City Corporate Yard and San Mateo County Corporate Yard. The timeline for development of the remaining properties is uncertain at this time.

Figure 5 Redwood City Master Community Design Conceptual Drawing Phase 1



d. Deployment Summary

Table 1 below provides a summary of the number, type, and design of units to be built, including the system size and utility connections. The Redwood City Community Microgrid will deploy 3,304 kW AC of new rooftop solar and solar carports combined. Additionally, the project will deploy 2.6 MWh of battery energy storage and 82 new L2 EV charging ports. Final sizing for deployment will depend on the amount of funding available and the ability to secure an off-taker for the solar power interconnected using a feed-in-tariff (FIT) at a favorable rate. The deployment summary for Phase 1 is included below the comprehensive deployment summary.

Table 1 Redwood City Master Community Design Deployment Summary

Site Name	Meters or Buildings	Critical Loads	Solar [kW AC]	Battery [kW]	Battery [kWh]	EVCI (Level 2)	Interconnection Type	PG&E Feeder
Stanford Redwood City Phase 1	P1, B1-B4	Campus emergency response	886	251	2,100	52	NEM2	RWC-1102, RWC-1105
Hoover Cluster	Hoover School	Shelter & food service	276	29	150	20	NEM2/ FIT	RWC-0409
	Boys & Girls Club	Shelter & food service	101	0	0	10	NEM2/ FIT	RWC-0405
	Hoover Park	Equipment staging	0	0	0	0	-	RWC-0409
Redwood City Corporate Yard	Redwood City Corporate Yard	Road and public facility maintenance and repair	488	58	360	*4	NEM2/ FIT	RWC-1101
San Mateo County Corporate Yard	San Mateo County Corporate Yard	Road and public facility maintenance and repair	298	58	240	*4	NEM2/ FIT	RWC-0409
Sobrato Broadway Plaza	Sobrato Broadway Plaza (multiple meters)	Low income housing	1,197	TBD	TBD	TBD	NEM2	RWC-1101
	Sobrato CVS	Pharmacy & grocery	83	TBD	TBD	TBD	NEM2	RWC-0408
New Deployments TOTAL			**3,329**	**-**	**2,850**	**82**	-	-

* Indicates existing on-site assets and are not included in the New Deployments Total at the bottom of the table.

Table 2 Redwood City Master Community Design Phase 1 Deployment Summary

Site Name	Meters or Buildings	Critical Loads	Solar [kW AC]	Battery [kW]	Battery [kWh]	EVCI (Level 2)	Interconnection Type	PG&E Feeder
Stanford Redwood City Phase 1	P1, B1-B4	Campus emergency response	886	251	2,100	52	NEM2	RWC-1102, RWC-1105
Hoover Cluster	Hoover School	Shelter & food service	276	29	150	20	NEM2/ FIT	RWC-0409
	Boys & Girls Club	Shelter & food service	101	0	0	10	NEM2/ FIT	RWC-0405
	Hoover Park	Equipment staging	0	0	0	0	-	RWC-0409
Redwood City Corporate Yard	Redwood City Corporate Yard	Road and public facility maintenance and repair	488	58	360	*4	NEM2/ FIT	RWC-1101
San Mateo County Corporate Yard	San Mateo County Corporate Yard	Road and public facility maintenance and repair	298	58	240	*4	NEM2/ FIT	RWC-0409
New Deployments TOTAL			**2,049**	**-**	**2,850**	**82**	-	-

e. Design Methodology

The design methodology used to produce the Master Community Design follows the steps outlined below:

- Identify site location.
- Determine grid capacity to host distributed energy resources using the ICA map from PG&E.
- Obtain site details including number of meters on-site, recent utility bills for each meter, 1 year of 15-minute interval data for each meter and determine if there is any proposed future electrical work for the site. The full details are included in the Site Information Request section of the appendix.
- Develop maximum and net-metered solar system design using solar modeling tool (PVWatts, PVSyst or Helioscope).

- Determine grid-connected system design parameters using Geli ESyst. ESyst is the leading tool on the market to quickly and easily determine a battery's energy and demand charge savings; however, the system is not able to model off-grid systems or systems for energy resilience.
- Develop critical load profile for the facility. This was approximated using an algorithm which maintains variability in the load profile and results in a load profile that is 20%-25% of the original load.
- Determine off-grid system design parameters using HOMER Pro optimization tool. For this project, since the focus is energy resilience, the allowable capacity shortage (the amount of time the system is allowed to be off for) was set to zero percent. However, a variety of sensitivity cases, around the allowable capacity shortage and other parameters including PV system size were explored to ensure an optimized design.
- Iterate between on-grid systems in ESyst and off-grid systems in HOMER Pro to find a system that maximizes energy bill savings and also allows backup for critical loads.
- Engage an electrical contractor to finalize system sizing, develop an electrical single line diagram (including any required upgrades to on-site electrical equipment) and develop engineering site plans and trenching plans.

f. Systems Integration Approach and Synergies

A systems integration approach for advanced energy communities allows proven, market-ready technology to be deployed in new and innovative ways that have a synergistic effect on the project benefits. The PAEC Master Community Design will use proven technologies including solar, battery energy storage, thermal energy storage, building management systems, demand response, energy efficiency, and fuel-switching measures to develop a comprehensive Community Microgrid that can provide the additional benefit of energy resilience during grid outages. While each of the technologies can help reduce energy costs and GHG emissions during blue sky scenarios, the addition of switches and a controller enable these assets to be harnessed during a grid outage to provide emergency backup power. Using proven and market-ready technology will reduce the financial risk and technical risk of the project and ensure that the project is built on-time and remains in service for the project lifetime. Other synergies are present throughout the sites selected for the Master Community Design.

The decision to implement SEMs and Community Microgrids at critical facilities and for critical loads only, versus full power backup for a site, ensures that communities can receive resilience benefits while the cost for this resilience is minimized. Typically, microgrids are installed to power all of a site's loads indefinitely and utilizes energy dense technologies like fuel cells. While this paradigm may make sense for large corporations that place a tangible cost on operational downtime or mission critical military bases, these systems are excessive and cost prohibitive for cities and community services. By siting emergency backup power for critical loads only, the costs can be minimized. Critical facilities include important public and private services such as city Public Works departments to clear roads after a storm, hospitals and clinics to continue caring of the ill and community shelters and emergency response staging areas to assist recovery after an emergency. Limiting a Community Microgrid to these critical services ensures that a community can continue to operate after and recover from a natural disaster or emergency.

Energy efficiency is the least expensive energy-saving option of the advanced energy technologies discussed in the report, and can yield incredible savings to customers. By selecting sites that have already reduced their energy footprint by implementing energy efficiency measures, customers can save money by installing a more appropriately sized solar and storage system.

Installing new EVCI at workplaces and residences increases the likelihood of customers purchasing and driving an electric vehicle with no tailpipe emissions, which can reduce local pollution levels and provide cleaner air for communities to breathe. While this is a great benefit, if the vehicle is charged with grid power coming from a fossil-fuel power plant, then the EV is not being used in a way that is truly emission-free. Incorporating solar into facilities with EV charging can ensure that the vehicles are charged with clean power. The benefits of providing EV charging are clear, but there are costs as well. One consequence of adding EV charging to a site is that if the site has a small energy load, such as a school or community center, the addition of Level 2 charging can increase the utility customer's energy use and also disproportionately increase a customer's demand charge. This effect is pronounced when multiple EV drivers charge their vehicle with high power Level 2 chargers at the same time. This provides an opportunity for a battery to be integrated into a site with EV charging so that EV drivers can continue to receive a high-power charge while mitigating demand charges for the site and reducing the impact of high-power charging on the grid. This synergistic effect brings more value to energy storage, and similarly reduces the cost of EVCI for a site.

g. Permitting

While permitting can sometimes be a barrier to developing projects that involve advanced energy technologies, there are no red flags for permitting delays associated with this project. The majority of deployment sites included in the Master Community Design fall under the City of Redwood City as the main permitting agency, which happens to have progressive renewables permitting policy and significant experience permitting projects involving battery energy storage and EVCI. Redwood City's permitting approach and fees are discussed in detail below in the section titled Streamlining Permitting. Hoover School falls under the permitting authority of the Department of State Architecture (DSA) which often has higher standards for permitting new projects compared to a municipal agency. The main challenge with permitting projects at Hoover School is the additional time and money required to prove the suitability of Hoover School's old rooftops for installing solar panels with a 25+ year lifetime. However, Hoover School has significantly more solar siting potential than is required to power the microgrid during both blue sky and grid-island mode operations; Therefore, sufficient solar can be provided with a combination of solar carports and rooftop solar mounted on the new rooftops. Because of this, time delays associated with DSA permitting is not an issue for this project.

h. DER Interconnection

All projects in the Master Community Design require interconnection approval from the local utility, PG&E. Additionally, some sites or some meters within a site receive their electric generation from Peninsula Clean Energy (PCE) the Community Choice Aggregator (CCA) for San Mateo County. PCE customers still receive their bill from PG&E and pay meter, delivery, and other fees to PG&E. Solar PV will be the only true generation resource included in the Master Community Design. PG&E offers several interconnection options for solar, including Standard Net Energy Metering (SNEM) for systems under 30kW, Expanded NEM for projects between 30kW and 1MW and other programs for larger systems.[2] If a program to enable interconnecting the solar to the distribution grid, most likely though a FIT, becomes available before the commencement of PAEC Phase 2, that interconnection option will also be considered. Interconnecting a solar asset as wholesale distributed generation through a FIT or similar program is advantageous because it allows a site owner to make a profit from solar deployed on their property, and also because it increases the solar capacity available to power a SEM or Community Microgrid during a grid outage. At this time, there is no suitable program to allow for this type of interconnection in PG&E territory. Expected interconnection types for solar is included in Table 1.

Energy storage is considered a generator under Electric Rule 21 and is subject to interconnection procedures[3]. The batteries will either be interconnected using PG&E's Non-Export tariff or NEM Multiple tariff. These tariffs are designed to prevent energy arbitrage that is made possible by large energy price differences for customers on Time-of-Use rates. Expected interconnection types for batteries are included in Table 1.

Because EVCI is a behind the meter load, there is no interconnection agreement required. However, one consequence of installing new EVCI, especially large quantities of Level 2 charging ports, is that it can increase the energy use and energy demand of a utility customer. The more significant of the two is the increase in energy demand; this can result in a demand charge 2-3 times greater than the maximum pre-EVCI demand charge and can also move customers to a more expensive tariff. This provides additional incentive to utilize a battery for peak shaving and demand charge management, especially after considering the utility bill impacts of Level 2 charging. Similarly, energy efficiency, demand response and the microgrid controller are all behind-the-meter assets and do not require an interconnection agreement with PG&E.

i. Commercial Viability and Funding

All solar and battery systems proposed in the Master Community Design have undergone preliminary economic analysis. This is a key step because it demonstrates how much grant funding will be needed to supplement the energy savings and demand charge savings so that it is financially favorable for a site to participate in the Community Microgrid and so they may receive economic, environmental, and resilience benefits. The economic analysis primarily explores total savings, net present value, and simple payback for systems that provide energy savings. For systems that will be more expensive than using grid power, analysis was based on optimization of the net present cost using Homer Pro. The key metric reported is the internal rate of return (IRR) which is the best indicator of weather a site should move forward with deploying a project or not.

Because there are several different entity types included in the microgrid, different ownership models will be needed. For public or non-profit facilities, third-party ownership is required to take advantage of the Federal Investment Tax Credit (ITC) and reap the most financial benefit from the solar system. For behind the meter solar interconnected using net metering, a power purchase agreement (PPA) and an energy service agreement will need to be in place to facilitate the sale of solar power and energy service from the project owner to the deployment site. For solar interconnected using a FIT, a lease agreement will need to be in place so the site owner can be compensated by the project owner for using their rooftop/ parking lot space. In order to finalize

[2] PG&E Interconnection and Renewables https://www.pge.com/en_US/for-our-business-partners/interconnection-renewables/interconnections-renewables.page?ctx=business

[3] PG&E Energy Storage Interconnection Guidelines https://www.pge.com/en_US/for-our-business-partners/interconnection-renewables/export-power/distributed-generation-handbook/net-energy-metering/energy-storage/energy-storage.page

these agreements, we need to determine the maximum price that off-takers can pay. PCE is slated to be the primary off-taker for the FIT solar, but, a maximum rate per kWh must still be determined. If the maximum rate the offtake can pay is too low to make the FIT projects economically viable, grant funding could be used to subsidize the cost of the system for the third-party owner. WHC, the EPC partner for the Redwood City Community Microgrid can also leverage their large portfolio and industry experience and bundle these proposed deployments with other projects that need third party financing to secure a project owner and financier. Some potential owners include Stone Edge Farm and Wooster Construction. Table 3 contains an economic summary of the Phase 1 projects.

