DR18.06 – Solar+: Enabling Clean Energy in Disadvantaged Communities with Integrated PV + Storage

OPPORTUNITY

WHAT IS THE PURPOSE OF THIS PROJECT?

The purpose of this project is to identify scalable community models to maximize the economic benefits of solar PV energy systems for low-income multifamily populations and to evaluate how these technologies could enable grid flexibility, environmental and other benefits that are beneficial to the entire rate base. Emphasis was placed on business models that supported the economic and environmental advancement of low income residents as California Investor Owned Utilities transition all residential customers, including those on affordable discount rates, to time of use (TOU) rates with time differentiation and peak pricing. The project developed a model in a residential building test site that could provide measurements of utility bill cost reduction and the larger rate base including balancing solar to avoid distribution upgrades and shave energy peaks. This resource integration project serves as a realized demonstration of technology innovations like Virtual Net Energy Metering that align with the policy direction of California targeting the low-income multifamily sector.

Figure 1: Residential Building Site and Deployed Technologies

BACKGROUND

This Mosaic Gardens at Willowbrook (Willowbrook) is an affordable multifamily housing property in Compton, California, a highly disadvantaged community (DAC) in Southern California. Constructed in 2017 by Linc Housing achieving LEED Silver certification, Willowbrook provides 61 housing units to low-income families, with 31 units reserved for individuals or families transitioning from homelessness. While EPRI, Linc, and its partners started development of the project shortly after Willowbrook's construction completion in 2017, construction of the solar + storage project scope only officially began in Fall 2020, once all necessary approvals were secured. The site was selected because it represented the target market of affordable multifamily housing, and the owner was motivated to investigate the benefits of solar + storage for their larger portfolio.

A 2017 CPUC pilot program to understand TOU impacts found that all PG&E and SCE DAC customers on California Alternate Rates for Energy (CARE) discounted electrical rates in hot climates experienced higher total annual electricity costs under TOU pricing. Willowbrook is a showcase of early-stage technologies based on their potential to effectively counter bill increases from the TOU rate transition.

TECHNOLOGY

WHAT IS THE TECHNOLOGY?

The team successfully incorporated several key innovations into the deployment and tested the resource integration demonstration comprised of the following technologies:

- 2 battery cells 60 kW / 2-hour, provided by EnergPort
- 2 60-kW bifacial solar photovoltaic (PV) arrays, provided by Canadian Solar
- DC-coupled PV and storage system, with Bi-directional inverters provided CE+T
- Inverter meeting CA Rule 21 Phase mandates for grid supportive functions
- A local controller coordinating PV, battery, and inverter, provided by GridScape
- Multi-Level Controls Integration through a Cloud-Based Open Demand Side Resources Integration Platform (OpenDSRIP), developed by EPRI and funded through another CEC grant (EPC 15-075), coordinating overall system controls
- A Community-Sharing Virtual Net Energy Metering (VNEM) model: The production and operation of the PV and battery is distributed (allocated) across each of the residential unit meters and the Common Building meter
- Common area lighting and air conditioning DC loads, directly coupled with the battery system

