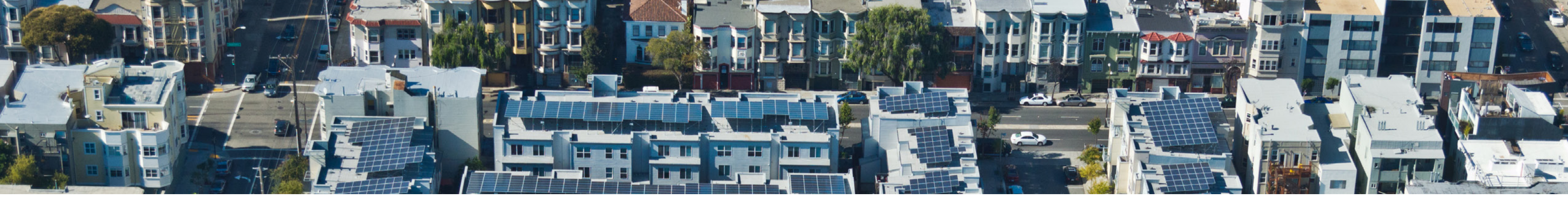

CLOSING THE CALIFORNIA CLEAN ENERGY DIVIDE

Reducing Electric Bills in Affordable Multifamily Rental Housing with Solar+Storage

May 2016

Clean Energy Group
Innovation in Finance, Technology & Policy

California Housing Partnership Corporation
California's Experts on Affordable Housing Finance, Advocacy & Policy

Center for Sustainable Energy®

with Geli

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Executive Summary

BATTERY STORAGE IS EMERGING AS AN effective new strategy for reducing electricity costs for affordable multifamily rental housing in California. Battery storage systems not only provide economic returns today, they can also preserve the value of solar in an evolving policy and regulatory environment. Because batteries empower owners of solar photovoltaic (PV) systems to take control of the energy they produce and when they consume it, storage can deliver deeper cost reductions that can be shared among affordable housing owners, developers, and tenants.

California has installed numerous integrated solar and battery storage projects; however, few have served low-income tenants or owners of affordable rental housing. This disparity is due to many factors, including a lack of information about the economics of these systems in multifamily housing. To provide that needed information, Clean Energy Group, California Housing Partnership, and Center for Sustainable Energy, with analytical support from Geli, are embarking on a series of reports on solar and storage in California affordable multifamily rental housing.

This first report examines the utility bill impacts of adding battery storage to stand-alone solar in affordable rental housing facilities in California's three investor-owned utility service territories, each with different rate structures. It is the first such report ever completed on these technologies in this sector in California.

The report reaches several key conclusions:

- Under current utility rate tariffs, the combination of solar and storage technologies ***could virtually eliminate electric bills for many owners of affordable housing properties.*** Unlike stand-alone solar, which reduces energy consumption expenses but does little to offset demand related charges, a properly sized solar and battery storage system can eliminate nearly all electricity expenses, resulting in an annual electric utility bill of less than a few hundred dollars in some cases.

- It makes ***good economic sense today*** for solar and battery storage to be installed in affordable multifamily rental housing in California. The addition of battery storage to solar improves the economics of each property analyzed across all utility territories, reducing project payback by over three years in some cases.

- The addition of storage technologies has the ***potential to nearly double stand-alone solar electricity bill savings at about a third of the cost of solar***. For example, the addition of a $112,100 battery storage system to a $385,000 solar installation increased savings from $15,000 per year to $27,900, an 85 percent increase in savings for only a 29 percent increase in cost.

Summary of Findings

FINDING NO. 1 Adding battery storage to an affordable rental housing solar installation in California can eliminate demand charges for building electricity loads, resulting in a net electricity bill of essentially zero.

FINDING NO. 2 Adding battery storage to California affordable rental housing can almost double the building electricity bill savings achieved over the savings realized through solar alone.

FINDING NO. 3 Adding battery storage can achieve incremental utility bill savings similar to solar for about a third of the cost of the solar system for owners of affordable rental housing properties in California.

FINDING NO. 4 Solar+storage projects result in a significantly shorter payback period than stand-alone solar projects.

These findings are particularly important because of the passage of California Assembly Bill 693, the Multifamily Affordable Housing Solar Roofs (Solar Roofs) program. This recently enacted legislation provides up to $1 billion in funding for deployment of solar system technologies in affordable multifamily rental housing over the next ten years. The Solar Roofs program, which is the largest program of its type in the country, offers an opportunity to scale integrated energy solutions for approximately one-third of the existing affordable multifamily rental properties in the state.

The findings detailed in this report present a compelling case to include battery storage in the implementation of the Solar Roofs program, to enhance the investment value of public funding and to improve the resiliency and long-term financial stability of affordable housing assets in California. The deployment of combined solar and storage technologies under this program will help enhance the state's transition to a smarter and more sustainable clean energy grid and extend the benefits of new clean energy solutions to underserved populations.

Additionally, uncertainty about the future direction of California's solar regulatory environment raises the issue of whether economically vulnerable affordable housing residents should be exposed to the future financial risks of stand-alone solar systems and how they should be assisted in mitigating such risks with the immediate consideration of energy storage systems. While the analysis found that, under current market conditions, the direct economic benefits from the addition of battery storage will be realized primarily by affordable housing property owners, with no direct impact on tenant bills savings at this time, it would be shortsighted to subsidize the installation of clean energy in affordable rental housing using only yesterday's technologies, whose economic benefits may be diminished by the time they are installed.

Exactly how the additional cost savings achieved through deployment of battery storage technologies can be passed on to tenants has yet to be determined. Possible scenarios include a greater share of solar generation being allocated to offset tenant electricity usage, a shared savings model where tenants are allocated a portion of demand charge savings, or applying some of the expected savings to cover the additional cost of making a building more power resilient during power outages. This is a challenge that still needs to be overcome and is beyond the scope of this report.

This report, the first of three, examines the role of battery storage integrated with solar PV in achieving meaningful, long-term electricity bill reductions in the affordable multifamily rental housing sector, describes the scope of this study, and details plans to conduct additional studies to explore the implications of this work for the implementation of the Solar Roofs program in California.

Following the report, three appendices detail the assumptions used in the analysis, the results for each building scenario analyzed, and a graphical illustration of the analysis for one building showing the impact of solar and storage on electricity consumption and demand.

The findings detailed in this report present a compelling case to include battery storage in the implementation of the Solar Roofs program, to enhance the investment value of public funding and to improve the resiliency and long-term financial stability of affordable housing assets in California.

Closing the Clean Energy Divide

WHILE CALIFORNIA HAS INSTALLED numerous integrated solar photovoltaic (PV) and battery storage projects (solar+storage), few have served the affordable multifamily rental housing sector, which provides housing to more than 450,000 low-income households.[1]

This disparity is due to many factors, including a lack of information about the economics of solar+storage systems in multifamily rental housing. This is not surprising as battery storage is still a relatively new technology. However, with energy costs often representing 20 percent or more of a property's operating costs and over 14 percent of a low-income household's income, it is important to fully explore the potential cost-saving benefits that battery storage can provide to reduce economic risk to both housing providers and renters.[2]

To provide this needed information, Clean Energy Group, California Housing Partnership, and Center for Sustainable Energy, with analysis support from Geli, are embarking on a series of studies on the benefits of combining solar PV with battery storage in California affordable multifamily rental housing. This report—the first such economic analysis conducted in California based on data collected from actual utility bills from affordable housing properties across the state—will examine the economic impacts of adding battery storage to stand-alone solar.

To date, solar+storage technologies have been adopted by a range of commercial customers, typically privately owned businesses, to reduce their utility bills. Ultimately, public policy must ensure that these emerging clean energy technologies are available and accessible to underserved populations that need them the most—to control costs and build healthier, more economically robust communities. It is time to bend the arc of the technology trend by implementing policies that allow solar+storage to better serve these vulnerable populations.

This analysis is particularly timely because of the passage of California Assembly Bill 693, the Multifamily Affordable Housing Solar Roofs (Solar Roofs) program, a ten-year program to support the deployment of solar system technologies in affordable multifamily rental housing.[3] The Solar Roofs program, funded through cap-and-trade proceeds, provides up to $1 billion in funding, making it the largest program in the country to target solar in affordable housing. It has the potential to reach approximately one-third of existing affordable multifamily rental properties in the state.

The California Public Utility Commission is now charged with establishing the implementation rules for the Solar Roofs program. As the proceeding gets underway, a key question is whether it makes economic sense for state policy to encourage solar+storage technologies in affordable multifamily rental housing now and provide the incentive and policy structure to encourage those installations.

As this report demonstrates, it does make sense for policy makers and housing developers to consider the economic benefits of solar+storage in affordable housing today. Based on the analytical results presented in this report, it is in the economic interest of the public, as well as in the long-term interest of affordable housing property owners and residents, to provide a single framework for integrated clean energy solutions, linking energy efficiency with solar and battery storage. Failure to do so would miss an opportunity to truly bridge the clean energy divide.

From Efficiency to Solar to Storage

In subsidized affordable rental housing, energy expenses are one of the few items that can be adjusted to reduce a building's operating budget. For over 40 years, energy efficiency has been an effective strategy in lowering electricity expenses for affordable rental housing tenants and property owners. While energy efficiency is and will remain the first step for reducing consumption, energy efficiency programs in California are challenged by split incentives and a lack of understanding of the unique economics of affordable multifamily rental properties that contribute to low and, in some cases, declining levels of participation in these traditional programs.[4]

In the last decade, solar PV has emerged as a second strategy to reduce electricity expenses in affordable housing, primarily due to declining costs and access to incentive programs. Now, clean energy advocates and the affordable housing sector are considering the next steps to cut energy costs for low-income tenants.[5]

While efficiency measures can reduce electricity consumption and solar can further offset the need for purchasing utility power, the next step in cost reduction will require more integrated strategies that enable property owners to better manage energy demand, improve the financial return on energy investments, and create more resilient and sustainable energy systems in affordable housing. As this report will show, battery storage may be the next logical step in this progression.

There are limits to the economic return that energy efficiency can deliver and, while solar can conceivably offset all building and tenant utility electricity consumption, solar can do little to offset demand charge expenses that property owners incur from utilities (see Appendix C for a graphical illustration of the impact of solar on electricity demand). Revenues from stand-alone PV systems are also highly dependent on policy and how utility rates are structured. For example, much of the value proposition for solar depends on favorable net energy metering (NEM) policies that credit PV system owners for electricity not directly consumed on-site and exported to the grid, which can often amount to over 50 percent of the energy generated by residential and commercial solar systems.[6]

Unfortunately, just as advocates and policymakers are expanding access to solar in affordable housing, both NEM policies and rate tariffs are beginning to shift away from preserving the value of solar investments. While a recent decision in California largely preserved NEM policy in the state, solar customers will soon be required to switch to time-of-use (TOU) rates, which are likely to diminish the value of stand-alone solar installations over time as peak electricity pricing periods shift away from periods of peak solar production.[7]

Battery storage can provide a solution to these economic uncertainties. Battery systems not only provide financial returns today, but they can also preserve the value of solar in a changing regulatory environment. Many commercial customers are already deploying storage technologies in California to reduce electricity costs, manage demand charges, and generate revenue through providing grid services. Battery storage empowers solar owners to take control of the energy they produce and consume, while also offering valuable flexibility to the electric power system. Because of this, it can achieve the next level of energy cost reductions in affordable housing—with the potential to virtually eliminate electricity bills for building owners. In time, storage could also enable further reductions in electricity bills for tenants of affordable housing.

Economic Analysis of Affordable Rental Housing in California

THE KEY OBJECTIVE OF THIS REPORT IS to determine whether adding battery storage to stand-alone solar installations in affordable multifamily rental housing can be justified on economic grounds alone. To achieve this, Geli, an energy software and solutions company, modeled an in-depth utility bill analysis of nine affordable housing projects across California's three investor-owned utility (IOU) territories: Pacific Gas & Electric Company (PG&E), Southern California Edison (SCE), and San Diego Gas & Electric (SDG&E). In total, these utilities account for nearly 80 percent of California electric utility customers and encompass 70 percent of the state's affordable housing rental properties and units.

The analysis compares the economic benefits of solar+storage against that of stand-alone solar installations for both common area building loads and tenant electricity usage under current utility rate structures (see Appendix A for an explanation of assumptions used in these analyses).

Specifically, through collaboration with affordable rental housing developers working in California, we obtained access to detailed utility electricity usage data for common area meters in three affordable rental housing properties in each of the utility territories (see Appendix B for more information about each property).[8] Each of the buildings analyzed is configured with one utility meter to account for building loads, such as common area lighting, elevators, meeting rooms, offices, and laundry facilities, and separate individual meters for each tenant residence.[9] Properties of different size and design were analyzed in each territory in order to assess the benefits of stand-alone solar and solar+storage systems under various scenarios.[10]

Through collaboration with affordable rental housing developers working in California, we obtained access to detailed utility electricity usage data for common area meters in three affordable rental housing properties in each of the utility territories.

A small set of electricity usage data from affordable housing tenants was also obtained in order to verify tenant usage assumptions based on a larger set of residential electricity load profiles (see Appendix A). At this time, residential utility rates do not typically include demand charges or TOU rates, so, while the bill savings the building owner receives from the addition of battery storage can be passed through to benefit affordable housing tenants, the tenants cannot directly save on their electricity bills with the addition of battery storage. Direct tenant benefits from battery storage under future scenarios, such as mandatory TOU rates, will be explored in the third report in this series.

The end results of the analyses show the specific financial outcomes for each scenario. Because tenants were not found to directly benefit from the addition of battery storage under current prevailing utility residential rate structures, the findings section of this report focuses on bill savings for common area building loads. Figures in the findings section illustrate the modeled bill effects of adding storage to solar in a real-world setting involving actual electricity usage profiles. More detailed results for each analysis can be found in Appendix B, pages 22 through 39.

FIGURE 1
Explanation of Charges Commonly Found on an Electric Bill

Charges on an Electric Bill

Electric bills are primarily composed of three types of charges: energy charges, demand charges, and fixed charges.

Energy charges:
Energy charges (measured in kilowatt-hours) are based on the amount of electricity consumed from the grid over each billing cycle. Energy charges can vary depending on season and the time of day electricity is consumed (time-of-use rates) or the amount of electricity consumed (tiered rates).

49%

SDG1 Annual Electric Bill

ENERGY

		Usage (kWh)	Cost ($/kWh)	Total cost ($)
Max	Summer	13,085	0.11447	1,497.82
	Winter	7,827	0.10565	826.97
Peak	Summer	15,259	0.10568	1,612.59
	Winter	35,189	0.09132	3,213.46
Part-Peak	Summer	26,959	0.07920	2,135.17
	Winter	46,612	0.07160	3,337.42
TOTAL		**144,932**		**$12,623.43**

DEMAND

		Avg peak (kW)	Cost ($/kW)	Total cost ($)
Max	Summer	33	22.55	2,958.56
	Winter	30	22.55	5,195.52
Peak	Summer	33	19.19	2,517.73
	Winter	24	6.86	1,279.49
Part-Peak	Summer	30	0.00	0.00
	Winter	30	0.00	0.00
TOTAL				**$11,951.30**

46%

FIXED

	Total cost ($)
Meter charge	1,397.28
TOTAL	**$1,397.28**

5%

TOTAL ANNUAL BILL $25,972.01

Demand charges:
Demand charges (measured in kilowatts) are based on the highest rate of electricity consumption during a billing cycle, called peak demand. Utilities assess peak demand by measuring the highest average demand that occurs over any 15-minute period each billing cycle. Demand charges can vary depending on season and the time of day when peak demand occurs. Demand charges are typically found only on commercial or industrial customer accounts, where they often represent about half of the cost of an electric bill. Residential customers are usually not assessed these charges.

Fixed charges:
Fixed charges are usually static and do not vary from one billing cycle to the next. These charges typically cover the costs of metering, billing, and other customer-related operating expenses not accounted for in energy and demand charges. Fixed charges can also include additional fees to cover system benefit programs such as energy efficiency and renewable energy programs. For simplicity, only fixed charges related to billing and metering are considered in this analysis.

Economic Analysis Findings

The economic analyses modeled for this research effort support several key findings about the financial benefits of installing solar+storage in affordable multifamily rental housing in California.[11]

FINDING NO. 1

Adding battery storage to an affordable rental housing solar installation in California can eliminate demand charges for building electricity loads, resulting in a net electricity bill of essentially zero.