Table 3 Economic Summary of Phase 1 deployments

Site	Stanford RWC	Hoover School	Redwood City Corporate Yard	San Mateo County Corporate Yard
PV System Size kW DC	886	73	136	98
Battery Output kW	251	29	58	58
Battery Duration Hours	4	5	6	4
Battery Storage kWh	2,100	150	360	240
Electric Vehicle Charging Stations	52	0	0	0
Total Project Cost	$4,670,000	$348,980	$769,282	$513,683
Federal Tax Credit %	30%	30%	30%	30%
1st Year Depreciation	100%	100%	100%	100%
Net Cost After Incentives	-$1,041,171	$214,681	$478,018	$308,890
Estimated Annual kWh Savings	1,688,032	149,805	203,205	102,016
Estimated Annual Utility Savings	$456,989	$33,299	$41,246	$16,462
Annual Operating Expenses*	($13,200)	($2,405)	($4,950)	($3,610)
Project 10 yr IRR	12.3%	18.7%	-0.8%	0.1%
Project 20 yr IRR	15.7%	14.2%	7.3%	5.4%

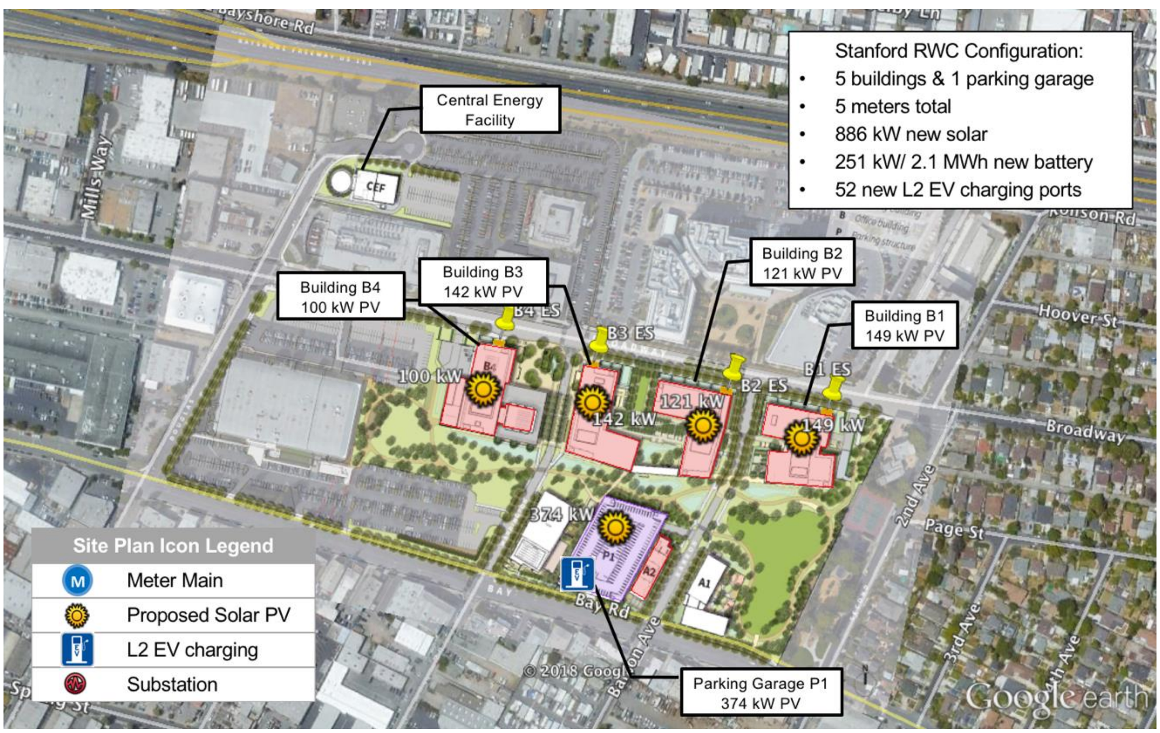
The economic analysis summary above has several exclusions and limitations. It is limited to sites that will have energy storage deployed on-site, so the Boys and Girls Club is excluded. The analysis is limited to the NEM2 interconnected solar and energy storage costs. The EVCI costs and all capital expenses and operational expenses associated with the proposed FIT were excluded due to uncertainty of the maximum rate the off-taker is willing to pay. The analysis reviews the assets to be deployed, the total project cost, any incentives including ITC, bonus depreciation and Self-Generation Incentive Program (SGIP) rebates. For all sites it is assumed that the ITC is 30%, full bonus depreciation will be taken in the first year, and that the energy storage qualifies for SGIP Step 2 in PG&E service territory. Estimates for annual energy savings and annual utility savings are included, and both a 10 and 20 year IRR are given. The economics for Stanford RWC and Hoover School look excellent with a 10 year IRR of 12.3% and 18.7%, while the economics for the two corporate yards are not as good. The 20 year IRR is around 6% which is typically the internal hurdle rate many private companies need to meet in order to make an investment in a project such as this. The major difference between the two projects that fare well economically and the two that don't are that the two corporate yards are not deploying any additional EVCI. EVCI deployment leads to load growth, an increase in demand, and an intermittent load due to EV charging. Without the need to mitigate these large, spikey loads, the energy storage cannot be effectively monetized.

The next steps to determining additional funding sources for this deployment are to finalize the terms and rates for a FIT pilot program with PG&E and PCE and develop the economic analysis for the FIT-interconnected solar. Then the projects will be bundled and shopped around to various investors.

V. Stanford Redwood City

Stanford Redwood City is a new, two-phase real estate development of more than a dozen buildings located in a disadvantaged community within Redwood City, shown in Figure 6. Phase 1 construction began in August 2017 and is scheduled to be completed with full occupancy by July 2019. This Community Microgrid use case is for a large campus with multiple buildings and meters as well as highly customized energy solutions for central heating and hot water, while the ownership model is representative of a non-profit site owner/ project beneficiary. Siting a Community Microgrid will allow Stanford to demonstrate how distributed energy resources (DER) can be configured to provide energy cost savings and resilience at campuses and multi-building, multi-meter clusters nationwide.

Figure 6 Stanford Redwood City overview map



The core of the Stanford RWC Community Microgrid will combine the data center load with 374 kW of solar on the parking garage, 2.1 MWh of lithium battery energy storage, and 52 Level-2 EV charging ports to minimize peak demand charges, minimize Stanford RWC's impact to the PG&E grid and maximize energy cost savings for Stanford. Additionally, the project will reduce GHG emissions by 54% compared to standard PG&E electric generation and natural gas. The DER elements will be integrated into, monitored and controlled by EOS, a product by Johnson Controls that enables high DER penetration microgrids. The project will also deploy 512 kW of solar across buildings B1-B4 to provide Stanford RWC with more carbon-free generation. Finally, the proposed DER will provide renewables-driven backup power to the campus data center (A2).

j. Deployment Summary

The solar assets in Table 4 will be deployed at Stanford Redwood City.

Table 4 Stanford Redwood City solar, energy storage and EVCI deployment summary

Building #	Building type	PV size [kW]	Annual production [MWh]	Energy storage capacity [kWh]	L2 EVCI ports
CEF	Energy	-	-	47,600	-
P1	Parking	374	586	2,100	52
A2	Data-center	-	-	-	-
B1	Office	149	249	-	-
B2	Office	121	199	-	-
B3	Office	142	235	-	-
B4	Office	100	167	-	-
TOTALS		886	1,436	49,700	52

k. Existing and Proposed DER

Because Stanford RWC is a new facility, all of the above-mentioned DER are proposed. The Stanford RWC facility was permitted in 2013 and is therefore designed to meet the efficiency requirements in the 2013 version of the California Building Code, Title 24 so some efficiency measures could be considered existing features. The project will provide resilience through an innovative combination of five distributed energy resources (DER) and a microgrid controller, as follows:

Energy efficiency: The Central Energy Facility (CEF) represents a fuel-switching, energy efficiency and thermal energy storage measure that will provide district-level heating, cooling, hot water 50% more efficiently than a comparable gas boiler district thermal system. The CEF supplies Stanford RWC with 47.6 MWh of thermal energy storage in the form of hot and cold-water storage tanks, and reduces the campus' on-peak energy demand for heating and cooling by following retail energy market price signals. The CEF is a small-scale replica of the $500 million SESI project4 that has been operational at Stanford University's main campus since 2015. The CEF uses electric heat pumps to support all Stanford RWC buildings and provides a unique opportunity to integrate thermal energy storage into a Community Microgrid.

Solar: 895 kW of new Solar PV will be provided by WHC.

Energy storage: 2.1 MWh of Tesla Powerpack lithium-ion batteries will enable electric energy storage.

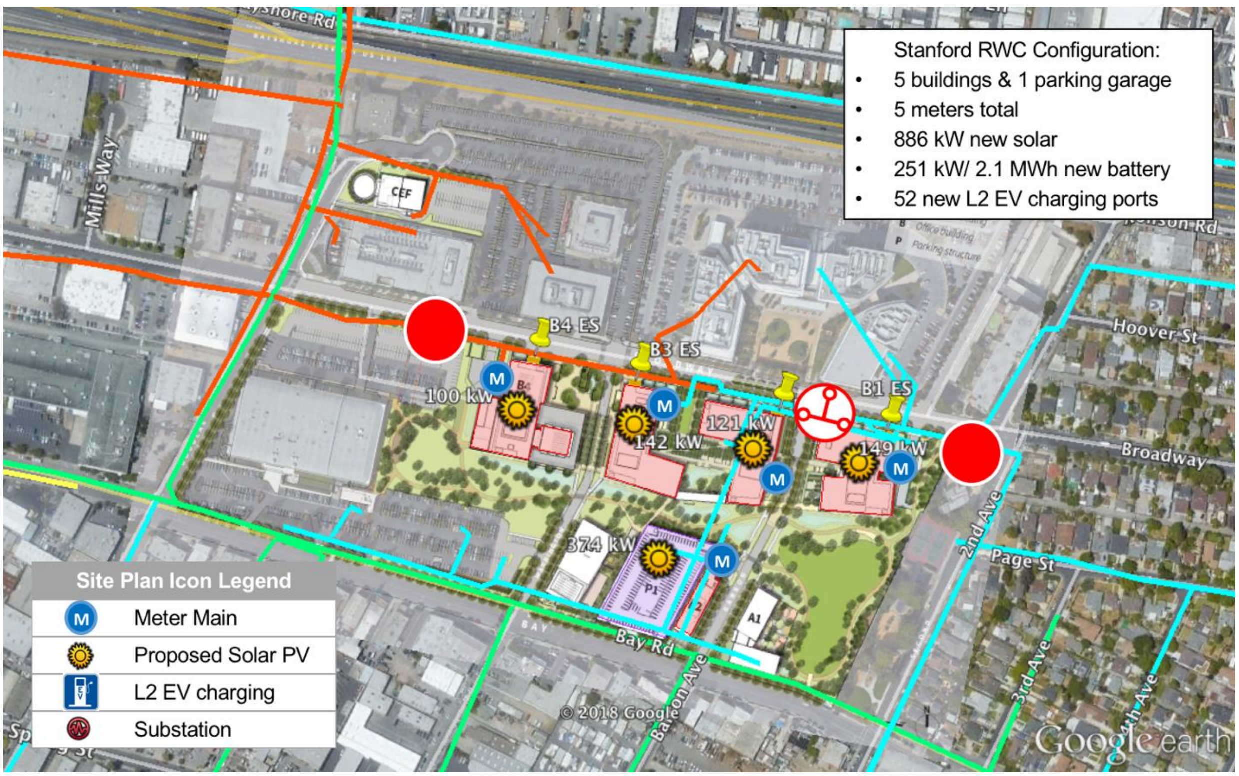
Demand response: Building management system (BMS) by Distech Controls will enable demand response.

Vehicle-Grid-Integration (VGI): VGI capable electric vehicle charging infrastructure (EVCI) will enable demand response with 52 ChargePoint. Inc. level 2 charging ports.

Microgrid controller: Johnson Control's Enterprise Optimization Solutions (EOS) software will serve as the master microgrid controller. EOS will integrate the CEF, BMS, solar, battery, and EVCI to co-optimize for daily energy operations; and for data center resilience benefits during grid outages. This project will explore unique co-optimization algorithms and will provide the CEC with recommendations to support rapid commercialization of multiple-DER microgrids.

Stanford Redwood City will utilize the existing distribution grid to connect the individually metered buildings together during a grid outage. Figure 7 shows the distribution feeders serving Stanford Redwood city. Each colored line represents a different feeder originating at the Redwood City substation. During a grid outage, switches represented by the large red circles will electrically isolate the campus from the grid. An existing grid-tie point represented by the white circle with a "T" will be closed so the two feeders can be connected.

Figure 7 Stanford Redwood City Phase 1 solar & circuit feeders



I. Support of Key Stakeholders

The Clean Coalition will be partnering with multiple entities to develop a successful Community Microgrid project at Stanford RWC. Stanford University will serve as the site host and off-taker of solar PPAs. Stanford University is particularly interested to further develop their innovative Central Energy Facility and thermal energy storage system to incorporate batteries and achieve additional energy savings and GHG emissions reductions. WHC will serve as the main technology partner and EPC for the solar and battery as well as engineering support for the development of EOS. WHC will also serve as the solar and battery owner. Johnson Controls (JCI) will serve as the microgrid integrator and operator. Stanford will contract JCI to customize their Enterprise Optimization Solutions software for this application and will provide all monitoring, communications, and controls for the project. DEVCON Construction, Inc. will serve as the EPC for the building management system. They will deploy Distech Controls software and Tridium Niagara hardware. Redwood Electric will serve as the electrical EPC for the EVCI portion of the project. PG&E will serve as the local utility and their participation and support for this project will be essential for determining the best option for interconnection and replicable market opportunities.

VI. Hoover Cluster

The Hoover Cluster is a Community Microgrid deployment that includes Hoover School, the Boys & Girls Club of the Peninsula and Hoover Park, a public Redwood City park. The facilities all play a role during a community disaster response scenario; Hoover School is a designated Red Cross emergency shelter, meaning that during an emergency, the Red Cross would staff and equip the facility to provide water, food and shelter to those in need. The Boys and Girls club would provide additional sheltering space while Hoover Park provides a large open field with bright night-time field lighting that is the ideal location for staging supplies and equipment. The addition of a Community Microgrid to these facilities will ensure that emergency responders have access to essential communications equipment and that the community can be sheltered comfortably long-term. Finally, all three sites are well-known community facilities, and are natural gathering places for families and communities during emergencies and long-term power outages. The Hoover Cluster also demonstrates a replicable opportunity for a Community Microgrid. Clusters such as these containing a school, community gathering place and open park space are prevalent throughout California. While the exact ownership and payment structure has not been determined, it’s anticipated that the system will be owned by a third party and paid for with a shared-savings model. Figure 8 below shows the site overview map for the Hoover Cluster.

Figure 8 Hoover Cluster Community Microgrid overview map

Figure 8 above shows that the total solar siting opportunity for Hoover Cluster is 667 kW on rooftops and parking lots combined. In total, there will be three solar carport arrays and 10 rooftop arrays. Note that not all of this solar PV is needed to offset the facilities' annual energy use (net-metering paradigm) nor power the critical loads indefinitely during a grid outage. Therefore, we have some flexibility during the schematic design phase to cost-engineer the deployments and select the systems to move forward with based on lowest installation and lifetime costs. The figure also shows siting opportunity for 2 individual energy storage batteries, one sited at Hoover School and the other on the south side of the Boys and Girls Club. Finally, there are three separate deployment sites for EVCI- two at Hoover School, one in each of the staff parking lots, and one at the Boys and Girls Club, with a total of 30 new Level 2 EV charging ports.

