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FINAL PROJECT REPORT

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PREFACE

The California Energy Commission Energy Research and Development Division supports public interest energy research and development that will help improve the quality of life in California by bringing environmentally safe, affordable, and reliable energy services and products to the marketplace.

The Energy Research and Development Division conducts public interest research, development, and demonstration (RD&D) projects to benefit California.

The Energy Research and Development Division strives to conduct the most promising public interest energy research by partnering with RD&D entities, including individuals, businesses, utilities, and public or private research institutions.

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- Renewable Energy Technologies
- Transportation

Commercializing Zero Energy New Home Communities is the final report for the Commercializing Zero Energy New Home Communities project (contract number 500-04-022) conducted by SunPower Corporation. The information from this project contributes to Energy Research and Development Division's Buildings End-Use Energy Efficiency Program.

For more information about the Energy Research and Development Division, please visit the Energy Commission's website at www.energy.ca.gov/research/ or contact the Energy Commission at 916-327-1551.

ABSTRACT

New home developers have historically resisted installing photovoltaic systems because of high initial cost, aesthetics and disruption to their production schedule. This occurred because photovoltaics and energy efficiency have been considered in isolation. Optimized integrated solutions can reduce house electric loads to the point where right-sized photovoltaic systems can reduce net peak summer electric loads to near zero for zero energy new homes at an economically viable cost. These barriers have not yet been addressed by the market due to the investment needed to develop and demonstrate the cost benefits and the need for innovative marketing, sales and financing approaches.

This report highlights the outcomes of the zero energy new homes project and how it provided innovative and cost-effective combinations of building energy efficiency and photovoltaic strategies in new housing developments, helping reduce homeowner cost, energy use and summer peak electricity demand in California. The project integrated new business model approaches with demonstrations of innovative zero energy new home designs and products to overcome cost and implementation barriers. This project helped to make zero energy new homes a mainstream part of California new home construction market.

SunPower Corporation used the results of this project to employ a turn-key systems approach to all of its homebuilders, combining proven energy efficiency and building integrated photovoltaic systems with innovative sales programs to develop a robust zero energy new homes industry in California.

This project supported California's goal to optimize energy conservation and resource efficiency as outlined in the California Energy Action Plan of 2003. It also added a project to the Energy Commission's research portfolio that provided for the future market utilization of projects funded through the program as mandated by the Warren-Alquist Act.

Keywords: Zero Energy New Homes, ZENH, solar, new home construction, PV, building integrated PV, BIPV, homebuilding, solar community, renewable energy, energy efficiency

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EXECUTIVE SUMMARY

1.1.1. Introduction

Historically, new home developers and builders have resisted installing solar systems because of high initial cost, aesthetics and lack of consumer demand. Residential solar and energy efficiency measures were largely installed as a construction afterthought by individual homeowners that were motivated to retrofit their existing homes. Few homes were actually built with integrated solar systems.

Over time, it became apparent that it was more cost effective to plan, design and build energy efficiency and renewable energy features into the home *before* the home was actually built. If builders were going to embrace this concept, however, they had many obstacles to overcome. Just a few years ago, without the benefit of well defined standards, a fully developed solar marketplace, and energy efficient products, the challenges associates with building net zero energy new homes appeared insurmountable.

That all changed when, in June 2005, the California Energy Commission Public Interest Energy Research Program commissioned SunPower to conduct a study entitled, "Commercializing Zero-Energy New Homes" (ZENH).

1.1.2. Project Purpose

The objectives of this project were to:

- Exceed Title 24 energy efficiency standards by 25 percent or more.
- Reduce homeowner energy costs by 70 percent.
- Cap peak electricity demand to one kilowatt (kW) during summer peak hours.
- Reduce incremental first-costs toward zero.

1.1.3. Project Results

SunPower Corporation explored innovative and cost-effective combinations and approaches to photovoltaic (PV) systems, energy efficient products, home design and strategies for the new housing construction marketplace. Market barriers to building new solar and energy efficient homes were studied, addressed and mitigated across the broad spectrum of market actors and influencers. New business models and approaches were defined for all facets of commercial homebuilding design, energy analysis and solar installation businesses.

The project included the following macro-tasks:

- Design ZENH homes.
- Develop ZENH business models.
- Build ZENH demonstration communities.
- Monitor and evaluate ZENH performance.
- Ensure ZENH market sustainability.
- Refine residential building integrated photovoltaic (BIPV) designs and products.
- Broaden the application of BIPV designs and products.

The marketplace changed considerably over the four years since the project's inception. The original prime contractor for this project was acquired by SunPower. The homebuilder market collapsed, adding substantial challenges to meeting the ZENH program objectives. New ZENH homebuilder partners were selected, new demonstration communities were identified and major ZENH program subcontractors were substituted in place of others. Despite this tumultuous market, SunPower achieved the following noteworthy initial results:

- Four ZENH demonstration communities with more than 150 single- and multi-family homes were built.
- ZENH building standards exceeded Title 24 requirements by 35 percent or more.
- Homeowner energy savings averaged 60-70 percent less than comparable non-solar housing.
- More than two dozen national and regional homebuilders partnered with SunPower.
- Advanced energy production and usage monitoring equipment was installed on all solar-equipped homes.
- The incremental first-cost of ZENH homes was reduced by the application of innovative financing alternatives.
- Positive customer satisfaction surveys and responses extolled the merits of ZENH homes.
- BIPV products were developed for ZENH communities.
- New processing standards were established for California's regulatory and local business practices.
- SunPower applied the results of this project to build more than 3,000 energy efficient, solar homes in California and expanded its ZENH business across the country.

Even in a depressed housing market, homebuilders and homebuyers alike have benefited from the successes of the ZENH program. California builders choosing to build solar communities with SunPower have realized faster sales rates and increased profitability. Homeowners have expressed a high level of satisfaction with their ZENH homes in surveys, focus groups, training, and other community events. Builders believed that the positive homeowner experience was resulting in increased referrals and improved satisfaction with their homes.

The benefits of this program have extended far beyond the most obvious market actors (builders and buyers) and stated program objectives. The research team recognized that to succeed in transforming the new homes market it needed to reach out to other key parties engaged in the industry, including new home sales consultants, realtors, appraisers, lenders, permitting agencies, regulators and other builder trade partners. SunPower elevated the industry's awareness of the benefits of new solar homes using a combination of learning tools and educational approaches to overcome the unique challenges hindering mainstream ZENH adoption.

SunPower's turn-key installation model removed critical programmatic barriers and made solar installation in production communities easy to implement. SunPower along with the Davis Energy Group and participating builder partners developed best-in-class packages of commercially-available energy efficiency measures for the ZENH demonstration communities.

SunPower's International Code Council (ICC) certified SunTile solar roofing product solved perceived aesthetic concerns and provided participating homebuilders with a way to differentiate themselves from their competition. These products can be integrated into predominant roof styles including flat tile, asphalt shingle, and s-tile.

SunPower trained builder employees to help them understand how to articulate the features and benefits to potential buyers. They also developed a comprehensive set of materials for builders and external marketing professionals to promote ZENH and to increase the demand for ZENH homes. They worked with builder partners to map out alternative system ownership and financing models. New approaches to streamlined permitting, interconnection and incentive processing were developed and a concerted effort was made to provide enhanced customer support and warranty programs.

The research team's holistic approach fostered a deeper understanding of the challenges that remain, the risks that need to be addressed and the future steps necessary to succeed in commercializing the ZENH marketplace. SunPower intended to continue developing, applying and expanding the reach of this study.

1.1.4. Project Benefits

This project helped to increase the market penetration of zero energy new homes in California using a combination of energy efficiency measures, integrated photovoltaic systems and innovative marketing, sales and financing approaches. The project supported California's goal to optimize energy conservation and resource efficiency as outlined in the California Energy Action Plan of 2003. Reduced energy use resulted in fewer greenhouse gas emissions that contribute to climate change as well as other emissions that cause air pollution. The construction of ZENHs also provided employment for many California workers.

CHAPTER 1: Overview

1.1 Program Objectives

The objective of the program was to demonstrate the technical feasibility and broad market acceptance of low-cost and highly effective zero energy new homes. SunPower's goal was to achieve a 50 percent market penetration of ZENH homes and to meet or exceed the following four main success criteria:

Table 1: CEC ZENH Goals

Goal	Characteristics	Units	2005	2008	2013
Energy	Energy Efficiency over 2005 T-24	%	25%	35%	45%
Peak Demand	Peak Demand during summer peak	kW	1	0.5	0
Cost	Incremental First Cost	$	$5,000	$2,500	$0
	Annual Electric Bill Savings	%	70%	85%	100%

To meet these goals, SunPower employed the following tactics.

- ***Develop innovative BIPV and energy efficiency design and products***
  - Aesthetic BIPV products, compatible with predominate CA roofs and PV cell technologies
  - Proven energy efficiency solutions that exceed Title 24 by more than 25 percent
  - Innovative in-home metering and PV system monitoring

- ***Define a turn-key value proposition and innovative business model***
  - Transaction cost minimization via single source turn-key provider
  - Reduce cost via volume purchases due to purchasing power (Largest in North America)
  - Third party financing of BIPV to remove incremental cost barrier

- ***Build ZENH demonstration communities with proven partners***
  - Single and multi-family homebuilder commitments received for 150+ homes
  - Proven PV, solar thermal (where applicable), and energy efficiency products
  - Measure and evaluate energy efficiency and distributed generation benefits

- ***Provide a focused and commercially-proven approach***
  - Extend SunPower's established track record of implementing successful PV and energy efficiency projects
  - Leverage SunPower's full range of partnerships including specialists in energy efficiency, supply chain and finance

1.2 Report Organization

The structure of this report follows the outline of the key research tasks that were called for at the commencement of this program. All key findings, conclusions and recommendations from the entire three-plus year project scope of work have been incorporated into this Final Deliverable. To follow is an abbreviated index of what the reader can find herein:

- Design ZENH Homes 30
- Develop ZENH Business Models 130
- Build ZENH Demonstration Communities 167
- Monitor and Evaluate ZENH Performance 171
- Ensure ZENH Market Sustainability 189
- Refine Residential BIPV 239
- Broaden the Application of BIPV 251

The Outcomes section contains the body of all deliverables created from this project. In each subheading or task highlighted therein, the reader will find the entire deliverable for the related task as it was originally submitted. For flow and continuity, some editing was necessary on each of these original task reports.

The Conclusions and Recommendations section is a final synthesis of the individual conclusions from each task deliverable

Please note that since their submission shortly after the commencement of work, *some of the reports are dated*. Where possible, this material was brought up to date. Some of the contributing authors, however, had moved on but their task findings have been left in this report because of the content's lasting relevancy to the task.

CHAPTER 2:
Approach

The general approach to this program was considered in light of a straightforward business development effort to plan, design, build, test, deploy and scale. The program's scope of work laid out an array of major tasks that generally fit into this business development model, key elements of which are reproduced here.

- Design ZENH Homes
- Develop ZENH Business Models
- Build ZENH Demonstration Communities
- Monitor and Evaluate ZENH Performance
- Ensure ZENH Market Sustainability
- Refine Residential BIPV
- Broaden the Application of BIPV

More than 400 task-level research activities and preliminary findings were developed in support of the 38 individual reports called for in the program scope of work.

Over time, the marketplace changed. For starts, the original prime-contractor for this contract, PowerLight, was acquired by SunPower. Most famously, the homebuilder market collapsed, adding additional challenges and opportunities to meeting the ZENH program objectives. Homebuilder partners were changed, new demonstration communities were selected, major subcontractors were substituted in place of others and the continued BIPV product development was restricted to the use of SunPower modules only.

The resulting approach to the program both meets the call of the original contract while simultaneously providing tangible market benefits that reflect the realities of current economic conditions.

CHAPTER 3: Outcomes

This ZENH research program yielded and array of findings about how to design, develop, build, monitor, support and extend the reach of integrated energy-efficiency and photovoltaic systems in the new homes marketplace. To these ends, SunPower has:

- ***Designed and built more than 150 ZENH homes.*** *In each of the homes, SunPower installed turn-key BIPV systems, included an in-home energy monitoring display, allowing customers to view their solar system energy production as well as their household energy consumption.*
- ***Delivered an integrated energy efficiency offering.*** *SunPower, along with the Davis Energy Group and our builder partners, developed best-in-class, commercially-available energy efficiency measures for the ZENH demonstration communities.*
- ***Designed and manufactured BIPV products for ZENH.*** *SunPower manufactures BIPV solutions that utilize the market's most efficient solar cells and advanced panel designs. These PV products integrate into predominant roof styles including flat tile, asphalt shingle, and s-tile.*
- ***Formed a new subdivision, generated new jobs and expanded throughout California.*** *While it did not exist at the inception of this program, a new business unit was formed: SunPower New Homes. It provides turn-key Zero-Energy New Homes solutions for the commercial homebuilder marketplace. Delivery capability spans California and all single and multi-family markets. The result for builders simplifies the process of going solar, lowers costs, improves quality and increases sales throughput.*

The following sub-sections correlate to the major tasks under this program. The deliverables – or Outcomes – from each of these tasks are found therein.

3.1 Administration

Over the course of more than three years, the ZENH program underwent a number of evolutionary changes. The original Prime Contractor – PowerLight – was bought out by SunPower Corporation. Some of the Major Subcontractors and homebuilder partners listed at the inception of the contract were later substituted out. Contract managers from both the Energy Commission as well as SunPower changed. Most significantly, however, was the dramatic downturn in the homebuilding marketplace and, in general, the global economic recession of 2008-2009.

Notwithstanding these changes, SunPower kept true to the original ZENH objectives, all within budget and with a lasting positive impact on the California new homes marketplace.

The following list of deliverables and activities from "Task 1: Administration" were delivered to the Energy Commission over the course of the project.

- Schedule of Deliverables and Gantt Chart
- List of Match Funds and Letters of Commitment
- List of Permits

- PAC members lists, schedules, agendas and reports
- Critical Project Review reports
- Closeout activities schedule
- Monthly Progress Reports
- Test Plans, Technical Reports and Interim Deliverables
- Final Report

Some of these Administrative deliverables were manifest during periodic meetings and others were bona-fide deliverables submitted directly to the Energy Commission. Throughout the contract term, deliverable scheduling flexibility was extended by all parties to the contract – inclusive of SunPower, the Energy Commission and both Major- and Minor-subcontractors. Critical Project Review meetings, Program Advisory Committee meetings and Progress Reports, for example, occurred but not as frequently as originally intended in the ZENH contract.

There were also a number of incidental but very important administrative activities that came out of this work. SunPower and the Energy Commission worked together on a series of internal and external affairs including ad-hoc public speaking events, inaugural ribbon-cutting ceremonies for ZENH demonstration communities, contract amendment proceedings, contract accounting and billing matters.

In sum, a substantial amount of the administrative work was dedicated to overseeing and managing the delivery of the ZENH program, a large, highly complex, long-term and far-reaching new market and technology based initiative.

3.2 Design ZENH Homes

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- Single Family Design Package Report 61
- Single Family Design Report 76
- Multi-Family ZENH Package Report 100
- Multi-Family Design Report 117
- Monitoring 128

1.1.5. 3.2.1 Design Charrettes

The Design Charrette was designed to accomplish the following two things:

- Influence the development/subdivision layout to improve solar access and minimize heat gain during summer months, if possible.
- Prepare a prioritized list of design features and practices for consideration by the developer. The list will be assessed according to energy impacts, cost, construction impacts, risk and buildability.

Davis Energy Group led three design charrettes and subsequent meetings for the three single-family builder participants in the Zero Energy New Homes Program. This chapter summarizes the design charrette meetings, outlines the measures considered, and identifies what was

selected for each of the builders. Each builder had unique issues, goals, and preferred strategies, as summarized below.

1.1.5.1 *3.2.1.1 Demonstration Project #1: Grupe Homes – Carsten Crossings, Rocklin*

Grupe has been a Building America builder partner since late 2004. Davis Energy Group (DEG) provided efficiency consulting, evaluation and support under Building America for the early phase of Grupe's Carsten Crossing community. Carsten Crossings is part of the 1,300-acre Whitney Ranch planned-unit development developed by Newland Communities in Rocklin, California. Grupe is building 144 3-5 bedroom, 2-3½ bath homes in the 2,168 to 2,755 square foot range on lots that are 6,000 square feet or larger. Construction of the Carsten Crossings homes began in September 2005.

Under their Grupe Green branding, Grupe is incorporating several energy efficiency measures, as well as a 2.4 kW DC PV system on every home, provided by SunPower (then PowerLight). Energy efficiency measures include:

- High performance (Low-E^2) vinyl frame windows (0.27 – 0.32 SHGC)
- 1″ (R-4) exterior foam building wrap
- Radiant barrier roof sheathing
- R-49 attic insulation with buried ducts
- Compact fluorescent lamps for permanently wired lighting fixtures
- Night ventilation cooling (SmartVent)
- 94 percent AFUE variable speed gas furnace
- 15 SEER AC, 12 EER w/TXV
- Tankless gas water heater
- PEX Home run hot water piping
- Continuous Ventilation System

In addition to these measures, the following Home Energy Rating System (HERS) inspections and tests are being performed:

- Quality Insulation Installation (QII) inspection
- Blower door test (3.0 SLA target)
- EER and TXV verification
- Tight duct testing (< 6 percent leakage)
- System airflow verification

In April 2007, SunPower approached Grupe to include the second phase of Carsten Crossing in the Zero Energy New Homes program. The homes, as built, met the ZENH goals of 25 percent better than Title 24, but Grupe was interested in meeting the California New Solar Homes Partnership (NSHP) Tier II goals of 35 percent better than Title 24 and 40 percent better than Title 24 cooling. With the current package of measures, all plans meet the 35 percent target, but several of the plans fall short of the 40 percent cooling target.

In June 2007, SunPower, DEG and Grupe met to discuss options for meeting the Tier II requirements. Attendees at the meeting included Bill Kelly, Chris Giaras, and Matt Brost from

SunPower, Bill Dakin from Davis Energy Group, and Mark Fischer and Linda Targowski from Grupe.

Higher efficiency air conditioning (15 SEER / 12 EER) and improved windows were both proposed and evaluated. A combination of these two measures was selected to achieve Tier II compliance. High efficiency air conditioning provided the necessary improvement on all plans, except the east-facing orientations on two plans. Because they did not have additional funds to commit to this community and because of the market slow down, Grupe could not afford to further increase home construction costs. The incremental cost for the AC upgrade was still economically viable with the $2,000 Tier II incentive, but window upgrades on all plans would be too costly. Since only a handful of east facing lots did not qualify with the high efficiency air conditioning, Grupe decided to use lower solar heat gain coefficient glass on the west facing windows of four lots to meet the Tier II requirements.

1.1.5.2 *3.2.1.2 Demonstration Project #2: Lennar– Chateau at Blackstone, El Dorado Hills*

The Sacramento division of Lennar Homes, based on the success of their first solar communities in Roseville, decided to include PV as a standard feature of all their future communities. The next Lennar communities (in Kavala Ranch, Rancho Cordova) in SMUD territory included 2.3 kW DC SunPower PV systems and additional energy efficiency features to meet the SMUD efficiency requirements of 20 percent better than Title 24 and 30 percent better than Title 24 in cooling. Energy efficiency measures in these earlier projects include:

- R-13 walls w/ 1" (R-4) exterior foam building wrap
- Radiant barrier roof sheathing
- R-38 attic insulation
- Compact fluorescent lamps on all recessed cans
- 92 percent AFUE gas furnace
- 14 SEER AC, 12 EER w/ TXV

In addition, the following HERS inspections and tests are being performed:

- Quality Insulation Installation (QII) inspection
- EER and TXV verification
- Tight duct testing (< 6 percent leakage)

Lennar's interest in energy efficiency increased as they saw the value of providing the homebuyer with a higher quality product, as well as the ability to differentiate their product in the marketplace. SunPower, the PV supplier, approached Lennar about participating in the ZENH program for their next master community, Blackstone in El Dorado Hills. Lennar was also interested in qualifying for additional incentives by meeting both the NSHP Tier II goals and the Federal Tax Credit requirements. A meeting was scheduled in April 2007 with Lennar, SunPower, and Davis Energy Group to discuss potential additional measures to consider for the Blackstone master community. This master plan includes three communities: Chateau, Shenandoah, and St. Laurent.

Prior to the meeting, DEG analyzed all of the plans in Chateau and Shenandoah to evaluate current performance levels based on the SMUD package of measures, and potential strategies for meeting ZENH, Tier II and Federal Tax Credit goals. Based on the measures listed above, both communities meet the federal tax credit requirements but fall short of the Tier II requirements. Table 2 summarizes some of the additional measures evaluated and their potential Title 24 benefit. All of the measures have a minor impact except for the tankless water heater and reduced envelope leakage. With tankless water heaters, all Chateau plans met Tier II. The Shenandoah plans still fell short of Tier II with tankless water heaters alone, but by adding a HERS blower door test with an envelope leakage rate of 3.5 or less and upgrading to 15 SEER air conditioners, the Shenandoah plans could also meet Tier 2.

Table 2: Potential Impact on Title 24

Measures	Title-24 Benefit
R-6 to R-8 Ducts	0.7% - 0.9%
14/12 SEER/EER AC to 15/12	0.2% - 0.4%
Tankless Water Heater	3.3% - 5.8%
R38 to R49 Attic Insulation	0.8% - 1.5%
3.5 SLA Envelope Leakage (Blower Door)	3.6% - 4.3%
Verify Airflow and AC Capacity	0.3% - 0.5%

Attendees at the meeting included Matt Brost from SunPower, Bill Dakin from Davis Energy Group, and Joel Johnson of Lennar Homes. During the meeting, Lennar still expressed reluctance to shift to tankless water heaters, mostly due to incremental costs. Lennar also felt that many of the plans would require two tankless units due to the size of the homes. If Lennar chose to participate in the PG&E prescriptive rebate program there would be $775 per house incentive available. The incremental incentive for the Tier II program is $1,225 and not enough to cover the incremental costs for switching to tankless water heaters.

Other options discussed included reducing glass area on the back orientation of the plans, better windows, and improved wall insulation. Window area reduction could not result in enough benefit without significantly affecting the elevations, since architectural plans had already been developed. Previous to the meeting, Lennar found out that they could get argon filled SolarBan 70 windows from their window supplier for a 3 percent increase from the windows they currently specify. Lennar also went back to their insulation subcontractor and was able to obtain good pricing for high density wall insulation.

DEG re-evaluated the Chateau and Shenandoah plans with the following measures, in addition to the original SMUD measures listed above:

- CertainTeed SolarBan 70 argon-filled windows (average U-factor = 0.31, SHGC = 0.23),
- High density wall insulation (R-15 for 2x4 walls, R-21 for 2X6 walls),

- R-49 ceiling insulation
- Tight building envelope – 3.5 SLA target w/ blower door test.

All plans in both communities meet the Tier II requirements with these measures. Since the incremental costs for these measures were less than the additional $1,225 incentive per house, Lennar chose to implement them in all of the Blackstone communities. Based on performance, the Chateau community was selected to be included as a demonstration community in the Zero Energy New Homes program. The Chateau community has the same energy features as Shenandoah, but the plans perform better relative to Title 24 due to architectural features, such as plan size, and window area and placement.

1.1.5.3 *3.2.1.3 Demonstration Project #3: Meritage Homes – Encore 2 and 3*

SunPower approached the Meritage Homes Bay Area division about participating in the Zero Energy New Homes program early in 2007. Jeff Jacobs, Vice President of Community Development at Meritage, was interested in doing a solar community. While working for Centex Homes, Jeff had been involved in several communities that had photovoltaics and energy efficiency features as options, as well as one community where it was standard, and was aware of the potential value of these communities to builders, buyers, and society as a whole. An initial meeting with SunPower and Meritage was scheduled for early February 2007. Prior to the meeting, DEG evaluated the Encore 2 and 3 plans. The Encore communities include five plan types. With options, there were 10 designs to evaluate. Since the Encore communities in Vacaville are two infill projects based on existing plans used in previous Meritage communities, there was not much flexibility in the architectural designs. The energy features Meritage initially proposed including at Encore included:

- Low-E^2 windows
- R-13 walls (Optima blown-in fiberglass) w/ 1" (R-4) exterior foam building wrap
- R-49 attic insulation
- 92 percent AFUE gas furnace
- 14 SEER AC
- R-6 duct insulation
- Tankless water heater
- 2.3 kW DC SunPower PV
- Along with the following HERS inspections and tests:
- Quality Insulation Installation (QII) inspection
- Tight duct testing (< 6 percent leakage)

Several of the plans fell short of the ZENH goal of 25 percent better than Title 24 with these measures alone. By including attic radiant barrier, 14 SEER / 12 EER with TXV and third party verification of these measures, all of the plans meet the 25 percent ZENH performance goals.

Attendees at the meeting included Bill Kelly, Jake Wachman, and Kurt Johnson from SunPower, Dave Springer and Mark Berman from Davis Energy Group, and Jeff Jacobs and Scott Kramer from Meritage Homes. During the initial meeting, costs and options were discussed. The Meritage cost target for all efficiency measures and the solar system was $20,000. Meritage was

interested in trying to meet the NSHP Tier II and Federal Tax credit targets, as well as to help offset the incremental cost for the additional measures.

Ventilation cooling was also discussed. Jeff had previous experience with NightBreeze while at Centex and was interested in the NightBreeze benefits. Since Beutler was likely to be the HVAC contractor, Meritage would work with Beutler to determine pricing for and evaluate feasibility for NightBreeze. Meritage originally had 92 percent AFUE furnaces with a standard PSC blower motors specified. The NightBreeze requires a variable speed furnace and the incremental cost for a 94 percent variable speed furnace was more than Meritage could justify, so they decided to see if they could meet Tier II with an 80 percent AFUE furnace with a variable speed blower.

Meritage was also interested in using the one-coat stucco with R-4 sheathing insulation on exterior walls, but the city of Vacaville was going to charge an additional $50,000 in inspection fees due to their concerns over installation methods. SunPower scheduled a meeting with the City of Vacaville to discuss the scope and goals of this project. They gave a presentation on the Meritage project, which generated enthusiastic support from the city, resulting in the additional fees being waived.

Additional measures were evaluated to meet the Tier II targets with an 80 percent AFUE furnace. NightBreeze adds significant benefit in terms of comfort, improved indoor air quality, and energy savings, but currently is not given credit in Title 24. Table 3 lists the selected measures for the Encore communities. Plans 1, 4 and 5 meet Tier II targets in all orientations with these measures, but Plans 2 and 3 fall short of the 35 percent Tier II targets in some orientations. All plans meet Tier II with a 94 percent AFUE furnace, but the additional cost of the furnace could not be justified for the entire project. Since both Encore 2 and 3 communities are pre-plotted, any lots with a Plan 2 or 3 (a total of four lots) specified that falls short of Tier II due to orientation will have a 94 percent AFUE furnace installed in order to meet Tier II.

Table 3: Encore Measures

Efficiency Measures
Low-E^2 windows
R-13 walls (fiberglass batt) w/ 1” (R-4) exterior foam building wrap
R-49 attic insulation
80% AFUE gas furnace
15 SEER / 12 EER AC w/ TXV
NightBreeze
R-6 duct insulation
Tankless water heater
HERS Inspections and Tests
Quality Insulation Installation (QII) inspection

Efficiency Measures
Tight duct testing (< 6% leakage)
Verified HVAC system airflow
Tight envelope (3.5 SLA blower door)

Right sizing of the air conditioning equipment was discussed and evaluated. Based on evaluation of system sizing using the Title 24 credit and Beutler's proposed equipment sizing, Plans 1 – 3 AC equipment is oversized. While Meritage was interested in looking at downsizing the equipment, Beutler was reluctant to downsize, and the verified capacity credit was not enough to bring the few lots into Tier II. It was decided that the project was too far along to overcome the challenge of right sizing.

Optima insulation, which was initially specified, was in the end too costly to justify for this project as well. Meritage decided to use batt insulation but coordinated with the HERS rater to work with the construction crew and insulation subcontractors to ensure that the quality insulation and envelope sealing practices were used. In the end, the above measures were the most cost-effective means of meeting Meritage's goals.

1.1.5.4 *3.2.1.4 Conclusion*

The design team developed a prioritized list of design features and practices to guide a discussion with the builders on how to increase efficiency. The team assessed the design features by taking into account the energy impacts, cost, and construction impacts, and worked with the builder to select the most effective features for the community. The design meetings helped the builders achieve Tier II program compliance for all communities in the ZENH Demonstration. While a goal of the design charrette was to influence the layout of the communities to improve solar access, this task was not accomplished for the demonstration projects since the construction process was too far along. Influencing the layout of communities needs to happen long before construction begins. It is SunPower's goal to develop strong relationships with our builder partners in order to be included in the planning stage of each community and to ultimately influence the community layout to maximize solar benefit for each home.

1.1.6. 3.2.2 Market Evaluation

New technologies are important to production builders whether they relate to home audio, kitchen design aesthetics, or energy efficiency. A builder, as well as his architect and subcontractors, must stay on top of changes to maintain a competitive advantage in the marketplace. While aesthetic appeal has long dominated home purchase decisions in the part, it appears likely that the years ahead will reflect an increased consumer focus on energy efficiency and household operating cost.

California has continued to take a leadership role in energy efficiency, especially in recent years with the introduction of the New Solar Homes Partnership. While homebuyers tend to associate photovoltaic systems with "energy efficiency", a much broader palette of emerging

energy efficiency technologies has entered the market in recent years. This market evaluation report provides an overview of five technologies that have significant potential to improve new home energy efficiency in the years ahead.

The five technologies are:

- Gas tankless water heaters
- Quality envelope construction practice
- Ventilation cooling
- Evaporative condenser vapor compression systems
- Advanced evaporative coolers

Each of the technologies is presented in terms of technology description, energy performance, cost, technical feasibility, market acceptance, and market availability. This section provides an overview of these five technologies with the goal of educating the builder to making a better informed decision on technology implementation.

1.1.6.1 *3.2.2.1 Gas Tankless Water Heaters*

Technology Description

Storage gas water heaters are the predominant residential water heating appliance used throughout California. Gas storage water heaters are characterized by low first cost, hot water delivery characteristics compatible with the cultural expectations of most U.S. homeowners, and lower than average seasonal efficiency compared to other gas heating appliances. Tankless gas water heaters have been available on a small scale for many years in this country, but have not yet achieved the widespread acceptance common in Europe and Japan. The current generation of tankless water heaters offers significant technology improvements over their predecessors. Variable burner capacity, higher heating capacities, and sophisticated controls have significantly improved delivery temperature characteristics under a range of flow rates. Elimination of standing pilots has significantly improved the standby performance of tankless units; nominal efficiencies (i.e. Energy Factors) are more than 35 percent higher than typical storage gas water heaters.

Tankless gas water heaters employ a burner and a heat exchanger that contains a small volume of water, typically less than one gallon. Water is heated in a single pass through the heat exchanger. By varying burner output in proportion to the water flow rate, hot water temperature is fairly precisely controlled. Virtually all of the newer models use combustion air blowers to achieve higher output and efficiency and to allow horizontal “direct” venting. Typical gas input ranges from about 60,000 to 200,000 Btu/hour, or roughly two to five times that of typical storage water heaters. The higher capacity models are capturing a larger market share because of their ability to meet the hot water needs of most single family homes. Figure 1 shows a garage installation of a tankless unit. The small size of these units allows them to be located in exterior water heater closets, interior closets (with proper ventilation), and mechanical rooms, as well as exterior wall installations.

Figure 1: Garage Mounted Tankless Unit with Sidewall Venting

Energy Performance

Tankless gas water heaters and storage gas water heaters both have to meet Federal Energy Factor (EF) efficiency requirements. Minimum efficiency levels for tankless units are currently 0.62 EF, while storage units are approximately 0.57, depending upon storage volume size. A majority of the new tankless units on the market have EF's exceeding 0.80. This significant performance advantage over storage units is primarily due to the elimination of storage losses associated with the standard center flue water heater design. A shortcoming of the EF test procedure for tankless water heaters is the underestimation of the small volume draws common to most households[1]. In ignoring small volume draws, the EF procedure overestimates tankless water heater efficiency.

Davis Energy Group completed monitoring to assess the impact of thermal cycling and draw volume magnitude on system performance. Based on the test results, the 2008 California Title 24 standards will implement an 8 percent de-rating on tankless water heater Energy Factors[2]. In a 2007 study for PG&E, Davis Energy Group used this result to estimate typical tankless water heater savings for single family homes in California. For typical household usage in the range of 44 to 65 gallons of hot water per day, annual savings of 47 to 51 therms per year are projected. Annual projected savings amount to about $60[3] at an assumed natural gas rate of $1.44 per therm[4]. Since natural gas rates are climbing, projected annual savings will increase.

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[1] These short draws degrade performance as the cold heat exchanger must be brought up to temperature.

[2] A nominal 0.80 EF tankless water heater will be treated as a 0.736 EF water heater in Title 24.

[3] Includes the impact of added electrical energy consumption due to combustion air blower and controls.

[4] Average marginal rate during February 2007 through January 2008 period.

Costs

The 2007 PG&E study surveyed two builders and three plumbing contractors involved in installing tankless water heaters in new homes in the Central Valley. An average incremental cost of $950 (including 10 percent builder markup) was calculated based on these estimates. PG&E, SCG, and SDG&E all offer new construction incentives of $200 per unit for qualifying single and multi-family applications. Table 4 presents homeowner economics (ignoring mortgage interest benefits) for a standard 30 year fixed rate loan at various interest rates and incremental costs based on the projected $60/year savings. At a net $750 incremental cost ($950 - $200 rebate), homeowner economics would be positive up to fixed interest rates of 7 percent. Escalating gas costs will improve the cash flow picture.

Table 4: Projected Annual Homeowner Cash Flow (New Construction Case)

Incremental	Interest Rate			
Cost	5%	6%	7%	8%
$300	$41	$39	$37	$34
$600	$22	$17	$13	$8
$900	$3	($4)	($11)	($19)
$1200	($17)	($26)	($35)	($45)

Technical Feasibility

Tankless water heaters require a larger gas supply line than the standard ½" line used for conventional gas storage water heaters. In new construction applications, upsizing the gas line to ¾" is not a significant cost adder, unlike in retrofit applications where significant labor may be involved to replace an undersized gas line. Similarly venting of the combustion air is easily handled in new construction. From a new construction perspective, installation barriers are minimal.

The Title 24 Residential Building Standards provide a significant credit for tankless water heater. MICROPAS runs were completed for 1,600 and 2,600 sq. ft. houses with both standard and tankless water heaters to quantify the benefit under the current 2005 Standards. For the smaller 1,600 sq. ft. house, the water heating budget was reduced by 35 percent generating a credit of 4.8 source TDV/sq. ft.-year[5]. For the larger 2,600 sq. ft. house, the water heating budget is reduced by 29 percent resulting in a 2.9 TDV/sq. ft. - year credit[6]. In comparison, a 90 percent AFUE condensing furnace would generate a credit of 1.92, or only 40 percent the size of the tankless credit for the 1,600 sq. ft. house in Sacramento (climate zone 12). Credits of this magnitude have, and will continue to attract attention from builders. In the 2008 Standards, the

[5] TDV, or "time dependent valuation", is the metric used to value electricity, natural gas, and propane on an hourly basis with the Title 24 Building Standards.

[6] The way Title 24 is structured, water heating measures have a far greater impact on smaller houses than on larger houses. For houses above 2,500 sq. ft., water heating loads are capped, resulting in further reduction in the impact of any efficiency measure.

magnitude of the tankless savings will be reduced by roughly 8 percent based on the EF performance de-rating. Even with the de-rating in effect, there will continue to be a fairly strong incentive for builders to use tankless water heaters as a means to achieving Title 24 compliance.

Market Acceptance

Long-term reliability of tankless water heaters is uncertain, but would logically be dependent upon local water conditions, use characteristics, and maintenance. At the DOE's Energy Efficiency and Renewable Energy website[7], an estimated 20 year life expectancy is offered as "typical" for tankless units. To assure continued performance, manufacturers recommend periodic flushing of the heat exchanger with a mild acid solution (vinegar) to prevent occlusion of the heat exchanger by water deposits. Since periodic maintenance is required (unlike storage water heaters where maintenance is non-existent), one would expect lifetimes exceeding that of storage water heaters. Clearly more field data is needed to better understand reliability, service intervals and cost, and equipment lifetimes.

Typical manufacturer warranties on tankless units range from 7 to 12 years on the heat exchanger and 2 to 5 years on other parts when the unit is installed by licensed and/or qualified[8] contractors in a single-family residential application. Most manufacturers provide a reduced warranty period if the unit is used in conjunction with a recirculating hot water system or if used as part of a hydronic heating system.

Tankless heaters impose an increase in hot water waiting time at the fixture because they require a few seconds before firing and then an additional 10-15 seconds before they supply hot water at the user-specified setpoint. In addition to the time delay issue (and the associated water waste), tankless units require a certain minimum water flow rate to fire, usually about 0.5 to 0.8 gallons per minute. These factors may affect customer satisfaction depending upon the configuration of the plumbing system, the location of the water heater relative to key use points, and personal preferences.

Market Availability

Tankless water heaters are available from several major international manufacturing companies. Recent California sales are estimated at 35,000 - 40,000 units annually. The products are mature and most plumbers are aware of installation and maintenance issues.

Summary

Tankless water heaters represent an attractive energy efficiency option for builders. The costs, after utility incentives, are not high and the current Title 24 credits are significant (credits will be reduced 8 percent with the 2008 Title 24 Standards). Customer acceptance is not totally clear as there are both opponents and proponents. Opponents point to delays in hot water delivery (water waste), inability to satisfy low flow rate draws, and potential energy waste due to the concept of endless hot water (people will take longer showers). Proponents tout the elimination

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[7] http://www.eere.energy.gov/consumer/your_home/water_heating/index.cfm/mytopic=12820

[8] "Qualified" may mean the contractor has undergone manufacturer-sponsored training.

of tank standby loss, energy savings, and ease of installation. The next few years will offer a good assessment of how the market values tankless water heaters. Currently, the Title 24 incentives will continue to provide a strong push to the market, especially as the more stringent 2008 Standards come into effect.

1.1.6.2 *3.2.2.2 Quality Construction Initiatives*

Technology Description

The effectiveness of the building envelope in reducing thermal loads on the HVAC system is dependent both upon the properties of the materials used in construction (framing, insulation, windows, caulking, etc.) and the attention to detail during the installation and construction inspection and diagnostic evaluation process.

Prescriptive approaches to energy efficiency often overlook many of these common problems:

- Improper insulation installation in walls, ceilings, and attic kneewalls
- Aligning the thermal and pressure boundaries
- Draftstopping of interior wall/soffit cavities (to avoid thermal short-circuiting)
- Sealing of penetrations that connect conditioned and unconditioned space
- Duct sealing
- Proper duct sizing for adequate room-by-room airflow
- HVAC equipment sizing
- Refrigerant charge

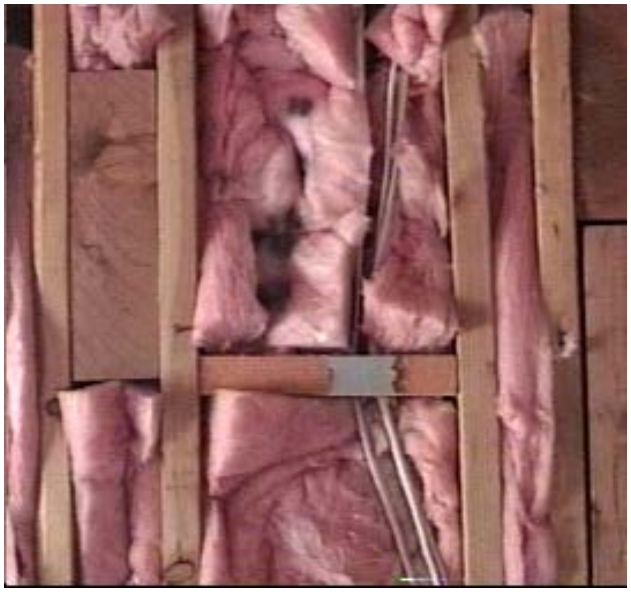
The 2002 CEC-sponsored Residential Construction Quality Assessment Project involved detailed field assessment of sixty homes statewide documenting problems that are all too common in new California homes. The photos below capture some of the key issues, which relate primarily to draftstopping and insulation instal

Prior to insulation, the photo below shows an interior wall cavity from the attic. In virtually all cases, this void will remain open when ceiling insulation is blown. Insulation will fall to the bottom of the cavity and the interior wall will have a direct thermal connection to the attic above.

Figure 2: Open Interior Wall Cavity

Batt insulation installed as a draftstop. Drywall will be installed at a level near the top of the arched doorway, separating the thermal envelope from the pressure envelope. With no insulation directly on the drywall, the winter convective heat transfer will be significant and the warmed air will easily pass through the batt insulation. Drywall and insulation must be in direct contact to be effective.

Figure 3: Insulation Draftstopping



Sloppy insulation installation not only compresses the insulation (decreasing the R-value), but also creates voids allowing convective cells to form within the wall cavity. Excessive framing, wiring, and plumbing, all contribute to non-standard cavities (as shown), which are frequently not properly addressed by the insulation crew.

Figure 4: Wall Insulation Defects

Architectural complexity in new homes, as well as a lack of supervision and attention to detail, all contribute to problems in building envelope performance. In an effort to address these problems, the 2005 Residential Title 24 code included a method to de-rate both wall and ceiling insulation performance and provide an avenue for credits with proper installation and third-party HERS-rater inspections.

Increasingly, builders and utilities are starting to focus on these areas to not only gain Title 24 compliance credits, but also to reduce liability exposure because of construction defects including envelope damage as a result of moisture intrusion or inadequate comfort due to HVAC systems prone to inadequate air distribution relative to actual room-by-room loads. A 2008 ACEEE paper titled "Case Study: The Effectiveness of Zero Energy Home Strategies in the Marketplace"[9] discusses how several builders benefited by embracing quality construction practices as part of their efforts to meet NSHP program goals.

Specialty insulation and HVAC contractors such as Rick Chitwood of Chitwood Energy Management have been successful at implementing "house as a system" quality installation approaches to custom home construction projects. By implementing this approach, loads are significantly reduced allowing the HVAC system capacity to be reduced. This results in saving both first cost and operating costs. Two recently monitored Chitwood projects[10] in Redding, CA resulted in cooling system sizings of 2 tons and 1.5 tons for a 3,477 and 2,440 sq. ft. homes, respectively. Cooling equipment sizings are roughly 1,600-1,700 sq. ft. per nominal ton, or less than half that of conventional Central Valley cooling system sizings.

Energy Performance

MICROPAS7 simulations were completed on a 1,882 sq. ft. prototype house to assess typical savings expected from implementation of quality insulation practices, envelope tightening, and adequate HVAC airflow. Using a 2005 Title 24 compliant home as the starting point, these added measures are projected to reduce heating and cooling compliance budgets by 10.5 percent and 12.3 percent, respectively, in climate zone 12 (Sacramento). Actual savings may be higher based on experiences from Chitwood and others. If the quality construction approach is fully embraced, other measures such as ducts in conditioned space, higher HVAC airflow (500 cfm/ton in cooling mode), reduced duct system size, etc. may all become part of an advanced building package. In the example of the 3,477 sq. ft. Redding Showcase Home, annual cooling energy savings of 50 percent were estimated based on monitored performance and utility bill analysis of neighboring conventional homes.

Costs

The concept of an integrated quality construction approach is fairly new to the building industry and it is therefore difficult to extrapolate costs to the broader production home market. We estimate costs of approximately $.75 per sq. ft. of conditioned floor area or less for implementation of these procedures based on our initial experiences with builders, subcontractors, and HERS raters. Reductions in cooling and duct system costs due to

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[9] "Case Study: The Effectiveness of Zero Energy Home Strategies in the Marketplace", Bill Dakin, David Springer – Davis Energy Group, Bill Kelly – SunPower Corporation, 2008 ACEEE Summer Study, American Council for an Energy Efficient Economy.

[10] One project is reported in a December 22, 2006 report to Redding Electric Utility ("Energy Use Monitoring at the Redding Showcase Home") and the second is presented as part of a PG&E sponsored evaporative condenser monitoring project (http://www.etcc-ca.com/database/summary.php?id=464).

downsizing, reduced builder callbacks and liability exposure will significantly reduce or eliminate this incremental cost.

Technical Feasibility

The feasibility of this approach will require effort from the builder in developing rigorous subcontractor bid specifications (for their framing, insulation, and HVAC contractors) and providing tight field construction supervision in coordination with a HERS rater. The first costs will be higher for such an approach, but as indicated in the Grupe case study (see Section 1.1.2), reduced carrying costs during the course of the subdivision build-out should more than offset any higher first costs. Long-term benefits include increased buyer satisfaction and reduced callbacks and liability.

Market Acceptance

There are two principal factors that will drive this initiative: 1) builders pursing either EnergyStar requirements or Federal Tax credit incentive levels (both require third-party Quality Insulation Installation inspections), and 2) builders recognizing the benefits of increased sales and reduced call-backs. Homeowner education could also drive these improved procedures. Currently, homeowners are not aware of how these construction details affect their house performance or whether Builder A makes a better house that Builder B. Quality construction initiatives supported by HERS-rater documentation could be play a key role in the education of homebuyers.

Market Availability

While many builders and HVAC contractors are familiar with duct testing, the strategies discussed here are currently being implemented by a handful of advanced builders and specialty contactors such as Chitwood Energy Management. The construction industry as a whole needs to be better educated on quality construction principles and learning how the architect, builder, and different trades can better coordinate with one another to achieve improved construction quality. This involves training, vigilant construction management, and HERS inspections with feedback to the installing contractors. The subcontractor infrastructure is fairly immature at the current time, but will hopefully expand as the construction industry recovers from its current sales downturn, and builders pursue more aggressive building performance requirements.

Summary

Quality construction concepts were beginning to gain some traction among progressive builders just as the housing slowdown came into effect in 2007. The benefits and opportunities are clear, but improved industry infrastructure and consumer education is needed to provide the mechanism to transform the production home construction market. Rising natural gas and electric rates will help focus attention on the benefits of quality construction in a manner analogous to the current consumer reaction to gasoline prices.

1.1.6.3 *3.2.2.3 Ventilation Cooling*

Technology Description

Ventilation cooling is a strategy for improving indoor comfort that has been in use for centuries, and involves ventilating spaces with outside air during times when the outdoor temperature is lower than the indoor temperature and ceasing ventilation when this condition is reversed. The interior mass of the building gives up heat while it is being ventilated, and absorbs heat during the warmer periods of the day. In its simplest form, ventilation cooling is controlled using windows, though whole house fans can be used to increase the air change rate. However, there are problems associated with the use of windows and whole house fans for ventilation. Optimal operation requires homeowner awareness of the times when conditions are favorable for ventilation cooling, as well as the diligence to carry out the opening and closing of windows. Also, outside air is not filtered and open windows compromise home security.

