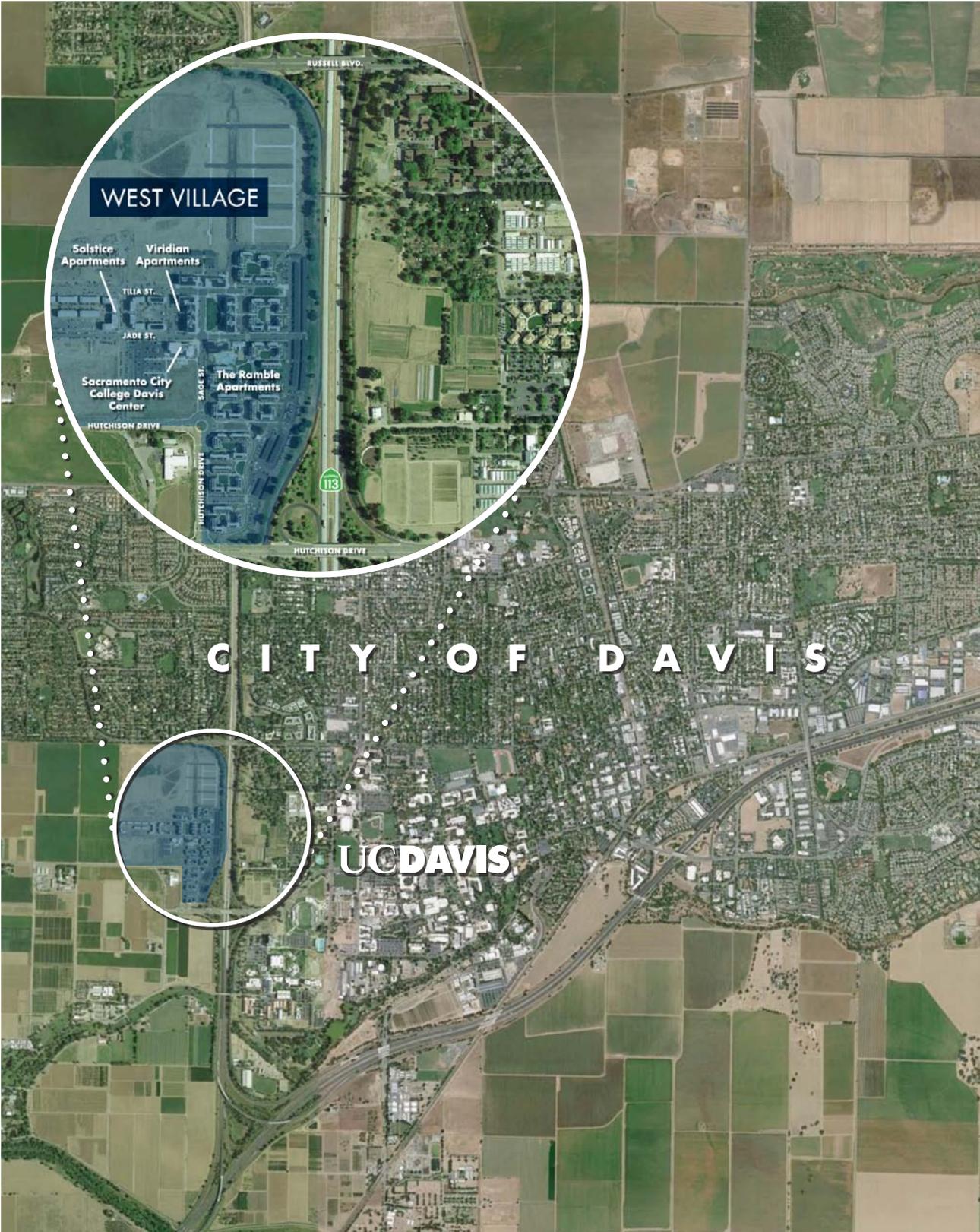




UC DAVIS WEST VILLAGE
ENERGY INITIATIVE ANNUAL REPORT
2012 - 2013



WEST VILLAGE

Solstice Apartments
Viridian Apartments
TILIA ST.
JADE ST.
SAGE ST.
Sacramento City College Davis Center
The Ramble Apartments
HUTCHISON DRIVE

CITY OF DAVIS

UC DAVIS

FOREWORD

“The most important advances in new technologies come through the process of building, debugging, and continually learning and improving technologies in use.”