While the necessity of large-scale EV charging installations may not be apparent in all disadvantaged communities, there is a need and desire in Redwood City, especially at the Hoover School. Residential and workplace charging have been identified as the key areas to make investments in EV charging infrastructure. Installations at Hoover Cluster would provide workplace charging to staff that often commute long distances and would also provide residential charging to tenants of nearby apartment buildings and other rental housing that do not have dedicated EV charging equipment. Presently, employees at Hoover School charge their low-range EVs using extension cords that are routed from classrooms, through open windows to the adjacent parking lot. This is not only unsafe, but it also does not allow the school district to recoup the cost of electricity used by their staff for personal purposes. Installing networked chargers will allow the school district to provide a safe charging service to their staff, possibly improving staff retention, while ensuring that the district is not burdened with on-going energy costs. The parking lots at Hoover Cluster are in-use during school and business hours from approximately 7am to 5pm; but, the lots could be used after hours to provide EV charging access to residents. While EV adoption rates among disadvantaged communities may be low right now, innovative solutions have the potential to increase adoption in the near future. There is a burgeoning secondary market for EVs, and the low price per mile makes it an attractive investment for any car owner. Even if the new EVCI installation at Hoover Cluster does not affect local EV ownership, it's just one piece of the puzzle, and other benefits such as workplace charging for staff and a cleaner local air quality persist. Furthermore, the State of California wants to expand EV adoption and reduce the number of gasoline fueled vehicles on the road. Without access to charging, this transition will be slow, and disproportionately slow in disadvantaged communities where there are fewer owner-occupied residences.

There is also an economic case to installing EVCI as part of the Redwood City Community Microgrid. The Hoover Cluster is already a strong candidate for indefinite, renewables-driven backup power through solar and energy storage. The systems require electrical upgrades to the main switchgear on site to accommodate the additional amperage associated with the solar and battery. When EVCI is incorporated into the design, the total EVCI installation costs and infrastructure upgrade costs can be reduced. By bundling the construction costs of a load like EVCI with a revenue generating asset like solar, it may also be possible to secure financing for these projects. If the economics still don't look good, it's also possible to plumb a site so that it is EV ready; when demand for EV charging increases, it's straightforward and relatively inexpensive to install the chargers.

m. Deployment Summary

Table 5 below shows the design results for the Hoover School only. Geli ESyst sizes the battery for demand charge management (DCM) and energy cost offset by avoiding the use of grid power during peak pricing times. HOMER Pro sizes battery for off-grid operation, which simulates grid-island mode for a grid-connected microgrid. The Baseline PV value was selected by using the solar siting survey estimates for new construction, flat rooftops and parking lots. Pitched roofs were not considered because of the anticipated permitting challenges; California public schools fall under the authority of the Department of State Architecture (DSA) which has a long turnaround time for approving rooftop solar project at schools with old buildings. The "ES" size recommendation is based on the system with the highest net present value.

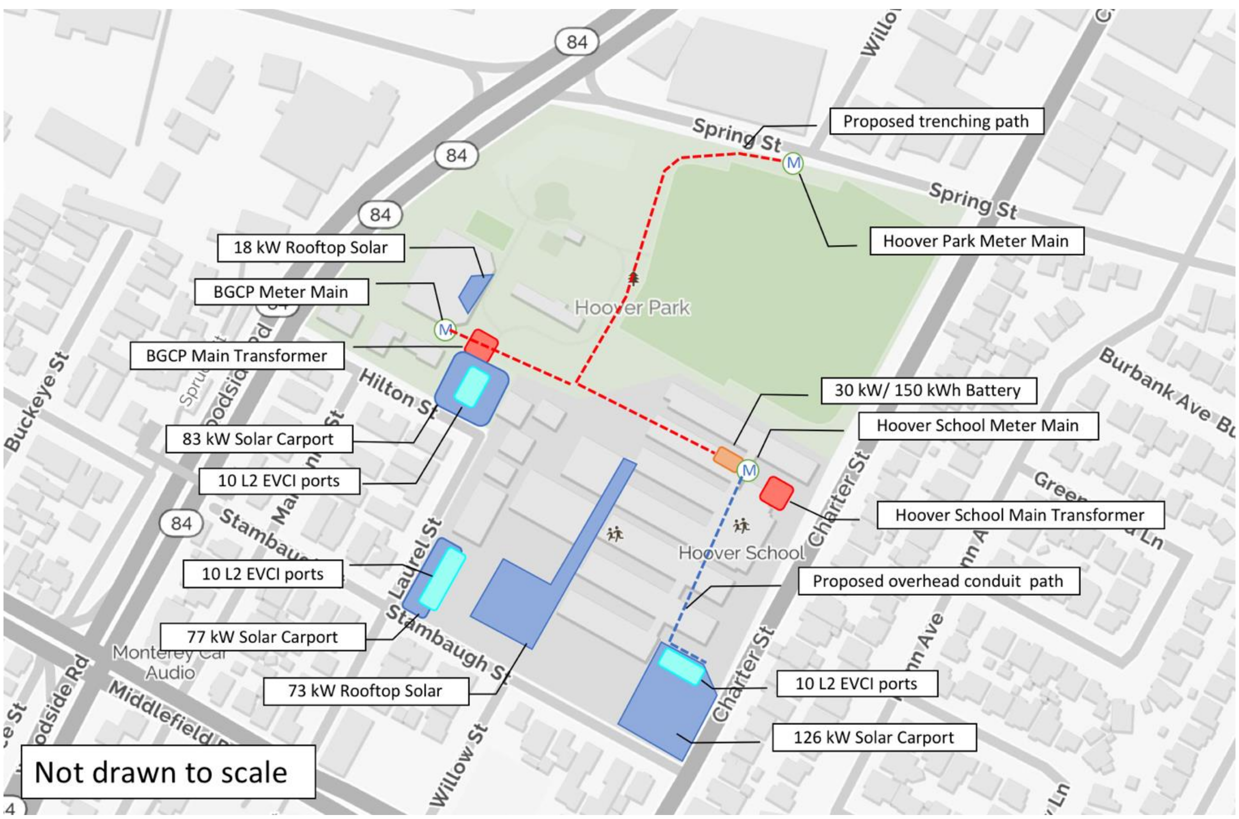
Table 5 Comparison of Hoover School Design Scenario Results

Hoover School Scenario	PV	ES	Modeling Tool
Baseline Load	87.4 kW DC/ 72.8 kW AC	29 kW/ 60 kWh	Geli ESyst
Baseline Load + EV Load	87.4 kW DC/ 72.8 kW AC	29 kW/ 120 kWh	Geli ESyst
Off-Grid Load (21% of Baseline Load)	25 kW DC	4 kW/ 135 kWh	HOMER Pro

Note that when the EV load was added to the school (which was modelled with five 3.3 kW low Level 2 chargers,) the energy storage 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 energy storage capacity.

This analysis shows that energy storage 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.

Figure 9 Hoover Cluster Community Microgrid Conceptual Drawing



The Hoover Cluster will deploy 359 kW of new solar on a combination of new rooftops and solar carports and a 30 kW 150 kWh lithium-ion battery sited at the Hoover School. Additionally, there will be 30 new L2 EV charging ports at the Hoover Cluster which will be used for both workplace and residential charging. The EV chargers will be equipped with smart charging features so that charging can be throttled during peak days for demand response. Some overhead conduit runs will be needed to connect the solar to the main electrical equipment at each of the sites. The proposed route for the 126 kW solar carport to connect to the main electrical is show by a dotted blue line in Figure 9 above. The battery will be interconnected behind the meter while the solar will be interconnected in part behind the meter and in part in front of the meter. The behind the meter systems will be net-metered while the front of the meter solar will be interconnected using a FIT or similar program. Clean Coalition is in the process of selecting an offtake for the wholesale energy.

Due to challenges making an economic case for a battery at the Boys and Girls Club, only solar will be deployed there; there will be an 83 kW solar carport in the Boys and Girls Club parking lot and an 18 kW rooftop system. The Boys and Girls Club will be connected to the Hoover School, and its battery, via a dedicated underground line that will be used during grid outages only. The proposed trenching path for the dedicated line is shown by a dotted red line in the figure above. Hoover Park will not have any solar or battery storage due to minimal blue-sky loads and due to poor solar siting opportunity because of tree shading. However, Hoover Park will be connected to the Hoover Cluster Microgrid, so the field lights may be used in an emergency to facilitate the use of the field as a staging area for emergency response equipment.

n. Existing and Proposed DER

Hoover School completed energy efficiency retrofits utilizing Prop 39 funds in prior years and completed the retrofit work in 2015. Redwood City School District (RCSD) is now authorized to spend remaining Prop 39 funds on solar for RCSD schools. RCSD engaged several solar developers including Sage Renewables and Siemens to prepare solar proposals, but Hoover School was not selected to receive rooftop solar, primarily because other district schools offered larger, less expensive installations or less impact to daily school operations. As a result, all of the proposed DER will be a part of a future deployment. The DER proposed for deployment include solar, energy storage and EVCI. The EVCI will be enabled with demand response functions. Finally, a microgrid controller will be needed to manage the battery, solar and critical loads, along with any load shedding needed during grid outages to ensure indefinite renewables-driven backup to critical loads.

o. Support of Key Stakeholders

Clean Coalition is working in collaboration with the Redwood City School District, Boys & Girl Club of the Peninsula and the City of Redwood City to bring this project to fruition. The key stakeholders of the Hoover Cluster are supportive of this Community Microgrid project. The project will result in operational savings for Hoover School and Boys and Girls Club through energy cost savings and will also provide a more resilient emergency gathering place for the students and the greater community. This project aligns with Redwood City's emissions reductions and sustainability goals, as outlined in their Climate Action Plan from 2013.5 Some of these goals include reducing GHG emissions within community and City operations to achieve a 15% reduction in 2005 GHG levels by 2020 and installing at least 900kW of solar power generation capacity for municipal facilities. The design process has included and will continue to include the relevant stakeholders.

VII. Redwood City Corporate Yard

The Redwood City (RWC) Corporate Yard houses Redwood City Public Works and serves as a critical facility during grid outages, especially after storm or other natural disaster events. The RWC Corporate Yard provides services that maintain public infrastructure such as roads, stop lights and street lighting that are essential to a community and can be affected severely by a natural disaster. They also have on-site fuel storage to fuel city repair and maintenance vehicles and are an essential facility for disaster recovery. Additionally, they could benefit from utility bill savings. This Community Microgrid use case is for a public facility with a large electric load that provides critical services for a city, while the ownership model is representative of a government non-profit site project beneficiary with third party ownership.

Figure 10 Redwood City Corporate Yard overview map

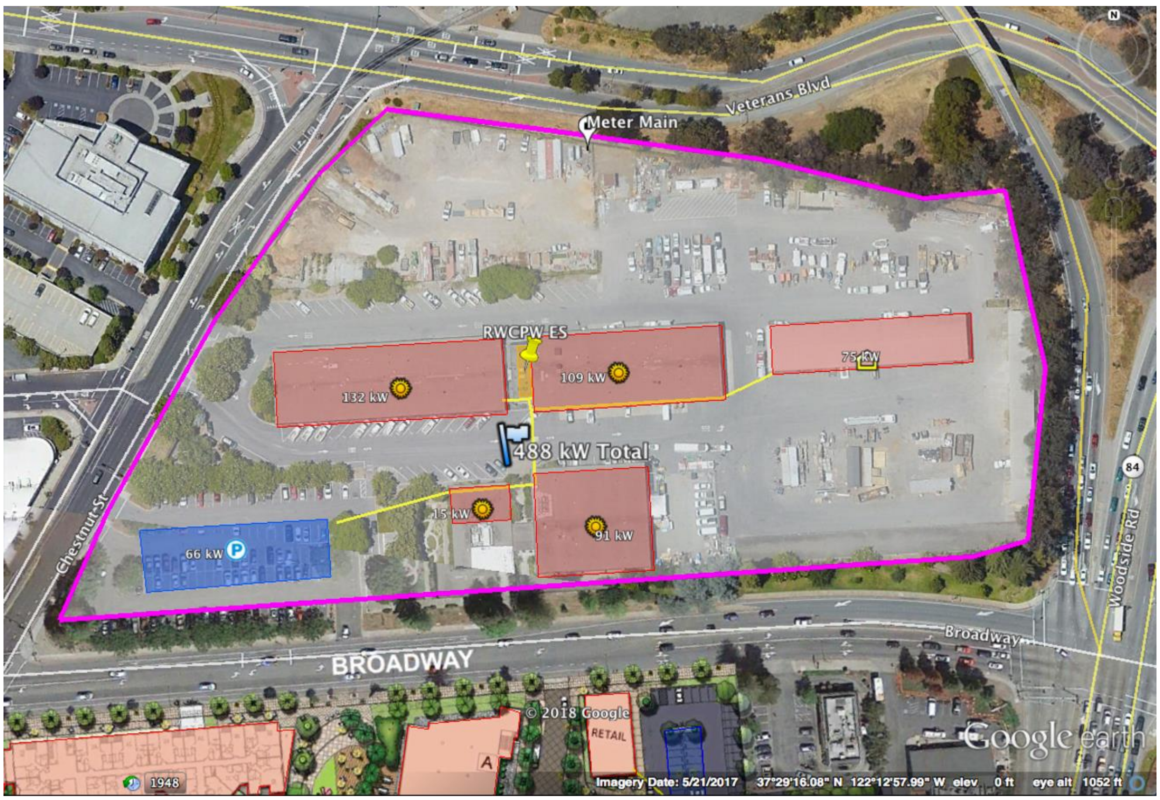
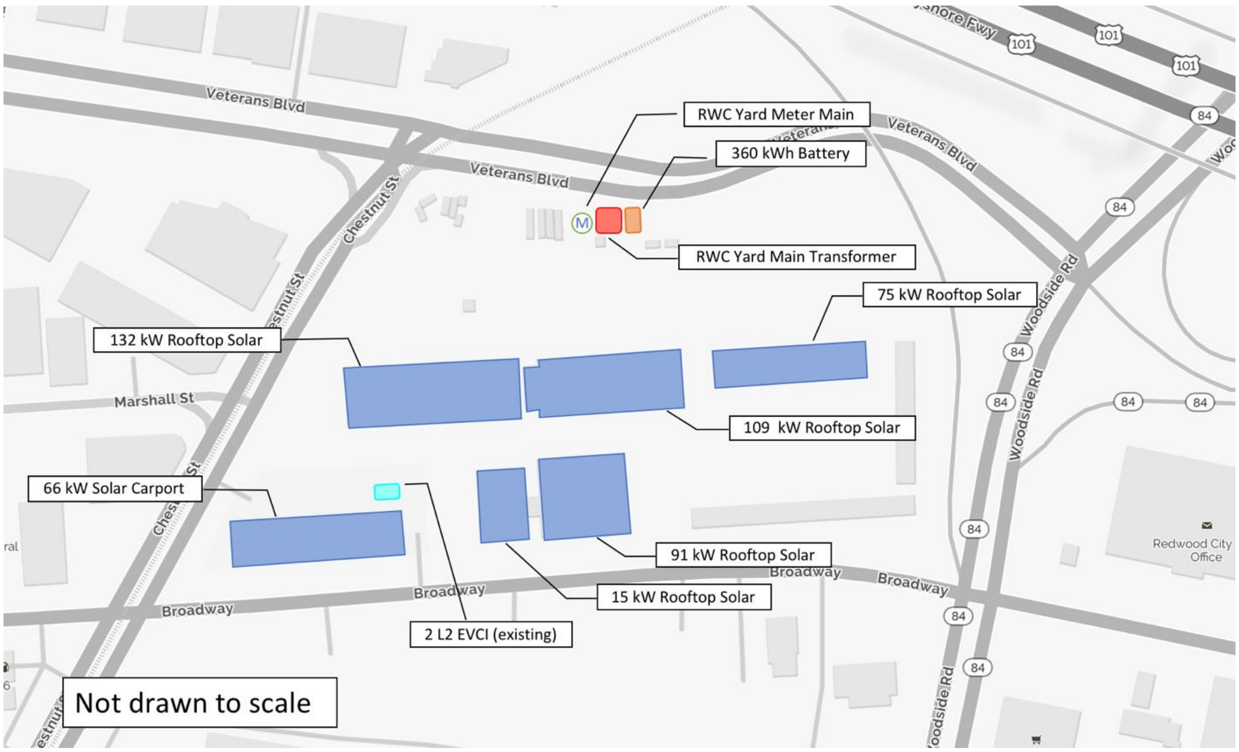


