California Solar Initiative

RD&D: Research, Development, Demonstration and Deployment Program

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Final Project Report:

West Village Energy Initiative Target Area Two: Innovative Business Models to Achieve Zero Net Energy

Grantee:

University of California, Davis
Design & Construction Management

July, 2015

www.CalSolarResearch.ca.gov

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Preface

The goal of the California Solar Initiative (CSI) Research, Development, Demonstration, and Deployment (RD&D) Program is to foster a sustainable and self-supporting customer-sited solar market. To achieve this, the California Legislature authorized the California Public Utilities Commission (CPUC) to allocate **$50 million** of the CSI budget to an RD&D program. Strategically, the RD&D program seeks to leverage cost-sharing funds from other state, federal and private research entities, and targets activities across these four stages:

- Grid integration, storage, and metering: 50-65%
- Production technologies: 10-25%
- Business development and deployment: 10-20%
- Integration of energy efficiency, demand response, and storage with photovoltaics (PV)

There are seven key principles that guide the CSI RD&D Program:

1. **Improve the economics of solar technologies** by reducing technology costs and increasing system performance;
2. **Focus on issues that directly benefit California**, and that may not be funded by others;
3. **Fill knowledge gaps** to enable successful, wide-scale deployment of solar distributed generation technologies;
4. **Overcome significant barriers** to technology adoption;
5. **Take advantage of California's wealth of data** from past, current, and future installations to fulfill the above;
6. **Provide bridge funding** to help promising solar technologies transition from a pre-commercial state to full commercial viability; and
7. **Support efforts to address the integration of distributed solar power into the grid** in order to maximize its value to California ratepayers.

For more information about the CSI RD&D Program, please visit the program web site at www.calsolarresearch.ca.gov.

West Village - Target Area Two

Submitted to the California Public Utilities Commission and ITRON

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Acknowledgements:

The authors would like to thank Smita Gupta and Ann Peterson at Itron, without their patient support and guidance this project would have not been possible. We would also like to acknowledge West Village Community Partnership, LLC , especially Nolan Zail, Ron Zeff and Neils Cotter for their cooperation and willingness to think outside the proverbial box. Finally, thanks to the E3 team under the leadership of Michele Chait and Snuller Price; Bill Dakin, Alea German , Marc Hoeschele and David Springer at Davis Energy Group; Ben Norris and Tom Hoff at Clean Power Research; and Adele Chang and Mark Rohling at Lim Chang Rohling & Associates.

Abstract:

Target Area Two of the UC Davis CSI RD&D project focused on using the West Village Energy Initiative and particularly the construction and sale of the single family homes as real world test-cases to evaluate various business models that would allow for the deployment of community scale solar distributed generation that would include a role for the local investor-owned utility, PG&E. Working with E3, DEG and CPR, extensive financial modeling was undertaken to determine the most cost-effective business model to effectuate the Zero Net Energy goals for the single family residences at a community scale. E3 developed a comprehensive economic model to be used in evaluating proposed alternative business models.

Keywords: 2008 Title 24, Biogas, California Solar Initiative, Clean Power Research, Davis Energy Group, E3, Electric Vehicles, Energy+Environmental Economics, Energy Efficiency , Faculty Staff Housing, ITRON, Net Metering, RECs, Roadmap, Rule 18, Solar PV, UC Davis, West Village, West Village Energy Initiative, Zero Net Energy

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Appendix A: *UC Davis West Village Zero Net Energy Project, Single-family Homes Roadmap,* August 2013, Energy+Environmental Economics.

Appendix B: Excel Financial Model, August 2013, Energy+Environmental Economics.

1.0 Introduction

1.1 Project Goals

Under the UC Davis West Village Energy Initiative: CSI RD&D Project, the goal of Target Area Two was to evaluate alternative business models for the construction, ownership and operations of the UC Davis West Village Energy Initiative system, especially as related to achieving Zero-Net-Energy (ZNE) for the single family homes for faculty and staff. This evaluation reports on the five Target Area Two Tasks:

- Task 1: Financial Modeling of Alternative Business Models
- Task 2: The Role of the IOU in Alternative Business Models
- Task 3: Regulatory Barriers to Adopting Alternative Business Models
- Task 4: Implementation of Alternative Business Models
- Task 5: Metrics of Success

1.2 Background: UC Davis West Village – A Public-Private Partnership

UC Davis West Village (West Village) is the largest planned ZNE community in North America. Upon completion, Phase I of the project will provide 1,980 beds (663 units) of student housing, 343 single family residences for UC Davis faculty and staff and approximately 42,000 square feet of ground floor commercial space around a mixed-use village square. Phase I of West Village is an approximately $300 million project on 130 acres located on UC Davis' west campus.

As of the fall of 2013, all of the student housing and commercial space was completed. At that time, the student housing enjoyed a 98% occupancy rate and over 75% of the commercial space was occupied. Construction of the models for the single family homes for faculty and staff has been delayed until 2016 at the earliest.

UC Davis initiated planning for a new campus mixed-use neighborhood, which would become West Village, in 2000 as part of its Long Range Development Plan process. The neighborhood was conceived as a way to address a shortage of relatively affordable housing for students, faculty and staff in the Davis community. After a competitive selection process, UC Davis selected West Village Community Partnership, LLC (WVCP), as the development team to deliver the project through a public-private partnership. WVCP is a joint venture of Carmel Partners of San Francisco and Urban Villages of Denver.

The business structure of the public-private partnership is a ground lease between The Regents of the University of California and WVCP. The ground lease requires WVCP to build the on-site infrastructure for the West Village community in exchange for the right to build, own and operate the student housing, commercial space and to build and sell the faculty/staff single family homes. ZNE was not an original goal of the project; rather, the decision to strive for ZNE was borne out of the project's core planning principles: Housing Affordability, Quality of Place, and Environmental Responsiveness.

Consequently, the ground lease agreement between The Regents and WVCP, signed before ZNE became a project goal, did not include any ZNE requirements for the West Village project, which has become a challenge in the implementation phase.

1.3 Deciding on ZNE as a Goal

The ZNE goal for West Village was an outgrowth of the collaborative design process between UC Davis and WVCP. In 2006, the business team at UC Davis engaged the UC Davis Energy Efficiency Center (EEC) to develop strategies for the implementation of deep energy efficiency measures in the design and construction of West Village. As part of their work, the EEC assembled a Project Advisory Committee consisting of multiple stakeholders from the University, government, private industry and the financial sector. The committee met several times for the purpose of brainstorming about strategies to optimize the use of energy efficiency measures in the West Village project. The EEC also worked with Davis Energy Group to develop three energy efficiency "packages" for the project and to provide a payback analysis based upon then current pricing for each package. The product of this research and collaborative process was the EEC's 2007 report. This report demonstrated to UC Davis and WVCP that energy savings of about 50% (when compared with Title 24) were achievable. Once it was demonstrated that energy consumption could be cut in half, the group started working on a larger goal, to achieve ZNE.

1.4 UC Davis West Village Energy Initiative

Following the EEC Report, and additional modeling work performed by Chevron Energy Solutions on behalf of WVCP, UC Davis and WVCP decided to pursue the ZNE goal for the West Village community. The teams formed a loose workgroup known as the UC Davis West Village Energy Initiative ("WVEI") to work collaboratively on the issues related to developing a ZNE community. These principles included:

- 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.
- The West Village project 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 other energy-related topics.

1.5 Defining Zero Net Energy

Multiple definitions exist for ZNE and each definition includes a different approach for measuring energy use and providing renewable energy generation. Each definition of ZNE, therefore, creates unique financial and technical implications for project teams working to implement a ZNE project. The West Village design team, including UC Davis and WVCP, chose to adopt the definition of

"ZNE Site Energy" for the West Village Energy Initiative. A common definition of this approach to ZNE is, "A ZNE Site building produces as much onsite renewable energy as it uses annually. This assumes that the building is connected to the grid and the extra energy can be bought and sold as needed."[1] Given that some end uses of energy at West Village are to be accomplished with natural gas, especially in the single family homes, the ZNE Site Energy definition expands to "ZNE Site Electric + Gas," whereby natural gas use is offset by equivalent increased energy production from on-site renewables or the purchase of biogas for the natural gas use. West Village will be predominantly powered by a solar photovoltaic system connected to the utility grid in a net energy metering (NEM) arrangement.

A more detailed discussion of the various definitions of ZNE is found in Appendix A of *Creating a Zero Net Energy Community: A Case Study of the UC Davis West Village Project* submitted by UC Davis to the California Energy Commission as part of its RESCO Technical Integration Implementation Project grant.

2.0 Financial Modeling of Alternative Business Models

2.1 Selection of Consulting Team

The first step of Target Area Two was to extend to the single family housing, the financial modeling related to the student housing that was performed by Chevron Energy Solutions under the California Energy Commission RESCO grant to UC Davis. To do this, UC Davis developed a "Request for Qualifications for Energy & Financial Analysis Consulting Services" that was released in April 2011. UC Davis received 14 responses to the Request for Qualifications and short-listed four teams. The West Village Energy Initiative workgroup interviewed the four consultant teams: Black & Veatch, California Center for Sustainable Energy, Stantec and Energy+Environmental Economics (with Clean Power Research & Davis Energy Group)("E3"). Following the interviews, the workgroup selected the E3 team and following a scoping meeting, agreed upon a scope of services for their portion of the Target Area Two.