A solar system designed to offset 100 percent of a building's electricity consumption through NEM can reduce the energy usage charges on a property owner's utility bill to zero, but energy consumption charges often amount to about half of the total bill (see Figure 1). For buildings that incur demand charges, which are based on the highest demand for power at any point over a billing period, the other half of the bill remains largely intact. Adding solar may result in a modest reduction in demand charge costs, but these savings are not guaranteed, as one cloudy day can erase savings for an entire period, and solar can do nothing to reduce peak demand occurring in early morning or evening hours (see Appendix C for an illustration of the impact of solar on electricity demand).

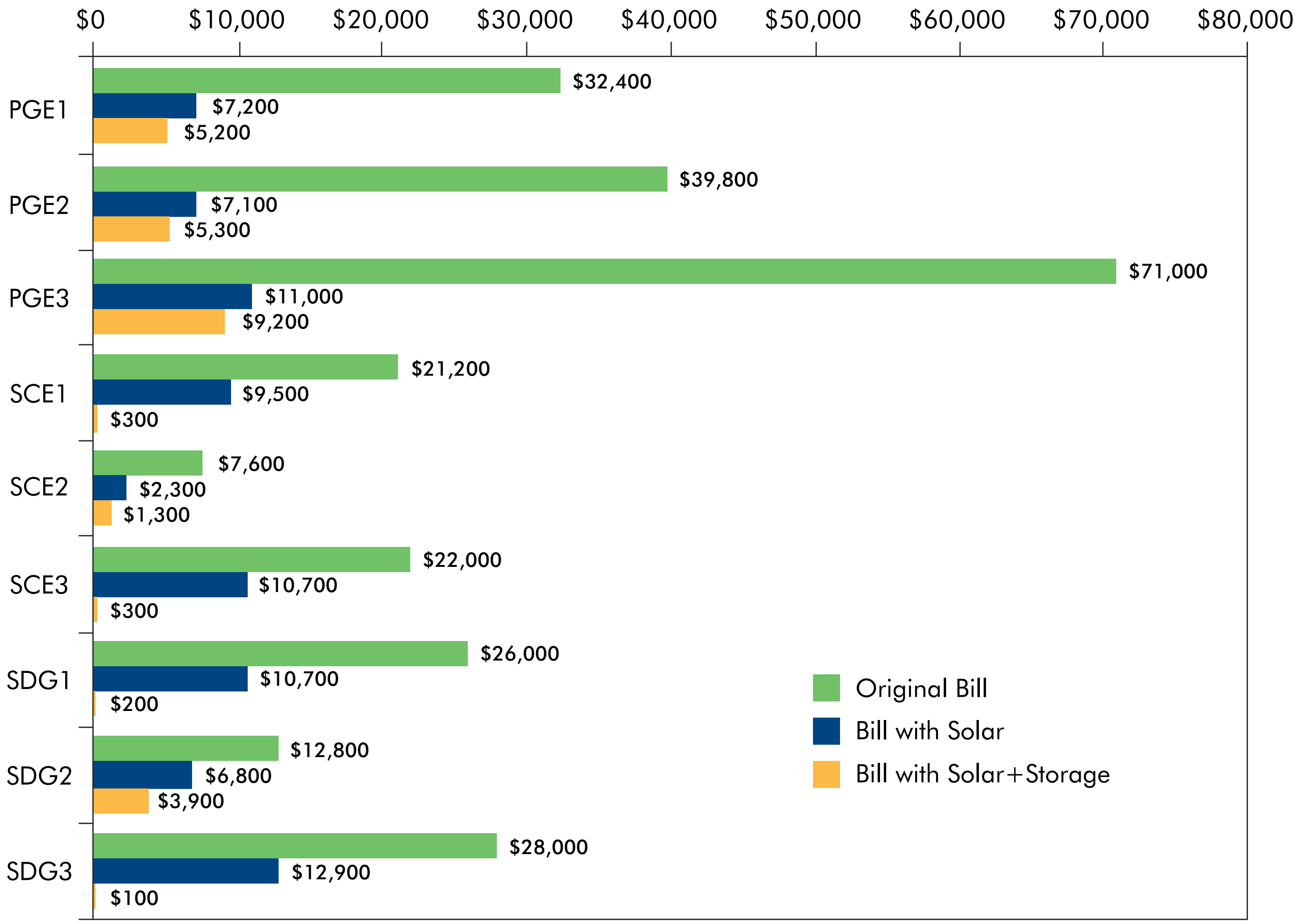
The addition of battery storage can reduce or even eliminate the remaining demand charges for building owners (see Figure 2). The analysis found that solar+storage deployed in certain buildings (see Appendix B, buildings SCE1, SCE3, SDG1, and SDG3) could lower electricity demand below a utility defined threshold, 20 kilowatts for both SCE and SDG&E, allowing property owners to switch to a utility rate structure with no demand charges (illustrated in Appendix C, Figure C.7).[12] This reduction in electricity demand not only eliminates the demand charge costs but also removes the need for certain metering and billing expenses, which can add significant fixed charge expenses to an annual utility bill.[13]

The end result of pairing battery storage with solar can be as drastic as a $13,000 reduction in demand charge costs each year, leading to total annual electricity costs amounting to no more than about $100 in fixed charges. Of course, buildings that are below the demand threshold may already be on a rate tariff without demand charges, and thus may not have the same economic incentive to install batteries to complement their solar system.[14]

PG&E currently has a much higher threshold for non-demand charge rates, 75 kilowatts. While the buildings within PG&E analyzed in this study have demand profiles below this threshold, because PG&E rate structures have comparatively low demand charge rates, it is more economic for these buildings to be billed for both energy and demand charges, instead of switching tariffs to one with increased energy charges and no demand charge. Because demand charges are lower in PG&E than the other IOUs and there is no economic incentive to switch to a rate structure that does not include these charges, the value proposition for storage is typically lower in this territory.

FIGURE 2

Annual Electricity Bill for Building Common Area Load after Deployment of Stand-Alone Solar and Solar+Storage



FINDING NO. 2

Adding battery storage to California affordable rental housing can almost double the building electricity bill savings achieved over the savings realized through solar alone.

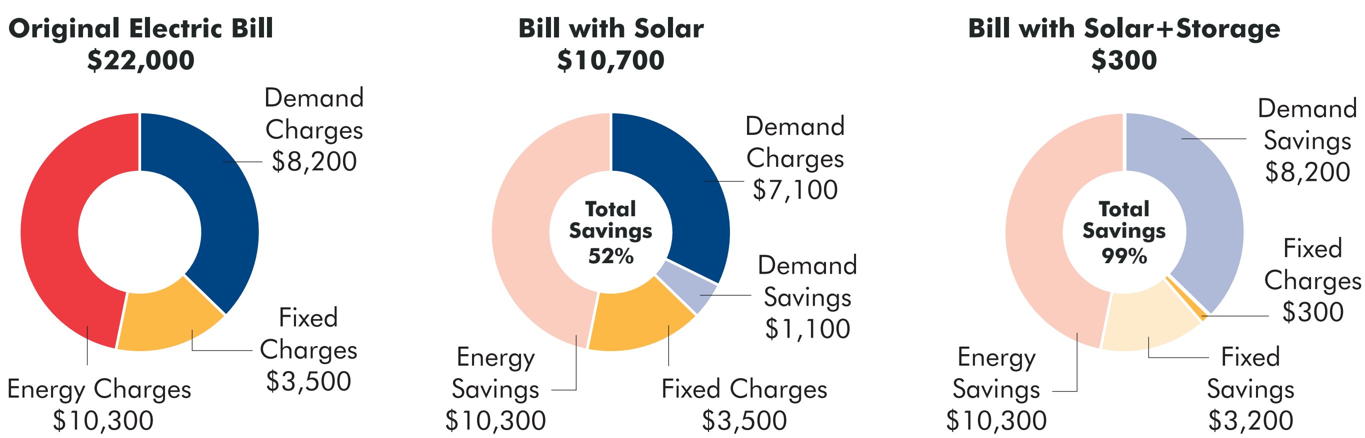
As mentioned in the previous findings, the amount many building owners pay for the kilowatt-hours that their property consumes only accounts for around half the cost of their electricbill. Solar can help reduce the remaining costs, but only battery storage can dependably manage and potentially eliminate the cost-per-kilowatt portion of a building's electric bill based on demand.

The economic analysis found that, in some cases, the addition of battery storage had the potential to almost double the utility bill savings that could be achieved by an affordable rental housing property owner over solar-alone systems.

For example, as shown in Figure 3, building SCE3 saved $11,400 with solar and an additional $10,300 with the incorporation of battery storage, a 90 percent increase in savings over stand-alone solar. These additional savings from storage, while not directly lowering tenant electricity bills, can be passed through to affordable housing tenants or used to improve the property in other ways beneficial to residents, such as designing the solar+storage system to provide backup power in emergencies. The value proposition for tenants will likely improve with upcoming changes to utility rate structures such as TOU rates and NEM policies, which will be explored in the third report of this series.

FIGURE 3

Example of Impacts from the Addition of Solar and Solar+Storage on Electricity Bills



SCE3 building original electric bill, electric bill and savings after deployment of solar, and electric bill and savings after deployment of solar+storage. Solar eliminates energy consumption expenses and lowers demand charges, saving $11,400. The addition of battery storage eliminates demand charge expenses and lowers fixed charges, saving an additional $10,300 per year.

FINDING NO. 3

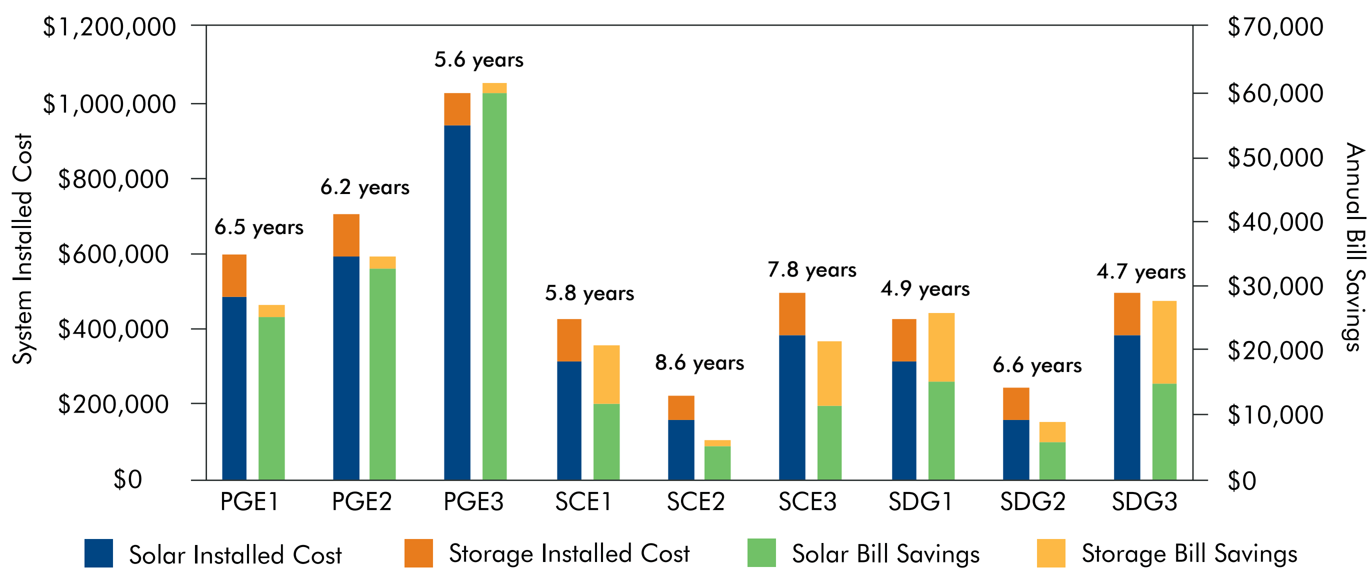
Adding battery storage can achieve incremental utility bill savings similar to solar for about a third of the cost of the solar system for owners of affordable rental housing properties in California.

The addition of battery storage to an affordable multi-family rental housing solar project can result in incremental savings essentially equal to those achieved through solar alone, while only increasing the installed cost of a project by about a third of the cost of the solar-only investment.

For example, in the analysis of the SDG3 installation, a $385,000 solar system was modeled to completely offset building electricity consumption. It saved about $15,000 per year. Due to the batteries' ability to manage demand below a 20 kilowatt threshold, adding a $112,100 battery storage system, at about a third the cost of the solar system, increased annual savings to $27,900. That amounts to an 85 percent increase in total savings for only a 29 percent increase in cost.

FIGURE 4

Installed Costs and Bill Savings for Building Common Area Loads



Installed cost of solar and battery storage systems to cover building common area loads (left axis) and the resulting annual electricity bill savings for the building (right axis). Project payback periods range from 4.7 to 8.6 years, noted above bars. Note that project payback periods factor in all available incentives, which are detailed in Appendices A and B.

FINDING NO. 4

Solar+storage projects result in a significantly shorter payback period than stand-alone solar projects.

The economics for solar in California affordable multifamily rental housing are generally favorable.

Our analysis found that the payback period for stand-alone solar projects offsetting building electricity consumption ranged from 5.6 to 10.5 years, and 4.8 to 8.8 years for solar offsetting tenant electricity consumption.[15]

While these time frames are well below the expected life of a solar project, we found that incorporating battery storage into a project reduced the payback period of stand-alone solar in every scenario analyzed. The payback reduction for property owners was quite significant in several cases. For the projects analyzed in this study, integrated solar+storage systems had a payback period of 4.7 to 8.6 years, shortening project payback by as much as 3.6 years and making for a much more favorable investment proposition (see Figure 4).

It is important to note that estimates of project payback and return on investment depend on a number of factors beyond the scope of this initial report. For instance, the results of these analyses assume that system owners are able to directly take advantage of available incentives, such as the 30 percent federal investment tax credit (ITC).[16] Such considerations will be explored further in the second report in this series.

The results are also highly dependent on current utility rate structures and state NEM policies, both of which are subject to change. Under the scenarios analyzed in this study, 53 to 78 percent of solar energy generation was exported to the grid as non-coincident with customer electricity demand. A shift in rates and/or policy that decreases the value proposition for non-coincident energy export would further bolster the value of battery storage technologies.

While these time frames are well below the expected life of a solar project, we found that incorporating battery storage into a project reduced the payback period of stand-alone solar in every scenario analyzed.

The findings also assume that system owners can participate in California's Self-Generation Incentive Program (SGIP), which provides incentives for advanced energy storage projects among other technologies.[17] The SGIP is currently undergoing modifications and the program structure and incentive rate may be subject to change. For the economics shown in these analyses to be realized in practice, a comparable incentive structure may need to be established to ensure affordable rental housing owners and tenants have the same access to these beneficial technologies as commercial customers. Such an incentive could be implemented through structuring of the Solar Roofs program.

Additional Questions to Be Answered

THIS REPORT DOES NOT ADDRESS ALL the questions that must be answered to create a comprehensive policy to achieve the results detailed above. Therefore, it will be followed by two subsequent reports addressing remaining questions.

Developers still need to know how various tax, incentive, and ownership options can impact the investment opportunity for solar+storage projects. The next report in this series will address these questions through an investment model financial analysis. In addition to setting out various incentive scenarios, business models, and related analyses, the report will look at policy options enabling affordable rental housing tenants and property owners to share in the economic benefits that can be achieved through integrated solar+storage technologies.

It also remains to be determined how the additional building electricity cost savings achieved through deployment of battery storage technologies can be passed on to tenants. Possible scenarios include a greater share of solar generation being allocated to offset tenant electricity usage, a shared savings model where tenants are allocated a portion of demand charge savings, or applying some of the expected savings to cover the additional cost of making a building more power resilient during power outages.[18] The addition of battery storage to an affordable rental housing solar incentive program could also enable more participation by properties with limited suitable space for solar panels. In this case, battery storage assets could be allocated to benefit the property owner, while the constrained solar capacity could be allocated to benefit tenants. The second report in this series will address these and related questions in greater detail.

Additionally, this analysis captures only the current policies and rate structures in place in California. It is a static picture of the economic benefits of solar+storage available today.

It also remains to be determined how the additional building electricity cost savings achieved through deployment of battery storage technologies can be passed on to tenants.