There are two available products that solve the control, filtration, and security problems: SmartVent and NightBreeze. Both products integrate with furnaces or air handlers and use the HVAC system fan to move air. A single 4-way damper or individual dampers are used to select between the recirculation of indoor air (for heating and air conditioning), and the supply of outside air and relief of indoor air (for ventilation cooling and fresh air ventilation). These two modes of operation are shown in Figure 5.

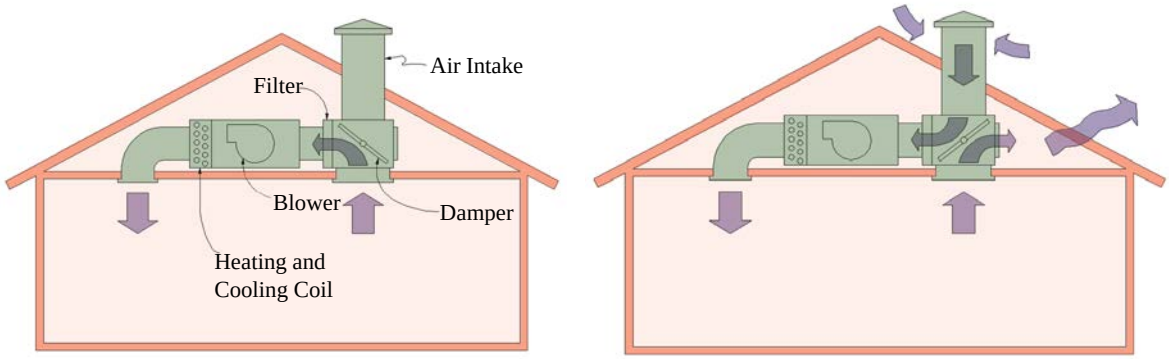

Figure 5: Operation of Ventilation Cooling Systems with 4-Way Damper

SmartVent was developed by Beutler Corporation to serve their builder customers. NightBreeze was created out of a multi-year California Energy Commission project called Alternatives to Compressor Cooling[11]. The objective of this project was to develop systems and design methods for eliminating the need for air conditioning in "transition" coastal climates, and to reduce air conditioning load in other climate zones. NightBreeze is currently marketed by Advanced Energy Products. Basic differences between the two are listed in Table 5.

Energy Performance

In the course of completing analysis under the Alternatives to Compressor Cooling Project, a special function was developed for the DOE-2.1 simulation that emulates the control capabilities

[11] Development and Testing of an Integrated Residential Night Ventilation Cooling System. ASHRAE Transactions. 2005. Vol. 111. Pt. 2.

of a variety of ventilation cooling systems, including SmartVent and NightBreeze. This simulation program was used to evaluate both system types in all sixteen California climate zones. Analysis results for a 3080 ft^2 home that was used as one of the two initial demonstration sites are displayed in Table 6. "SmartVent Original" applies the simple indoor-outdoor differential temperature control function and fixed low indoor temperature limit used by the SmartVent system. "SmartVent (NB)" applies the same variable low temperature limit used by the NightBreeze controls. "NightBreeze" implements the predictive control logic used by NightBreeze to vary both the low limit temperature and the fan speed based on current weather conditions. (The low limit temperature is decreased and the fan speed increased during hotter weather.)

As shown in Table 6 projected energy savings are small or non-existent in the milder climate zones but electricity demand savings are substantial, suggesting that ventilation cooling might be able to displace air conditioning in Climate Zones 1-8. Although demand savings are comparable for the two systems, the SmartVent saves little or no energy because the fan operates at the same speed regardless of the need for ventilation cooling, whereas the NightBreeze, which uses a more efficient ECM motor and varies the fan speed based on weather conditions, conserves this fan energy.

Table 5: Comparison of SmartVent and NightBreeze System Capabilities

	SmartVent	NightBreeze
System type	Any type of furnace	Variable speed hot water air handler or variable speed furnace
Ventilation air flow	Fixed	Varies with expected cooling demand (higher on hot days, lower on mild days)
Low limit temperature	Fixed at owner's setting	Varies with expected cooling demand (lower on hot days, higher on mild days)
Winter fresh air ventilation option	No	Yes. Ventilation rate can be adjusted to meet ASHRAE 62.2 requirements.
Feedback on the consequences of cooling temp settings (low limit and AC)	None	Graphic predicts what the indoor temperature range will be based on the temperature settings, and warns if the air conditioner is likely to run.
Self-diagnostics	None	Yes. Detects damper failure or heating/air conditioning failure and activates 'Service' light
Zoning capability	Up to 4 zones	Up to 2 zones

Actual energy savings will vary considerably with occupant behavior and comfort tolerances. For example, a homeowner who uses their air conditioner to maintain 70°F indoor temperatures throughout the summer would benefit less because there would be fewer hours when the outdoor temperature is more than 5°F cooler than the indoor temperature. Also, occupants who extensively operate their windows for ventilation would also not derive as many benefits from the operation of the integrated automatic systems. Monitoring data from two Livermore houses with identical floor plans, shown in Figure 6, lends support to the energy savings predicted by the simulation model. During this one example day, the NightBreeze equipped vent cooling house used no air conditioning but maintained indoor temperatures that were generally lower than the comparison "control" house and while using one fifth of the energy.

Title 24 credit is not currently available for ventilation cooling systems. A "codes and standards enhancement" report was provided to the Energy Commission during the 2005 standards rulemaking process, but because correct modeling would require substantial changes to the ACM manual, consideration of the proposal was postponed. Sempra is currently supporting the development of a compliance option for ventilation cooling that could be introduced before the next rulemaking.

Table 6: Comparative Performance of Ventilation Cooling Systems in California Climates

	Vent Cooling Savings w/ 13 SEER AC					
	HVAC kWh Savings			Demand kW Savings		
Climate Zone	NightBreeze	SmartVent (NB)	SmartVent Original	NightBreeze	SmartVent (NB)	SmartVent Original
CZ 01	(196)	(33)	(69)	(0.1)	-	-
CZ 02	608	(159)	(206)	2.5	2.7	2.7
CZ 03	(159)	(432)	(669)	1.9	2.0	2.0
CZ 04	534	(414)	(549)	2.5	2.6	2.6
CZ 05	(217)	(403)	(572)	1.1	1.2	1.2
CZ 06	173	(688)	(1,186)	1.9	2.2	2.1
CZ 07	416	(631)	(1,195)	1.6	2.2	3.1
CZ 08	779	(410)	(782)	2.7	2.8	2.9
CZ 09	890	(180)	(416)	2.3	2.5	2.5
CZ 10	1,013	52	(58)	2.9	2.7	2.7
CZ 11	1,152	242	189	2.7	2.4	2.4
CZ 12	1,079	68	22	2.1	1.9	1.9
CZ 13	983	128	53	1.9	1.6	1.6
CZ 14	845	57	8	2.6	2.3	2.3
CZ 15	383	(507)	(566)	3.0	2.7	2.7
CZ 16	720	(38)	(69)	2.1	2.0	2.0

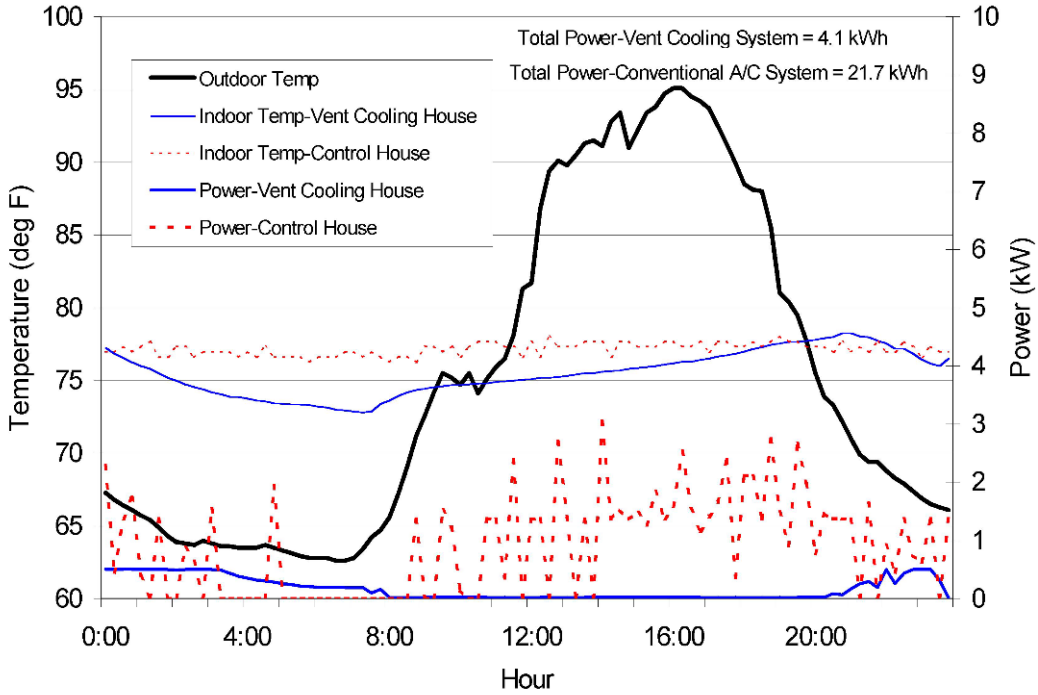

Figure 6: Temperature and Energy Use Comparison for Ventilation Cooled vs. Standard House

Costs

Installed costs for the SmartVent, including controls, damper, and outside air intake and ducting, are currently between $1000 and $1200 for new construction. The NightBreeze system

is available in two versions, an "air handler" version that includes the fan, heating coil, controls and damper; and a "furnace" version that includes only the controls and damper, but that requires a variable speed furnace. The trade price for the air handler version, which eliminates the need for a furnace, is $3,047. The trade price for the furnace version is $1,395. The incremental installed cost for a furnace system is approximately $1,850. If the specified furnace does not have a variable speed fan the upgrade cost for the furnace would be approximately $600.

Both the SmartVent and NightBreeze controls include zoning capability. Zone controls may add $250-500 to the system cost, so where zoning is required the cost can be offset by this amount. Since the NightBreeze eliminates the need for a fresh air ventilation system, the cost may be offset by an additional $150-300, bringing the overall incremental cost down to a range of $1,650-2,050.

PG&E currently offers a $250 incentive for non-variable speed systems and a $500 incentive for variable speed systems under their new construction prescriptive rebate program. SMUD also offers a $500 incentive for the NightBreeze.

Technical Feasibility

There are few remaining technical hurdles. Beutler has installed more than 20,000 SmartVent systems in the Sacramento area. SmartVent controls rely on the thermostat fan signal to operate the furnace fan, and some furnace controls do not allow this signal to operate the fan at its maximum speed. Beutler has used a relay work-around to solve this problem. NightBreeze controls communicate directly with the fan motor controller, and can run the fan at its highest speed. However, the furnace version of NightBreeze is current only available with Lennox variable speed furnaces. Over 100 NightBreeze systems are in service.

Market Acceptance

Buyers seem to readily grasp the concept of ventilation cooling, particularly the value of having the system operate automatically and of filtering outside air. Beutler representatives have stated that about 80 percent of the customers who come through their showroom buy the SmartVent option.

Market Availability

So far, Beutler has been marketing SmartVent solely to their Northern and Central California builder customers. AEP offers NightBreeze to all builders and contractors throughout the western states, but most sales have been in California. Because the more popular furnace product only became available midway through 2007, the housing slump has impacted sales, but AEP has stated they currently have the capacity to deliver about 2000 units per year[12].

Summary

Ventilation cooling is a market-ready technology that has been demonstrated to significantly reduce both energy use and peak demand while improving indoor air quality. At current

[12] Personal communication, 5/29/08.

electric rates energy savings approximately equal the incremental mortgage payments required to finance the system (at 7 percent, 30 years) in Climate Zones 10, 11, 12, and 13. With available incentives ventilation cooling can provide a positive annual cash flow as high as $500 while contributing to improved indoor air quality.

1.1.6.4 *3.2.2.4 Evaporative Condensers*

Technology Description

Residential evaporative condensers offer efficiency advantages over conventional air-cooled air conditioners by using evaporative cooling to improve condensing unit performance. These systems use cooling tower technology to replace the typical air cooled condenser resulting in 30-40°F reductions in peak refrigerant condensing temperatures relative to air-cooled system condensers. Reduced refrigerant condensing temperatures translate to higher cooling capacity and reduced compressor demand, resulting in higher operating efficiencies. Equally as significant as the improved performance is the resulting stable cooling capacity with outdoor temperature. Unlike air-cooled systems that lose cooling capacity at a rate of roughly 5 percent per ten degrees of outdoor temperature rise, evaporative condensers demonstrate much more stable performance. Since summer heat spells in California are characterized by very dry outdoor conditions, the relative benefit of evaporative condensers actually increases during heat storm events when the electrical grid is most heavily taxed. Figure 7 provides a schematic of Beutler's AquaChill evaporative condenser. A water sump at the base of the unit collects water that is pumped from the sump to the water spray system. The condenser fan pulls air through the base of the unit past the sprayed condenser coil. Typical configurations would have only one condensing unit (and refrigeration circuit), though multiple compressors may be used with larger capacities. The impact of improved condenser to water heat transfer and the powerful evaporative cooling effect contributes to the enhanced heat transfer and improved efficiencies.

Costs

Current California contractor pricing for the AquaChill unit is roughly equivalent to that of high-end two-stage cooling systems with SEER ratings of 16 - 20 and EER ratings ranging from 12 - 14. AquaChill retail incremental costs (relative to 13 SEER equipment) is roughly $550 - $600 per ton. In today's market where evaporative condensers represent a niche product, incremental costs to the homeowner are likely in the $1,000 to $1,300 per ton range. SMUD is currently offering per unit evaporative condenser incentives of $1,100[13]. These incentive levels are expected to continue at least through 2009. PG&E incentives do not exist yet but are anticipated as well.

[13] See Tier 4 level at http://smud.org/rebates/images-rebates/summary_ac_heatpumpprogram.pdf

1. Compressor/refrigerant 410a
2. Condenser fan
3. Electrical controls
4. Condenser coil
5. Water level float
6. Water pump
7. Purge pump

Figure 7: Evaporative Condenser Schematic[14]

Technical Feasibility

The evaporative condenser technology has the potential to transform the residential air conditioning market since the system is a drop-in replacement for the existing air-cooled condensing unit. The system's improved performance (relative to air-cooled) at design outdoor conditions results in indoor comfort conditions equal to or better than conventional air-cooled systems.

Contractor education and training is needed to insure proper installation and maintenance. To date, insufficient data exists to adequately address product service life and what level of maintenance will be needed over the years. The introduction of water to the condensing unit increases maintenance needs relative to conventional air-cooled equipment. In recognition of this increased maintenance need, Beutler suggests semi-annual maintenance and include maintenance at no cost for the first two years. Although most homeowners can perform the basic maintenance, a skilled HVAC technician should provide a better assessment of potential near term problems that may be corrected. The cost of an ongoing HVAC service contract will negatively impact homeowner savings, and in some cases may exceed the cooling energy savings.

Market Acceptance

Title 24 compliance credits are available for evaporative condensers. The credits are significant (>20-30 percent savings on the cooling budget in most climate zones) providing a strong incentive for builders targeting Tier 1 or 2 performance levels. The lack of a long-term track

[14] Courtesy: Beutler Corporation (https://www.beutler.com/product_manual.asp)

record for the technology and uncertainty over product lifetime may cause builders to move slowly.

Major HVAC manufacturers have yet to embrace the evaporative condenser technology as a viable option with two key reasons being concerns about maintenance and product longevity, as well as a strong desire to market products to larger national, not regional markets.

Many advanced cooling technologies consume utilize evaporative processes to achieve the high efficiencies that lead to energy and peak demand savings. This tension between water vs. energy efficiency is an important issue in dry Southwestern climates where water resources are limited, but evaporative technologies also have the greatest energy savings potential. For the two units monitored for PG&E in 2007, water use ranged from 2.8 to 3.5 gallons/ton-hour (total use of 2,543 to 3,279 gallons over the three month summer period).

Market Availability

During the summer of 2009, Beutler's AquaChill system was the only product on the market. Freus, headquartered in Anthony, Texas, also had an evaporative condenser on the market but at this time it does not appear to be commercially available. Freus had produced approximately 6,500 by mid-2006, with the bulk of sales in the southwestern United States. Thirty AquaChill units were installed in the Sacramento area during the summer of 2008 as part of a SMUD field testing program. Approximately 32 units are in the field at this time. 2009-2010 production goals are uncertain at this time.

Summary

Evaporative condensers are an emerging technology that offers significant energy and demand benefits, exceptional performance at high temperatures, and sizable Title 24 credits for builders. Although it is fairly clear that future California energy efficiency efforts will target efficient cooling technologies such as evaporative condensers, the lack of a long-term track record for this technology may cause builders to move cautiously.

1.1.6.5 *3.2.2.5 Advanced Evaporative Coolers*

Technology Description

Evaporative cooling is a technology that holds considerable promise for reducing cooling system energy use and peak load in dry Western climates where high summer dry bulb temperatures and generally dry conditions allow for good performance. In California, approximately 5 percent of households utilize evaporative coolers; typically low cost aspen pad coolers that have short equipment lives and mediocre cooling performance. Evaporative cooler benefits include energy and peak demand savings (typically 50-80 percent reduction) and the delivery of fresh, filtered outdoor air.

Of the evaporative coolers common to the California market, a vast majority are direct evaporative coolers. These coolers pass outdoor air through a wetted media to deliver cooler, more humid air to the space. Indirect and indirect-direct evaporative coolers are much less common in the marketplace. These coolers utilize an upstream heat exchanger to indirectly cool

outdoor air without adding moisture. Indirect coolers deliver this cooled air[15] to the indoor space, while indirect-direct coolers further cool this air with a direct evaporative stage.

Advanced direct evaporative coolers utilize more efficient rigid evaporative media, higher quality pumps and fans, and corrosion-resistant cabinets. One product, the Breezair ICON, by Seeley, features an efficient high airflow fan. The sole current indirect cooler on the market is the Coolerado R600, although Seeley will be releasing the Climate Wizard soon[16]. Currently, the only indirect-direct cooler available on the market is from Speakman CRS. Adobe Air used to have indirect modules, but since Champion bought Adobe, the indirect module is not commercially available.. Unlike Adobe Air where the indirect module is field installed on a direct cooler, Speakman's OASys unit is an integrated product. The OASys is newly commercialized with expected 2008 sales of about 500 units.

Direct Evaporative Process Indirect-Direct Evaporative Process

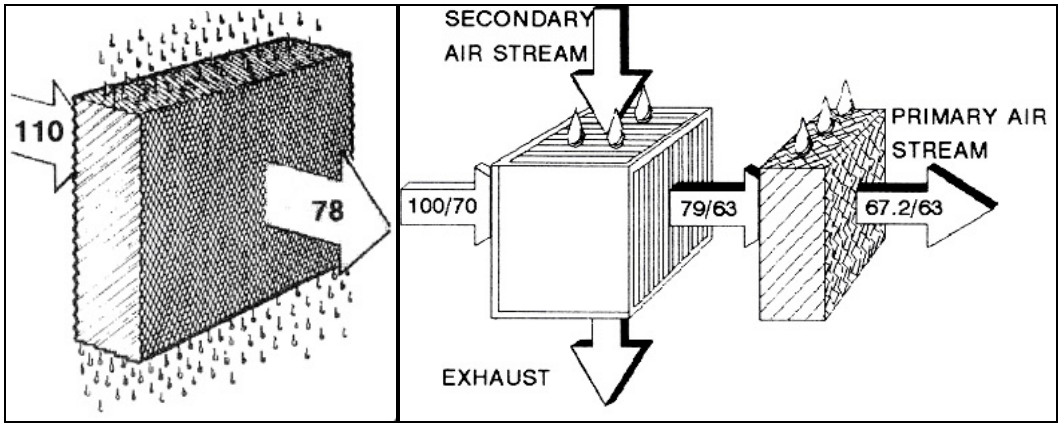

Figure 8: Schematic of Direct and Indirect-Direct Evaporative Processes

[15] Typically, indirect coolers deliver slightly warmer, but considerably drier air to indoors than direct evaporative coolers.

[16] A prototype unit will be tested by the Western Cooling Efficiency Center at UC Davis before the end of 2009.

Energy Performance

A monitoring and evaluation project was completed by PG&E in 2007 to assess field performance and projected economics for five different advanced residential evaporative cooler technologies[17]. The advanced coolers included:

- A Breezair variable-speed direct evaporative cooler
- A Coolerado indirect evaporative cooler
- Two Essick Air direct units with 12" thick rigid media (monitored in two separate houses)
- An Essick Air direct unit coupled with an add-on indirect evaporative module
- An OASys indirect-direct evaporative cooler

The six houses, located from Fresno to Chico in the Central Valley, were monitored through the 2007 summer. Of the five cooler types monitored the OASys indirect-direct and the Breezair direct unit were found to offer the best performance. The Essick Air direct unit offered good performance (at a lower installed cost), but hourly simulation runs were completed on a 1,600 sq. ft. house prototype based on the monitoring results. Advanced cooler energy savings were computed for the Sacramento and Fresno climates relative to a standard SEER 13 air conditioner. Projected energy savings relative to the SEER 13 base case range from 66-82 percent[18] and demand savings range from 64-83 percent, with slightly higher percentage savings projected in the hotter Fresno climate. At an assumed average PG&E summer electric rate of $0.15 per kWh, projected Sacramento savings average $75 per year (400-570 kWh/year) and Fresno savings average $211 (1,150-1,530 kWh/year) annually. Higher cooling energy use customers or higher utility rates will result in increased savings.

The 2008 Title 24 Residential Building Standards, which will go into effect in January 2010, will offer compliance credit for qualifying indirect and indirect-direct units. A report describing how the systems are modeled and the necessary installation criteria can be found at the California Energy Commission's website[19]. Average cooling budget energy savings are in the range of 20-30 percent, depending upon climate zone and equipment performance characteristics.

Costs

Detailed HVAC contractor cost information was available for the advanced evaporative coolers in the 2007 PG&E project. The costs summarized below represent the incremental cost (equipment only) relative to a baseline direct evaporative cooler (i.e. "swamp" cooler) available at a big box retail store. The advanced cooler costs were high, with four of the five system types

[17] http://www.etcc-ca.com/database/summary.php?id=461

[18] From highest to lowest projected savings based on the field monitoring results, the units are ranked as follows: Breezair, Essick Direct, OASys, Coolerado, and Essick indirect-direct. The Coolerado and OASys performed best in terms of maintaining lower indoor humidity levels. Actual performance and comfort is highly dependent on the magnitude of the cooling loads and the indoor cooling setpoints.

[19] http://energy.ca.gov/title24/2008standards/prerulemaking/documents/2006-05-18_workshop/2006-05-11_COOLING_REVISED.PDF

showing an incremental cost of between $2,000 - $3,000. Costs must clearly be reduced for these advanced coolers to achieve any significant market penetration, since the current costs are not significantly less than a 13 SEER vapor compression system.

- Direct cooler: $1,250
- Breezair variable speed direct: $2,130
- Coolerado: $2,900
- OASys: $2,600
- Indirect-direct: $2,300

Since many of these advanced coolers are not currently produced in high volumes, some form of incentive is needed to generate market demand.

Technical Feasibility

Evaporative cooler installation is generally a straightforward process. Units are generally roof-mounted, although the OASys can easily be installed in a through-the-wall configuration, in an attic, or an exterior closet. Water must be provided to these units and bleed or dump water from the unit must be directed to an acceptable drain line or to the ground. Evaporative coolers can share a duct system with a conventional HVAC system provided a barometric damper is installed to isolate the evaporative cooler during return air recirculation operation. Evaporative coolers also require a mechanism to relieve indoor air since the system provides 100 percent outdoor air. This is commonly achieved by adding ceiling "up-ducts"[20], or barometric dampers, that open whenever the house is pressurized by cooler operation. The location of the up-ducts dictates the airflow path from the supply registers. Strategic location of the up-ducts is important in achieving comfort in the key living and sleeping areas of the house. Window operation can be used as an alternative to up-ducts, although there are safety/security concerns, as well as the need for someone to open the windows prior to cooler operation.

An advantage of evaporative coolers relative to vapor compression equipment is their relative simplicity. The homeowner can perform basic system maintenance and complete basic troubleshooting which may involve verifying adequate water flow to media, uniform flow over the media, and water fill operation. The basic maintenance is essential for evaporative coolers, unlike most vapor compression systems, which are ignored unless something goes wrong. Long term reliability and service life of these advanced coolers is certainly better than for "swamp" coolers, but to achieve broader market acceptance a fifteen year service life is expected.

Market Acceptance

Mainstream builders and new homebuyers generally do not hold positive views of evaporative cooling. The comfort associated with vapor compression systems has become a minimum

[20] Most up-duct products are square sheet metal frames that are installed in the ceiling drywall. A lightweight barometric damper opens to the attic when the evaporative cooler pressurizes the house. Up-ducts compromise the thermal integrity of the ceiling (no insulation can be installed above the damper) to a small degree and also add a leakage path to unconditioned space.

standard that most buyers expect. In addition, "swamp" coolers have been historically perceived as a low efficiency cooling device that provides poor indoor temperature control and excessive indoor humidity. Evaporative coolers are also generally roof-mounted, contributing to aesthetic concerns in many markets.

Newer, more efficient evaporative coolers will do a better job in maintaining comfort and reducing daily operating hours. More importantly, the improved building envelopes in new homes (better wall and ceiling insulation, low solar gain windows, attic radiant barrier, higher efficacy lighting, etc.) will contribute to reduced cooling loads and therefore improved comfort. We feel that in the short term, these market acceptance issues will represent a significant barrier in the production home market. Rising electric rates and other external factors will provide some support of this efficient technology, but broader acceptance will depend on long-term reliability and demonstrated comfort.

System water use is a concern for many, despite the significant energy and demand savings associated with evaporative coolers. Typical water use for most coolers is about 3-4 gallons per operating hour. Water agencies are concerned about water use because cooler consumption is highest during the hottest part of the day when water agencies may also be experiencing strain on their water distribution system.

Market Availability

Advanced direct evaporative coolers such as the Breezair ICON unit are widely available in regions of the state where evaporative coolers are commonly installed. The advanced indirect (Coolerado) and indirect-direct products (OASys) are also available, but on a more limited basis. Contractor familiarity with the latter products is not widespread, since the systems are fairly new to the market.

Summary

Evaporative coolers are a highly efficient, low energy cooling system that is well suited to hot-dry climates such as the southwestern U.S. Most evaporative systems (with the exception of indirect systems such as Coolerado) add moisture to indoor air, which is beneficial during much of the summer, but will likely lead to excessive indoor humidity when cooling loads are high and/or outdoor wet bulb temperatures are high. It is anticipated that continuing improvements in new home building envelopes will reduce cooling loads, improving the ability of advanced evaporative coolers to meet the load and better maintain indoor comfort. Market acceptance issues still represent a significant hurdle in the production home arena, as both builders and homebuyers recognize vapor compression cooling as the minimum standard, despite high operating costs and peak demand impacts.

1.1.6.6 *3.2.2.6 Conclusions*

Five emerging technologies are presented in this report. These technologies have both benefits and risks for builders.

Table 7 summarizes key attributes of the five measures and provides an overall assessment of near term value to production builders.

Table 7: Measure Comparison

	Gas Tankless Water Heater	Quality Envelopes	Ventilation Cooling	Evaporative Condensers	Advanced Evap Coolers
Title 24 Recognition	Yes	Yes	2010 Likely	Yes	Jan 2010 (2008 Title 24)
Title 24 Credit	Significant	Moderate	Moderate Credit Likely	Significant	Significant
Builder Acceptance	Most	Some	Few	Few	None
Customer Acceptance	Most	Most	Some (education needed)	Some (education needed)	Few (education needed)
Proven Reliability	Partial	Yes	Partial	No	No
Developed Infrastructure	Yes	Some (more contractor training)	Some	Marginal	Marginal
Near Term Builder Value	High	High	Moderate	Moderate	Low

1.1.7. 3.2.3 Single Family Design Package Report

1.1.7.1 *3.2.3.1 Introduction*

The primary goal of 'ZENH Design' is to plan, design, analyze, and support the construction of residences that meet the goals set forth by the CEC's ZENH program. This 'Single-Family Zero Energy New Homes Design Report' describes how packaging PV systems with carefully selected energy efficiency measures can improve home marketability and buyer value. This report identifies marketing opportunities and other benefits that become available to builders when houses are designed to ZENH standards, describes general best practices, and provides detailed specifications for a cost-effective package that has been developed through research conducted under ZENH and other programs. Project examples and builder-buyer economics are also discussed for three specific project examples in Section 1.1.3 of this report. The recommended package is appropriate for single family homes in cooling dominated climates such as the Sacramento and San Joaquin valleys and represents current best practices.

1.1.7.2 *3.2.3.2 Market and Cost Benefits Available to ZENH Builders*

Programs That Support Zero Energy New Home Projects

There is a potpourri of existing and emerging programs and initiatives that builders can take advantage of to aid the entitlement process, help them market their homes, and to offset costs. An increasing number of communities are requiring building performance that exceeds Title 24. Partially as a result of the California Global Warming Solutions Act of 2006 (AB 32), requirements for reductions in energy use and greenhouse gas emissions are finding their way into the entitlement process. Meanwhile, programs such as LEED for Homes, GreenPoint Rated, and the new DOE Builders Challenge programs are using performance in excess of code

to earn credits for certification and performance labeling. The key, then, is to strategically implement combinations of these programs and incentives to achieve the maximum return for the builder and maximum benefit for the buyer.

Utility / State Incentives

Beginning January 1, 2007, the CEC offered an incentive through the NSHP for qualifying solar systems at production housing (approximately $2.60 per watt). In order to qualify for this incentive, all homes must be at least 15 percent better than required under Title 24 and all appliances must be Energy Star. The amount of the CEC incentive does not increase with higher efficiency levels. The actual incentive is based on the Expected Performance Based Incentive Calculation, which accounts for the tested performance of the module and inverter, the mounting type and cell temperature, the orientation and tilt of the modules, and the shading, solar and climatic conditions for the locales, and time-of-use value of the system generation relative to the utility system (TDV). The IOUs currently administer the New Solar Home Partnership (NSHP) program for the CEC, and administer the energy efficiency programs for Residential New Construction (RNC). The current NSHP incentive is $2.50 per watt.

To align with the CEC NSHP, the IOUs adopted the same Title 24 compliance margin requirement (15 percent) for the base level of their partner energy efficiency program (Tier I), and pay $400-$500 per home depending on the climate zone. The IOUs also offer a second "Tier" in the energy efficiency program, which requires homes to be 35 percent above Title 24, and the cooling budget to be 40 percent above the Title 24 cooling budget, and pay $2000 per qualifying home. The Energy Star Homes Program (ESH) and the Tier 1 energy efficiency program are separate offerings, even though in most cases the compliance margins and the incentives are the same. Since ESH is an EPA offering, the program requires additional testing such as the Thermal Bypass Checklist and the Quality Insulation Installation. Tier 1 and Tier 2 homes do not need those tests unless they are used in the compliance of the home.

Municipal utilities such as SMUD and Roseville Electric have their own incentive programs for both solar and energy efficiency. Many of the utility sponsored programs include third-party verification of Quality Insulation Installation (QII) as a requirement for participation.

Federal Incentives

The Energy Policy Act of 2005 (EPACT) authorized a one-time solar energy investment tax credit (ITC) to homeowners with PV systems equal to 30 percent of the system cost, up to a maximum of $2,000. The solar tax credit was renewed in 2009 and is now slated to expire on 12/31/2016. Also, systems placed in service after January 1, 2009 are no longer subject to the maximum credit of $2,000. All demonstration homes built as part of the Zero Energy New Homes were completed before January 2009 and were thus not able to take credit for more than the $2,000 credit.

EPACT also authorized a one-time energy efficient home tax credit for the builder of the home, totaling $2,000 if the home is certified to have an annual level of heating and cooling energy consumption at least 50 percent below the energy consumption of a comparable home built to

2004 IECC standards. The home must also have building envelope component improvements providing a level of heating and cooling energy consumption that is at least 10 percent below that of a comparable home. The energy tax credit is slated to expire on 12/31/2009, but pending legislation may extend them. All applicants are required to meet third-party QII criteria to qualify.

Table 8 presents some approximate amounts of the solar and energy efficiency incentives and tax credits available for a typical home under Tier I and Tier II with a 2.4 kWp PV system in California CZ 11-12.

Table 8: Example Summary of Incentives and Federal Tax Credits

Program(s) Efficiency Requirements	Tier I	Tier II
% of total energy above Title 24 (kBTU/sf-yr)	15%	35%
% reduction in cooling load	n/a	40%
All Appliances Energy Star	yes	yes
CEC and IOU Incentives		
IOU Energy Efficiency Rebate[21]	$500	$2,000
CEC Solar Rebate (est. for a 2.4 kWp system)	$4,600	$4,600
Federal Tax Credits		
for Homeowner [22]	$4,300	$4,300
for Builder [23]	(evaluate)	$2,000
Total Builder Incentives and Tax Credits	**$5,100**	**$8,600**
Total Homeowner Incentives and Tax Credits	**$4,300**	**$4,300**

Branding and Labeling Programs

Several programs available to builders provide assurance of home construction quality and energy efficiency. Like the NSHP, the GreenPoint Rated program also requires performance 15% above Title 24, as does EPA's Energy Star for Homes program. However, Energy Star also requires a "Thermal Bypass Checklist" be completed that involves inspections of insulation for quality installation and testing. The same inspections and testing can be used to earn additional Title 24 credits and can be used to achieve the 35 percent Tier 2 performance level. Homes that meet the LEED Certified rating must also meet Energy Star standards. The DOE Builders Challenge, LEED, and GreenPoint Rated (GPR) programs all require compliance with certain

[21] Tier I = $400 for coastal CZs 1-7 and $500 for inland CZs 8-16, Tier II = $2,000 for all CZs.

[22] Under the Federal Energy Policy Act of 2005, homeowners with PV systems may qualify for a one-time person tax credit equal to 30% of the system's initial cost, currently through 2016. See IRS form 3468. Incentive amount based on 2.4 kW system and an estimated cost of $6 / watt after CEC NSHP rebate.

[23] $2,000 for a dwelling unit that is certified to have an annual level of heating and cooling energy consumption at least 50% below the annual level of heating and cooling energy consumption of a comparable dwelling unit (2004 IECC), etc. See IRS form 8908.

quality criteria in addition to above-code energy performance. Some communities are requiring that new homes be built to Energy Star, GPR, or other standards and this trend is likely to grow.

New Energy Standards

California has approved new Title 24 energy standards that will require such measures as Low-E[2] windows, making compliance much more challenging beginning 2010. The builder that learns how to meet this challenge and capitalize on improved energy performance in advance of the standards implementation will have a much better chance of succeeding in the marketplace.

Maximizing Benefits

A strategic approach to building and marketing high performance zero energy homes would be to develop home designs that qualify for selected programs while taking advantage of qualification criteria that are common amongst them. The builder can choose the branding/labeling program or combination of programs that is likely to attract the most attention in the particular market. For example some communities might respond better to energy savings and others to "green" marketing approaches. Energy use is the primary concern of the ZENH program, but builders will likely benefit by incorporating the components of the other programs by offering homes that demonstrate higher quality, health, and comfort attributes in addition to energy savings. In a survey conducted under the federal Zero Energy Homes program in 2003, respondents ranked quality of construction as the most important feature of new homes, higher than energy savings, and high quality homes have reduced callbacks.

1.1.7.3 *3.2.3.3 Defining the Zero Energy New Home*

The California Energy Commission defines the ideal Zero Energy New Home for the purposes of this project as a home that meets the 2005 targets listed in Table 1 on page 24. Summer peak demand for a ZENH is defined as the maximum daily power drawn from the electric utility on weekdays during the four hours surrounding the system peak, averaged across the utility system's hottest month.

Homes built under ZENH have easily demonstrated over 25 percent energy savings relative to Title 24. The maximum summer peak demand goal of 1 kW is possible to achieve with a ZENH design, but is highly dependent on what appliances and other electricity consuming items the owner brings into the house and how they are used. It is also possible to achieve a 70 percent utility bill reduction, particularly if favorable time-of-use rates can be applied[24]. The incremental first cost is a much more difficult goal to achieve given current construction costs, but as is explained in this report, it is possible for a builder to absorb nearly all of the incremental cost while remaining highly profitable.

[24] PG&E withdrew its very favorable E-7 time of use rate in 2007.

ZENH Best Practices

➢ ***What Are ZENH Best Practices?***

There is an immense combination of possible improvements that can be made to reduce home energy use. The goal should be to adopt the most cost-effective combination, or package, that will produce the greatest energy savings. Many individual energy efficiency measures can interact with others, that is, as one measure is added to a particular house design it affects how other measures perform. For example, reducing the cooling load by improving the envelope (by adding insulation, high performance windows, and shading), decreases the energy savings that can be obtained from the installation of an efficient air conditioner. Using the same example, the envelope improvements can reduce the size and cost of the required air conditioner, as well as the PV system, compounding the value of the envelope measures. An exhaustive "sequential analysis[25]" of different combinations of energy efficiency measures is needed to develop the most cost-effective combination, or package.

Through research completed under the Department of Energy's Zero Energy Homes and Building America programs, the sequential analysis method has been used to optimize measure packages for California's Central Valley climate. The performance of these packages has been verified using a new design optimization tool called BEopt that was developed at the National Renewable Energy Laboratory (NREL), and by comparing Micropas evaluations for a range of features. The resulting best practices, recommended in this report, are reasonably valid for a range of building envelope designs and building orientations.

1.1.7.4 *3.2.3.4 The Importance of Integrated Design*

"Integrated design" refers to the practice of involving the entire project team in the design process from schematic through construction drawings. Several energy efficiency measures are difficult or impossible to implement if they are not considered early in the design process. Some examples of this include window shading, advanced framing, locating ducts in conditioned space, and parallel piping. Using the latter example, shortening the amount of piping between the water heater and the fixtures saves both water and energy, but requires planning of the water heater, bathroom, and kitchen locations.

As another example, the practice of siting the same plan on lots with multiple orientations can result in the elevation that has most of the windows facing west, which can increase cooling energy use by 25 percent or more compared to a north or south-facing orientation. Tailoring house designs to the lot orientation saves energy, reduces the required size of cooling equipment (saving money), improves homeowner comfort and satisfaction, and makes energy compliance much easier to achieve.

In addition to siting optimization, preliminary meetings with architects, energy consultants, and subcontractors at the schematic design stage can be useful in suggesting configuration changes (e.g. building aspect ratio) that can reduce the amount of construction materials needed and

[25] The sequential analysis process was pioneered under Pacific Gas & Electric's Advanced Customer Technology Test for Maximum Energy Efficiency (ACT²), a research project that was initiated in 1990. See http://207.67.203.54/Qelibrary4_p40007_documents/ACT2/act2fnl.pdf for the project summary.

simplify the installation of piping, ducting, PV systems, and other components. Energy influences are clearly not a predominant driver on building siting and form, but consideration at the schematic design stage allows these factors to at least be taken into consideration.

1.1.7.5 *3.2.3.5 Recommended ZENH Package Energy Efficiency Measures*

This section lists and describes each recommended energy efficiency measure (EEM) and provides information about their availability, maintenance requirements, verification and inspection requirements, and estimated costs. All measures listed have been found to yield a positive cash flow when combined, that is the additional cost to finance them in the mortgage is less than the energy savings they produce at current gas and electric rates, and when packaged with PV systems result in energy savings that are consistent with ZENH goals.

Building Envelope Measures

Exterior Wall Insulation

Measure Specification:	R-15 fiberglass batt with 1" exterior foam sheathing. Where 2 x 6 walls are required for structural or other reasons, use R-21 batt. All wall insulation, including attic knee walls, must meet Thermal Bypass Checklist (TBC) and Quality Insulation Installation (QII) criteria.
Availability:	Readily available.
Installation & Verification:	Include TBC/QII requirements in insulation subcontract. Requires HERS inspection to qualify for Title 24 and Energy Star credits, Federal Tax Credit, as well as for participation in utility incentive programs and LEED.
Estimated Cost:	For houses that are using stucco systems that include exterior insulation sheathing, the incremental cost for the materials can be zero. Where it is applied under stucco or other siding materials, R-4 sheathing can add about $0.25 per s.f. of exterior wall surface area. Upgrading to high density batt insulation costs about $0.07 per s.f. of exterior wall area. The total cost of HERS inspections, including insulation, blower door and duct testing, and TXV/SEER verification is about $300 per house.

Roof/Ceiling Insulation

Measure Specification:	R-49 blown fiberglass or cellulose insulation in ceiling and R-19 batt insulation below equipment platform. All ceiling insulation should meet Thermal Bypass Checklist (TBC) and Quality Insulation Installation (QII) criteria.
Availability:	Readily available.
Installation & Verification:	Include TBC/QII requirements in insulation subcontract. Requires HERS inspection to qualify for Title 24 and Energy Star credits, Federal Tax Credit, as well as for participation in utility incentive programs and LEED.
Estimated Cost:	Upgrading from R-30 to R-49 ceiling insulation costs about $0.35 - $0.40 per s.f. of ceiling area.

Radiant Barrier

Measure Specification:	OSB or plywood roof sheathing with reflective foil laminated to underside with an emissivity 0.5 or less. Must be applied to all roof surfaces that are over conditioned space.
Availability:	Available from Louisiana Pacific, Georgia Pacific, Polar-Ply, and other manufacturers.
Installation & Verification:	Installation same as standard roof sheathing. Verified by HERS inspector.
Estimated Cost:	About $0.25 per square foot of roof area.
Other Information:	Some concerns have been raised about the effect of radiant barriers on the life of asphalt roofing. Tests conducted at the Florida Solar Energy Center have shown that roof temperature is only increased by a few degrees, suggesting that the effect on roofing lifetime is probably insignificant.

Tight Construction

Measure Specification:	Tightly sealed envelope with specific Leakage Area (SLA) less than 3.5.
Availability:	Accomplished through application of a house wrap and customary caulking of plates and framing penetrations, draft stopping, and installation of weather stripped doors and Energy Star windows.
Installation & Verification:	Include sealing requirements in insulation subcontract. Requires HERS blower door testing to qualify for Title 24 and other credits.
Estimated Cost:	The total cost of HERS inspections, including insulation, blower door and duct testing, and TXV/SEER verification is about $300 per house.
Other Information:	More credit in Title 24 for lower SLA. If taking credit for less than 3.0 SLA, mechanical ventilation is required.

High Performance Windows

Measure Specification:	U-value of 0.35 or less and SHGC of 0.32 or less.
Availability:	Available from all major window manufacturers.
Installation & Verification:	Follow manufacturer's instructions, particularly for flashing. Verified by HERS rater.
Estimated Cost:	About $0.40 - $1.00 per square foot of window area, depending on ratings of windows used to meet Title 24.
Other Information:	Higher performance windows are currently available and specified with SHGC of 0.26 and lower. In cooling dominated climates with the potential for orientations with significant east or west glazing, these higher performance windows can offer significant improvements in performance.

Mechanical & Plumbing Systems

High Efficiency Heating and Cooling Equipment

Measure Specification:	Variable speed furnace with AFUE greater than 0.90 and air conditioner SEER/EER equal to or greater than 14/12. Cooling coil installed with a thermostatic expansion valve (TXV).
Availability:	Available from all major manufacturers. Include ratings and requirements in HVAC subcontract.
Installation & Verification:	Furnace requires PVC venting instead of "B" vent and condensate drain. Otherwise, installation is the same as for standard systems. Direct venting allows furnace to be installed inside conditioned space (recommended). HERS rater verifies nameplate data and presence of TXV.
Maintenance:	Maintenance requirements are the same as for conventional equipment (filter replacement, periodic check of refrigerant charge, etc.)
Estimated Cost:	Experience has shown the furnace efficiency upgrade from 80 to 90+ AFUE, and motor upgrade from PSC to variable speed can cost anywhere from $300 to $1,000. The air conditioner upgrade costs in the range of $100 to $350 for SEER/EER's of 14/12 to 15/12.5.
Other Information:	More credit is given in Title 24 for a high EER rating than SEER rating because the EER rating is more reflective of actual operation in California climates.

Proper HVAC System Sizing

Measure Specification:	Size Heating and cooling equipment in accordance with ACCA Manual J and S or other methods acceptable to the California Energy Commission.
Availability:	Materials are readily available. Proper HVAC sizing using ACCA Manual J procedures are not uniformly practiced by HVAC trades.
Installation & Verification:	Include HVAC sizing requirements in HVAC subcontract. HERS rater can verify equipment sizing.
Maintenance:	None
Estimated Cost:	Contractors and/or Title 24 consultants usually offer sizing as a part of their service, resulting in no incremental cost. Proper sizing based on the actual building envelope measures can result in reduced equipment sizing.

Proper HVAC Refrigerant Charge

Measure Specification:	HVAC contractor to properly charge any refrigerant based air conditioning system or heat pump, and provide temperature measurement access ports on either side of the evaporator coil, and saturation temperature measurement sensors for non-intrusive HERS inspection. The measurement and regulation of correct refrigerant charge can significantly improve the performance and air conditioning equipment.
Availability:	Materials are readily available. Proper HVAC charging is not uniformly practiced by HVAC trades.

Installation & Verification:	Include HVAC refrigerant charging requirements in HVAC subcontract. HERS rater must be able to verify refrigerant charge.
Maintenance:	None. Proper refrigerant charge should result in longer AC life.
Estimated Cost:	Contractors usually charge the air conditioning equipment, but the charge is not usually verified. $100 additional cost for saturation measurement sensors. $200 cost for HERS verification.

Efficient Air Distribution System Design and Sizing

Measure Specification:	R-6 ducts with leakage less than 6 percent of system airflow, sized in accordance with ACCA Manual D or other methods acceptable to the California Energy Commission. For two story houses provide separate zones for first and second floors with automatic dampers. Do not use furnace bypass dampers. Keep duct runs as short as possible (avoid installing registers on exterior walls where possible). Allow ducting to lay on bottom chord of roof trusses so it can be covered with blown-in insulation. Alternatively, install all ducting in conditioned space. The duct design should be documented in construction drawings. Provide dedicated returns or transfer grilles for all bedrooms to ensure proper operation and distribution when doors are closed.
Availability:	Materials are readily available. Proper HVAC sizing using ACCA Manual D procedures and design of adequate return air flow are not uniformly practiced by HVAC trades.
Installation & Verification:	Include duct sizing, tight duct testing, and installation requirements in HVAC subcontract. Sizing and specification of return air flow from all rooms should be documented. HERS rater verifies leakage. Airflow testing by a HERS rater is recommended. Correct operation of the zoning system should be verified by builder field staff.
Maintenance:	None
Estimated Cost:	Frequently, contractors and/or Title 24 consultants will offer sizing as a part of their service, resulting in no incremental cost. As noted, comprehensive HERS inspection costs are about $300.