During the summer of 2011, E3 performed their analysis and evaluation and created the proposed roadmap to reach ZNE for the Faculty Staff Housing.

2.2 Project Goals and Key Questions

E3's primary project goal was to develop a roadmap for the development of ZNE homes for the Faculty Staff housing portion of West Village at no higher cost to the developer or to the homeowners, while using generation located on-site from multiple renewable resources. The roadmap, to the extent economically feasible, sought to incorporate community-scale resources, created integrated technology applications, provided roles for the investor-owned utility, and to developed approaches that are

[1] Heschong Mahone Group, In., "The Road to ZNE: Mapping Pathways to ZNE Buildings in California." Pg. 68.

replicable.[2] One of the largest challenges in creating a roadmap was to do so while accounting for the "multiple sources of uncertainty" and to develop a model that provided a flexible framework that could accommodate change.

As it started its analysis, E3 posited several key questions that would need to be addressed in developing the roadmap. These included[3]:

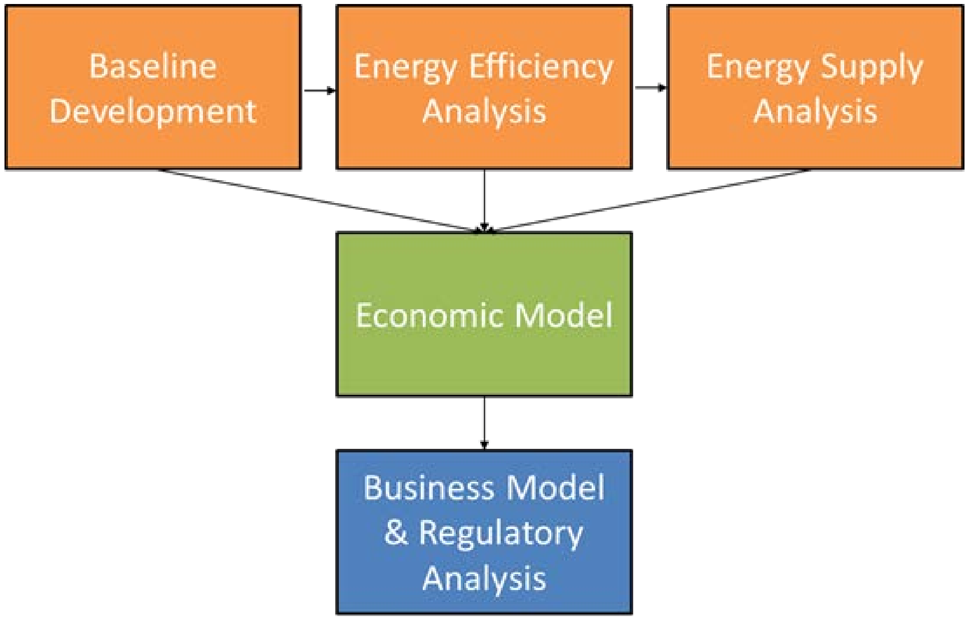
- What level of energy-efficiency is cost-effective in West Village homes?
- What kind and level of onsite renewable generation strategy is most cost-effective for the West Village?
- How can "advanced" energy end-use and supply technologies be employed for the West Village?
- Can storage and fuel cells be deployed economically?
- How should future uncertainty be treated in the West Village project?
- What role does resident behavior play in achieving ZNE at the West Village?
- What are the most beneficial regulatory change for the West Village project, and which, if any should be pursued?

2.3 Modeling Framework

There were three main components to the roadmap analysis: Baseline Home Development, Energy Efficiency Analysis and Energy Supply Analysis. These components fed into the Economic Model created by E3, which, in turn, informed the Business Model and Regulatory Analysis.

[2] Energy+Environmental Economics, UC Davis West Village Zero Net Energy Project, Single-family Homes Roadmap, p. 14.
[3] Id. p. 15.

Figure 1.Modeling Framework[4]



2.4 Baseline Home Development

To create an economic model, E3 first needed to determine a representative floor plan to use in its analysis. At the time E3 was making this determination, WVCP provided five potential floor plans. Since these were floor plans only and not fully detailed construction drawings, E3 made assumptions related to the window area of each floor plan. Plan 3 was selected as the base case home for analysis because it represented an average size in both floor area and window area.

Table 1. Floor Plan Specifications[5]

Floor Plan	CFA (square feet)	Window Area (% of CFA)
Plan 1	1,404	26%
Plan 2	1,587	25%
Plan 3	1,756	25%
Plan 4	1,874	23%
Plan 5	2,001	23%

[4] Id. p. 17.
[5] *Roadmap,* p. 32.

Once Plan 3 was selected as the base case, detailed modeling on energy consumption and energy production was undertaken. To account for the variability in home sizes, E3 developed usage multipliers to scale the base case consumption data.

Table 2. Natural Gas and Electricity Use Multipliers[6]

Usage Scenario	Usage Multipliers
Natural Gas – small home	0.850
Natural Gas – medium home	1.000
Natural Gas – large home	1.090
Natural gas – extra-large home	1.230
Electricity – small home	0.843
Electricity – medium home	1.000
Electricity – large home	1.057
Electricity – extra-large home	1.169

Project results assume 100 each of small, base and large homes with an additional 43 extra-large homes. It was also assumed that 60% of the homes would include an optional studio unit.

Working with DEG, E3 established the Base Case Energy use for the Baseline using both 2008 Title 24 and 2008 Title 24 + 15% (which means that the energy usage is 15% LESS than, or better than, under 2008 Title 24) which is the standard used for new construction within the City of Davis. The detailed assumptions are included in the *Single-family Homes Roadmap.*

Applying these assumptions, E3 established the estimated annual energy use in Baseline Homes.

Table 3. Estimated Annual Energy Use in Baseline Homes[7]

	Electricity (kWh)	Natural Gas (Therms)
Title 24	9,573	795
Title 24 + 15%	9,173	633

[6] *Roadmap,* p. 35.
[7] *Roadmap,* p. 37.

The Baseline Energy Use and the associated costs became the bench mark against which alternative business models could be judged.

2.5 Energy Efficiency Analysis

UC Davis and WVCP, working with Davis Energy Group and E3, undertook a comprehensive energy efficiency analysis to determine the optimal package of energy efficiency measures to incorporate in the design of the Faculty Staff housing at West Village. The guiding principle for this effort was "energy efficiency first," that is, incorporating all cost-effective energy efficiency into the building design before sizing the renewable energy necessary to meet the project's ZNE goals.

DEG started the process by modeling the proposed houses using NREL's BEopt software and EnergyPro. Using these programs, DEG was able to estimate the energy usage for Plan 3 in each of the four cardinal orientations. They modeled the energy usage assuming a 2008 Title 24 base case to establish a baseline for the analysis. For the purpose of evaluating individual energy efficiency measures, the West facing orientation, which resulted in the greatest total source energy use, was selected.[8] The South orientation was used for developing the hourly annual data in the evaluation of total community level energy use.

Once the baseline was established, DEG led the design team in an all-day design charrette. For the charrette, Plan 3 was used as the basis of evaluation and discussion.[9] The charrette focused primarily on establishing common project goals and discussing energy efficiency measures that, while technically feasible, might pose constructability or design issues. Some energy efficiency measures were rejected because of constructability or design problems.

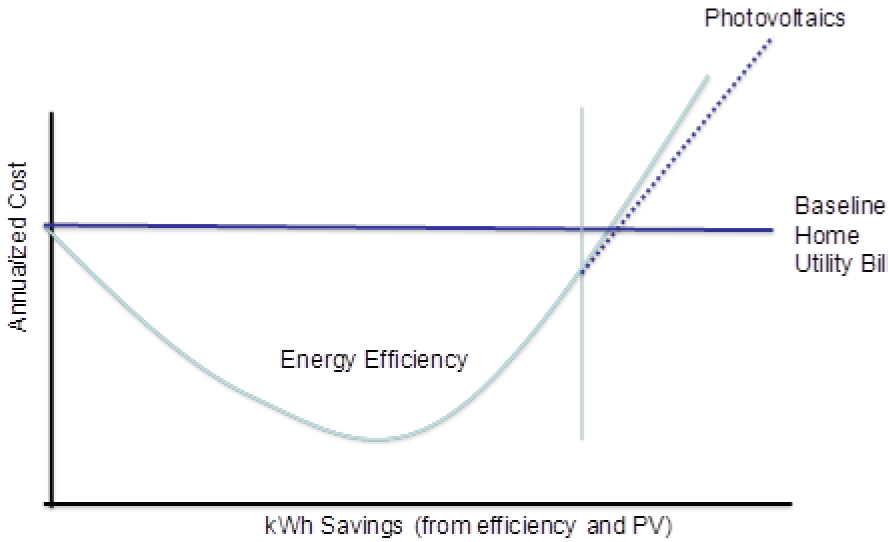
Those energy efficiency measures that were not eliminated at the design charrette were then evaluated by DEG from a cost efficiency standpoint. DEG evaluated 38 energy efficiency measures and estimated an incremental cost for each measure over what was required under Title 24.[10] This incremental cost was important because WVCP had no contractual obligation to build anything above and beyond Title 24. This incremental cost evaluation helped in evaluating the energy efficiency measures through the filter of "no higher cost to the developer."