Over the next decade, California solar policy and utility rate structures are likely to change dramatically. At the very least, based on the recent net energy metering proceeding (NEM 2.0), residential NEM customers will be required to shift from the flat tiered rate structures of today to TOU rates that vary depending on defined periods of peak and off-peak electricity pricing.[19] This is particularly important because, as more solar comes online, peak pricing periods are expected to shift away from periods when solar production is at its maximum. Thus TOU rates will inevitably result in a degradation of the value of stand-alone solar to system owners over time.[20]

This erosion of the value of solar presents another unique challenge for publically supported energy investments for affordable rental housing, such as the Solar Roofs program. Rather than exposing the most economically vulnerable residents to the future financial risks of stand-alone solar, low-income housing residents should be assisted in mitigating such risks with the immediate consideration of battery storage systems. It would be shortsighted to subsidize only yesterday's technologies in affordable housing today and install systems whose value may be obsolete by the time they are built. Because battery storage control systems can economically optimize when solar energy is consumed and when it stored for later use, they can insulate solar customers from drastic policy and rate changes, as have recently occurred in Nevada and Hawaii.[21]

The third report in the series will explore how future regulatory scenarios in California could impact the economics of solar+storage and the resulting effects on property owner and tenant electricity bills. This upcoming analysis will be designed to give policymakers the information they need to ensure that low-income customers have equal access to battery storage technologies now in order to secure the economic value of solar in the future. Because equal access to advanced clean energy technologies will benefit the grid, ratepayers, and affordable housing residents, concerns about energy democracy and bridging the clean energy divide must be addressed.

This is especially important because Multifamily Affordable Housing Solar Roofs is a ten-year program, while the regulatory environment governing solar in California is likely to change substantially over the same period. Such a long-term horizon also suggests that other policy measures should be considered in implementing the Solar Roofs program, such as California's Zero Net Energy (ZNE) requirements for residential buildings, including affordable rental housing, and the California Public Utility Commission Distributed Resources Plan proceeding, which might further implicate energy storage.[22]

Because equal access to advanced clean energy technologies will benefit the grid, ratepayers, and affordable housing residents, concerns about energy democracy and bridging the clean energy divide must be addressed.

Conclusion

THE ANALYSIS DETAILED IN THIS REPORT makes a strong case for the value proposition of solar+storage in California affordable rental housing today.

It is clear that the addition of battery storage to affordable rental housing solar installations can provide a compelling economic return for many properties in California. While this study only examines a limited number of properties from a small sample size, most affordable housing properties in California that are subject to demand charges are expected to see a similar return on storage investments. These incremental savings can be leveraged to provide greater direct solar benefits to affordable rental housing tenants, or directly passed on to tenants through a shared savings model. Savings could also allow buildings to provide power resiliency to tenants during emergencies, thereby enabling vulnerable populations to shelter in place.

Any solar incentive program designed to benefit affordable rental housing, such as the Solar Roofs program, should carefully consider the inclusion of battery storage technologies. An incentive for solar alone may limit the potential economic benefits that combined solar+storage technologies can offer. Additionally, without battery storage, the value proposition for solar is vulnerable to looming shifts in solar policy and utility rate design. The economic results for battery storage under current rate structures and policy conditions detailed in this report are likely to improve over time, and the cost of this technology is likely to decline.

This report lays the groundwork for consideration of battery storage in a solar incentive program, but more work needs to be done to inform the process. These analyses were based on a small sample of affordable rental housing properties. There are many additional scenarios that were not explored in our research and it would be beneficial to undertake a broader analysis of the value proposition for storage in affordable housing throughout California.

While this study only examines a limited number of properties from a small sample size, most affordable housing properties in California that are subject to demand charges are expected to see a similar return on storage investments.

The challenges ahead are to: (1) demonstrate that property owners can make a financially sound investment in solar+storage technologies, (2) structure an incentive program that provides for an integrated, inclusive mitigation package that includes efficiency, solar, and energy storage for the benefit of low-income tenants and owners of affordable rental housing properties alike, and (3) make the case for the value of storage under likely future California solar policies and utility rate structures.

The next two reports in this series will provide the information for all parties to address these challenges. These California-specific reports build upon the regional analysis of solar+storage in affordable housing that Clean Energy Group presented in a previous report in October 2015. That report, *Resilience for Free*, outlines the continued need to provide policy support to close the clean energy divide in the United States.[23] Informed policies should help ensure that low-income residents obtain the benefits of solar and energy storage now, allowing those most in need to realize the same economic returns that commercial customers currently enjoy.

ENDNOTES

1 See *http://www.cbpp.org/sites/default/files/atoms/files/4-13-11hous-CA.pdf.*

2 U.S. Department of Housing and Urban Development, Progress Report and Energy Action Plan Report to Congress, December 2012.

3 See *https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201520160AB693.*

4 Utility Program Administrator presentations at California Energy Efficiency Coordinating Meeting, Residential Sector Subcommittee, April 18, 2016. See: *http://www.caeecc.org/#!blank-26/grypo.*

5 A longer treatment of these issues can be found in *http://www.greentechmedia.com/articles/read/affordable-housings-progress-toward-integrated-energy-solutions.*

6 Under the scenarios analyzed in this study, 53 to 78 percent of solar energy generation was exported to the grid as non-coincident with customer electricity demand. Also see Rocky Mountain Institute, The Economics of Demand Flexibility, August 2015.

7 Time-of-use rates charge different prices for electricity consumed during peak and off-peak periods. When peak (i.e. higher price) periods occur outside the hours of solar generation, the value of net metered systems can begin to erode. As more and more solar comes online, peak pricing periods are likely to shift away from periods of maximum solar production.

8 Due to data access limitations and considering the climate similarities between SCE and SDG&E territories, building electricity usage data for three buildings located in SCE territory were also used to analyze solar and storage under SDG&E rate structures.

9 The utility metering configuration of individually metered tenant accounts with a separate meter for building loads is the most common arrangement for electricity monitoring in multifamily affordable housing. Some affordable housing developments are master metered, with tenants and building loads all serviced by one shared utility meter; however, this configuration is much less common.

10 Interval data access was limited to a small set of 14 affordable housing properties. Due to this limited data set, it was not possible to explore every possible scenario for affordable housing in California.

11 Key findings are based on specific economic cases illustrated through the analyses. Solar+storage may not be the optimal solution for every type of multifamily affordable housing. See Appendix B for more information on individual building analyses.

12 In order to switch from a utility rate tariff that includes demand charges to a rate tariff without demand charges, a building may be required to demonstrate demand below the specified threshold for a period of 12 months; however, some utilities may allow customers to switch earlier and demonstrate demand performance while being billed under the non-demand tariff. If a building exceeds demand during this demonstration period, the tariff will be switched back retroactively.

13 See *http://bit.ly/Resilience-For-Free* and *http://bit.ly/Energy-Storage-And-Electricity-Markets* for more information on demand charge management.

14 Buildings below a certain size may not have high enough power demands to be subject to utility rate structures with demand charges. Larger multi-story buildings may represent a better economic opportunity for battery storage demand management than smaller buildings or dispersed housing where multiple buildings with few tenants are individually metered across a housing complex.

15 Many affordable housing tenants participate in the California Alternate Rates for Energy Program (CARE). CARE electric utility rates are typically discounted by 30 to 35 percent. These discounts were not factored into the expected costs and savings associated with tenant accounts. In our analyses, tenant utility expenses represent the total retail cost of electricity. Analysis of the overall societal impact of offsetting CARE discounted electricity consumption is beyond the scope of this report.

16 Internal Revenue Service recognizes energy storage as eligible for ITC as part of a solar energy system as long as the storage assets are charged by on-site solar electricity generation at least 75 percent of the time.

17 See *http://www.cpuc.ca.gov/General.aspx?id=5935.*

18 The additional cost of making a solar+storage system resilient varies greatly depending on the current electrical configuration of a building. For new construction and existing buildings with critical loads already isolated, the incremental cost may be no more than a small fraction of the cost of the entire system. However, the cost may be prohibitively expensive for buildings requiring extensive electrical reconfiguration. See *http://www.cleanegroup.org/ceg-resources/resource/solar-storage-101-an-introductory-guide-to-resilient-solar-power-systems/* for more information on resilient solar+storage system design.

19 See *http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M158/K060/158060623.pdf.*

20 See *http://www.energy-storage.news/news/storage-will-help-ease-solar-value-deflation-as-grid-penetration-increase-g.*

21 In 2015, both Nevada and Hawaii changed their net metering programs to compensate solar customers at the wholesale rate for electricity exported to the grid. This rate is anywhere from half to a third of the value of retail rate compensation previously in place. The change to Nevada's net metering policies impacts both existing and new net metered customers; whereas, only new solar customers will be limited to wholesale compensation in Hawaii.

22 See *http://www.californiaznehomes.com/* and *http://www.cpuc.ca.gov/General.aspx?id=5071.*

23 See *http://bit.ly/Resilience-For-Free* and *http://ssir.org/articles/entry/bridging_the_clean_energy_divide.*

APPENDIX A

Economic Analysis Basic Assumptions

The following information details the basic assumptions used in all economic analyses presented in this report. Assumptions relate to solar PV system parameters, battery storage system parameters, and electricity rates and usage.

Solar PV system

Warranty:
25 years

Expected lifetime:
25 years

Discount rate:
6%

Sizing:
Building electricity usage: Offset 100%
Tenant electricity usage: Offset 75%

Cost:
Installed cost: $3.50 per watt[1]
O&M: $15 per kilowatt
O&M escalator: 2% per year

Performance:
Annual energy production: 1,500 kilowatt-hours per kilowatt (modeled solar energy production based on PVWatts Calculator developed by the National Renewable Energy Lab)[2]
Performance degradation: 0.5% per year

Incentives:
Federal ITC: 30%

Depreciation:
Depreciation basis: 85%
Federal depreciation schedule: 5-year MACRS
State depreciation schedule: Straight-line

Battery storage system

Battery chemistry:
Lithium-ion

Warranty:
10 years

Expected lifetime:
15 years[3]

Discount rate:
6%

Sizing:
Designed to optimize economic return[4]

Cost:
Installed cost:[5]
- 15 kilowatt/36 kilowatt-hour: $63,900
- 30 kilowatt/45 kilowatt-hour: $87,700
- 30 kilowatt/90 kilowatt-hour: $112,100

Performance:
Performance degradation: 0.5% per year
Round-trip conversion efficiency: 81%[6]

Incentives:
Federal ITC: 30%
California Self-Generation Incentive Program (SGIP): $1.58 per watt ($1.31 per watt with 20% multiplier for California manufacturers)[7]
SGIP performance calculated rebate: 38% of project cost
SGIP cap: 30% of system cost

Depreciation:
Federal depreciation schedule: 5-year bonus MACRS
State depreciation schedule: Straight-line

Electricity

Utility rates:
Energy charge escalator: 3% per year
Demand charge escalator: 5.5% per year

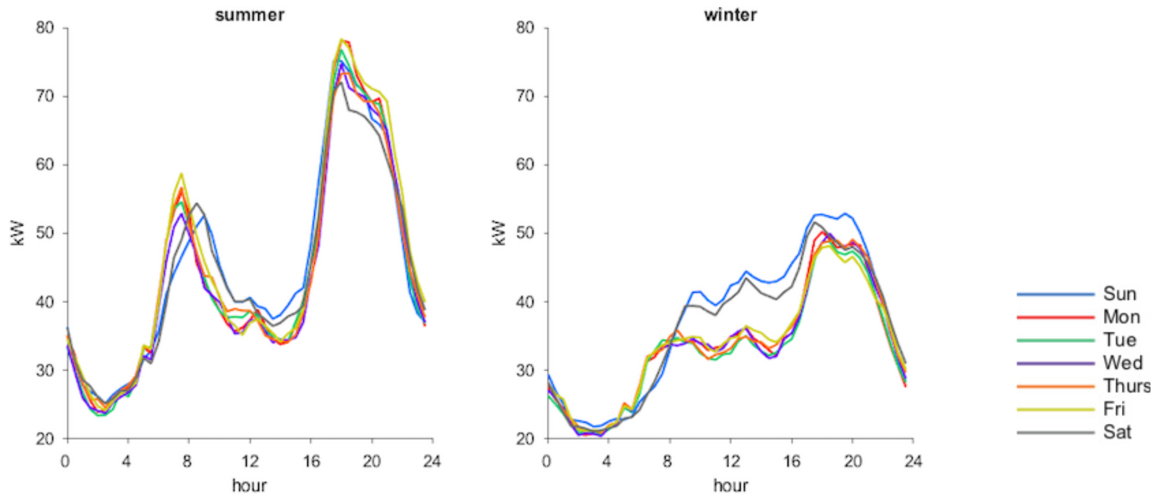
Electricity usage:
Building: Utility interval data[8]
Residential units: 550 kilowatt-hours per month per residential unit

(Due to access restrictions for residential tenant accounts, residential electricity usage for tenants was modeled by aggregating profiles from other residential accounts and scaling those to match average electricity consumption for customers participating in the California Alternate Rates for Energy Program (CARE), which is approximately 550 kilowatt-hours per month.[9] Access was provided for two multifamily affordable housing tenant accounts within the SCE territory. As shown in Figure A.1, the shape of aggregated electricity profiles was compared to this small set of tenant profiles in order to validate the methodology. The correlation between load shapes of actual data and aggregated profiles was deemed to be within an acceptable range for the purposes of our analyses.)

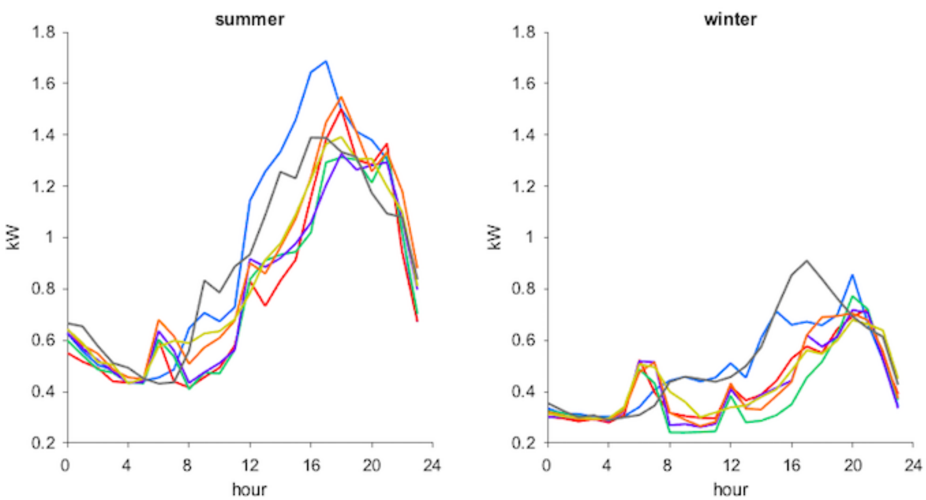
FIGURE A.1

Electricity Load Profiles

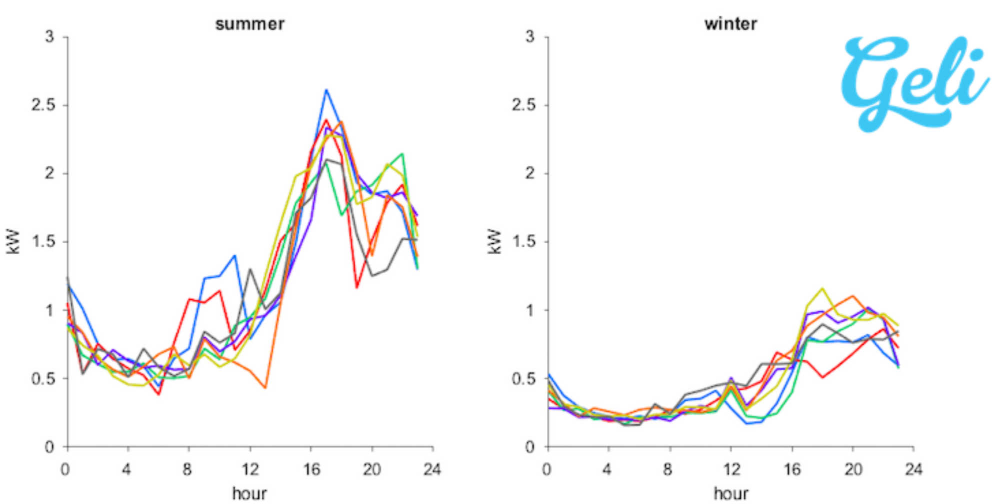
a) Aggregated residential load profile



b) Actual utility interval tenant profile 1



c) Actual utility interval tenant profile 2



Comparison between electricity load profile shapes for an aggregation of 50 scaled California residential load profiles (a) and two multifamily affordable housing tenant load profiles generated from utility account interval data (b, c).