Fresh Air Ventilation and Ventilation Cooling

Measure Specification:	System to provide fresh air ventilation compliant with ASHRAE 62.2-2004, and automatic ventilation cooling using the furnace or air handler fan to deliver at least 0.6 cfm of outside air per square foot of conditioned floor area. The ventilation cooling system consists of an outside air damper and controls and reduces air conditioner energy use by ventilating with cool outside air during summer nights.
Availability:	System components are readily available.
Installation & Verification:	Correct operation of the dampers and controls should be verified by builder field staff. The 2008 Title 24 standards (going into effect January 2010) will require mechanical fresh air ventilation in all new homes. There is currently no Title 24 compliance option for the ventilation

	cooling component; hence there are no inspection or verification requirements.
Maintenance:	Requires more frequent filter changes due to filtering of outside air.
Estimated Cost:	The incremental installed cost for a ventilation cooling system designed to operate with a variable speed furnace, including zoning capability and variable speed furnace, is approximately $2,600. Zone controls may cost around $300, so where zoning is required the cost can be offset by this amount. Since the system integrates fresh air ventilation, the cost may be offset by an additional $400. PG&E currently offers a $500 incentive for variable speed systems, so the net incremental cost would be approximately $1,400. Net incremental cost for mechanical ventilation systems, not incorporated with the ventilation cooling equipment, range from $400 for exhaust-only systems to $1,500 for balanced systems (HRV/ERV).

Water Heating

Measure Specification:	Tankless (on demand) gas water heater, 80 EF or higher.
Availability:	Available from multiple manufacturers.
Installation & Verification:	Venting costs can be reduced or eliminated by installing the water heater on the inside of an exterior wall in the garage, on an exterior wall, or recessed into an exterior wall. Most plumbers are familiar with these units and should be trained in their installation and service. No verification is required.
Maintenance:	Manufacturers recommend periodic flushing to remove water deposits, though this is typically not required more frequently than at two year intervals depending on hardness of water supply.
Estimated Cost:	$1,000 (incremental vs. 50 gallon gas water heater). Long vent pipe runs should be avoided because of the high cost of materials (Category IV stainless steel venting is required).

Hot Water Distribution Piping

Measure Specification:	The optimal hot water distribution system type is based on the size and configuration of the home, number of stories, and local code requirements. LEED and GPR programs award points for certain design features. General guidelines are provided here. During the design of the house consideration should be given to laying out the location of hot water fixtures, (especially bathrooms and kitchen) close to the water heater. Piping systems should be engineered by a consultant or contractor who has an understanding of energy efficiency and water conservation. Homes less than 2,500 ft^2 where cross-linked polyethylene (PEX) is allowed by local codes: "Home run" or "parallel" piping system using PEX. The connection between the water heater and the manifold should not be greater than 10 feet (6 feet for LEED points), and should be insulated. Runs to fixtures should not be sized larger in diameter than

required by the plumbing code and should be kept as short as possible. The pipe run to the kitchen should also be insulated.

Homes greater than 2500ft²: Branched piping using copper or PEX, or a combination of branched and home run piping with "demand" recirculation. All main lines must be insulated (to R-4 as per Title 24) and lines between mains and fixtures should be kept shorter than 10 feet. Engineering of these systems to meet local requirements and to optimize green points is highly recommended. Uncontrolled and time / temperature recirculation systems should be avoided.

Availability:	Specified piping and recirculation controls are readily available.
Installation & Verification:	Plumbing contractors should follow engineering drawings and specifications. Verification by field superintendent and/or GPR / LEED rater.
Maintenance:	Recirculation pump lifetime should be greater than 10 years.
Estimated Cost:	Costs for home run piping are typically comparable to or less than those for branched copper hot water systems. Installed costs for demand recirculation systems range from about $600 to $800 for pushbutton, remote control, and motion sensor activated systems.

Lighting & Appliances

Indoor Lighting

Measure Specification:	Lighting installed in accordance with proposed 2008 Title 24 standards, which require high efficacy lamps in most fixtures, except where controlled by dimmers or motion sensors.
Availability:	Fluorescent luminaries are currently available and product offerings are expanding.
Installation & Verification:	Lighting compliance is typically verified by building officials.
Maintenance:	High efficacy lighting has a longer life.
Estimated Cost:	Fluorescent can fixtures are typically $40 per fixture, compared to incandescent fixtures at $10, but incandescent fixtures would require a $30 - $40 dimmer control per switch.

Outdoor Lighting

Measure Specification:	Lighting installed in accordance with proposed 2008 Title 24 standards, which either require high efficacy lamps or motion sensors plus photo sensors or time controls.
Availability:	Fluorescent luminaries are currently available and product offerings are expanding.
Installation & Verification:	Lighting compliance is typically verified by building officials.
Maintenance:	High efficacy lighting has a longer life.

Estimated Cost:	Incandescent lamps with required controls are more expensive than fluorescent lamps.

Appliances

Measure Specification:	All builder-supplied appliances are Energy Star labeled.
Availability:	Available at all wholesale and retail appliance outlets.
Installation & Verification:	By builder procurement and field personnel.
Maintenance:	Similar to conventional appliances.
Estimated Cost:	Energy Star dishwashers range from about $200 to $500 more than non-labeled models, depending on other features. Other appliances are typically not builder-installed.

Photovoltaic (PV) Systems

Measure Specification:	There are numerous reliable PV systems available for new homes, including both conventional rack-mounted systems and "building integrated" systems that interface with roof tile. The systems should be sized to the anticipated annual electrical load. Over-sizing results in generation of excess electricity that is not credited on utility bills under current net metering rules. Under-sizing does not take full advantage of the investment in the inverter and other components that must be installed regardless of the size of the system. Typical systems installed on production housing range from about 1.5 to 3.0 kW (DC, STC rated).
Availability:	Residential systems are available from numerous manufacturers.
Installation & Verification:	By builder procurement and field personnel. Inspection by a PV certified HERS rater is required for participation in state / utility incentive programs and federal tax credit verification.
Maintenance:	No periodic maintenance is required.
Estimated Cost:	Manufacturers / installing contractors normally file for and collect the Solar Homes Partnership rebate and charge the builder for the net cost. The installed cost varies depending on the system size and type, the number of homes in the community, and other factors. Rack-mounted modules are less expensive than building integrated systems. Installed costs currently range from about $6 to $8 per Watt (DC, STC rated).

ZENH Package Examples - Projects and Package Descriptions

The SunPower ZENH team worked with three production builders to design near zero energy homes. These include The Grupe Company's Carsten Crossings project in Rocklin, Lennar's Blackstone community in El Dorado Hills, and Meritage Homes' Encore project in Vacaville. See the Single Family Design Report on page 76 for summaries of each of these case studies, including list of specific efficiency features, savings, and incremental costs. The measures adopted by these three builders included most of those listed above and were similar to each other. Lennar used higher performance windows, slightly better air conditioners, and did not

install tankless water heaters or ventilation cooling (for which savings are not included in evaluation results). Meritage offered condensing furnaces as a buyer option.

1.1.7.6 *3.2.3.6 Builder and Buyer Costs and Benefits*

Performance relative to Title 24, incremental costs, and energy savings predicted by simulations of the homes in the three ZENH case studies are provided in Table 9. All three projects exceeded Title 24 by much more than the 25 percent ZENH goal, but only the Grupe project met the 70 percent bill savings goal listed in Table 9.

Table 9 also lists the incremental mortgage cost (at 7 percent and 30 years) for the energy improvements, and compares this to the energy savings to determine a first year annual cash flow. No incentives, such as the $2,000 federal tax credit, are included in the incremental cost other than the New Solar Homes Partnership incentive that is factored into the net cost of the PV system. Energy savings are based on current first year utility costs. Energy costs will escalate over time while the mortgage payments will remain flat.

Table 9: ZENH Performance Comparison

	Grupe	Lennar	Meritage
Percent Improvement Over Title 24	37-43%	37-40%	33-39%
Incremental Cost	$18,118	$20,800	$20,940
Amortized Cost	$1,446	$1,672	$1,661
Energy Savings	$1,604	$1,184	$1,279
Annual Cash Flow	$158	($488)	($382)
Electric Bill Savings	74%	62%	53%

It can be beneficial for the builder to avoid passing on some or all of the incremental costs. Grupe did not include the cost of the energy features in their sale price, but estimated net savings of about $14 million by reducing carrying costs as a result of the accelerated absorption rate they experienced relative to the competition. Figure 9 shows the extent to which Grupe's home sales exceeded the level at which they were recovering their investment in efficiency and photovoltaics, and how they performed relative to the competition. They estimate that if only 18 percent of the sales are attributable to the energy features, the investment was worthwhile.

Lennar and Meritage have also experienced greater sales than competing projects. Clearly today's buyers are factoring the cost of utility bills and sustainability into their home choices.

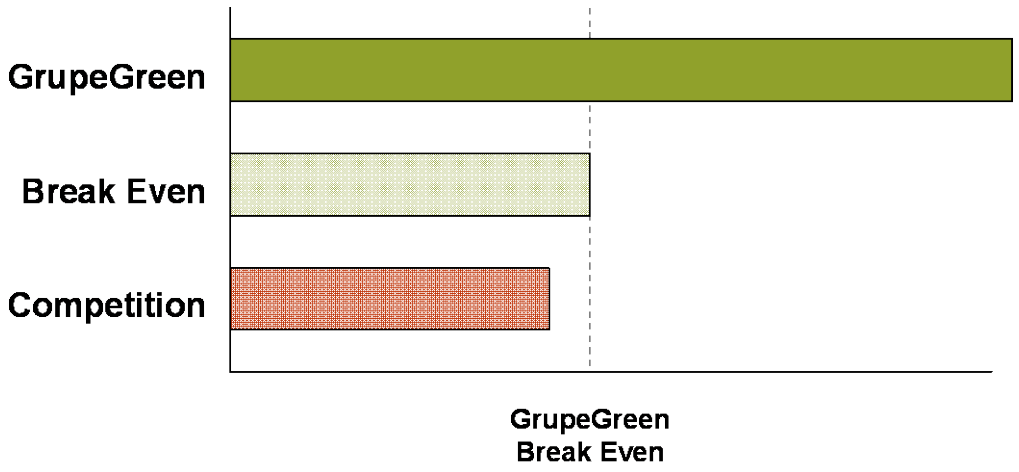

Figure 9: Carsten Crossings (Grupe) Monthly Average Home Sales Relative to the Break Even Cost

1.1.7.7 *3.2.3.7 Conclusions*

Builders can apply technologies and design practices that are in common use to achieve energy savings that exceed Title 24 by 40 percent or more with minimal adjustments to their business practices. By applying appropriate incentives to reduce costs and using branding programs such as Energy Star, GreenPoint Rated, LEED, and Builders Challenge, builders can demand higher prices and turn homes over more quickly, making ZENH a strong value proposition for the builder. For the homebuyer, the decreased cost of ownership, improved home quality, and relative immunity from future hikes in utility rates is attractive, particularly given the current energy outlook. For the utilities, the peak load reduction offered by ZENH's means less pressure to provide and operate peaking plants, potentially decreasing their cost of providing service.

As production home industry standards rise to the levels described in this report, progressive builders looking for a market edge will need to continue to look to new and emerging technologies to maintain a strong market position. The need for technology will continue to be fed by the California Energy Commission's Public Interest Energy Research Program, the Department of Energy's Building Technologies program (including Building America), and utility emerging technologies programs.

1.1.8. 3.2.4 Single Family Design Report

This 'Single Family Zero Energy New Homes Design Report' summarizes the design features included in the single family ZENH project.

The Single-Family (SF) ZENH Design Report includes the following items:

- Description of SF designs, including the energy efficiency features,
- Discussion of the iterative design efficiency analysis identifying energy, demand, and cost issues,
- Predictions of annual energy use for all major end-uses relative to Title-24 baseline, and
- Predicted performance on summer peak day during peak period.

Davis Energy Group led the three design charrettes and subsequent meetings for the three single-family builder participants in the ZENH Program. Each builder had unique issues, goals, and preferred strategies, so each builder project is summarized individually in this report.

1.1.8.1 *3.2.4.1 Methodology*

As part of the work under the SunPower ZENH program, Davis Energy Group (DEG) evaluated the projected energy and demand savings, based on the proposed ZENH energy features.

Total energy savings were estimated from the following two sources:

- MicroPas for space heating and cooling, and water heating
- Department of Energy's Building America Benchmark tools for estimating non-HVAC loads such as lighting, appliance, and miscellaneous electric loads (MELs).

Hourly simulations were completed using version 7.2 of the MicroPas software. Building America Benchmark hourly load profiles were also used for lighting and appliances.

PV production values are based on average hourly production profiles for each month for a south-facing SunPower building integrated system, using the respective system sizes for each community.

"Summer Peak Demand" for a ZENH was defined by the CEC in the project solicitation as the maximum daily power drawn from the electric utility on weekdays during the four hours surrounding the system peak, averaged across the utility system's hottest month. The peak hour and day in the MicroPas weather file is 5 pm on August 7. The daily peak between 3-7 pm for August was averaged to determine the summer peak demand for this plan.

1.1.8.2 *3.2.4.2 Summary of ZENH Goals*

The CEC defines a Zero Energy New Home for the purposes of this project as a home meeting the *2005 targets* listed in Table 10. The goal of this project is to demonstrate homes achieving the 2005 targets.

Summer peak demand for a ZENH is defined as the maximum daily power drawn from the electric utility on weekdays during the four hours surrounding the system peak, averaged across the utility system's hottest month. In 2007, the hottest month for PG&E was August.

1.1.8.3 *3.2.4.3 Demonstration Projects*

The SunPower ZENH team worked with three production builders to design near zero energy homes. The three SF Demonstration Projects are located in climate zones 11 and 12 within PG&E service territory. These include The Grupe Company's Carsten Crossings project in Rocklin, Lennar's Blackstone community in El Dorado Hills, and Meritage Homes' Encore project in Vacaville. Measures adopted by these three builders included most of those listed in the previous section and were similar to each other. Lennar used higher performance windows, slightly better air conditioners, and did not install tankless water heaters or ventilation cooling (for which savings are not included in evaluation results). Meritage offered condensing furnaces as a buyer option.

Demonstration Project #1: Grupe Homes – Carsten Crossings, Rocklin

This section summarizes the analysis and evaluation of the six plans at Grupe Home's Carsten Crossings Village 12 community in Rocklin, California. PV production values are based on average hourly production profiles for each month for a south-facing 2.4 kWp SunPower PV building integrated system.

Table 10 summarizes the six plan types at Grupe Carsten Crossings. The one and two story plans range from 2,168 to 2,921 square feet. All plans were run in the four cardinal orientations. The worst orientation for each plan was used in all evaluations and results, therefore the results are conservative estimates of savings since the actual orientation of the homes are randomly determined according to the lot orientation.

Table 10: Grupe Carsten Crossings Plan Descriptions

Plan #	C.F.A. (sq. ft.)	# Stories	# Bedrooms
1	2,168	1	3
2	2,408	1	4
2	2,515	1	4
3	2,507	2	4
3	2,667	2	4
4	2,543	2	4
4	2,775	2	4
5	2,685	1	4
5	2,884	1	4
6	2,755	2	5
6	2,921	2	5

In addition to participating in the ZENH Program, Grupe was also interested in meeting the Tier II goals of the NSHP (35 percent better than Title-24 and 40 percent better than Title-24 cooling) in order to take advantage of the additional incentives to help offset the additional costs for these measures.

Table 11 summarizes the Title 24 and ZENH design assumptions used to meet Grupe's goals. The ZENH design measures include the package of energy efficiency measures (EEMs) Grupe had incorporated into the design of the Carsten Crossing, and the 2.4 kWp PV system. In order to meet the PG&E Tier II requirements, Grupe added 15 SEER air conditioning to all lots and better windows on some east facing lots.

Table 11: Grupe Carsten Crossings Building Description (T24 and Design)

	Title 24 Base	*Zero Energy Home Design*
ENVELOPE:		
Walls (Exterior)	2x4 16" o.c. R-13 + 1" foam 2x6 16" o.c. R-19 + 1" foam	2x4 16" o.c. R-13 + 1" foam 2x6 16" o.c. R-19 + 1" foam
Walls (Garage)	2x4 16" o.c. R-13	2x4 16" o.c. R-13
Roof (Attic)	R-38	R-49
Roof (at Furnace)	NA	R-19
Attic Radiant Barrier	No	Yes
House Wrap / SLA Credit	No	Yes / 3.0 SLA
Quality Insulation Credit	No	Yes
GLAZING:		
U-Factor	0.38	0.35 average
SHGC	0.35	0.32 average
HVAC:		
Heating / AFUE	0.80	0.94, Variable speed fan
AC / SEER	13.0	15 / 12 EER
TXV	No	Yes
Ducts	R-4.2 / Tested	R-6 / Tested
ACCA Duct Design	No	Yes
Ventilation Cooling	No	SmartVent
Airflow Testing	No	Yes
WATER HEATING:		
Tank Volume	50 gallon	Tankless
Energy Factor	0.575	0.82
MISCELLANEOUS:		
3rd Party Inspections & Testing		
Quality Insulation Installation (QII) inspection		Yes
Blower door test (3.0 SLA target)		Yes
EER and TXV verification		Yes
Tight duct testing (< 6% leakage)		Yes
System airflow verification		Yes
Fluorescent Lighting	Per T-24	Kitchen, Baths, Recessed cans
2.4 kWp Solar PV		Yes

Energy Performance Relative to Title 24

With the proposed efficiency features installed, the houses perform 37 percent-41 percent better than Title 24, based on MicroPas Title 24 results. The homes qualify for the PG&E Tier II Incentives. All of the plans meet the ZENH energy performance goal of 25 percent better than Title 24. Incorporating the efficiency features (not including SmartVent ventilation cooling, PV or lighting), all plans perform at least 35 percent better than Title 24, achieving the 2008 ZENH

energy performance goal. Performance relative to Title 24 is based on the time-of-use value of the savings to the utility system, or time dependent valuation (TDV) of energy. Lighting, ventilation cooling, and PV cannot be evaluated in Title-24, and are not reflected in the savings relative to Title-24, and are therefore not accounted for in the ZENH energy performance goal.

East-facing plans 3 (2,667) and 4 fall just short of the 40 percent better than Title-24 for cooling requirement for Tier II, so a handful of east-facing lots will be built with SolarBan 70 glass on the west facing windows. A summary of percent improvement over Title 24 for the worst orientation for each plan is shown in Table 12.

Table 12: Percent Improvement over Title 24

Plan # / CFA	Total	Cool	Heat	Water Heat
1 / 2,168	40.4%	42.2%	40.0%	31.3%
2 / 2,408	38.6%	44.5%	37.6%	29.6%
2 / 2,515	37.1%	41.3%	37.3%	29.0%
3 / 2,507	38.3%	41.4%	38.5%	31.0%
3 / 2,667	41.2%	42.1%	38.3%	31.0%
4 / 2,543	41.1%	45.5%	37.0%	30.9%
4 / 2,775	41.3%	45.0%	38.9%	31.0%
5 / 2,685	39.4%	44.7%	39.4%	28.9%
5 / 2,884	39.0%	41.5%	40.2%	28.9%
6 / 2,755	39.7%	40.0%	39.3%	30.9%
6 / 2,921	40.4%	40.1%	40.6%	31.0%

Whole House Performance

DEG estimated the electrical energy by end use for both the Title-24 standard case and the ZENH case for one plan in the Carsten Crossings community. Plan 3 with 2,667 square feet was selected because it is the plan closest to the average community square footage, and because it has a fairly typical total and cooling compliance margin. This section presents the results for an east-facing Plan 3 (2,667 square feet), which is the worst orientation, or the least compliant of all four orientations for Plan 3. The analysis presents Plan 3 with the windows used in the majority of homes in the project.

Energy Use and Utility Savings

Table 13 (below) shows the estimated annual electric and gas use by end use. Lighting energy use assumes fluorescent fixtures in the kitchen and bathrooms as required for Title 24 in the base case and fluorescent lighting in all recessed can fixtures as well as the kitchen and bathrooms for the ZENH. Table 14 presents the annual usage and peak demand comparisons and savings for the Title-24 base case and the EEM package with PV (ZENH), with costs calculated using the E-1 rate.

With a 2.4 kWp PV system and the efficiency design upgrades, the average home is expected to reduce annual electricity costs by 80 percent and annual electricity use by 74 percent. Average monthly utility cost comparisons are shown in Figure 10.

Table 13: Grupe Carsten Plan 3 (2,667) - Estimated Electrical Energy by End Use

	Estimated Annual Electrical Use (kWh/year)		Estimated Annual Gas Use (Therms/year)	
End Use	**Title 24 Compliant House**	**ZENH House**	**Title 24 Compliant House**	**ZENH House**
Space Heating	208	154	535	325
Space Cooling	2,680	869		
DHW			262	181
Refrigerator	669	669		
Washer	123	123		
Dryer	89	89	62	62
Dishwasher	240	105		
MEL's	2,522	2,522	45	45
Plug-in Lighting	518	518		
Hard-Wired Lighting	1,703	728		
PV Production		-3,531		
Total	***8,751***	***2,244***	***903***	***612***

Table 14: Grupe Carsten Plan 3 (2,667) – Estimated Annual Energy Use and Savings Summary

Case	**Electric (kWh)**	**Gas (Therms)**	**Utility Cost ($)**	**Electric Cost ($)**
Title-24 Base House	8,751	903	$ 2,636	$1,313
Grupe ZENH	2,244	612	$ 1,032	$257
ZENH Savings	6,506	291	$ 1,604	$1,056
% Savings of ZENH Relative to T-24	74%	32%	61%	80%

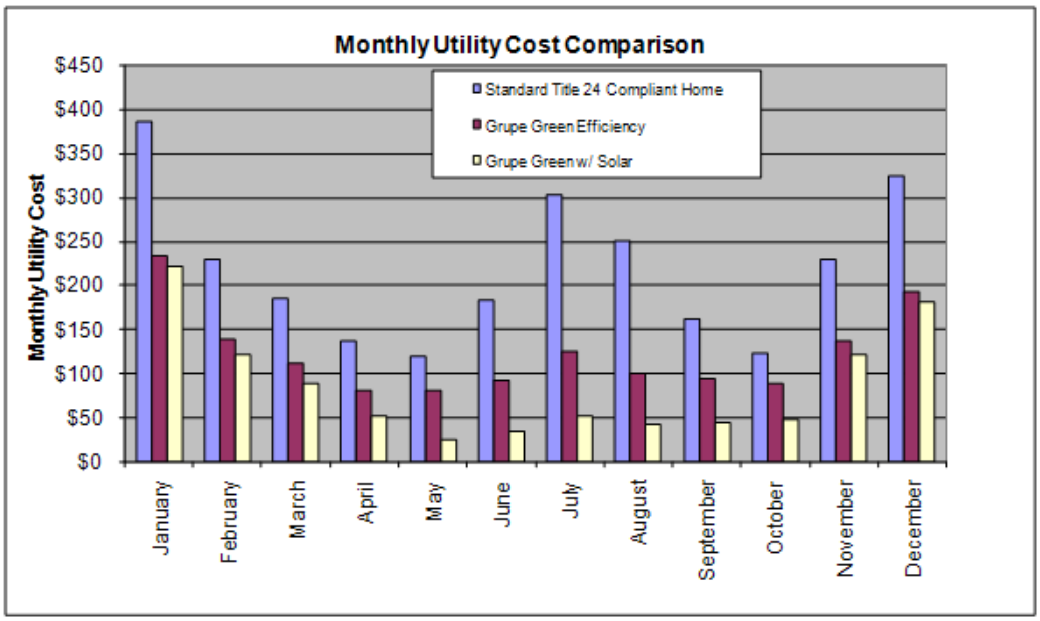

Figure 10: Grupe Carsten Plan 3 (2,667) – Estimated Monthly Energy Use Comparison

Peak Demand Reduction

Peak demand and load reduction due to the ZENH energy features is summarized in Table 15. The Grupe ZENH design has a peak demand of 1.5 kW. Hourly load profiles for the peak are shown in

Figure 12 shows the end use contribution to the peak demand.

Table 15: Grupe Carsten Plan 3 (2,667) – Estimated Peak Demand and Reduction Summary

Case	Peak Demand (kW)
Title-24 Base House	3.7
Grupe ZENH	1.5
ZENH Savings	2.2
% Savings of ZENH Relative to Title-24	60%

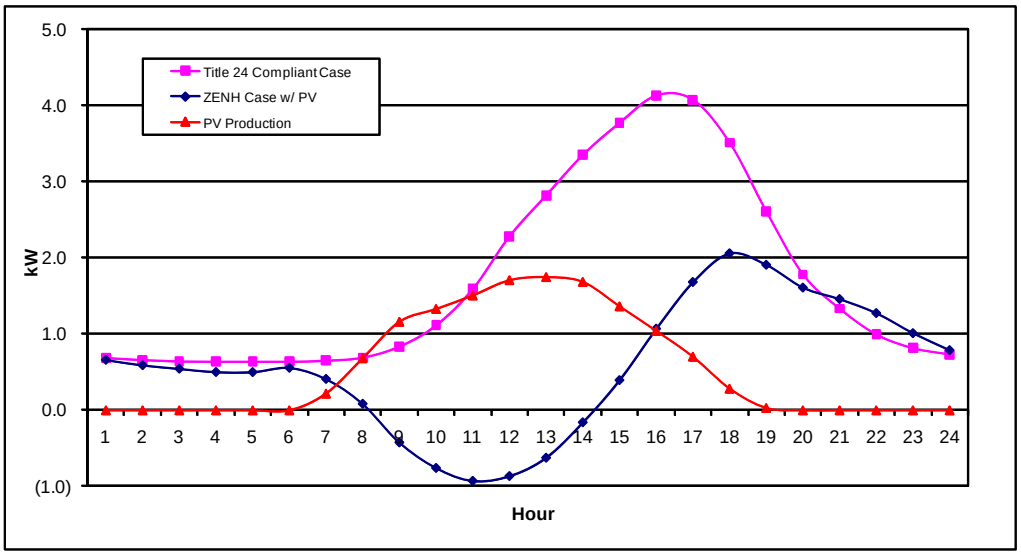

Figure 11: Grupe Plan 3 (2,667) – Peak Day Demand Profile August

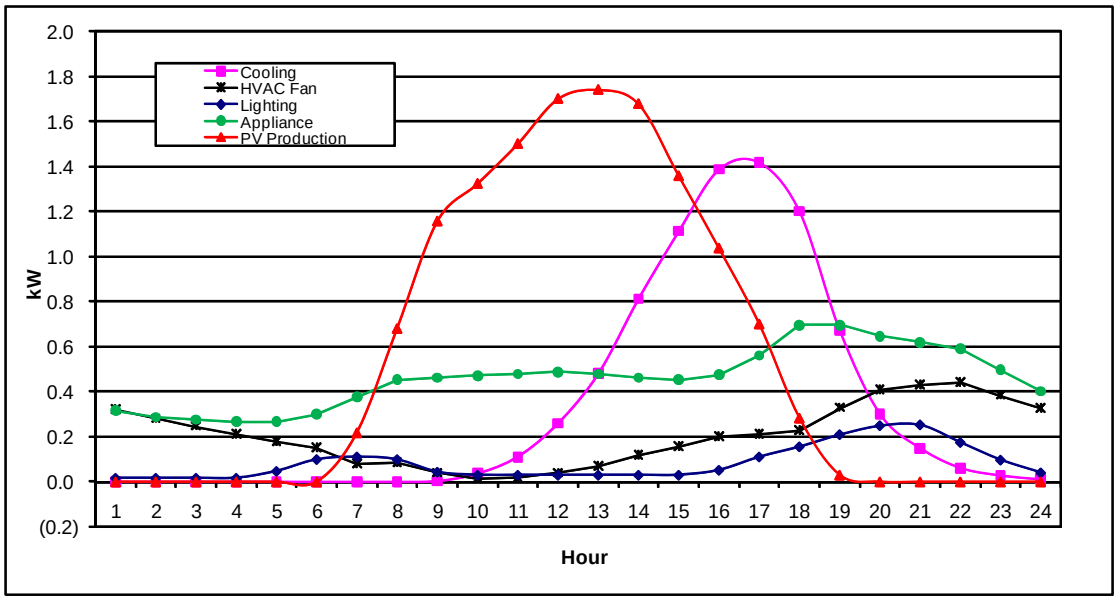

Figure 12: Grupe Plan 3 (2,667) – ZENH Peak Demand Day Profile Breakdown

Demonstration Project #2: Lennar– Chateau at Blackstone, El Dorado Hills

This section summarizes the analysis and evaluation of the five plans at Lennar Home's Blackstone Chateau community located in El Dorado Hills, California. The plans range from 1,700 to 2,961 square feet. Total savings were estimated using MicroPas for space heating and cooling, and water heating, and using estimates for non-HVAC loads based on the Building America Benchmark analysis. PV production values are based on average hourly production profiles for each month for a south-facing 2.3 kWp PV SunPower building integrated system.

Table 16 summarizes the five plan types in the Lennar Community. The one and two story plans range from 1,700 to 2,961 square feet. All plans were run in the four cardinal orientations. The worst orientation for each plan was used in all evaluations and results.

Table 16: Lennar Chateau Plan Descriptions

Plan #	C.F.A. (sq. ft.)	# Stories	# Bedrooms
3501	1,700	1	3
3502	2,396	2	4
3503	2,753	2	5
3511	2,363	2	4
3504	2,961	2	5

In addition to participating in the Zero Energy New Homes Program, Lennar was also interested in meeting the Tier II goals of the New Solar Homes Partnership (NSHP) (35 percent better than Title-24 and 40 percent better than Title-24 cooling) and the Federal Energy Tax Credit, in order to take advantage of the additional incentives to help offset the additional costs for these measures.

Table 17 summarizes the Title 24 and Zero Energy New Home (ZENH) design assumptions used in the study. The ZENH design measures are a combination of the package of energy efficiency measures (EEM's) Lennar already had incorporated in the design, measures evaluated and proposed through the ZENH process, and a 2.3 kWp PV system.

Lennar had earlier decided to install high efficacy fluorescent lights for all recessed can fixtures. For the Blackstone community, Lennar also added high efficacy lighting in all bedroom fixtures.

Energy Performance Relative to Title 24

With the proposed efficiency features installed, the houses perform 36 percent-40 percent better than Title 24, based on MicroPas Title 24 results. The homes qualify for the PG&E Tier II Customized Energy Efficiency/Demand Response Prescriptive Incentives. All of the plans meet the ZENH performance goals of 25 percent better than Title 24. Incorporating the efficiency features (not including PV or lighting), all plans perform at least 35 percent better than Title 24. Performance relative to Title 24 is based on time dependent valuation (TDV) of energy. Lighting, and PV cannot be evaluated in Title-24, and are not reflected in the savings relative to Title-24. A summary of percent improvement over Title 24 for the worst orientation for each plan is shown in Table 18.

Table 17: Lennar Chateau Building Description (T24 and Design)

	Title 24 Base	Zero Energy Home Design
ENVELOPE:		
Walls (Exterior)	2x4 16" o.c. R-13 + 1" foam 2x6 16" o.c. R-19 + 1" foam	2x4 16" o.c. R-15 + 1" foam 2x6 16" o.c. R-21 + 1" foam
Walls (Garage)	2x4 16" o.c. R-13	2x4 16" o.c. R-15
Roof (Attic)	R-30	R-49
Roof (at Furnace)	NA	R-19
Attic Radiant Barrier	No	Yes
House Wrap / SLA Credit	No	Yes / 3.5 SLA
Quality Insulation Credit	No	Yes
GLAZING:		
U-Factor	0.38	0.31 average
SHGC	0.35	0.23 average
HVAC:		
Heating / AFUE	0.80	0.92
AC / SEER	13.0	14 / 12 EER
TXV	No	Yes
Ducts	R-4.2 / Tested	R-6 / Tested
ACCA Duct Design	No	Yes
Ventilation Cooling	No	No
WATER HEATING:		
Tank Volume	50 gallon	50 gallon
Energy Factor	0.575	0.62
MISCELLANEOUS:		
3rd Party Inspections & Testing		Yes
Quality Insulation Installation (QII) inspection		Yes
Blower door test (3.5 SLA target)		Yes
EER and TXV verification		Yes
Tight duct testing (< 6% leakage)		Yes
System airflow verification		No
Fluorescent Lighting	Per T-24	All fixtures except Dining
2.3 kWp Solar PV		Yes

Table 18: Percent Improvement over Title 24

Plan #	CFA	Total	Cool	Heat	Water Heat
3501	1,700	36.6%	58.0%	32.2%	7.7%
3502	2,396	39.3%	55.9%	35.8%	7.3%
3503	2,753	38.4%	56.7%	35.3%	7.2%

Plan #	CFA	Total	Cool	Heat	Water Heat
3504	2,961	39.8%	57.4%	36.1%	7.2%
3511	2,363	37.5%	53.7%	32.8%	7.3%

Whole House Performance

Estimated electrical energy by end use for both the Title-24 standard cases and the homes with the ZENH energy features were estimated for one typical plan in the community. Results for Plan 3503 (2,753 square feet) are summarized below. Lighting energy use assumes fluorescent fixtures in the kitchen and bathrooms as required for Title 24 in the base case and fluorescent lighting in all recessed can fixtures and surface-mounted bedroom fixtures for the ZENH case. Energy use comparisons and savings based on the proposed EEM package and EEM package with PV (ZENH) are also summarized for Plan 3503.

Energy Use and Utility Savings

Table 19 shows the estimated annual electric and gas use by end use. Lighting energy use assumes fluorescent fixtures in the kitchen and bathrooms as required for Title 24 in the base case and fluorescent lighting in all recessed can fixtures as well as the kitchen and bathrooms for the ZENH. Table 20 presents the annual usage and peak demand comparisons and savings for the Title-24 base case and the EEM package with PV (ZENH), with costs calculated using the E-1 rate.

With a 2.3 kWp PV system and the efficiency design upgrades, the average home is expected to reduce annual electricity costs by 68 percent, and annual electricity use 62 percent. Average monthly utility cost comparisons are shown in Figure 13.

Table 19: Lennar Plan 3503 - Estimated Electrical Energy by End Use

	Estimated Annual Electrical Use (kWh/year)		Estimated Annual Gas Use (Therms/year)	
End Use	Title 24 Compliant House	ZENH House	Title 24 Compliant House	ZENH House
Space Heating	199	143	512	312
Space Cooling	1,551	643		
DHW			265	246
Refrigerator	669	669		
Washer	123	123		
Dryer	89	89	62	62
Dishwasher	240	240		

	Estimated Annual Electrical Use (kWh/year)		Estimated Annual Gas Use (Therms/year)	
End Use	**Title 24 Compliant House**	**ZENH House**	**Title 24 Compliant House**	**ZENH House**
MEL's	2,546	2,546	45	45
Plug-in Lighting	531	531		
Hard-Wired Lighting	1,926	1,104		
PV Production		-3,105		
Total	***7,875***	***2,984***	***883***	***665***

Table 20: Lennar Plan 3503 – Estimated Annual Energy Use and Savings Summary.

Case	Electric (kWh)	Gas (Therms)	Utility Cost ($)	Electric Cost ($)
Title-24 Base House	7,875	883	$ 2,349	$ 1,061
Lennar ZENH	2,984	665	$ 1,165	$ 341
ZENH Savings	4,891	219	$ 1,184	$ 720
% Savings Relative to Title-24	62%	25%	50%	68%

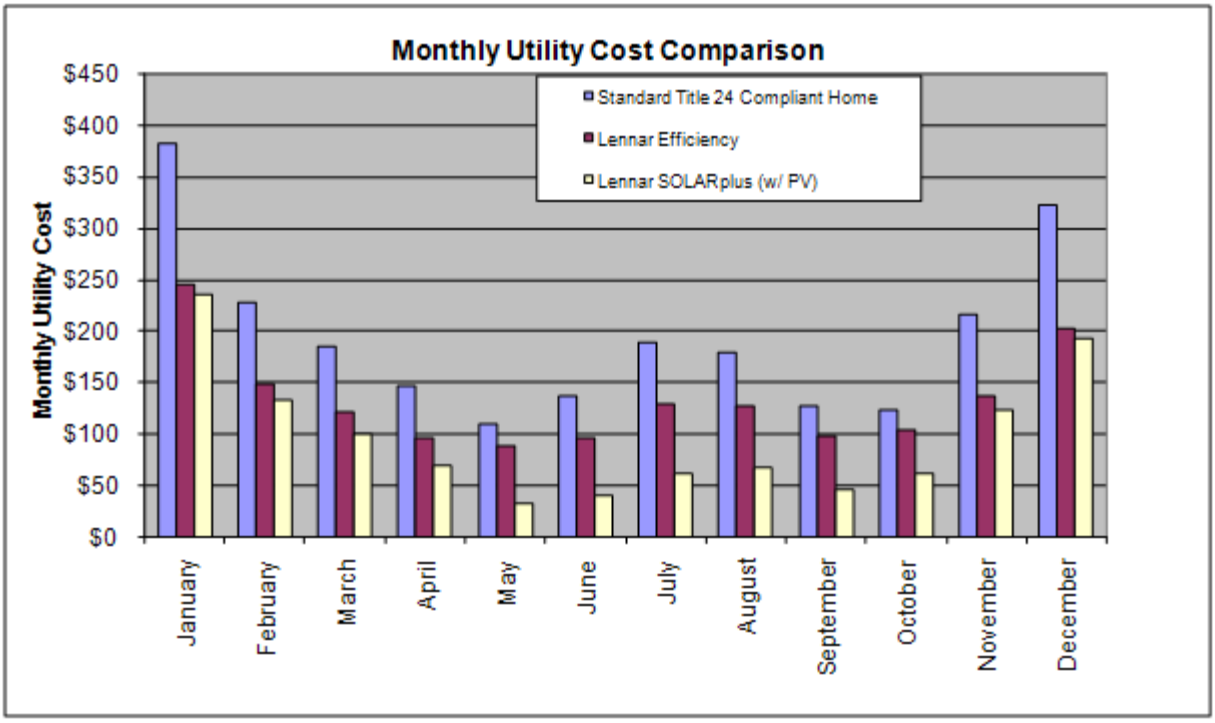

Figure 13: Lennar Plan 3503 – Estimated Monthly Energy Use Comparison

Peak Demand Reduction

Peak demand and load reduction due to the ZENH energy features is summarized in Table 21. The Lennar ZENH design has a peak demand of 1.4 kW. Hourly load profiles for the peak are shown in Figure 14. Figure 15 shows the end use contribution to the peak demand.

Table 21: Lennar Plan 3503 – Estimated Peak Demand and Reduction Summary

Case	Peak Demand (kW)
Title-24 Base House	3.8
Lennar ZENH	1.4
ZENH Savings	2.4
% Savings	64%

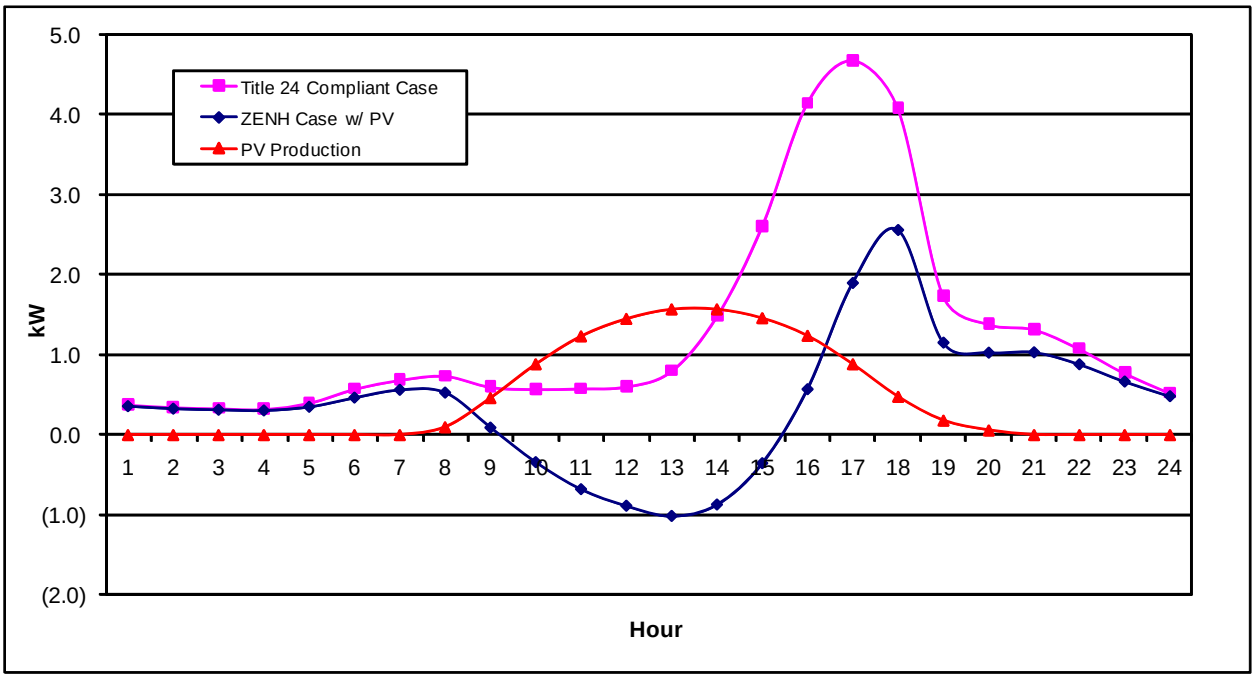

Figure 14: Lennar Plan 3503 (2,753) – Peak Demand Day Profile August

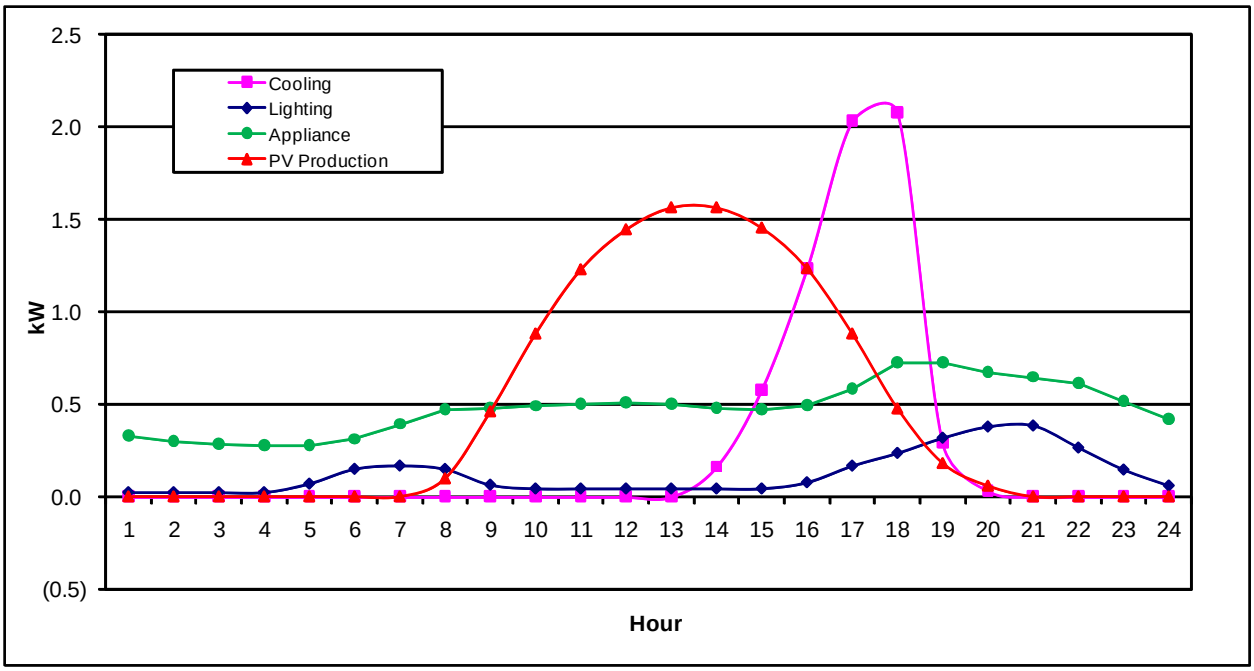

Figure 15: Lennar Plan 3503 (2,753) – ZENH Peak Demand Day Profile Breakdown

Demonstration Project #3: Meritage Homes – Encore 2 and 3

This section summarizes the analysis and evaluation of the five plans at Meritage's Encore II and III communities located in Vacaville, California. The plans range from 2,080 to 3,714 square feet. PV production values are based on average hourly production profiles for each month for a south-facing 2.3 kWp SunPower building integrated PV system.

Table 22 summarizes the five plan types in the Meritage Communities. The one and two story plans range from 2,080 to 3,714 square feet. All plans were run in the four cardinal orientations. The worst orientation for each plan was used in all evaluations and results.

Table 22: Meritage Encore Plan Descriptions

Plan #	C.F.A. (sq. ft.)	# Stories	# Bedrooms
1	2,080	1	3
1	2,286	1	4
2	2,580	1	3 / 4
2	2,720	1	3 / 4
3	2,996	2	4
3	3,306	2	4
4	3,373	2	4 / 5
4	3,633	2	4 / 5
5	3,714	2	5 / 6

In addition to participating in the ZENH Program, Meritage was also interested in meeting the Tier II goals of the NSHP (35 percent better than Title-24 and 40 percent better than Title-24 cooling) in order to take advantage of the additional incentives to help offset the additional costs for these measures.

Table 23 summarizes the Title 24 and ZENH design assumptions used in the study. The ZENH design measures are a combination of the package of energy efficiency measures (EEMs) Meritage already had incorporated in the design, measures evaluated and selected through the ZENH process, and a 2.3 kWp PV system.

Energy Performance Relative to Title 24

With the proposed efficiency features installed, the houses perform 35 percent-39 percent better than Title 24, based on MicroPas Title 24 results. The homes qualify for the PG&E Tier II Incentives. All of the plans meet the ZENH energy performance goal of 25 percent better than Title 24.

Incorporating the efficiency features (not including NightBreeze ventilation cooling, PV or lighting), all plans perform at least 35 percent better than Title 24, achieving the 2008 ZENH energy performance goal. Performance relative to Title 24 is based on time dependent valuation (TDV) of energy. Lighting, ventilation cooling, and PV cannot be evaluated in Title-24, and are not reflected in the savings relative to Title-24.

Depending on orientation, plans 2 and 3 were less than 35 percent better than Title-24. Since the lots were pre-plotted, any lots that fell below the Tier II requirements (4 lots) will have a 94 percent AFUE furnace installed in order to meet Tier II. A summary of percent improvement over Title 24 for the worst orientation for each plan is shown in Table 24.