DEG took the data from the incremental cost analysis and created energy efficiency measure packages. The levelized energy efficiency measures incremental costs were compared against a base case energy cost.[11] If the cost-effectiveness of an energy efficiency measure exceeded the estimated

[8] *Roadmap,* p. 44.
[9] *Roadmap,* p. 46.
[10] *Roadmap,* pp. 51-53.
[11] *Roadmap,* p. 54.

price of renewable energy, the energy efficiency measure was not included in the package.[12] This concept is best demonstrated in the graph that shows the tipping point for the installation of solar PV.

Figure 2. Illustration of Cost-Effectiveness Comparison between Electric energy efficiency measures and PV[13]



Based upon its analysis, DEG created two advanced packages: Advanced A and Advanced B. These packages were measured against the Title 24 base case and then the Basic Performance Package that WVCP was proposing (which was more energy efficient than the Title 24 base case). DEG provided data summarizing the energy usage with each of the energy efficiency measure packages and calculated the Source Energy Savings of the advanced packages when compared with the Title 24 base case and the Basic Performance Package.

[12] Id.
[13] *Roadmap,* p. 57.

Table 4. Total Annual Energy Use for Each Energy Efficiency Scenario[14]

Package	Annual kWh		Annual therms	
	Main House	Studio	Main House	Studio
Title-24	7,135	4,064	717	131
Title-24 + 15%	6,907	3,777	588	75
Basic Performance	5,436	3,177	495	72
Advanced Package A	5,118	3,116	438	64
Advanced Package B	4,873	3,005	414	64

Table 5. Source Energy Savings Compared to Title-24 and Title-24 +15% Base Cases[15]

Package	Source Energy Savings Over Title-24		Source Energy Savings Over Title-24 + 15%	
	Main House	Studio	Main House	Studio
Basic Performance	28%	29%	18%	14%
Advanced A	34%	31%	26%	17%
Advanced B	38%	33%	30%	19%

The last step in the Energy Efficiency Analysis was to evaluate the total package costs on an actual cost basis and then taking into account the net cost after incentives. These costs and incentives were current when this evaluation was performed in the summer of 2011.

[14] *Roadmap,* p. 72.
[15] Roadmap, p. 73.

Table 6. Total Package Costs Excluding Incentives versus the Title-24 and Title-24 + 15% Base Cases

Package	Incremental Cost versus Title-24		Incremental Cost versus Title-24 + 15%	
	Main House	Studio	Main House	Studio
Basic Performance	$5,395	$1,338	$4,320	$1,123
Advanced A	$5,052	$4,207	$3,977	$3,992
Advanced B	$10,080	$5,082	$9,004	$4,866

Table 7. Net Package Costs Including Incentives versus Title 24 and Title 24 + 15% Base Cases

Package	Net Incremental Cost versus Title-24	Net Incremental Cost versus Title-24 + 15%
Basic Performance	$2,667	$1,831
Advanced A	$3,390	$2,554
Advanced B	$8,719	$7,883

Taking into account the costs of the various packages and the available incentives, E3 recommended pursuing Advanced Package A as the preferred energy efficiency measures package.[16]

2.6 PV System Analysis

E3 also provided a PV System Analysis in their Roadmap report. Both a residential and community solar PV system were analyzed for the Faculty Staff portion of the West Village project. Working with DEG and CPR, E3 determined the projected usage and the total required PV capacity. The average annual home usage was about 6,800 kWh (including 60% of studio use).[17] Certain assumptions were made as to orientation, shading, tracking or non-tracking and the rate of degradation. Below is a table summarizing the PV modeling results including the LCOE for each proposed system.

[16] *Roadmap, p. 147.*
[17] *Roadmap, p. 92.*

Table 8. Overview of PV Modeling Results

	Rooftop	Community
Inverter	Xantrex 6 kW (Model XW6048-120/240)	Xantrex 6 kW (Model XW6048-120/240)
PV Array	Sunpower 100 W (Model PL-ASE-100)	SunPower 100 W (Model PL-ASE-100)
Orientation	West, 4:12 roof pitch (18^0)	South, 38^0
NZE Ratings (per generic home)	7.8 kW DC, 6.392 kW CEC-AC	6.7 kW DC, 5.491 kW CEC-AC
5-year Energy Production (per generic home)	51,427 kWh	51,597 kWh
Cost ($/kW, CEC-AC)	$7,418	$5,138
LCOE (2011$/kWh)	$0.1884	$0.1626
Current incentive levels	NSHP: $2.35/W (2012)	CSI: $0.09/kWh (2012)

These modeling results were fed in to the larger Economic Model developed by E3 as part of their Roadmap report. CPR produced annual utility bills using its Powerbill software. 180 usage scenarios were evaluated and bills were produced for each scenario. These bills are included as an appendix to the Road Map, which is attached as Appendix A.

2.7 Biogas Analysis and Electric Vehicle Analysis

E3 also analyzed two other variables that could ultimately impact the economic model and the roadmap recommendation: (i) the use of natural gas in the design of the Faculty Staff Housing; and, (ii) to what extent electric vehicles would be incorporated into the neighborhood.[18]

Gas-electric homes were the strong preference of the WVCP and UC Davis teams. In striving for a ZNE neighborhood, how would the natural gas usage be offset? E3 outlined three options for "netting" natural gas use:

- Produce and/or purchase biofuel
- Generate additional electricity to sell to the grid
- Generate additional electricity for electric vehicles to displace gasoline or diesel use.[19]

Based upon their analysis of the costs, E3 concluded that the simplest and most cost-effective option would be to purchase biogas offsets, with the biogas injected into the natural gas pipeline

[18] *Roadmap,* pp. 99-109.
[19] *Roadmap,* p. 100.

system, but not directly combusted at West Village.[20] Further, from a practical standpoint, E3 recommended that the biogas offsets be procured at the community level rather than at the individual homeowner's level.[21] Assumptions as to the incremental cost of acquiring these biogas offsets were incorporated as assumptions into the Economic Model.

Although automobiles were not part of the ZNE scope defined for the West Village Faculty Staff Housing, electric vehicles were included in the analysis that led to the Roadmap recommendations. [22] E3 used the "medium" penetration scenario under the EPRI study for the purpose of the Economic Model. [23] This means that by 2030, approximately 12.4% of the vehicles in the Faculty Staff Housing portion of West Village would be an electric vehicle.[24] Further, E3 made certain assumptions regarding vehicle miles traveled for the Faculty Staff Housing at West Village. In the analysis, it was assumed that 65% of EV's were owned by commuters and 35% by errand runners. [25] Assumed costs for each of these types of drivers were also included in the Economic Model that informed the Roadmap recommendations.

2.8 Potential Business and Regulatory Models

In the Roadmap, E3 evaluated seven ZNE business models that would be feasible under the current regulatory environment:

- **Rooftop, PPA:** This model combined rooftop solar PV under a power purchase agreement (lease).
- **Two Loops, 2013 Commercial Operations Date, and PPA:** This model incorporated two third-party financed community solar arrays with a 2013 operations date.
- **Two Loops, 2013 Commercial Operations Date, UC Davis + Tax Equity Financing:** Like the prior model, this model incorporated two community solar arrays with a 2013 operations date. The difference in this model is that UC Davis would construct and own the community arrays and seek a private tax equity financing partner to take advantage of the federal investment tax credit.
- **Two Loops, 2013 & 2015 or 2018 Commercial Operations Date, PPA:** This model incorporated two third-party financed community solar arrays but has varied the operations dates.
- **Two Loops, 2013 & 2015 or 2018 Commercial Operations Date, UC Davis + Tax Equity Financing:** Like the prior model, this model incorporated two community solar arrays with the

[20] *Roadmap,* p. 101.
[21] *Roadmap,* p. 102.
[22] *Roadmap,* p. 105.
[23] EPRI, Transportation Electrification: A Technology Overview, July 2011. Table 4-1 and Figure 4-3. Available at: http://my.epri.com/portal/server.pt?space=CommunityPage&cached=true&parentname=ObjMgr&parentid=2&control=SetCommunity&CommunityID=404&RaiseDocID=000000000001021334&RaiseDocType=Abstract_id.
[24] *Roadmap,* p. 105.
[25] *Roadmap,* pp. 106-107.

same operations dates but coupled this with UC Davis ownership and delivery with a tax equity financing partner.

- **Rooftop then Delayed 2017 Loop, PPA:** This model used a hybrid approach in which rooftop solar PV would be installed in the beginning of the project followed by a community solar array with third-party financing to be constructed in 2017.
- **Rooftop then Delayed 2017 Loop, UC Davis+ Tax Equity Financing:** Like the prior model, this model used a hybrid approach in which rooftop solar PV would be installed in the beginning of the project followed by a community solar array with UC Davis + tax equity financing to be constructed in 2017.