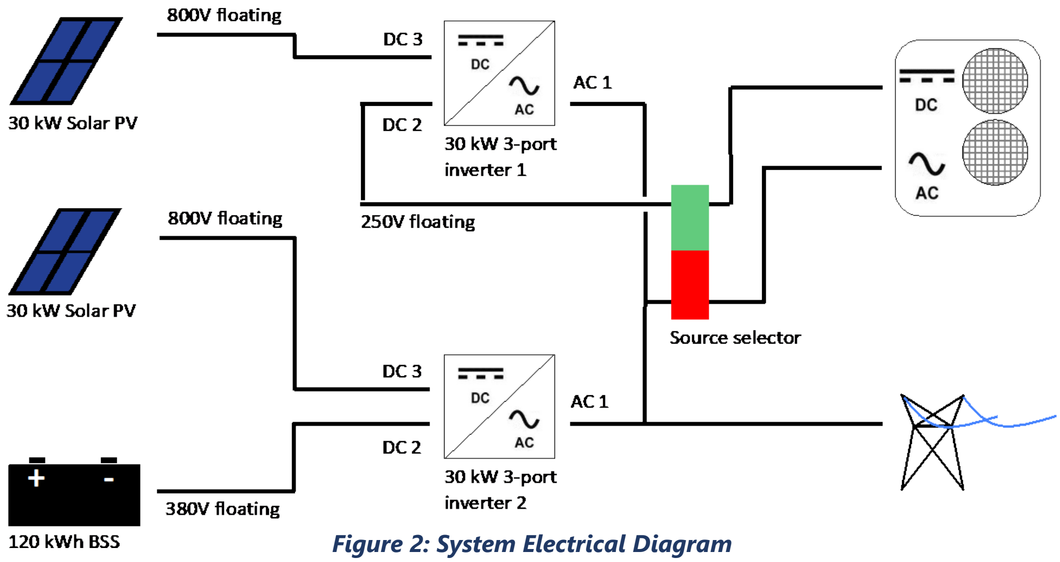

Figure 2: System Electrical Diagram

Most of the chosen innovations are emerging technologies, which were challenging to deploy due in part to limited product availability, lack of familiarity by permitting authorities and stakeholders, code limitations, and compatibility issues. Still, this resource integration project has garnered heightened attention not only for its energy efficiency and DR benefits, but as a realized demonstration of DC distribution and appliances that can be expanded with the provision of automatic transfer switch to offer low-income communities' resiliency.

APPROACH

WHAT WAS THE EVALUATION APPROACH?

EPRI collected data at 1-second, 1-minute, or 15-minute intervals (depending on metric and sensor device) and reported back to EPRI's server to provide technical support for deployed systems. An example of data collected can be seen below in Figure 3, where the basic timeline of charging, discharging, and TOU rate changes is quantified. The study analyzed metrics using a measurements-based, statistical approach for the following:

- Battery and PV functionality
- Solar energy performance
- PQ implications: study of common power quality factors
- Comparison of energy utilization pre- versus post- treatment
- Load shed DR performance
- EPRI evaluated multiple battery control scenarios

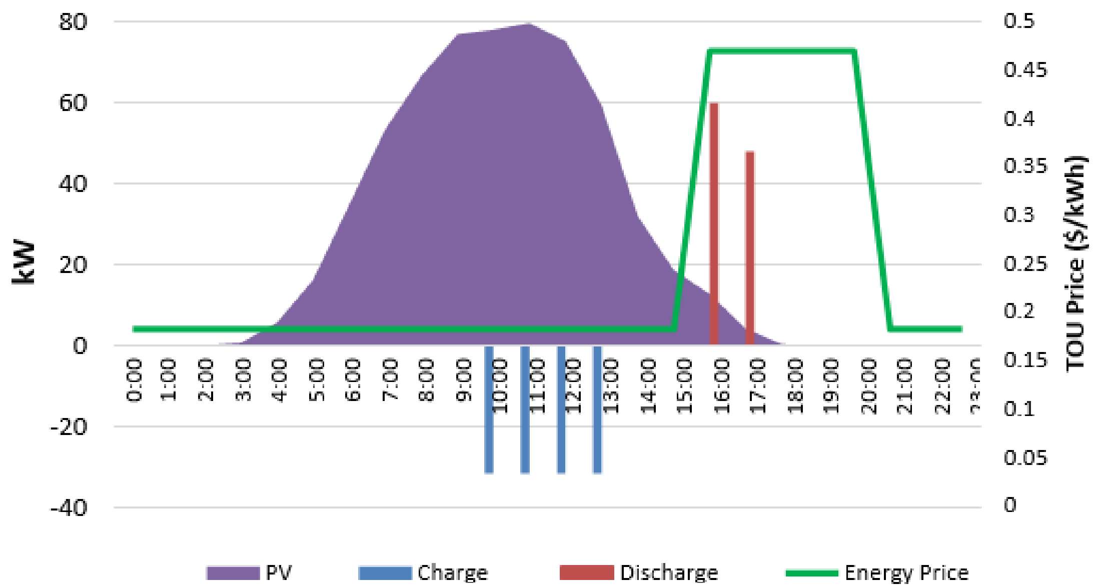

Figure 3: Energy and Rate Chart per Hour

FINDINGS

WHAT WERE THE MAJOR FINDINGS?