APPENDIX B
Detailed Economic Analysis Results

The following section details the economic analysis results for each of the nine affordable multifamily rental housing properties modeled in this study. Results are organized by the location of each property within the IOU territories: PG&E (PGE1, PGE2, PGE3), SCE (SCE1, SCE2, SCE3), and SDG&E (SDG1, SDG2, SDG3).

On the first page of results for each property, under “BUILDING,” solar PV and battery storage system installed costs, incentives, and modeled electricity bill savings are presented for building common area electricity loads. On the second page of each set of results, under “TENANTS,” aggregated results for the affordable housing property’s tenants are detailed, including installed costs, incentives, and electricity bill savings for solar-alone. Because residential tenant utility rate structures do not include demand charges or TOU rates, there is currently no value proposition for battery storage to provide additional tenant electricity bill savings at this time.

A 58-kilowatt solar photovoltaic (PV) system atop the 34-unit Townspeople Apartments in San Diego.

PGE1

RESIDENTIAL UNITS: **49**
UTILITY TERRITORY: **PACIFIC GAS & ELECTRIC**

BUILDING

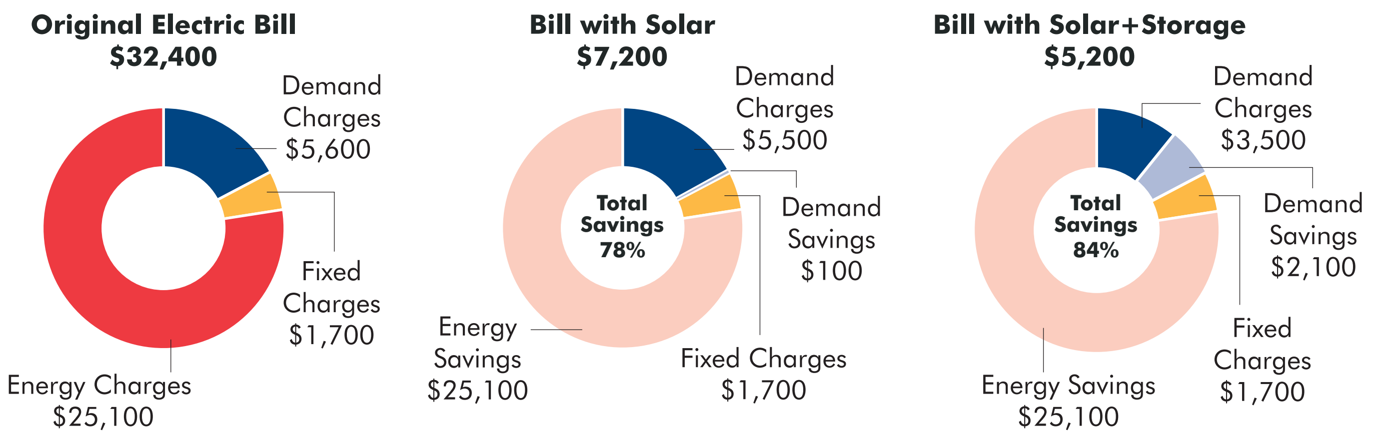
UTILITY RATE TARIFF

A-10-S (TOU rate with demand charges)[10]

TABLE B.1
PGE1 building solar and storage system costs and benefits.

	System size	Installed cost	ITC value	Depreciation tax savings	Additional incentives	Annual bill savings	Percent savings	Payback period (years)
Solar	140 kW PV	$490,000	$147,000	$189,100	$0	$25,200	78%	6.7
Battery storage	30 kW/90 kWh battery	$112,100	$33,600	$43,300	$37,000	$2,000	6%	4.8
Solar+ storage	140 kW PV + 30 kW/90 kWh battery	$602,100	$180,600	$232,400	$37,000	$27,200	84%	6.5

FIGURE B.1
PGE1 building original electric bill, electric bill and savings after deployment of solar, and electric bill and savings after deployment of solar+storage.



TENANTS

UTILITY RATE TARIFF

E-1 (non-TOU, flat tiered-rate)[11]

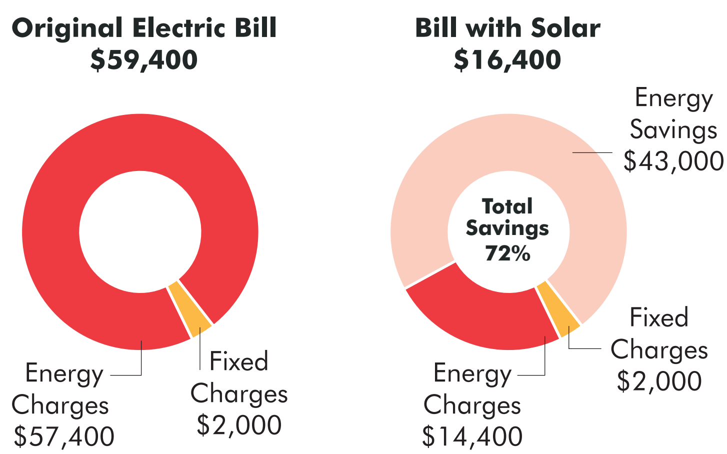
TABLE B.2

PGE1 tenant solar system costs and benefits.

	System size	Installed cost	ITC value	Depreciation tax savings	Additional incentives	Annual bill savings	Percent savings	Payback period (years)
Solar	155 kW PV	$542,500	$162,800	$209,400	$0	$43,000	72%	4.8

FIGURE B.2

PGE1 tenant original aggregated electric bill and electric bill and savings after deployment of solar.



PGE2

RESIDENTIAL UNITS: 73
UTILITY TERRITORY: PACIFIC GAS & ELECTRIC

BUILDING

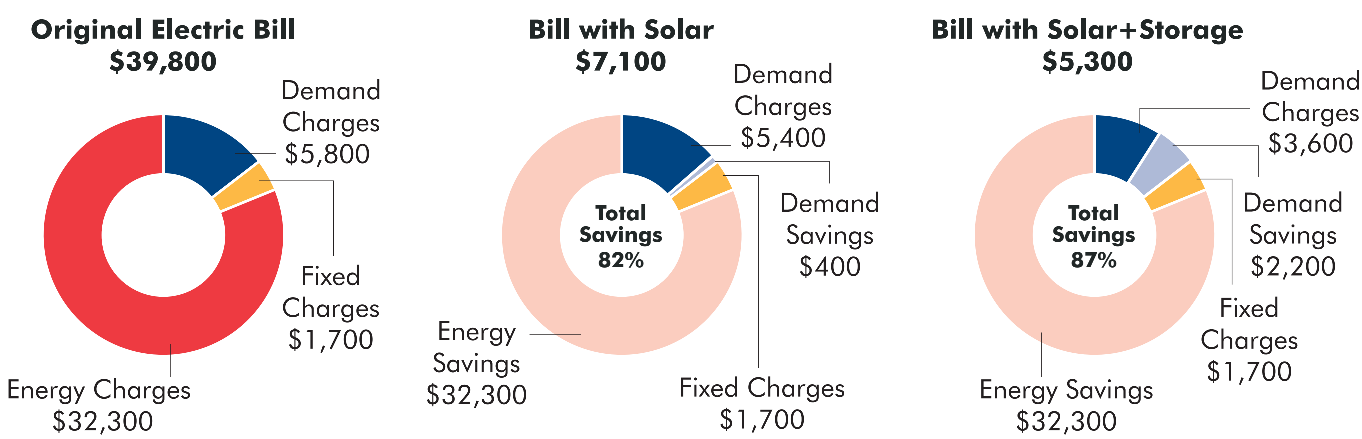
UTILITY RATE TARIFF

A-10-S (TOU rate with demand charges)

TABLE B.3
PGE2 building solar and storage system costs and benefits.

	System size	Installed cost	ITC value	Depreciation tax savings	Additional incentives	Annual bill savings	Percent savings	Payback period (years)
Solar	170 kW PV	$595,000	$178,500	$229,600	$0	$32,800	82%	6.3
Battery storage	30 kW/90 kWh battery	$112,100	$33,600	$43,300	$37,000	$1,800	5%	4.9
Solar+ storage	170 kW PV + 30 kW/90 kWh battery	$707,100	$212,100	$272,900	$37,000	$34,600	87%	6.2

FIGURE B.3
PGE2 building original electric bill, electric bill and savings after deployment of solar, and electric bill and savings after deployment of solar+storage.



TENANTS

UTILITY RATE TARIFF

E-1 (non-TOU, flat tiered-rate)

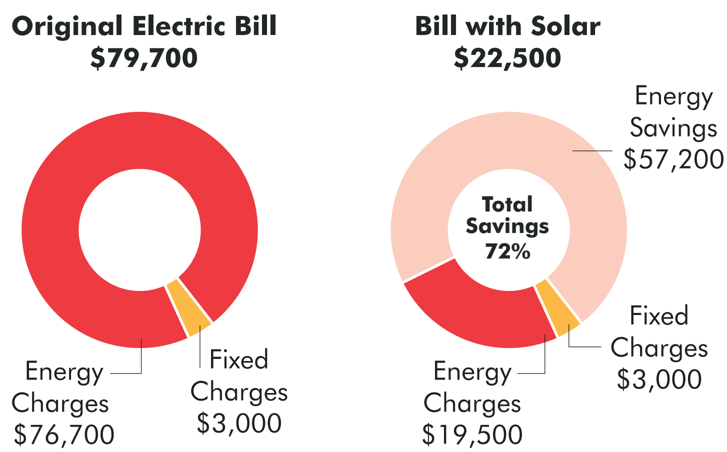
TABLE B.4

PGE2 tenant solar system costs and benefits.

	System size	Installed cost	ITC value	Depreciation tax savings	Additional incentives	Annual bill savings	Percent savings	Payback period (years)
Solar	224 kW PV	$784,000	$235,200	$302,500	$0	$57,200	72%	5.1

FIGURE B.4

PGE2 tenant original aggregated electric bill and electric bill and savings after deployment of solar.



PGE3

RESIDENTIAL UNITS: 136
UTILITY TERRITORY: PACIFIC GAS & ELECTRIC

BUILDING

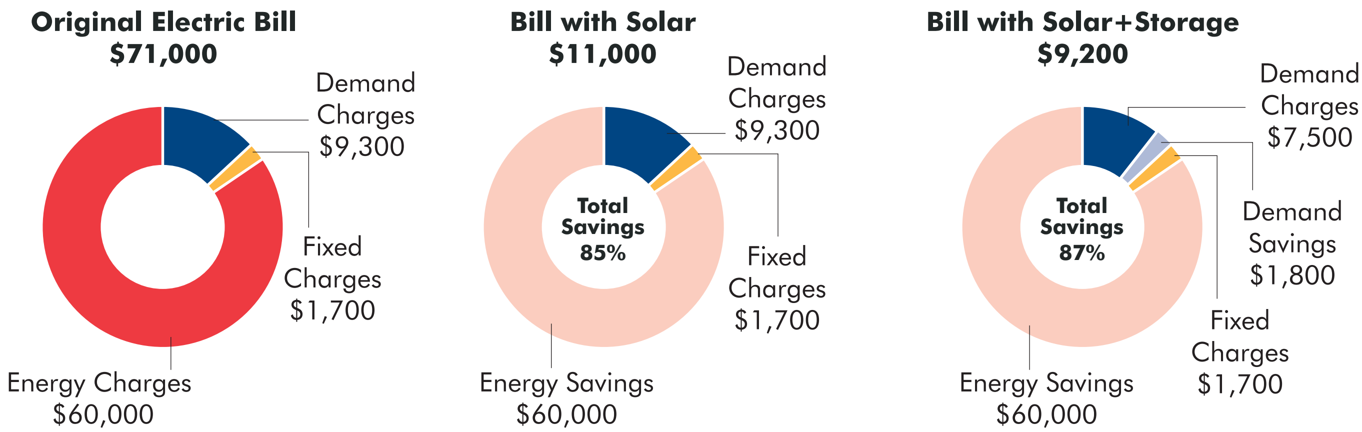
UTILITY RATE TARIFF

A-10-S (TOU rate with demand charges)

TABLE B.5
PGE3 building solar and storage system costs and benefits.

	System size	Installed cost	ITC value	Depreciation tax savings	Additional incentives	Annual bill savings	Percent savings	Payback period (years)
Solar	270 kW PV	$945,000	$283,500	$364,700	$0	$60,000	85%	5.6
Battery storage	30 kW/45 kWh battery	$87,700	$26,300	$33,800	$29,400	$1,800	3%	4.3
Solar+ storage	270 kW PV + 30 kW/45 kWh battery	$1,032,700	$309,800	$398,500	$29,400	$61,800	87%	5.6

FIGURE B.5
PGE3 building original electric bill, electric bill and savings after deployment of solar, and electric bill and savings after deployment of solar+storage.



TENANTS

UTILITY RATE TARIFF

E-1 (non-TOU, flat tiered-rate)

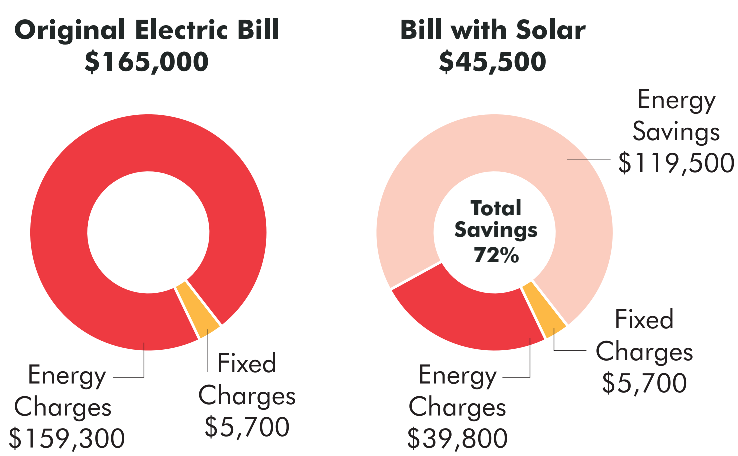
TABLE B.6

PGE3 tenant solar system costs and benefits.

	System size	Installed cost	ITC value	Depreciation tax savings	Additional incentives	Annual bill savings	Percent savings	Payback period (years)
Solar	430 kW PV	$1,505,000	$451,500	$580,800	$0	$119,400	72%	4.8

FIGURE B.6

PGE3 tenant original aggregated electric bill and electric bill and savings after deployment of solar.



SCE1

RESIDENTIAL UNITS: 50
UTILITY TERRITORY: SOUTHERN CALIFORNIA EDISON

BUILDING

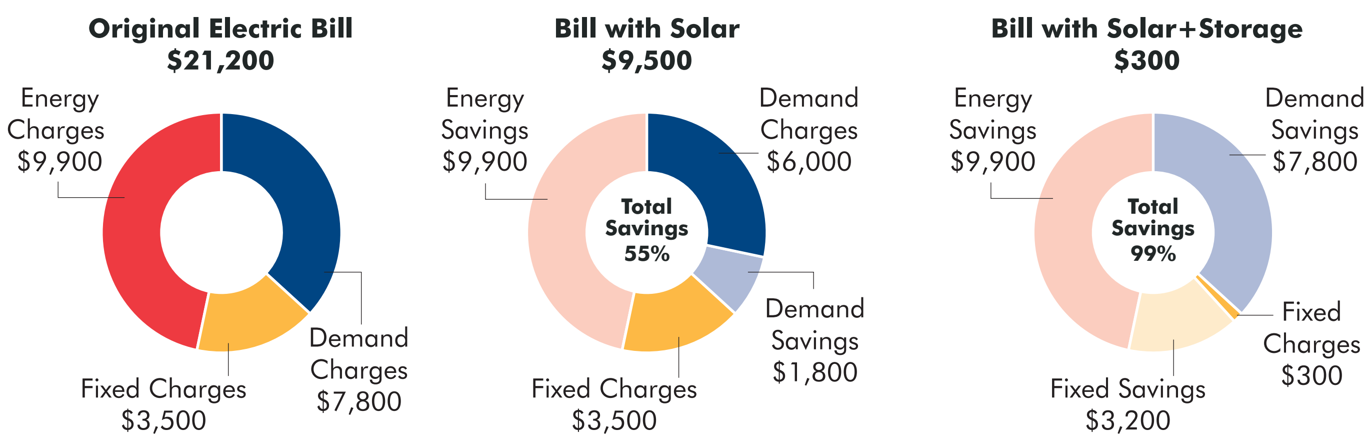
UTILITY RATE TARIFF

TOU-GS-2-B (TOU rate with demand charges)[12]
TOU-GS-1-A (TOU rate with no demand charges)[13]
(With the addition of battery storage, the building is able to manage demand below a 20 kilowatt threshold, allowing the building to switch from a rate tariff with demand charges, TOU-GS-2-B, to a tariff with no demand charges, TOU-GS-1-A)

TABLE B.7
SCE1 building solar and storage system costs and benefits.