Table 9. Business Models and Sensitivities[26]

Business Models	Sensitivities
➢ Rooftop, PPA	**Home Construction Rate**
➢ Two Loops, 2013 COD, PPA	➢ 30 homes/year
➢ Two Loops, 2013 COD, UCD + Tax Equity Financing	➢ 60 homes/year
➢ Two Loops, 2013 & 2015 or 2018 COD, PPA	➢ 100 homes/year
➢ Two Loops, 2013 & 2015 or 2018 COD, UCD + Tax Equity Financing	**Learning Curve Progress Ratio[27]**
➢ Rooftop then Delayed 2017 Loop, PPA	➢ 75%
➢ Rooftop then Delayed 2017 Loop, UCD + Tax Equity Financing	➢ 90%

E3 took these models and adjusted them for each of the variables related to the home construction rate and the cost trajectory of PV. The results of E3's analysis area measured as net present value the cost difference West Village Faculty Staff homes and baseline homes from 2012-2024.[28] A positive NPV indicates that the West Village home was more economic, a negative NPV indicates that the West Village home was less economic.

[26] *Roadmap,* p. 118.
[27] The Learning Curve Progress Ratio is the ratio between initial costs and costs after a doubling of cumulative production value. A 90% progress ratio, for instance, would imply that a doubling of base year PV capacity would reduce costs by 10%. *Roadmap,* p. 112.
[28] *Roadmap,* p. 119.

Table 10. NPV of Incremental Costs for the Seven Business Models, 30, 60, and 100 Homes per Year, 90% Progress Ratio (M$)[29]

Home Constr Rate	EEM Package	Learning Curve	Two Loops 2013 COD PPA	Two Loops COD 2013 & 2015 (60) or 2018 (30) PPA	Two Loops 2013 COD UCD + Tax Equity	Two Loops COD 2013 & 2015 (60) or 2018 (30) UCD + Tax Equity	Rooftop PPA	Rooftop + Delayed 2017 Loop PPA
30	Proposed	90%	(2.5)	(2.6)	(1.7)	(1.4)	(2.5)	(1.0)
30	Adv A	90%	(1.7)	(1.8)	(1.0)	(0.7)	(1.7)	(0.3)
30	Adv B	90%	(2.6)	(2.7)	(1.9)	(1.6)	(2.5)	(1.1)
60	Proposed	90%	(2.0)	(1.8)	(1.2)	(1.0)	(1.3)	(1.0)
60	Adv A	90%	(1.2)	(1.1)	(0.5)	(0.3)	(0.5)	(0.2)
60	Adv B	90%	(2.2)	(2.0)	(1.5)	(1.3)	(1.4)	(1.0)
100	Proposed	90%	(1.7)	n/a	(0.9)	n/a	(0.2)	(0.8)
100	Adv A	90%	(1.0)	n/a	(0.2)	n/a	0.6	(0.2)
100	Adv B	90%	(2.0)	n/a	(1.6)	n/a	(0.4)	(1.3)

In this scenario, the only economic alternative was the Advanced A EEM package with a home construction rate of 100 homes per year.[30]

Table 11. NPV of Incremental Costs for the Seven Business Models, 30, 60, and 100 Homes per Year, 75% Progress Ratio (M$)[31]

Home Constr Rate	EEM Package	Learning Curve	Two Loops 2013 COD PPA	Two Loops COD 2013 & 2015 (60) or 2018 (30) PPA	Two Loops 2013 COD UCD + Tax Equity	Two Loops COD 2013 & 2015 (60) or 2018 (30) UCD + Tax Equity	Rooftop PPA	Rooftop + Delayed 2017 Loop PPA
30	Proposed	75%	(1.8)	(1.3)	(1.1)	(0.4)	0.2	0.6
30	Adv A	75%	(1.1)	(0.7)	(0.5)	0.2	0.9	1.3
30	Adv B	75%	(2.0)	(1.6)	(1.3)	(0.7)	-	0.3
60	Proposed	75%	(1.3)	(0.2)	(0.6)	(0.3)	1.0	0.9
60	Adv A	75%	(0.6)	(0.2)	0.1	0.4	1.8	1.5
60	Adv B	75%	(1.6)	(1.2)	(1.0)	(0.7)	0.8	0.9
100	Proposed	75%	(1.1)	n/a	(0.4)	n/a	1.8	1.0
100	Adv A	75%	(0.4)	n/a	0.2	n/a	2.5	1.7
100	Adv B	75%	(1.4)	n/a	(0.8)	n/a	1.4	0.6

In this scenario, all business models that begin with rooftop PV were economic, and the most economic case was the rooftop PPA with the Advanced A EEM package.[32]

[29] *Roadmap,* p. 121.
[30] *Roadmap,* p. 120.
[31] *Roadmap,* p. 122.
[32] *Roadmap,* p. 121.

Four clear trends were evident when reviewing these results: 1) building the homes faster was more economic because more homes are built before incentives decline or expire; 2) the economics were most difficult when PV cost declines were slow; 3) two loops were always less economic than either rooftop or rooftop + delayed loop; and 4) Advanced A EEM Package was always most economic.[33]

Table 12. Optimal Business Models and their NPV (M$) under Different Home Construction Rates and PV Learning Curve Progress Ratios[34]

Home Construction Rate	PV Cost Scenario (Progress Ratio)	Business Model	NPV (M$)
30 homes / year	Fast decline (75%)	Rooftop	0.9
		Rooftop, then delayed Community-scale	1.3
	Moderate decline (90%)	Rooftop, then delayed Community-scale	-0.3
60 homes / year	Fast decline (75%)	Rooftop	1.8
	Moderate decline (90%)	Rooftop, then delayed Community-scale	-0.1
100 homes / year	Fast decline (75%)	Rooftop	2.5
	Moderate decline (90%)	Rooftop	0.6

The rooftop approach had better economics and would face the least regulatory risk when compared with the other scenarios. The challenge of adopting a rooftop only approach was that there was no balancing element available for over-consumption or under-consumption by the homeowner. It will be difficult, if not impossible, to predict the size of the household for each home, not to mention how the behavior of the members of each household will affect consumption. Accordingly, the best developers and planners can do is to rely on models that make assumptions about average number of occupants in a household and consumption estimates. This means that hitting the ZNE goal becomes virtually impossible without a balancing mechanism, such as a community array, or an ability to purchase RECs to mitigate the impacts of over-consumption or under-consumption when compared with the energy models.[35]

E3 suggested two changes in regulatory policy that, if adopted, could greatly improve project economics. One suggestion was a Community Virtual Net Metering approach. An appropriately-sized

[33] *Roadmap,* p. 122.
[34] *Roadmap,* p. 123.
[35] *Roadmap,* p. 128.

community array would be installed and connected directly to the PG&E distribution system.[36] This approach would be similar to the VNM approach allowed for multi-family buildings, but would need to broaden the concept of a "Single Delivery Point."[37] Residents of West Village would subscribe to a portion of the community array and would be billed by PG&E for their consumption less their portion of the community array.[38] The ability to pursue this alternative would better the ZNE project economics by approximately $1.8 Million. Current regulations would not allow for this approach, and, the IOUs have successfully rebuffed any and all attempts to change these regulations. This issue is explored in more depth in Section 4.0, below.

The second suggested change would be a change to the rules related to the New Solar Homes Partnership ("NSHP"). When the Road Map was developed, incentives were offered to homebuilders on a house by house basis for the installation of solar for single family homes. This favored the installation of solar PV at the building scale rather than the community scale. If the NSHP incentives were allowed to be aggregated for a community solar PV array, this would provide for a much more cost-effective and economic solution. If the California Energy Commission allowed for aggregated NSHP incentives, this would translate in to a $3 Million (NPV) improvement to the West Village ZNE economics.[39]

2.9 West Village Roadmap

E3 concluded that the goal of achieving ZNE at no higher cost to the developer and no higher cost to the homeowner was nearly within reach. Based upon the financial modeling, the developer costs for constructing the ZNE homes were approximately $2,500 per home relative to a comparable home in the City of Davis, net of incentives. If these costs were passed on to the homebuyer, or covered in a UC Davis financing arrangement, the developer could actually achieve the goal of no higher cost. From the homeowner's perspective, the lifecycle costs were variable and difficult to predict. If PV cost reductions and home construction rates are slower, then the lifecycle costs of a ZNE home would be higher than a comparable home in the City of Davis. On the other hand, if PV costs were lower and the homes were built out more quickly, a ZNE home would cost less than a conventional home across the street in the City of Davis.

[36] *Roadmap,* p. 129.
[37] *Roadmap,* p. 130.
[38] Ibid.
[39] Ibid.

Based upon their analysis and evaluation of the various systems necessary for a ZNE home, E3 recommended the following roadmap.[40]

- Pursue mid-level EEM package Advanced A.
- Because of regulatory obstacles to community-based solar, use rooftop solar strategy for electricity generation through 2014, then re-evaluate.
- Use tradable RECs and offsets for demand/supply balancing of PV and biogas, given the challenge of forecasting future electricity and natural gas demand and solar PV degradation.
- Pursue natural gas homes with biogas offsets to reduce costs, improve system efficiency, and improve marketability of homes.
- Foster electric vehicle adoption; car share and /or in-home charging can improve economics and reduce overall carbon footprint of the community.
- Explore feedback mechanisms to manage energy consumption post-construction.
- Explore a smaller, community-based system coupled with downsizing of rooftop PV to improve customer economics and optics.

3.0 The Role of the IOU in Alternative Business Models

E3 considered potential roles for PG&E in the ZNE models for the Faculty Staff Housing. They are summarized in the table, below.