Andrew Hargadon
UC Davis Graduate School of Management,
Charles J. Soderquist Chair in Entrepreneurship
and Professor of Technology Management

In his remarks at the UC Davis West Village ribbon cutting ceremony in October 2011, Andrew Hargadon likened the West Village Energy Initiative to the invention process of Thomas Edison. For example, before Edison broke ground on the first central power plant ever built in the U.S., he had produced 14 patents involving electric light. Once he began construction, he produced 368 more.

The UC Davis West Village Energy Initiative follows on Edison’s tradition. From its inception as an “environmentally responsible campus housing project” to its current status as the nation’s largest planned zero net energy (ZNE) community and home to the University’s Energy and Transportation innovation center, UC Davis West Village has steadily contributed to the practical knowledge of how to plan, construct, operate and improve upon a large-scale, sustainable, mixed-use neighborhood.

This first annual report provides an overview of the energy initiative and results to date. We describe lessons learned and next steps in the ongoing process. UC Davis and its developer partner, West Village Community Partnership, LLC (WVCP), are committed to continuing progress toward our mutual energy goals. We are extremely proud of how far we have come, even as we recognize that there is still much work to be done to achieve our ultimate goal of ZNE.

From the earliest planning stages, UC Davis West Village aspired to extraordinary goals. As the project has progressed, it has moved from being extraordinary to being transformational — as a campus neighborhood and as an experience for all involved in its creation and evolution. West Village started as a public-private partnership to develop much-needed housing for UC Davis students, faculty and staff and is now home to nearly 2,000 students in 663 apartments in a district anchored by recreational amenities and a community college. Along the way, UC Davis and WVCP embraced the aspirational goal of making West Village the largest planned ZNE community in the United States.

Through catalytic grants from the U.S. Department of Energy, California Energy Commission and the California Public Utilities Commission, UC Davis West Village is poised to be a roadmap around the technological, financial and regulatory barriers that projects face in striving to be ZNE. It already is becoming a living laboratory for energy efficiency and renewable energy research providing not only valuable data but also a test bed for new technologies and business models related to ZNE.



ABOUT UC DAVIS WEST VILLAGE

A NEW CAMPUS COMMUNITY

UC Davis West Village (West Village) is a new campus neighborhood designed to be the home for approximately 3,000 students and 500 staff and faculty families. Located on the UC Davis campus, the overarching goals for the community are:

Quality of Place – to create a great community and desirable place to live that will help UC Davis recruit the best and brightest students, faculty and staff, to let them live within walking or cycling distance of the campus, and to participate fully in campus life.

Affordability – to enable faculty and staff to purchase new homes locally at below market prices and to expand the choices for students to live near campus.

Environmental Responsiveness – to develop the site and buildings according to sound environmental principles so as to reduce reliance on cars, limit energy consumption, enable renewable energy production, and contribute to a healthy environment.

The community was developed through a public-private partnership between UC Davis and West Village Community Partnership, LLC, a joint venture of Carmel Partners from San Francisco and Urban Villages from Denver.



THE WEST VILLAGE ENERGY INITIATIVE

Through the collaborative design process with WVCP, UC Davis expanded upon its core principle of making UC Davis West Village environmentally responsive and launched the WVEI. Working together, the UC Davis and WVCP team first looked for ways to make West Village as energy efficient as possible. In 2007, UC Davis commissioned a study with its own UC Davis Energy Efficiency Center and local consulting firm, the Davis Energy Group, to help identify deep energy efficiency measures that could be included in the design of the student housing and single family residences to be built as part of West Village. The results of this study demonstrated that by adopting deep energy efficiency measures, WVCP could reduce consumption in West Village by nearly 50 percent compared to the California Energy Efficiency Building Code.