Figure 10 above shows that the total solar siting opportunity for Redwood City Corporate Yard is 488 kW on rooftops and parking lots combined. Total there will be one solar carport array and five rooftop arrays. Note that not all of this solar PV is needed to off-set the facilities' annual energy use (net-metering paradigm) nor to power the critical loads indefinitely during a grid outage. Therefore, we have some flexibility during the schematic design phase to cost-engineer the deployments and select the systems to move forward with based on the lowest installation and lifetime costs. The figure above also shows an energy storage battery. Because of challenges with limited parking, this site is not a candidate for new EVCI. There are however four existing charging ports in the public parking lot at the site.

p. Deployment Summary

The Redwood City Corporate Yard will deploy 488 kW of new solar on a combination of rooftops and solar carports and a 360 kWh lithium-ion battery sited on the north end of the site adjacent to the meter main and main transformer, as shown in Figure 11. The siting location next to the meter main and switchgear is advantageous because it simplifies the electrical connection for the battery and reduces project cost by avoiding expensive trenching and additional conduit runs. The site is already equipped with critical load shedding capabilities. The converter size for the battery is 58 kW.

Figure 11 Redwood City Corporate Yard conceptual drawing



q. System Optimization

The figures below demonstrate the steps taken to size the energy storage for this project. First the maximum and net-metered solar system design was developed using the PVWatts solar modeling tool. The grid-connected system design parameters were determined using Geli ESyst. ESyst is the leading tool on the market to quickly and easily determine a battery's energy and demand charge savings; however, the system is not able to model off-grid systems or systems for energy resilience. Next, the critical load profile for the facility was developed using an approximation algorithm that results in a load profile that is 20%-25% of the original load. Then the off-grid system design parameters are determined using HOMER Pro optimization tool. For this project, since the focus is energy resilience, the allowable capacity shortage (the amount of time the system is allowed to be off for) was set to zero percent. However, a variety of sensitivity cases, around the allowable capacity shortage and other parameters including PV system size were explored to ensure an optimized design. Finally, multiple iterations between on-grid systems in

ESyst and off-grid systems in HOMER Pro were performed to find a system that maximizes energy bill savings and also allows backup for critical loads. The results are shown in Figure 12, Figure 13, and Figure 14.

Figure 12 Redwood City Corporate Yard Geli Optimization Results; PG&E E19S tariff and 150 kW solar

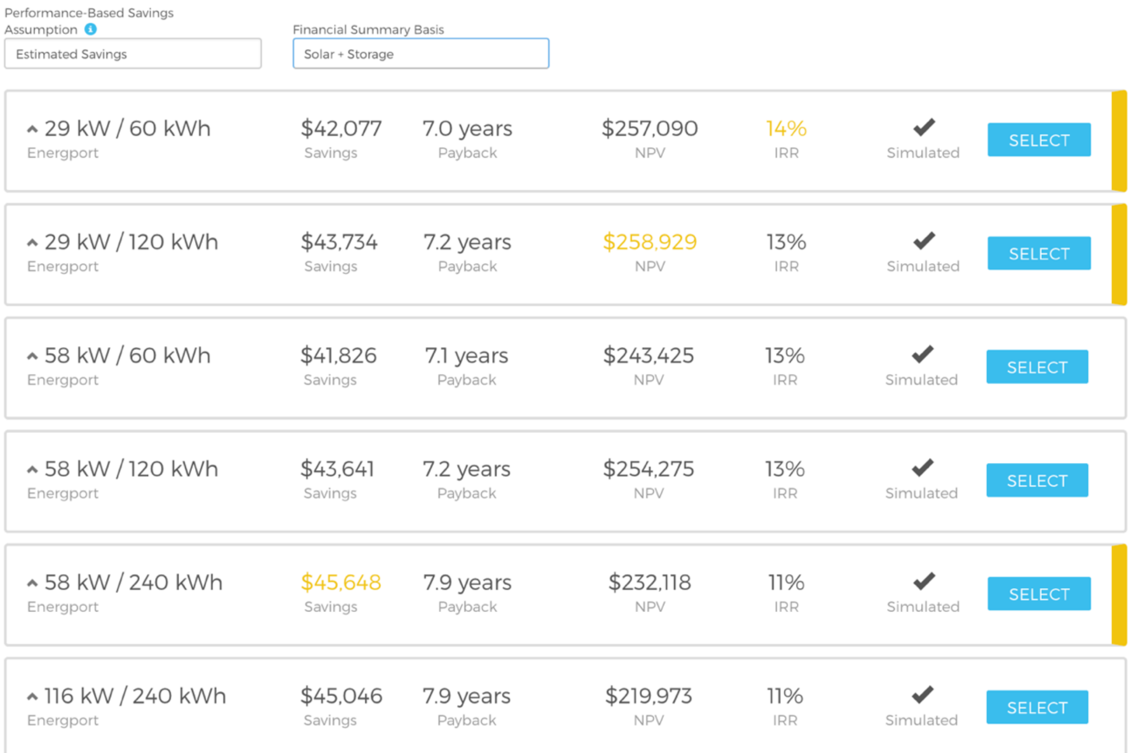
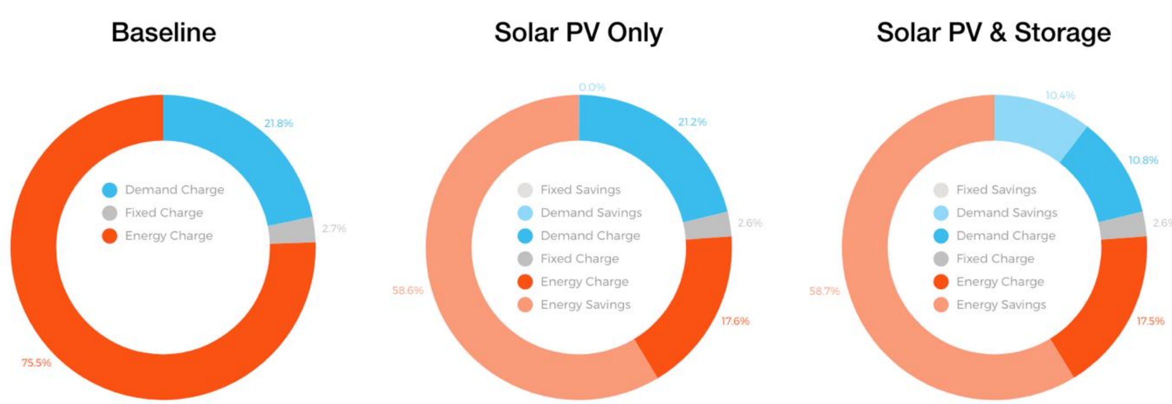


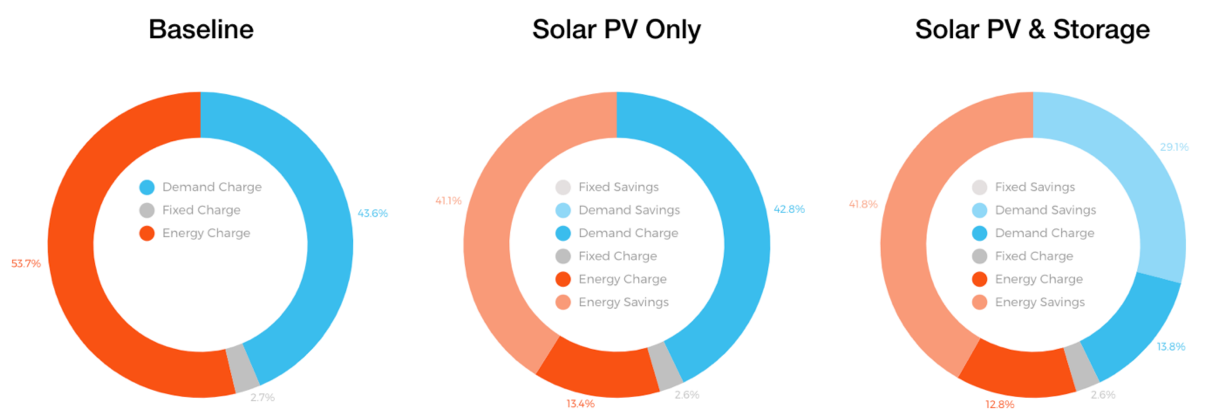
Figure 13 Redwood City Yard solar + storage savings plot modelled with PG&E's E19S tariff, 150 kW solar and 29 kW 60 kWh energy storage



Tariff:	E-19-TOU-NOPDP	Tariff:	E-19-TOU-NOPDP-NEM2	Tariff:	E-19-TOU-NOPDP-NEM2
Energy Charges:	$ 33,999	Energy Charges:	$ 8,664	Energy Charges:	$ 8,580
Demand Charges:	$ 27,605	Demand Charges:	$ 27,605	Demand Charges:	$ 12,096
Fixed Charges:	$ 1,679	Fixed Charges:	$ 1,679	Fixed Charges:	$ 1,679
Total Utility Bill:	$ 63,283	Total Utility Bill:	$ 37,948	Total Utility Bill:	$ 22,354
		Energy Savings:	$ 26,480	Energy Savings:	$ 26,568
		Demand Savings:	$ 0	Demand Savings:	$ 15,509
		Energy Assets:	$ 0	Energy Assets:	$ 15,509
		Tariff Switch:	$ 0	Tariff Switch:	$ 0
		Fixed Savings:	$ 0	Fixed Savings:	$ 0
		Total Savings:	$ 26,480	Total Savings:	$ 42,077
		Payback:	11.97 years	Payback:	6.96 years
		NPV:	$ 15,314	NPV:	$ 257,090
		IRR:	6.59 %	IRR:	13.51 %

This smaller energy storage system has a higher Net Present Value (NPV) of $257,090 but does not provide nearly enough storage for off-grid use.

Figure 14 Redwood City Yard solar + storage savings plot modelled with PG&E's E19S tariff, 150 kW solar and 58 kW 240 kWh energy storage



Tariff:	E-19-TOU-NOPDP	E-19-TOU-NOPDP-NEM2	E-19-TOU-NOPDP-NEM2
Energy Charges:	$ 33,999	$ 8,664	$ 8,238
Demand Charges:	$ 27,605	$ 27,605	$ 8,880
Fixed Charges:	$ 1,679	$ 1,679	$ 1,679
Total Utility Bill:	$ 63,283	$ 37,948	$ 18,797
Energy Savings:		$ 26,480	$ 26,923
Demand Savings:		$ 0	$ 18,725
Energy Assets:		$ 0	$ 18,725
Tariff Switch:		$ 0	$ 0
Fixed Savings:		$ 0	$ 0
Total Savings:		$ 26,480	$ 45,648
Payback:		11.97 years	7.88 years
NPV:		$ 15,314	$ 232,118
IRR:		6.59 %	11.41 %

This larger energy storage system has a lower Net Present Value (NPV) of $232,118 and provides more energy savings than the smaller system described above. It also provides closer to the necessary amount of storage for off-grid use.

Homer Pro recommends a 13 kW 361 kWh battery to meet 100% of the load in off-grid or grid-island mode. For that reason, we recommend a larger converter to match the Geli converter recommendation of 58 kW and the larger battery capacity recommended by Homer Pro. The EPC will need to select an off-the-shelf battery product from a vendor that closely matches or exceeds the sizing indicated here.

VIII. San Mateo County Corporate Yard

The San Mateo County (SMC) Corporate Yard serves as a critical facility during grid outages, especially after storm or other natural disaster events. They provide services that maintain public infrastructure such as roads that are essential to a community and can be affected severely by a natural disaster. Additionally, the SMC Corporate Yard has a different jurisdiction than the RWC Corporate Yard, so participation of both sites in the Redwood City Community Microgrid is advantageous. They also have on-site fuel storage to fuel city repair and maintenance vehicles and are an essential facility for disaster recovery. Additionally, they could benefit from utility bill savings. This Community Microgrid use case is for a public facility with a large electric load that provides critical services for a city, while the ownership model is representative of a government non-profit site project beneficiary with third party ownership.