Table 13. Potential Utility Roles[41]

Area	Role
Solar PV	Tax equity participation in solar PV ownership
Biogas	Biogas offset provider
EV	Pilot program for submetering of EVs
Administrative	Billing mechanisms, such as on-bill energy efficiency financing
Other	Participation in West Village visitor center or lab house

3.1 Tax Equity Participation

[40] Energy+Environmental Economics, *UC Davis West Village Zero Net Energy Project, Single-family Homes Roadmap, p. 147.*
[41] *Roadmap,* pp. 132-134.

PG&E could participate as an investor in the provision of solar PV equipment in exchange for payments, including federal ITC and 5-year MACRS tax depreciation.[42] Another for-profit investor could also serve this role. This ensures that the tax benefits allowable for a renewable energy generation project will be optimized.

3.2 Biogas Offset Provider

PG&E could sell biogas offsets to the West Village project. West Village residents would pay a premium to PG&E for biogas rather than natural gas that would normally be provided to residents. [43]

3.3 Pilot Program for Submetering of EVs

Currently, there is no submetering program for EVs, which means that under tiered rates, vehicle charging can move a homeowner to a higher rate tier. Submetering the EV charging station could significantly improve EV economics and potentially encourage a faster penetration of EVs at West Village. West Village could provide PG&E with a useful opportunity to pilot an EV Submetering program.[44]

3.4 Billing Mechanisms

There are two potential mechanisms that could provide a program enhancement to the West Village project: on-bill financing and on-bill billing. With on-bill financing, PG& E would provide the financing for either the solar pv or the incremental costs related to the energy efficiency measures. The costs would be amortized over the useful life of the solar pv or the energy efficiency measures and the homeowner would have a line item on their PG&E bill each month for the "loan" payment. With on-bill billing, financing for the solar pv or the incremental cost of the energy efficiency measures would be billed by PG&E (perhaps for a small service charge) and the payments would flow through to the entity providing the financing. The advantage to either of these mechanisms is that all of the homeowner's utility costs would be on one bill, rather than a separate payment through an HOA or through the residential lot lease. Based upon preliminary conversations with PG&E, this would be extremely difficult to implement through their billing department and IT specialists. Because the Faculty Staff housing portion of the project has been delayed, further conversations were not pursued.

3.5 Participation in West Village Visitor Center or Lab House

There have been discussions of creating a West Village Energy Initiative Visitor Center at the West Village Square. The goal of having a Visitor Center would be to provide education and outreach related to the West Village project and its goal of attaining ZNE. PG&E could provide funding to build out the Visitor Center, staff the Visitor Center or underwrite exhibits in the Visitor Center.[45]

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[42] *Roadmap,* p. 137.
[43] Id.
[44] *Roadmap,* p. 137.
[45] *Roadmap,* p. 138.

The West Village Energy Initiative team also discussed having a lab or demonstration house that would provide UC Davis researchers and other industry experts with a house that could be used to demonstrate emerging technologies. PG&E would be a natural industry partner for a demonstration or lab house and could provide underwriting for the demonstration/lab house. In addition, PG&E could provide valuable data to UC Davis researchers to aid in their research projects.

The West Village Energy Initiative team had preliminary conversations with key PG&E staff about underwriting opportunities, but these have not moved forward with the delay in the Faculty Staff housing portion of the project.

4.0 Regulatory Barriers to Adopting Alternative Business Models

4.1 Introduction: Regulatory Barriers to Adopting Alternative Business Models

Creation of the largest Zero-Net Energy community in North America required the implementation of business models that had not been previously tested on large-scale residential development in California. The business models evaluated for the West Village project pushed the boundaries of financial feasibility for the incorporation of energy efficiency and renewable energy generation (RG) in market-rate residential construction, and development of the project revealed regulatory limitations that constrained the project team from pursuing the best economic and technical solutions available. At the time of design, the impact of these regulations was the adoption of RG solutions that would allow the project to attain ZNE performance but would do so at higher cost than required and with less efficiency than would be possible with an appropriate regulatory structure aimed at supporting ZNE construction. As a result of their desire to attain ZNE performance, the developers of West Village were willing to accept these solutions as the best available options. It is questionable if development teams working in different contexts would be willing or able to adopt such solutions and create a profitable and widely marketable product. Fortunately, several of the regulations that posed barriers to the West Village team appear to have been addressed by recent policy innovations that have reshaped the regulatory landscape of incorporating RG into new residential communities. However, the late emergence of these policies means that extensive analysis will be required to determine one or more new business models for West Village. Additionally, although policy innovations have occurred, several remaining policies will continue to create barriers to ZNE deployment in California. The regulatory barriers that existed at the time of project planning (2008-2010) are discussed, below, as are the impact that they had on the project's design, policy innovations that have developed since that time, and remaining regulatory barriers to community-scale ZNE development.

4.2 Background/History

Initial planning for the West Village project began in 2000, but the concept of designing the project as a ZNE community did not emerge until 2007 as the result of an analysis of the economic feasibility of incorporating renewable generation into the project. This analysis, led by the UC Davis Energy Efficiency Center (EEC), did not initially propose ZNE but included an analysis examining the financial feasibility of including renewable generation systems. Team members from the University, and

WVCP continued to explore the concept of combining deeply efficient buildings with renewable generation systems, and in 2009 enlisted Chevron Energy Solutions (CES) to perform a technical and economic analysis that included an analysis and pathway to achieving ZNE performance. Central to this concept was the constraint that ZNE be achieved with no added cost to the project's developer, future tenants, or homeowners. Articulating this broad conceptual goal into a financially attractive development proposal required additional detailed study of the economics of energy efficiency measures, renewable generation, available incentive programs and regulatory constraints.

This effort was undertaken as part of this Grant by a team consisting of the project developer, UC Davis personnel, Davis Energy Group, Clean Power Research, andE3. As discussed in more detail, above, the team produced the, "UC Davis West Village Zero Net Energy Project: Single-Family Homes Roadmap" (Roadmap). The Roadmap, as the name suggests, guided the physical design of the project and defined the business model that would be used to achieve ZNE. Major project elements impacting ZNE goals were used as variables and examined under multiple scenarios representing possible courses of action available to the development team. These components included:

- Alternate approaches to energy efficiency
- Various scenarios of incorporating renewable generation
- Varying timelines for home construction
- The effect of future price changes of photovoltaic systems
- The effect of electric vehicles on electrical demand

The results of this analysis were presented in terms of Net Present Value (NPV) relative to a "baseline" non-ZNE home constructed in Davis. Broadly, the results of the analysis indicated that the highest NPV occurred with a rapid (100 homes/year) construction schedule, rooftop mounted photovoltaics (PV), and a rapid decline in the price of PV systems. Development alternatives incorporating community-scale PV systems and/or slower rates of construction resulted in lower, and in some cases negative NPV.

As indicated in the Roadmap, the determination of NPV for various development alternatives was based on the landscape of regulations and incentives that existed at that time. Due to the time that has elapsed since the creation of the Roadmap this landscape has changed, but the business models evaluated for the implementation of ZNE at West Village remain based on historical information. This may be inevitable for projects with multi-year planning cycles, as energy policy is constantly evolving and incentive programs have limited lifespans. However, it remains instructive to examine the regulatory factors that led to the current arrangement and to determine if further policy adjustment is needed to advance the business case for ZNE single-family homes.

4.2.1 *Achieving Community-Scale ZNE*

The West Village development consists of multifamily, mixed-use, and community buildings in addition to 343 planned single-family homes for UC Davis faculty and staff. The multifamily portions of the project will be owned by the developer and leased to tenants, while the single family homes will be sold to University faculty and staff under residential lot leases. The same developer is undertaking all portions of the project, and at the time of this writing the single-family homes have yet to be constructed. The goal of ZNE applied to the entire project, although different approaches to RG were used in the multifamily buildings and single-family homes. Developer-owned rental properties provided the owner with a relatively large degree of control over the systems and appliances within the buildings, and provided some degree of control over tenant behavior. For-sale single-family homes, on the other hand, presented a challenge in terms of attaining ZNE as there is no way to accurately predict or control future occupant behavior, nor the equipment or appliances that the future homeowners will own, or the size of their household. Because of this uncertainty, estimates have been made about future energy loads in the homes. The consultant team reviewed historical residential energy use trends (based on the U.S. Department of Energy's Build America Program) and used this information to create energy models for each of the single-family housing types. Energy use was totaled for all single family homes and the determination made that a 2.6MW PV system would be required to offset the estimated energy demand. As suggested by the Roadmap, energy demand in excess of generation could be offset by the purchase of Renewable Energy Credits (RECs) by the community, while energy production in excess of consumption would result in credits on individual homeowner's electrical bill via Net Energy Metering (NEM) arrangements between each homeowner and the utility.

Given the Roadmap's recommendation that renewable generation capacity be provided as individual rooftop systems due to financial considerations, the net result was that the project's developer would bear the expense of the PV system (less incentives) at the time of construction and pass this expense on to the homebuyer. The homebuyer would realize savings in monthly electricity bills as a result of a NEM arrangement, and this savings would accrue over time to offset the cost of the PV system and eventually provide financial benefit for the owner. The arrangement of PV systems behind each homeowner's electrical meter would make the purchase of RECs at a community level difficult given the level of information sharing that would be required to facilitate a community-scale purchase of RECs; however, because the homeowners will each be subject to a residential lot lease with the university, it is possible to include requirements about sharing energy usage as part of the lot lease. Purchase of RECs at the scale of individual homeowners would be limited to those that consumed more energy than their PV system produced and could be required as a condition under the residential lot lease.