With this result, WVCP and UC Davis realized that a much larger goal was within reach – the goal of making West Village a ZNE community. In 2008, WVCP engaged Chevron Energy Solutions to evaluate the financial feasibility of achieving a ZNE goal defined as “zero net electricity from the grid measured on an annual basis.”

In 2009, WVCP and UC Davis decided to strive for this goal. Because West Village had to be accessible for UC Davis faculty, students and staff, the ZNE goal had to be balanced against the goal of affordability. In response to these competing principles, WVEI was created and the following principles were adopted by the team:

- West Village would strive to use ZNE from the grid measured on an annual basis.
- ZNE needed to be achieved at no higher cost to the developer.
- ZNE needed to be achieved at no higher cost to the consumer.
- West Village would adopt deep energy efficiency measures to reduce energy demand.
- ZNE would be achieved through multiple renewable resources developed on-site at a community scale.
- West Village would be used as a living laboratory for further energy-related topics.



ENERGY DESIGN AND PERFORMANCE

West Village's first-phase components

have achieved a remarkable 87 percent of the initial ZNE goal, years ahead of the full completion of the community. Along the way, a number of challenges and issues emerged and, with them, lessons learned.

The following report includes:

1. Major milestones in construction of West Village and its energy systems
2. Progress towards ZNE
3. Lessons learned about implementing ZNE
4. UC Davis West Village Living Lab
5. Outreach and Awards
6. Next steps towards achieving ZNE

Other aspects of the WVEI reported here include UC Davis existing and on-going energy-related research and teaching activities related to West Village.

REPORTING PERIOD

The reporting period for this initial annual report is March 2012 through February 2013. This period was chosen because it is the first 12-month period for which both electricity demand (consumption) and generation (production) data were available for a significant portion of the community. Prior to this period, some apartments were occupied, but solar panels that are part of the renewable electricity generation capacity had not been installed and commissioned, or were installed but the apartments were not yet occupied. Thus, this is the first meaningful period where progress towards the ZNE goal could be documented. Other aspects of the WVEI initiative that occurred through August 2013 also are reported.

Future annual reports will describe results by prior leasing year (September through August). The second WVEI annual report scheduled for winter 2015 will report on results from September 2013 through August 2014.



MAJOR MILESTONES IN THE CONSTRUCTION OF UC DAVIS WEST VILLAGE

The Phase I Ramble Apartments (192 units with 654 student beds) were occupied in September 2011. The mixed-use buildings around the Village Square, including the Viridian Apartments (123 units with 192 beds) on the second through fourth floors, were occupied in September 2011. The Viridian Apartments are a higher-end product consisting of one and two bedroom units and are occupied by faculty and staff as well as students. The first floor of these mixed-use buildings includes approximately 42,500 square feet of office/retail space. This space was unoccupied until January 2013 when UC Davis established its Energy and Transportation uHub at West Village and moved the associated centers and institutes into approximately two-thirds of the ground floor office space. However, the solar panels were operating prior to occupancy.

The Phase II Ramble Apartments (192 units with 630 student beds) opened in September 2012. The final phase of student housing built by WVCP, the Solstice Apartments (156 units with 504 beds) opened in September 2013. Construction of single family homes is expected to start in 2014 with a spring opening of the first models. The first building of the Sacramento City College West Village Center opened in January 2012. The community college currently is not a participant in the ZNE goal.

A total of 2.1 megawatts of photovoltaic solar panels (PV) was installed to serve the Phase I Ramble and Viridian apartments, Viridian commercial spaces and the Leasing Recreation Center. An additional 1.1 megawatts were installed to serve Phase II Ramble Apartments. PV systems were sized to serve common area and parking lot lighting. PV systems were installed on building rooftops and on carport shade structures. To comply with net metering laws applicable at the time, each Ramble apartment has its own utility meter and associated PV system.