	System size	Installed cost	ITC value	Depreciation tax savings	Additional incentives	Annual bill savings	Percent savings	Payback period (years)
Solar	90 kW PV	$315,000	$94,500	$121,600	$0	$11,700	55%	8.6
Battery storage	30 kW/90 kWh battery	$112,100	$33,600	$43,300	$37,000	$9,200	43%	2.5
Solar+ storage	90 kW PV + 30 kW/90 kWh battery	$427,100	$128,100	$164,900	$37,000	$20,900	99%	5.8

FIGURE B.7
SCE1 building original electric bill, electric bill and savings after deployment of solar, and electric bill and savings after deployment of solar+storage.



TENANTS

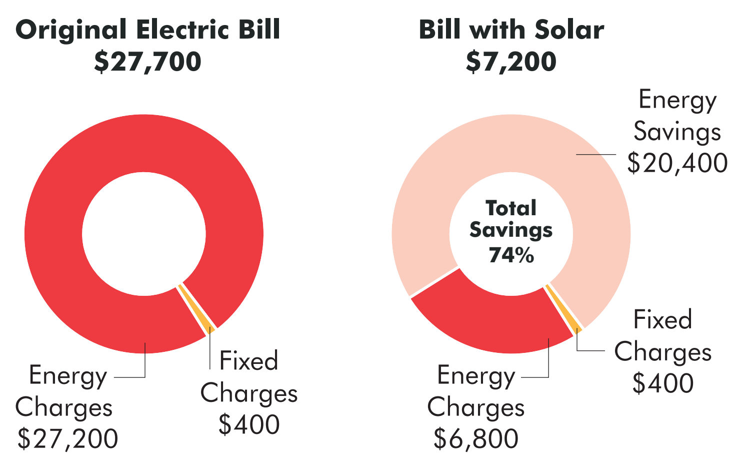
UTILITY RATE TARIFF

D (non-TOU, flat tiered-rate)[14]

TABLE B.8
SCE1 tenant solar system costs and benefits.

	System size	Installed cost	ITC value	Depreciation tax savings	Additional incentives	Annual bill savings	Percent savings	Payback period (years)
Solar	157 kW PV	$549,500	$164,800	$212,000	$0	$20,400	74%	8.8

FIGURE B.8
SCE1 tenant original aggregated electric bill and electric bill and savings after deployment of solar.



SCE2

RESIDENTIAL UNITS: 80
UTILITY TERRITORY: SOUTHERN CALIFORNIA EDISON

BUILDING

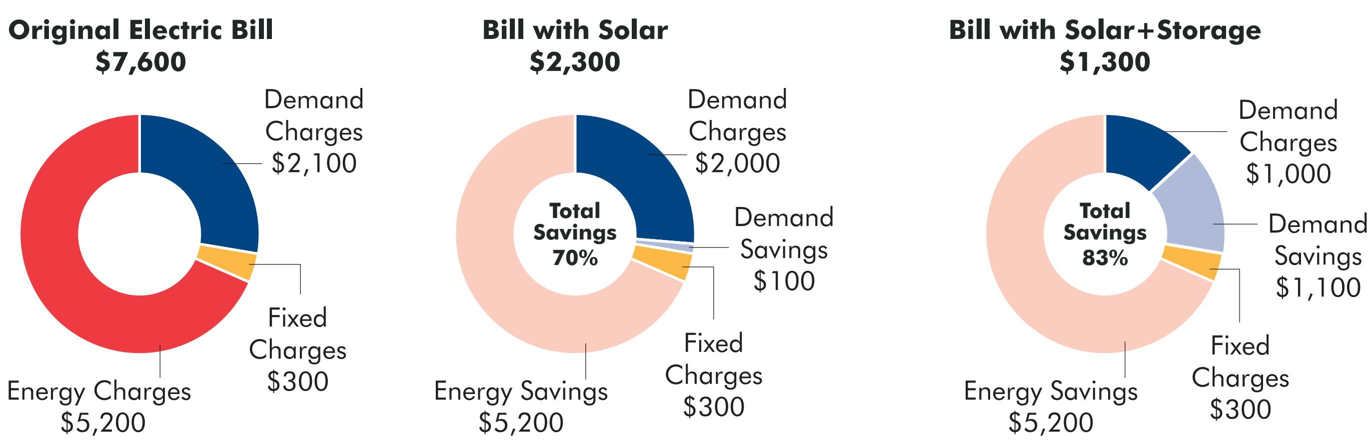
UTILITY RATE TARIFF

Utility rate tariff: TOU-GS-1-B (TOU rate with demand charges)[15]

TABLE B.9
SCE2 building solar and storage system costs and benefits.

	System size	Installed cost	ITC value	Depreciation tax savings	Additional incentives	Annual bill savings	Percent savings	Payback period (years)
Solar	45 kW PV	$157,500	$47,200	$60,800	$0	$5,300	70%	9.4
Battery storage	15 kW/36 kWh battery	$63,900	$19,200	$24,700	$20,800	$1,000	13%	5.0
Solar+ storage	45 kW PV + 15 kW/36 kWh battery	$221,400	$66,400	$85,500	$20,800	$6,300	83%	8.6

FIGURE B.9
SCE2 building original electric bill, electric bill and savings after deployment of solar, and electric bill and savings after deployment of solar+storage.



TENANTS

UTILITY RATE TARIFF

D (non-TOU, flat tiered-rate)

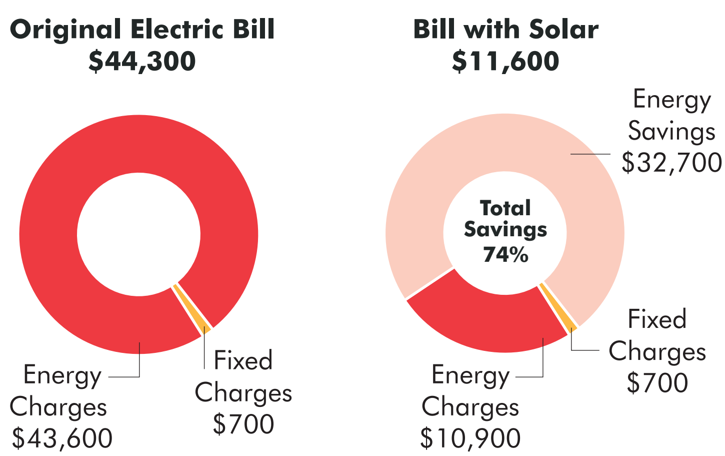
TABLE B.10

SCE2 tenant solar system costs and benefits.

	System size	Installed cost	ITC value	Depreciation tax savings	Additional incentives	Annual bill savings	Percent savings	Payback period (years)
Solar	253 kW PV	$885,500	$265,600	$341,700	$0	$32,700	74%	8.8

FIGURE B.10

SCE2 tenant original aggregated electric bill and electric bill and savings after deployment of solar.



SCE3

RESIDENTIAL UNITS: 230
UTILITY TERRITORY: SOUTHERN CALIFORNIA EDISON

BUILDING

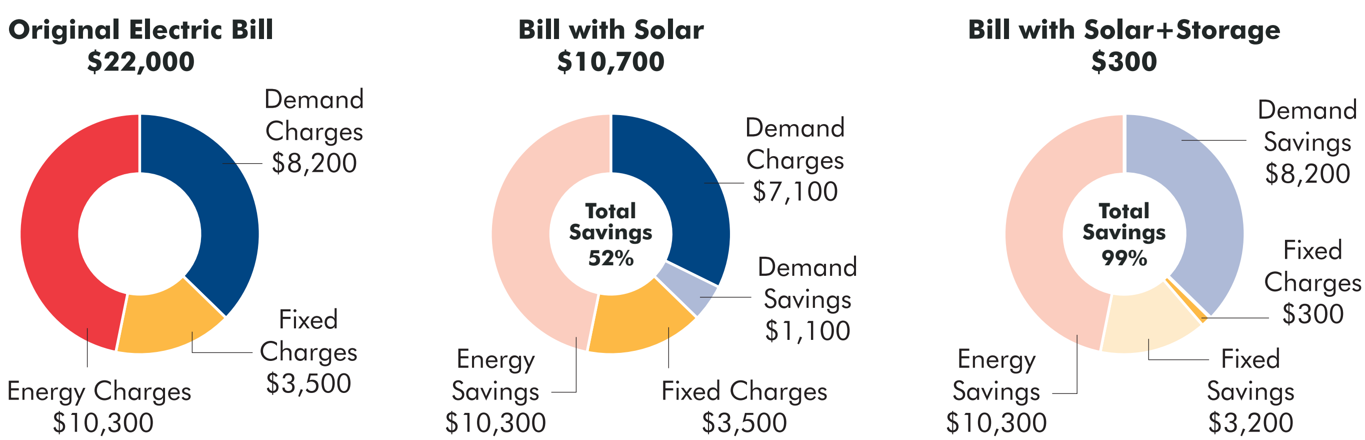
UTILITY RATE TARIFF

TOU-GS-2-B (TOU rate with demand charges)
TOU-GS-1-A (TOU with no demand charges)
(With the addition of battery storage, the building is able to manage demand below a 20 kilowatt threshold, allowing the building to switch from a rate tariff with demand charges, TOU-GS-2-B, to a tariff with no demand charges, TOU-GS-1-A)

TABLE B.11
SCE3 building solar and storage system costs and benefits.

	System size	Installed cost	ITC value	Depreciation tax savings	Additional incentives	Annual bill savings	Percent savings	Payback period (years)
Solar	110 kW PV	$385,000	$115,500	$148,600	$0	$11,400	52%	10.5
Energy storage	30 kW/90 kWh battery	$112,100	$33,600	$43,300	$37,000	$10,300	47%	3.3
Solar+ storage	110 kW PV + 30 kW/90 kWh battery	$497,100	$149,100	$191,900	$37,000	$21,700	99%	7.8

FIGURE B.11
SCE3 building original electric bill, electric bill and savings after deployment of solar, and electric bill and savings after deployment of solar+storage.



TENANTS

UTILITY RATE TARIFF

D (non-TOU, flat tiered-rate)

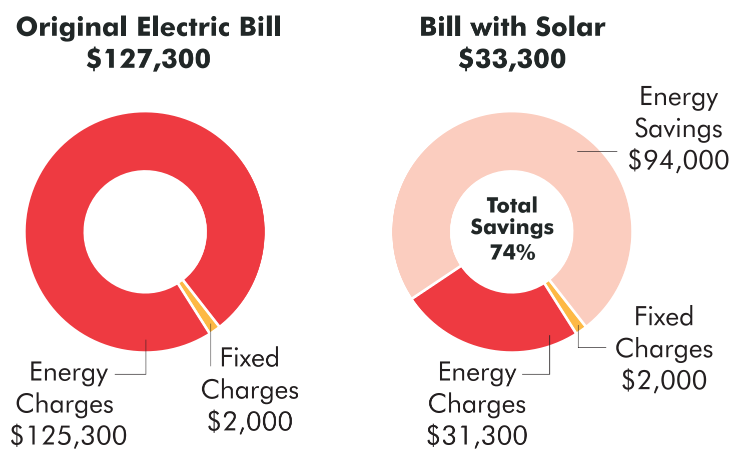
TABLE B.12

SCE3 tenant solar system costs and benefits.

	System size	Installed cost	ITC value	Depreciation tax savings	Additional incentives	Annual bill savings	Percent savings	Payback period (years)
Solar	727 kW PV	$2,544,500	$763,400	$981,900	$0	$93,900	74%	8.8

FIGURE B.12

SCE3 tenant original aggregated electric bill and electric bill and savings after deployment of solar.



SDG1

RESIDENTIAL UNITS: 50
UTILITY TERRITORY: SAN DIEGO GAS & ELECTRIC

BUILDING

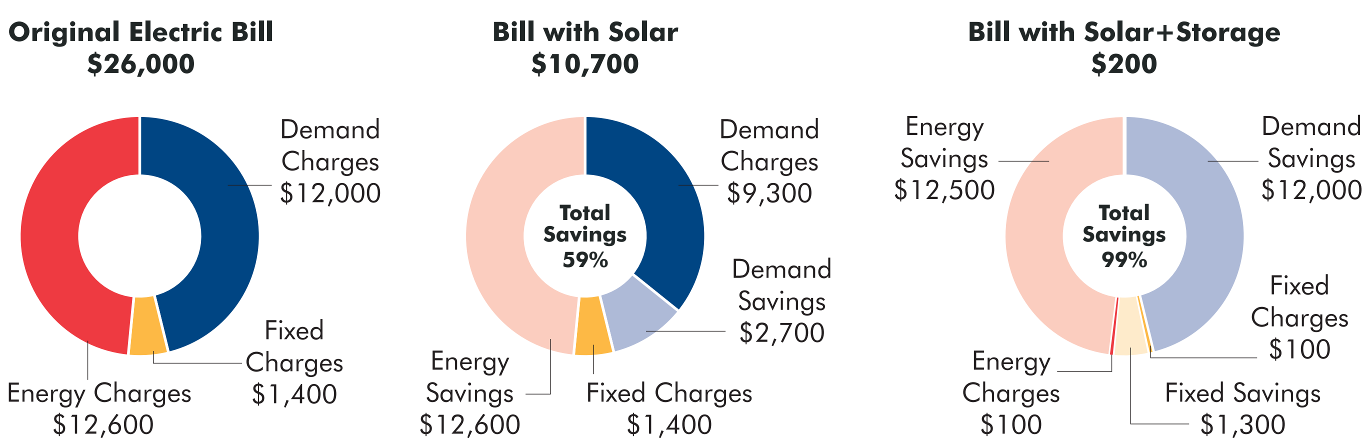
UTILITY RATE TARIFF

AL-TOU (TOU rate with demand charges)[16]
TOU-A (TOU with no demand charges)[17]
(With the addition of battery storage, the building is able to manage demand below a 20 kilowatt threshold, allowing the building to switch from a rate tariff with demand charges, AL-TOU, to a tariff with no demand charges, TOU-A)

TABLE B.13
SDG1 building solar and storage system costs and benefits.

	System size	Installed cost	ITC value	Depreciation tax savings	Additional incentives	Annual bill savings	Percent savings	Payback period (years)
Solar	90 kW PV	$315,000	$94,500	$121,600	$0	$15,200	59%	6.9
Battery storage	30 kW/90 kWh battery	$112,100	$33,600	$43,300	$37,000	$10,600	40%	2.3
Solar+ storage	90 kW PV + 30 kW/90 kWh battery	$427,100	$128,100	$164,900	$37,000	$25,800	99%	4.9

FIGURE B.13
SDG1 building original electric bill, electric bill and savings after deployment of solar, and electric bill and savings after deployment of solar+storage.