4.3 West Village Regulatory Barriers

California has long been a leader in adopting innovative policies to advance energy efficiency and renewable generation. The success of these policies has been evident on multiple fronts, from California becoming the nation's largest market for PV to the relative flat-lining of per-capita energy consumption since the late 1970's.[46] California's energy policies have achieved many of their intended results through a blend of policy innovation and market creation. As the state moves into the future with the Big Bold Energy Goals of the California Energy Commission and CPUC,[47] some of the policies that have helped the state achieve success in the past may act as a barrier to future progress, particularly with respect to ZNE construction and the widespread integration of distributed renewable generation. Net Energy Metering (NEM), Virtual Net Metering (VNM), Rule 18, and the structure of incentive programs are examples of regulatory areas that created barriers to the adoption of the best financial and technological approaches available at West Village.

4.3.1 Net Energy Metering

California's Net Energy Metering (NEM) policy allowed owners of RG systems under 1MW in size to connect the system "behind the meter" of their home and receive credit for electricity generated in excess of their consumption. Credits accrued to the homeowner at the retail electrical rate, which acts as a direct offset to energy purchased from the utility grid. These credits and the subsequent reduction in the amount the homeowner pays to the utility can offset the purchase price of the RG system over time. Provisions of the NEM regulations stated that only renewable generation systems that are smaller than or equal to the estimated annual energy consumption of the home are eligible for NEM arrangements. Energy consumption of a new home is calculated based on the home's design (including the types of appliances and fixtures in the home) and assumptions regarding how the home will be used, based on historical averages for California. These regulations are intended to restrict a homeowner from becoming a net generator of electricity on an annual basis. While the regulations helped to ensure that all homeowners financially contribute to maintaining the services of the electrical grid, they are at odds with the requirements for building and maintaining a ZNE home.

To achieve a net-zero energy balance on an annual basis, renewable generation systems must be sized equal to a home's anticipated energy demand over a year, and this balance must be maintained over the lifetime of the home. Accurately anticipating the size requirements of a PV system on a for-sale, single family home is difficult as these properties have a large range of possible energy use profiles. The number of occupants, appliance types and use patterns, age, occupation (work at home, student, professional, etc.), and personal preferences all factor into how much energy will be consumed by a home, and none of these factors is controllable as a function of building or PV system design. NEM regulations use estimated energy use rates to determine the maximum size of a PV system allowed and do not fully account for variability in how the home is ultimately used. This creates a situation whereby home energy use may consistently exceed energy generation, making ZNE goals unattainable.

[46] Adrienne Kandel, Margaret Sheridan and Patrick McAuliffe, *A Comparison of per Capita Electricity Consumption in the United States and California* (Pacific Grove, California: California Energy Commission, August 2008), p. 16 <http://www.energy.ca.gov/2009publications/CEC-200-2009-015/CEC-200-2009-015.PDF> [accessed 12 January 2014].

[47] 'California Energy Efficiency Strategic Plan: January 2011 Update' (California Public Utilities Commission, 2011) <http://www.energy.ca.gov/ab758/documents/CAEnergyEfficiencyStrategicPlan_Jan2011.pdf>.

In addition to limiting RG system size to 1MW and to a home's estimated energy consumption, NEM regulations (AB920-Net Surplus Compensation[48]) stipulate that NEM customers that generate electricity in excess of demand (averaged over a year) are eligible for reimbursement at a rate calculated by each utility. In 2010, the reimbursement rate for excess electricity generated from NEM customers was four cents per kilowatt-hour.[49] This reimbursement rate was well below the retail rate that customers received in an NEM arrangement. This low rate of reimbursement created the conditions such that systems were more likely to be undersized, as the rate of return for investment in increased generation capacity beyond what is needed for ZNE is extremely low. Thus, the builder of a home designed to standards of high efficiency (such as those at West Village) is incentivized to provide the smallest RG system possible to meet annual energy requirements, even if this system is well below the 1MW NEM cap, or if a larger system were allowed under other NEM provisions. The net effect of this has been to discourage including a buffer in sizing the system for ZNE, which may be necessary given the variability in use discussed above.

Due to limits on the size of renewable generation systems allowed, NEM regulations limited the ability of a ZNE project to remain energy-neutral over its lifetime. Degradation of PV systems is commonly estimated to occur at a rate of approximately 0.5% per year[50]. The result of this is that West Village's PV arrays will operate at approximately 89% efficiency after 25 years, which is the warrantied lifespan of the systems. Unless system output is increased by the addition of PV modules during this timeframe, the difference between energy consumption and production will progressively increase due to declining output from the aging PV system (all other factors remaining equal). Degradation is common to all PV systems, and due to the dominant role PV will play in the state's goals for widespread ZNE construction, the loss of system efficiencies over time may require incentive programs and NEM arrangements that allow PV systems to be oversized to achieve policy goals. Adjustment of incentive programs at the state and federal levels to encourage the upsizing of PV systems at the time of initial purchase, or incentive programs that provide for expanding system capacities during a project's lifetime could address this issue. For their part, PV manufacturers have improved efficiency durability over the past 20 years and research and development of improved solar technologies have been made by the U.S. government and private industry on an ongoing basis.[51]

[48] California Public Utilities Commission, 'California Public Utilities Commission: Net Surplus Compensation', *Net Surplus Compensation (AB 920)*, 2011 <http://www.cpuc.ca.gov/PUC/energy/DistGen/netsurplus.htm> [accessed 12 January 2014].
[49] California Public Utilities Commission, 'Net Surplus Compensation FAQ's' (California Public Utilities Commission) <http://www.cpuc.ca.gov/NR/rdonlyres/C085BDE6-7DC1-4FD8-8208-52300A082672/0/FAQs_NSC_91411.pdf> [accessed 13 January 2014].
[50] Dirk C. Jordan and Sarah R. Kurtz, *Photovoltaic Degradation Rates - An Analytical Review* (NREL, June 2012), http://www.nrel.gov/docs/fy12osti/51664.pdf.
[51] Dirk C. Jordan and Sarah R. Kurtz.

Climate change also represents a large variable in the ability of a project to achieve ZNE status over a significant timespan. Historical regional weather variability is accounted for in the climate profiles used by the energy modeling software that is used to determine a building's future energy consumption, but warming or cooling of longer-term climate trends will impact the energy use of buildings by creating higher demand for space conditioning. Because these two components together will account for approximately 28% of energy use in the single family homes at West Village,[52] a small increase to either building service can have notable impacts to overall building energy consumption, and thus impact a project's ability to maintain ZNE status without corresponding adjustments to the energy generation capacity of the PV system.

NEM regulations also created a financial barrier to the implementation of community-scale renewable generation. Although the lack of VNM arrangements for single family homes prevented homeowners from being credited directly for energy produced by a community PV array, alternate arrangements may be possible that would allow the use of a community-scale system to benefit individual homeowners. One such arrangement is a community-scale PV system fed directly into the grid, with energy purchased by the utility via a Power Purchase Agreement (PPA). Revenue generated from the sale of this electricity would offset the cost of the PV array, and eventually generate revenue for the community once the costs of the array had been fully recovered. Due to the restrictions that existed in VNM regulations at the time of design, this arrangement was not possible for reasons previously mentioned, including a 1MW system size cap. More significantly, the utility's PPA rate of four cents/kilowatt hour was deemed to be too low to provide reasonable payback period for a community PV array, and would have created additional costs for the developer and homebuyers. As a fundamental goal of the West Village project is to achieve ZNE at no added cost to either of these parties, NEM regulations made the use of a community-scale PV array economically infeasible.

4.3.2 Virtual Net Metering

Virtual Net Metering (VNM) "is a tariff arrangement that enables a multi-meter property owner to allocate a solar system's energy credits to other tenants."[53] This arrangement allows the use of a single community-scale PV system to serve the needs of multiple homeowners. As described in the Roadmap, such community-scale PV installations offered significant financial and performance benefits over individual rooftop systems. These benefits included reduced cost of construction and maintenance as well as better alignment of renewable energy output and a community's energy consumption. As opposed to a single small PV array being permanently paired to a single home, the use of a community-scale PV array would allow energy output to be more easily balanced with community consumption in that variations in energy output over time would be more easily matched with variations in the energy demand of multiple homes. At the time of the design of West Village, California's regulations allowed for

[52] Bill Dakin, P.E., Marc Hoeschele, P.E. and Christine Backman, 'UC Davis West Village Community Energy Efficiency Study' (Davis Energy Group, 2010).
[53] 'California Public Utilities Commission | Virtual Net Metering', *Virtual Net Metering*, 2011 <http://www.cpuc.ca.gov/PUC/energy/DistGen/vnm.htm> [accessed 6 January 2014].

VNM arrangements for low-income multi-family housing only, under the MASH program (VNM regulations have since been revised, as discussed on page 34). Alternate arrangements for assigning production from a community-scale renewable system to individual user's accounts are conceivable, such as directly wiring portions of a community PV system to each resident's home. As discussed in the Roadmap, such approaches would add construction cost and would negate the financial savings of a community-scale system. For these reasons, it was determined that PV systems mounted to the rooftop of each home provided the most viable path forward in terms of regulatory compliance, although this arrangement did not result in the optimal use of RG resources in terms of efficiency or long-term economic performance.