INSTALLED PHOTOVOLTAIC CAPACITY - PHASE 1

Facility	Installed PV (Rated kW STDC)
Phase I Ramble	1,072
Viridian	872
Leasing Recreation Center	154



PROGRESS TOWARDS THE ZNE GOAL

For the purposes of the WVEI, ZNE is defined as “zero net energy from the grid measured on an annual basis.” More specifically, this means the community would produce enough energy on site to offset its annual consumption. It is connected to the regional electrical grid and during peak hours will be feeding electricity into the grid while at night it will be drawing electricity from the grid.

In spring 2013, WVCP engaged the Davis Energy Group to perform a comprehensive evaluation of the West Village energy consumption and production for the March 2012 through February 2013 reporting period. This early “snapshot” of the community’s energy performance against its ZNE goals was to inform UC Davis and WVCP of progress to date and to help with future implementation of the WVEI. The study was also a way to share with other developers, policy makers and institutions how they could learn from the West Village experience.



ENERGY PRODUCTION AND CONSUMPTION - MARCH 2012 THROUGH FEBRUARY 2013¹

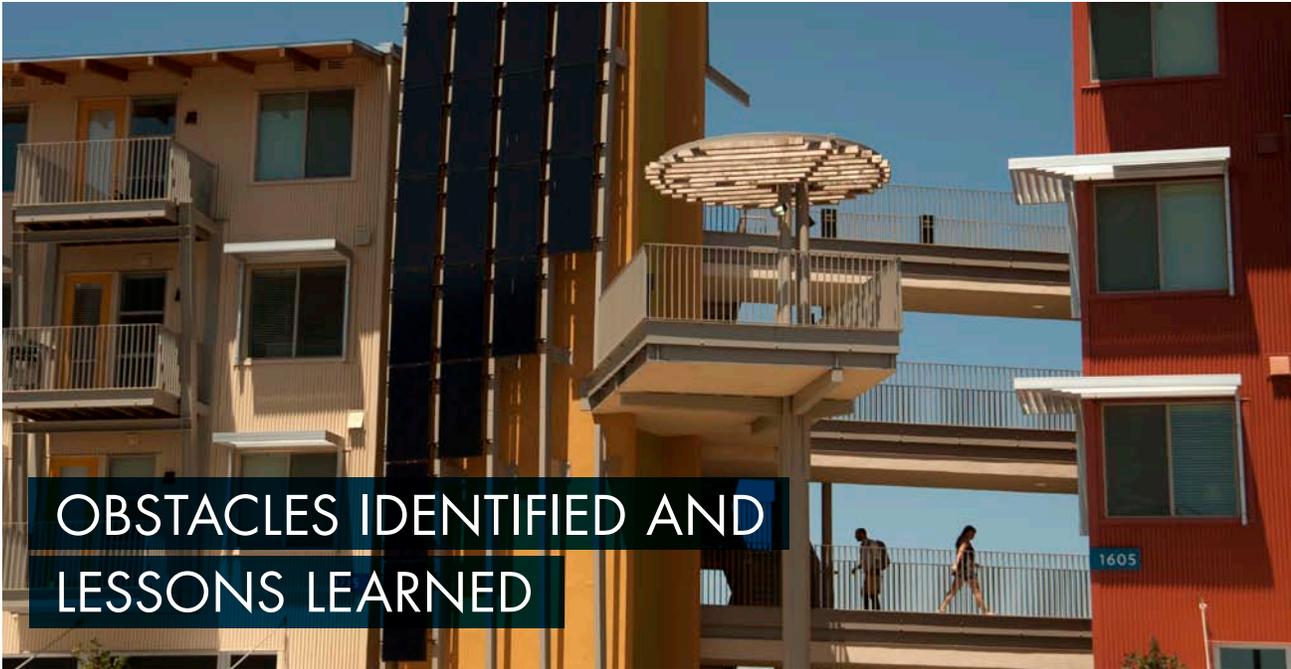
Source: Evaluation of UC Davis West Village Phase I Energy Use and PV Production. Davis Energy Group, Inc. September 19, 2013