Table 23: Meritage Encore Building Description (T24 and Design)

	Title 24 Base	***Zero Energy Home Design***
ENVELOPE:		
Walls (Exterior)	2x4 16” o.c. R-13 + 1” foam 2x6 16” o.c. R-19 + 1” foam	2x4 16” o.c. R-13 + 1” foam 2x6 16” o.c. R-19 + 1” foam
Walls (Garage)	2x4 16” o.c. R-13	2x4 16” o.c. R-13
Roof (Attic)	R-30	R-49
Roof (at Furnace)	NA	R-19
Attic Radiant Barrier	No	Yes
House Wrap / SLA Credit	No	Yes / 3.5 SLA
Quality Insulation Credit	No	Yes

	Title 24 Base	*Zero Energy Home Design*
GLAZING:		
U-Factor	0.38	0.35 average
SHGC	0.35	0.32 average
HVAC:		
Heating / AFUE	Varies 0.80	Varies 0.80 - 0.94
AC / SEER	13.0	15 / 12 EER
TXV	No	Yes
Ducts	R-4.2 / Tested	R-6 / Tested
ACCA Duct Design	No	Yes
Ventilation Cooling	No	NightBreeze
WATER HEATING:		
Tank Volume	1-story – 50 gallon	Tankless
Energy Factor	0.575	0.82
MISCELLANEOUS:		
3rd Party Inspections & Testing		
Quality Insulation Installation (QII) inspection		Yes
Blower door test (3.5 SLA target)		Yes
EER and TXV verification		Yes
Tight duct testing (< 6% leakage)		Yes
System airflow verification		Yes
Fluorescent Lighting	Per T-24	Per T-24
2.3 kWp Solar PV		Yes

Table 24: Percent Improvement over Title 24

Plan # / CFA	Total	Cool	Heat	Water Heat
1 / 2,080	35.1%	51.7%	20.5%	33.3%
1 / 2,286	35.4%	58.2%	20.7%	31.7%
2 / 2,580	32.8%	46.6%	24.7%	30.3%
2 / 2,720	35.5%	43.9%	32.2%	30.2%
3 / 2,996	35.0%	42.4%	25.9%	32.3%
3 / 3,306	37.0%	38.5%	37.7%	32.2%
4 / 3,373	37.2%	44.0%	27.9%	32.2%
4 / 3,633	38.9%	43.6%	32.1%	32.1%
5 / 3,714	37.6%	45.5%	28.4%	32.1%

Whole House Performance

DEG estimated the electrical energy by end use for both the Title-24 standard case and the ZENH case for one typical plan in the Meritage community. Plan 3 with 2,996 square feet was selected because it has a fairly typical total and cooling compliance margin. This section

presents the east-facing results for Plan 3 (2,996 square feet), which is the worst orientation, with a standard 80 percent AFUE furnace.

Energy Use and Utility Savings

Table 25 shows the estimated annual electric and gas use by end use. Note that Title 24 requires fluorescent fixtures in the kitchen and bathrooms and fluorescent lighting in all recessed can fixtures. The same lighting was used in the ZENH case.

Table 26 presents the annual usage and peak demand comparisons and savings for the Title 24 base case and the EEM package with PV (ZENH). With a 2.3 kWp PV system and the efficiency design upgrades, the average home is expected to reduce annual electricity costs by 61 percent, and annual electricity use 53 percent. The electricity cost savings are likely conservative since they were calculated using an E-1 rate. Average monthly utility cost comparisons are shown in Figure 16.

Table 25: Meritage Plan 3 (2,996) - Estimated Electrical Energy by End Use

	Estimated Annual Electrical Use (kWh/year)		Estimated Annual Gas Use (Therms/year)	
End Use	**Title 24 Compliant House**	**ZENH House**	**Title 24 Compliant House**	**ZENH House**
Space Heating	224	158	576	397
Space Cooling	1,840	759		
DHW			265	180
Refrigerator	669	669		
Washer	123	123		
Dryer	89	89	62	62
Dishwasher	240	240		
MEL's	2,614	2,614	45	45
Plug-in Lighting	570	570		
Hard-Wired Lighting	1,835	1,835		
PV Production		-3,173		
Total	***8,204***	***3,884***	***948***	***684***

Table 26: Meritage Plan 3 (2,996) – Estimated Annual Energy Use and Savings Summary

Case	**Electric (kWh)**	**Gas (Therms)**	**Utility Cost ($)**	**Electric Cost ($)**
Title-24 Base House	8,204	948	$ 2,538	$1,177
Meritage ZENH	3,884	684	$ 1,259	$461
ZENH Savings	4,320	264	$ 1,279	$715
% Savings Relative to Title-24	53%	29%	50%	61%

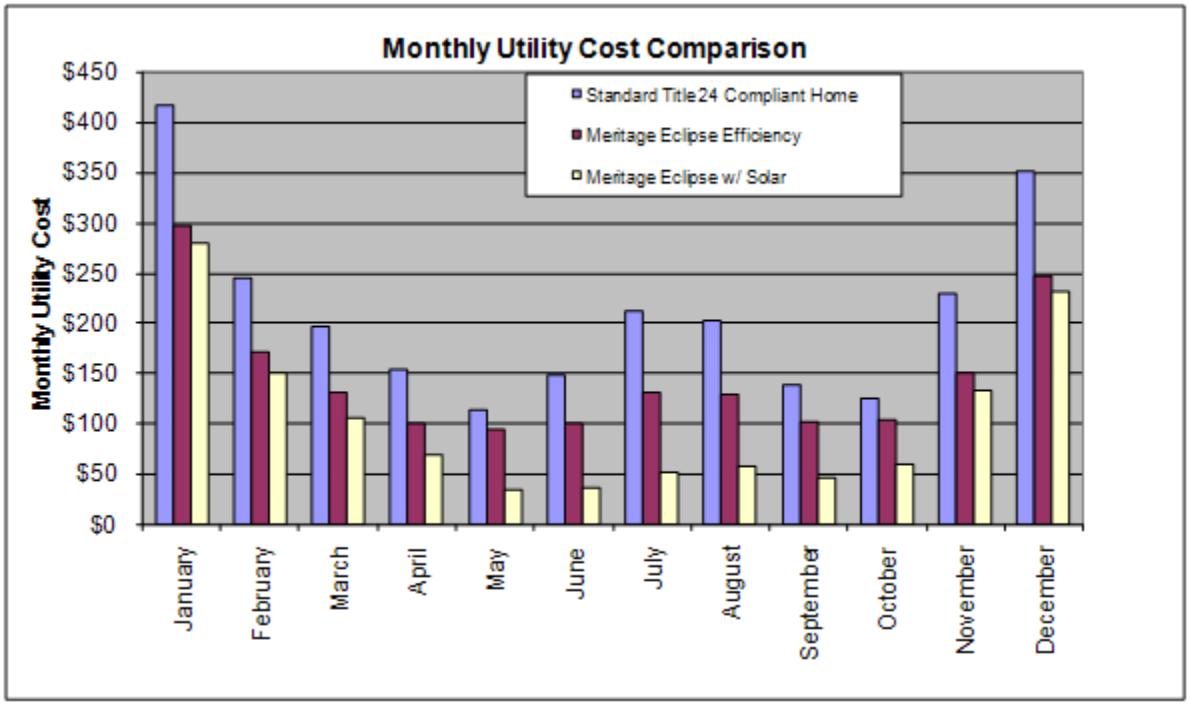

Figure 16: Meritage Plan 3 (2,996) – Estimated Monthly Energy Use Comparison

Peak Demand Reduction

Peak demand and load reduction due to the ZENH energy features is summarized in Table 27. The Meritage ZENH design has a peak demand of 1.9 kW. Hourly load profiles for the peak are shown in

Figure 18 shows the end use contribution to the peak demand.

Table 27: Meritage Plan 3 (2,996) – Estimated Peak Demand and Reduction Summary

Case	Peak Demand (kW)
Title-24 Base House	4.0
Meritage ZENH	1.9
ZENH Savings	2.2
% Savings of ZENH Relative to Title-24	54%

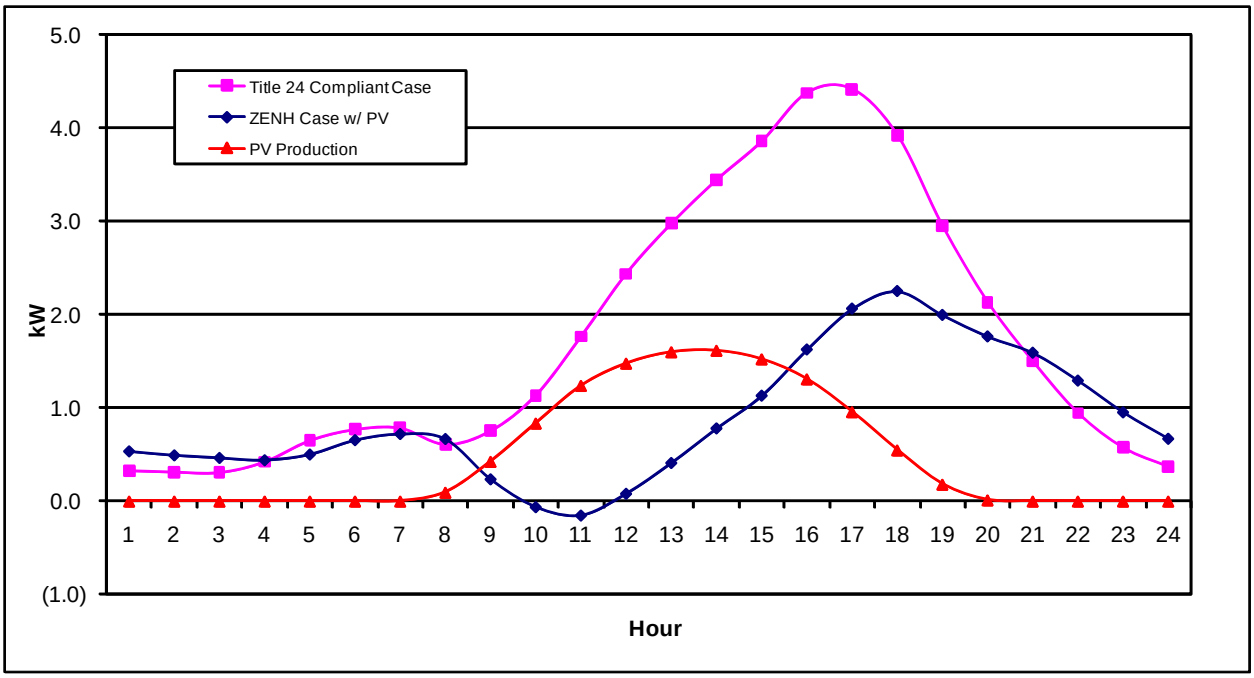

Figure 17: Meritage Plan 3 (2,996) – Peak Day Demand Profile August

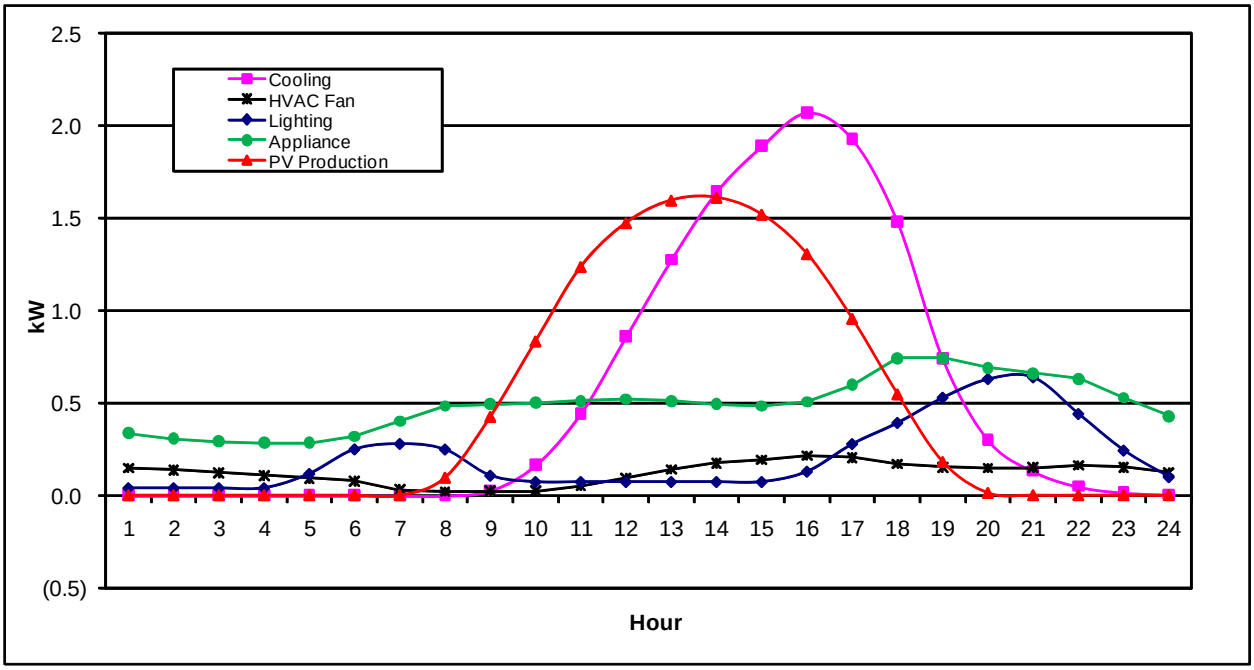

Figure 18: Meritage Plan 3 (2,996) – ZENH Peak Demand Day Profile Breakdown

Incremental Costs

The solar and energy efficiency incremental measure costs were discussed with the builders at each step in the design process to ensure that the designs and costs were acceptable such that they would participate in the ZENH program and build the demonstration communities. In this section we summarize the efficiency and PV measure costs that the builders added to the

ZENH communities. We have opted to not present this information at the builder level to protect builder confidentiality.

A summary of the approximate efficiency and PV measure costs are summarized in Table 28. Incremental costs for these measures vary by builder and plan. Incremental costs are based on additional measures to each of the builders' standard practice prior to ZENH. The costs shown are based on the approximate weighted average of all the plans for the communities.

Based on the evaluation using the tax credit version of Micropas, all three demonstration communities are eligible for the $2,000 federal energy tax credit. In all four cardinal directions, the homes meet the 50 percent reduction requirement in heating and cooling energy use relative to the 2004 IECC supplement.

Table 28: Summary of Incremental Costs

System Measure	Approximate Cost Range
Ceiling Insulation (R-38 to R-49) Ceiling (R-38 to R-49) + Wall (R-13 to R-15) Ceiling Insulation (R-30 to R-49)	$300 - $1,200
Attic Radiant Barrier	$500 - $800
Air Conditioning (13 SEER to 15 SEER/12 EER) Air Conditioning (13 SEER to 14 SEER/12 EER)	$100 - $400
Furnace (80 AFUE, 94 AFUE w/ ECM blower) Furnace (80 to 92 AFUE) Furnace (80 AFUE, PSC to ECM blower)	$250 - $1,000
Night Ventilation Cooling	$750 - $2,000
Tankless Water Heater	$1,000
Fluorescent Lighting Package	$300 - $400
HERS Tests and Inspections (Insulation, TXV, SEER, Blower Door, System Airflow)	$150 - $300
2.3 to 2.4 kWp PV System	$18,500-$21,000
Incremental Cost	**$22,500-$27,000**

As the example in Table 8 showed, the approximate incentive and tax credits that are available to the builders with Tier II communities with systems around 2.3 kWp is in the range of $8,000-$9,000. The difference between the incremental measure cost and the rebates and credits is around $14,000-$18,000, with widely varying costs depending on the rebate amounts and measure costs. The homeowners realize a $2,000 Federal Tax Credit upon move-in, further reducing the non-reimbursed solar and EE cost from $12,000-$16,000. Due to the irregularities in the current new home market, such as the tens of thousands of dollars in move-in incentives and optional features that builders are now including in the sale price for each home, it is *extremely* difficult for SunPower and the builders to quantify the amount of incremental first cost to the homeowner. Our observation is that many builders are using the market appeal of solar to sell more homes at a faster rate, thereby recovering much of the initial capital material

investment in solar and energy efficiency, and are not passing much of the incremental cost of the system on to the homebuyer. Due to the large losses that builders are experiencing, this pass through may not be sustainable, and SunPower is developing new marketing strategies to assist builders with recovering some of the cost.

1.1.8.4 *3.2.4.4 Conclusion*

The design team developed a prioritized list of design features and practices to guide a discussion with the builders on how to increase efficiency. The team assessed the design features by taking into account the energy impacts, cost, and construction impacts, and worked with the builder to select the most effective features for the community. The design meetings helped the builders achieve Tier II program compliance for all communities in the SF Demonstration. While a goal of the design charrette was to influence the layout of the communities to improve solar access, this task was not accomplished for the demonstration projects since the construction process was too far along. Influencing the layout of communities needs to happen long before construction begins. It is SunPower's goal to develop strong relationships with our builder partners in order to be included in the planning stage of each community and to ultimately influence the community layout to maximize solar benefit for each home.

Grupe Carsten Crossings Summary

Based on Plan 3 (2,667 sq. ft.) and the recommended efficiency measures, including the SmartVent night ventilation cooling system, assuming the worst orientation and a 2.4 kWp PV system, the homes are anticipated to save 74 percent in annual electricity, and are at least 35 percent above Title-24 as Tier II participants, meeting the ZENH energy performance goal of 25 percent better than Title 24. The homes are anticipated to save 80 percent in annual electricity costs, meeting the ZENH energy cost savings goal of 70 percent. The homes are anticipated to draw 1.5 kW at peak demand, higher than the ZENH demand goal of 1 kW.

Table 29: Grupe ZENH Electricity and Peak Demand Savings Summary

Plan 3 – 2,667 sq. ft.	Title 24 Compliant	Grupe ZENH House	Savings	% Savings
Electrical Energy Use (kWh)	8,751	2,244	6,506	74%
Annual Electric Costs ($)	$ 1,313	$ 257	$ 1,056	80%
Peak Demand (kW)	3.7	1.5	2.2	60%

Lennar Chateau at Blackstone Summary

Based on Plan 3503 (2,753 sq. ft.) and the recommended efficiency measures, assuming the worst orientation and a 1.942 kW PV system, the homes are anticipated to save 62 percent in annual electricity, and are at least 35 percent above Title-24 as Tier II participants, meeting the ZENH energy performance goal of 25 percent. The homes are anticipated to save 68 percent in annual electricity costs, falling just short of the ZENH energy cost savings goal of 70 percent. The homes are anticipated to draw 1.4 kW at peak demand, higher than the ZENH demand goal of 1 kW.

Table 30: Lennar ZENH Electricity and Peak Demand Savings Summary

Plan 3503 – 2,753 sq. ft.	Title 24 Compliant	Lennar ZENH House	Savings	% Savings
Electrical Energy Use (kWh)	7,875	2,984	4,891	62%
Annual Electric Costs ($)	$ 1,061	$ 341	$ 720	68%
Peak Demand (kW)	3.8	1.4	2.4	64%

Meritage Encore Summary

Based on Plan 3 (2,996 sq. ft.) and the recommended efficiency measures, including the NightBreeze night ventilation cooling system, assuming the worst orientation and a 2.47 kW PV system, the homes are anticipated to save 53 percent in annual electricity, and are at least 35 percent above Title-24 as Tier II participants, meeting the ZENH energy performance goal of 25 percent. The homes are anticipated to save 61 percent in annual electricity costs, meeting the ZENH energy cost savings goal of 70 percent. The homes are anticipated to draw 1.9 kW at peak demand, higher than the ZENH demand goal of 1 kW.

Table 31: Meritage ZENH Electricity and Peak Demand Savings Summary

Plan 3 – 2,996 sq. ft.	Title 24 Compliant	Meritage ZENH House	Savings	% Savings
Electrical Energy Use (kWh)	8,204	3,884	4,320	53%
Annual Electric Costs ($)	$ 1,177	$ 461	$ 715	61%
Peak Demand (kW)	4.0	1.9	2.2	54%

1.1.8.5 *3.2.4.5 Final Summary*

In conclusion, all of the homes in the three demonstration communities are Tier II participants, meaning that all homes are at least 35 percent above Title-24 and cooling is 40 percent above Title-24. This level of efficiency surpasses the 2005 ZENH energy performance goal of 25 percent above Title-24, and complies with the 2008 ZENH energy performance goal of 35 percent above 2005 Title-24.

The estimated annual electricity cost reduction for the typical plan in the three communities is between 61-80 percent using an E-1 rate. The ZENH cost reduction goal is 70 percent savings on the annual electric bill, which the Grupe community surpasses. E-1 is a tiered, non-TOU rate. Since peak solar production coincides with peak electrical demand, a TOU rate could be more beneficial for solar homeowners depending on their usage patterns, and increase their bill savings.

The modeled peak demand for the typical plan in the three communities varies from 1.4 to 1.9 kW, higher than the 2005 ZENH peak demand goal of 1.0 kW. However, the percentage reduction in demand relative to a home built to Title-24 varies from 54-64 percent, a significant reduction in peak demand. Alternative measures were explored with the builders to further

reduce peak demand; however the other measures were not deemed to be cost effective and were not implemented.

Table 32 also lists the incremental mortgage cost (at 7 percent and 30 years) for the energy improvements, and compares this to the energy savings to determine a first year annual cash flow. No incentives, such as the $2,000 federal tax credit, are included in the incremental cost other than the New Solar Homes Partnership incentive that is factored into the net cost of the PV system. Energy savings are based on current first year utility costs. Energy costs will escalate over time while the mortgage payments will remain flat.

Table 32: ZENH Performance Comparison

	Grupe	Lennar	Meritage
Percent Improvement Over Title 24	37-43%	37-40%	33-39%
Incremental Cost	$18,118	$20,800	$20,940
Amortized Cost	$1,446	$1,672	$1,661
Energy Savings	$1,604	$1,184	$1,279
Annual Cash Flow	$158	($488)	($382)
Electric Bill Savings	74%	62%	53%

1.1.9. 3.2.5 Multi-Family ZENH Package Report

1.1.9.1 *3.2.5.1 Introduction*

The primary goal of this task is to plan, design, analyze, and support the construction of multi-family projects that meet the goals set forth by the CEC's ZENH program. This 'Multi-Family Zero Energy New Homes Package Report' describes how packaging PV systems with carefully selected energy efficiency measures can improve marketability, overall value, and in affordable units, reduce monthly costs and effects of fuel price increases. This report identifies marketing opportunities and other benefits that become available to builders when units are designed to ZENH standards, describes general best practices, and provides detailed specifications for a cost-effective package that has been developed through research conducted under ZENH and other programs. A project example and builder-buyer economics are also discussed based on the Grupe Villa Monterey case study in Section 3.2.6, page 117. The recommended package is appropriate for low-rise multi-family units in cooling dominated climates such as the Sacramento and San Joaquin valleys and represents current best practice. This report was developed for low-rise multi-family construction perspective, but much of the information here can also be applied to mid-rise multi-family.

1.1.9.2 *3.2.5.2 Market and Cost Benefits Available to ZENH Builders*

Programs That Support Zero Energy New Home Projects

As with single family projects, there is a potpourri of existing and emerging programs and initiatives that multifamily developers can take advantage of to aid the entitlement process, help them market their projects, and to offset added construction costs. An increasing number of communities are requiring building performance exceeding Title 24 minimum requirements. As a result of the California Global Warming Solutions Act of 2006 (AB 32), requirements for

reductions in energy use and greenhouse gas emissions are finding their way into the entitlement process. Meanwhile, programs such as LEED for Homes, GreenPoint Rated, and Energy Star are using performance in excess of code to earn credits for certification and performance labeling. The key is to strategically implement combinations of these programs and incentives to achieve the maximum return for the developer with downstream benefits for the buyer and/or tenant.

Utility / State Incentives

Beginning January 1, 2007, the CEC offered an incentive through the NSHP for qualifying solar systems at production housing (approximately $2.60 per watt). For affordable projects this incentive is $4.00 per watt for residential units systems and $3.30 per watt for common area installations. In order to qualify for this incentive, the units must be at least 15 percent better than required under Title 24 and all appliances must be Energy Star. The amount of the CEC incentive does not increase with higher efficiency levels. The actual incentive is based on the Expected Performance Based Incentive Calculation, which accounts for the tested performance of the module and inverter, the mounting type and cell temperature, the orientation and tilt of the modules, and the shading, solar and climatic conditions for the locales, and time-of-use value of the system generation relative to the utility system (TDV).

Aligned with the CEC NSHP, the IOUs have the same requirement for the base level of their partner energy efficiency program (California Multifamily New Homes Program (CMFNH)), and pay $150-$200 per unit depending on the climate zone. The builder can also participate in the Energy Star Homes Program (ESH). In order to participate in the ESH Program, the builder is required to include additional testing such as the Thermal Bypass Checklist and the Quality Insulation Installation, as well as meet the Energy Star HVAC sizing requirements. Multifamily projects do not need those tests unless they are used for compliance. In addition, a $50 per unit incentive is available for energy consultants (up to $10,000 per consultant and project) and a $60 per unit incentive is available for the HERS raters (up to $12,000 per project). Additional incentives are available to the builder for installing Energy Star appliances and/or hard-wired, high efficacy lighting fixtures <u>with</u> controls.

Municipal utilities such as SMUD and Roseville Electric have their own incentive programs for both solar and energy efficiency. Many of the utility sponsored programs include third-party verification of Quality Insulation Installation (QII) as a requirement for participation.

The Energy Policy Act of 2005 authorized a one-time solar energy investment tax credit (ITC) to homeowners with PV systems up to 30 percent of the system cost, up to a maximum of $2,000 with an expiration date of 12/31/08. The solar tax credit was renewed in 2009 and is now slated to expire on 12/31/2016. Also, systems placed in service after January 1, 2009 are no longer subject to the maximum credit of $2,000.

Table 33. Incentives and Federal Tax Credits (Example)

New Solar Home Partnership	Tier I / CMFNH
% of total energy above Title 24 (kBTU/sf-yr)	15%
% reduction in cooling load	n/a
All Appliances Energy Star	yes
CEC and IOU Incentives	
IOU Energy Efficiency Rebate[26]	$200
CEC Solar Rebate (est. for a 1.23 kWp system)	$2,350
Federal Tax Credits	
for Homeowner [27]	$2,200
for Builder [28]	$0
Total Builder Incentives and Tax Credits	$2,550
Total Homeowner Incentives and Tax Credits	$2,200

The Energy Policy Act of 2005 also authorized a one-time energy efficient home tax credit for the builder of the home, totaling $2,000 if the units are certified to have an annual level of heating and cooling energy consumption at least 50 percent below the annual level of heating and cooling energy consumption of a comparable dwelling unit (2004 IECC). The home must also have building envelope component improvements providing a level of heating and cooling energy consumption that is at least 10 percent below that of a comparable home. The energy tax credit is slated to expire on 12/31/2009, but pending legislation may extend them.

Branding and Labeling Programs

Several programs available to builders provide assurance of construction quality and energy efficiency. Like the NSHP, the EPA's Energy Star for Homes program and green programs like LEED for Homes and the GreenPoint Rated (GPR) program also require performance 15 percent above Title 24. However, Energy Star also requires a "Thermal Bypass Checklist" be completed that involves third party inspections of insulation installation quality and testing. The same inspections and testing can be used to earn additional Title 24 credits. Homes that meet the

[26] CMFNH = $150 for coastal CZs 1-7 and $200 for inland CZs 8-16.

[27] Under the Federal Energy Policy Act of 2005, homeowners with PV systems may qualify for a one-time person tax credit equal to 30% of the system's initial cost, up to a maximum of $2,000, currently through 2016. See IRS form 3468. Incentive amount based on 1.23 kW system and an estimated cost of $6 / watt after CEC NSHP rebate.

[28] $2,000 for a dwelling unit that is certified to have an annual level of heating and cooling energy consumption at least 50% below the annual level of heating and cooling energy consumption of a comparable dwelling unit (2004 IECC), etc. See IRS form 8908. Grupe has not been able to apply for this in the past. They are the builder but not the owner.

LEED Certified rating must also meet Energy Star standards. LEED, and GPR programs all require compliance with certain quality criteria in addition to above-code energy performance. Some communities are requiring that new projects be built to Energy Star, GPR, or other standards and this trend is likely to grow.

New Energy Standards

California has approved new more stringent Title 24 energy standards that will make compliance more challenging beginning 2010. Developers that learn how to meet this challenge and capitalize on improved energy performance in advance of the standards implementation will have a much better chance of succeeding in the marketplace. Understanding the new standards is the first step in identifying preferred strategies for meeting and exceeding the new Title 24 requirements.

Maximizing Benefits

A strategic approach to building and marketing high performance zero energy projects would be to develop building designs that qualify for selected programs while taking advantage of shared qualification criteria. The builder can choose the branding/labeling program or combination of programs that is likely to attract the most attention in their particular market. For example some communities might respond better to energy savings and others to "green" marketing approaches. Energy use and peak demand reduction is the primary concern of the ZENH program, but builders will likely benefit by incorporating the components of the other programs by offering homes that demonstrate higher quality, health, and comfort attributes in addition to energy savings. In a 2003 survey conducted under the federal Zero Energy Homes program, respondents ranked quality of construction, higher than energy savings, as the most important feature of new homes. A significant builder benefit of high quality homes is reduced construction callbacks.

1.1.9.3 *3.2.5.3 Defining the Zero Energy Multi-Family Project*

The California Energy Commission defines the ideal Zero Energy New Home as a living unit that meets the 2005. Summer peak demand for a ZENH is defined as the average weekday power drawn from the electric utility during the four hours surrounding the system peak, averaged across the hottest summer month.

Due to lower space conditioning loads in attached housing, it can be more challenging to meet the 25 percent energy savings relative to Title 24. The summer peak demand reduction goal of 1 kW is possible to achieve with a ZENH design, but the actual demand savings is highly dependent on the appliances and other electrical devices the owner or tenant brings into the living unit and how they are used. It is also possible to achieve a 70 percent utility bill reduction with properly sized PV systems. The incremental first cost is a much more difficult goal to achieve given current construction costs, but it is possible for a builder to absorb nearly all of the projected incremental costs while remaining highly profitable through good marketing and improved sales. This strategy has proven effective in the single-family production home market.

1.1.9.4 *3.2.5.4 ZENH Best Practices*

What Are ZENH Best Practices?

There are many combinations or packages of energy efficiency measures that can be developed to reduce energy use of multi-family projects. The goal should be to adopt the most cost-effective package while maximizing energy savings. Many energy efficiency measures have an interactive effect with other measures, that is, as one measure is added to a design it affects the performance impact of other measures. For example, reducing the cooling load by improving the building envelope (by adding insulation, high performance windows, or exterior shading), decreases the potential energy savings that can be achieved by installing an efficient air conditioner. Using the same example, the envelope improvements can reduce the size and cost of the air conditioner and duct system, reducing the required size and cost of the PV system, increasing the value of the envelope measures. An exhaustive "sequential analysis[29]" of the full universe of energy efficiency measures is needed to develop the most cost-effective package. This analysis process involves an iterative process of individually evaluating measures, and adding the most cost effective option, which then defines the base case for subsequent measure evaluations.

Through research completed under the Department of Energy's Zero Energy Homes and Building America programs, the sequential analysis method has been used to optimize measure packages for single family homes in California's Central Valley climate. While there are issues unique to multi-family construction, the performance of similar packages has been verified using Micropas or EnergyPro evaluations for a range of features. The resulting best practices, recommended in this report, are reasonably valid for a range of building envelope designs and building orientations.

The Importance of Integrated Design

"Integrated design" refers to the practice of involving the entire project team in the design process from schematic design through construction drawings. Several energy efficiency measures are difficult or impossible to implement if they are not considered early in the design process. Some examples of this include building siting, window shading, advanced framing, locating ducts in conditioned space, and optimized hot water distribution piping. Using the latter example, shortening the amount of piping (i.e. entrained water) between the water heater and the fixtures saves both water and energy, but requires planning on water heater location, as well as location of bathrooms and kitchen fixtures relative to the water heater location, and optimizing hot water recirculation loop for central water heating applications.

As another example, building siting can have a significant impact on building cooling energy use. The same building oriented in different directions can have a 25 percent increase in cooling energy use if significant window area is oriented to the west. Tailoring building designs to orientation saves space conditioning energy, reduces the required size of cooling equipment

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[29] The sequential analysis process was pioneered under Pacific Gas & Electric's Advanced Customer Technology Test for Maximum Energy Efficiency (ACT^2), a research project that was initiated in 1990. See http://207.67.203.54/Qelibrary4_p40007_documents/ACT2/act2fnl.pdf for the project summary.

(saving money), improves homeowner comfort and satisfaction, and makes energy compliance easier to achieve.

In addition to siting optimization, preliminary meetings with architects, energy consultants, and subcontractors at the schematic design stage can be useful in suggesting configuration changes (e.g. building aspect ratio) that can reduce the amount of construction materials needed and simplify the installation of piping, ducting, PV systems, and other components. Energy influences are clearly not a predominant driver on building siting and form, but consideration at the schematic design stage allows these factors to at least be taken into consideration.

Multi-Family PV Implementation Issues

One of the complexities associated with multi-family PV projects relates to implementation difficulties associated with central system concepts. In many applications, a central system approach represents a more cost effective installation strategy for PV. However current CPUC rules preclude electrical sub-metering, effectively eliminating this strategy as a viable alternative. While some projects in municipal utility territories may be able to install central systems for tenant use, projects in investor-owned utility territories are subject to the CPUC rules. Multi-family developers are then presented with the option of either installing individual systems for each tenant unit or installing PV for common areas only.

Installing individual systems is the more costly alternative. While there are some scale advantages with installing multiple systems at a single location, the component costs are higher for individually metered installations, because of individual inverters, disconnects, wiring, and conduit required. Depending on architecture and building layout, it may be more challenging to find adequate roof area for individual systems. There are additional limitations with owner occupied multi-family construction, if the roof is owned by the occupant. Then there may be some units that due to roof orientation do not have suitable siting, and having individually owned PV systems installed over another owned unit can lead to code and liability issues.

Installing PV for common area loads is straightforward and results in lower capital costs, but does not provide any direct benefits to tenants, offsetting only a fraction of the total building electrical energy use. There is usually adequate roof area for these types of systems.

The California IOU's submitted a proposal to the CPUC in the fall of 2008 to allow for a "virtual tariff" approach that would allow affordable multi-family project developers to install a central PV facility and generate a credit that would appear on each of tenant's electric bill. Although this proposal is still in the CPUC public review process, approval would help in increasing PV implementation viability in affordable housing projects.

A second strategy that should increase a developer's interest in implementing ZENH strategies in affordable multi-family projects involves the development of a utility allowance calculator. Historically local housing authorities were forced to use Utility Allowance schedules to determine typical monthly utility costs. These schedules generally overestimated tenant utility costs, reducing the maximum rent that the housing authority could charge. This proves to be a disincentive for multi-family projects that adopt efficient building practices or zero energy strategies, since the lower utility bills are not recognized by the Utility Allowance schedules. In

2008 the CEC and KEMA released the California Utility Allowance Calculator, developed in conjunction with the affordable housing community and the California Tax Credit Allocation Committee. This new tool provides for more accurate assessments of utility bills, providing an incentive for developers to incorporate energy efficiency and PV in their projects, and allowing them to charge higher rents as a result of lower utility costs.

Unlike typical single family PV applications where the owners pursue PV by choice, affordable multi-family projects will often involve tenants who may not have an in-depth understanding of PV benefits and how their usage patterns compliment or detract from the PV performance and affect their monthly utility costs. Education of tenants is important to maximizing PV benefits during the utility peak periods.

Another tenant issue that needs to be resolved relates to net metering and the annual utility bill true-up at the end of the year. For owner-occupied systems, true-up bills can be surprising, and represent a financial burden, but in affordable projects this annual bill adjustment can represent a financial catastrophe. As part of the tenant education, it is critically important that the tenants are aware of the billing procedures, and that they pay a certain amount monthly, so they are not caught with a big burden at the true-up period. The building owners should periodically review tenant utility bills and provide recommendations on monthly payment amounts. If the building owners can get access to the tenants' monthly utility bills they can use that information to provide payment options and tailored energy savings recommendations.

Additionally, if a tenant should move, they will have some financial responsibility for the final end of year bill adjustment. It is important for this to be handled in an equitable fashion without imposing an economic hardship on either the leaving or the incoming tenant.

1.1.9.5 *3.2.5.5 Recommended ZENH Package Energy Efficiency Measures*

This section describes each recommended energy efficiency measure (EEM) and provides information about their availability, maintenance requirements, verification and inspection requirements, and estimated costs. All measures listed have been found to yield a positive cash flow when combined, that is the additional cost to finance them in the mortgage is less than the energy savings they produce at current gas and electric rates, and when packaged with PV systems result in energy savings that are consistent with ZENH goals.

Building Envelope Measures

Exterior Wall Insulation

Measure Specification:	R-15 fiberglass batt with 1" exterior foam sheathing. Where 2 x 6 walls are required for structural or other reasons, use R-21 batt. All wall insulation, including attic knee walls, must meet Thermal Bypass Checklist (TBC) and Quality Insulation Installation (QII) criteria.
Availability:	Readily available.
Installation & Verification:	Include TBC/QII requirements in insulation subcontract. This measure requires third-party HERS inspection to qualify for Title 24 and Energy Star credits, Federal Tax Credit, as well as for participation in utility incentive programs and LEED.

Estimated Cost:	For projects that use stucco systems that include exterior insulation sheathing, the incremental materials cost can be zero. Where it is applied under stucco or other siding materials, R-4 sheathing will add about $0.25 per s.f. of exterior wall surface area. Upgrading to high density batt insulation costs about $0.07 per s.f. of exterior wall area. The total cost of HERS inspections, including insulation, blower door and duct testing, and TXV/SEER verification is about $200 per unit.

Roof/Ceiling Insulation

Measure Specification:	Minimum R-38 blown fiberglass or cellulose insulation in ceiling and R-19 batt insulation below any attic equipment platforms. All ceiling insulation should meet TBC and QII criteria. R-49 insulation may be justified in some applications such as one and two story townhouses in more extreme climates.
Availability:	Readily available.
Installation & Verification:	Include TBC/QII requirements in insulation subcontract. This measure requires third-party HERS inspection to qualify for Title 24 and Energy Star credits, Federal Tax Credit, as well as for participation in utility incentive programs and LEED.
Estimated Cost:	Upgrading from R-30 to R-38 ceiling insulation costs about $0.20 - $0.25 per s.f. of ceiling area.

Radiant Barrier

Measure Specification:	OSB or plywood roof sheathing with reflective aluminum foil laminated to underside with an emissivity 0.05 or less. Must be applied to all roof deck surfaces over conditioned space.
Availability:	Available from Louisiana Pacific, Georgia Pacific, Polar-Ply, and other manufacturers.
Installation & Verification:	Installation same as standard roof sheathing. Verified by HERS inspector.
Estimated Cost:	About $0.25 per square foot of roof area.
Other Information:	Some concerns have been raised about the effect of radiant barriers on the life of asphalt roofing. Tests conducted at the Florida Solar Energy Center have shown that the roof surface temperature is only increased by a few degrees, suggesting that the effect on roofing lifetime is insignificant.

Tight Construction

Measure Specification:	Tightly sealed envelope with Specific Leakage Area (SLA) less than 3.0.
Availability:	Accomplished through application of a house wrap and customary caulking of plates and framing penetrations, draft stopping, and installation of weather stripped doors and Energy Star windows.
Installation & Verification:	Include sealing requirements in insulation subcontract. Requires HERS blower door testing to qualify for Title 24 and other credits.

Estimated Cost:	The total cost of all HERS inspections, including insulation, blower door and duct testing, and TXV/SEER verification is about $200 per unit.
Other Information:	Title 24 credit is available for a tested SLA lower than the default value. If taking credit for less than 3.0 SLA, mechanical ventilation is required. Under the 2008 Title 24 standards (set to go into effect in August of 2009), mechanical ventilation will be required.

High Performance Windows

Measure Specification:	U-value of 0.35 or less and SHGC of 0.32 or less.
Availability:	Available from all major window manufacturers.
Installation & Verification:	Follow manufacturer's instructions, particularly for flashing. Installation to be verified by HERS rater.
Estimated Cost:	About $0.40 - $1.00 per square foot of window area, depending on the manufacturer and the specifications of the windows required to meet Title 24.
Other Information:	Higher performance windows are currently available and specified with SHGC of 0.26 and lower. In cooling dominated climates these higher performance windows can offer significant improvements in performance.

Mechanical & Plumbing Systems

High Efficiency Heating and Cooling Equipment

Measure Specification:	Variable speed condensing furnace with AFUE greater than 0.90 and air conditioner efficiency equal to or greater than 14 SEER and 12 EER. Cooling coil installed with a thermostatic expansion valve (TXV). For heat pump applications, specify heat pumps with HSPF of 8.5 or greater.
Availability:	Available from all major manufacturers.
Installation & Verification:	Installation of high efficiency heat pumps is the same as for standard systems. Condensing furnaces require condensate drain, and PVC venting instead of the conventional "B" vent. Otherwise, installation is the same as for standard systems. Direct venting allows furnace to be installed inside conditioned space (recommended). HERS rater verifies nameplate data and presence of TXV.
Maintenance:	Maintenance requirements are the same as for conventional equipment (filter replacement, periodic check of refrigerant charge, etc.)
Estimated Cost:	Experience has shown the furnace efficiency upgrade from 80 percent to 90 percent+ AFUE, and motor upgrade to variable speed can cost anywhere from $300 to $1,000. The air conditioner upgrade costs in the range of $100 to $350/per ton for SEER/EER's of 14/12 to 15/12.5.
Other Information:	More credit is given in Title 24 for a high EER rating than SEER rating because the EER rating is more reflective of actual operation in California climates. Include required efficiency ratings in HVAC subcontract.

Proper HVAC System Sizing

Measure Specification:	Size heating and cooling equipment in accordance with ACCA Manual J and S or other methods acceptable to the California Energy Commission.
Availability:	Materials are readily available. Proper HVAC sizing using ACCA Manual J procedures are not uniformly practiced by HVAC trades.
Installation & Verification:	Include specification of HVAC sizing requirements in HVAC subcontract. HERS rater can verify equipment sizing.
Maintenance:	None
Estimated Cost:	Contractors and/or Title 24 consultants usually offer sizing as a part of their service, resulting in no incremental cost. Proper sizing based on the actual building envelope measures can result in reduced equipment sizing, resulting in cost savings and improved system performance.

Proper HVAC Refrigerant Charge

Measure Specification:	HVAC contractor to properly charge any refrigerant based air conditioning system or heat pump, and provide temperature measurement access ports on either side of the evaporator coil, and saturation temperature measurement sensors for non-intrusive HERS inspection. The measurement and regulation of correct refrigerant charge can significantly improve the performance and air conditioning equipment.
Availability:	Materials are readily available. Proper HVAC charging is not uniformly practiced by HVAC trades.
Installation & Verification:	Include HVAC refrigerant charging requirements in HVAC subcontract. HERS rater must be able to verify refrigerant charge.
Maintenance:	None. Proper refrigerant charge should result in longer AC life.
Estimated Cost:	Contractors usually charge the air conditioning equipment, but the charge is not usually verified. $100 additional cost for saturation measurement sensors. $200 cost for HERS verification.

Efficient Air Distribution System Design and Sizing

Measure Specification:	R-6 ducts with leakage less than 6 percent of system airflow, sized in accordance with ACCA Manual D or other methods acceptable to the California Energy Commission. Keep duct runs as short as possible (avoid installing registers on exterior walls where possible). Design buildings so that duct runs are in conditioned space. Alternatively, allow ducting to lay on bottom chord of roof trusses so it can be covered with blown-in insulation. The duct design should be documented in construction drawings. Provide dedicated returns or transfer grilles for all bedrooms to ensure proper system operation and air distribution when interior doors are closed.
Availability:	Materials are readily available. Proper HVAC sizing using ACCA Manual D procedures and design of adequate return air flow are not

	uniformly practiced by HVAC trades. There are greater opportunities for installing ducts in conditioned space and reducing duct runs in multi-family applications.
Installation & Verification:	Include duct sizing, tight duct testing, and installation requirements in HVAC subcontract. Sizing and specification of return air flow from all rooms should be documented. HERS rater to verify duct leakage. Room by room supply airflow testing by a HERS rater is recommended.
Maintenance:	None
Estimated Cost:	Frequently, contractors and/or Title 24 consultants will offer sizing as a part of their service, resulting in no incremental cost. As noted, comprehensive HERS inspection costs for multi-family projects are about $200 per unit.

Ventilation Cooling

Measure Specification:	Automated nighttime ventilation cooling using the furnace or air handler fan. The ventilation cooling system consists of an outside air damper and controls and reduces air conditioner energy use by ventilating with cool outside air during summer nights.
Availability:	System components are readily available for single family, which can be applicable to some multi-family applications (townhomes), but equipment is limited in multi-family with limited HVAC equipment space.
Installation & Verification:	Correct operation of the dampers and controls should be verified by builder field staff. The proposed 2008 Title 24 standards (effective January 2010) will likely require a HERS inspection of the fresh air ventilation system. Space considerations for outside air and relief dampers.
Maintenance:	Requires more frequent filter changes due to filtering of outside air.
Estimated Cost:	The incremental installed cost for a ventilation cooling system designed to operate with a variable speed furnace, including zoning capability and variable speed furnace, is approximately $2,400.

Fresh Air Ventilation

Measure Specification:	A mechanical system that provides fresh air ventilation compliant with ASHRAE 62.2-2004. Mechanical ventilation is more important in multi-family applications with common walls and less ability for providing fresh air through passive means.
Availability:	System components are readily available. Supply-only, exhaust-only and balanced systems are available. Heat recovery ventilators (HRV) recommended in cold or hot climates. Energy recovery ventilators (ERV) recommended in either very dry or humid climates.
Installation & Verification:	Beginning January 2010, under the 2008 Title 24 code, mechanical ventilation will be required. Since performance of ventilation systems is not evaluated, there are currently no HERS inspections under Title 24.

Maintenance:	May require filter changes due to filtering of outside air.
Estimated Cost:	The incremental installed cost for a mechanical ventilation systems range from $400 for exhaust-only systems to $1,500 for balanced systems (HRV/ERV).

Water Heating

Measure Specification:	Multi-family water heating can either be a central system design or individual water heaters serving each unit. Central systems can serve the entire project with a large boiler, storage tank, and recirculation loop, or can serve individual buildings with a smaller boiler (or large storage water heater) and a smaller recirculation loop. Condensing boilers, properly commissioned controls, and intelligent distribution system design are three key efficiency options that should be carefully evaluated. The higher loads on central systems generate more favorable economics for the more expensive condensing systems. Central systems are more conducive to solar water heating than are individual unit installations. Individual unit water heater efficiency options include tankless (on demand) gas water heaters with Energy Factors of 0.80 or higher.
Availability:	Available from multiple manufacturers.
Installation & Verification:	For tankless units, venting costs can be reduced or eliminated by installing the water heater on an exterior wall or recessed into an exterior wall. Most plumbers have become familiar with tankless units and should be trained in their installation and service. Installation verification is not required.
Maintenance:	Manufacturers of tankless water heaters recommend periodic flushing to remove water deposits, though this is typically not required more frequently than at two year intervals, depending upon the hardness of the local water. Central systems typically require less maintenance then individual water heaters.
Estimated Cost:	Incremental cost for a condensing boiler or condensing storage water heater is approximately $1500-$2000. Incremental cost for a tankless water heater is ~$800 relative to a 40 gallon gas storage water heater, although the space savings of a tankless unit may offer benefits to the builder. Long vent pipe runs should be avoided because of the high cost of the Category IV stainless steel vent pipe.

