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CSI RD&D PROGRAM

Distributed Energy Resources Integration

Grantee:
University of California, Davis

Partners:
University of California Davis Energy Institute, Energy & Environmental Economics, Davis Energy Group, General Electric

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$1,718,004

Match Funding:
$1,300,000

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2011-2014

RD&D Project Portal:
calsolarresearch.ca.gov/csi/75

Itron | CSI RD&D PROGRAM MANAGER

West Village Energy Initiative

BACKGROUND

West Village is an on-campus neighborhood designed for students, faculty and staff at the University of California, Davis (UC Davis). The UC Davis West Village Energy Initiative (WVEI) is one of the first large scale communities to be zero net energy (ZNE) entirely through energy efficiency and on-site generation. This unique community also provides an outstanding opportunity for sustainable energy development because the community is a living laboratory for UC Davis faculty, staff and students. This research is complimentary to a project being funded by the California Energy Commission's Renewable Energy Secure Communities (RESCO) Program. The UC Davis research project is broken into two target areas:

Target Area 1:
Improved Photovoltaic (PV) Production Technologies

Target Area 2:
Innovative Business Models to Achieve ZNE

West Village, UC Davis

This document provides a brief project description. For more detail on the project and the California Solar Initiative's (CSI) Research Development, Demonstration & Deployment (RD&D) Program, please visit calsolarresearch.ca.gov

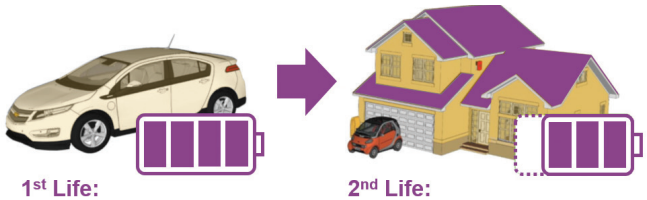
The CSI RD&D Program is managed by Itron on behalf of the California Public Utilities Commission (CPUC).

Target Area 1: Improved PV Production Technologies

OVERVIEW AND OBJECTIVES

The UC Davis team developed, designed, installed and evaluated advanced PV technologies as part of the West Village Energy Initiative. There were three primary tasks, two of which included demonstrations of integrated solar power and hybrid solar thermal systems and energy storage and another to evaluate advanced metering infrastructure for West Village. The project was intended to enhance PV production technologies in these key areas:

- Testing and demonstration of existing energy storage technologies capable of working with smaller PV systems in residential and commercial applications.
- Research on the integration of advanced metering infrastructure (AMI) with solar PV and other distributed energy resource (DER) technologies and providing recommendations to optimize existing PG&E and developer owned meters and power systems.
- Testing and demonstration of innovative hybrid solar (thermal/PV) development in multifamily and single family applications.



Single-family home 2nd life Li-ion battery energy storage

METHODOLOGY

The stationary battery energy storage demonstrations consisted of:

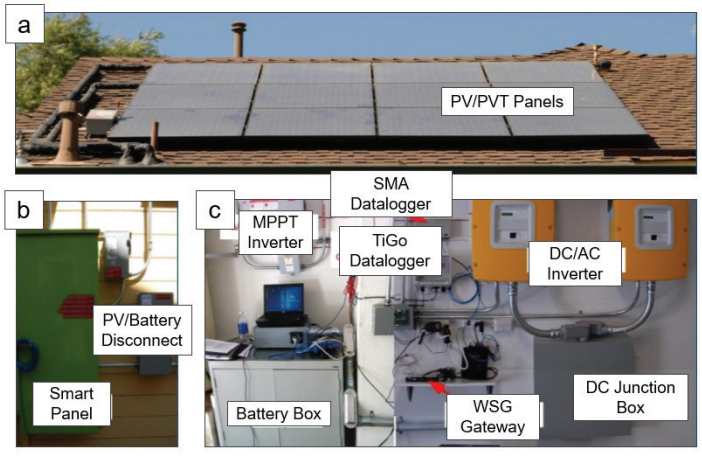
- An energy storage demonstration focused on a commercial, workplace electric vehicle (EV) charging application. The system stores energy from local PV generation and uses the stored energy to charge electric vehicles. This demonstration attempted to optimize EV charging from the PV resource.
- An energy storage demonstration that evaluated the use of second-life batteries for application in single family homes. This demonstration was deployed at an existing residential home, and the batteries were retired from EVs. This demonstration provided the opportunity to evaluate the grid benefits of storing PV energy to shift loads off-peak and to better align with remaining on-peak energy use.

The integration of AMI with solar PV and other DER technologies can offer opportunities to improve overall system performance and efficiency. The two research objectives were to:

- Understand baseline energy performance for the existing and planned new construction buildings at UC Davis West Village.
- Recommend the functional specification for a monitoring and control systems architecture that integrates the customer demand side AMI with solar PV production and other DER technologies, to be able to measure and adjust performance against the ZNE goal on a dynamic, ongoing basis.