Facility	Production (MWh)			Consumption (MWh)			Percent (AP/AC)
	Modeled (MP)	Actual (AP)	Percent (AP/MP)	Modeled (MC)	Actual (AC)	Percent (AC/MC)	
RAMBLE APARTMENTS PHASE 1							
Apartments	1,024	1,110	108%	1,127	1,377	122%	81%
Common Areas ²	471	451	96%	390	602	155%	75%
TOTAL	1,495	1,561	104%	1,516	1,979	131%	79%
VIRIDIAN APARTMENTS							
Apartments	519	530	102%	530	515	97%	103%
Common Areas	321	314	98%	141	432	306%	73%
TOTAL	839	844	101%	672	947	141%	89%
VIRIDIAN COMMERCIAL AREAS							
TOTAL	415	358	86%	377	84	22%	424%
LEASING AND RECREATION CENTER							
Building	225	218	97%	225	292	130%	75%
Pool / Outdoor	0	0	n/a	0 ³	109	n/a	0%
TOTAL	225	218	97%	225	402	178%	54%
TOTAL	2,974	2,981	100%	2,790	3,412	122%	87%

¹ Includes buildings/meters with full year of occupancy and production. Los Rios Community College is not part of the ZNE goal and so not included in this analysis.

² Common areas include central heat pump water heaters, common area lighting and elevators, and common area meters also have parking lot and path lighting loads attached.

³ Pool equipment and outdoor lighting were not included in the original modeling.



OBSTACLES IDENTIFIED AND LESSONS LEARNED

While achieving an exceptional 87 percent of our initial ZNE goals years ahead of fully completing the community, a number of challenges and issues emerged during that time period. Each brought with it important lessons. Key reasons that electrical consumption exceeded production during the first reporting period are summarized below.

COMMISSIONING

Commissioning newly constructed systems to work as designed is critical to achieving optimum performance. Commissioning issues surrounding the central heat pump water heaters (HPWHs) contributed to West Village falling short of its ZNE goal for this first measurement period.

The heat pump water heaters installed for the student housing initially failed to perform according to specification, causing the heating control system to automatically shift to less energy efficient, back-up resistance-type electrical heaters to meet the water heating demand of the residents. During commissioning, this problem was identified and has been resolved by the WVCP team. Nonetheless, reliance on the backup water heating systems added substantial unanticipated power demand to the project.

The initial commissioning challenges have been addressed, and the project has improved its commissioning practices as more solar PV is installed and additional student housing is built.

Lessons Learned:

- With new technologies and strategies, it is important to test and commission building systems to ensure that they are operating as designed.
- Provide alarms on the heat pump water heaters that can notify operations staff when a system goes down. WVCP has worked with the manufacturer to install alarms on all heat pump water heater systems.
- Implement ongoing commissioning of the more complex building systems, such as the central heat pump water heaters and the mechanical systems at the Leasing Recreation center.

MODELING AND DESIGN

Reviewing consumption data for the first measurement period, the Davis Energy Group discovered that some of the earlier modeling assumptions were not consistent with actual consumption data. The modeling assumptions for student apartments were based on several published sources for multi-family projects¹. Evident from the consumption data collected for the first measurement period is a distinct difference among students compared to residents of other multi-family projects within the more general population in terms of miscellaneous electrical loads (plug loads). In a typical multi-family setting, there may be only one or two computers for the household, one gaming system, and other multi-user appliances. In contrast, a four-bedroom student housing apartment turns out to resemble four separate households, each with its own computer, smart phone, gaming system, television, and other separate appliances. WVCP, working with researchers at UC Davis, is developing educational programs to encourage students to conserve energy. Additional solar PV alternatives to offset overconsumption are being evaluated.

Original modeling assumptions also assumed plug load consumption reductions based on the implementation of plug load controls through a “one-switch” device and energy consumption displays in each apartment. The proposed “one-switch” device would enable the occupant to turn off non-critical plug loads when not needed, while the energy consumption display would provide occupant feedback on real-time energy use, allowing them to better reduce apartment energy use. Due to challenges with finding cost-effective products to serve these needs, neither of these devices has been implemented in the project at this time.

In the initial design modeling for the community, energy demand for the recreational swimming pools and common area lighting were not included. The modeling focused on the buildings that make up the student apartments. These demands are, however, included in

this reporting of progress toward the ZNE goal. Strategies to reduce overall consumption and other ways to offset overconsumption due to incorrect modeling assumptions are being developed.