Hot Water Distribution Piping

Measure Specification:	The optimal hot water distribution system type is based on the size and configuration of the building, number of stories, and local code requirements. During the design phase, consideration should be given to locating hot water fixtures, especially bathrooms and kitchen, close to each other and close to the water heater. Piping systems should be engineered by a consultant or contractor who has an understanding of energy efficiency and water conservation. Dwelling units less than 2,500

ft² with individual water heaters, and where cross-linked polyethylene (PEX) is allowed by local codes: "Home run" or "parallel" piping system using PEX may be the best design option. The supply line between the water heater and the manifold should not be greater than 10 feet (6 feet for LEED points) and must be insulated. Lines from the manifold to the fixtures should be no larger than ½", preferably 3/8" for fixtures with low flow requirements. The pipe run to the kitchen must also be insulated.

Central water heating systems with hot water recirculation loops:

- Temperature controls on the recirculation pump should be provided.
- Provide minimum of 1" pipe insulation on all hot water recirculation runs.
- Minimizing recirculation pipe lengths. Consider multiple central water heating systems located more central to the fixtures, if building layout justifies it. Avoid locating central water heating in a separate building and long underground piping runs.

Availability:	Specified piping and recirculation controls are readily available.
Installation & Verification:	Plumbing contractors should follow engineering drawings and specifications. Verification by field superintendent and/or GPR / LEED rater.
Maintenance:	Recirculation pump lifetime should be greater than 10 years.
Estimated Cost:	Costs for home run piping are typically comparable to or less than those for branched copper hot water systems.

Lighting & Appliances

Indoor Lighting

Measure Specification:	Lighting installed in accordance with proposed 2008 Title 24 standards, which require high efficacy lamps in most fixtures, except where controlled by dimmers or motion sensors. Energy efficient LED downlights are entering the market with increasing product offerings. Other efficient lighting options include bi-level lighting systems for hallways and stairwells, and fluorescent bath fixtures.
Availability:	Fluorescent and LED luminaries are currently available and product offerings are expanding.
Installation & Verification:	Lighting compliance is typically verified by building officials.
Maintenance:	High efficacy lighting has a longer life.
Estimated Cost:	Fluorescent can fixtures are typically $40 per fixture, compared to incandescent fixtures at $10, but incandescent fixtures would require a $30 - $40 dimmer control per switch. LED downlights are still fairly high costly (~$95), but prices are falling.

Outdoor Lighting

Measure Specification:	Lighting installed in accordance with proposed 2008 Title 24 standards, which either require high efficacy lamps or motion sensors plus photo sensors or time controls. Parking lot and walkway lighting can benefit from bi-level lighting systems that offer significant savings (>30 percent) during the many hours of standby operation. A lighting designer can specify appropriate outdoor lighting for individual applications.
Availability:	Fluorescent and bi-level luminaries are currently available and product offerings are continually expanding.
Installation & Verification:	Lighting compliance is typically verified by building officials.
Maintenance:	High efficacy lighting has a longer life.
Estimated Cost:	The costs for the advanced lighting systems may be higher than conventional, but significant savings should contribute to short paybacks (<2 or 3 years).

Appliances

Measure Specification:	All builder-supplied appliances are Energy Star labeled.
Availability:	Available at all wholesale and retail appliance outlets.
Installation & Verification:	By builder procurement and field personnel.
Maintenance:	Similar to conventional appliances.
Estimated Cost:	EnergyStar dishwashers range from about $200 to $500 more than standard models, depending primarily on features. Other appliances (refrigerator, washer, dryer) may not be builder-installed. Local utilities may offer EnergyStar appliance rebates that could help defray these costs.

Photovoltaic (PV) Systems

Measure Specification:	There are numerous reliable PV systems available including both conventional rack-mounted systems and "building integrated" systems that interface with roof tile. The systems should be sized to the anticipated annual electrical load. Over-sizing results in generation of excess electricity that is not credited on utility bills under current net metering rules. Under-sizing does not take full advantage of the investment in the inverter and other components that must be installed regardless of the size of the system. Typical systems installed on individual multi-family units range in size from about 1.0 to 1.5 kW (DC, STC rated).
Availability:	Residential systems are available from numerous manufacturers.
Installation & Verification:	By builder procurement and field personnel. Inspection by a PV certified HERS rater is required for participation in state / utility incentive programs and federal tax credit verification.
Maintenance:	No periodic maintenance is required.

Estimated Cost:	Manufacturers / installing contractors normally file for and collect the Solar Homes Partnership rebate and charge the builder for the net cost. The installed cost varies depending on the system size and type, the number of buildings in the project, and other factors. Rack-mounted modules are less expensive than building integrated systems. Installed costs currently range from about $6 to $8 per Watt (DC, STC rated).

1.1.9.6 *3.2.5.6 Conclusions*

Achieving high levels of energy savings is more challenging for multi-family projects than for detached housing since space conditioning loads generally make up a smaller percentage of total energy use due to less envelope area per sq. ft. of floor area. Typically miscellaneous energy use is a larger component in multi-family projects and the builder has little or no control over that end use. Builders can however utilize technologies, design practices, and inspection procedures that are commonly available to achieve energy savings that exceed Title 24 by 25 percent, or more, with minimal adjustments to their business practices. By applying appropriate incentives to reduce costs and using branding programs such as Energy Star, GreenPoint Rated, LEED, and Builders Challenge, builders may be able to demand higher prices, making ZENH a strong value proposition for the builder. In addition, these energy efficiency strategies could lead to an increased ZENH market in affordable housing projects, if a mechanism exists for the developers to charge higher rents as a result of lower projected utility bills.

For the homebuyer or tenant, the decreased cost of ownership, improved construction quality, and higher insulation from future utility rate hikes is attractive, particularly given the current energy outlook. For the utilities, the peak load reduction offered by ZENH's represents a decentralized resource that contributes to reduce need for new generation facilities and infrastructure upgrades.

As the California Building Energy Standards rise to the efficiency levels described in this report, progressive builders looking for a market edge will need to continue to evaluate emerging technologies to maintain a strong market position. Technology development will continue to be fed by the California Energy Commission's Public Interest Energy Research Program, the Department of Energy's Building Technologies program (including Building America), and utility emerging technologies programs.

Other conclusions

The Villa Monterey project presented in this report featured individual PV systems for each apartment unit. This is a more costly installation strategy than having one central system with shared benefits among all tenants. Modifying the utility billing arrangements to allow this strategy would be very beneficial for multifamily projects.

The annual utility bill true-up creates complexities, especially in rental housing where tenants move more frequently. Developing a fair, but easily implementable monthly billing approach is needed to avoid large end of year utility bills.

1.1.10. 3.2.6 Multi-Family Design Report

This 'Multi-Family Zero Energy New Homes Design Report' summarizes the design features included in the multi-family ZENH project.

The Multi-Family (MF) ZENH Design Report includes the following items:

- Description of MF designs, including the energy efficiency features,
- Discussion of the iterative design efficiency analysis identifying energy, demand, and cost issues,
- Predictions of annual energy use for all major end-uses relative to Title-24 baseline,
- Predicted performance on summer peak day during peak period, and
- Architectural designs with placement of solar systems on complex's roofs.

Davis Energy Group led a design charrette and subsequent meetings for the Villa Monterey multi-family builder participants in the ZENH Program. Each builder had unique issues, goals, and preferred strategies, so each builder project is summarized individually in this report.

1.1.10.1 *3.2.6.1 Methodology*

As part of the work under this program, Davis Energy Group (DEG) evaluated the projected energy and demand savings, based on the proposed ZENH energy features.

Total energy savings were estimated from the following two sources:

- MicroPas for space heating and cooling, and water heating, and
- the Department of Energy's Building America Benchmark tools for estimating non-HVAC loads such as lighting, appliance, and miscellaneous electric loads (MELs).

Hourly simulations were completed using version 7.3 of the MicroPas software. Building America Benchmark hourly load profiles were also used for lighting and appliances.

PV production values are based on average hourly production profiles for each month for a south-facing SunPower "Smart Mount" system.

"Summer Peak Demand" for a ZENH was defined by the CEC in the project solicitation as the maximum daily power drawn from the electric utility on weekdays during the four hours surrounding the system peak, averaged across the utility system's hottest month. The peak hour and day in the MicroPas weather file is 5 p.m. on August 7. The daily peak between 3-7 p.m. for August was averaged to determine the summer peak demand for this plan.

1.1.10.2 *3.2.6.2 Summary of ZENH Goals*

The CEC defines a Zero Energy New Home for the purposes of this project as a home meeting the *2005 targets*. The goal of this project is to demonstrate homes achieving the 2005 targets.

Summer peak demand for a ZENH is defined as the maximum daily power drawn from the electric utility on weekdays during the four hours surrounding the system peak, averaged across the utility system's hottest month. In 2007, the hottest month for PG&E was August.

1.1.10.3 *3.2.6.3 Demonstration Project: Visionary Partners – Villa Monterey, Stockton*

This report summarizes the analysis and evaluation Visionary Partners' 45 unit Villa Monterey apartment complex located in Stockton, California being built by Grupe Homes. The Villa Monterey project is located in climate zone 12 within PG&E service territory. The apartment complex contains twenty 680 square foot one bedroom units, sixteen 857 square foot units, and 5 two bedroom corner units ranging from 1,025 to 1,080 square feet. The complex also contains a 4-plex consisting of four 2-bedroom 945 square foot units. The existing apartment units will be gutted and rebuilt. The 4-plex is new construction and will be built in the interior courtyard of the apartment units. Total savings were estimated using MicroPas for space heating and cooling, and water heating, using estimates for non-HVAC loads based on the Building America Benchmark analysis. For modeling purposes the 4-plex units were modeled separately from the rest of the 41 apartment units. PV production values are based on average hourly production profiles for each month for a south-facing 1.23 kW DC PV SunPower "Smart Mount" product which consists of six 205 watt modules per unit. The apartment building also consists of some non-residential areas, including offices, clubroom and activity room, and laundry that are not included in this evaluation or report. Construction was completed in early 2009.

Table 34: Grupe Villa Monterey Plan Descriptions

Plan Type	Conditioned Floor Area (sq. ft.)	# units	# Bedrooms
Apartment		41	
1 BDRM /1 BR	680	20	1
2 BDRM / 1BR	857	16	2
Corner Unit #1	1,025	2	2
Corner Unit # 2	1,080	3	2
4-plex (New Construction)	945	4	2

In addition to participating in the Zero Energy New Homes Program, Grupe was also interested in meeting the Tier I goals of the New Solar Homes Partnership (NSHP) (15 percent better than Title-24) and the California Multifamily New Homes (CMFH) Performance Program in order to take advantage of the additional incentives to help offset the additional costs for these measures.

Table 35 summarizes the Title 24 and Zero Energy New Home (ZENH) design assumptions used to meet the goals. The ZENH design measures include the package of energy efficiency measures (EEM's) Grupe incorporated in the design of Villa Monterey, including the 1.23 kW DC PV SunPower "Smart Mount" product which consists of six 205 watt modules per apartment unit.

Table 35: Grupe Villa Monterey Building Description (T24 and Design)

	Title-24 Base	ZENH Features
ENVELOPE:		
Walls (Exterior)	2x4 16” o.c. R-13 2x6 16” o.c. R-19	2x4 16” o.c. R-13 spray foam 2x6 16” o.c. R-19 spray foam
Wall (Garage)	n/a	n/a
Kneewall (2x4)	2x4 16” o.c. R-13	2x4 16” o.c. R-13 spray foam
Floor (Above Garage / Cantilever)	n/a	n/a
Roof Insulation (Attic)	R-38	R-49
Roof Insulation (at Furnace)	NA	R-19
Housewrap - SLA Credit	No	Yes / SLA 3.0
Attic Radiant Barrier	Yes	No
Quality Insulation Inspection Credit	No	Yes
GLAZING: (U-factor / SHGC)		
U-Factor	0.57	0.35
SHGC	0.40	0.29
HVAC SYSTEM:		
Heat Pump HSPF	7.70	Apartment: 8.0; 4-plex: 8.5
AC SEER / EER	13.0	14 / 12 EER
TXV Valve	Yes	Yes
Duct Insulation	R-6.0	R-6.0
Duct Testing	Yes	Yes
WATER HEATING:		
Tank Volume (gal)	*Apartment*: Central 100 gal *4-plex*: 50 gal	*Apart*:Central 1-50 gal., 3-100 gal. *4-plex*: Gas Tankless per unit
Energy Factor (EF)	Apartment: 0.8 RE 4-plex: 0.575 EF	Apartment: 0.62 EF 4-plex: 0.82 EF
3RD PARTY HERS INSPECTIONS / TESTS		
Tight duct testing (< 6% leakage)	Yes	Yes
EER Verification	No	Yes
TXV Verification	Yes	Yes
Blower door test (3.0 SLA target)	No	Yes
Quality Insulation Installation (QII) Inspection	No	Yes
Fluorescent Lighting	Per Title-24	At all fixtures except Dining
PV SYSTEM:		
1.23 kW DC PV system	No	Yes

Incremental Costs

A summary of the efficiency and PV measure costs that Grupe added to the Villa Monterey project are summarized in Table 36. Switching to higher efficiency heat pumps was recommended to meet the ZENH performance goals. When Grupe went back to their HVAC contractor for pricing on the higher efficiency equipment, they found that they could go with a different manufacturer and get the higher efficiency for the same price. The smaller apartment units were only available with an 8 HSPF, but the larger units specified for the 4-plex had 8.5 HSPF. PV incremental costs are net cost to Grupe after the NSHP rebate.

A $200 per unit utility incentive is available under Pacific Gas and Electric's (PG&E) California Multifamily New Homes (CMFH) Performance Program if they are 15 percent better than Title 24. Grupe is also installing EnergyStar refrigerators and Tier II dishwashers in all of the units. Under PG&E's appliance rebate program, $50 per appliance is also available. Table 36 summarizes both total and net system costs for the project as well as per unit costs.

Table 36: Summary of Incremental Costs

System Measure	Incremental Cost	
	Total	Per Unit
Ceiling Insulation (R-38 to R-49)	$ 5,700	$ 127
Attic Radiant Barrier (4-plex only)	$ 850	$ 212
Heat Pumps (13 SEER to 14 SEER/12 EER) (7.7 HSPF to 8.0 – 8.5 HSPF)	$ 0	$ 0
HERS Tests and Inspections (Insulation, TXV, EER, Blower Door)	$ 13,500	$ 300
1.23 kW DC PV System	$360,000	$ 8,000
Total	$380,050	$ 8,639
Utility Performance Incentives (CMFH)	$ 9,000	$ 200
Utility Appliance Incentives	$ 4,500	$ 100
Net Incremental Cost	$ 366,550	$ 8,339

1.1.10.4 *3.2.6.4 Energy Performance Relative to Title 24*

All of the unit types meet the ZENH performance goals of 25 percent better than Title 24. Incorporating the efficiency features (not including PV), all plans perform at least 25 percent better than Title 24. Performance relative to Title 24 is based on time dependent valuation (TDV) of energy. Lighting, ventilation cooling, and PV cannot be evaluated in Title-24, and are not reflected in the savings relative to Title-24. A summary of percent improvement over Title 24 for each building, as well as percent improvement in each category is shown in Table 37.

Table 37: Percent Improvement over Title 24

Unit Type	% Better Than Title 24			
	Total	Cool	Heat	DHW
Apartment	25.5%	36.9%	32.5%	7.6%
4-plex	37.1%	30.6%	35.2%	41.8%

1.1.10.5 *3.2.6.5 Whole House Performance*

DEG estimated the electrical energy by end use for both the Title-24 standard case and the ZENH case for both the apartments and the 4-plex. This section presents the results for both apartments and the 4-plex building.

Energy Use and Utility Savings

Estimated electrical energy by end use for both the Title-24 standard cases and the apartments with the ZENH energy features were estimated for each unit type; apartment and 4-plex. A summary of energy use by component for apartment and the 4-plex units are summarized in Table 38 and Table 39 below. Values in the tables are average use per apartment unit. Lighting energy use assumes fluorescent fixtures in the kitchen and bathrooms as required for Title 24 in both the base case and the ZENH case. Energy use comparisons and savings based on the proposed EEM package and EEM package with PV (ZENH) are also summarized on a per unit basis for both apartment and 4-plex units in Table 40 and Table 41.

For both apartment and 4-plex units, the ZENH efficiency design upgrades with 1.23 kW DC PV system are expected to reduce average annual energy use and costs by approximately 40 percent relative to a similar units built to code. Average monthly utility cost comparisons for both apartment and 4-plex units are shown in Figure 19 and Figure 20.

Table 38: Apartment - Estimated Electrical Energy by End Use

	Estimated Annual Electrical Use (kWh/year)		Estimated Annual Gas Use (Therms/year)	
End Use	Title 24 Compliant House	ZENH House	Title 24 Compliant House	ZENH House
Space Heating	649	433		
Space Cooling	426	263		
Cooking			45	45
DHW			107	99
Refrigerator	669	537		
Washer				
Dryer				

Dishwasher	240	105		
MEL's	1,570	1,570		
Plug-in Lighting	218	218		
Hard-Wired Lighting	822	822		
PV Production		-1,625		
Total	4,594	2,323	152	144

Table 39: 4-plex - Estimated Electrical Energy by End Use

	Estimated Annual Electrical Use (kWh/year)		Estimated Annual Gas Use (Therms/year)	
End Use	**Title 24 Compliant House**	**ZENH House**	**Title 24 Compliant House**	**ZENH House**
Space Heating	911	574		
Space Cooling	369	215		
Cooking			45	45
DHW			191	174
Refrigerator	669	537		
Washer				
Dryer				
Dishwasher	240	105		
MEL's	1,696	1,696		
Plug-in Lighting	242	242		
Hard-Wired Lighting	909	909		
PV Production		-1,625		
Total	5,036	2,653	236	219

Table 40: Apartment – Estimated Annual Energy Use and Savings Summary.

Case	Electric (kWh)	Gas (Therms)	Utility Cost ($)
Title-24 Base House	4,594	152	$ 729
Grupe EEM	3,949	144	$ 640
Grupe ZENH	2,324	144	$ 431
Savings	2,270	8	$ 297
% Savings	49%	5%	41%

Table 41: 4-plex – Estimated Annual Energy Use and Savings Summary.

Case	Electric (kWh)	Gas (Therms)	Utility Cost ($)
Title-24 Base House	5,036	236	$ 913
Grupe EEM	4,278	219	$ 778
Grupe ZENH	2,653	219	$ 560
Savings	2,383	17	$ 353
% Savings	47%	7%	39%

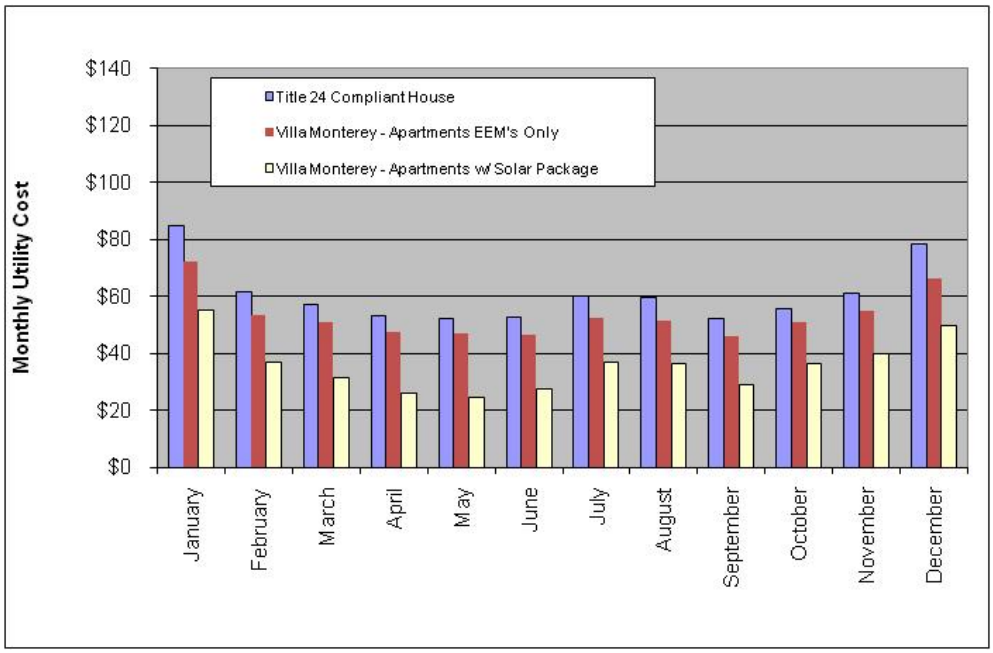


Figure 19: Apartment – Estimated Monthly Energy Use Comparison

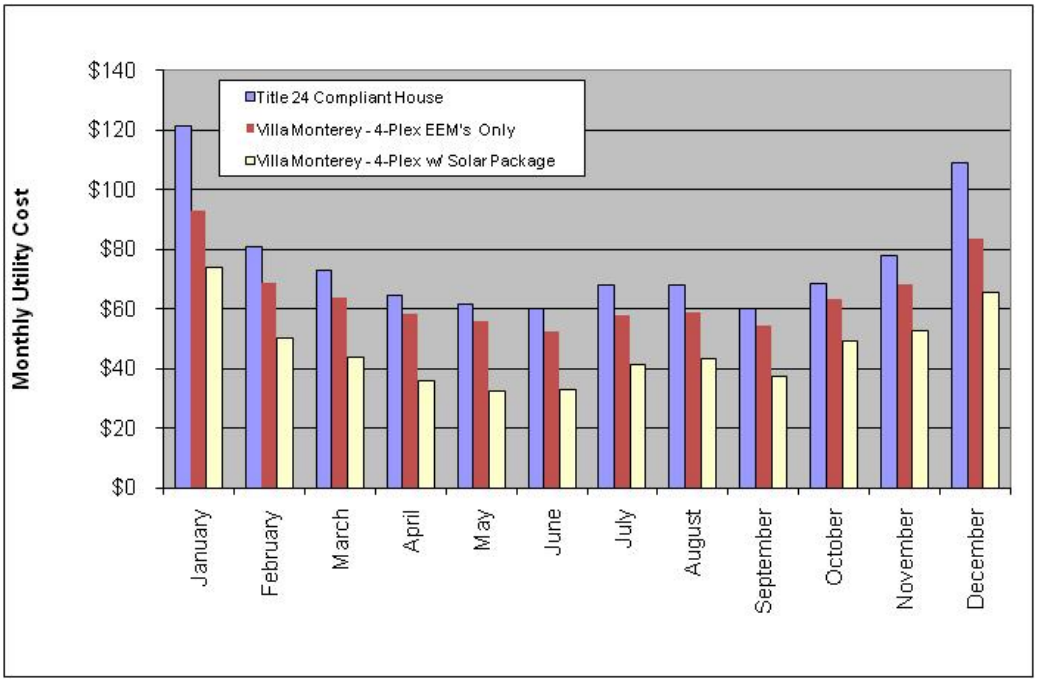


Figure 20: 4-plex – Estimated Monthly Energy Use Comparison

1.1.10.6 *3.2.6.6 Peak Demand Reduction*

"Summer Peak Demand" for a ZENH was defined by the CEC in the project solicitation as the maximum daily power drawn from the electric utility on weekdays during the four hours surrounding the system peak, averaged across the utility system's hottest month. The peak hour and day in the MicroPas weather file is 5 pm on August 7. The daily peak between 3-7 pm for August was averaged to determine the summer peak demand. The peak load calculations are based on a per unit basis for a typical apartment unit and a four-plex unit.

Peak demand and load reduction due to the ZENH energy features is summarized in Table 42. Hourly peak load profiles for apartment and 4-plex units are shown in Figure 21 and Figure 22. Figure 23 and Figure 24 show end use contributions to peak demand for both apartment and 4-plex units.

Table 42: Villa Monterey – Estimated Peak Demand and Reduction Summary

Case	Peak Demand (kW)	
	Apartment	4-Plex
Title-24 Base House	1.2	1.3
Grupe EEM	1.0	1.0
Grupe ZENH	0.5	0.5
EEM Savings	0.3	0.3
ZENH Savings	0.7	0.8
% Savings of EEM Relative to Title-24	23%	25%
% Savings of ZENH Relative to Title-24	59%	59%

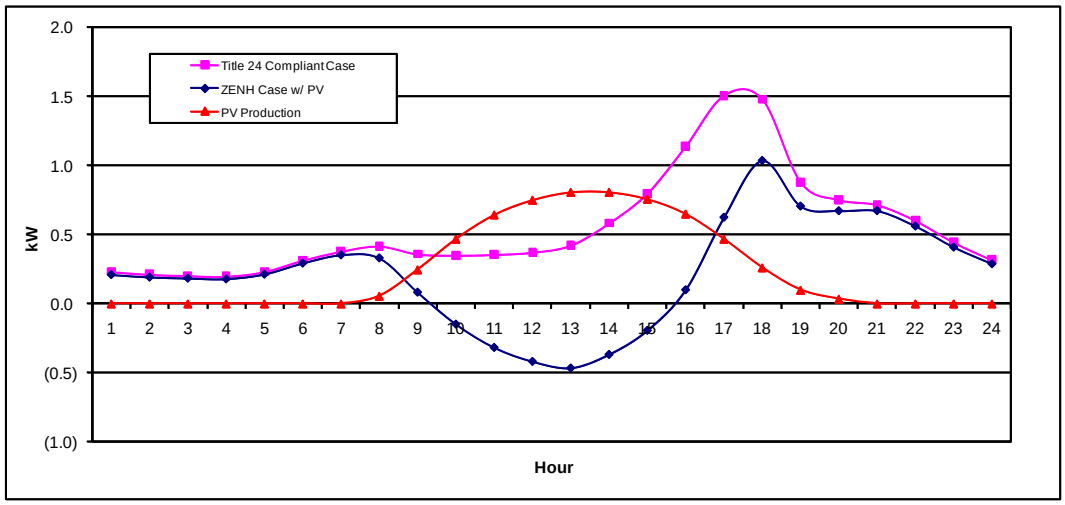


Figure 21: Apartment – Peak Day Demand Profile for August

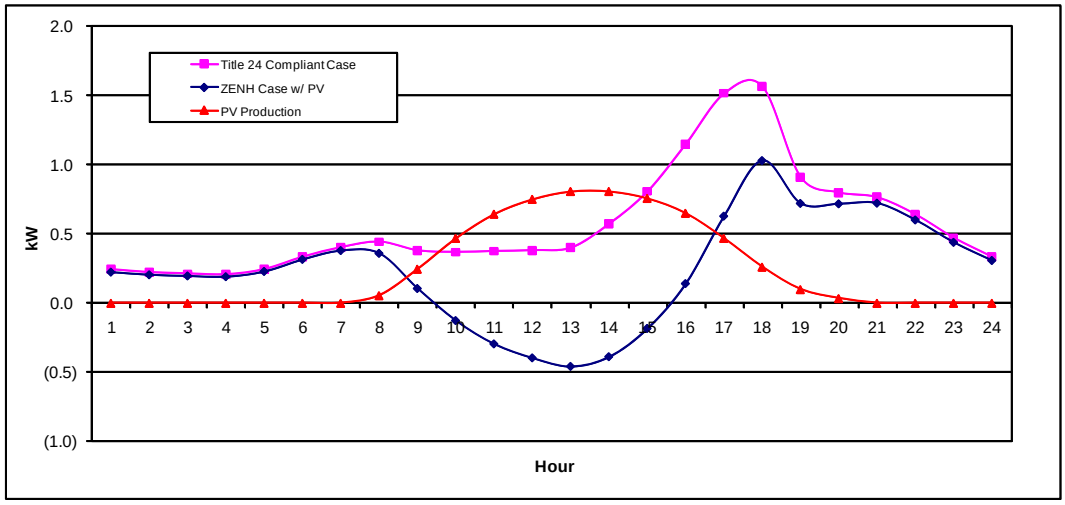


Figure 22: 4-plex – Peak Day Demand Profile for August

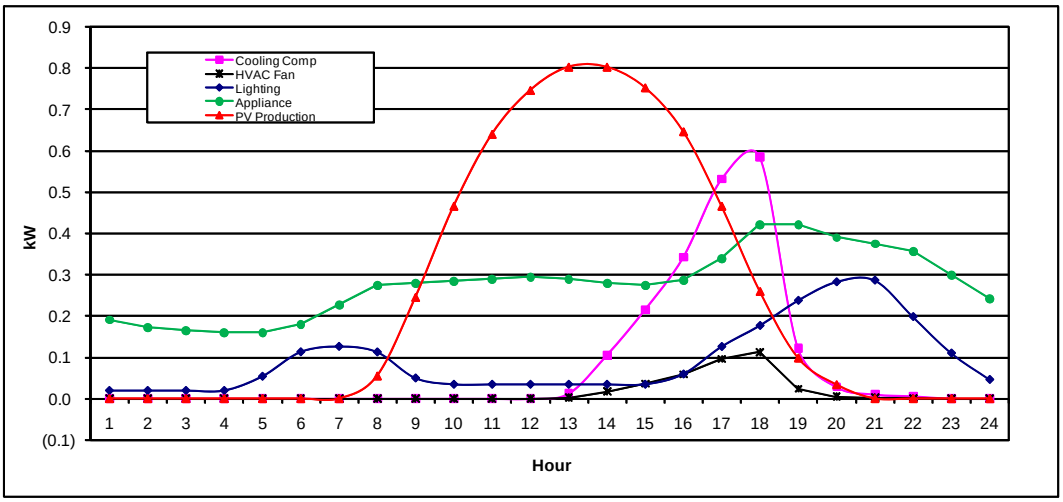


Figure 23: Apartment – ZENH Peak Demand Profile Breakdown

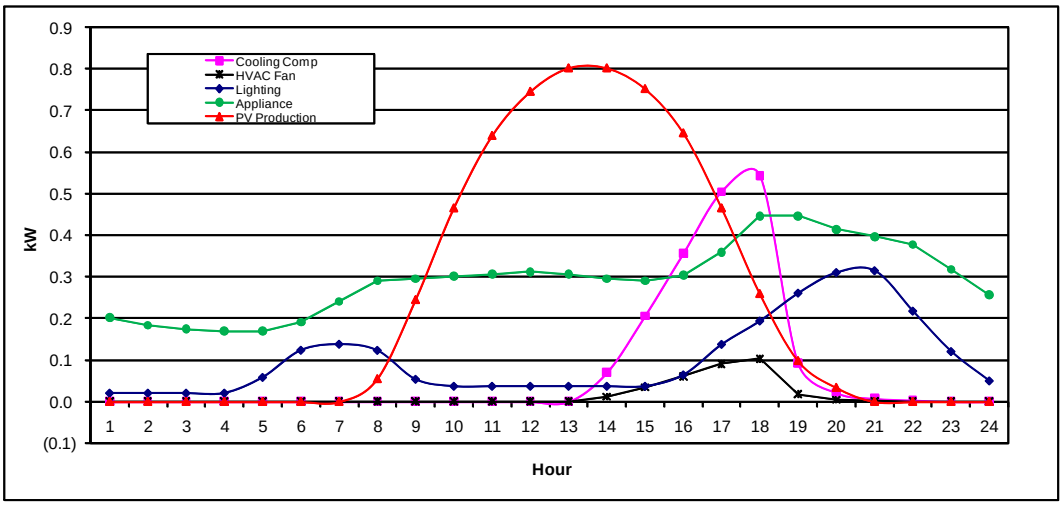


Figure 24: 4-Plex – ZENH Peak Demand Profile Breakdown

1.1.10.7 *3.2.6.7 Conclusion*

The design team developed a prioritized list of design features and practices to guide a discussion with the builders on how to increase efficiency. The team assessed the design features by taking into account the energy impacts, cost, and construction impacts, and worked with the builder to select the most effective features for the project. The design meetings helped the builders achieve the 25 percent ZENH energy requirements in the MF Demonstration. Because the project was a gut rehab, influencing the layout of the project was not possible. It is SunPower's goal to develop strong relationships with our builder partners in order to be included in the planning stage of each community and to ultimately influence the community layout to maximize solar benefit for each home.

Villa Monterey Estimated Annual Energy Cost and Peak Demand Savings

Based on apartment and 4-plex units, and the recommended efficiency measures and a 1.23 kWp PV system, the homes are anticipated to save approximately 40 percent in total annual

energy costs compared to the Title 24 standard model. Average anticipated peak period demand reduction compared to Title 24 standard model for the peak, including PV contribution, is 0.75 kW depending on unit type. This is equivalent to offsetting a 1/2 to 1 ton AC system during system peak.

Table 43: Villa Monterey Energy Use Summary

	Title 24 Compliant	ZENH	Savings	% Savings
Apartment				
Electrical Energy Use (kWh)	4,594	2,324	2,270	49%
Annual Utility Costs ($)	$ 729	$ 431	$ 297	41%
Peak Demand (kW)	1.2	0.5	0.7	59%
4-Plex				
Electrical Energy Use (kWh)	5,036	2,653	2,383	47%
Annual Utility Costs ($)	$ 913	$ 560	$ 353	39%
Peak Demand (kW)	1.3	0.5	0.8	59%

Table 44: Villa Monterey Savings Summary

		Annual Savings		
	# Units	kWh	kW	Utility Cost ($)
Apartment	41	93,060	30.1	$12,185
4-Plex	4	9,533	3.0	$1,410
Total	45	102,593	33.1	$13,595

1.1.11. 3.2.7 Monitoring

The goal of "Customer Display Design Enhancement" is to develop an attractive, affordable in-home power monitoring display that provides the following benefits to homeowners:

- Communicate of energy cost and generation information to affect behavior, and
- Ensure consistent PV system operation by sending SunPower alerts when the PV system needs service.

This section presents the information that is provided to SunPower solar homeowners on the in-home system monitoring solution that SunPower currently offers. The monitoring system is currently a web-based portal that displays production and consumption information in a daily, monthly, and annual format. SunPower monitors the production information and has automatic prompts for service calls when systems fall outside the quality control range.

1.1.11.1 *3.2.7.1 Owner's Manual*

Performance Monitoring Overview and Setup

The Online Performance Monitor displays energy data online.

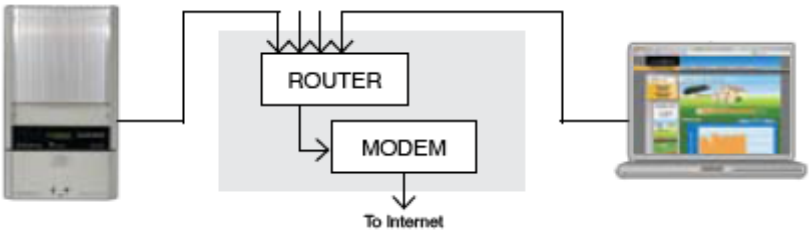
SunPower Performance Monitoring enables SunPower to monitor your home's electricity production and ensure optimal system performance. SunPower makes this production data available to homeowners online at SunPowermonitor.com. With monitoring, homeowners have the peace of mind that their solar electric system is producing electricity whenever the sun is shining.

Register Today – No Charge

Homeowners without structured wiring hubs should call SunPower customer service at 877.34.HOMES for assistance with monitoring setup.

Step 1: Connect the solar cable

To connect your system to the Internet, first locate the solar cable in your home's structured wiring hub, located in either your master bedroom closet or your home's garage.



Simply plug the solar cable into an open network port on your router or modem.

Step 2: Record the inverter number

Your inverter number is required for online registration. If you have not been provided this number by your builder representative, you can retrieve it directly from the inverter located in your garage. The number is located directly under the barcode on the top of the inverter (see page 10 for more information).

Step 3: Register online

Visit SunPowermonitor.com and follow the on-screen instructions. When you revisit the site, simply use your e-mail address and password to view system performance—24 hours a day!

Routers and Modems

To take advantage of structured wiring features—including SunPower Performance Monitoring—you should install your Internet modem (cable or DSL) and home networking router in your home's structured wiring hub. The router sends Internet signals to your solar electric system and throughout your home. If a technician installs your Internet service, be sure to tell them to take advantage of your home's structured wiring capability by placing your modem and router in the structured wiring hub. Some Internet Service Providers offer modem-router combinations with extra ports for connecting various devices to the Internet.

Locating the Inverter Number

Your system's unique identification number, which is required for online registration, is located on the inverter in your home's garage. Look for the label on the top of the inverter. The number, which starts with the letter "B," is located under the barcode circled in the diagram to the left. The identification number is a total of nine characters in length (e.g. B12345678).

A temporary outage in the SunPower Performance Monitoring Website does not indicate failure of the SunPower system and may be due to Internet downtime. To confirm system operation during network outages, check your inverter as described in this manual.

SunPower Performance Monitoring requires a high-speed, Internet-connected computer network. Electricity data will be incomplete if the inverter does not connect to the Internet regularly. If the SunPower solar cable, often located in your home's networking closet, is not connected within a month of system activation, initial electricity figures will be lost.

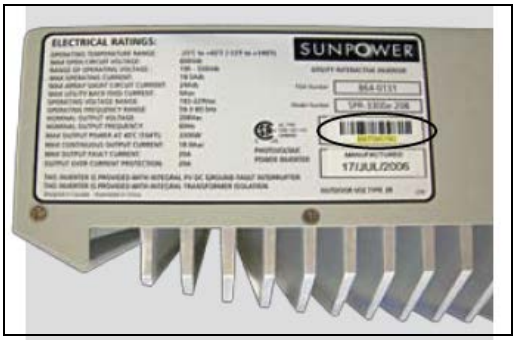


Figure 25: Top View of Inverter

3.3 Develop ZENH Business Models

Historically, new home developers have resisted installing photovoltaic (PV) solar systems because of high initial cost, aesthetics, and disruption to their production schedule. Because PV and energy efficiency have previously been considered in isolation, PV systems have been inaccurately sized, leading to excessive costs.

The goal of this task is to develop a turn-key systems integration model for large, commercial-scale grid-connected PV systems and energy efficiency installations to new residential construction, both single family and multi-family buildings.

By taking a systems approach, peak electric loads can be minimized, allowing a commensurate reduction in PV size. Optimized and integrated solutions can reduce house electric loads to the point where right-sized PV systems can now reduce net peak summer electric loads to near zero for ZENH at an economically viable cost (e.g. the savings is greater than the cost over time). Such solutions can also be designed as a standard feature and part of the builder/developer's routine construction process, minimizing transaction costs and scheduling disruptions.

Prior to this report, such integrations and business models had not been addressed by the market. Now, however, through the California Energy Commission's Public Interest Energy Research grant, SunPower has successfully established innovative new marketing, sales and finance resources to bring about an integrated, economical and scalable ZENH business model.

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1.1.12. 3.3.1 Turn-Key ZENH Offering

1.1.12.1 *3.3.1.1 Training Philosophy*

Without a successfully trained sales staff, adding benefits like solar and energy efficiency do little to differentiate one builder's product from another. The builder's commitment to add solar power to their project is simply the first step. The second, most important thing is for the builder to realize a positive return on his investment. This can come in several forms: greater sales, faster closing ratio, higher selling price, enhanced reputation, and/or higher customer satisfaction ratings. To help the builder achieve as many of these benefits as possible, SunPower works closely with builder employees to help them understand how to articulate the features and benefits to potential buyers.

1.1.12.2 *3.3.1.2 Audience Trained*

Since the inception of this program, over 900 individuals throughout California have attended SunPower training courses. This includes builders' executives, customer care managers, construction team members, and sales agents from over 85 new home communities and 25 builders. We also train real estate appraisers to help them understand how to value solar homes, and real estate agents not employed by builders. Our "Green Eggs & Solar" class for real estate agents is approved by the California Department of Real Estate for three continuing education units (CEUs).

1.1.12.3 *3.3.1.3 Training Format and Delivery*

In-person Training and Coaching

The majority of our training is delivered in person. This includes classroom training and one-on-one coaching sessions with sales agents to help them ramp up quickly.

SunPower University (Web-based education)

SunPower has also made a significant investment in a Learning Management System for delivering self-paced training classes. This powerful software platform is used by major organizations worldwide (e.g., Internal Revenue Service, Capital One, General Electric) to quickly and effectively scale training programs.

Training Plan and Schedules

When a builder makes a decision to add solar to a project, we establish a training schedule to coincide with solar being offered to homebuyers. The first step is for everyone in their organization who will be communicating with the customer to attend Solar & Energy Efficiency, Part 1. Two weeks later, we schedule a follow up training, Solar & Energy Efficiency, Part II, with their sales agents to help them strengthen their skills and learn to articulate the features and benefits to homeowners.

A week or two before the first home buyer moves in to their solar home, we schedule a Customer Care module with the sales agents, construction, and customer care team members. Individual coaching sessions are scheduled at various times throughout the sales cycle to help agents continuously develop their knowledge and solar skills.

Once several homeowners have moved into a solar community, we encourage agents to participate in our Community Building and Leadership class. This module is led by a former sales agent of an award-winning, energy efficient and solar community and is designed to teach agents how to use their role in the community to foster social relationships, build a sense of community, and grow their referral business.

Secret Shopping

We have utilized "Secret Shopping" to gauge the effectiveness of our training program and to look for areas of improvement. This feedback also helps us identify the agents who need additional coaching to help them improve their performance.

Trainee Feedback

When SunPower was developing the program, trainees were regularly polled to get their feedback on how to improve the training. SunPower consistently scored in the high 90's (using a 100-point scale), based on the following criteria:

- Value to me as a sales agent
- Standard of Sales Manual
- Practical Examples/Role Plays
- Trainer (knowledge, enthusiasm, delivery)
- Training Room
- Standard of Training Equipment
- Overall Quality of Training

We had almost unanimous "Yeses" to the questions:

- Would you like to attend additional solar and energy efficiency training sessions offered by SunPower?
- Would you recommend this training module to others?

Trainee Comments

➢ ***Woodside Homes – Folsom Division Office: Solar Basics, Part I – Nov 30, 2007***

"Truly valuable information for progressive technology."

"I'm excited about the additions of the solar along with all the other changes and energy efficiency along with it."

➢ ***Woodside Homes – Fresno Division Office: Solar Basics, Part I – Nov 26, 2007***

"Very well put together. Good amount of information."

- ***Woodside Homes – Modesto Division Office: Solar Basics, Part I – Nov 28, 2007***

"All topics were beneficial and helpful. Sales Agents need to understand all aspects to better sell. They must reach a comfort level to be able to talk about this without thinking."

- ***Woodside Fresno: Solar & Energy Efficiency, Part II – Jun 23, 2008***

"Very helpful. More training reinforces knowledge and stronger presentation to potential buyers."

- ***Standard Pacific – Sacramento: Customer Care – Jan 23, 2008***

"I feel really confident with the information and training that you have provided us. Thank you!"

- ***Lennar Bay Area Division: Solar Basics – Oct 8, 2007***

"Very helpful and informative. I'd like to discuss similar training for our customer care reps."

- ***Lennar Bay Area Division Office: Energy Efficiency Basics – Mar 5, 2008***

"I enjoyed the implementation of the cost savings features together with window U rated and R rated for attics and radiant barrier and how that helps homeowner to save money and help reduce C02 gases."

- ***Lennar Fresno Division: Solar Basics – Jul 3, 2007***

"Show the Sacramento 'Marketing' video at the start of the training to develop excitement; thanks for answering our sometimes off the wall questions—great, useful info. I am better prepared to market this feature."

- ***Lennar Fresno Division: Solar Basics, Part I – Aug 6, 2007***

"It was a very thorough & extremely interesting presentation. I'm impressed & look forward to having it in our homes."

"Simple and efficient presentation and straight to the point."

- ***Lennar Fresno – Division Office: Smarter Solar – Nov 16, 2007***

"This was the best presentation so far—Very useful tools that will assist our New Home Consultants to explain SunPower's advantage - Thanks a million Chris!!"

"Very informative. Over and above good information! Thank you."

- ***Lennar – S.C.: Solar & Energy Efficiency, Part II – Jun 18, 2008***

"Easy to understand info. I feel like I have the basic tools to be able to sell solar better."

- ***Centex – Bay Area: Solar Basics – Feb 12, 2008***

"Very useful, surprised that the training was targeted to builders and not just being technical."

"SunPower is extremely helpful in providing information and the promptness of either getting us information and/or helping to train or answer questions."

Success Stories

In April 2008, the Ryness studied 13 new home communities that were powered with SunPower solar systems. They discovered that the solar homes were selling more than twice as fast, on average, as new homes without solar. We believe this is due, in part, to the effectiveness of the SunPower Builder Sales Training Program.

Training Modules

Energy 101

Topics covered:

- What is energy?
- Where does energy come from?
- Difference between renewable and nonrenewable sources of energy
- Environmental impacts of different sources of energy
- Electricity measurement and billing
- How power from solar systems is measured
- How solar helps to lower utility bills

Solar & Energy Efficiency, Part I

Topics covered:

- What is a solar and energy efficient home?
- Why is now an ideal time for solar?
- Who is SunPower?
- How solar works
- Financial benefits to homebuyers
- Environmental benefits
- Energy efficiency features and benefits

Solar & Energy Efficiency, Part II

This is a review of Solar & Energy Efficiency, Part I, combined with role play activities to help the agents' effectively convey to potential buyers the features and benefits of living in a solar and energy efficient home.

Customer Care

Topics covered:

- Preparing a home for move-in (system check)
- What SunPower is responsible for vs. what the builder is responsible for
- How utility building changes with a solar home
- Connecting system to free Online Performance Monitoring
- Filing for the Federal Tax Credit
- Understanding system warranty and service policy

Community Building & Leadership

- Designed to teach agents how to use their role in the community to foster social relationships, build a sense of community, and to grow their referral business.
- Led by a former sales agent of an award-winning, energy efficient and solar community.

Green Eggs & Solar

- This course is designed for California licensed real estate brokers
- Provides brokers with an introduction to solar and energy efficient homes and what the benefits are to homebuyers.
- Approved by the California DRE for three CEUs

Solar Valuation 101

- This course is intended for California real estate appraisers
- Provides appraisers with an overview of the solar electric industry and gives them an introductory set of tools to appraise solar in residential real estate properties.

1.1.13. 3.3.2 Alternative Financing

Driving towards the program objective of reducing the first-cost impact of purchasing a ZENH home, the goal of this work was to develop a financing model that would allow homebuyers to avoid the upfront cost related to the PV system installed on their new energy efficient home.

SunPower worked with key partners and advisors to map out an alternative system ownership and financing model and established goals and performance metrics for testing the concept with one of its ZENH demonstration partners.

This section highlights the alternative financing development work and the SunPower Access program as it is being implemented in one of the ZENH demonstration communities today.

Market Overview

SunPower has made substantial headway in promoting, delivering and expanding its approach to building solar-powered homes, capturing approximately 85 percent of the California homebuilder marketplace. However, builders recently have become less confident that they can obtain a higher purchase price for the home to cover the net cost of the solar system, for the following reasons:

- Despite the educational efforts being made by the California Energy Commission and the solar industry, many homebuyers are still not aware of the full value that a solar system can provide at this nascent stage of the industry's development. This can make it difficult for builders to command a price premium for solar homes.
- Homes are not priced based upon the cost of building the home. Given the variety in available amenities and features, it is difficult for buyers to fully account for the value of each feature when assessing the fairness of the asking price from the builder. Therefore, homes are typically priced based upon the prices of surrounding new (and existing) solar and non-solar homes.
- In highly competitive market conditions like those faced by the industry today, builders have a general problem selling homes for higher prices than those available for nearby homes,

irrespective of the features contained therein. As an extreme example, in some markets appraisers are using older homes in foreclosure as market price comparables when assessing the value of a new solar home.