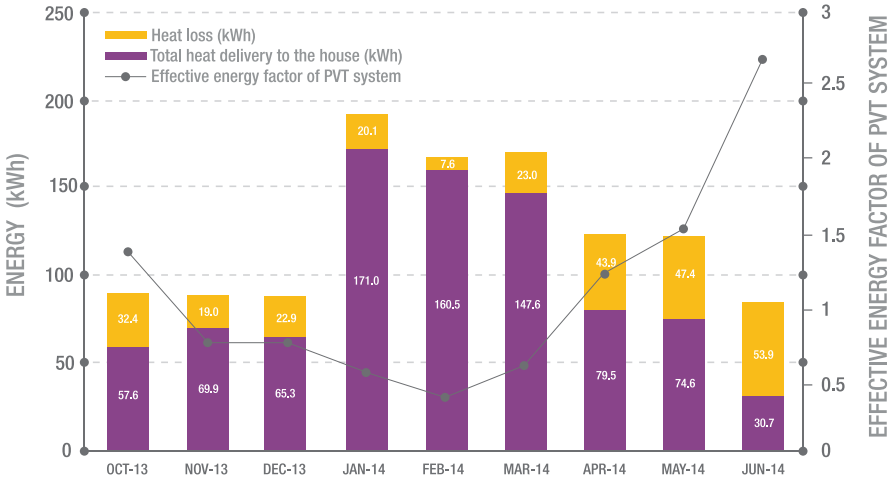
Single-family and Multifamily Hybrid Solar Technology demonstrations consisted of:

- A demonstration to evaluate existing and innovative hybrid photovoltaic/thermal (PVT) technologies and strategies for solar hot water production in multifamily installations. The team developed, designed, purchased, installed, tested and assessed the electricity and hot water production from a hybrid photovoltaic/thermal (PVT) system for two West Village apartment units.
- A demonstration to evaluate hybrid PVT technologies and strategies for solar hot water production in a residential single family environment. The research team developed, designed, purchased, installed, tested, and assessed the electricity and hot water production from a PVT system for a single-family home at Aggie Village. By collecting actual data from the PVT system, assessments can be made as to the performance and energy savings in comparison to the existing means of hot water production.



Smart Grid PV Battery System (a) Roof-mounted PV/PVT panels (b) Smart panel and PV/battery disconnect (c) Battery box, inverter, dataloggers

RESULTS AND OUTCOMES



Monthly heat delivery, heat loss, and effective energy factor of PVT system

The key findings and challenges from the stationary battery energy storage demonstrations include difficulty with system permitting and that no turn-key solution is available in the market and system components must be pieced together from various vendors. The second life battery storage was found to be extremely effective in providing significant load shifting in a residential application. From a time-of-use perspective this did not necessarily optimize the value of the PV system, however it provided load-shifting benefits to the utility and grid.

The AMI integration research found that, at the time of the analysis, the overall energy consumption to production ratio for West Village was projected at 1.25, indicating that additional means would be required to achieve ZNE for the community. Implementation of a master energy management system was recommended to automate ongoing tracking of energy performance and to communicate with residents and addressable devices (programmable communicating thermostats). Encouraging greater energy savings among residents may also be needed to meet the ZNE goals for West Village including both behavior modification approaches and greater centralized control of thermostats with temporary local override capability.

The hybrid solar technology research demonstrations found that in the near term, both flat-plate PVT and solar concentrator PVT are available in the market. Flat-plate PVT has lower efficiency but is better adapted to the roofs of individual houses or buildings. In comparison, most concentrated solar PVT has greater total energy output for the same area but also requires a tracking system, increasing system cost, and hindering applications for residential use.

PUBLIC BENEFITS

Continues to yield critical information for use by other communities in California on mitigating utility impacts as the number of electric and hybrid-electric vehicles increases.

Demonstrates that improved monitoring of energy supply and demand is critical in providing information relevant to control end use decisions in meeting ZNE objectives.

Installed one of the first hybrid PVT systems in California. The fully instrumented system has distinct advantages and can be monitored continuously to the benefit of enhanced design and performance.

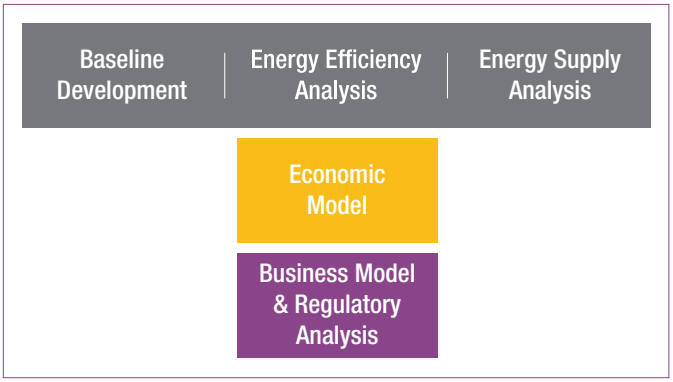
Demonstrates new control strategies for PVT that can influence the pattern of energy use by the building occupants and increase energy efficiency at a reduced cost.