Lessons Learned:

- Apartment plug load energy use assumptions should be higher to account for the higher number of electronic devices found and the increased use of these devices in student housing.

OCCUPANT BEHAVIOR VARIABILITY

Individual apartment consumption for high energy use apartments was up to three times higher than low energy use apartments. This large difference suggests significant behavioral variability between occupants. High energy use is primarily occupant related and most likely due to occupant-supplied plug loads. Since occupants do not directly pay for their utilities and do not have access to records of how much energy they consume, there is little awareness of their consumption habits or how their behavior affects energy use. As mentioned above, WVCP is developing an educational program to encourage students to conserve energy.

Lessons Learned:

- Develop and implement community engagement strategies to encourage energy conservation. Educate the community to the occupant’s role in a ZNE building and better translate the ZNE vision. Strategies could include incentives for apartments that deviate from the targets, contests, and awareness campaigns.
- Identify “high use” apartments early in the school year and develop a strategy to discourage excessive (larger than estimated) energy consumption.

Provide means for occupant feedback and control of consumption. Evaluate currently available products on the market to determine if there are cost-effective solutions to providing occupant feedback and control.

¹ End use profiles for different end uses were based on two sources: Department of Energy’s Building America House Simulation Protocols (NREL, 2008) and the California Residential Appliance Saturation Study (KEMA, 2004).



UC Davis West Village is now the home for the first UC Davis-based “University Hub” or “uHub” — a prototype for future “Innovation Hubs” aimed at better fostering collaboration among related research units, enhancing interaction with the private sector and accelerating the transfer of university inventions from the lab to the marketplace. The Energy and Transportation uHub at West Village is now the physical home for these UC Davis research centers:

- Center for Water-Energy Efficiency
- China Center for Energy and Transportation
- Energy Efficiency Center
- Institute of Transportation Studies
- Plug-In Hybrid & Electric Vehicle Research Center
- Policy Institute for Energy, Environment and the Economy
- Program for International Energy Technologies
- Sustainable Transportation Energy Pathways Program
- Energy Institute
- Urban Land Use and Transportation Center
- Western Cooling Efficiency Center

The co-location of these research centers at West Village supports the uHub concept. It also creates the opportunity to use West Village as a “living lab” to evaluate and develop energy and transportation technologies and solutions at the building and community scales. In addition to monitoring activities relating to ZNE for West Village, several other research investigations are underway, including:

Battery Buffered Electric Vehicle Charging Station: The project combines on site solar energy, a high voltage lithium-ion battery pack and electric vehicle charging stations to store PV energy and charge vehicles, day or night, without adding loads to the grid. The system’s primary source of energy is a PV tower located in the Village Square, but is also grid-connected. This allows the system to be operated in a number of ways including mitigating electric vehicle charging loads, reducing demand during peak hours and load shifting services for vehicle charging and building loads.

Multifamily Hybrid Solar Demonstration: To demonstrate advanced ZNE technologies, a 24-panel PV-plus-thermal hybrid solar system has been installed at Solstice student housing. The system provides PV electricity to one apartment and supplies thermal energy to the building's central hot water system. The PV-plus-thermal system was integrated with the central hot water system to interact with the high efficiency air-to-water heat pump to investigate how to optimize both water heating systems for multifamily applications.

Single Family Hybrid Solar and Demand Side Management Retrofits: Since single family homes are not yet available at West Village, these technologies are being investigated at Aggie Village, an existing university faculty and staff community located in downtown Davis. The technologies in the test home include a PV-plus-thermal hybrid solar system, a lithium ion 2nd life battery, and a home energy management system. The energy management system monitors and controls plug loads, appliances, battery storage charging and discharging, and electric vehicle charging. Future plans include installing a ground source heat pump system for heating and cooling of the home. The goal of the project is to achieve ZNE in a retrofit environment and transfer learned lessons to future single family homes in West Village and elsewhere.