- Some appraisers are not experienced in valuing solar systems and are not able to fairly assess the full value of the solar system. As a result, even if a builder has convinced the homebuyer to pay a higher price for a solar home, the lender may not agree to provide a mortgage based upon that sales price.
- In markets where home prices are relatively low and energy consumption is relatively high, builders are also challenged to increase the price of a home to cover the cost of a correctly-sized solar system given the percentage of the overall price represented by the system. This will remain an issue in these markets irrespective of the health of the housing market.

As a result, over the past two years, builders have become increasingly reluctant to add solar as a standard feature on new homes. In the face of the difficulties mentioned above, builders are still highly interested in selling homes that include solar systems, for the following reasons:

- Existing solar homeowners are highly satisfied with new solar homes
- Solar homes were selling at twice the pace of non-solar homes
- Benefits from municipalities stemming from the construction of solar communities

It was these two market phenomena taken together that provided SunPower with the commercial motivation, beyond this contract with the CEC, to develop and offer third party leased systems to new home builders and homebuyers.

1.1.13.1 *3.3.2.1 Approach*

SunPower, in partnership with one of their leading national homebuilder customers, began discussing a solar lease offering, an alternative financing mechanism to the Power Purchase Agreement (typically employed for larger, commercial solar systems). The proposition was based on the idea that builders can implement a lease program at fraction of the cost of purchasing entire systems. The single greatest barrier to widespread solar adoption on new homes could now be significantly diminished.

The initial scope of the discussion was limited to California but, once tested in a pilot program, could also be rolled out on a national scale.

Program rules, procedural guidelines, compensation models, legal recourse, exceptions and scope of work were hashed out ex-novo.

A multitude of legal matters were raised and resolved and required the advice from subject matter experts in a variety of disciplines, including real estate, construction, energy, consumer, tax and solar law. From inception, it took many months of discussion, collaboration, reviews and revisions in order to achieve a comprehensive agreement between both SunPower and the builder.

In the course of establishing the agreement between SunPower and the builder, a number of ancillary documents and adjunct agreements were also drawn up. These included, but were not limited to:

- Construction Agreement (Master)
    - Work Agreement per Community
- Lease and related documents
    - Easement
    - Notice of Independent Power Producer Contract
    - Plain Language Disclosure
    - Warranty
    - Performance Guarantee
    - Escrow Instructions
- Builder-specific Documents
    - Department of Real Estate filings
    - Addendum to Home Purchase Contract
    - Modifications to Community Covenants, Conditions and Restrictions

For the homebuyer, escrow company, jurisdictional authorities and other stakeholders, the result was a comprehensive package of standardized lease documents. See Figure 26.

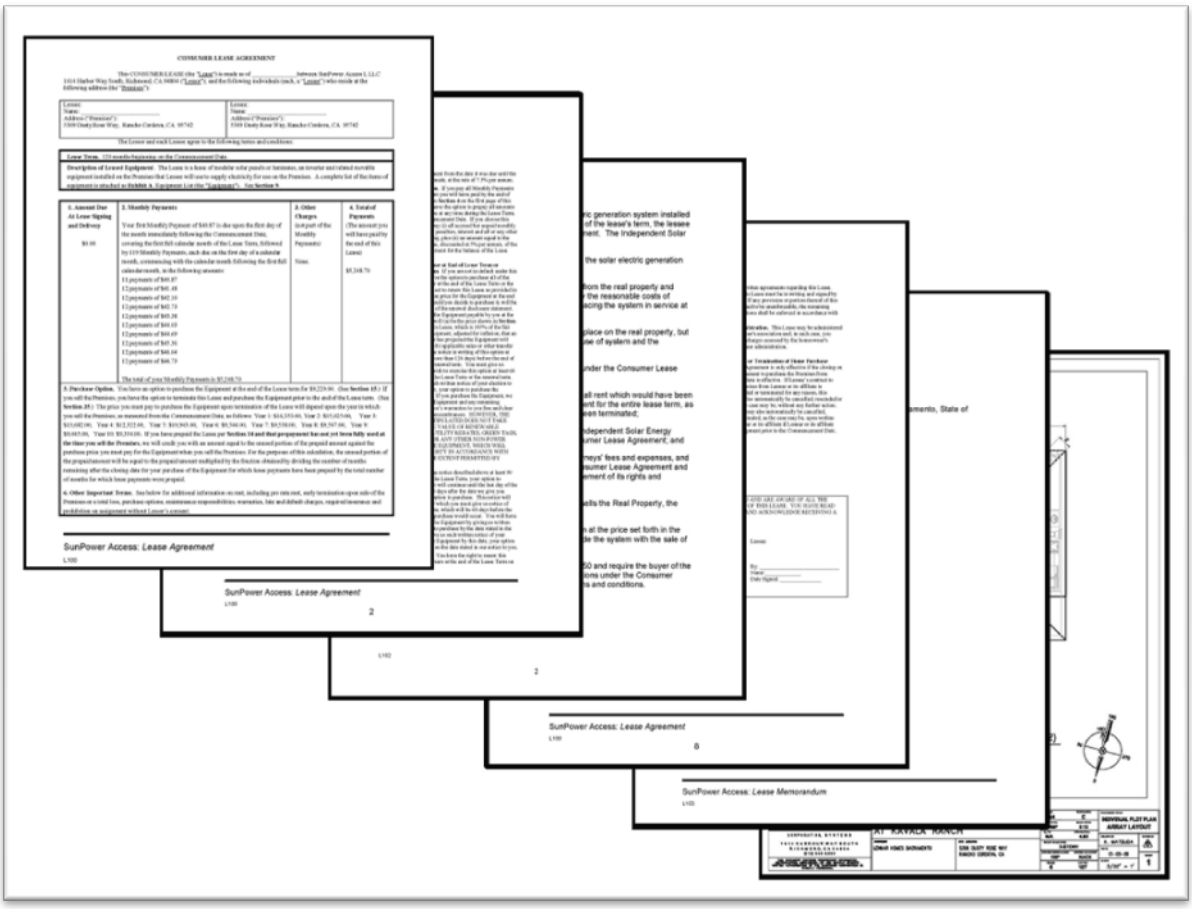

Figure 26: Homebuyer Lease Agreement Documents

With the foundation of a program in place, SunPower and the homebuilder set out to run a limited pilot before expanding the program to a larger number of communities throughout California. A host of additional activities followed, including the establishment with SunPower of lease administration services, sales agent training, marketing collateral development, system design and local community-sponsored education events for prospective homebuyers. -

As of the writing of this report, nearly 57 pilot-community homes had been purchased, with 50 of those homebuyers electing to lease the system rather than purchase it.. An additional 20 homes with leased systems are expected to close by the end of 2009 with more in the pipeline for 2010.

Initial customer feedback has been very positive and the builder is actively promoting the program to new prospective homebuyers.

Program Benefits

With the advent of this new lease program, SunPower has squarely addressed one of the most substantial obstacles to mass-market adoption of solar: system cost. The builder bears a small portion of the cost for certain system components that cannot be easily removed (e.g. wiring in the walls) and the homebuyer is able to offset a significant portion of their utility bills with the typically lower monthly cost of their lease agreement.

Key benefits also include:

- Addresses the homebuilder's requirement to control homebuilding costs
- Provides choice for homebuyers with limited borrowing capacity
- Improves affordability of large systems installed on homes with relatively large electrical loads
- Lease price per kWh offered at an effective discount from prevailing utility rates
- Rates locked for period of lease, providing the homeowner with a hedge against rising residential electricity rates
- System performance guarantee, locking in the value of the leased system
- Service and support offering for the term of the lease

1.1.13.2 *3.3.2.2 Conclusions and Recommendations*

This ZENH alternative financing leasing option has expanded the market for solar system installations with today's cost-conscious commercial homebuilders. Homebuyers similarly are not burdened with the substantial first-cost burden of a solar system purchase. Energy bill savings start on day one and ample provisions are made to ensure the integrity of the lease program benefits.

Despite success in coordinating with the building community and initial investors, there remain a number of challenges that must be overcome before the homebuilding and solar communities can expect broad acceptance of solar leases from the institutional investment community.

SunPower and partners such as the Davis Energy Group have worked intermittently with leading mortgage lenders to develop 'solar-friendly' mortgage products, but past efforts could be greatly enhanced with a concentrated effort by the parties to permanently solve the problem.

Agreeing to a standard method of valuing solar, like those promulgated by entities such as RESNET, communicating that methodology and obtaining recognition of the lending community of the rights of institutional investors in pools of solar systems should positively impact the uptake of solar on new homes.

Further, educating the industry of the value and benefits of solar system ownership should positively impact the homebuyer's ability to qualify for a mortgage in the event the homebuyer elects to finance the system using the mortgage.

When the homebuyer is offered a lease from a third party, the savings from the solar system should properly offset the lease payment in any debt-to-income calculation that is part of the mortgage underwriting process. Further, the mortgage industry should properly recognize the presence of the solar system and protect the rights of the owner of that system during any transfer of the home.

With these measures in place:

- The builder can confidently add solar as a feature without worrying about losing the percentage of its sales margin represented by the cost of the solar system because it will either be able to increase its price or have another investor cover the capital cost of the solar system.
- In the case of a lease, homebuyers will not need to be asked to pay a higher price for a solar home over a comparable non-solar home. They only need to be asked if they are willing to make a monthly lease payment instead of a higher monthly utility bill. Further, appraisers will not need to include the value generated by the solar system in their appraisal of the home as part of the underwriting process.
- If the system is purchased, the appraiser will have a framework for valuing the inclusion of the solar system.

1.1.14. 3.3.3 Streamlined Permitting, Interconnection and Incentive Processes

SunPower has worked with key stakeholders to attempt to streamline the areas of ZENH building permitting, interconnection and incentive processing. These are complicated and challenging tasks but SunPower believes that there are fundamental benefits for all parties in developing simplified and universal processes.

1.1.14.1 *3.3.3.1 Permitting and Inspection*

Approach

In order to streamline the permitting and inspection process, SunPower met with numerous building departments and builders for input. The focus of these meetings was to develop a simplified process for obtaining solar permits for tract home developments. Below is the list of stakeholders with whom we met at various times:

Building Departments

- City of Modesto
- City of San Diego
- Orange County
- City of Bakersfield
- City of Live Oak
- City of Rocklin
- Contra Costa County
- City of San Ramon
- City of Woodland
- Yuba County

Builders

- William Lyon Homes
- Lennar Homes
- Shea Homes
- Standard Pacific Homes
- Davidson Communities
- Castle and Cooke
- Premier Homes
- Grupe Homes
- Woodside Homes
- Centex Homes
- Christopherson Homes

A generic 'permit package' format, outlined below, was developed as a result of SunPower's discussions with the various building departments consulted and covers most if not all requirements for each jurisdiction. The documents in the package detail all system components and how they are mechanically and electrically installed. In addition they demonstrate structural compliance, including local wind loading and attachment requirements, with calculations shown as necessary. National Electrical Code and International Building Code or other applicable codes, are referenced citing specific sections to facilitate cross-referencing for reviewers and inspectors. The permit pack is generally required to be signed by either a professional engineer of record or by an electrical or structural engineer as determined by the jurisdiction.

The permit package should also be made available to builders for reference during pre-construction and once building commences.

Guidelines

Permit Package Preparation

a) Request and receive roof plans and site map (AutoCAD) from builder
b) Plot potential solar arrays on all roof plans and elevations
c) Review and receive approval from builder for roof layouts

d) Complete the 'permit package' comprising three sets of 24" x 36" wet-stamped drawings with roof layout, structural, and electrical pages.

Permitting Process

a) In consultation with the builder determine best strategic approach to permitting for every community. Permitting will be by whole community, phase or individual lot depending on construction schedule and sequence.
b) Discuss with the building department whether it is more appropriate to obtain separate permits for each house or to submit the 'Permit Package' as an addendum to the master plan community and obtain permits as houses are released
c) Submittal will usually consist of (i) three sets of the stamped and signed 'Permit Package,' (ii) a complete list of addresses and lot numbers for each site identified for solar array installation; (iii) contractor license information; (iv) city business license information; (v) worker compensation information; and (vi) payment means (check or money order for appropriate fees for plan review and permit issuance to the building department that governs area in which the solar community is to be constructed).
d) Submit permit pack at the appropriate time to coincide with construction schedule for the community.
e) Pay appropriate fees at time of submittal. Fees may be deferred until plan check complete. The builder may have an account set up with the building department in which case they should pay permit fees direct.
f) Plan for a review period. This will typically be two or more weeks. Some building departments may have an expedited process to allow solar permits to be pulled over the counter but this is unusual.
g) Receive and respond to written comments on the 'Permit Package', if applicable. Revise drawings accordingly and re-submit the 'Permit Package,' including the wet-stamped revised drawings. Typically, resubmission can be over the counter but may be subject to full review depending on the building department. Once approved, obtain permit cards for the homes and set of stamped 'field' drawings

Note that the 'Permit Packages' will be distributed as follows. The building department will retain two sets of plans for (i) internal records and (ii) inspector reference. The third set, with the inspection cards should be taken to site and maintained by the superintendent responsible for construction.

Inspection Process

a) On completion of the system rough wiring, the superintendent should call the building department and request that the work be inspected. Typically, this inspection is completed at the same time of the MEPS (mechanical, electrical, plumbing, and structural) inspection which occurs prior to insulation and sheetrock.
b) If any corrections are required, the inspector will write them on the inspection card.
c) Once corrections are completed, the building department should be called to request a re-inspection.

d) Subject to satisfactory completion, the inspector will sign off on the rough wiring of the system.
e) The next inspection will occur after the system is 100 percent complete. The same process pertains to this portion of the inspection with respect to required corrective actions, documentation, and sign off, as described above.
f) On completion of final inspection and sign off by the building inspector, a copy of the approved permit inspection card will be sent to the utility to finalize the interconnection application documentation.
g) With the utility interconnection package complete and approved a system inspection will be scheduled and carried out.
h) Provided that the utility approves the system installation it will grant 'Authority to Operate' in writing and at that, point the system may be switched on.

Summary

No universal process for solar permitting currently exists in California and, as a result, requirements differ greatly between building departments. Such diverse and often stringent requirements have made it extremely challenging to develop a truly universal process or permit pack format. However through extensive dialogue with Building Departments and mutual education it has been possible to reach agreement on a generally acceptable format which allows flexibility to account for minor variations based on specific local requirements. This proactive approach taken by SunPower has been well received by building departments that in most cases are facing the challenge of high-volume plan checks and photovoltaic systems permitting for entire communities.

1.1.14.2 *3.3.3.2 Interconnection*

This section explores the opportunities that a more streamlined interconnection process represents for all stakeholders in the context of a future of anticipated significant volume increases of residential solar electric system installations. Through this work, SunPower has determined that enabling an online, bulk solar electric system interconnection application process to replace current paper-based process has many benefits for utility companies, photovoltaic system integrators, builders, and consumers.

Overview

There is a need to respond to the increasing number of residential solar electric systems being completed in California, particularly in new home communities. All will at some point require subsequent interconnection to existing local utility electric grids which is currently a lengthy complex and paper base process. This write-up is submitted in advocacy of and as a means to suggest, ways in which to streamline the paper based interconnection application process with the goal of making it less complex, more expedient, with fewer delays and reduced potential for error.

The documentation required to complete the interconnection application process was originally conceived for 'one-off', retrofit, and other single-home installation scenarios. For this purpose and to this point it has been effective. In the context of low volume, irregular applications the documentary component of the process did not have the compounding, time-intensive impact it

has today as photovoltaic systems are increasingly installed in the high volume new home construction market. Utilities, photovoltaic integrators, and builders now need to have the ability to apply for often 10's or even 100's of systems at a time.

The time that is required to fill out, process, and manage each of the mandatory paper forms is substantial for the utility company as well as the photovoltaic integrator—and potentially for the consumer. Clearly, when applying for multiple new-home interconnections for an entire development (or even for a partial development or subdivision), preparation of the substantial amount of documentation required is a daunting task.

As the incentive and rebate programs offered by utility companies continue to expand, and as more and more California communities are planned and constructed incorporating residential photovoltaic systems, the volume of applications to be processed will increase. As such, it will better serve all stakeholders—utilities, photovoltaic integrators, builders, and consumers, —if interconnection applications can be streamlined through adoption of automated process as soon as possible.

Existing Process

As mentioned the current interconnection application process was originally designed for single instance and retrofit photovoltaic installations. The documents required at various points in the application process to successfully interconnect a photovoltaic system are shown below and are required for *each* and *every* photovoltaic system installed.

- Interconnection Application
  - Lists and describes all required documentation.
  - Notes that PG&E does not even begin to process the application package until all of the main documents have been received by PG&E.
  - Enables the customer to enter information about the responsible parties, the generation facilities and equipment and details about the associated account.
- Interconnection Agreement
  - An exhaustive legal document that binds the customer and the utility to specific rate, design, and service requirements.
- Single-Line Electrical Diagram
  - Provides details on the solar electric system wiring, from the modules to the utility meter.
- Insurance Policy Declarations page
  - Provides proof that the building on which the solar electric system is installed is insured.
- Authorization to Operate (form USP 23)

- This document has the provision for the author to attach a list of properties, such that the solar installation company can then act on behalf of the builder or property owner as agent with respect to homes within the development that will incorporate individual solar systems.

The time required to collate and complete such a quantity of forms is significant, as is time required for the utility to process them. Considerable savings could be realized by streamlining and automating the application process.

Where a photovoltaic integrator is working with a builder to interconnect every system installed in a community the completion of such a list of documents for every home becomes extremely burdensome, especially when the degree of effort and logistics involved in first obtaining and then verifying all relevant builder and homeowner details, permits, and signatures is factored in.

From the utilities perspective every individual interconnection submitted by the photovoltaic integrator must be received, processed, checked and auctioned at various points a task which becomes with volume, ever more labor intensive, time-consuming and costly.

A streamlined and to some extent automated process would be highly beneficial to the utility, the photovoltaic integrator and their mutual customers the builders and homeowners.

Consumer Benefits

To the extent that the interconnection application process is administratively burdensome for all parties involved, simplifying and expediting the process could affect a net increase in the number of residential solar electric system customers.

Consumers play an active and fundamental role in shaping the demand for photovoltaic system-equipped residences. Through their shared experiences, if positive, they can ultimately help to drive demand in the solar market—and potentially affect the reputation of the utility. Therefore it is critical that all aspects of the builder's and consumers' experience in relation to application for interconnection for, approval and activation of their photovoltaic system be seamless and altogether positive.

Documentation is a common source of delay, headache, and frustration throughout many phases of new home construction and sales. In the context of the new home sales closing process, the utility industry would certainly benefit from implementing a standardized, streamlined photovoltaic system interconnection application-filing process. Such a process will reduce the overall amount of documentation that a new homeowner is required to complete and will increase the likelihood that the customers they share with the builder would have a positive experience.

A simplified and streamlined process with the reduced potential for error would in all likelihood lead to a reduction in the amount of time that the utility has to spend addressing and resolving questions from consumers, builders, photovoltaic system integrators, and home sellers about the interconnection process and about delays to that process. This would certainly increase customer satisfaction.

Arguably, a more tangible benefit for the consumer of a streamlined and expedited inter connection process, would be that of faster realization of their solar-enabled energy savings. This is a key factor in many homebuyers decision to purchase a solar home.

One of the selling points that help justify the added cost of residences that include solar systems is the immediacy with which the homeowner can realize the savings on their utility bill. If a home is sold in Redding, CA, in July, for example, where the daytime temperature can average 98° F[30] (see Figure 27 below) , it is important that the application and approval processes are optimized so the customer (homeowner) does not experience any issues whatsoever with the interconnection of their system (delay-related or otherwise). The new owner of a home that incorporates built-in solar will especially scrutinize their first utility bill to evaluate the impact of their cutting-edge (and potentially much-hyped) system. Any potential for delay in the activation and interconnection of these systems must therefore be identified and eliminated.

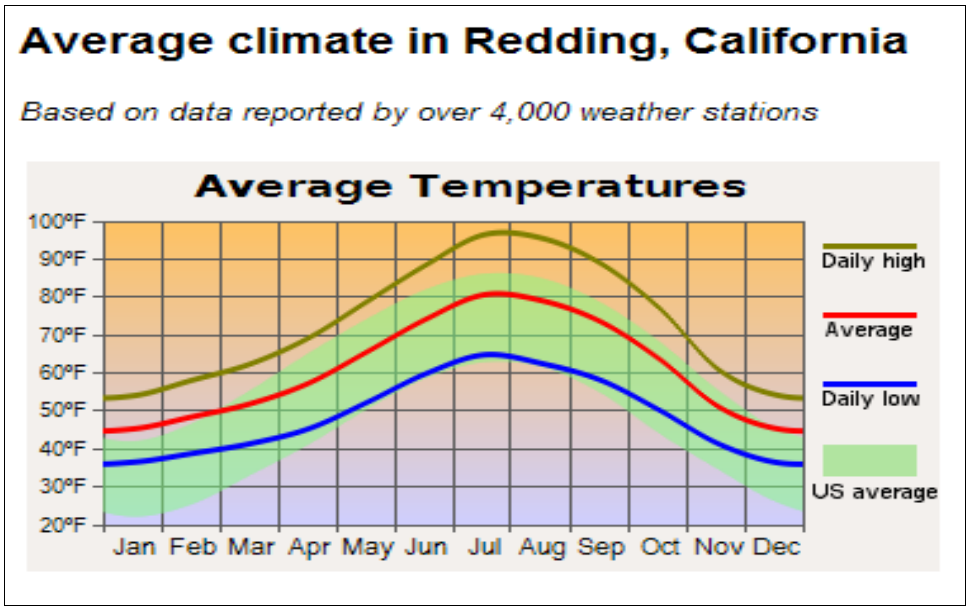

Figure 27: Redding, CA Temperatures

Significant increases in the number of residential solar electric systems with more 'on site' power generation means that the utility company may potentially be able to downsize local distribution infrastructure requirements and even ultimately, in the long term, to be relieved of the need to build additional conventionally fueled power plants. A reduction in the output of existing or the construction and operation of additional, proximate coal- or petroleum-burning power plants will result in better environmental quality for the residents of the solar-oriented and other communities alike.

An existing plant's output—of both energy and pollutants—decreases in direct proportion to the amount of residential solar energy being fed into the grid. All residents of the utility

[30] City Data (2005) Redding, California [Online]. Available at www.city-data.com/city/Redding-California.html

district's service territory unquestionably benefit from the reduction of the harmful emissions associated with non-renewable resources.

Utility Benefits

As the number of interconnected residential solar electric systems increases, utility companies realize several key benefits:

- ***Reduced need to purchase additional power from alternate sources at higher prices***

The base load of a given municipality is most often met by the combined use of hydroelectric and nuclear power generation facilities[31]. (See Figure 28 below.) However, as the demand increases during peak hours, the utility must typically dispatch additional plants ("peaker plants"), or otherwise source additional capacity, in order to keep up with the increasing load. The presence of additional generating facilities in the form of residential photovoltaic systems lowers the demand on the utility, thereby potentially offsetting that utility's need to purchase more expensive additional power.

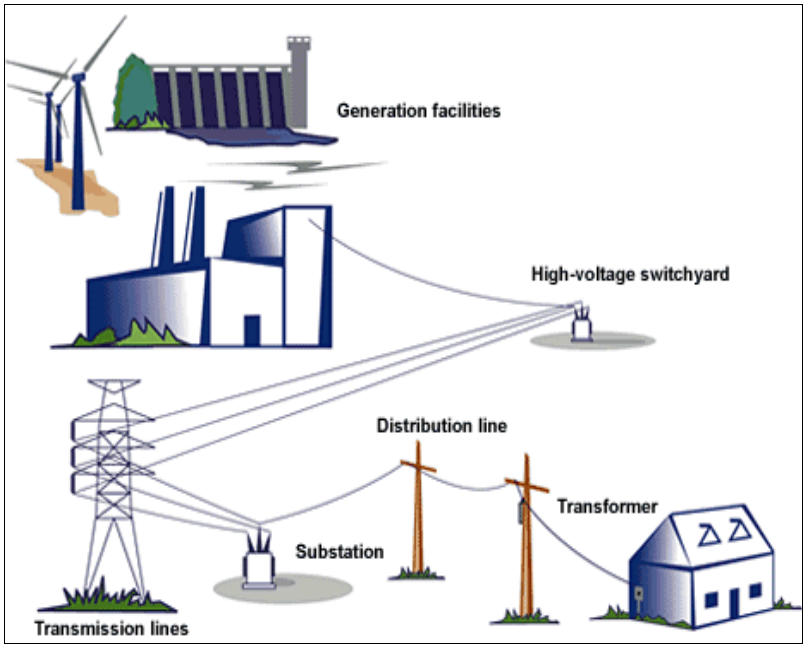

Figure 28: Electricity Generation & Distribution

- ***Reduced need to build additional power plants***

Often, additional power plants are constructed in order to meet only a small percentage of peak demand. Throughout a given year, the additional capacity provided by these newly constructed plants might only be required for a few hours a day, during a few of the hottest months of the year—precisely the hours during which residential photovoltaic systems could be contributing the most to the grid, offsetting the need for those additional plants.

[31] "Seeing A Path to the Future: Renewable Energy Research at PIER," Public Interest Energy Research, presentation, October 24, 2002

➢ ***Reduced strain on existing infrastructure***

The presence of additional generating facilities in the form of residential photovoltaic systems also lessens the strain placed upon the utility's infrastructure. Residential photovoltaic installations could significantly reduce the utility's need to upgrade its transmission and distribution infrastructure, and thereby affect a significant reduction of wear on the local grid. As a community grows while still leveraging the existing, original distribution and transmission infrastructure, an increase in demand raises the prospects of brownouts and blackouts. This is typically the consequence of a failure of some part of the transmission system due to overload, or of a deliberate shutdown undertaken to avoid damage to the system.

Because photovoltaic systems operate most efficiently in the middle of the day—when demand on the grid is at its peak—solar electricity directly and immediately reduces the strain on the utility during peak hours, thus extending the longevity of existing power plants and infrastructure, and further lowering the cost of real energy production.

Figure 29 displays the peak load horizon for a June day in California in the year 2000. It should also be noted that the average temperature in California has risen steadily, with 2005 being the hottest year on record[32].

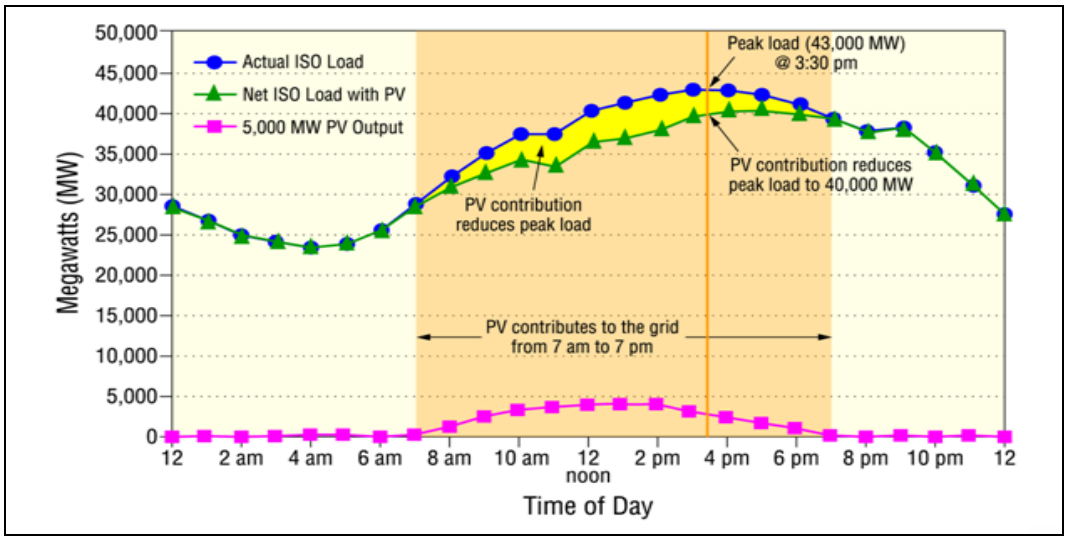

Figure 29: Load

➢ ***Ability to leverage customer-owned generation facilities***

Utility companies increasingly evaluate commissioning and incorporating their own solar electric generation facilities in order to contend with fluctuations in demand, yet this necessary capacity can be significantly offset by the proliferation of residential solar electric systems within that utility's service territory. The utility realizes a reduction in demand (and will thus benefit) whether or not it owns the system. The distribution system cannot distinguish between whether the power originated at a power plant or on customer's rooftop; it just experiences less

[32] Union of Concerned Scientists (2005) Global Warming [Online]. Available at www.ucsusa.org/global_warming/science/recordtemp2005.html

demand and therefore less strain on the components making up its infrastructure. In this way, the utility company can leverage an existing, logical trend while keeping its costs down, because customer-owned solar electric systems provide a higher net value to the utility than do utility-owned systems[33].

- ***Elimination of fuel cost variations***

Electricity produced by residential solar electric systems eliminates altogether the variations inherent in the costs a utility must incur for the fuels it must purchase to create its electricity. After the solar system is installed, the subsequent cost (for both the homeowner and the utility) to generate the electricity is zero—for the life of the system.

The Case for Application Process Streamlining

The dramatic increase in residential solar electric systems is both necessary and inevitable. As the number of planned residential system installations increases almost exponentially, the amount of time spent processing the necessary paperwork will increase correspondingly.

This dramatic expansion of solar electric system interconnection means that California currently claims 85 percent of all grid-connected systems in the United States[34], and it is very likely that subsequent growth in the state will continue to reflect the current trend[35]

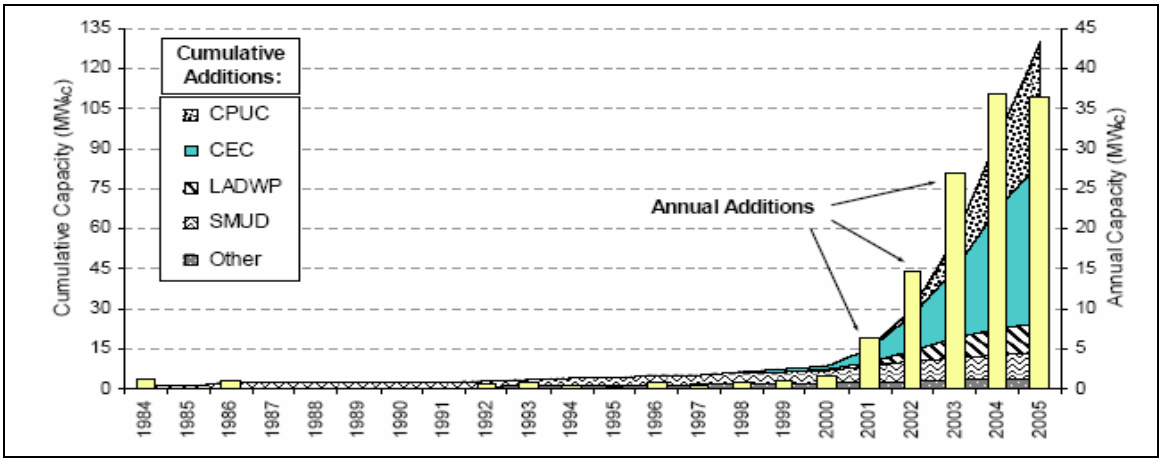

Figure 30: Capacity Growth

California added well over 36 MW of grid-connected photovoltaic systems in 2004. The state's cumulative figure for 2005 will exceed 130 MW (including systems installed under municipal utility programs)[36].

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[33] Sacramento Municipal Utility District (SMUD) (2006) Utility system capability & customer demand value [Online]. Available at http://www.smud.org/pier/projects/pv1_3.html

[34] SolarBuzz (2005) US Grid Connect PV Market 2005 [Online]. Available at www.solarbuzz.com

[35] Lawrence Berkeley National Laboratory (2006) Letting the Sun Shine on Solar Costs: An Empirical Investigation of Photovoltaic Cost Trends in California [Online]. Available at http://eetd.lbl.gov/EA/EMP

The yearly totals for PG&E alone are nearly 5 MW for 2003, 7.4 MW for 2003, and 11.9 MW for 2004. Perhaps the year 2007 will reflect 15 MW *for PG&E alone!* The scale at which solar system interconnections are going to be sought justifies dedicating resources to the revision and streamlining of the current interconnection application process.

One key consideration in committing to the development of a streamlined, automated or batch-oriented application procedure is that it will consistently reduce the points at which data input errors can be introduced and create additional delays. Entering and transmitting the information electronically reduces the opportunities for input error and thus the possibility that further time will elapse before the application is processed and finalized—and before the customer can begin reaping the rewards of their solar solution.

The less time each individual utility company employee must spend reviewing and approving the required forms, the higher the overall productivity of that employee, and the higher the profitability of his or her company. Thus, streamlining the interconnection application process would also eliminate the need for the utility to hire additional individuals specifically to contend with the coming influx of interconnection application paperwork.

Recommendations

In making these recommendations, we seek to serve all stakeholder interests with a revamped and more efficient photovoltaic system interconnection process.

Based on the assembly and review of these facts about the possible ramifications of residential solar electric generation facilities upon an existing utility company's infrastructure, the degree to which the associated interconnection application process facilitates or delays the activation of—and therefore the realization of benefits from—residential solar electric systems, and thus consumers' opinions of and demand *for* the residential systems, we recommend the following changes to the process:

- Streamline the interconnection application process by enabling photovoltaic system integration companies to transmit, in bulk, applications for new home subdivisions where photovoltaic systems are to be installed. This transmission should occur via email or over the Internet. Using a tab-delimited Microsoft Excel file, a solar electric installation company would be able to load data for an entire community and submit the file electronically (online), using the utility's web page, or could transmit the data in an email attachment, wherein an accompanying PDF file could contain any required digital signatures.
- Except for the physical system inspections, enable all transacting to occur over the Internet.
- Explore the prospect of removing altogether the need for "wet" signatures.

SunPower's ongoing efforts to streamline the application process include collaboration with PG&E in the development of a process utilizing a spreadsheet containing information and the specific fields from the Interconnection Application for Net Energy Metering. SunPower enters

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[36] California Energy Commission (CEC) (2005) [Online]. Available at www.energy.ca.gov/renewables/emerging_renewables/GRID-CONNECTED_PV.XLS

specific data on the spreadsheet for any number of homes in a given development and submits it to PG&E in a batch.

Because the receiving utility (PG&E) simply uploads the information in the spreadsheet instead of entering it manually from a multiple handwritten forms, this batch submission method saves considerable time and reduces the instances at which errors can be introduced.

The following fields (Table 45, below, from the existing Interconnection Application) have been incorporated into the current spreadsheet:

Table 45: Application Fields

Name Shown on PG& E Service Account	Account (Electric Account Number)
Address (Street Address)	City
State	Zip Code (Zip)
Mailing Address: Street Number	Street
City	State
Zip Code	Business Phone
Home Phone	Fax
Email	Contractor
Mailing Address	City
State	Zip Code
Business Phone	Fax
Email	Contractor to be used as PG & E contact
Disconnect Switch Manufacturer	Disconnect Switch Model Number
Inverter Quantity	Inverter Manufacturer
Inverter Model	Module Manufacturer
PV Panel Model	Quantity of Modules
Rate Schedule	New Generating Facility
Existing or New PG&E Account	Other Energy Provider
New Subdivision	Vehicle Recharging Facility
Expected Date of Final Signed-Off Building Permit	

In addition, when a buyer actually takes possession of a home, Form 79-994 must be filed as part of that transfer-of-ownership process. This form is another excellent candidate for conversion to online filing, because the smoother, easier, and less time-consuming we can make

the *entire* process, the less the chance that any resistance will accumulate to the general idea of the inclusion of solar electric systems in single-family homes.

Online Solar Interconnection Application Process

One potential overall solution would be to create a ***Solar Interconnection Application Process*** button or link on, for example, the PG&E website for new home construction.

PG&E website navigation (http://www.pge.com/mybusiness/customerservice/brochuresforms/):

- ***Your Home, Brochures & Forms, Business Customers***

Under the New Construction heading, perhaps add a link called Interconnection Application for Residential Solar Systems (or Interconnection Application for Net Energy Metering).

The destination form or web page would include all of the fields currently in the existing mass interconnection application spreadsheet, and would also incorporate the following fields and information from the Interconnection Agreement, into the existing spreadsheet (alternatively, create an additional spreadsheet for this information):

- Current Account Number
- Customer Name
- Project Identification Number
- Type of Generator (Solar/Wind/Hybrid)
- Generator Rating
- Manufacturer for Inverter Used with Generator
- Inverter Model Number
- Inverter Rating (watts)[37]

- ***Site Address***
  - Street
  - City
  - Facility ready for operation on or about (date)
  - Rate Schedule selected

- ***Customer-Generator Name***
  - Street or PO Box
  - City
  - State
  - Zip Code

- ***Signatures***
  - Customer-Generator Name
  - By (Signature)

[37] Tech Alive (2005) Electricity [Online]. Available at www.techalive.mtu.edu/meec/module13/Electricity.htm

- Date
- Type/Print Name
- Title
- Signature (PG&E)
- Date
- Type/Print Name
- Title

This destination page would also include a pair of buttons, such that the user would not be able to advance unless he or she clicked the first one:

- I Have Read and Accept the Terms and Conditions
- I Do Not Accept the Terms and Conditions

PG&E could extract, create, and transfer all the language necessary from the existing forms.

Another option (albeit a more costly but nonetheless extremely logical, efficient, and viable near-term collaborative goal) is to convert the application, agreement, insurance, and authorization documents into actual application pages by which parties can enter, verify, and extract information via the Internet. There are many such applications available to the commercial market. All of the required information could be captured in fields designed by the utility and accessed by the solar installation company, the builder, or the customer for data entry and completion.

Software vendors could easily customize their applications to meet the needs of organizations seeking the ability to transact online. The following are examples of the kinds of pages such a database can support.

Conclusion

Undertaking a focused effort now to streamline and automate the interconnection application process for residential solar electric system installations will enable all stakeholders to realize significant benefits—and will not inhibit the growth of a vital industry.

Streamlining the interconnection process is a logical and necessary step in the process of growing the number of grid-connected solar electric systems in California, and ultimately throughout the country. The volume of documentation and the time taken for its completion as required currently constitute one of several barriers to the increased uptake of solar electric systems by new home builders and consumers.

Utilities such as PG&E that demonstrate a willingness to work with others such as builders and photovoltaic integrators are well positioned to reap the benefits of an expedited process—not the least of which will be enhanced profitability and improved customer satisfaction.

1.1.14.3 *3.3.3.3 Incentive Processing*

Though the Emerging Renewables Program (ERP) considers a variety of new construction types, this paper focuses on the incentive applications and payment for single and multi-family new residential construction, mostly of the large-scale, production home variety. Lessons

learned here can be applied in part or whole to other aspects of the Emerging Renewables Program.

Overview

The California Energy Commission's (CEC) Emerging Renewables Program (ERP presents a unique opportunity – state-sponsored production rebates -- for builders and new home buyers interested in integrated solar. The program also presents a burden not usually seen in the home building market – a complex certification and payment procedure that requires the coordination of state and local government, a utility, and various business actors.

The ERP's origins in the home retrofit market make it particularly burdensome for new and promising solar markets, most notably production homes. To make installing new solar as effortless as possible for homebuilders and buyers, solar integration companies (e.g. SunPower) often handle a community's rebate process and factor rebate savings into the price of their photovoltaic systems. Though the current process is becoming more efficient, rebate applicants such as SunPower must still complete a discrete set of rebate claim applications for each home in a community. Streamlining these procedures will help to maximize the ERP's value to solar installers, consumers, builders, and the State of California itself. Less administrative overhead – through digitization, information triangulation, and consolidation – will increase the program's true economic value, which will likely lead to increased interest, increased volume, and reduced system costs.

Existing Process

The current ERP incentive application process was mainly designed for the home retrofit market. It divides into two parts, the pre-installation rebate reservation procedure and the post-installation payment claim procedure.

For production home installation, the rebate reservation process requires:

1. Reservation Request Form (CEC-1038 R1)

2. Copy of agreement to purchase and install system

Installation contract if 3rd party installed:

3. Payee data record (Form STD-204) for rebate recipient

4. Evidence that load is supplied by electrical utility (building permit)

Rebate applicants can mail or fax these documents to the CEC Sacramento offices.

The payment claim process requires:

- Payment Claim Form (CEC-1038 R2)
- Documentation Confirming Final Payment and System Installation
- Final Invoices or Copy of Final Agreement
- Actual paid by purchaser (must match cost information provide in R2, explanation if differs from R1.

- Clear indication of the extent to which rebate lowered the cost of the system
- Final Building Permit and Final Inspection Sign Off
- 5 Year Warranty (CEC-1038 R3)
- Evidence that Site Electricity Load Supplied by Eligible Utility
- Utility statement or written confirmation of meter installation and that service commenced prior to reservation expiration
- Letter from C-10 license that load is appropriate for system size
- Letter from Utility authorizing to interconnect the system
- Payee Data Record (STD-204) (if different from originally filed form with R1)

Because the signatures on the R2 and R5 forms must be with "wet," rebate applicants must mail, not fax, the payment claim documents to the CEC's Sacramento offices.

While the Rebate Reservation process can require as few as four forms for an entire new home development, the Payment Claim process currently requires roughly eight documents for each home in a development. The concurrent interconnection procedure, which has not yet been streamlined for production homes, quickly adds to this total.

Rationale for Change

Though relatively well-suited for the individual homeowner, the current rebate process is not designed to scale to production home solar installation of the type featured in the ZENH report. While the first half of the application process, the Rebate Reservation, has been streamlined considerably (see next section), the current Payment Claim procedure, the second half, overburdens builders, subcontractors, and the CEC alike.

For new home developments, much of payment claim process is unnecessarily repetitive. When a solar purchaser makes payment claims for a 300-home development, for example, the paperwork overhead is considerable. Under the current system, large home developments require thousands of documents, each of which must be printed and mailed to the CEC. Contractors, inspectors, and utilities generate these documents on varying schedules. For the rebate applicant, compiling these often far-flung papers, even for one home, is logistically demanding. With this administrative overhead, production solar homes become less economically appealing. The rebate's real value decreases.

As the following sections will show, a more streamlined process could achieve the same goals of protecting and appropriately distributing rebate money while reducing administrative costs to all parties. Some data, for example, could be triangulated through other means and organizations. Much of the rebate claim process could be handled *en masse* rather than piecemeal, with some documents representing an entire development rather than an individual home. Given the number of new homes involved, even small changes could cascade into large time and cost savings.

Reduced administrative overhead will reduce rebate payment times, increase investor certainty about rebate reimbursement dates, and improve rebate applicants' cash flow. Rebate applicants will be more likely to invest in new solar if they are more certain of the date on which their rebate money will be returned. Having that money at their disposal will then allow for more

rapid reinvestment. Of course, improved cash flow could lead to greater volume, reduced costs, and accelerated adoption of PV.

Imagining a future in which thousands of production homes reserve and claim rebates in a given year, the CEC should move quickly to streamline its processes. Addressing these issues today will help all parties avoid potentially debilitating delays in the near future.

Temporary Solutions

To help streamline the current rebate process prior to further regulatory relief, SunPower has sought two changes to the standard rebate reservation system.

First, SunPower has successfully sought to use "Final Maps" to certify that the developer has finalized the number of homes in a community and that the local municipality has approved them. This document stands in place of the "master permit," which is referenced in the ERP Guidebook. Because "master permits" do not exist in most communities, a rebate applicant would need to provide proof of a building permit for each qualifying home. For developments of more than a few homes, this quickly becomes burdensome. Production homebuilders seek building permits as their construction schedules dictate. Relying on those permits could lead to numerous and sporadic rebate reservation mailings. A Final Map centralizes the data points earlier and more efficiently without compromising that information's value to the CEC.

Secondly, SunPower has adopted "Summary Agreements" in place of Builder Agreements in the rebate reservation process. The latter agreements are typically multi-page, highly customized documents that cover a wide variety of topics, some of which are not relevant to the rebate reservation process. The Summary Agreement takes the relevant data from the Builder Agreement, adds additional information, and incorporates everything into a standard, compact form. As with many potential solutions to other inefficiencies, this saves both SunPower and the CEC time and money as they are processing shorter, more readable documents.

It is our recommendation that the CEC adopt and publicize these solutions for every PV contractor and production home developer. SunPower's work here could benefit those actors as they design their internal rebate and payment claim procedures.

Recommendations

In making these recommendations, we seek to serve all stakeholder interests with a revamped and more efficient rebate reservation and claim system.

As we see it, the CEC is interested in ensuring that rebates are not misallocated to non-existent projects, that the amount paid to the system purchaser fits the system profile, and that final home owners' own safety, economic, and quality interests are protected at every stage of the PV process. Utilities are interested in integrated systems that will not disrupt their existing grids.

Protecting and serving these interests is possible while simultaneously streamlining the rebate application process. The CEC can adopt some of these measures immediately. Other components depend on information technology investments by the CEC and its partner organizations.

In the short term, the CEC should consider:

Adopting R2 & R3 Summary Forms

Rather than requiring individual forms for each house in a development, the CEC should allow for R2 and R3 forms that cover an entire development or phase thereof. The R2 Rebate Payment Claim Form mirrors the R1 form, which rebate applicants can already submit for multiple homes. The CEC might need to adjust the R2 for rebate applicants to use it in such a way, or it might create a new, similar form that specifically targets the production home market. Either way, the benefits of reduced paperwork likely outweigh the potential costs to develop these new forms.

The R3 Minimum Warranty Form is largely similar for each home in a production community. Given the need to create economies of scale through volume and uniformity, solar installers are unlikely to apply different warranties to individual homes in a new development. The CEC should therefore make the R3 form universal to a development. The burden for non-standard agreements, in which different warranties cover different homes in a community, should be on the non-standard rebate applicant, who would then submit multiple R3 forms for each warranty type.

Reducing Paperwork for Utility Service Documentation

The CEC should allow interconnection validation to serve as evidence of utility service. The utility will not allow interconnection without service. The CEC can infer utility service connections from interconnection data.

Restructuring Utility C-10 Documentation

The C-10 certification requires that "if an electric utility bill is not provided, the applicant must provide a separate letter from a qualified architect, engineer, or electrical contractor (C-10 licensed) that identifies the expected electrical consumption at the site and verifies the consumption will satisfy the program requirements for system size." Those program requirements require that solar production homes produce energy that "not be more than twice the historical or expected electrical needs of the electricity consumer at the site of installation." According to the CEC, "the average annual residential electricity consumption in California is about 7,000 kWh/ year." The maximum allowed system size for the average home is therefore "13 kW."