Ongoing monitoring will support highly applicable assessments on potential for commercialization, economic and environmental impacts, and replication throughout the state.

Target Area 2: Innovative Business Models To Achieve ZNE

OVERVIEW AND OBJECTIVES

The UC Davis team avaluated alternative business models for the construction, ownership, and operations of the UC Davis WVEI to achieve ZNE in faculty and staff single-family homes. The overall goals of the WVEI were to achieve ZNE with no higher cost to the developer or the consumer, utilizing multiple renewable resources developed on-site at a community scale. Additionally, West Village would be used as a living laboratory for other energy-related topics.



Model Framework for Economic Model

METHODOLOGY

The UC Davis West Village Project research team performed financial modeling of alternative business models feasible under the current regulatory environment. A roadmap for the development of ZNE homes was completed and included the following three main components:

- Baseline home development.
- Energy efficiency analysis.
- Energy supply analysis.

The potential roles for PG&E were also considered. These roles included:

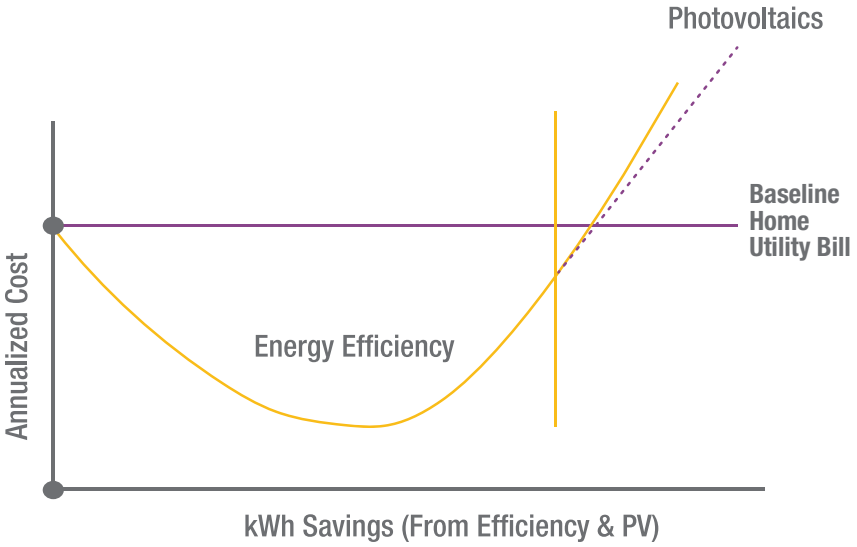
- Tax equity participation in solar PV ownership.
- Biogas offset provider.
- Pilot program for sub metering of EVs.
- Billing mechanisms, such as on-bill energy efficiency financing.
- Participation in West Village visitor center or lab house.

The team also documented regulatory barriers to adopting alternative business models, including net energy metering, virtual net metering, the CPUC's Rule 18 (owners of multifamily residential buildings cannot charge building occupants for electricity) incentive programs, and utility policies. It was not possible to complete two of the research tasks (implementation of alternative business models and metrics of success) since the construction of the faculty and staff housing was delayed and has not yet begun.

RESULTS AND OUTCOMES

Financial Feasibility: The research team found that achieving ZNE at no higher cost to the developer or the homeowner was possible, even assuming no regulatory change. Depending on the assumptions used for the financial model about absorption rates and construction costs, the proposed ZNE homes would cost the same or less than comparable conventional homes.

Virtual Net Metering: Under a community virtual net metering model, one community solar PV array would be sized for the electrical demand of the entire faculty and staff housing community and directly connected to PG&E's grid, rather than being tied to individual meters. Homeowners would be billed based upon their consumption less their share of the community array. By using a virtual net metering model for West Village, the project economics would be improved by approximately $1.8 Million (net present value). Currently, virtual net metering has not been extended to single-family homes.



Cost Effective Comparison between Energy Efficiency and PV

PUBLIC BENEFITS

Other communities pursuing ZNE can leverage the methods, approaches, analysis, and findings from this research project.

The *Zero Net Energy Project: Single-Family Homes Roadmap* and the Excel financial model developed as part of this project are available to other stakeholders interested in pursuing ZNE communities and strategies.

Provides insight on state energy policy concerning community-scale solar projects. If New Solar Homes Partnership incentives were expanded to include community arrays, project economics for West Village could improve by at least $3 million and encourage future community developments.