TENANTS

UTILITY RATE TARIFF

DR (non-TOU, flat tiered-rate)[18]

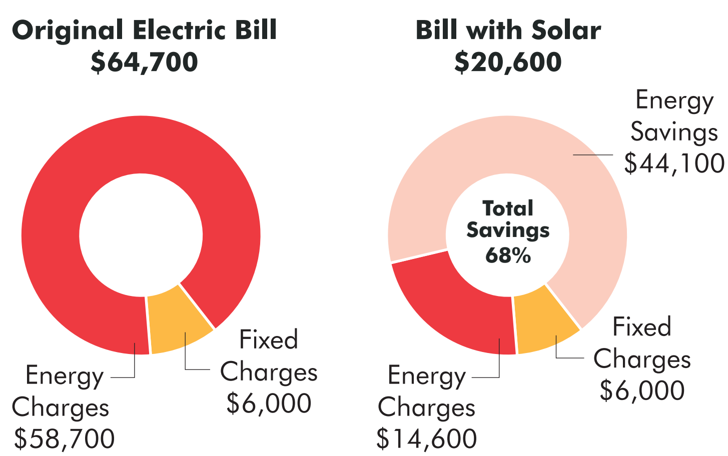
TABLE B.14

SDG1 tenant solar system costs and benefits.

	System size	Installed cost	ITC value	Depreciation tax savings	Additional incentives	Annual bill savings	Percent savings	Payback period (years)
Solar	157 kW PV	$549,500	$164,800	$212,000	$0	$44,100	68%	4.8

FIGURE B.14

SDG1 tenant original aggregated electric bill and electric bill and savings after deployment of solar.



SDG2

RESIDENTIAL UNITS: 80
UTILITY TERRITORY: SAN DIEGO GAS & ELECTRIC

BUILDING

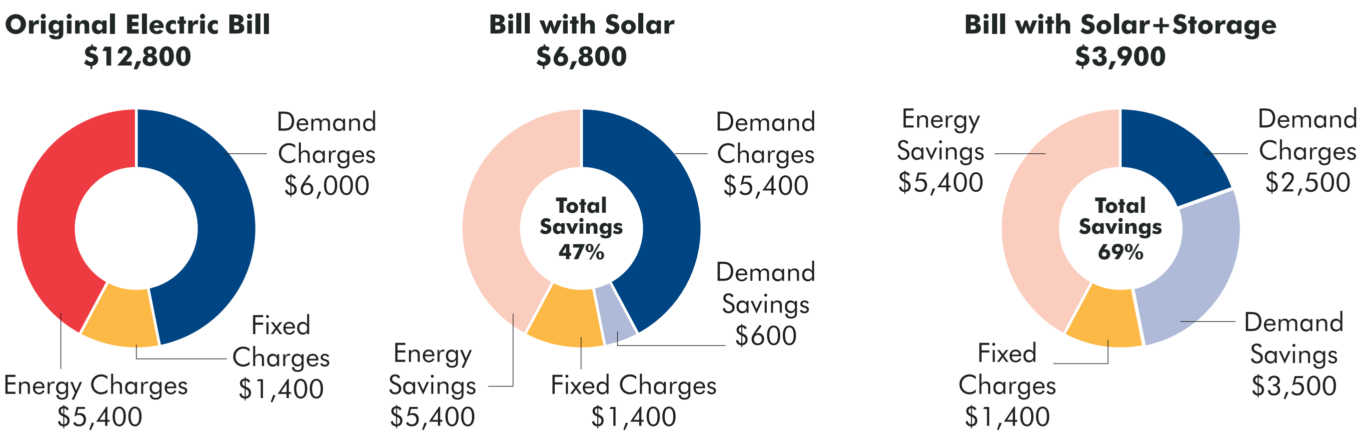
UTILITY RATE TARIFF

AL-TOU (TOU rate with demand charges)

TABLE B.15
SDG2 building solar and storage system costs and benefits.

	System size	Installed cost	ITC value	Depreciation tax savings	Additional incentives	Annual bill savings	Percent savings	Payback period (years)
Solar	45 kW PV	$157,500	$47,200	$60,800	$0	$6,000	47%	8.5
Battery storage	30 kW/45 kWh battery	$87,700	$26,300	$33,800	$29,400	$2,900	22%	3.2
Solar+ storage	45 kW PV + 30 kW/45 kWh battery	$245,200	$73,500	$94,600	$29,400	$8,900	69%	6.6

FIGURE B.15
SDG2 building original electric bill, electric bill and savings after deployment of solar, and electric bill and savings after deployment of solar+storage.



TENANTS

UTILITY RATE TARIFF

DR (non-TOU, flat tiered-rate)

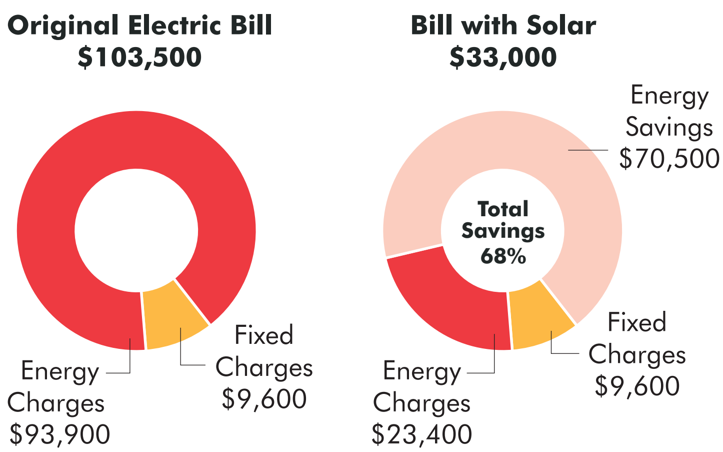
TABLE B.16

SDG2 tenant solar system costs and benefits.

	System size	Installed cost	ITC value	Depreciation tax savings	Additional incentives	Annual bill savings	Percent savings	Payback period (years)
Solar	253 kW PV	$885,500	$265,600	$341,700	$0	$70,500	68%	4.8

FIGURE B.16

SDG2 tenant original aggregated electric bill and electric bill and savings after deployment of solar.



SDG3

RESIDENTIAL UNITS: **230**
UTILITY TERRITORY: **SAN DIEGO GAS & ELECTRIC**

BUILDING

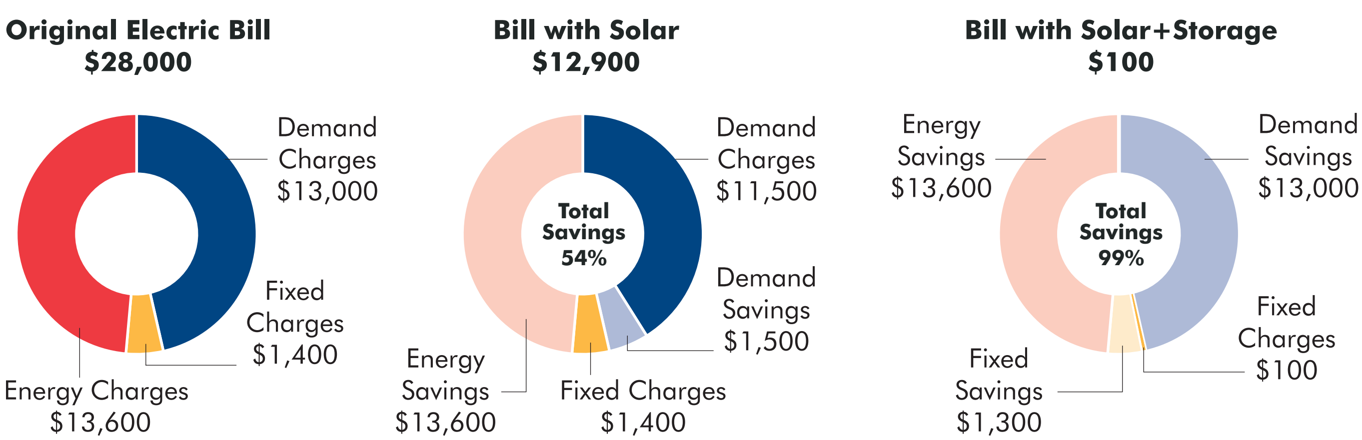
UTILITY RATE TARIFF

AL-TOU (TOU rate with demand charges)
TOU-A (TOU with no demand charges)
(With the addition of battery storage, the building is able to manage demand below a 20 kilowatt threshold, allowing the building to switch from a rate tariff with demand charges, AL-TOU, to a tariff with no demand charges, TOU-A)

TABLE B.17
SDG3 building solar and storage system costs and benefits.

	System size	Installed cost	ITC value	Depreciation tax savings	Additional incentives	Annual bill savings	Percent savings	Payback period (years)
Solar	110 kW PV	$385,000	$115,500	$148,600	$0	$15,000	54%	8.3
Battery storage	30 kW/90 kWh battery	$112,100	$33,600	$43,300	$37,000	$12,800	46%	1.6
Solar+ storage	110 kW PV + 30 kW/90 kWh battery	$497,100	$149,100	$191,900	$37,000	$27,900	99%	4.7

FIGURE B.17
SDG3 building original electric bill, electric bill and savings after deployment of solar, and electric bill and savings after deployment of solar+storage.



TENANTS

UTILITY RATE TARIFF

DR (non-TOU, flat tiered-rate)

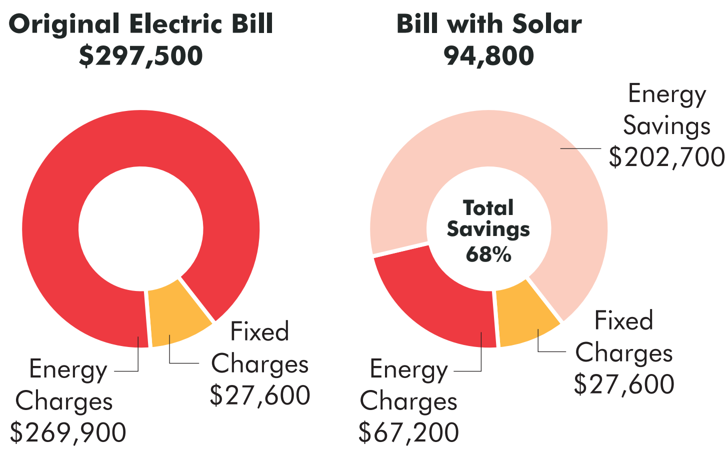
TABLE B.18

SDG3 tenant solar system costs and benefits.

	System size	Installed cost	ITC value	Depreciation tax savings	Additional incentives	Annual bill savings	Percent savings	Payback period (years)
Solar	727 kW PV	$2,544,500	$763,400	$981,900	$0	$202,700	68%	4.8

FIGURE B.18

SDG3 tenant original aggregated electric bill and electric bill and savings after deployment of solar.



APPENDIX C

Illustration of Solar and Storage Impact on Electricity Consumption and Demand

The following figures provide a visual illustration of the impacts that solar and battery storage technologies have on building common area and tenant electricity consumption and demand profiles. While this analysis was performed for all buildings presented in this report, the figures below only relate to building SCE1. While results vary for each individual property, the relative impact of solar and storage technologies is similar for the additional property analyzed.

BUILDING

FIGURE C.1

Seasonal average daily load profiles for SCE1 building electricity usage generated from real-world utility interval data.

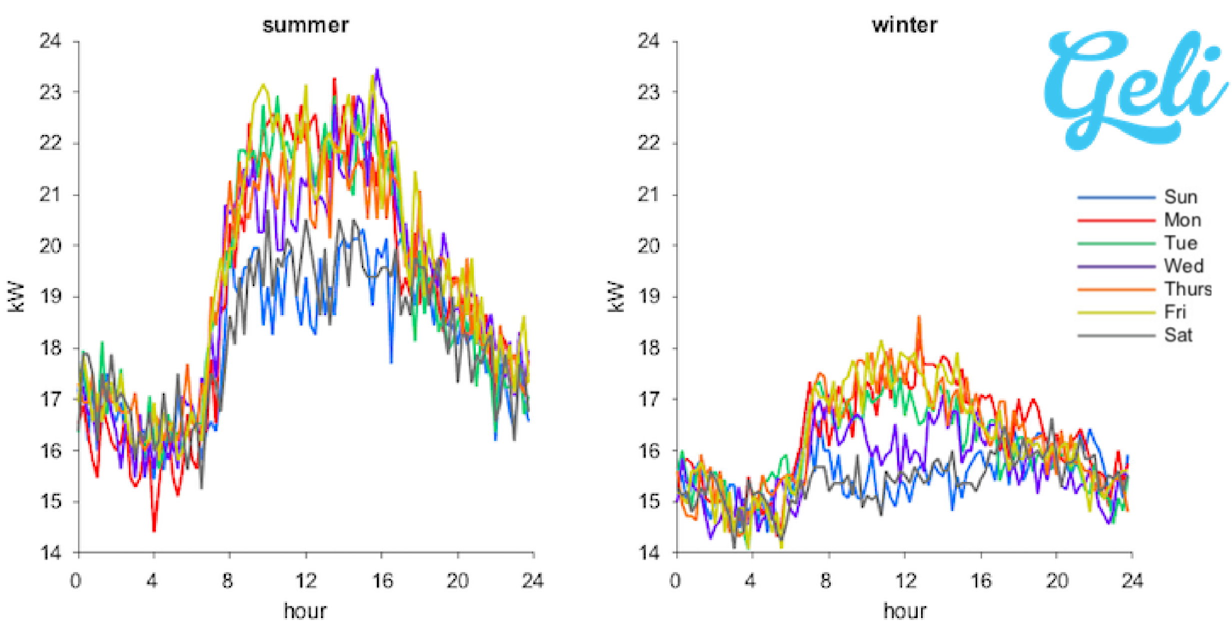


FIGURE C.2

Heat map of SCE1 daily building electricity demand. Each row of pixels represents the demand for a single day, with high demand mapped to hotter colors (red hues) and low demand mapped to cooler colors (blue hues).

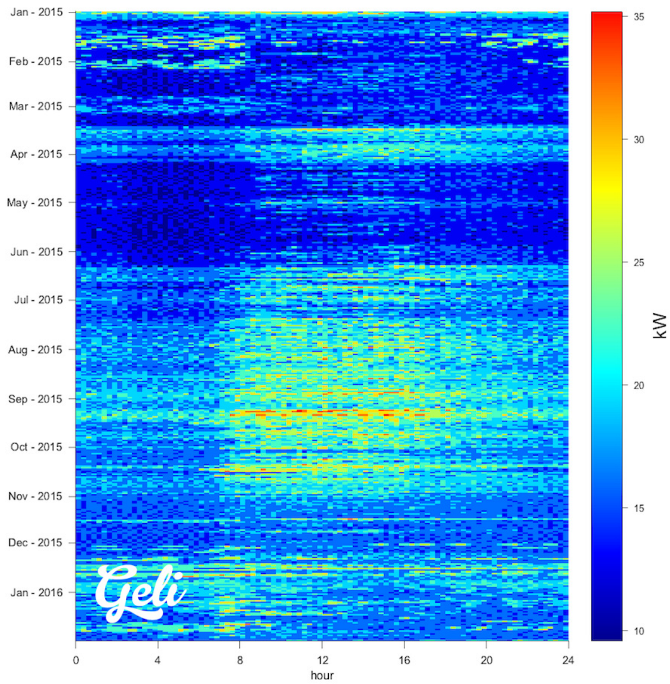


FIGURE C.3

Heat map of daily estimated solar electricity production for a 90 kilowatt PV system designed to offset 100% of building electricity consumption at SCE1. Production is based on output from National Renewable Energy Lab's PVWatts solar calculator tool. Each row represents the production for a single day, with high production mapped to lighter colors (yellow hues) and low production mapped to darker colors (purple hues).