Figure 15 San Mateo County Corporate Yard overview map

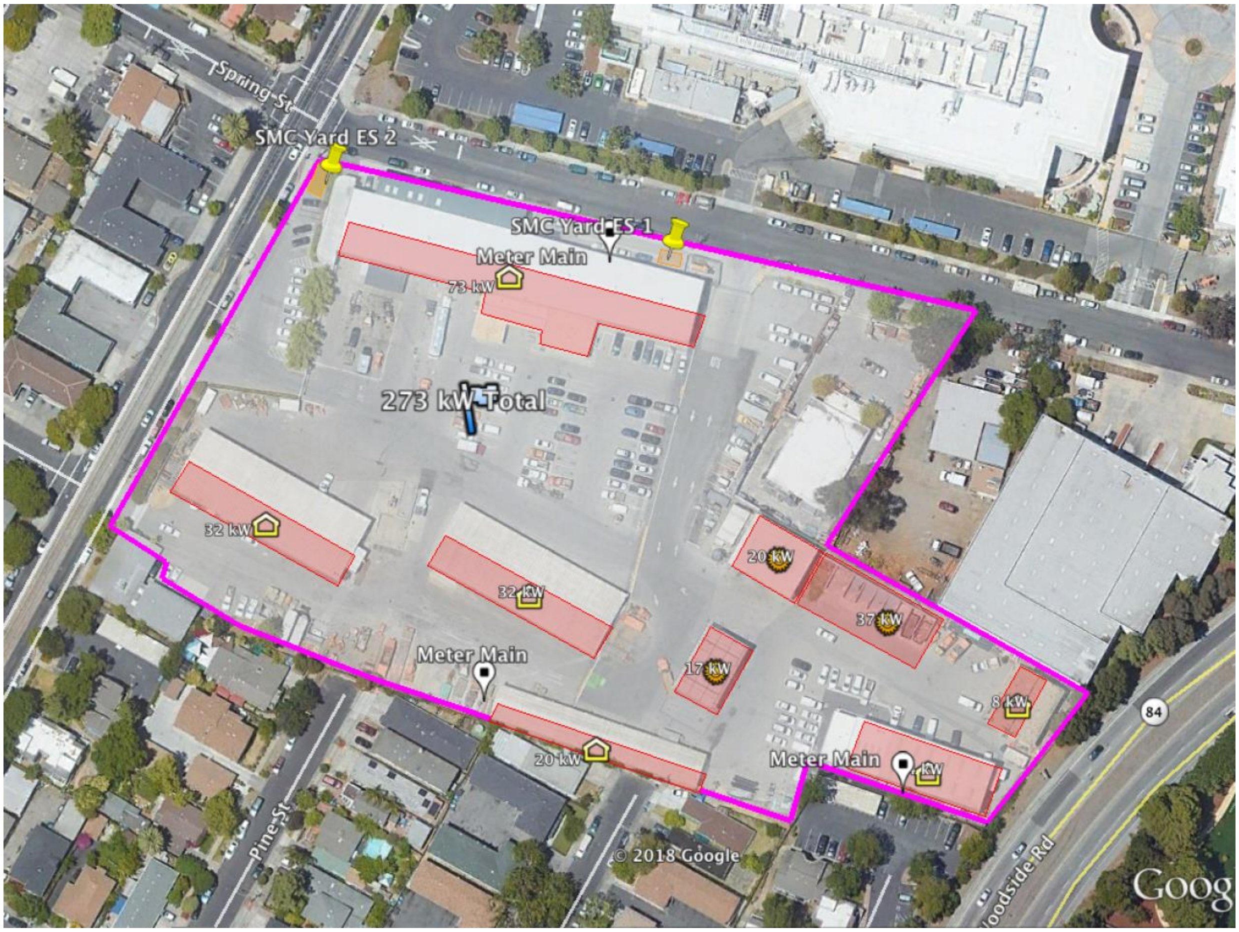


Figure 15 above shows that the total solar siting opportunity for SMC Corporate Yard is 273 kW on rooftops and parking lots combined. In total, there will be one solar carport array covering a materials storage area and eight rooftop arrays. Note that not all of this solar PV is needed to offset the facilities' annual energy use (net-metering paradigm) nor power the critical loads indefinitely during a grid outage. Therefore, we have some flexibility during the schematic design phase to cost-engineer the deployments and select the systems to move forward with based on lowest installation and lifetime costs. The figure above also shows two siting opportunities for energy storage batteries, marked by a yellow pin. Because of challenges with limited parking, this site is not a candidate for new EVCI. There are, however, 4 existing charging ports in the yard for city vehicles.

IX. Sobrato Broadway Plaza

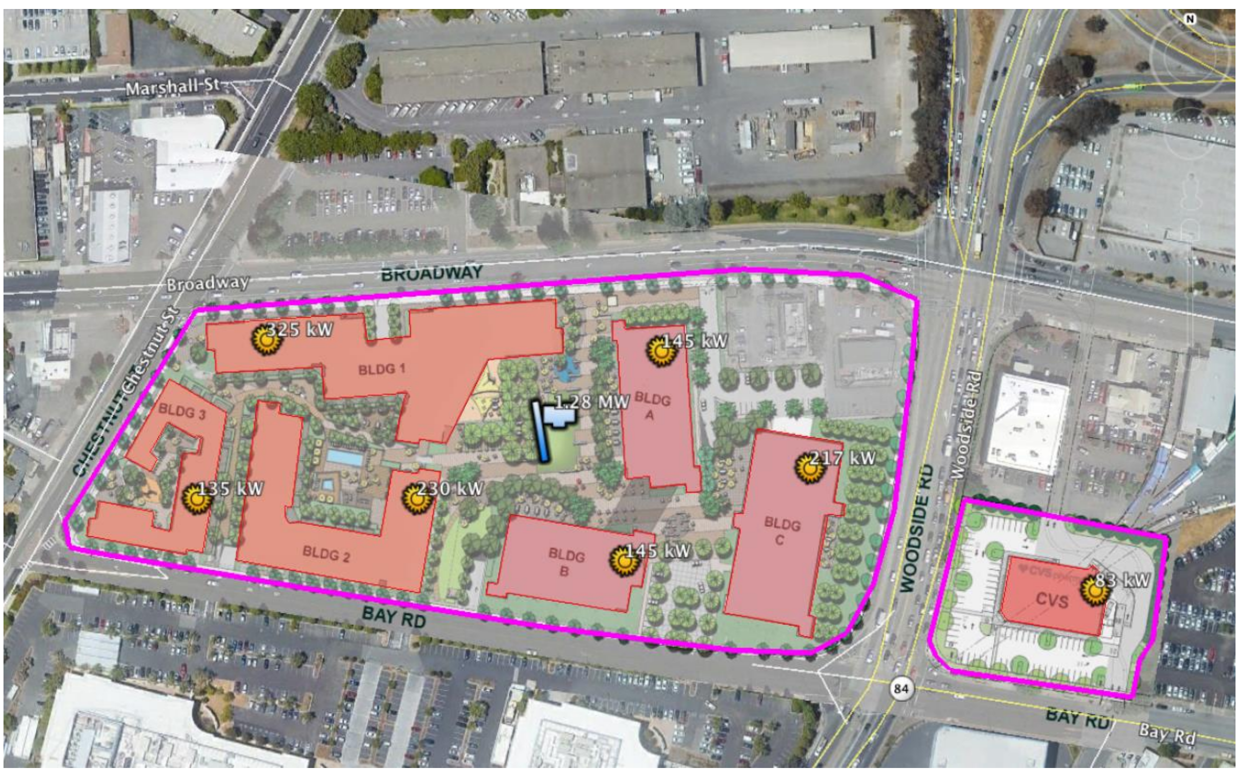
Sobrato is a well-established builder in the San Francisco Bay Area, currently pursuing a new retail and multi-family housing development in Redwood City. The new development provides a unique use case for a Community Microgrid and will demonstrate the time and cost savings associated with implementing these technologies on new construction versus doing a retrofit. The timeline for the development of this project is in Table 6.

Table 6 Sobrato project development timeline

Q1 2017- Q2 2018	Conceptual design and permitting. Total there will be 3-4 rounds of conceptual design.
Q3 2018	EIR draft release for public review
Q1 2019	EIR certification and action on Entitlements
Q2 2019	Schematic design. This is when recommendations for solar, energy storage, EVCI, energy efficiency and fuel switching will occur.
Q3 2019	Design development
Q3 2020	Construction begins
Q4 2021	Building online

The Sobrato development, shown in Figure 16, is not included in detail in the Master Community Design because the timelines did not align and it will likely not be possible to include this site in PAEC2. It is still a strong candidate site for a future develop phase of the Redwood City Community Microgrid.

Figure 16 Sobrato Broadway Plaza overview map



The Sobrato Broadway Plaza and adjacent CVS, which is also to be developed by Sobrato, have a combined solar siting opportunity of 1.28 MW. This number was developed using an approximation for the achievable solar density based on model buildings of this type. The site boasts underground parking, and efforts are going towards making an EV charger available to all future residents with parking included in their rental unit. As mentioned above, this project has not yet been permitted and is subject to change. Until the building's conceptual design is complete, no work can be done to size a battery or otherwise develop a conceptual design of the microgrid on this site.

X. Lessons learned for streamlining AEC design

The design and development of the Master Community Design provided an excellent learning experience for understanding some of the challenges and solutions to implementing advanced energy technologies in California communities. This section of the report reviews the process for developing Community Microgrid project and then dives into a few lessons learned to streamline future developments of AECs.

r. CMI Methodology Overview

The Clean Coalition utilizes the following six proven steps to plan and deploy successful Community Microgrids:

1. **Set Goals**: Identify the Target Grid Area, such as a region served by a substation or substations and define the Community Microgrid goals based on desired levels of local renewables, grid performance, and cost-effectiveness.

2. **Perform Baseline Grid Analysis**: Assess the existing grid performance based on the local grid infrastructure, loads, and generating resources. Include identifying critical facilities that should be considered for backup power during outages. Critical facilities generally include hospitals, fire and police stations, and critical service facilities like those providing water and communications services.

3. **Conduct Renewables Siting Survey**: Conduct a comprehensive survey of the renewable energy potential in the target grid area specific to local resources and siting opportunities. For example, in order to assess the amount of local solar that can be achieved, it is necessary to assess solar resource quality and the availability of rooftops, parking lots, and brownfields for siting solar projects.

4. **Perform DER Optimization**: Establish an optimized combination of local renewables, energy storage, demand response, and other DER with respect to cost and grid performance metrics. As part of this optimization process, test various DER combinations that achieve the Goals, building on the results of the Baseline Grid Analysis and the Renewables Siting Survey.

5. **Analyze the Economic Benefits**: Conduct a comprehensive analysis of the costs and benefits associated with the Community Microgrid – spanning energy, economic, and environmental benefits. This economic analysis includes assessing the energy costs under a streamlined and bulk approach to deploying local renewables and other DER, reductions in transmission and distribution (T&D) investments and anticipated local job creation.

6. **Establish Deployment Plan**: Design bulk procurement and interconnection processes that facilitate streamlined and scalable deployment of the local renewables and other DER, fulfilling the

Goals of the Community Microgrid project. The Deployment Plan will often include designing a Request for Proposal (RFP), or similar requirements documentation, that allows for a straightforward assessment of proposed solutions.

The following technical work products are developed as part of the methodology described above.

- Solar Siting Survey (to granular level specified, typically siting opportunities of 100 kW or greater; .kmz file and .xlsx file)
- Electric Load Analysis (of 15-minute interval electric usage data; .xlsx file)
- Utility Bill Analysis (if separate from electric load analysis; .xlsx file)
- System Sizing Analysis details (for PV, energy storage and other DER; pdf reports from analysis tools and possibly .xlsx files)
- Economic Analysis (including assumptions for utility rate increases, capital costs and 10-20 year operations and maintenance costs; .xlsx file)

s. Efficient Scoping

During the project development process, the main challenge faced by the design team was deciding a project scope and timeline for the Community Microgrid that all key stakeholders could agree on. Community Microgrid projects implemented on sites undergoing new construction have many moving parts including all construction subcontractors (civil, architectural, electrical, etc.) and public utilities (electricity, gas, water and sewage) making it even more challenging to design and implement an additional layer of energy infrastructure. In addition, each stakeholder has different priorities, so a clear definition of the benefits to each stakeholder are key to finalizing a project scope and cost.

In order to provide efficient scoping, it's necessary for the team developing the project to have the ability to quickly ask for and obtain site information (examples included in the Appendix) perform analysis on utility bills, develop system sizing estimates and economic analysis, and then me able to quickly adjust the design based on stakeholder feedback. Often, this process is most efficient when these capabilities are in-house so that quick turn-around times are possible. Another solution utilized by many project developers is to wait until almost all of the site information is received before beginning work on a specific site- this reduces the time wasted on starting analysis only to find that a key piece of information is missing and must be received before moving forward with the design.

t. Design Tools

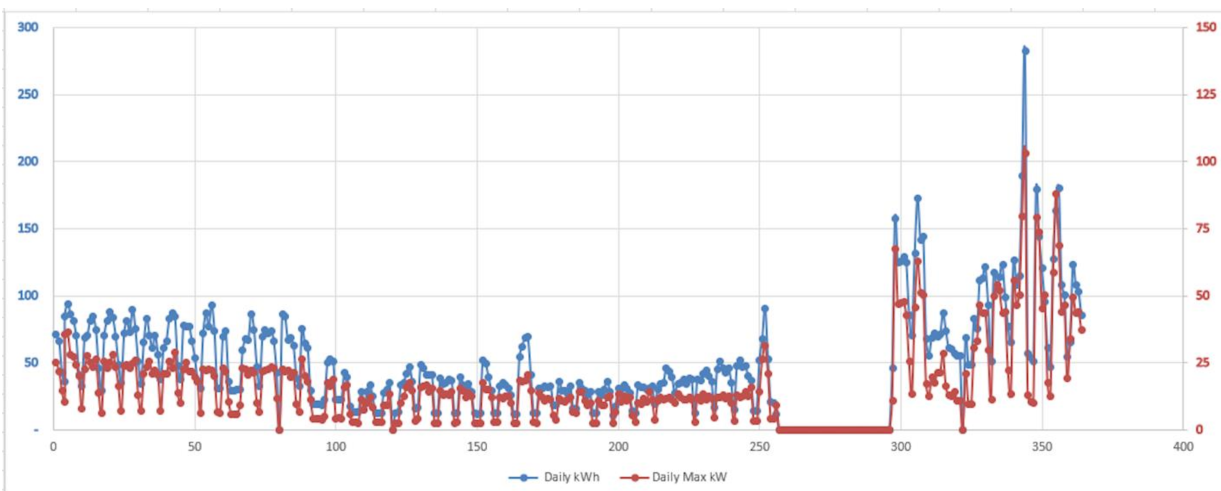
The primary tools used to develop the conceptual designs for SEMs and Community Microgrids in the Master Community Design were UtilityAPI, PVWatts, Geli ESyst and HOMER Pro. Due to challenges acquiring more streamlined, accurate and task-specific tools, these were used. UtilityAPI streamlines the process of obtaining 15-minute interval data from customers. While the concept of this is very straightforward, it was time-consuming to find the right person to fulfill this request, especially amongst municipal entities such as San Mateo County.

u. Challenges with Utility Data

Good data can lead to good results. Similarly, bad data can lead to bad results. Several challenges with data were encountered during the development of the Master Community Design, including lack of data, incomplete data, and uncertainty on how to model certain utility rates due to lack of transparency. A challenge is that there are still several meters that were encountered during the scoping process that are not smart meters; this means that 15-minute interval data, which is essential for sizing solar and essential for sizing battery systems, cannot be obtained. This leads to more guesses made during the design development and can lead to uncertainties in the economic modelling. In these situations, model load profiles are used; however, uncertainties in the economic model persist.