AEC Behavior Study: Architectural Energy Corporation, in conjunction with PG&E and Sustainable Design + Behavior is working closely with the West Village management team to create a monitoring and outreach program for the community. This program includes monitoring approximately 140 apartment units to understand end-use loads and provide specific monthly intervention messages to those units, based on their observed consumption. The program has initiated a community-wide outreach program that provides messaging and information on energy consumption. This includes regular outreach activities, such as contests, that promote education and energy conservation within the community.

Honda Smart Home Demonstration Project: This unique, high-tech sustainable home will demonstrate an approach to meeting California's goal of requiring all new residential construction to be ZNE by 2020. Technologies featured in the home include: a solar power system, a smart-grid Honda Energy Management System, direct solar PV-to-vehicle charging, and high-efficiency HVAC (heating, ventilation and air conditioning) and lighting systems designed by UC Davis.





TOURS

Since its opening in 2011, West Village has attracted tremendous interest from around the region and the world. UC Davis faculty and staff and WVCP employees host several tours of West Village each week with visitors ranging from researchers to environmental scientists, energy regulators and elected officials. Foreign visitors have come from as far away as the Netherlands, Saudi Arabia, Abu Dhabi, and Lithuania. Since 2011, there have been approximately 250 onsite tours of West Village with thousands of participants.

MEDIA COVERAGE

West Village and its ZNE goals have been featured in the New York Times, CNN International, the Wall Street Journal, National Public Radio, Sunset Magazine, Forbes, San Francisco Chronicle, Los Angeles Times, and in multiple mainstream and trade publications.

AWARDS

- 2013 Urban Land Institute Global Awards of Excellence Winner
- 2013 PCBC Gold Nugget Awards for Best Community Site Plan and Judges Special Award of Excellence
- 2012 Sacramento Business Journal Green Leadership Award for a Game-Changer project
- 2012 Breathe California Clean Air Award for Innovative Strategy
- 2012 Sacramento Valley American Planning Association California Chapter Local Vision Award
- 2012 Green Dot Award for the West Village square



NEXT STEPS

Several major milestones will occur during the next reporting period, which ends in August 2014.

- The Solstice Apartments opened in September 2013 and bring on both new energy demand and new renewable energy supply.
- Ground floor commercial/office areas around the Village Square will be nearly fully occupied. These uses will bring on new demand without adding new supply. The demand will include UC Davis energy-related laboratories which were not anticipated when the original modeling for the ZNE goal was adopted.
- An evaluation of opportunities to install additional solar PV to offset overconsumption at existing facilities will be undertaken.
- WVCP will begin implementation of its energy use and efficiency educational program for West Village residents.
- Renewable Energy Anaerobic Digester at the UC Davis landfill will open offsite. At this biodigester, organic waste will be used to generate biogas which will be used to produce approximately 4 million kWh of electricity per year. This project was a spinoff of the original West Village ZNE planning, and the renewable energy produced may be credited towards West Village consumption to achieve the ZNE goal.

ACKNOWLEDGEMENTS

The WVEI has truly been and will continue to be a coordinated effort of the University of California and its development partners who are committed to making West Village more sustainable and extending results of the project to the broader community. This project would not have been possible without the commitment and efforts of:

- West Village Community Partnership, LLC (Carmel Partners and Urban Villages)
- Nolan Zail Consulting
- U.S. Department of Energy
- California Energy Commission
- California Public Utilities Commission
- Pacific Gas & Electric Company
- Chevron Energy Solutions
- Davis Energy Group
- Energy+Environmental Economics
- ITRON
- UC Davis Energy Efficiency Center
- UC Davis California Lighting Technology Center
- UC Davis Institute for Transportation Studies
- UC Davis Energy Institute
- UC Davis Western Cooling Efficiency Center



WESTVILLAGE

UCDAVIS

1580 Jade Street
Davis, CA 95616
www.ucdaviswestvillage.com

UCDAVIS

**ENVIRONMENTAL STEWARDSHIP
AND SUSTAINABILITY**

436 Mrak Hall
University of California, Davis
One Shields Avenue
Davis, CA 95616
www.sustainability.ucdavis.edu