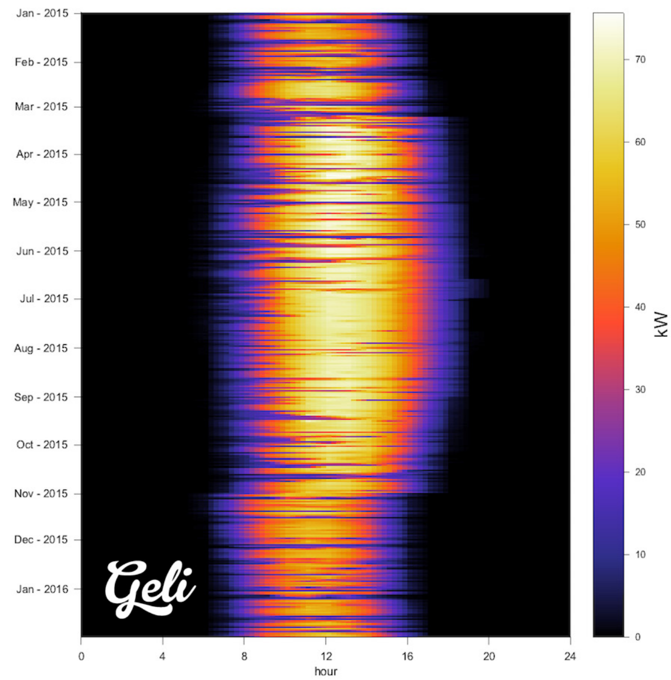


FIGURE C.4

Heat map of SCE1 estimated net daily building electricity demand after installation of 90 kilowatt PV system. This heat map is the product of overlaying original building demand (Figure C.2) with PV system production (Figure C.3).[19]

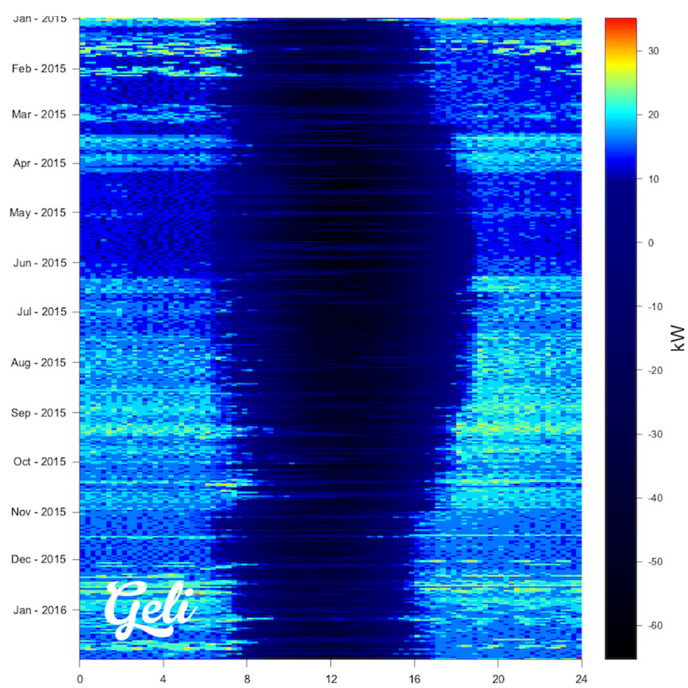


FIGURE C.5
Scatter plot of daily maximum building electricity power demand in kilowatts versus the time-of-day at which it occurred for SCE1. Maximum demand for each month is highlighted in red. The histograms show the time-density (bottom) and power-density (left) of daily peak demand events

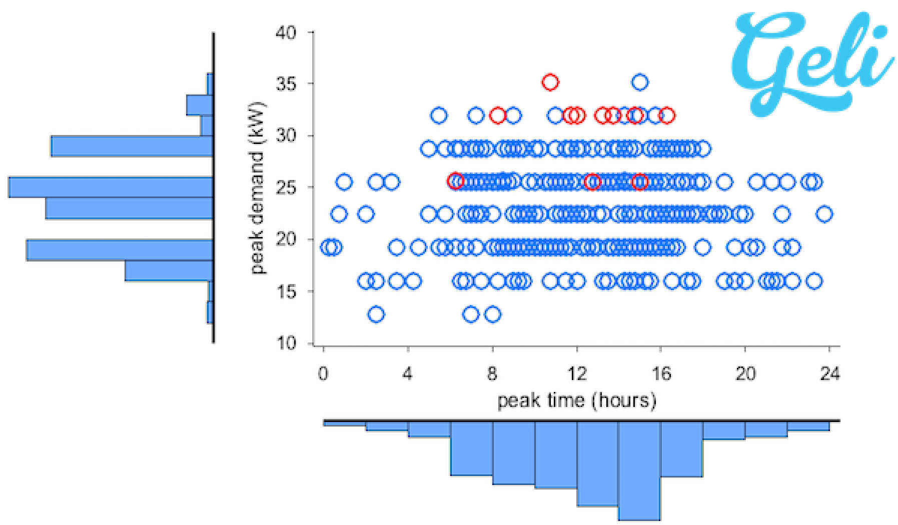


FIGURE C.6
Scatter plot of daily maximum building electricity power demand in kilowatts versus the time-of-day at which it occurred for SCE1 after the installation of 90 kilowatt PV system. Note that in this analysis PV production essentially eliminates peak demand events during the mid-day hours of maximum production; however, this reduction is not guaranteed and maximum demand for each month (highlighted in red) is only moderately reduced.

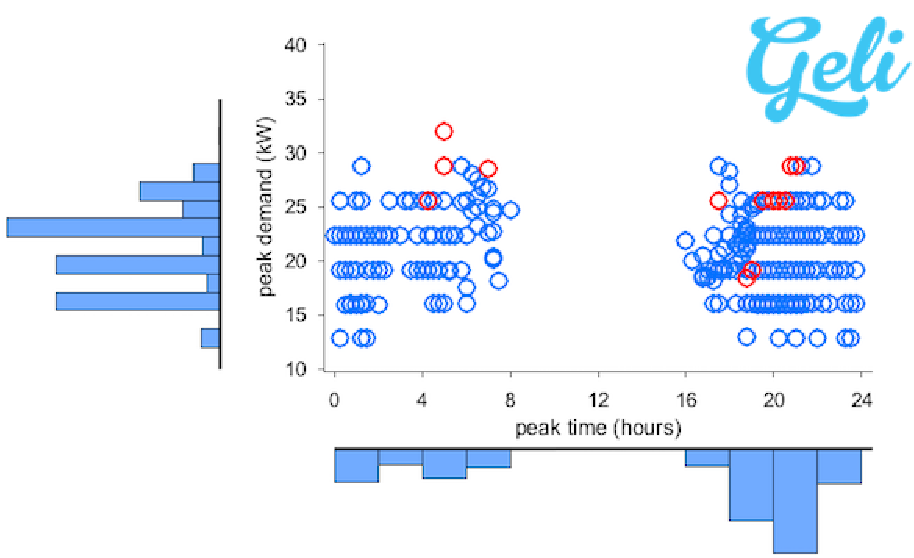
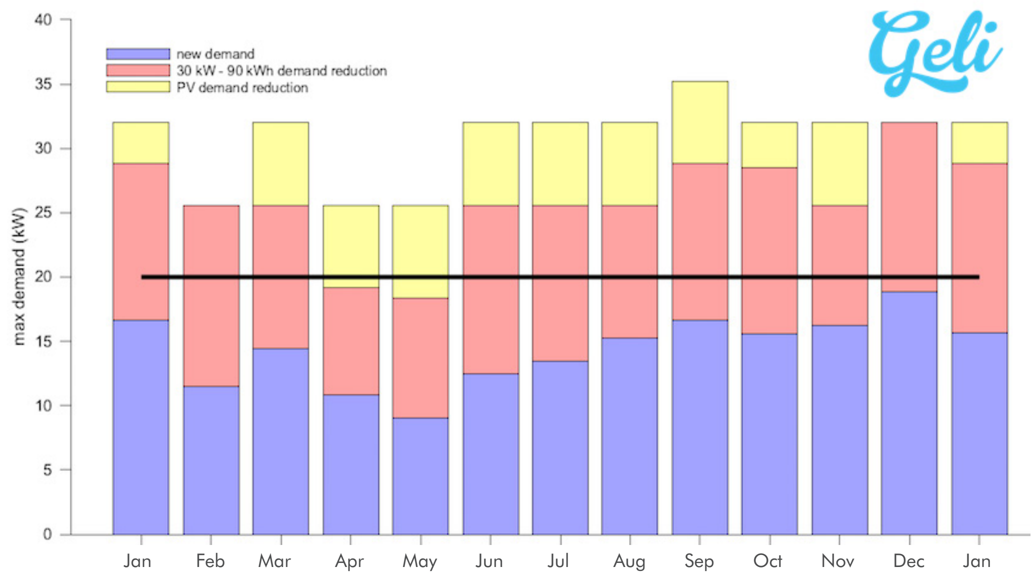


FIGURE C.7

Impact of installing 90 kilowatt PV system and 30 kilowatt / 90 kilowatt-hour battery storage system on maximum monthly demand for SCE1. Black line represents the utility defined 20 kilowatt peak demand management threshold necessary to allow SCE1 to eliminate demand charges by shifting to a new rate structure that does not include demand charges.[20]



TENANT

FIGURE C.8

Seasonal average daily load profiles for modeled SCE1 tenant electricity usage, generated from aggregated representative residential load profiles scaled to average 550 kilowatt-hours per month of consumption over a year for each residential account.

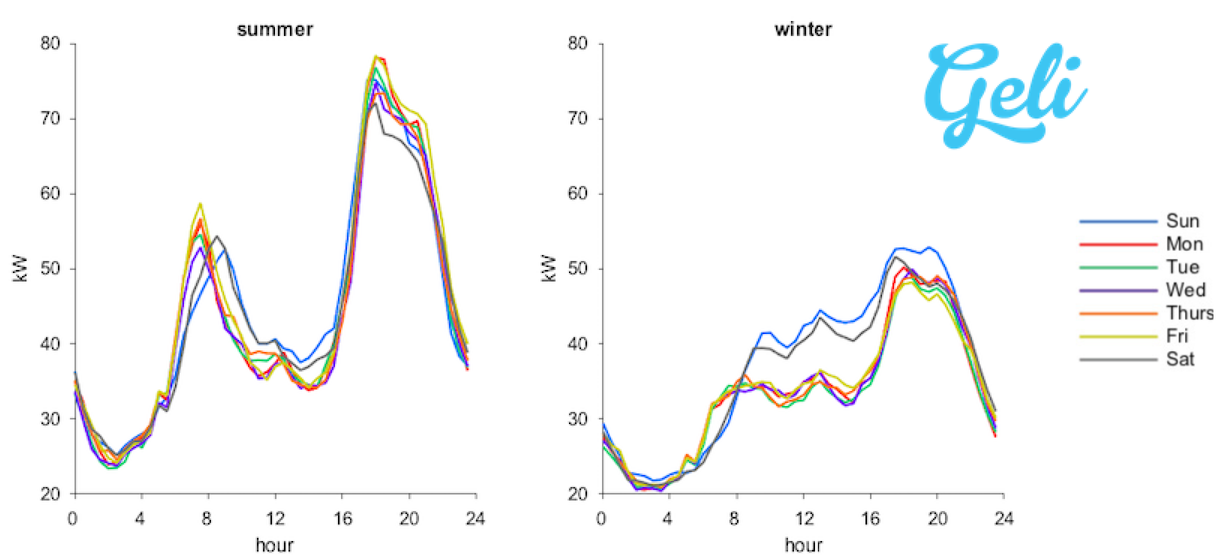


FIGURE C.9
Heat map of SCE1 daily tenant electricity demand. Note that, unlike building electricity demand, tenant demand is often at its highest in the evening and mid-morning hours.

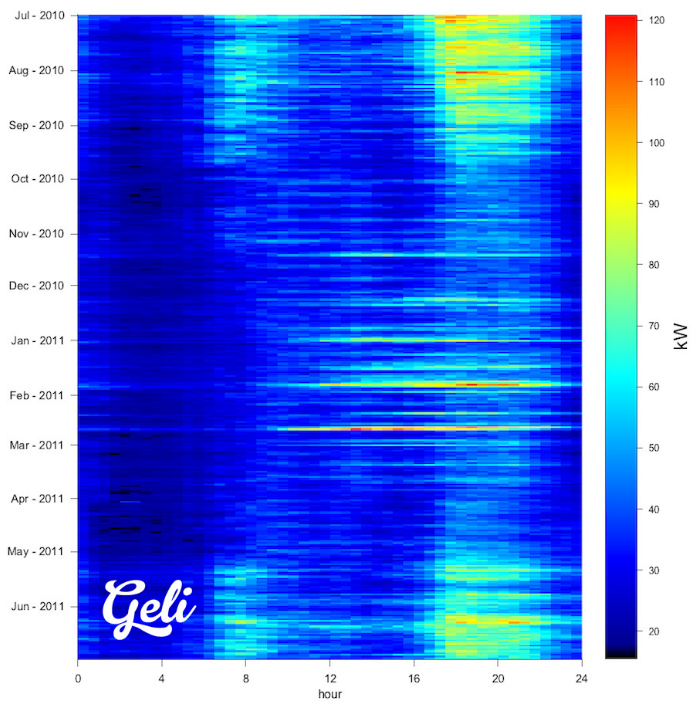


FIGURE C.10
Heat map of daily estimated solar electricity production for 145 kilowatt PV system designed to offset 75 percent of tenant electricity consumption at SCE1. Production based on output from National Renewable Energy Lab's PVWatts solar calculator tool.

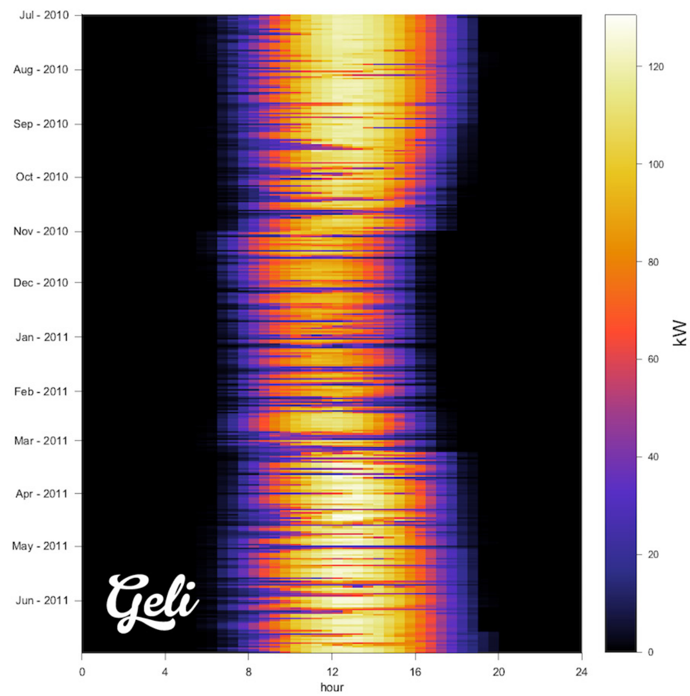


FIGURE C.11
Heat map of SCE1 estimated net daily tenant electricity demand after installation of 145 kilowatt PV system. This heat map is the product of overlaying original tenant demand (Figure C.9) with PV system production (Figure C.10).

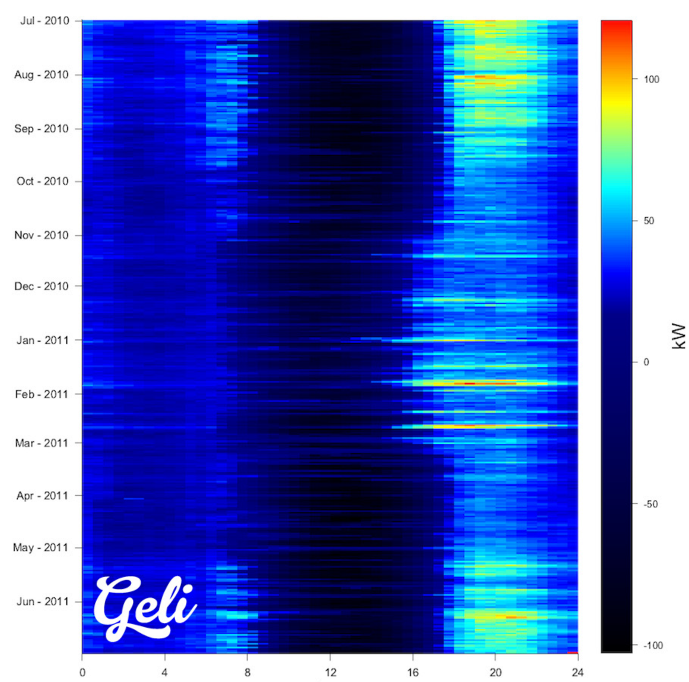


FIGURE C.12

Scatter plot of daily maximum tenant electricity power demand in kilowatts versus the time-of-day at which it occurred for SCE1. Maximum demand for each month is highlighted in red. The histograms show the time-density (bottom) and power-density (left) of daily peak demand events.