The project finds clear benefits to the property, utility and rate base, GHG reduction, net peak load reduction and utility bill savings. The DC minigrid was found to be a promising model for resiliency, in addition to its energy efficiency and DR capability, as it can provide backup power and support critical loads like medical devices and AC during local outages.

BATTERY OPERATION FOR GHG REDUCTION – During the TOU Winter months (Oct 1 thru May 31), the battery system was set to a "GHG Emissions Reduction" profile where the battery discharges from 3AM to 8AM, which is the time period with the highest average grid GHG emissions based on CAISO 2019 emissions data. By charging the battery with renewable power and discharging it during the periods of highest GHG emissions, the GHG Emissions profile attempts to zero out the building's source GHG emissions (Scope 2 emissions) during the periods of highest GHG intensity in the Grid. Extending the results of this project to California low-income multifamily households shows a potential energy use reduction of 1,182 GWh per year and statewide CO2 reduction of ~83,331 metric tons per year for California's low-income populations.

DC DISTRIBUTION AND APPLIANCES – The DC-coupling demonstration at Willowbrook evaluated the avoided conversion losses and the associated reduction in inverter capacity and cost by using DC power direct from the solar and battery system to feed 24V lighting and a DC-enabled 4-ton variable speed mini split heat pump. The complex implementation of hybrid AC/DC resilient systems and scarcity of DC components, like high-voltage DC breakers, calls for more time set aside in testing and interconnection. The substitution of 24W 2600 lumens DC light fixtures resulted in a 3.6 percent efficiency gain in terms of lumens per watt, thus the project found that keeping the system “all-DC” may not result in the expected efficiency gains.

HIGH-EFFICIENCY BIFACIAL SOLAR PV – This project deployed 170 Canadian Solar CS3U 355-watt bifacial panels to optimize use of limited roof space, collecting energy from the front and back of the modules to improve yield. Comparisons of module conversion efficiency found that bifacial solar modules may not provide improved performance where GRI cannot be maximized, and mismatch cannot be managed though careful and uniform array design.

RELIABILITY FROM CONTROLLED BATTERY DISPATCH – The team modeled 3 scenarios that deployed the storage to address project control objectives to determine which offered the greatest benefits to the property and the rate base. Ultimately, Scenario 3 (a top-down scenario prioritizing 10 percent annual peak load reduction at the feeder level while only secondarily addressing other control objectives) proved that the stacked benefit approach was most effective at providing the most notable annual bill savings and net annual peak load reduction for a residential distribution circuit. With load-shifting from the 4-9pm timeframe to the 12-3pm timeframe, the reduction in energy use is estimated at 1.48 MWh over the summer period (June 1 thru September 15, 2021).

DEMAND SIDE RESOURCES INTEGRATION PLATFORM (OpenDSRIP) – The DR aggregation program issued custom messaging on behavioral energy and demand reduction recommendations to prime residents for TOU rates coming into effect. During the June to September 2021 timeframe, there were 42 unique events, with 619 resident opt-ins or an average of 16 opt-ins per event. The performance suggests that residents were actively engaged, and that monetary incentives and gamification mechanisms are motivating factors for participation.

COMMUNITY-SHARING VIRTUAL NEM BUSINESS MODEL – This project utilized a Virtual Net Energy Metering (VNEM) tariff that enables the property owner to choose how to allocate production from behind the meter systems freely to different utility customer accounts. Due to the Solar on Multifamily Housing (SOMAH) program, employing the VNEM rate structure accrues the benefits of solar PV towards tenants.

Conclusions and Challenges

From the metrics analyzed and implementation process, an overarching lesson learned was the need for ample time and resources to source, integrate, and operate emerging technologies, compared to industry standard technologies. Willowbrook’s innovative technology demonstration persevered through challenges ranging from power quality issues with multiport inverters to code limitation of DC voltages to provide technology implementation pathways and recommendations in scaling solar, storage, DC, and controls, for more effective project, program, and policy targeting the low-income multifamily sector in California with integrated resource deployments.

The full findings are based on the report “DR18.06 – Solar+: Enabling Clean Energy in DAC with Integrated PV + Storage” which is available at: **www.dret-ca.com**.