Most production home solar equipment produces 1-3 kW. It is the rare case that a home exceeds this class of panel, and even rarer in the production market, where 4 kW+ systems is prohibitively expensive to use across an entire development. A new home would need to consume just 1500-2000 kWh/year of energy to be in danger of violating the production requirements with a 3kW system. Consumption numbers are even lower for the more typical 1.6 kW and 2.3 kW solar systems.

The CEC should therefore eliminate the C-10 documentation requirement for all but the largest solar systems. Any system over 4 kW, for example, could require inspection.

Centralizing Interconnection Documentation

Instead of verifying interconnection with a letter from the utility, the CEC could verify it directly with the utility in question, ideally in a computer-mediated transaction.

In light of the preexisting communication between the CEC and the utilities, added authentication with an interconnection letter seems excessive. According to the ERP Guidebook, the CEC already confirms this data with the utility. Page 19 reads: "by applying for program funding, purchasers authorize the Energy Commission during the term of the ERP to exchange purchaser information with the purchaser's utility in order to verify compliance with program requirements, including requirements for system interconnection to the utility grid." The CEC will even allow for rebate reimbursement prior to proof of interconnection if the applicant provides written authorization allowing the Commission to communicate with his utility. Since the applicants are authorizing the CEC to communicate with their utilities simply by applying for funding, this written authorization is repetitive and could also be eliminated. Even if it is not, production home rebate applicants could complete blanket "Authorization to Receive Customer Information or Act on a Customer's Behalf" for entire communities.

Creating Full Map Audit

While still more manageable than sets of building permits, the Final Map is a physically awkward document. Rebate applicants cannot easily fax or digitally transmit it.

The CEC could further streamline operations by requiring only a reference to the Final Map (i.e. the contact information for the municipal office where it is located) in the R1 form. Rebate applicants would be kept honest under threat of audit from the CEC. Since the CEC might periodically audit this information anyway, the streamlining could come at little additional cost to the Commission.

Removing Wet Signature Requirement

First, "wet" signatures or the R2 form seem to be particularly anachronistic in this digital era. Requiring them is a major roadblock to the automation and integration of the incentive application process.

Fully Digitizing Workflow

The CEC should provide conduits for systems integrators to submit rebate documentation online and en masse. Currently, the CEC uses automated PDF-generation technology to help with completing R1 forms. PDFs are not machine readable. Much like paper forms, the information within them is not always easily converted into standard database formats.

The CEC should instead consider creating digital conduits that will accept fully digital and malleable data, including Microsoft Excel documents. Ideally, rebate applicants would submit Excel files with inventories of their homes, all the relevant home data, and digital signature files.

Alternately, the CEC could adopt a more standards-based XML data transfer environment. Rebate applicants could export data, wrap it in a set of standard tags, and send it as plain text files to the CEC. A helper application could enable this process.

Whatever the chosen technology, it should interact well with the databases that rebate applicants will use to track their production homes. Automated import/export procedures should be favored over manual input; industry standards over proprietary systems; and web-based applications over desktop.

Integrating the Interconnection Process

Over time, interactions with utilities could be computer mediated as well. This would lead to eliminate utility paperwork from rebate applicants.

On a related not, the CEC should do whatever it can to facilitate universal forms among utility companies. More radically, interconnection information could be handled through the CEC. The CEC would ask for those few extra data points required by the utilities and then forward any relevant information to the utilities' computer systems.

Considerations

- Information security: Allows more secure transactions if properly encrypted.
- Information integrity: Reduced data errors through digitalization
- Reduced burden to CEC: Can be applied to other rebate categories.
- Reduce multiple information intakes – fax, mail, and Internet (to an extent) – to one.

Conclusions

For installed solar to succeed in the long term, it will need the same certainty of economic returns as installing more efficient appliances. Streamlining the rebate process -- which in turn will encourage large-scale installation, reduce costs and promote additional PV investment-- will hasten the arrival of a rebate-less future in which solar is effortlessly integrated into mainstream production homes.

To accomplish this streamlining over the short term, the CEC should centralize and consolidate processes. Digital automation will be key to this process in the longer term.

In many ways, this requires a parallel application process different from the retrofit market. Since there are large relevant differences between the production home market and all others, trying to shoehorn that process into another is unadvisable. As we see here, combining both processes in one set of forms, while seemingly attractive, can be counterproductive to achieving program goals.

We understand that this recommendations break with the CEC's current protocols. But upon reevaluating those protocols' objectives, one can see new ways to achieve the same goals while protecting all parties' interests.

1.1.15. 3.3.4 Tailored Maintenance, Warranty and Customer Service

1.1.15.1 *3.3.4.1 Introduction*

The 'Maintenance, Warranty, and Customer Service Plan' identifies the customer service strategy and implementation that is key to SunPower's service offering. The research consisted of numerous meetings with the BIPV product development team, the installation team, the

manufacturing team, the legal team, builders, and new homebuyers in order to obtain the required input for our current maintenance, warranty, and customer service plan.

1.1.15.2 *3.3.4.2 Approach*

New home builders place a high premium on customer satisfaction and are eager to maintain a reputation among homebuyers for quality, reliability and responsiveness. Providing service and support to builders and homeowners is essential to ensure the success of solar in new homes. SunPower has an in-house dedicated customer service team working specifically on new home offerings. SunPower's new homes customer service team is committed to making solar ownership a positive and enjoyable experience for the builder and the homeowner. The key components to SunPower's new homes customer service offering are:

- High quality and rapid customer service
- Preventative quality assurance and maintenance
- Comprehensive, industry leading warranty terms

This report summarizes the decisions and items that are being implemented to provide world class customer service to SunPower's builders and solar homeowners.

1.1.15.3 *3.3.4.3 Customer Service*

SunPower's customer service team is responsible for system commissioning, online system monitoring, service calls, and builder customer care support. This section gives an overview of these pre and post sales activities.

System Commissioning

SunPower always performs a performance check after the system has been fully installed to ensure that the systems operate properly before a homeowner moves in. The performance check includes a system voltage check, a performance monitor installation check, a performance check, and an orientation check. It is mission critical that any under-performing systems as a result of installation issues are identified at commissioning in order to ensure that customers view solar as a positive addition to their home, and not a maintenance issue.

Homeowner Move In

Education and support for new homeowners is a key factor in the successful deployment of solar new homes. While the systems require very little attention or maintenance from owners, there are some actions required when they first move in. Solar is a new technology to many people and setting expectations as to how the system will operate is key to driving high satisfaction. All homeowners are provided information on:

- What they have installed on their home and how it works,
- How to establish monitoring,
- Utility interconnection, and
- The Federal Tax Credit.

The final walkthrough of the home is an ideal time for the builder to explain the solar system and to present the utility interconnection paperwork and educational information to the buyer.

SunPower works with the builder customer care team before the walkthroughs to educate them on the solar system and provides them with information that should be conveyed to the new homeowner.

Ongoing Support and Monitoring

All new homeowners are provided with online monitoring of their system's electricity production and home consumption. Homeowners can visit the website to verify that their system is performing whenever the sun is shining. After receiving feedback from builders and homeowners that the addition of a consumption monitor would improve the system, SunPower added the electricity consumption monitor. System production and consumption can be viewed in a daily, monthly, or annual graphical format. Figure 31 shows a screen capture of the main page of the online monitor with the daily production and consumption presented in 15-minute intervals.

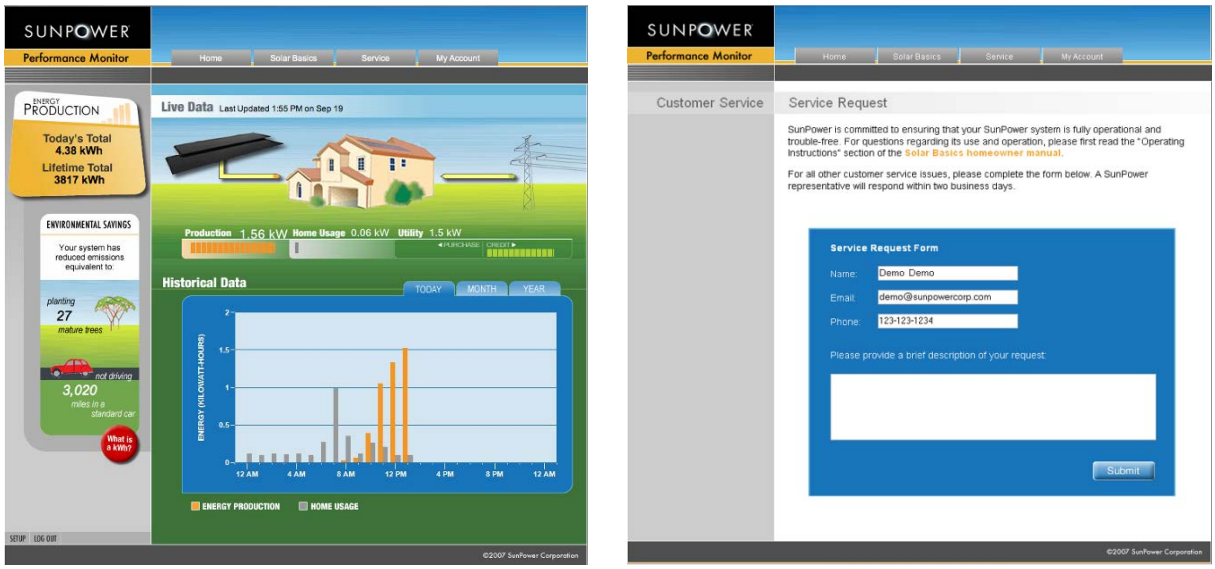

Figure 31: Screen Captures of SunPower's Online Performance Monitor

The online monitoring site is also a web-based information portal for homeowners. The portal contains information on the basics of a solar system, how to interconnect with the grid, the federal tax credit, provides answers to Frequently Asked Questions (FAQ's), and provides a service request form plus a 1-800 number and an email address for any questions or issues on their solar system. SunPower encourages and assists all new homeowners with setting up the monitoring system since we view this as a main source of information for the homeowners to learn about their system and to potentially alter their consumption patterns based upon the instantaneous feedback. SunPower customer service will work with homeowners over the phone or in person at their new home to ensure that the monitoring is successful.

The customer service team also supports community events organized by the builders and SunPower. These have ranged from 'countdown' events for potential buyers of homes, solar orientations, and meet your neighbor events. SunPower presents information to homeowners and potential buyers on how solar and energy efficiency features work, what other solar

homeowners are saying, the federal tax credit, the online performance monitor, and warranty and service.

1.1.15.4 *3.3.4.4 Maintenance*

System Monitoring

The system production monitoring is a critical component of SunPower's offering. Monitoring of solar production and home usage allows us to proactively verify the system's health. Listed below are a couple of examples of the frequent system reports that prompt service calls:

- Inverter operation - reports on inverters that are not operating during daylight hours
- Lost connections - inverters that were successfully reporting that have stopped reporting

Operational Service Calls

SunPower places a high value on rapid reaction to service calls and being proactive rather than reactive. The regional customer service team responds to service calls within three hours of receiving them, resolves system outages within 24 hours of noticing them, and all other calls within 72 hours. Each visit takes approximately 1.25 hours including travel time. Currently the service team visits about half of the new homes, mainly to assist the new homeowners with the monitoring setup and to provide a personalized orientation to the system. Moving forward, SunPower is striving to reduce the number of in-home visits by providing improved web-based instructions and increasing the amount of training provided by the customer care teams and SunPower orientations.

1.1.15.5 *3.3.4.5 Warranty*

Each SunPower solar system is covered by a 10-year limited warranty on all components, parts, and labor. If a problem arises during this period, SunPower will repair the components to restore them to operation. The solar cells and their power output are covered by a 25-year limited warranty. The inverter carries a 10-year limited warranty. The full warranty terms comply with all of the conditions set forth in the New Solar Homes Partnership Guidebook.

1.1.15.6 *3.3.4.6 Conclusion*

SunPower's in-house customer service team has all the capabilities necessary to provide these critical support functions. To date, customer satisfaction has been high and SunPower is continually striving to improve the process to increase satisfaction. Additional staffing of customer support positions requires a level of occupied homes before there is sufficient service demand to warrant dedicated resources. As SunPower installs solar at more new homes and expands our offering into different regions, the customer service team will proportionally increase to ensure that SunPower's customer service remains world class, and growing the industry through high customer satisfaction and increased demand for new solar homes.

1.1.16. 3.3.5 Service and Customer Satisfaction Report

Purpose

The gold of this task is to quantify the motivations and experiences of buyers of homes that had SunPower's systems installed.

This section reviews the results of a survey taken of SunPower New Home over the last two years. It summarizes the relative importance of the solar system in the decision to purchase a home.

Report

In December 2007 SunPower conducted a survey of buyers that had bought homes with our solar systems during the previous two years. This process was repeated in 2008.

230 surveys were sent to homeowners across the state where SunPower had contact information available for the buyer of the home. Homeowners we very enthusiastic in replying with a 59 percent response rate, 135 completed surveys. In 2008, 450 responses were received with a 52 percent response rate.

Survey Highlights

Solar was key in decision to buy the home. Over 90 percent of buyers identified the solar system as an important factor in purchasing their home. Solar system ranked as third most important reason to purchase a particular home.

Solar Homeowners are satisfied customers. 92 percent would recommend a solar home to a friend. 85 percent were likely or definitely likely to buy a solar home in the future.

The survey results showed a great response from SunPower solar home buyers. Over 90 percent of buyers identified the solar system as an important factor in purchasing their home. More than 92 percent would recommend a home with solar to a friend.

Buyers were asked to identify the top three reasons for purchasing a home from a list of 20 industry standard choices.

Several questions asked buyers about their experience living in the home with solar and satisfaction with the solar and energy efficient features. There was generally a very high reception for the products and service SunPower has developed.

When asked how the savings they were getting compared to their expectation before moving into the home, a majority were meeting or exceeding their expectations.

Buyers were also asked about their experience when they had needed service to their system or had questions. A high majority of buyers were satisfied with the experience they had received, or had no service issues to speak of.

Builders Sales Tool

The results of this survey were included in a flyer to Homebuilders. This was used by builders in community sales offices to demonstrate the success and satisfaction of buyers with solar homes.

Figure 32: SunPower Customer Survey Report

Summary

The results from this survey indicate that solar can be used by production home builders to capture incremental home sales, drive word-of-mouth referrals, and impact future home buying trends.

This survey was a valuable validation tool for the business plan SunPower presented to California builders. It clearly demonstrates that home buyers see the benefit when builders include a solar and energy efficiency package. There is a clear message that solar was a key component in buyer's decision making process. Once in the home buyers maintain their positive opinion of the solar system, and are happy with the experience.

In conjunction with this deliverable, SunPower has developed a comprehensive set of materials with builders and external marketing professionals to sell and promote ZENHs. The homebuilder partnerships that have been formed as a result of this work have been successful, measured by the increasing adoption rate of new solar homes in California. SunPower will continue to work with the relevant parties to adapt and expand our service and customer satisfaction reporting metrics.

3.4 Build ZENH Demonstration Communities

The goal of this task was to work with SunPower's builder-partners to demonstrate two communities of at least 75 homes each, one single-family and one multi-family, which meet the ZENH design requirements (see Table 1, page 24). The demonstration communities are also used to evaluate the overall construction and marketing of the ZENH design.

At the writing of this report, SunPower had built four official ZENH demonstration communities with more than 150 ZENH homes (Table 46), including both single- and multiple-family units. In addition, SunPower's ZENH-inspired homebuilding approach and lessons learned have helped SunPower's homebuilder partners develop more than 70 communities, constructing 2000+ solar homes throughout California. See Figure 33.

Table 46: ZENH Demonstration Communities

	Grupe		Lennar	Meritage	Grupe (MF)
Community	Village 11	Village 12	Blackstone	Encore	Villa Monterey
City	Rocklin		El Dorado Hills	Vacaville	Stockton
Systems	65	20	15	20	46

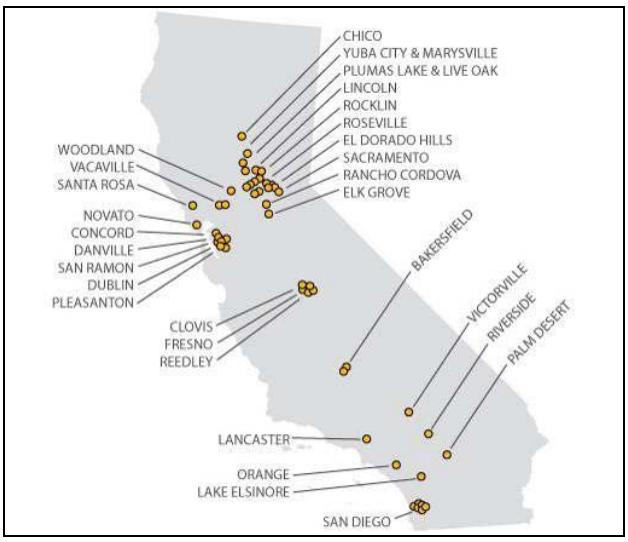

Figure 33: SunPower New Homes Communities

In each of the homes, SunPower installed turn-key BIPV systems, included an in-home energy monitoring display, allowing customers to view their solar system energy production as well as their household energy consumption. System sizes were varied according to the energy analysis for each home. All installs were verified by 3rd party HERS raters and used as input for the design, construction and performance monitoring work discussed later in this report.

With generous match-funding commitments totaling more than $2,000,000, all ZENH installations were financed by SunPower's builder partners, some of which are highlighted in Figure 34.

Figure 34: Representative Builder Partners

With customer surveys and focus groups studies, SunPower further determined the importance of PV and energy-efficiency features in the buying and financing decision for their ZENH homes. These market assessment findings are documented in Figure 32 on page 166.

1.1.17. 3.4.1 Facilitate Builder Marketing, Sales & Implementation

1.1.17.1 *3.4.1.1 Objectives*

Training is an essential element to rolling out new ZENH homes. To this end, SunPower sought out to train builder staff, subcontractors, and building department staff on installation procedures for turn-key BIPV and ZENH measures. For this work, SunPower had to:

- Develop procedures for builder, contractor, and building department staff training and creating a complete set of ZENH Construction Training Materials
- Conduct training for builder staff and participating contractors during construction
- Train building department staff and create comprehensive building permit packages

1.1.17.2 *3.4.1.2 Approach*

Since solar is a relatively large financial investment compared to other features in a new home, it is critical that sales agents can effectively sell the solar to achieve the gains from the investment – selling more homes and faster than the competition. SunPower provides a comprehensive sales training program to ensure that the investment in solar is effectively leveraged to improve sales across the communities.

1.1.17.3 *3.4.1.3 Results*

SunPower's "Builder Management Orientation"is used by SunPower to train builder sales staff and to facilitate the marketing, sales, and implementation of ZENHs. Many builders are including solar as a standard feature to differentiate their homes from the competition.

SunPower also hosts follow-up sessions as requested by the builder to ensure that the sales agents always have a current understanding of the benefits of the solar and energy efficiency features. The sales training is continually being updated based upon feedback that we receive from the sales agents and requests that we receive from the builders.

SunPower hired an in-house professional trainer to develop and implement the builder sales training program. The trainer first performed a needs assessment to understand the major stakeholders' areas of knowledge and their ability to communicate the benefits of energy

efficiency features and solar electric systems. The trainer interviewed SunPower employees, builder managers and sales agents, and also observed sales agents in the sales offices. The results of the interviews and observations were used to determine the format, length, audience, and content of SunPower's world class Builder Sales Training Program.

SunPower provides a 2-3 hour module on solar basics once a builder decides to go solar in a community. Since this takes place in advance of launching sales in the community, SunPower provides a follow-up 'refresher' course approximately 1-2 days before the community opens. In addition, SunPower spends time in the sales offices of the solar communities providing marketing support and continuing to develop the sales agents. SunPower also videotapes some of the sales agents during training in order for them to view and improve their performance. These performances are available to the builder management at a web portal. SunPower also provides a certificate to each sales agent upon completion of the training module.

Supporting collateral, signage, demonstration kiosks (interactive DVD material on an Apple™ workstation) and other marketing resources are also supplied to the builder.

1.1.17.4 *3.4.1.4 Conclusion*

To date, SunPower has trained hundreds of builder employees across California. SunPower also provides the builder management team a summary of sales agent performance during the training to give the managers an idea of the benefits of the training.

3.5 Monitor and Evaluate ZENH Performance

This section evaluates the ability of homes in the demonstration communities to achieve the goals of the ZENH program. These goals are to:

- Improve building energy efficiency by 25 percent over the baseline standards established by the CEC Title 24,
- Reduce peak demand to 1kW or less,
- Reduce the incremental first cost to a ZENH homeowner to $5,000 or less, and
- Reduce the electricity bill by up to 70 percent.

The outcome of this work shows that homes in the three SunPower-enrolled communities achieved a 25 percent or higher efficiency improvement, but the peak demands were generally much greater than 1kW, while the incremental costs averaged by community were at best $4,000 above the goal. The average annual bill savings also fell short of the target, achieving only about 59 percent improvement.

The following material discusses how SunPower, through its work with KEMA, developed and documented the protocols, tools and methodology for monitoring and evaluating the success of ZENH.

- Approach to Evaluation, Measurement and Verification 172
- Analysis of Implemented Data Acquisition and Monitoring Plan 175
- Evaluation of ZENH Performance Outcomes 180

1.1.18. 3.5.1 Approach to Evaluation, Measurement and Verification

1.1.18.1 *3.5.1.1 Net Consumption and Solar Production Meter Data*

With access to sampling data from the SunPower monitoring equipment installed in each ZENH demonstration home, SunPower provided hourly net electrical usage and solar production meter data for 53 participant sites from three separate California communities: Carsten Crossing in Rocklin, Chateau at Blackstone in El Dorado Hills, and the Encore Community in Vacaville. The meter data was checked to verify that there was adequate data to obtain an estimated annual usage; sites with less than 12 consecutive months (May 2008 to May 2009) of data were dropped in order to have a set of homes with data containing usage during a complete range of seasons, especially the summer months, during which electrical load is especially high due to air conditioning usage. Data from unoccupied model homes were also dropped, since they did not properly represent a typical load profile for a single family home. This left 21 sites remaining for analysis.

1.1.18.2 *3.5.1.2 Compliance Models*

Title 24 compliance models (MP7 files) were provided by the homebuilders' design consultants, Davis Energy Group, for each of the three communities. They include all of the builder-affected energy related features of the house, such as types of building surfaces, window shading, and radiant barriers. ZENH participant models were produced with the CEC approved compliance software MICROPAS, which compares the participant modeled consumption to a baseline version of the home based on climate zone-dependent package D minimum requirements found in the CEC Title 24 guidelines.

1.1.18.3 *3.5.1.3 Baseline Models*

For the purposes of studying whether a SunPower ZENH site achieved a 70 percent bill reduction over its baseline counterpart, models were created using the baseline characteristics prescribed by the CEC Title 24 guidelines. In order to construct a baseline version of each home, building data for homes in the same climate zone as the ZENH sites from the California Public Utilities Commission Residential New Construction (RNC) Program baseline study were used. The Residential New Construction program is part of a cluster of programs intended to increase the adoption of energy efficient equipment and practices in both the single family and multifamily building industry. The program provides support to encourage high-performance building design that exceeds the 2005 California Energy Efficiency Standards in overall performance design by 15 percent or more, while also aiming to increase the installation and adoption of individual high efficiency measures in residential new construction, such as efficient heating, cooling, lighting, and appliances. The purpose of the RNC baseline study itself was to obtain net savings estimates resulting from the investor-owned utilities' (IOUs) RNC programs as well as compliance rates used for the Codes and Standards evaluation.

The construction types for the walls and roofs were determined by which was the most predominant type among the RNC baseline sites. Building characteristics with specific values, such as U- and R-values and solar heat gain coefficient (SHGC) for windows, were determined by averages taken from the RNC data.

Wall areas were summed according to orientation and assigned a wall construction of wooden 2x4's with 16 inch frame spacing and an R-value of 16. The baseline roof type was wood construction with an R-value of 38. Because the ZENH homes were all built on slabs, the baseline floors were not different from the ZENH participant model floors. The total glazing surface area was also determined by the average glazing area as a percentage of the total floor area from the RNC data (19.78 percent). For ZENH sites that were not within ±0.05 percent of this value, the window areas were weighted by the difference. As mentioned above, the SHGC and U-factor were determined by the averages of these values for all RNC windows. Individual window orientation, shading, and overhangs were not altered.

The baseline A/C type was also determined from the RNC Baseline data. The baseline A/C is a split system with a SEER rating of 13.6, an EER rating of 11.3, and a thermal expansion valve (TXV). The SEER and EER ratings were calculated as the average weighted by tonnage. Whether the unit had a TXV was determined by what the majority of RNC systems had. The value of verified air flow, fan wattage, and maximum cooling capacity were all ignored, as these were not measured for most of the RNC sites.

The baseline duct system had a baseline R-value of 5.9 and was located in the attic. The duct location was determined by what type was the majority and the R-value was determined by the average R-value weighted by floor area of the RNC sites. Because the average leakage percentage was greater than 6 percent, the baseline duct system did not have a leakage credit according to the 2005 Energy Efficiency Standards of the California Energy Commission. This leakage percentage was computed in the following way: The nominal system airflow was determined by multiplying the cooling capacity in tons by 400CFM/TON where CFM is cubic feet per minute. The sum of two duct leakage tests was then divided by the nominal system airflow to determine the duct leakage percent. The value of this test was in CFM and was converted to SLA (Specific Leakage Area) with the formula SLA = 10,000 (ELA/Floor Area) where ELA = BlowerCFM501/2700. BlowerCFM501 is the value of an infiltration test, which is in cubic feet per minute at 50 Pa (Pascal) house pressure relative to outside pressure. The location and yes/no setting for verified leakage, surface area, and buried ducts were determined by which value had the majority.

1.1.18.4 *3.5.1.4 Weather Data*

MICROPAS utilizes CTZ weather data files developed by the CEC for each of California's 16 climate zones to compute energy budgets for Title 24 simulations. These CTZ files were developed from historical data over the past 30 years and are representative of a typical climate year. However, there are significant weather variations from year-to-year that in turn have a significant impact on heating and cooling end-uses in the compliance models. Therefore, it was necessary to adjust the model outputs to account for the actual weather conditions during the metering period.

The SunPower ZENH sites custom weather files were created using data from a California Irrigation Management Information System (CIMIS) remote weather station in Fair Oaks, California. This location was chosen because it is close to Rocklin and El Dorado Hills and in an area with a similar climate to Vacaville.

A custom weather-packing utility from Enercomp, the producers of the MICROPAS software, was used that transformed the weather files into a form compatible with custom MICROPAS runs. For MICROPAS modeled sites, the models with the site-specific weather file for the metering period were thus run using the custom weather file. The output from these runs were compliance-model estimates of annual energy usage by end-use, including A/C, heating, and water heating, under the same weather conditions the houses experienced during end-use metering.

1.1.18.5 *3.5.1.5 PG&E Rate Schedules*

In order to simulate the annual utility bills for ZENH homeowners, the E-1 electric rate schedule description was pulled from PG&E's website. It lists the rates for different territories as well as the summer and winter seasonal rates. A link to details of the schedule is below (PDFs) and can also be found under the title "E-1" at the tariff page of PG&E:

- http://www.pge.com/tariffs/ERS.SHTML#ERS

1.1.19. 3.5.2 Analysis of Implemented Data Acquisition and Monitoring Plan

This section compares the energy costs of a sample of participant homes across Time-of-Use (TOU) and non-TOU rates in Pacific Gas and Electric's (PG&E) service territory.

Due to the fact that solar production peaks during the middle of the day, which corresponds to the highest prices charged on a TOU rate schedule, any solar-equipped home with a relatively flat usage profile will experience savings under a TOU schedule as compared to a standard rate schedule.

Homes with substantial peak usage that more than offsets the solar production will still have to pay for higher price mid-day electricity and would pay less remaining on the standard rate schedule.

For this performance analysis, we focused on the impact of TOU rates on the homes' bill performances by estimating and comparing the energy bills of the homes under both non-TOU and TOU rates. Figure 35 shows the annual savings of accepting a TOU rate over a non-TOU rate. Eight homes had usage profiles with high peak usage relative to off-peak usage such that the flat rates were either close to equal to TOU rates, or actually cost them less, even with solar production factored in. One home in particular had very high peak energy usage, and thus would save $120 annually by staying on the non-TOU rate. On the other hand, 13 sites saved money by switching to TOU rates, with savings ranging from $20 per year up to $80 per year. These savings are in addition to the savings of the homes above baseline as computed in the main evaluation report.

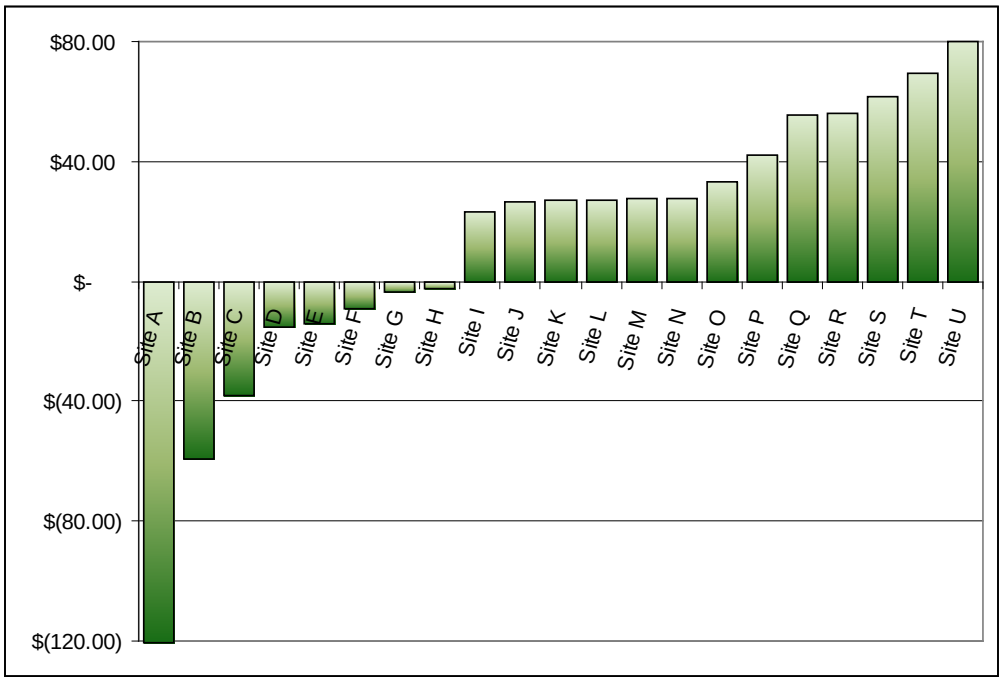

Figure 35: Annual Schedule Comparison: Savings of Switching to TOU Rates from Non-TOU Rates

1.1.19.1 *3.5.2.1 Data Description*

- ***Net Consumption and Solar Production Meter Data***

SunPower provided hourly net electrical usage and solar production meter data for 53 participant sites from three separate California communities: Carsten Crossing in Rocklin, Chateau at Blackstone in El Dorado Hills, and the Encore Community in Vacaville. The meter data was checked to verify that there was adequate data to obtain an estimated annual usage; sites with less than 12 consecutive months (May 2008 to May 2009) of data were dropped in order to have a set of homes with data containing usage during a complete range of seasons, especially in the summer months, during which electrical load is especially high due to air conditioning usage. Data from unoccupied model homes were also dropped, since they did not properly represent a typical load profile for a single family home. This left 21 sites remaining for analysis.

- ***PG&E Rate Schedules***

In order to study the effects of E-6 TOU and E-1 non-TOU schedules on the utility bills for ZENH homeowners, the electric schedule descriptions were pulled from PG&E's website. The schedule lists the rates for different territories as well as the peak/off-peak hours and seasons for the TOU schedules. The TOU rates are set up to incentivize customers to shift usage from the utility peak period (which for PG&E is from 1 pm to 7 pm) to periods where there is less usage on the system. The reason for this is that during the peak hours if the system draws reaches its capacity, the utility has to turn on additional power plants to meet the excess demand or purchase outside generation, both of which can be very expensive. If the utility is able to shift this usage to hours where there is less draw on the system, the electricity is cheaper for the

utility to provide. Links to details of the two schedules are below (PDFs) and can also be found under the titles "E-1" and "E-6" at the tariff page of PG&E:

- http://www.pge.com/tariffs/ERS.SHTML#ERS
- E-6 schedule
- E-1 schedule

The E-6 schedule is a three-tiered schedule, with off-peak and partial-peak periods during both summer and winter, and an additional full-peak period during the summer months. Summer is defined for the PG&E E-6 rate as May through October, and winter is from November through April. Under the E-6 schedule, the rate charged by PG&E changes at 101, 131, 201, and 301 percent of a PG&E defined baseline usage rate, which vary by PG&E territory and season. Under the E-6 rate schedule the summer periods are defined as follows: peak is defined as the hours 1:00 pm to 7:00 pm, partial-peak is defined as 10:00 am to 1:00 pm and 7:00 pm to 9:00 pm Monday through Friday and 5:00 pm to 8:00 pm Saturday and Sunday, and off-peak are all other hours including holidays. The winter partial-peak hours are 5:00 pm to 8:00 pm Monday through Friday and all other hours are off-peak.

The E-1 schedule is PG&E's non-TOU schedule. Like the E-6 schedule, the E-1 rates charged by PG&E change at 101, 131, 201, and 301 percent of the PG&E defined territory-dependent baseline usage rate. Additionally, the rates differ in the summer and winter months like the E-6 schedule.

1.1.19.2 *3.5.2.2 Analysis*

➢ ***Time-Of-Use Rate Savings***

The billing amounts of the participants were calculated based on PG&E's E-6 TOU schedule and the E-1 non-TOU schedule. Hourly net meter data provided by SunPower was used to calculate monthly and annual bills with rates from each of these schedules. The value of surplus energy produced by the home PV systems was subtracted from the annual bills to imitate the "true-up" period PG&E rebates solar customers. None of the homes' solar production value was greater than the usage cost on an annual basis. In such a circumstance, the home would receive a net annual bill of $0 and would not receive payment for any surplus energy sold back to the grid.

1.1.19.3 *3.5.2.3 Results*

Monthly and annual costs were calculated for the standard and TOU rates by home. For the SunPower participants, 13 of the 21 sites in the study saved more money under the E-6 schedule rather than the E-1 schedule. One of the sites saved over 60 percent on their total electric bill while the majority saved around 5 percent. Eight sites saved under the E-1 schedule as opposed to the E-6 schedule, with savings ranging from $120 to $2 shown in Figure 35. Sites that would save money on the E-1 rate saved between 1 percent and 8 percent even though the largest dollar savings occurred on this rate.

An example of a profile that will benefit from being on the TOU schedule is shown in Figure 36. This home will save more under the E-6 TOU schedule than the standard E-1 because the solar production during the peak hours, from 1 pm to 7 pm, is larger than the usage in the house, which means that the home will be rebated for the energy produced. This also means that this

home is not only avoiding being charged for using electricity at the highest rate, but is also being credited from production for the highest rate from the TOU schedule. Further, the home appears to have shifted a large portion of its load from the peak hours in the middle of the day to hours of 9 pm to 11 pm which are off peak hours on the TOU schedule.

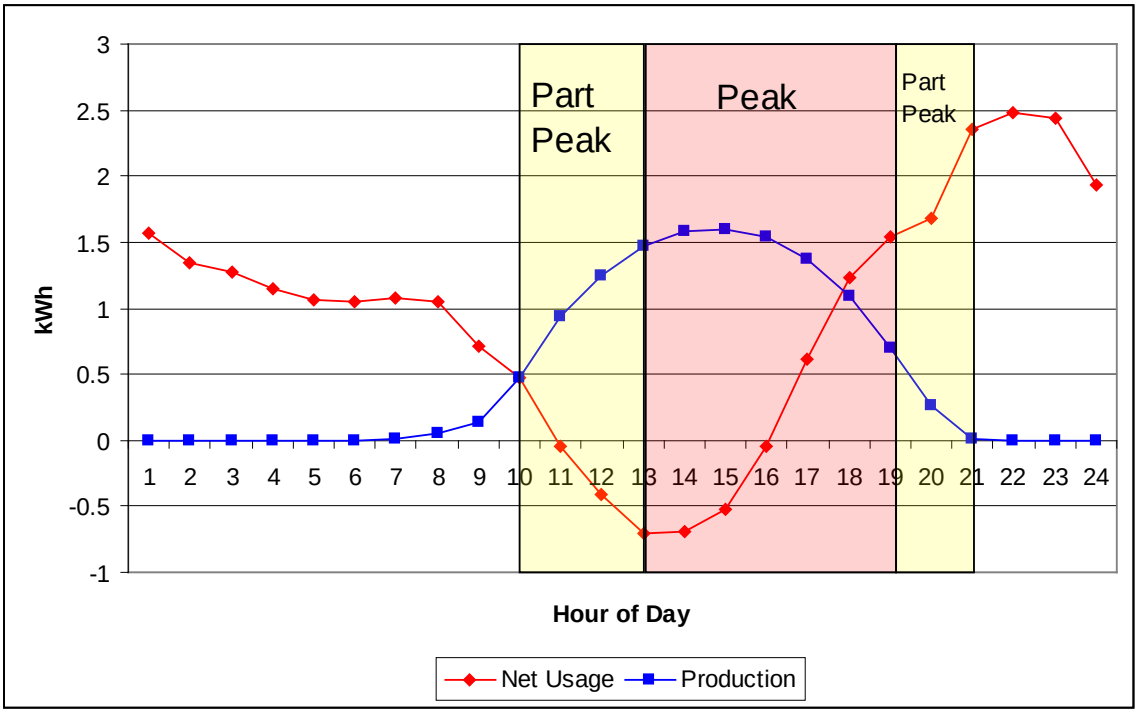

Figure 36: Profile of Home Benefiting from E-6 Rate

On the other hand, an example of one of the sites that saved more under the E-1 schedule is shown in Figure 37. This home had more usage than solar production during all of the peak hours from the TOU schedule with over 1.5 kWh during the 6:00 pm hour.

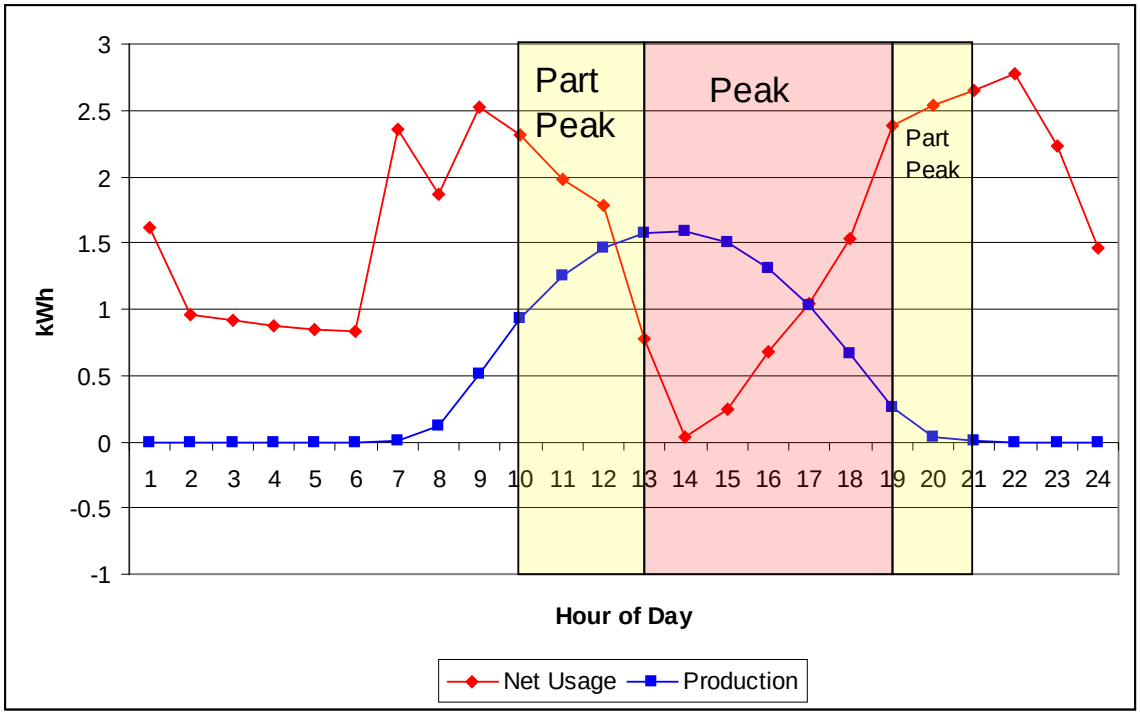

Figure 37: Profile of Home Benefiting from E-1 Rate

Depending on electricity usage patterns within a house on a typical weekday, a homeowner could potentially save hundreds of dollars a year on one rate versus another. However, if the usage during the peak period is substantially greater than the offset from the solar production, as was the case with site A, then it may make more sense for the homeowner to avoid the peak-hour fees by staying on the E-1 schedule. Figure 35 shows the dollar savings each site would have achieved under the E-6 schedule rather than the E-1 schedule during the period from May 2008 through May 2009.

1.1.20. 3.5.3 Evaluation of ZENH Performance Outcomes

1.1.20.1 *3.5.3.1 Improved Energy Efficiency*

PIER set a target that all ZENH demonstration homes would meet or exceed a rate of 25 percent lower energy usage than the title 24 minimum requirements (package D). This factor does not take into account the non-builder-affected uses, such as lighting and appliances. Only builder-affected uses such as A/C, space heating, and water heating are considered. Hard-wired lighting and other builder-affected uses which use less energy were are not considered.

- ***Methodology***

Building energy simulation models, MICROPAS MP7 files, were provided by the homebuilders' energy modelers for 123 of the ZENH demonstration sites. These models were put through a standard compliance run in MICROPAS which simulates energy usage for the home for one year, taking into account energy use of HVAC and water heating systems. At the same time, MICROPAS runs a simulation of annual energy use of a baseline version of the model

complying with the minimum standards set by package D of the Title 24 Energy Efficiency Standards for Residential and Nonresidential Buildings.

- ***Results***

Based on the compliance simulation runs, the average overall efficiency improvement for the 123 sites considered was 37.2 percent. The histogram in Figure 38 shows the percent improvements of each site's model over their Title 24 baseline counterparts. Percentage values on the figure represent the upper bound of each bin. For example, the 30 percent bin contains all sites with savings between 30.1 and 31 percent. The overall improvement rating combines space heating and cooling efficiency as well as water heating, and all models exceeded this 25 percent improvement mark over their standard designs. In fact, all ZENH models are more than 29 percent more efficient than a baseline home meeting the CEC Title 24 standards, with 96 percent of the sites passing the 34 percent efficiency improvement mark. The upper bound in Figure 38 refers to the upward limit of each bar, i.e. the values in the bar labeled 38 percent range between 37.1 and 38 percent. The numbers over each bar indicate the number of sites in that percentile.

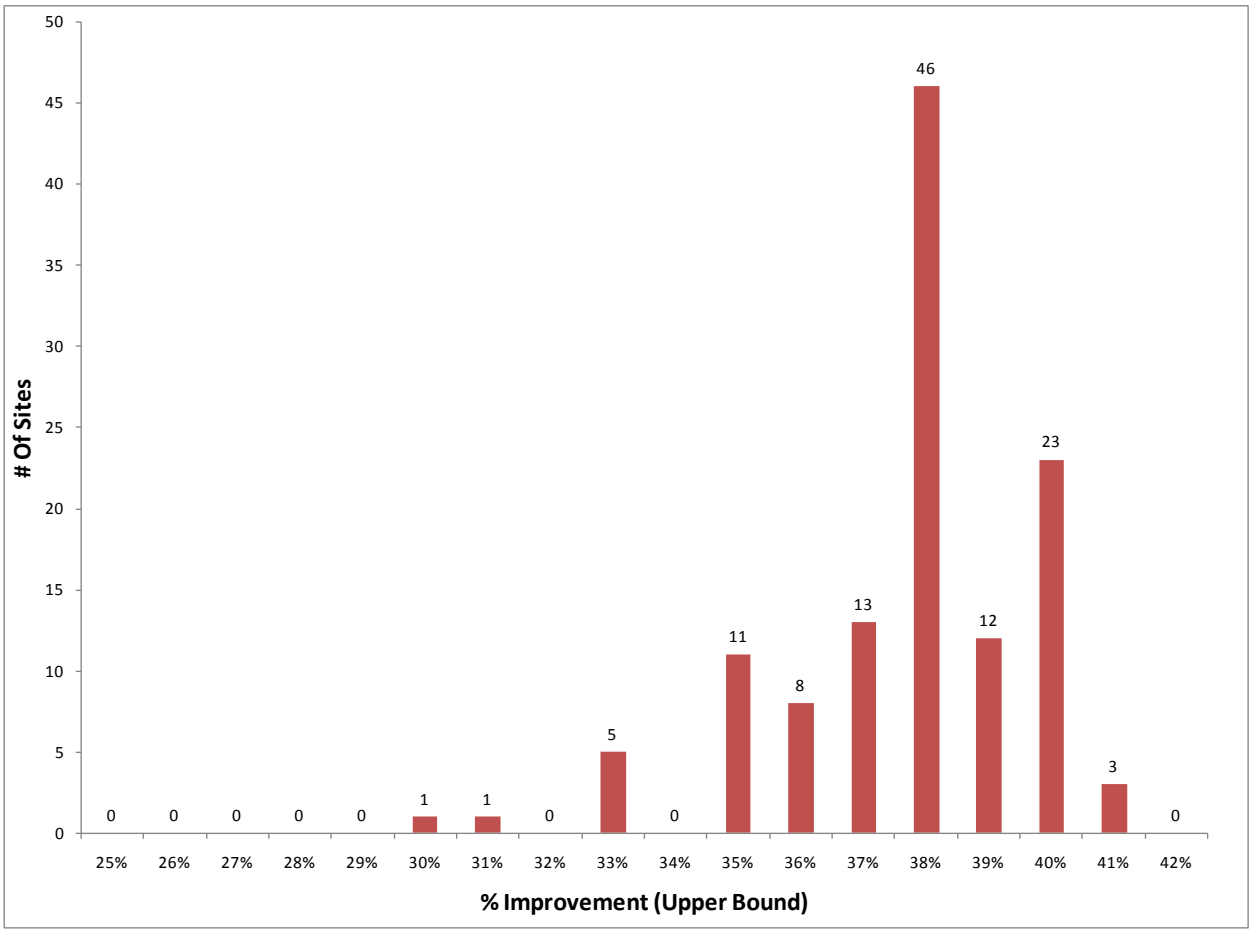

Figure 38: Percent Improvement of ZENH Sites over the Title 24 Baseline

The histogram in Figure 39 shows that when only the space cooling percent improvement was examined, which accounts for the majority of the peak electrical load during the summer

months in the Sacramento area, all models exceeded 35 percent efficiency improvement, with the average AC efficiency improvement being 49.5 percent. Additionally, 38 models (out of 123) showed more than 50 percent improvement over the Title 24 baseline. In other words, almost one in three ZENH model AC systems used less than half of the electricity of a baseline AC system. The upper bound in Figure 39 refers to the upward limit of each bar, i.e. the values in the bar labeled 40 percent range from 35.1 to 40 percent. Numbers over each bar indicate the number of sites in that percentile. Again, these numbers are based on compliance software outputs using builder-provided models.