4.3.3 Rule 18

The CPUC's Rule 18 creates a direct relationship between a utility company and the end user of electricity.[54] The Rule states that owners of multifamily residential buildings cannot charge building occupants for electricity; in other words, a building owner cannot act as an intermediary agent between the utility and the customer. At West Village this rule impacted the implementation of renewable generation systems in a number of ways. At the multifamily portions of the project, the Rule resulted in the project's developer acting as the customer of record for all utilities, thus removing the financial incentive for energy conservation from building tenants, an issue that the developer is still working to resolve following completion of that phase of work. The 343 single-family homes were also impacted by Rule 18, in that it created barriers to the use of a community-scale renewable generation system.

The traditional arrangement of electricity distribution, whereby each individual home has its own electrical meter, was only one possible scenario for providing electrical services. Alternate arrangements may be possible, and the West Village project offered the opportunity for innovative solutions in this respect. Because the project is located on University of California land, one possible arrangement would be that the University would provide electricity to residents and bill them for use. This energy could be supplemented or offset completely with a community-scale renewable generation system, thus aiding the entire community in achieving the goal of ZNE. Alternatively, another entity such as an HOA or LLC formed by the community could serve this role. Such an arrangement would also help to foster community involvement and raise awareness of energy generation and consumption, which are also important goals of the West Village project. Because either of these arrangements would rely on a third party to act as the billing agent for electricity however, they were in conflict with Rule 18 and therefore not permitted.

4.3.4 Incentive Programs

All forms of electricity generation involve up-front capital expenditures that are recovered over time via receipt of NEM credits or by the sale of surplus electricity. The amortized cost per unit of producing electricity relative to what that electricity would have costs from the grid determines the rate

[54] Brian K. Cherry, 'Electric Rule No. 18: Supply to Separate Premises and Submetering of Electric Energy' (PG&E, 2010) <http://www.pge.com/tariffs/tm2/pdf/ELEC_RULES_18.pdf> [accessed 20 November 2013].

of payback for the particular system. Lower generating costs typically equals faster payback and are a more attractive investment than systems with longer payback times. Incentive programs sponsored by the state and federal government are aimed at reducing the cost to purchasers of renewable systems and have played a large role in determining the selection and configuration of renewable generation systems at West Village.

The developers of West Village took advantage of state and federal incentive programs in developing the business model for the project. At the state level, the New Solar Homes Partnership (NSHP) was anticipated to be used to support the purchase of roof-mounted PV systems for each home. At the federal level, the single-family portion of the project was designed to take advantage of accelerated depreciation and Investment Tax Credits (ITC). ITC rates are currently worth 30% of total system cost.[55] The project developer will likely use the accelerated depreciation benefits directly, but will need a third party investor with an appetite for tax credits to gain benefit from this incentive. The need to introduce a third party into the purchase of renewable generation systems increases transaction costs for the developer.

Following the financial crises of 2008, the 1603 Treasury Grant program was established whereby purchasers of renewable generation systems could choose to receive a cash grant in lieu of tax credits for up to 1/3 the cost of a renewable generation system. This program expired on December 31, 2011, after awarding $11.6 billion dollars to almost 38,000 projects.[56] West Village's developer took advantage of this program to assist with funding of the renewable generation systems for the multifamily portion of the project, but was unable to utilize it for the single-family portion of the project that had not yet started construction.

The NHSP program is intended to fund rooftop-mounted solar systems in new construction and provides funding for up to 30% of the cost of the PV system. The program is designed for single-family homes and as such does not provide awards for community-scale PV systems. The California Solar Initiative (CSI) is the state's other major solar energy incentive program and is designed for "…existing homes, existing or new commercial, agricultural, government and nonprofit buildings".[57] The program does not address new home construction, multifamily buildings, or community-scale renewable generation systems.

As noted previously, the use of community-scale PV systems would offer superior energy performance, construction cost efficiency, and more achievable attainment of ZNE for a community

[55] 'DSIRE: Database of State Incentives for Renewables & Efficiency', *Federal Incentives/Policies for Renewables & Efficiency* <http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=US37F> [accessed 13 January 2014].
[56] John Harper and Michael Mendelsohn, '1603 Treasury Grant Expiration: Industry Insight on Financing and Market Implications' (NREL, 2012) <http://www.nrel.gov/docs/fy12osti/53720.pdf>.
[57] 'About the California Solar Initiative (CSI) - Go Solar California', *About the California Solar Initiative (CSI)*, 2007 <http://www.gosolarcalifornia.org/about/csi.php> [accessed 26 November 2013].

than what would be feasible with individual rooftop PV systems. However, the lack of incentive programs for community-scale systems effectively would increase their cost, thus limiting their deployment, which would have consequences for the implementation of ZNE communities in the state.

4.3.5 Advice Filing

Advice Filings are a method for entities to petition the CPUC to allow for deviations from current utility regulations. The West Village project team developed a number of innovative concepts for the implementation of renewable generation that would have maximized the financial and technical performance of these systems, but which also deviated from then-current regulations and would have required consent from the CPUC prior to implementation. Typical of market-driven private development projects, the schedule of West Village was optimized for the rapid design and delivery of housing, with no "float" to allow the team to pursue regulatory deviations. For this reason the team did not pursue an Advice Filing at the time of design, and instead attempted to work within the framework of existing regulations.

In hindsight, the development team and the West Village project as a whole did have sufficient time to pursue an Advice Filing, as the project's developer has yet to begin construction on the single-family portion of the project. It is unknown at this time when the developer will choose to commence construction, or if the previously developed business plan for the integration of renewable generation will be modified in light of recent policy innovations.

4.3.6 Utility Policy

Construction of residential developments requires coordination between the project developer and utility provider to ensure that all needed utility services are available in a timely manner and that the utility company has the capability to serve the new loads created by the development. Utility companies have established procedures for establishing service on new developments, a process that begins early in the design phase of a project and continues through project occupancy. Involvement of the utility company requires a non-refundable deposit by the developer, which allows the utility to perform a number of functions for the project, including:

- Performing an analysis on the grid infrastructure serving a project and conducting any off-site upgrades that are required prior to a project coming on line;
- Review of plans for conformance with utility company standards;
- Inspection of utility infrastructure during construction (the developer is responsible for trenching, conduit installation, and purchase of transformers or other equipment required for the site);
- Provision and installation of electrical and gas meters;
- Pulling of conductors through the site infrastructure to each meter, and
- Energizing the system.

Utilities calculate the price that a developer must pay based on the size of the project and the amount of system upgrades that will be required. Developers are typically presented with two different prices by the utility:

A. A higher price, for which the developer would receive rebates as individual accounts (meters) are activated in the name of the new homeowner, and,

B. A lower price, for which the developer would receive no rebates. This price is approximately 50% of scenario A, although exact percentages vary on each project and are calculated by the utility.

Under scenario A, rebates per home are small relative to the total deposit paid to the utility, but are typically calculated by the utility to result in lower total fees for the developer once all meters have been activated and all rebates provided. In this way, utilities incentivize developers to pay a large down payment which is then distributed back to the developer incrementally as the project comes on line. Inclusion of renewable generation systems configured on the customer's side of the electrical meter in an NEM (or VNM, in the case of multi-family buildings) agreement do not impact the utilities' involvement or pricing, as this work is carried out by the developer.

Innovative applications of renewable generation systems such as those proposed at West Village are important to extend the boundaries of feasibility for ZNE construction. Safe, cost-effective and efficient arrangements of renewable generation systems that are attractive to developers from a financial standpoint are needed to facilitate widespread deployment of ZNE construction and meet the state's goals for ZNE attainment. Utility policies that allow flexibility in these matters without penalizing developers for creating atypical arrangements are needed that support these goals.

4.4 Recent Policy Innovations

4.4.1 SB 43

California Senate Bill 43 (Wolk) was approved by Governor Brown on September 28, 2013 and became law on January 1, 2014. The legislation enacts the Green Tariff Shared Renewables Program, which requires regulated utilities with more than 100,000 customers, "to implement a program enabling ratepayers to participate directly in offsite electrical generation facilities that use eligible renewable energy resources…"[58] The effect of SB43 will be to allow utility customers to purchase up to 100% of their energy from off-site, renewable sources. Adoption of this option by residents of West Village may simplify the process of balancing energy use with renewable energy production. Prior to passage of this bill, the West Village Roadmap proposed that such balancing could occur with the purchase of RECs. The purchase of RECs may now be unnecessary.

[58] Wolk, 'SB-43 Electricity: Green Tariff Shared Renewable Program' <http://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201320140SB43> [accessed 7 January 2014].

4.4.2 AB 327

Assembly Bill 327 (Perea) was approved by the Governor on October 7, 2013 and became law on January 1, 2014. AB 327 impacts NEM regulations and allows the CPUC to consider revisions to tiered utility rate structures, specifically those of low-income customers as well as the rates of the largest users of electricity.