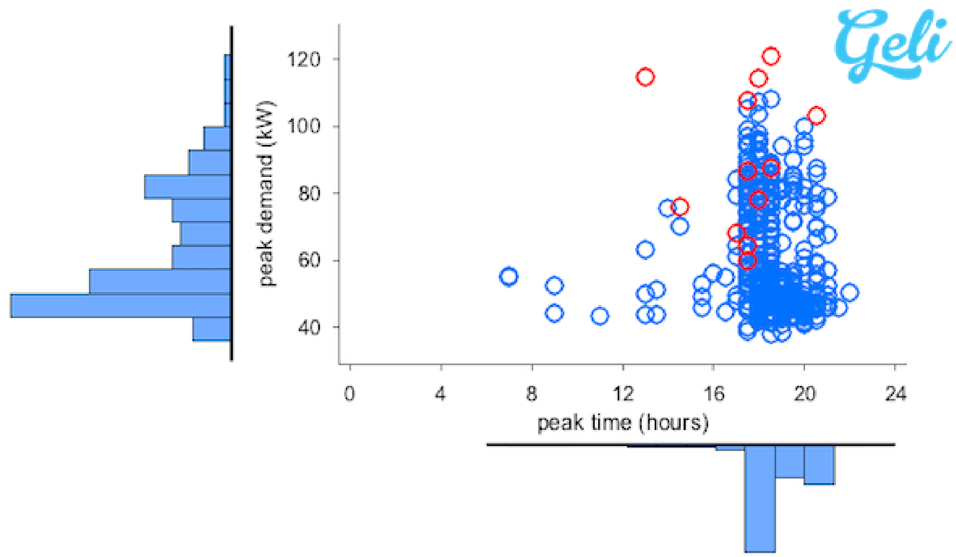
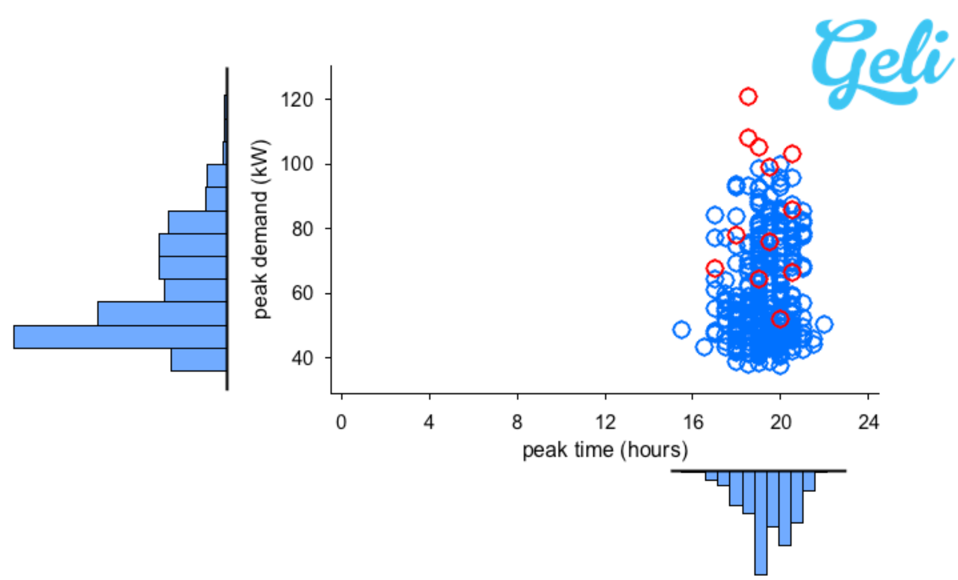


FIGURE C.13

Scatter plot of daily maximum tenant electricity power demand in kilowatts versus the time-of-day at which it occurred for SCE1 after the installation of 145 kilowatt PV system. Note that, unlike the impact of PV on building electricity demand, PV production has only a minimal impact on the timing and magnitude of monthly peak demand events (highlighted in red).



APPENDICES ENDNOTES

1 There is little publicly available data to ascertain the current average installed cost of PV in California multifamily affordable housing. Our estimate of $3.50 per watt, which includes hardware, installation, and related expenses, is believed to be a conservative and reasonable estimate, which has been vetted by housing advocates and solar developers active in the affordable housing market.

2 See *http://pvwatts.nrel.gov.*

3 Expected lifetime is based on anticipated operation of the system and battery cycle life expectancy.

4 In order to determine optimal sizing, battery power ratings were varied in 30 kilowatt increments and capacity ratings were varied in 45 kilowatt-hour increments. For example, optimal system sizing could compare the economic return for a 30 kilowatt/45 kilowatt-hour battery versus a 30 kilowatt/90 kilowatt-hour battery versus a 60 kilowatt/90 kilowatt-hour battery. A 15 kilowatt/36 kilowatt-hour energy storage system was also considered for buildings with lower electricity demands.

5 Energy storage system (battery, inverter, related hardware, and management system) installed costs include design, permitting, and installation expenses, as well as a 10 percent developer margin and 9.3 percent sales tax.

6 Round trip efficiency is based on reported performance of the specific battery storage system used in the modeling analysis. Round trip efficiency will vary depending on battery chemistry and manufacturer.

7 As of 2016, the SGIP incentive for advanced energy storage is $1.31 per watt. There is an additional 20 percent multiplier for systems provided by a California supplier, resulting in an adjusted incentive of $1.58 per watt. SGIP requires a 2-hour system capacity; incentives for systems under this threshold are adjusted with a rating set at one-half of capacity, so a 30 kW / 45 kWh would have an SGIP rating of a 22.5 kW. When also taking the ITC, there is an SGIP cap set at 30% of system cost.

8 Fifteen-minute electricity usage interval data covering at least a 12-month period was provided for each building through direct access to utility account records.

9 Based on investor-owned utility Energy Savings Assistance Program and CARE Program 2012 Annual Reports, the average electricity consumption for CARE participants is 547 kilowatt-hours per month. This value may be an overestimate for multifamily affordable housing participants, as the average includes single-family households with typically higher electricity needs.

10 See *http://www.pge.com/tariffs/tm2/pdf/ELEC_SCHEDS_A-10.pdf.*

11 See *http://www.pge.com/tariffs/tm2/pdf/ELEC_SCHEDS_E-1.pdf.*

12 See *https://www.sce.com/wps/wcm/connect/c07b114a-b2a6-4d0e-a097-e9afeb255fa1/Business_2_TOU_Fact_Sheet_OptionB.pdf?MOD=AJPERES.*

13 See *https://www.sce.com/wps/wcm/connect/268945e8-db43-4737-9783-abf224ffbbbc/Business_1_TOU_Fact_Sheet_OptionA.pdf?MOD=AJPERES.*

14 See *https://www.sce.com/NR/sc3/tm2/pdf/ce12-12.pdf.*

15 See *https://www.sce.com/wps/wcm/connect/8b7ae330-151c-4ad0-a84c-1d98e3427ca2/Business_1_TOU_Fact_Sheet_OptionB.pdf?MOD=AJPERES.*

16 See *http://www2.sdge.com/tariff/com-elec/ALTOUPrimary.pdf.*

17 See *http://regarchive.sdge.com/tm2/pdf/ELEC_ELEC-SCHEDS_TOU-A.pdf.*

18 See *http://regarchive.sdge.com/tm2/pdf/ELEC_ELEC-SCHEDS_DR.pdf.*

19 Note that building demand is for a specific 12-month period; whereas, PV production is based on an aggregation of performance over a number of years. Because of this, a warm sunny day that may result in high building electricity demand for cooling may not necessarily correspond to a day of high PV production.

20 While battery storage can help manage demand for any commercial utility customer, not every customer will have the same opportunity to lower expenses through shifting to a new utility rate structure.

ABOUT CLEAN ENERGY GROUP

Clean Energy Group is a leading national, nonprofit advocacy organization working on innovative technology, finance, and policy programs in the areas of clean energy and climate change. Clean Energy Group, in partnership with Meridian Institute, founded the Resilient Power Project to help states and municipalities with program and policy information, analysis, financial tools, technical assistance, and best practices to speed the deployment of clean, resilient power systems in their communities. For more information, visit *www.cleanegroup.org* and *www.resilient-power.org*.

ABOUT THE CALIFORNIA HOUSING PARTNERSHIP

The California Housing Partnership Corporation (CHPC) is a state-created nonprofit organization that helps to preserve and expand the supply of homes affordable to low-income households in California. CHPC does this by providing financial consulting services, technical assistance, trainings, policy research, and advocacy leadership to nonprofit and government housing organizations throughout the state. CHPC's efforts have leveraged more than $8 billion in private and public financing to preserve and create more than 30,000 affordable homes for low-income households. In recognition of the key role that energy and water costs play in the long-term financial feasibility of operating affordable housing developments, CHPC runs the Green Energy Rental Home Energy Efficiency Network (GREEN), a coalition of more than 80 affordable housing, environmental, and resource efficiency organizations. For more information, visit *www.chpc.net*.

ABOUT THE CENTER FOR SUSTAINABLE ENERGY®

Founded in 1996, the Center for Sustainable Energy (CSE) is a mission-driven nonprofit, providing clean energy program design and management, and technical advisory services. Governments, regulators, utilities, businesses, property owners and others look to CSE as an objective implementation partner to develop customized solutions that help lower energy costs and increase consumer choice and accessibility to clean energy technologies. CSE's suite of services includes expertise in transportation, energy efficiency and building performance, research and analysis, emerging technologies, policy support, workforce development, and marketing, education and outreach. Headquartered in San Diego, CSE works nationwide with support of offices in Los Angeles and Boston and Oakland, Calif. For more information, visit *www.energycenter.org*.

ABOUT GELI

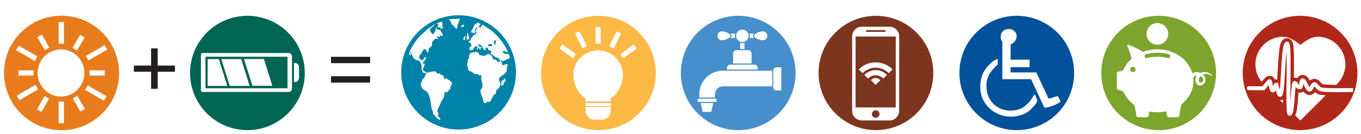
Geli provides software and business solutions to design, automate, and manage energy storage systems. Geli's suite of products creates an ecosystem where project developers, OEMs, financiers, and project operators can deploy advanced energy projects using a seamless hardware-agnostic software platform. For more information, visit *www.geli.net*.

ABOUT THE RESILIENT POWER PROJECT

The Resilient Power Project, a joint initiative of Clean Energy Group and Meridian Institute, is working to accelerate market development of solar PV plus battery storage (solar+storage) technologies for resilient power applications serving low-income communities. The Resilient Power Project works to provide new technology solutions in affordable housing and critical community facilities to address key climate and resiliency challenges facing the country:

- **Community Resiliency** — Solar+storage can provide revenue streams and reduce electricity bills, enhancing community resiliency through economic benefits and powering potentially life-saving support systems during disasters and power outages.
- **Climate Adaptation** — Solar+storage systems can provide highly reliable power resiliency as a form of climate adaptation in severe weather, allowing residents to shelter in place during power disruptions.
- **Climate Mitigation** — Battery storage is an enabling technology and emerging market driver to increase adoption of solar PV for distributed, clean energy generation and to advance climate mitigation efforts.

The Resilient Power Project is supported by The JPB Foundation, Surdna Foundation, The Kresge Foundation, Nathan Cummings Foundation, and the Barr Foundation.



Learn more about The Resilient Power Project at www.resilient-power.org.

OTHER RESILIENT POWER PROJECT RESOURCES

Clean Energy Group's Resilient Power Project has produced reports and analysis on a wide range of resilient power policy, finance, and technology application issues. Please see a sample of those reports below. For a complete list of the Resilient Power Project's other informational resources, please visit *www.resilient-power.org* to access its extensive knowledge base, including webinars, blogs, and presentations.

2015

Resilience for Free: How Solar+Storage Could Protect Multifamily Affordable Housing from Power Outages at Little or No Net Cost, by Lew Milford, Robert Sanders, Seth Mullendore, Clean Energy Group. This report uses project data for buildings in New York, Chicago, and Washington, D.C. to examine the financial case for installing solar+storage systems to support critical common area loads in multifamily affordable housing. The report concludes that with the right market structures and incentives, solar+storage systems can provide a positive economic return on par with energy efficiency or stand-alone solar. In some cases, the addition of batteries improves affordable housing project economics by generating significant electric bill savings through reducing utility demand charges and creating revenue by providing grid services. October 2015.

What States Should Do: A Guide to Resilient Power Programs and Policy, by Todd Olinsky-Paul, Clean Energy Group. States are making important progress in deploying clean, resilient power technologies that can keep the power on at critical facilities during grid outages caused by extreme weather events. In this first-of-its-kind report, Clean Energy Group profiles the leading state programs and makes recommendations for what other states can do to support the deployment of clean, resilient power systems. New resilient power technologies such as solar PV combined with energy storage can provide electricity during outages as well as valuable grid services year-round. This guidebook is intended to help states establish new policies and support new markets to advance clean resilient power nationwide. June 2015.

Solar + Storage 101: An Introductory Guide to Resilient Solar Power Systems, by Seth Mullendore and Lewis Milford, Clean Energy Group. This guide provides a basic technical background and understanding of solar+storage systems. It is meant as a starting point for project developers, building owners, facility managers, and state and municipal planners to become familiar with solar+storage technologies, how they work, and what's involved in getting a new project off the ground. March 2015.

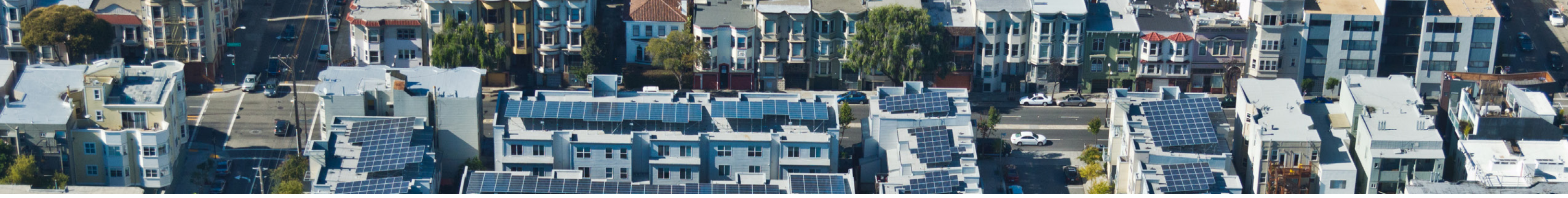
What Cities Should Do: A Guide to Resilient Power Planning, by Robert G. Sanders and Lewis Milford, Clean Energy Group. This paper describes a plan of action for cities to become more "power resilient" using new technologies like solar and battery storage, which can be more reliable than diesel generators to protect vulnerable populations from harm due to harmful power outages in severe weather. March 2015.

Ramp Up Resilient Power Finance: Bundle Project Loans Through a Warehouse Facility to Achieve Scale, by Robert G. Sanders, Clean Energy Group. This report outlines a new clean energy finance model for many resilient power systems to protect vulnerable communities and critical infrastructure from severe weather events. January 2015.

2014

Financing for Clean, Resilient Power Solutions, by Robert G. Sanders, Clean Energy Group. This paper describes a broad range of financing mechanisms that are either just beginning to be used or that have a strong potential for providing low-cost, long-term financing for solar with energy storage. The goal is to identify financing tools that can be used to implement projects and that will attract private capital on highly favorable terms, thereby reducing the cost of solar and resilient power installations. October 2014.

Resilient Power: Evolution of a New Clean Energy Strategy to Meet Severe Weather Threats, by Clean Energy Group. This paper describes the progress of "resilient power" efforts since the New York City blackouts in 1999 to Superstorm Sandy. It outlines the dangers that power outages can pose to our most vulnerable populations, the failures of traditional backup power sources, and the opportunities to develop distributed energy systems with clean and dependable energy technologies. The paper goes on to announce the launch of Clean Energy Group's Resilient Power Project and describes the importance of new technologies like solar PV with energy storage to provide resilient power as weather patterns become increasingly volatile and longer power outages become more frequent. September 2014.



RESILIENT POWER

A Project of Clean Energy Group and Meridian Institute

Clean Energy + Battery Storage = Climate Mitigation, Lighting & Electricity, Running Water, Telecom, Elevators & Accessibility, Savings & Revenue, Life-Supporting Technology

RESILIENT POWER — PROTECTING COMMUNITIES IN NEED

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