Another challenge is that even when 15-minute interval data is obtained, it's not always complete and may not give a good idea of what a building's energy use profile looks like. For example, see the building load profile in Figure 17 for the Boys and Girls Club below. There are about 50 days without any data, followed by a month of unexpected peaks. The team assumed that the peaks are due to warm weather days, however with insufficient data it's simply speculative. Sometimes a prior year's data can be used to supplement holes in data, however, if a building was recently retrofitted for energy efficiency, the reduced load may not be reflected in older data.

Figure 17 Boys and Girls Club Load Profile (Daily kWh and Daily Max kW)



Finally, determining the proper method of modeling a customer's current utility bill based on their rate tariff (to provide a baseline for any future expected savings) proved challenging due to the variety of rates offered, in addition to rate options such as Peak Day Pricing and PG&E Option R for customers with solar. The lack of transparency in a customer's rate and options, and lack of understanding on how rates are calculated made this a challenging task and led to the team using Geli ESyst to model utility bills instead of developing an in-house tool. One solution is to have more education for developers on how bills are calculated and how to select the appropriate rate both pre- and post- solar and energy storage to enable a streamlined design process.

v. Timing

Getting involved with the design process for new construction at the proper time allows an AEC developer to make the most impact with solar, energy storage and EVCI. Large construction projects typically have the following stages: conceptual design, permitting, entitlements, schematic design, design development and construction. The proper time to start working with a building developer is as soon as possible. This is so that there is time to develop a relationship and understand what technologies the building developer would like to include and understand what issues they would like solved such as high building operations and maintenance costs. After this groundwork is done, an AEC developer must wait until the schematic design phase to give input on energy related features of the building. This input can include feedback on the rooftop design to maximize solar, accommodating siting opportunity for batteries, including EVCI as well as charging ports, and appropriately sizing the main switchgear and electrical bus to accommodate DER.

With Stanford Redwood City, Clean Coalition got involved in the design process later than the ideal time. The result is still a great project that combines thermal energy storage with solar and batteries to peak-shave the EVCI loads at the parking garage and support data center backup, but not to the extent that may have been possible if we got involved during the schematic design phase. Earlier involvement could have led to innovative solutions, for example, since space is at a premium in many growing California cities, siting a battery underground or on a rooftop can save valuable space. Another possibility is that instead of metering each building separately (as is the case now,) Stanford RWC could have a single campus meter which would make deploying a Community Microgrid with shared solar and energy storage much easier from a utility interconnection perspective. Sobrato Broadway Plaza provides an opportunity to influence the building's design during the schematic design phase; if timelines align, then they will be a great addition to PAEC Phase 2.

w. Permitting

One of the previously identified barriers to developing advanced energy communities was the time and cost associated with permitting advanced energy technologies. To identify the challenges associated with permitting such projects for PAEC in Redwood City, multiple interviews with the Redwood City Planning and Building departments were conducted. However, neither the Planning Department nor Permitting Department expressed any concern or anticipated any roadblocks with installing photovoltaics, lithium battery energy storage nor electric vehicle chargers. In fact, all technologies appear to be relatively standard.

Thy typical permit application process requires submission of and application along with three sets of plans and a permitting fee. Each site/project must submit a separate application. The Planning Department performs the first review and subsequently forwards the plans to the necessary departments, Building Department, Engineering Department or Fire Department, for review. The Engineering department must get involved if the project will infringe upon a public right-of-way. The Fire Department and PG&E make the final determination regarding location and placement of the battery energy storage and interconnection. The approximate review period timelines are three weeks for the first review, two weeks for the second review and one week for the third review.

Occasionally external reviews are needed for specialized project types. If a project requires an external review, the permit review process is likely to take longer. On the other end of the spectrum, if the project is relatively straightforward, it might be possible to proceed with an over-the-counter plan check, and the permit would be issued immediately.

Current fees for solar installations are $372 per system for residential systems but are considerably larger for commercial solar installation. Permitting fees for commercial solar installations are assessed at 10-13% of the project valuation. Fortunately, there is a policy change in process now, with more favorable rates expected this spring. The new rates were mandated by the state to reduce barriers to installing new solar. The expected new rates are included below in Table 7.

Table 7 Summary of Redwood City PV permitting fees

Project Applicant	PV System Size	Projected Permitting Fee
Residential	Less than 15 kW	$376
Residential	Greater than 16 kW	$376 base plus $15 per additional kW
Commercial	Less than 50 kW	$1253
Commercial	Between 50 kW and 250 kW	$1504 base plus $7 per additional kW
Commercial	Greater than 251 kW	$1880 base plus $5 per additional kW

The permit fee for battery storage would be a fee of $124 and for electric vehicle chargers it's $248 each.

One potential challenge for the Redwood City Community Microgrid is that each site/ project must submit a separate permit application. While the Community Microgrid is a single project, because it crosses property lines or parcel lines it may be required to submit separate permit applications. While this may add time and cost to the project, it is not an insurmountable challenge. The Hoover site might be a bit more complicated and require more coordination and planning because modifications to the school must be approved through the Department of State Architects (DSA).7. If, the project involves connections between the school and the park/Club, then Redwood City would have to figure out how to process the approval. They have experience doing this, so it's not deal breaker, but when the agency authority line is blurred, the stakeholders need to communicate and coordinate, which can take some time.

Because of the relative ease of permitting these technologies (solar, energy storage and EVCI) in Redwood City, Clean Coalition is not developing a permit application assessment tool to streamline this process. It was not possible to include the tools used for permit application assessment within Redwood City Planning and Building departments in this report.

XI. Design limitations and opportunities for future work

Opportunities for future work beyond the work committed to for the Master Community Design include developing new programs and tariffs for PG&E so that distributed energy generation sources (such as solar) can be interconnected on the distribution grid, enabling wholesale distributed generation through a feed-in-tariff and also developing a tariff for sharing the real and economic benefits of solar and storage microgrids across utility meters and customer entities. This is an essential next step to enabling Community Microgrids on a large scale. Another opportunity for future study is to scope and deploy a true full-scale Community Microgrid. The design presented in the Master Community Design demonstrates four distinct use cases for microgrids that are replicable throughout suburban and rural communities in California and beyond. However, the designs presented are small-scale demonstrations of the true potential for a Community Microgrid. A full-scale Community Microgrid serves an entire substation grid area, with more than 25% of the local energy use coming from local renewable generation sources. Coupled with energy storage, this local generation enables indefinite power backup to critical facilities and critical loads during an extended grid outage cause for example by a transmission outage due to fires, earthquakes or other natural disasters.

This larger long-term vision for a Community Microgrid can be piloted by scoping and deploying a pared-down version in which the Community Microgrid is limited to a distribution grid feeder segment containing critical facilities. Siting the Community Microgrid at the end of a feeder line can minimize the need for expensive high voltage, automated switching. The next step beyond scoping the project is to design and execute the utility pilot, as described above, and develop further recommendations based on the learnings associated with that pilot.

XII. Conclusion

The Redwood City Master Community Design proposes deploying a Community Microgrid that combines solar, energy storage and EVCI at five separate sites and 11 or more utility meters within a disadvantaged community in Redwood City. The Community Microgrid will result in economic, environmental and resilience benefits for the site owners and patrons as well as for the wider community. There will be no new fossil-fuel generation, and each site will experience indefinite renewables-driven backup power to critical loads.

The project showcases Community Microgrid deployments at four unique site types and demonstrates four unique use-cases and ownership models for Community Microgrids. The critical facilities that will receive indefinite, renewables-driven power backup include a sheltering facility at Hoover School and the Boys and Girls Club, Public Works services including road and public facility repair services at the two Corporate Yards, low-income housing and a pharmacy at the Sobrato Broadway Plaza and Stanford Redwood City. Finally, all of the project sites are highly replicable opportunities for microgrid deployment. Redwood City is a growing suburb in the San Francisco Bay Area and is representative of many other suburban California communities. This project demonstrates how to incorporate advanced energy technology onto existing public buildings, existing private buildings, as well as new private buildings owned by non-profit and for-profit entities. The deployment of this project will result in new learnings regarding challenges and opportunities specific to each site type, and also how to structure asset ownership (solar, battery, EVCI, building management systems and microgrid controller) for each site type.

The Master Community Design is almost a shovel-ready project. The single line diagrams, system sizing and economic analysis have been completed, and the best interconnection sites have been determined. Clean Coalition is working with PG&E to develop a design to connect multiple meters together using the distribution grid for Stanford Redwood City. After this is complete, the project will be submitted for preliminary permitting review.

The Redwood City Community Microgrid will deploy new DER, and leverage investments in EVCI and thermal energy storage and will provide an excellent learning opportunity for future Community Microgrid deployments. This project will also leverage completed PAEC work that streamlines interconnection and local permitting. The systems integration approach will minimize both technical and financial risk and ensure that this project is deployed on-time and operates successfully throughout the project lifetime.

XIII. Appendix

x. Obtaining PG&E utility maps

Utility maps that show the utility distribution grid feeders, their names/ identification numbers as well as switches and tie-points with other feeders must be requested from PG&E directly. To obtain these maps, a property owner, manager or project developer must send the following information to DelineationMapRequests@pge.com. There is a two week lead time to receive this information.

- PROJECT ADDRESS
- PROJECT CITY & ZIP CODE
- MAPPING INQUIRY / REQUEST (Gas and/or Electric)
- CUSTOMER NAME
- PHONE NUMBER
- EMAIL ADDRESS
- BEST TIME TO CALL
- RELATIONSHIP TO PROJECT
- PROJECT TYPE
- COMMODITY
- Request for feeder numbers to be included on the maps, and request a map legend.

y. Stanford Redwood City detailed engineering documents

The documents below contain engineering drawings for the Community Microgrid proposed at Stanford Redwood City. These are the files needed to develop a shovel-ready project. After the permit is awarded, schematic design will commence and detailed construction drawings will be developed.