AB 327 revises several structural issues of existing NEM regulations that acted as barriers to increased use of distributed renewable generation and adversely affected goals for ZNE deployment. Primary among these is that the current NEM regulations, set to expire on December 31, 2014, would be extended to July 1, 2017. The bill provides specific NEM caps for each of the major investor-owned utility companies (IOU), and states that the IOU's must offer NEM agreements to their customers until these caps have been met, or until the NEM expiration date (July 1, 2017), whichever occurs first. After that date, a "NEM 2.0" program will begin, with several significant departures from current NEM regulations. The revisions that are applicable to ZNE deployment include:

Removal of 1MW size limits from NEM agreements
NEM 2.0 eliminates the size limitation of 1MW for individual renewable generation systems. Constraints to NEM agreements imposed by a home's projected energy consumption are not affected; therefore the impacts of this provision on individual homeowners may be limited. However, removal of the 1MW limitation, in conjunction with revisions to Virtual Net Metering regulations, may create financial incentives for purchase of community-scale systems capable of serving multiple homes. Whether or not these financial incentives materialize is dependent on the implementation of new rate structures under AB 327, which are at the discretion of the CPUC and are not known that this time.

Removal of utility caps to NEM
Under NEM 2.0, the number of systems allowed to connect to the utility grid under NEM agreements, and the aggregate generating capacity of those systems, will be unlimited. Removal of utility caps will allow increased use of NEM agreements, and may increase the deployment of local renewable distributed generation sources. Allowing for increased deployment of these renewable sources works to the advantage of ZNE construction, which is dependent upon available renewable energy. Similar to removal of 1MW size limitations, the effect of the removal of utility caps will be contingent on revisions to utility rate structures, which are not yet known.

Extension of current NEM agreements
Current NEM customers, and those that enroll prior to the end of the current NEM program, will have their NEM agreements extended to protect them from incurring new fees or experiencing benefit reductions that may occur under NEM 2.0. These provisions may encourage customers not yet enrolled in an NEM agreement to do so prior to the expiration of NEM 1.0.

The revisions to the NEM regulations that AB 327 creates are ostensibly aimed at increasing the quantity of renewable generation in California that is covered with an NEM agreement. However, other provisions of the bill that are intended to create a fair financial environment for utility companies and those utility customers that don't participate in an NEM agreement are controversial among solar energy advocates. Under AB327, current tiered-rate structures would be “flattened”, resulting in higher rates for small users and lower rates for large users of electricity. Additionally, AB 327 allows the CPUC to consider a uniform charge of up to $10.00 per month for all ratepayers to offset the distribution of utility company costs of energy delivery. Some advocates for solar energy are opposed to these provisions, with some claiming that these provisions will remove financial incentives for the purchase of renewable generation systems, while others argue that current NEM regulations create a hidden subsidy for participants in NEM arrangements that should be removed. The CPUC has been tasked with implementing revisions to electrical rate structures, and it remains to be seen how any revisions will impact the deployment of renewable generation via NEM agreements in the future.

4.4.3 Virtual Net Metering

As noted previously, Virtual Net Metering (VNM) “is a tariff arrangement that enables a multi-meter property owner to allocate a solar system's energy credits to other tenants.”[59] VNM was initially intended for use in low-income housing under the CSI’s Multi-Family Affordable Solar Housing (MASH) program, but was expanded in 2011 to include all multi-tenant properties and all types of renewable generation.[60]

Presently no regulation exists that would apply the principals of VNM to single family homes connected to an on-site, community scale source of renewable energy. Although SB 43 and Community Choice Aggregation programs (AB 117, passed in 2002 and implemented CCA’s in the state[61]) allow utility customers to opt to purchase energy from renewable sources or energy from entities other than the state’s IOU’s, respectively, neither bill provides for the purchase of electricity from directly from renewable sources located on site and owned by a third party.

4.5 Policy Recommendations

1. Create a single-family home equivalent of Virtual Net Metering to allow multiple private utility customers to share the output of a community-scale renewable generation system.
2. Remove limitations to system sizes in Net Energy Metering agreements based on home energy consumption levels.

5.0 Implementation of Recommended Business Model

As of the date of this Report, UC Davis and WVCP have not reached agreement on the terms of the Sub-Phase Lease Agreement for the construction of the Faculty Staff Housing at West Village. Without a Sub-Phase Lease Agreement there can be no construction project, and with no construction

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[59] ‘California Public Utilities Commission | Virtual Net Metering’.
[60] ‘DSIRE: Database of State Incentives for Renewables & Efficiency’, *California Net Metering*, 2013 <http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=CA02R&re=0&ee=0> [accessed 13 January 2014].
[61] Migden, *Assembly Bill No. 117. Chapter 838*, *California Public Utilities Code*, 2002 <http://www.leginfo.ca.gov/pub/01-02/bill/asm/ab_0101-0150/ab_117_bill_20020924_chaptered.pdf>.

project there could be no implementation of a business model related to ZNE. Accordingly, work on this task became infeasible and was not pursued.

Although the timing and the delivery method for developing and selling the Faculty Staff Housing remains unclear, UC Davis is still committed to striving for ZNE for the Faculty Staff Housing, when the project moves forward.

6.0 Metrics of Success

Establishing meaningful metrics of success for this project was relatively simple since the WVEI workgroup adopted clear planning principles when we decided to pursue ZNE for the West Village neighborhood. These principles were applied to each business model through the economic modeling effort led by E3.

- 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.
- The West Village project 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 other energy-related topics.

7.0 Conclusion

The Project set out to use the West Village community as a real world test-case to evaluate various business models to determine an “optimal” model that would allow for the deployment of community scale solar distributed generation that also provided a role for the local investor-owned utility. The second part of the Project was planned to be the implementation of the “optimal” business model.

The first part of the Project (including Tasks 1-3), which primarily involved financial modeling and analysis was completed with the help of E3, CPR and Davis Energy Group. Their work resulted in the *UC Davis West Village Zero Net Energy Project: Single-family Homes Roadmap* and the Excel financial model that they developed in their analysis. These are attached as Appendices A & B respectively.

The key conclusion in the Roadmap was that achieving ZNE at no higher cost to the developer or the homeowner was (very nearly) possible, even assuming no regulatory change.[62] Depending on the assumptions used for the financial model about absorption rates and construction costs, the proposed

[62] *Roadmap, p. 146.*

ZNE homes would cost the same or less than comparable conventional homes.[63] E3 recommended the following Roadmap Measures:

Table 9. Rationale for Roadmap Measures[64]

Roadmap Measure	Rationale
Pursue mid-level EEM package Advanced A.	This package delivers the most economic set of energy efficiency measures, providing source energy savings versus a Title 24 + 15% home of 26% for the main house and 17% for the studio, at an incremental cost of $2,554.
Use rooftop solar strategy for electricity generation through 2014, then re-evaluate.	Due to current virtual net metering regulations, community-scale PV is not economic. The West Village team should potentially pursue a community-scale PV system in the future should virtual net metering regulations change and the economics of a community PV system improve.
Use tradable RECs and offsets for demand/supply balancing of PV and biogas, given the challenge of forecasting future electricity and natural gas demand and solar PV degradation.	The strategy of using RECs and biogas offsets to balance renewable energy supplies provides great flexibility to the West Village ZNE development. For electricity, any future usage growth or shortfalls in PV panel generation due to degradation can be easily supplied using PG&E retail electricity and made renewable via RECs. Similarly, biogas offsets can be procured in amounts to match construction period phase-in, as well as future usage fluctuations.
Pursue natural gas in homes with biogas offset (rather than all-electric homes)	The use of natural gas in homes, with a biogas offset, rather than developing all-electric homes, reduces costs, improves system efficiency, and improves marketability of homes.
Foster electric vehicle adoption	In-home charging and/or car share programs can improve West Village economics and reduce the overall carbon footprint of the community.
Explore feedback mechanisms to manage energy consumption post-construction.	The economic success of the West Village hinges on reinforcing energy efficient behaviors among residents throughout the life of the development. Exploring feedback mechanisms and integrating education and behavior reinforcement will be keys to ensuring zero net energy is achieved at the West Village at no higher cost.

[63] Ibid.
[64] *Roadmap, p. 148.*

The Roadmap also highlighted two key changes in regulatory policy that potentially could improve project economics: 1) virtual net metering; and 2) aggregated NSHP.[65] Under a community virtual net metering model, one community solar PV array would be sized for the electrical demand of the entire Faculty Staff Housing community and directly connected to PG&E's grid, rather than being tied in behind individual meters. Homeowners would be billed based upon their consumption less their share of the community array. By using a virtual net metering model, the project economics would be improved by approximately $1.8 Million (NPV).[66] Currently, virtual net metering has not been extended to single family homes.

The second key change would be to allow the aggregation of NSHP incentives for a community array. Under current regulations, the NSHP incentives are limited to rooftop installations that serve individual homes or multi-family projects, but are not available for community arrays. If the California Energy Commission were to allow aggregated NSHP, the project economics would be improved by at least $3 Million.[67] Taken together, allowing virtual net metering for a community array and aggregating NSHP incentives could make a significant impact on future ZNE single-family developments in California.[68]

As sometimes happens in "real world test-cases," the construction of the Faculty Staff Housing was delayed and has not yet commenced. Accordingly, the second part of the Project (including Tasks 4-6), did not move forward. Without the underlying construction project, the business model could not be implemented and these Tasks could not be meaningfully completed.

[65] *Roadmap,* p. 129.
[66] *Roadmap,* p. 130.
[67] Ibid.
[68] *Roadmap,* p. 131.