Figure 18 Stanford Redwood City site plan and trenching diagram

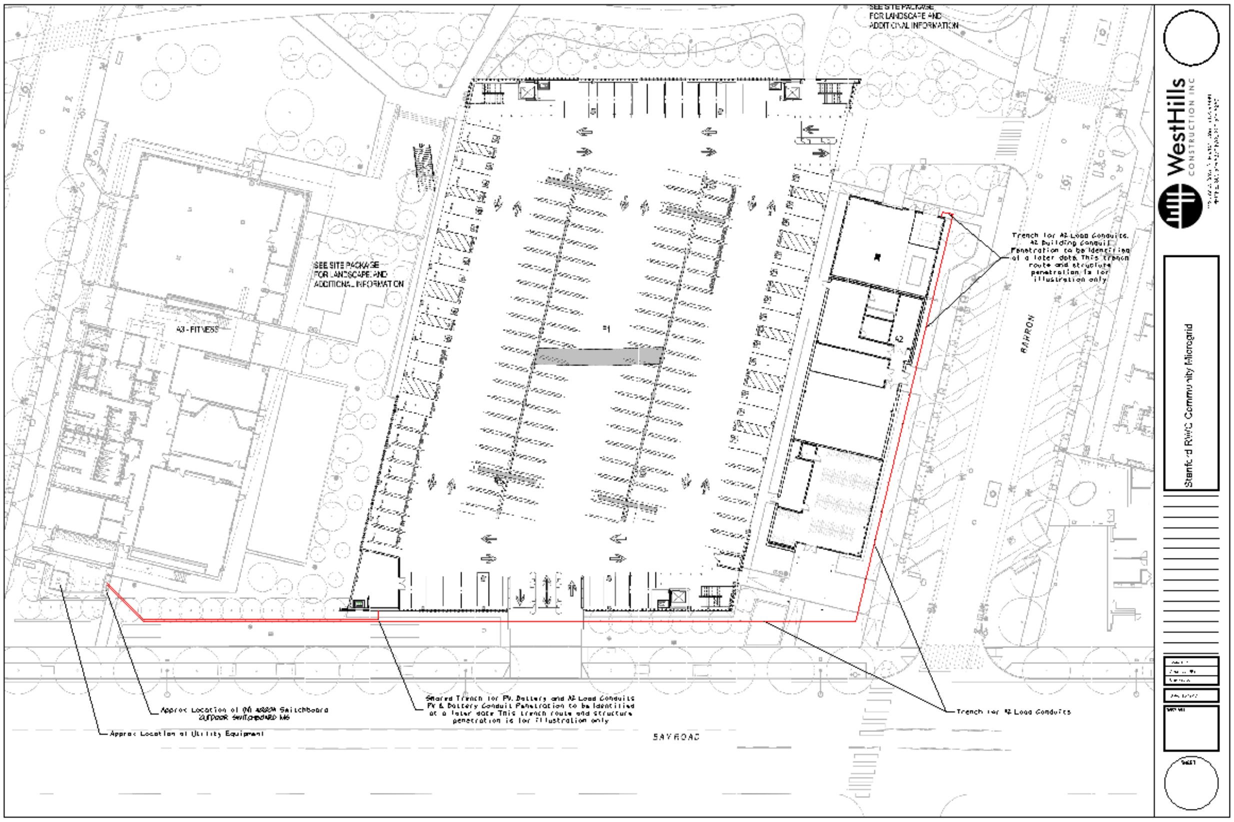


Figure 19 Stanford Redwood City single line diagram

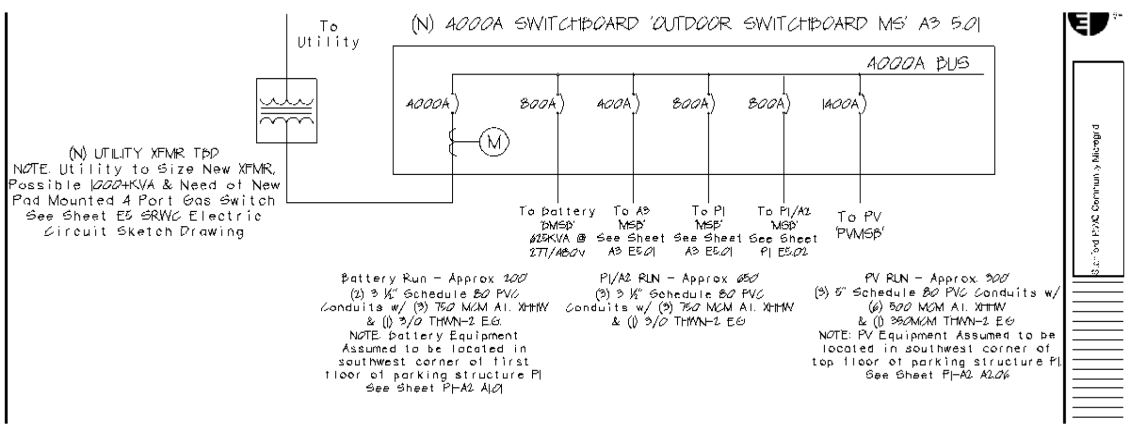


Figure 20 Stanford Redwood City Parking Garage 1 PV layout

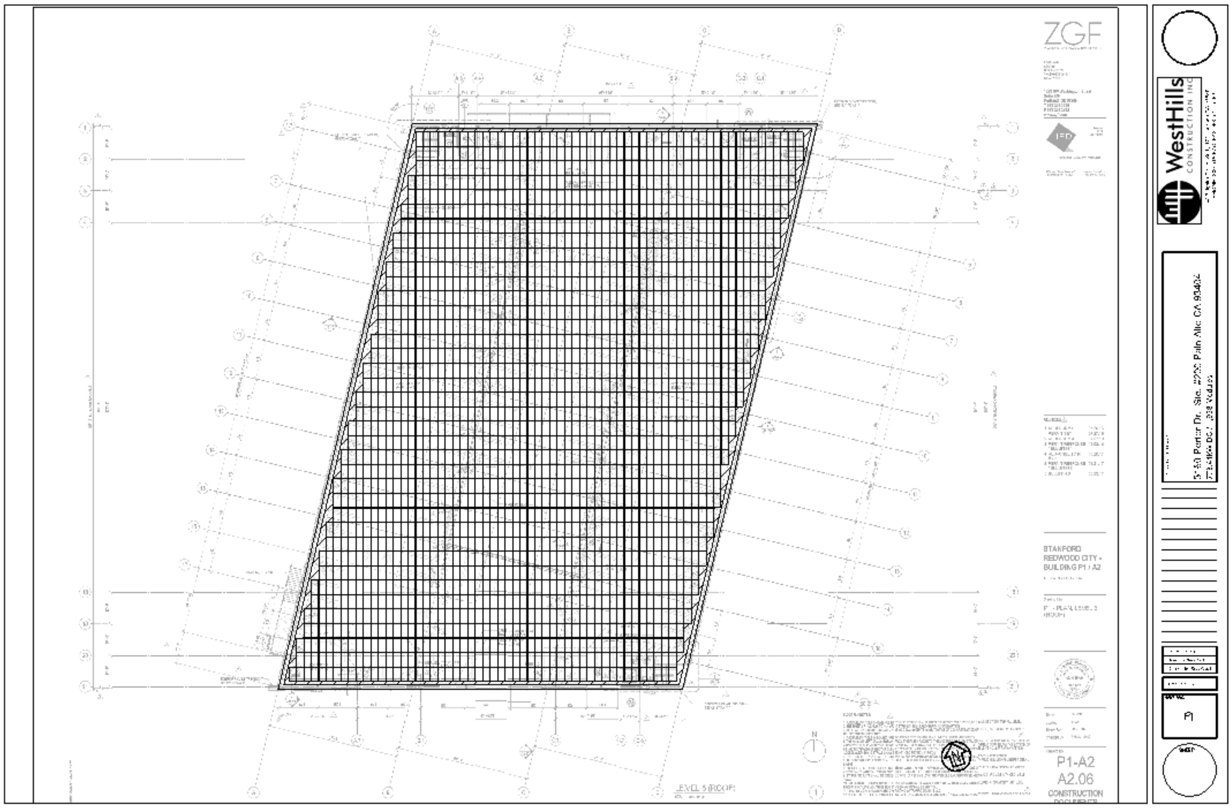


Figure 21 Stanford Redwood City Building 1 PV layout

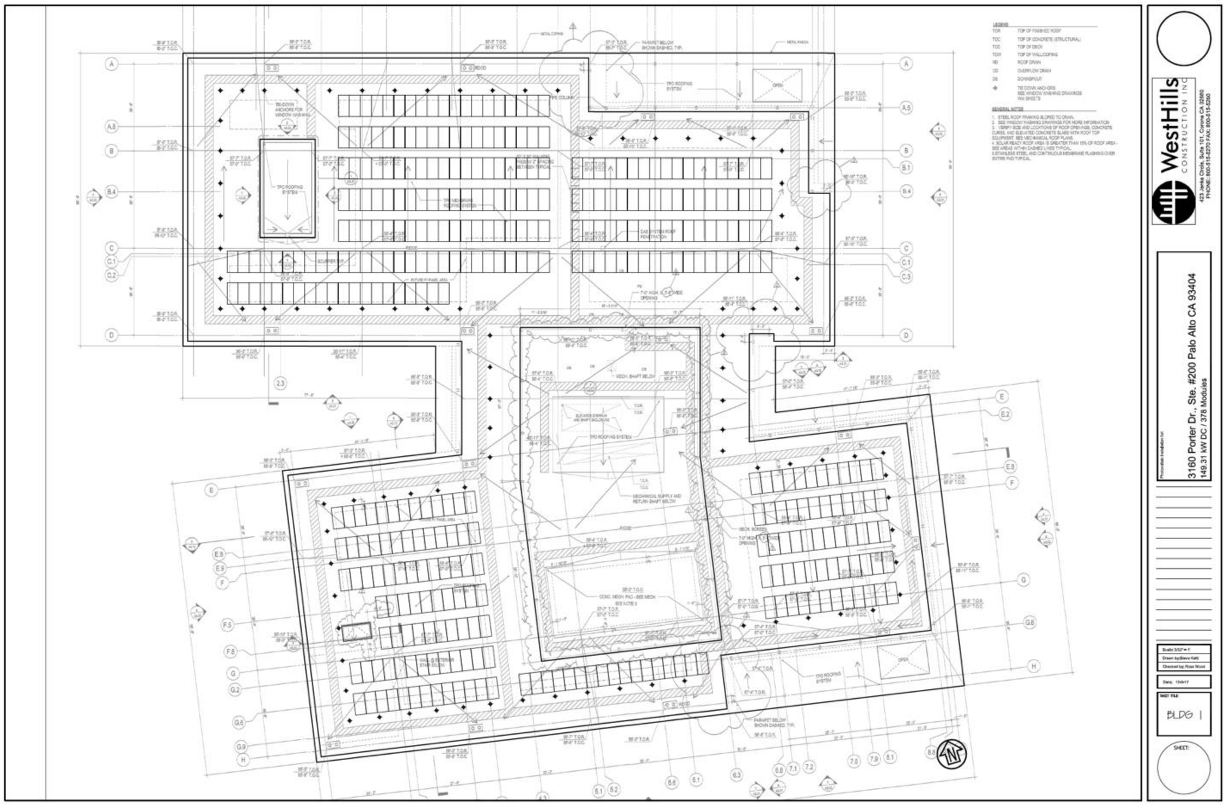


Figure 22 Stanford Redwood City Building 2 PV layout

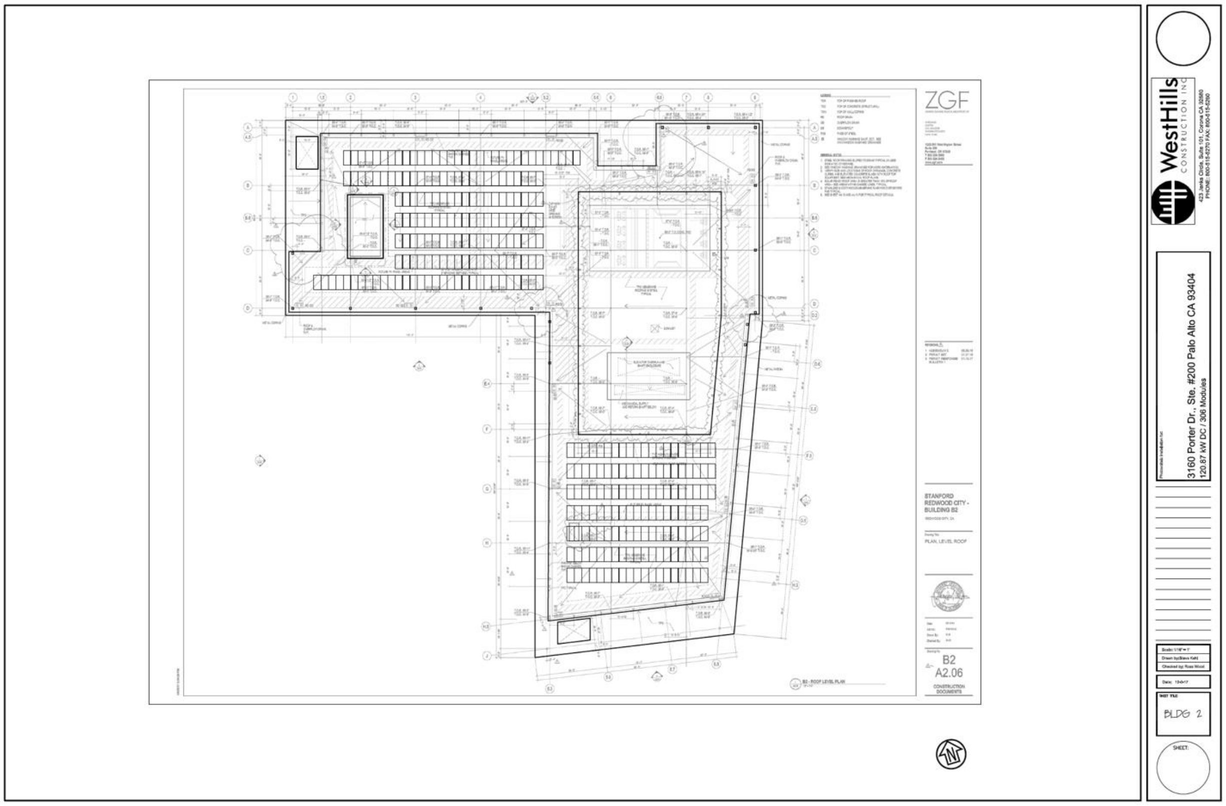


Figure 23 Stanford Redwood City Building 3 PV layout

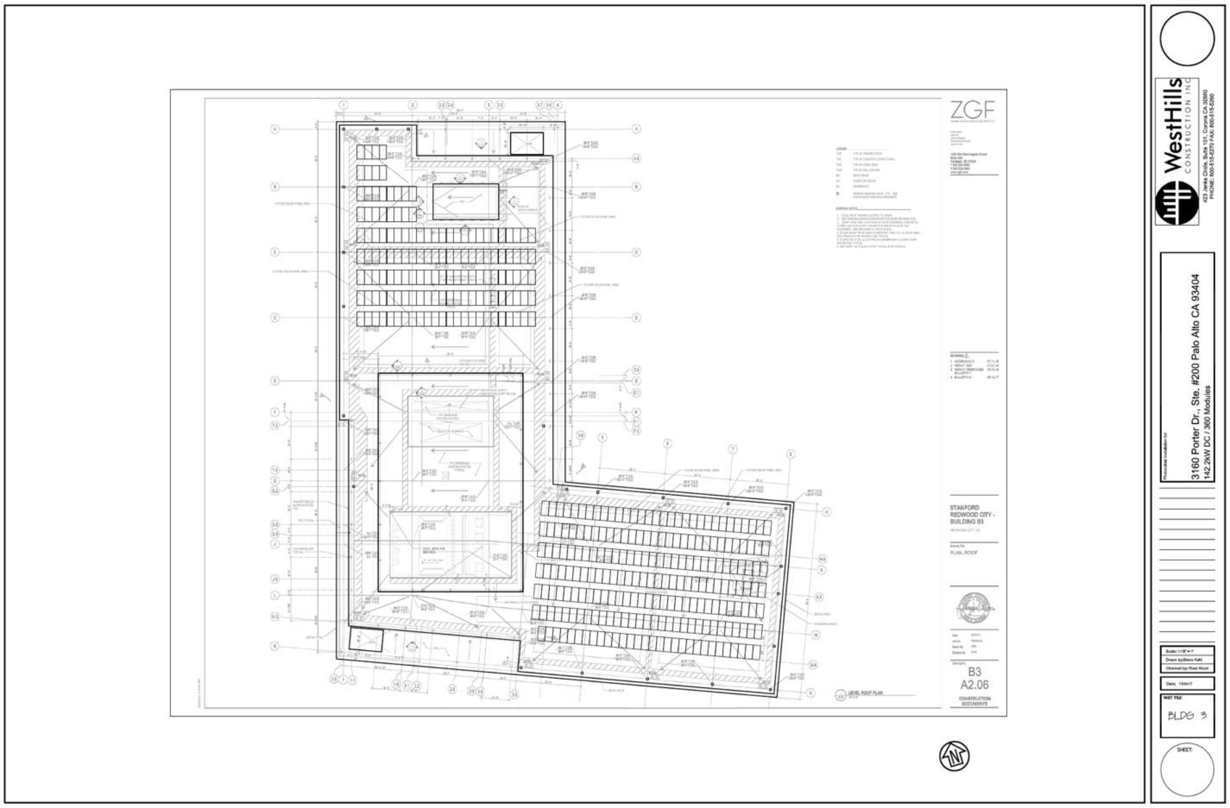
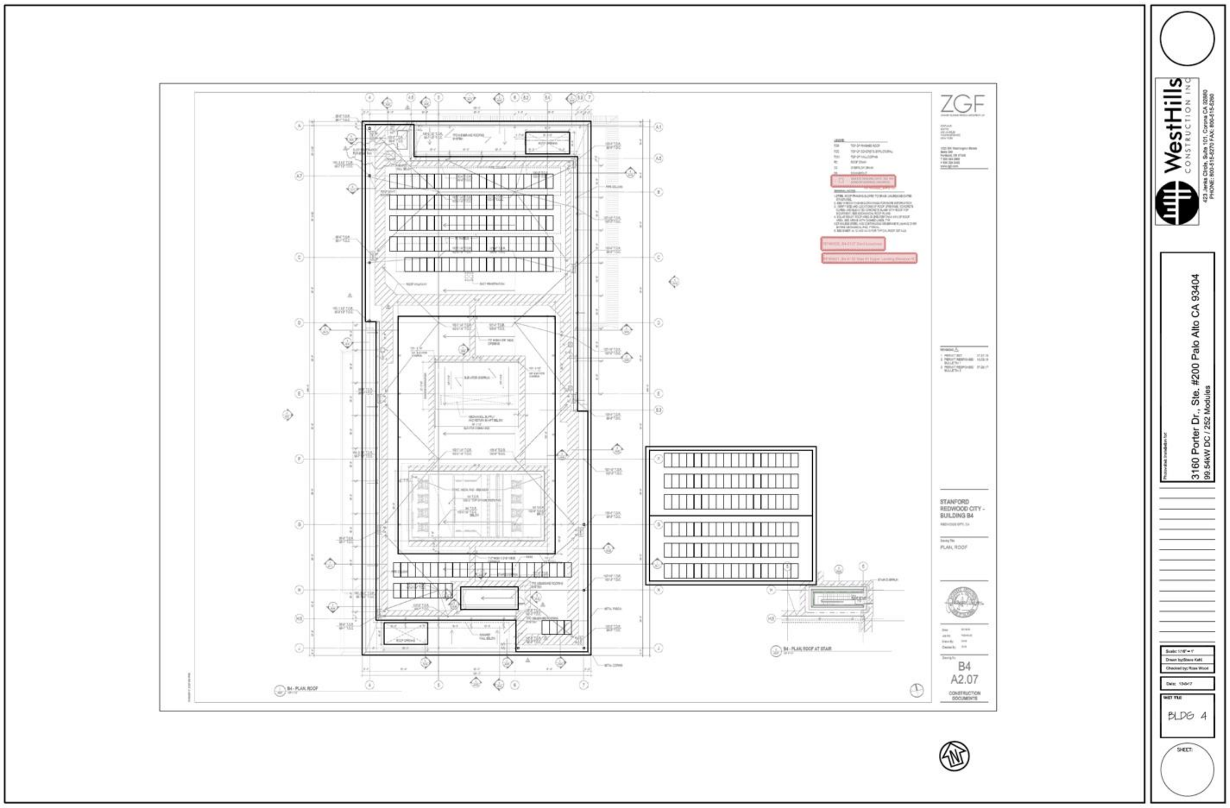
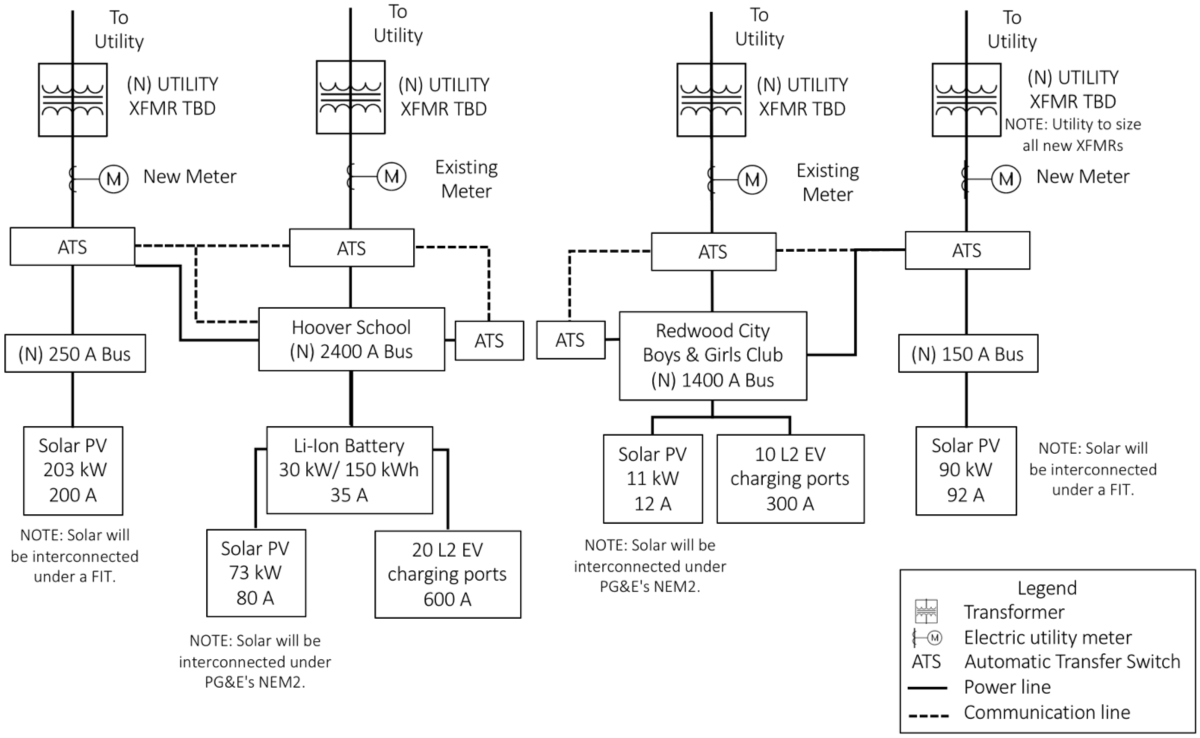


Figure 24 Stanford Redwood City Building 4 PV layout



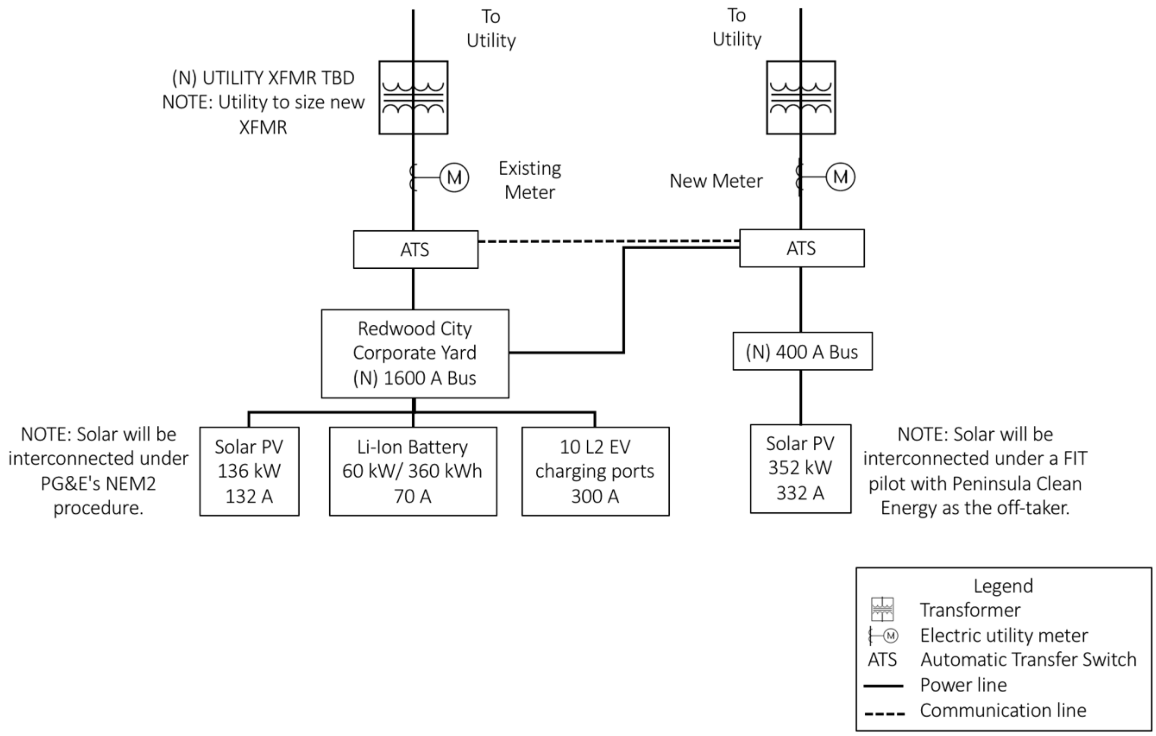
z. Hoover Cluster detailed engineering documents

Figure 25 Hoover Cluster Single Line Diagram Block Diagram



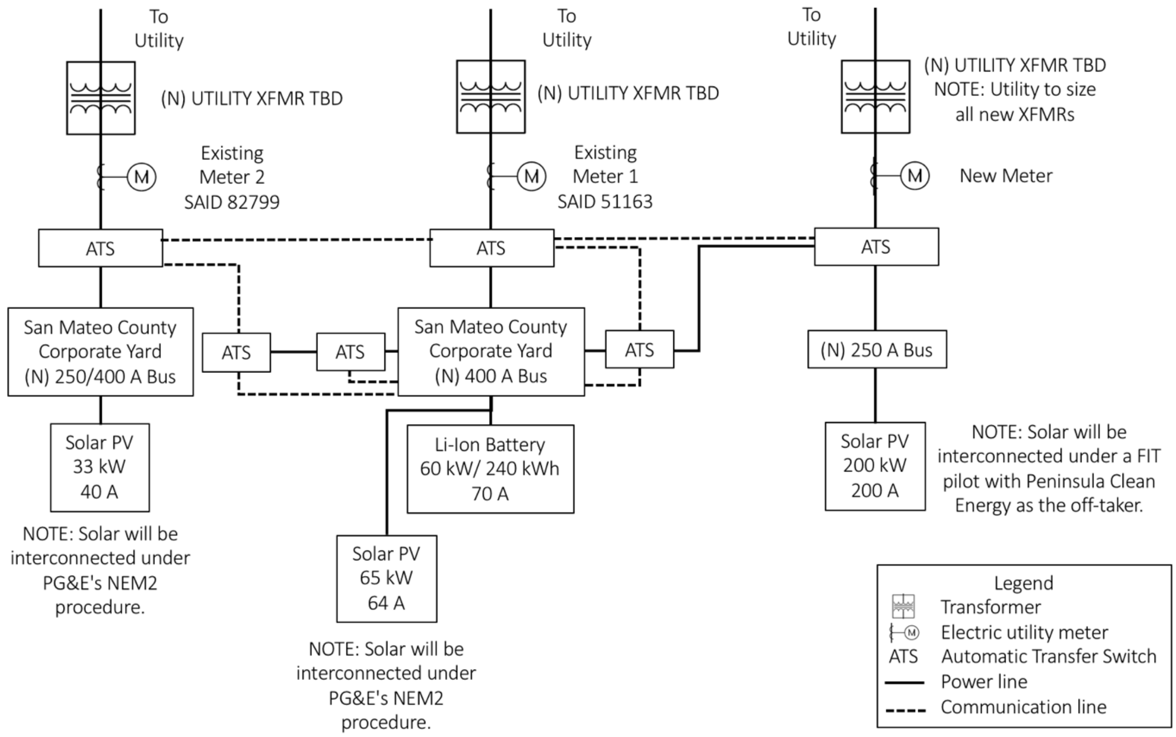
aa. Redwood City Corporate Yard detailed engineering documents

Figure 26 Redwood City Corporate Yard Single Line Diagram Block Diagram



bb. San Mateo County Corporate Yard detailed engineering documents

Figure 27 San Mateo County Corporate Yard Single Line Diagram Block Diagram



cc. Site Information Request

☐ ☐ ☐	Accounting Department: ● 1 year of 15-minute interval data for **each meter** ● 1 year of electric utility bills for each meter (if interval data is not available) ○ Spreadsheet breakdown of this type of information would be great, but it needs to include the monthly bill breakdown of charges including demand charges.
☐ ☐ ☐ ☐ ☐ ☐	Facilities Department: ● Campus map with building names ● Campus map marked with location of each electric meter Electrical and architectural as-built drawings for all buildings ○ Must include Single Line Diagram (SLD) ○ Must include electrical panel schedule ● Electrical and structural as-built drawings for all parking garages ○ Must include SLDs ○ Must include electrical panel schedule ○ Must include structural calculations to determine if we can install solar canopies

☐ ☐ ☐	• Table of all on-site diesel generation and fuel storage (including generator size, tank size and location)
 ☐ ☐ ☐	Sustainability Department: • Existing and planned EVCI including charger types (model, power rating) and locations on-site • Existing and planned PV system design details including ownership structure • 1 year of PV production/ generation data
 ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐	Critical loads, listed in priority order: • First Aid • Food storage • Security (electrical/ magnetic doors) ○ Elevator recovery • Communications equipment • Lighting • Main sheltering area • Thermal control (electric alternatives) • Meal preparation (ovens/ electric alternatives) • Restrooms/ showers • Walkways to parking lot & restroom • HVAC