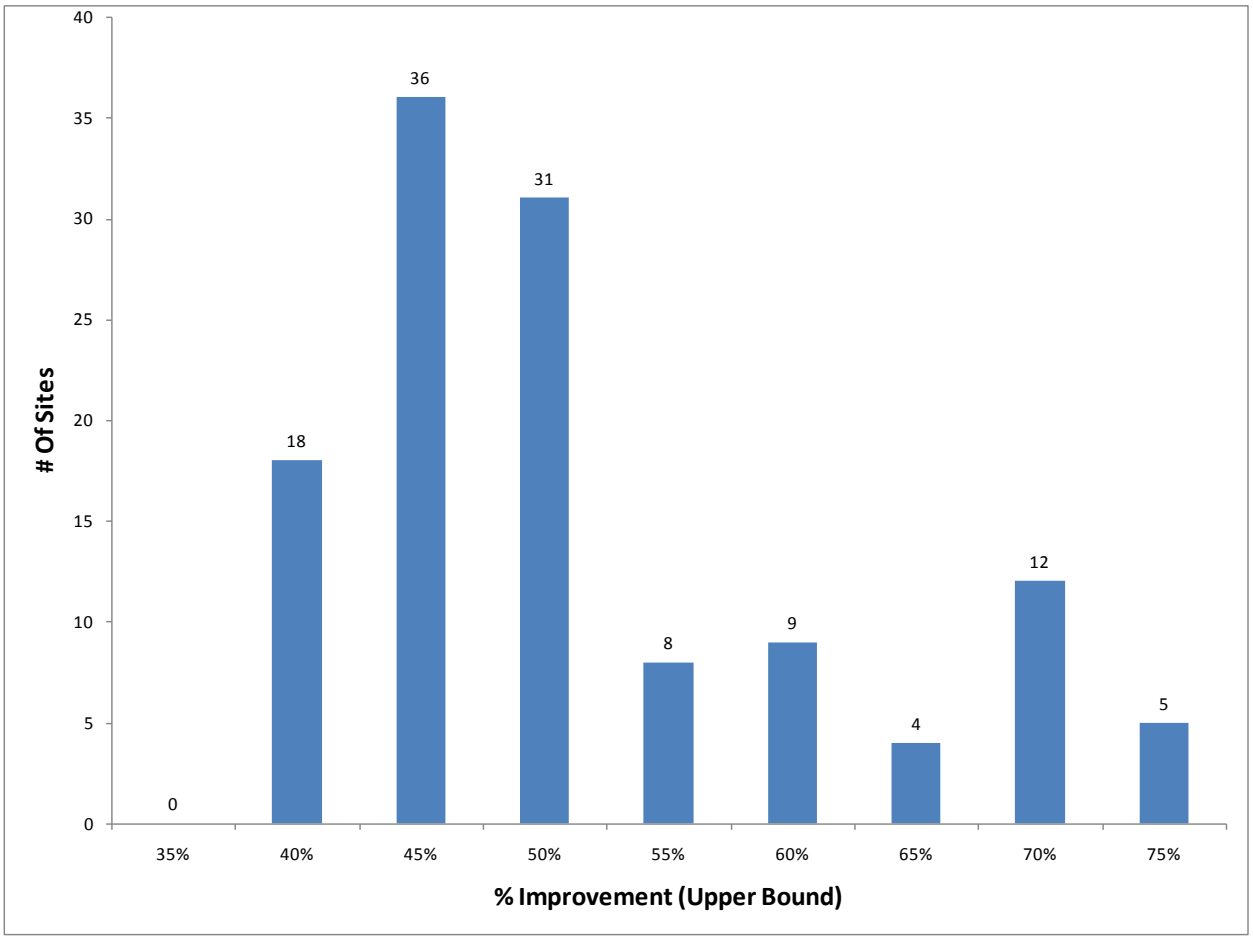

Figure 39: Percent Improvement of ZENH A/C Systems over the Title 24 Baseline

1.1.20.2 *3.5.3.2 Reduce Peak Demand*

PIER set a target that all ZENH houses would have a maximum peak demand of 1kW or less to help reduce the peak hour demand on the system. All SunPower ZENH homes were located in PG&E territory which is a summer peaking utility.

- ***Methodology***

Hourly net meter data provided by SunPower were examined for peak hour usage during the summer. The summer peak hours were considered to be 1pm to 6pm on weekdays during June, July, and August, following the summer peak period of the E-6 meter schedule. For each house,

the peak hour with the highest consumption was collected, as was the average of loads of the top 5 peak hours. 21 sites with data from the entire summer period of 2008 were considered.

➢ ***Results***

As can be seen in Figure 40, the SunPower ZENH peak loads fall short of the PIER goal; no home had a peak demand of 1kW or less. The lowest peak hour demand of the sites included in this study was 2.91 kW, while the average was 6.39 kW.

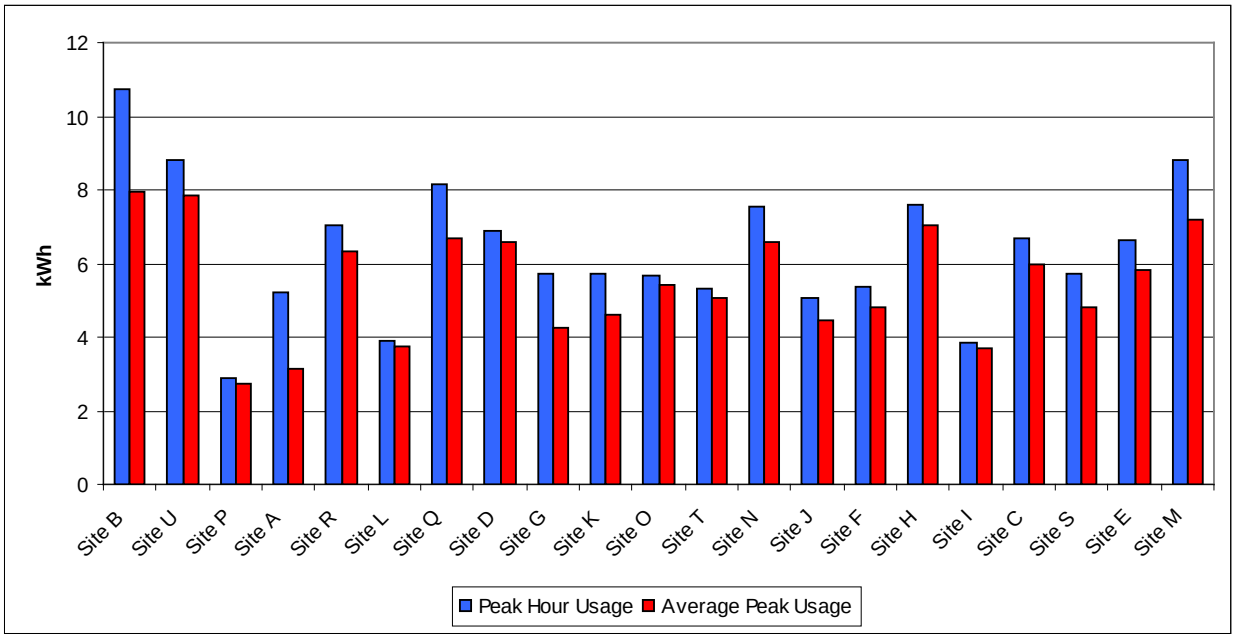

Figure 40: Peak Hour Usage and Average of Top 5 Peak Hours by Site

1.1.20.3 *3.5.3.3 Reduce Incremental First Cost*

One of the standards PIER set was for the ZENH homeowners to pay no more than $5,000 in incremental costs upon purchasing a zero-energy home. This includes upgraded insulation, fenestration, and HVAC systems which make the home more efficient than a home meeting the minimum Title 24 standards, as well as the photovoltaic system included with each ZENH unit. PIER assumes these cost goals to be post-rebate. The rebates include an investor-owned utility (IOU) $2,000 energy efficiency rebate for homes that are at least 35 percent above Title 24 standards, as well as a $4,600 CEC solar rebate for a 2.4 kilowatt peak (kWp) system.

➢ ***Methodology***

For the analysis of the ZENH incremental first costs, a report by the Davis Energy Group (DEG) on behalf of SunPower titled "Commercializing Zero-Energy New Home Communities" was cited. In the DEG report, the average incremental costs of homes in the three communities examined for the ZENH analysis were presented.

- ***Results***

According to the incremental costs analysis performed by Davis Energy Group, none of the three SunPower participant communities have post-rebate incremental costs below $9,000. The PV system is by far the most expensive add-on component of the ZENH home, accounting for roughly 75 percent of the total incremental first cost for the homeowners. Accordingly, for every community, the rebates covered the costs of everything except the PV system. The tankless water heater was the second most expensive cost for 2 of the communities. The verification tests were the cheapest component of the costs, except for particular A/C and heating additions. The cost of the A/C and heating systems themselves varied widely: A/C ranged from $100 to $375, and the furnaces ranged from $265 to $1,000. Table 47, Table 48, and Table 49 show the reported incremental costs from the DEG report.

Table 47: Incremental Costs for Homes in Development A

System Measure	***Incremental Cost***
Ceiling Insulation (R38 to R-49)	$323
Attic Radiant Barrier	$740
Air Conditioning (13 SEER to 15 SEER/12 EER)	$340
Furnace (80 AFUE, 94 AFUE w/ ECM blower)	$350
SmartVent Night Ventilation Cooling	$772
Tankless Water Heater	$1,018
Fluorescent Lighting Package	$325
HERS Tests and Inspections (Insulation, TXV, SEER, Blower Door, System Airflow)	$300
2.4 kWp PV System	$13,950
Total Incremental Cost	**$18,118**
Cost minus rebates ($6,600)	**$11,518**

Table 48: Incremental Costs for Homes in Development B

System Measure	*Incremental Cost*
Ceiling Insulation (R38 to R-49) and Wall (R-13 to R-15)	$350
Attic Radiant Barrier	$500
Air Conditioning (13 SEER to 14 SEER/12 EER)	$100
Furnace (80 to 92 AFUE)	$1,000
SolarBan 70 Windows	$200
Flourescent Lighting Package	$400
HERS Tests and Inspections (Insulation, TXV, SEER, Blower Door, Duct Testing)	$150
2.3 kWp PV System*	$12,996
Total Incremental Cost	**$15,696**
Cost minus rebates ($6,600)	**$9,096**

*The cost of the PV system for this development was not in the DEG report and was provided by SunPower.

Table 49: Incremental Costs for Homes in Development C

System Measure	*Incremental Cost*
Ceiling Insulation (R30 to R-49)	$1,200
Attic Radiant Barrier	$800
Air Conditioning (13 SEER to 15 SEER/12 EER)	$375
Furnace (80 AFUE, PSC to ECM blower)	$265
NightBreeze Night Ventilation Cooling	$2,000
Tankless Water Heater	$1,000
HERS Tests and Inspections (Insulation, TXV, SEER, Blower Door)	$300
2.3 kWp PV System	$15,000
Total Incremental Cost	**$20,940**
Cost Minus Rebates ($6,600)	**$14,340**

1.1.20.4 *3.5.3.4 Reduction of Electricity Bill*

A goal was established by PIER for ZENH demonstration homes to have an annual electricity bill which is 70 percent smaller than that annual bill of a baseline version of the same home. This will be achieved through the combination of solar panels offsetting usage, more efficient building construction methods, and more efficient heating/cooling and water heating systems.

- ***Methodology***

The SunPower ZENH participant models and their baseline counterparts were run in MICROPAS to give a simulation of an entire year of hourly electricity data for the cooling and heating systems, taking into account only the builder-affected share of the energy. Non-builder-affected energy use, such as lighting and plug load, are accounted for in the meter data provided by SunPower. This isn't accounted for in the MICROPAS models as the models attempt only to capture the performance of water heating and space conditioning and not the appliances and lighting in the house. Additionally, homeowners' use of lighting and appliances vary widely from home to home and is not affected by participation in the ZENH program. Therefore meter data is a better indicator of electricity usage in this case. The compliance model files were run using a custom weather file with data from a remote weather station in Fair Oaks, CA.

Meter data of 21 sites were provided which served as the primary data used for calculating billing estimates of the ZENH sites. The baseline net usage for each site was calculated on an hourly basis as

Baseline = (MP baseline model – as-built MP Model) • EStar ratio + Gross Meter

Figure 41 below illustrates the methodology for calculating electricity savings for this analysis. The top of the methodology diagram shows the original data sources described in the data section. Once the housing characteristics of the compliance models were set to baseline (also described in the data section), both the baseline model and the original compliance model were used to simulate the hourly energy usage for an entire year. The baseline hourly usage was then subtracted from the participant electrical usage to obtain the difference between the two values. This "baseline difference" was then multiplied by the inland climate zone meter scaling factor from the Energy Star report explained below in further detail.

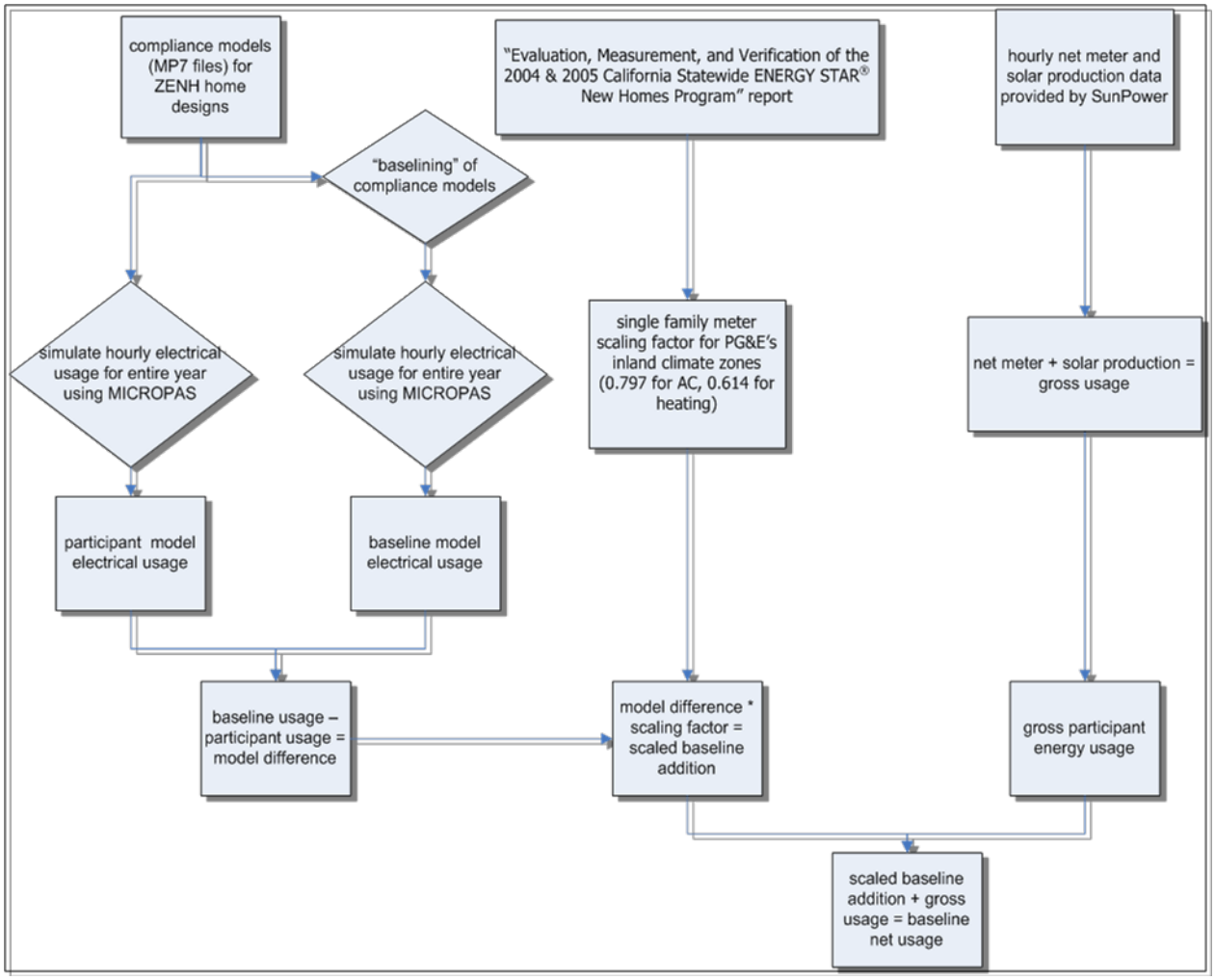

Figure 41: Methodology for Baseline Model Hourly Usage

The baseline home was assumed not to have solar panels. Because of this the hourly net electrical usage and solar panel production were added together to obtain a gross meter value. This was then added to the scaled "baseline difference" to obtain an hourly baseline consumption value.

For the baseline calculation, the gross meter value was calculated as the sum of the solar and gross usage meter data provided by SunPower. The Energy Star (EStar) ratio was determined by the meter data analysis of a previous report titled the "Evaluation, Measurement, and Verification of the 2004 & 2005 California Statewide ENERGY STAR® New Homes Program." Specifically, the ratio is the single family meter adjustment factor for PG&E's inland climate zones. The meter adjustment factor accounts for the difference between compliance model estimates of usage and metered actual homeowner energy usage. The ratios were computed by comparing a full year of end-use meter data from 101 sites to those same sites' compliance model predictions when modeled under actual year weather conditions (pg. 23 of EStar report). Table 50 shows the table from the Energy Star report from which the meter adjustment factors were pulled. Ratios in the highlighted rows were used in this study.

Table 50: Single Family Meter Adjustment Factors by Climate Zone and End Use[38]

End Use	Climate	Sample n	Ratio Meter Usage to Modeled Usage	Relative Precision
AC	Coastal	14	1.752	49.0%
	Inland	72	0.797	14.3% *
	Desert	5	0.664	18.3% *
Heat	Coastal	14	0.589	28.9% *
	Inland	76	0.614	11.6% *
	Desert	6	0.837	25.3%
Hot Water	N/A	87	0.813	10.3% *

* Indicates statistically significantly different from ratio = 1

Once an hourly baseline electricity usage was established, monthly and annual bills for both the baseline and the original meter data were created using the non-time-of-use schedule (E-1).

Under PG&E's solar program, when a home's solar system produces more power than is consumed for a particular hour, it is recorded along with the rate per kWh for that hour. Every twelfth month is a "true-up month," in which PG&E deducts from that month's bill an amount equal to the rates for the surplus energy produced in the previous eleven months. This was confirmed with a representative of PG&E's Solar Customer Service Center. The value of the surplus solar power produced annually by each site was subtracted from the annual bill. PG&E also charges minimum daily energy and meter fees, but these fees were not included in these calculations.

- ***Results***

The goal of 70 percent savings on annual electric bills for ZENH homes was not achieved, with the average percent savings for all sites being 49.9 percent. Figure 42 is a graph showing the billing and energy savings as a percent of baseline.

[38] All relative precisions were computed at the 90% level of confidence. The relative precisions indicate what percentage of the estimates the error bounds represent. If the estimate plus or minus that error bound does not include 1, then the estimate is determined to be statistically different from 1.

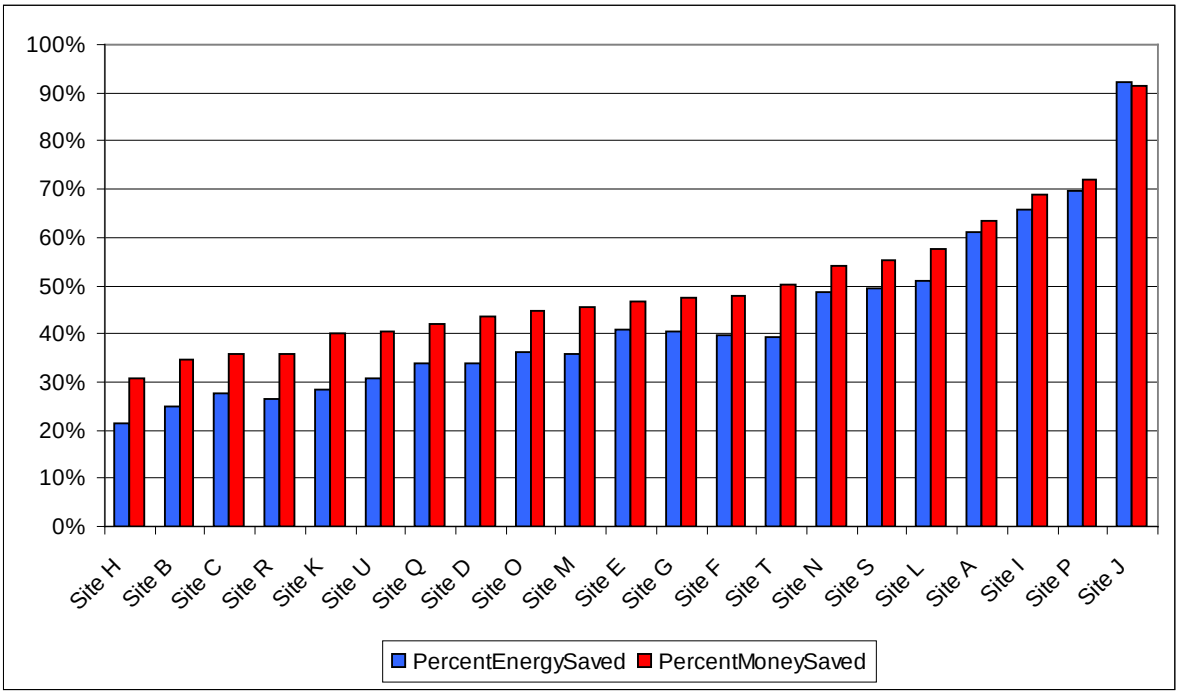

Figure 42: Percentage of Energy and Money Savings over Simulated Baseline Models

As shown in Figure 42, the amount of energy and money each home saved varies. Eight of the 21 sites had 50 percent or greater savings over the baseline annual bill. Site J, had the largest monetary savings, showing over 91 percent, had an annual bill of under $50 for the period from May 2008 to May 2009.

1.1.20.5 *3.5.3.5 Conclusions*

Of the four goals for ZENH program established by CEC, one was achieved: a minimum 25 percent improvement in efficiency over baseline. The goals of having no more than 1kW of peak demand during the summer months, homeowners paying no more than $5,000 up front, and having annual bills 70 percent less expensive than the baseline versions of the same site were not met.

3.6 Ensure ZENH Market Sustainability

The goal of this task is to initiate actions to ensure long-term sustainability of ZENH developments even in the event of no state subsidies or greatly reduced state subsidies.

A key component of reduced costs will be simplification of all the processes that differentiate a ZENH from a typical new home. This includes development of a set of energy-efficient features that builders will be willing to adopt, and that are readily available and affordable. Turn-key systems integration needs to be adapted to new residential construction.

Another key component is a large market for ZENH. The team will work with national builders active in California and work through them to expand the program outside California. In addition, task lead Building Industry Research Alliance (BIRA) is a US DOE Building America (BA) team; they propose to export the key findings from this project to other states and other

BA teams. Successful national market transformation will dramatically increase the market for both the energy-efficiency components and the solar components, increasing production and reducing costs.

The most appropriate and effective sales and marketing approach for ZENH's has to be determined in this project and promulgated through this task. Investing in on-site solar electric generation coupled with energy efficiency upgrades requires an attractive value proposition for both the builder/developer and the home owner with a positive impact to the home builder's core business through improved sales and/or margins.

- Transform the Marketplace 190
- Market ZENH Homes 204
- Increase Homeowner Demand 218

1.1.21. 3.6.1 Transform the Marketplace

[Editor's Note: ConSol originally developed the work in this section between 2005 and 2006. It served as some of the seminal work that served as a springboard for the work that followed. ConSol was subsequently replaced by Davis Energy Group. While a broad overview of considerations is made in this section, Davis Energy Group and SunPower were ultimately responsible for choosing the right ZENH mix of energy efficiency and PV measures and homebuilder partners, all of which are addressed in section 3.2, page 30.]

1.1.21.1 *3.6.1.1 Purpose*

This section provides a ZENH Marketing and Economic Plan, focused on the new home builder market for implementation of ZENH communities consistent with the SunPower ZENH program goals.

Energy efficiency features, target market opportunities, ZENH-beneficial utility rate structures, and rebate and incentive opportunities are identified.

This section begins the development of a market sustainability plan to ensure long-term success and growth of the ZENH residential sector and support efforts to develop a turnkey product.

1.1.21.2 *3.6.1.2 Market Overview*

Why does peak demand matter? Utilities attempt to provide every industrial, institutional, and residential customer with adequate electrical power whenever it is needed. They must be prepared to supply the maximum amount of electricity that might be demanded. During the lower "normal" electrical load periods, per kilowatt-hour electricity is cheaper. However, during a peak demand period, electricity is much more expensive to generate and distribute. Utilities pass higher peak demand rates onto their customers. Reducing demand and consumption during anticipated peak demand periods allows homeowners to save on the overall cost of electricity. In addition, PV usually works best during peak demand.

General Energy Efficiency Measures

The key element in designing a ZENH home is that the home must first reduce overall energy use through energy efficiency measures. These features are as follows:

R-38 attic insulation with radiant barrier – Higher insulation levels reduce heat gain in the summer and reduce heat loss in the winter. Radiant barrier at the inside of the roof reduces solar gain and keeps the attic cooler.

R-13 wall insulation (in mild climate zones) and R-13 + 1″ foam (in extreme hot climate zones)

3.5 SLA or low air infiltration rate - Tight building envelope helps to minimize outside/inside air from entering/exiting the home. With lower infiltration of unconditioned air and exfiltration of conditioned air, less conditioning is required, making the home more efficient. Homes with low air infiltration/exfiltration are often quieter and cleaner.

Dual pane, non-metal frame windows with spectrally selective glass with U- factor and Solar Heat Gain Coefficient no greater than those found in Table 51**.**

Table 51: Window Glazing Ratings

	U-value	Solar Heat Gain Coefficient (SHGC)
Slider	0.40	0.40
Single Hung	0.40	0.40
Fixed	0.40	0.40
Sliding Patio / French Dr	0.40	0.40

This type of glazing helps increase the comfort level of the home by reducing solar insulation into the house. In the summer, spectrally selective glass lets in visible sunlight while blocking 80 percent of both the infrared and ultraviolet solar energy that drives up cooling costs and degrades curtains, window treatments, carpeting and furnishings. In the winter, these glazing products offer reduced heating costs by reflecting room-side radiant heat back into the room[39]. In hot climates, this type of glazing typically enables builders to reduce the size of air conditioners and decrease other building energy related features.

Engineered System with Heating, Ventilating and Air Conditioning (HVAC) efficiencies of: 90 percent AFUE for furnace / 14 SEER (12 EER) for AC with thermostatic expansion valve (TXV) – Licensed mechanical engineers size and select HVAC systems, design duct sizes and register locations. The final product of these engineered systems will have properly sized and balanced HVAC systems with correct duct sizes and placement of registers to assure that conditioned air will be evenly distributed throughout the whole house. They will also provide improved efficiency and comfort. The TXV is a metering device for refrigerant flow into the evaporator of an air conditioner. A TXV improves efficiency.

[39] Supplemental Catalogue for Cardinal IG: LoE^2 Glass Products "The Choice for Year-Round Energy Savings and Comfort"

R-4.2 buried in insulation (R-13 equivalent) with tight duct and ACCA Manual D designed by a licensed mechanical engineer – Duct leakage can have a significant impact on HVAC performance, household infiltration/exfiltration rates, moisture levels in the house, water heater and furnace safety, and overall occupant comfort. A tight duct system is one that does not leak more than 6 percent of the fan airflow. Excessive air leakages in duct systems make HVAC systems work harder, using more time and energy to cool or heat the home due to insufficient air delivery. Leakage results in higher energy bills and less comfort for homeowners/occupants, which often triggers callbacks. Duct leakage typically occurs at:

- Poorly fitted and improperly sealed joints and seams in the ductwork
- Disconnected and partially disconnected boot connections
- Holes in the ducts
- Use of improperly sealed building cavities for supply and return ducts
- Poor connections between room registers and register boots
- Poorly fitted air handler doors, filter doors and air handler cabinets

Tight duct systems increase forced air distribution efficiency, resulting in improved comfort and lower utility bills for homeowners. Tight ducts are required to be tested by a third party.

Tankless water heater with a minimum Energy Factor (EF) of 0.82. R-4 insulation on all trunk lines, including any hot water lines located in concrete slabs or underground -- A tankless water heater has high efficiencies. Hot water is heated upon demand and has no storage tank.

Fluorescent lighting or incandescent with motion/occupancy sensor as per 2005 Title 24 standards

Gas dryer stub – Providing stubs encourages the use of gas dryers, which are less expensive to operate than electric.

1.1.21.3 *3.6.1.3 Candidate ZENH Efficiency Features*

While the overall energy efficiency measures listed above are important in all climate zones, the specific efficiencies, amounts of insulation and PV size may vary from one climate zone to another. Below are other possible ZENH features that could further enhance the energy efficiency:

T-Mass pre-cast concrete walls by Dow Chemical - Using STYROFOAM*-brand insulation in conjunction with leading edge concrete construction methods enables the construction of extremely energy efficient homes that better withstand the forces of hurricanes, tornados and wildfires (when compared with traditional wood frame construction).

Optimum Value Engineering (OVE) wall construction – OVE uses engineering principles to minimize material usage and labor costs while meeting model building code structural performance requirements and improving energy performance for the building.

Compressorless cooling options – These options reduce the compressor cooling loads in California houses and require an integrated systems design that includes the house design, building envelope, cooling technologies, and control systems and operation. This integrated systems approach to house design and performance is not part of current design practice.

Analysis tools, design guidelines, and demonstrated effectiveness with currently available technologies and building trades are necessary for alternative cooling strategies to be adopted, demonstrating to homebuilders and buyers that houses built with no or reduced compressor cooling can be comfortable, practical, and marketable.

Night pre-cooling (NightBreeze system) - Cool nighttime air is circulated through a home to remove heat stored during the day. This helps maintain cool temperatures during the day with little or no need for conventional air conditioning equipment.

Water-cooled AC compressor (Freus) - Water cooling is used to remove heat from the refrigerant and at the same time reduce the work of the compressor. Water cooled A/C achieves higher SEER than typical air cooled A/C in extreme hot weather.

Ducts in conditioned space – Placing ducts in conditioned space minimizes the 20-35 percent air loss that occurs if ducts are placed in attics, garages, or basements.

Buried ducts in attic insulation – Buried ducts can approach the energy performance of duct system located in a conditioned space

Movable shading – Shading acts as a shield to excess solar radiation

Movable insulation – Movable insulation such as insulative shade, shutter panels, or curtains can reduce heat loss at night and during cloudy periods as well as heat gain during the day in warm weather.

Radiant heated floors – Activated by a pump that circulates hot water through tubing in the floor, radiant heated floors have a reputation for being clean, quiet, comfortable and efficient.

Solar water heaters - Using the sun to heat either water or a heat-transfer fluid in collectors, a typical system will reduce the need for conventional water heating by about two-thirds.

1.1.21.4 *3.6.1.4 PV Systems*

Once a home has been made most energy efficient, a relatively small photovoltaic (PV) solar system can effectively lower the electricity usage of a home by half or more. According to many experts, there is no other form of energy that is more effective and pristine than electricity generated from a solar photovoltaic system. The beauty and elegance of this method of energy production is that it is continually self-renewing.

Many builders are moving toward Building Integrated Photovoltaic (BIPV) systems (laminate sandwiched between glass sheets), which are built into the roofing materials. For reasons, such as aesthetics, minimizing roof penetrations, and achieving discounts on bulk orders, BIPV systems are a good choice for production homes. Typical BIPV systems are 2.4 kW DC. These systems may vary depending on the home size and climate zone.

Although installing the PV system on the south orientation can produce maximum annual generation, it does not shave the peak load as much if it is installed on the west orientation. For most utilities, the system peak time (summer) is usually between 12 PM and 7 PM. To offset peak load, installing the PV system on the west orientation captures the most sunlight and maximizes kWh production.

1.1.21.5 *3.6.1.5 Criteria for Identifying and Prioritizing Top ZENH Markets in California*

Using the following criteria, market research was used to identify, size, and prioritize top ZENH markets:

- Highest new home growth areas
- Utility rate structures
- Climate zone

ConSol conducted a search of high new home growth areas in California for this report. Data from the Meyers Group, Sage Communications, and Construction Industry Research Board (CIRB) were sourced for the number of lots and building permits issued by each local jurisdiction.

Table 52 illustrates the median home price for various areas throughout California in the year 2004.

Table 52: 2004 Top Eight High Growth Areas and Median Home Prices

Area	Median Home Price 2004
Bakersfield	$199,000
Fresno	$221,500
Riverside	$276,000
Stockton	$290,000
Greater Sacramento	$356,000
Los Angeles/Long Beach/Glendale	$443,000
Oakland/Fremont/Hayward	$457,000
San Diego	$551,833

1.1.21.6 *3.6.1.6 Utility Rate Structures*

ConSol also researched various utility providers in the targeted area. California is a "net metering" state. Net metering allows consumers to offset the cost of electricity they buy from a utility by selling back renewable electric power generated at their homes or businesses. In essence, a customer's electric meter can run both forward and backward in the same metering period, and the customer is only charged for the net amount of power used. Net metering programs offer the potential for consumers to gain greater financial benefits from installing renewable energy systems.

Seven utility providers were researched for this report: Pacific Gas & Electric (PG&E), Southern California Edison (SCE), San Diego Gas & Electric and Southern California Gas (Sempra Energy), Sacramento Municipal Utilities District (SMUD), Roseville Electric, and Los Angeles Water and Power District (LAWPD). In addition to offering net metering, all utilities researched also offer time of use (TOU) and regular tier rate services. In studies based on software analyses, there are savings switching from tier to TOU rate structure in areas where the cost of electricity (kWh) is high. The savings may vary depending on the sizes of the homes, climate zones and the cost of electricity for each utility.

1.1.21.7 *3.6.1.7 Climate Zones*

The map below shows the 16 climate zones established by the California Energy Commission. ranging from cool coastal temperatures, to very high, often dry temperatures in inland and desert areas. Cool, coastal areas are less likely to require air conditioning, which is the single largest component of peak load on the energy system. We propose that residential marketing efforts should target the hotter climate zones such as zones 11, 12, and 13. Hot, dry climates enjoy abundant solar radiation almost year-round, providing the optimal conditions for effective use of PV electricity generation. These climates are also most likely to see heavy use of air-conditioning, which puts the greatest amount of strain on the utility grid particularly during the peak demand period.

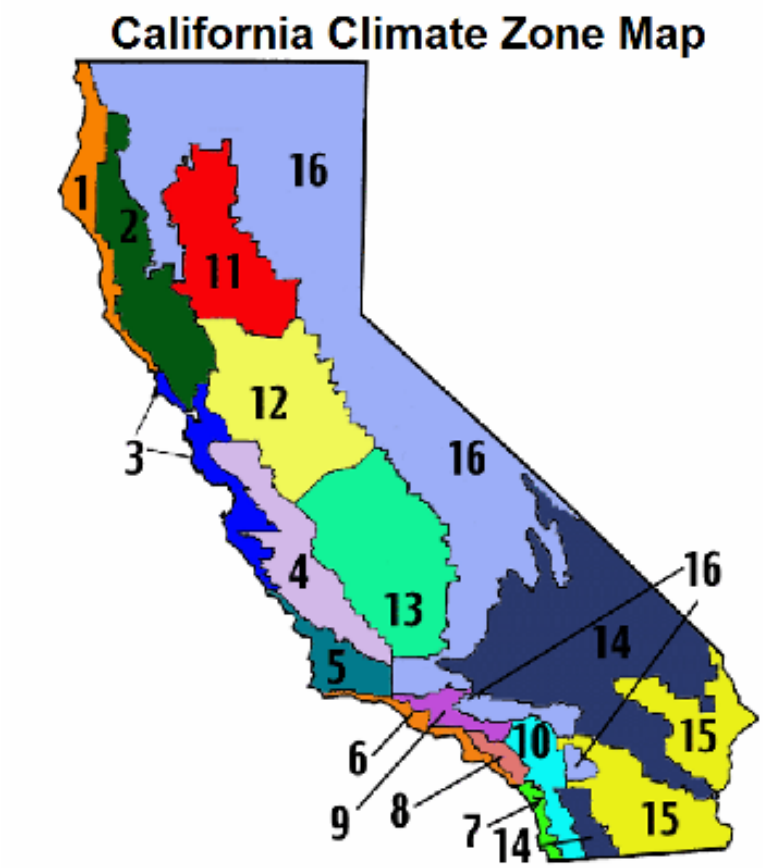

Figure 43: California Climate Zones

1.1.21.8 *3.6.1.8 Targeted Areas and Builders*

As the following tables illustrate, urban areas in California are still the fastest growing, i.e., Riverside, Los Angeles, San Diego, Greater Sacramento, Alameda County (San Francisco Bay Area), and Orange County (Southern California). These areas also have the highest density of new residential construction, as seen by the number of multi-family homes built.

The top seven growth areas of new residential home construction in California for the years 2004 and 2005 were identified, as follows:

Table 53: Top Seven High Growth Areas for Highest Residential Home Construction for 2004 and 2005

Rank	City/Cities	County	Climate Zone	Single family homes 2004	Multiple family homes 2004	Single family homes 2005	Multiple family homes 2005
1	Riverside, San Bernardino	San Bernardino	10	43211	8717	43600	5649
2	Greater Sacramento	Sacramento, Placer	11 & 12	18646	3581	15644	5361
3	Los Angeles, Long Beach, Glendale	Los Angeles	8 & 9	11717	15199	12057	12632
4	San Diego, San Marcos, Carlsbad	San Diego	7 & 10	9554	7752	8465	8605
5	Bakersfield	Kern	13	6634	800	7430	1158
6	Oakland, Fremont, Hayward	Alameda	3	6458	4622	6955	2819
7	Santa Ana, Anaheim	Orange	8	4289	4794	3333	5508

Correspondingly, the top three builders were identified in each of the areas, as shown in the following table:

Table 54: Top Three builders in the Seven High Growth Areas for 2004 and 2005

City/Cities	County	Climate Zone	#1 Builder(s)	#2 Builder(s)	#3 Builder(s)
Riverside, San Bernardino	San Bernardino	10	Lennar/KB Home	Pulte	K Hovanian/ Lennar
Los Angeles, Long Beach, Glendale	Los Angeles	8 & 9	KB Home	DR Horton	S&S/ Shapell
Greater Sacramento	Sacramento, Placer	11 & 12	Pulte	Lennar	Beazer
San Diego	San Diego	7 & 10	D.R Horton	Lennar	Shea Homes
Oakland/Fremont/Hayward	Alameda	3 & 4	Standard Pacific	Pulte	KB Home
Santa Ana/Anaheim	Orange	6 & 8	Standard Pacific	Shea Homes	William Lyon Homes/ John Laing
Bakersfield	Kern	13	Lennar	Centex	KB Home

1.1.21.9 *3.6.1.9 Federal Rebate Policies*

The energy bill passed by the US Congress and signed into law by President Bush in 2005 provides several energy-efficiency tax credits, as follows:

- A 30 percent tax credit for the purchase of residential solar water heating and photovoltaic equipment, with a maximum credit of $2,000 for solar equipment, expires 12/31/2007 (to the homeowner).
- A 10 percent personal tax credit for energy efficient improvements to existing homes, with a maximum credit of $500 ($200 for windows), expires 12/31/2007
- A business tax credit for new energy efficient homes, with a 50 percent credit for homes meeting certain standards, expires 12/31/2007.

1.1.21.10 *3.6.1.10 State of California Rebate Policies*

The State of California has passed much energy-related legislation over many years, such as appliance standards, energy efficient building codes and tax incentives. Additionally, there are several state agencies with broad overview of energy policy, such as the California Energy Commission (CEC) and the California Public Utilities Commission (CPUC).

California's Energy Action Plan, released in 2005, endorsed by the Governor, CPUC, and CEC, establishes energy efficiency as the state's top priority procurement resource. To implement this policy, the CPUC has laid the foundation over the past few years for an aggressive energy efficiency effort:

- Removing utility disincentives for investments in energy efficiency by decoupling revenues from sales,
- Setting stretch energy saving goals for the utilities,
- Requiring the utilities to invest in energy efficiency whenever it is cheaper than procuring power,

- Adopting an administrative structure that integrates energy efficiency into utility procurement, delineating clear rules for the efficiency programs, and
- Encouraging all stakeholders to work together to develop the next generation of efficiency programs.

The new administrative structure calls for the utilities to invest in energy efficiency whenever it is cheaper than power plants. As a result, California's largest utilities will more than double the level of energy savings achieved over the next decade, bringing enormous economic and environmental benefits to California. The energy efficiency programs will be implemented by a wide variety of entities, including private companies, local governments, non-profit organizations, utilities, future community choice aggregators, and community-based organizations, through partnerships and competitive solicitations administered by the utilities and overseen by the CPUC.

The CEC offers rebates of up to $2.80 per watt to builders who use photovoltaic solar systems in new home construction, which can be a substantial subsidy. These "buy downs" are critically important, because they act as incentives to builders and encourage them to use new technologies that take stress off the already over-stressed power grid. Note: the builder has a choice to get the rebate from the utilities or the CEC, but not both.

In California, where the legislature adopted net metering in 1995, residents can receive the full retail value of electricity generated by solar-powered systems (between 8 to 32 cents per kilowatt-hour [kWh], depending on the utility) and use existing electric meters to measure the flow of electricity between their home and the utility company. On sunny days, the resident's solar system is often able to provide all the household electric needs and generate excess electricity to sell to the utility. In the evenings or on cloudy days, the household will often use power from the utility. Since the consumer sells power and buys power at the same rate, the utility bill is calculated only on the net electricity that the consumer bought from the utility. Metering is usually done monthly, although occasionally the period extends for a full year.

1.1.21.11 *3.6.1.11* *Rebate Impact*

In recent ZEH projects in CA, rebates from the utilities or the CEC were the determining factor in building ZEH for builders. Builders are more inclined to build ZEH with rebates and incentives to offset their initial costs. Up to date there are approximately 900 ZEH homes built in California and many are on the way. With the new $2000 federal tax credit to the builder for building 50 percent above the 2003 International Energy Conservation Code (IECC), builders are also more inclined to increase the energy efficiency measures of the building envelope. Typical ZENH and ZEH homes usually have these high energy efficiency measures already and will save even more energy once coupled with a PV system. In addition, there is also a $2000 tax credit to the homeowner for installing a PV system. Through the ZEH/Building America program sponsored by the US Department of Energy, ConSol has found that builders are likely to build ZEH and ZENH homes with rebates and incentives (up to 50 percent) to offset their first costs.

1.1.21.12 *3.6.1.12 Current and Proposed ZENH Projects*

While developing the ZENH marketing and economic plan, ConSol and SunPower are already pursuing builders to build ZENH. ConSol is responsible for developing the energy efficiency measures while SunPower is responsible for sizing the PV systems. Both concepts are sold to the builders as one ZENH package. Below are the current and proposed ZENH projects since ZENH program started in July of 2005.

Table 55 lists the projects currently committed to the ZENH program.

Table 55: Current ZENH Projects

Builder	City / Climate Zone (CZ)	Project Name	#of Homes
Victoria Homes	Victorville, CA (CZ 14)	Orange Grove Villas	86
Victoria Homes	Victorville, CA (CZ 14)	Victorville Estates	155
Centex Homes	Pleasanton, CA (CZ 12)	Avignon	31

Table 56 lists the projects that have demonstrated interest in participating in the ZENH program but have not committed as of this report.

Table 56: Proposed ZENH Projects

Builder	City / Climate Zone (CZ)	Project Name	#of Homes
Centex Homes	Fresno, CA (CZ 13)	TBD	TBD
Castle and Cooke	Bakersfield, CA (CZ 13)	TBD	TBD

1.1.21.13 *3.6.1.13 Summary and Conclusion*

New home developers have resisted installing PV because of high initial costs, aesthetics, disruption to their production schedule and fear of the unknown or change. However, new product is now visually pleasing and by constructing the most energy efficient homes and then adding a right-sized PV system as standard, construction costs and disruption can be minimized. Incentives can reduce the first costs. Innovators who have overcome the fear factor have discovered that their sales have happened quicker with less advertising and with incredible amounts of good will press. The innovators, those brave souls who pull for change, are very important to getting the next group of builders on the bandwagon and will help transform the market.

The innovator builders' stories and their successes lend a comforting factor to those builders less inclined to try new ideas. A great tool to sell the next wave of builders will be to tell these stories covering different topics. Stories about successes and solutions to problems will be the most effective way to educate and encourage those standing on the sidelines, anxious to cross over, but cautious. The innovators' experience and knowledge can address the construction angle (installation, issues with city, inspections, call backs, grid hook-up), the rebates, the warranty, the public relations and press events, the sales agent training and their perspective, the home owners' manuals, the buyers' questions and enthusiasm or lack thereof.

A targeted list of potential big builders has been created. Progressive builders must show:

- Demonstrated willingness to work with new technology

- Interest in environmental issues
- Experience with PV
- Desire for market differentiation.

It is critical to note that the big builders have not been the innovators, but we have recently seen some of them test the waters (KB Home, Centex). It might be prudent to continue to seek out the smaller or medium builders who are more agile, who don't have to report to a Board of Directors, and who are less likely to resist change. But big builders will transform the market more quickly so if their experience is positive they will pull the majority of the market with them. Price points in targeted climate zones should also be a consideration. Median home prices in the hot, dry areas continue to rise at a healthy rate and appear sustainable for the long term.

We cannot influence incentives and rebates, but we can involve the utilities at an early stage. If the utility provides incentives or support, builders are usually more inclined to build ZENH. Helping the builder apply for all rebate/incentives and filling out the utility agreements will ensure a smoother process.

Buyers have resisted PV as well. When available as an option, they view PVs as just one more thing that might need maintenance; high additional costs without a clear picture of return on investment; and too futuristic for their circumstance. Besides, with the hot real estate market we have recently experienced, just buying a house, nearly any house, was the task at hand. And then, tangible items like Corian and game rooms, are the options of choice over long-term investment.

Clarum Homes built 247 homes with solar as standard. In a survey of those buyers, we were amazed to find many did not know what they had until after they had it. This occurred despite an informative green room display that had to be entered to get to the models and well-informed sales agents who loved their product and promoted it greatly. Only when they got their utility bills did the buyers realize that they had found a pot of gold. The same could also be said of two Premier Homes communities with PV as standard. The buyers now question each other monthly as to how low their electric bills are and are eager to have the lowest. Some of these buyers have appeared on national TV as well as in Newsweek magazine. It is essential to create a clear marketing message for potential homebuyers.

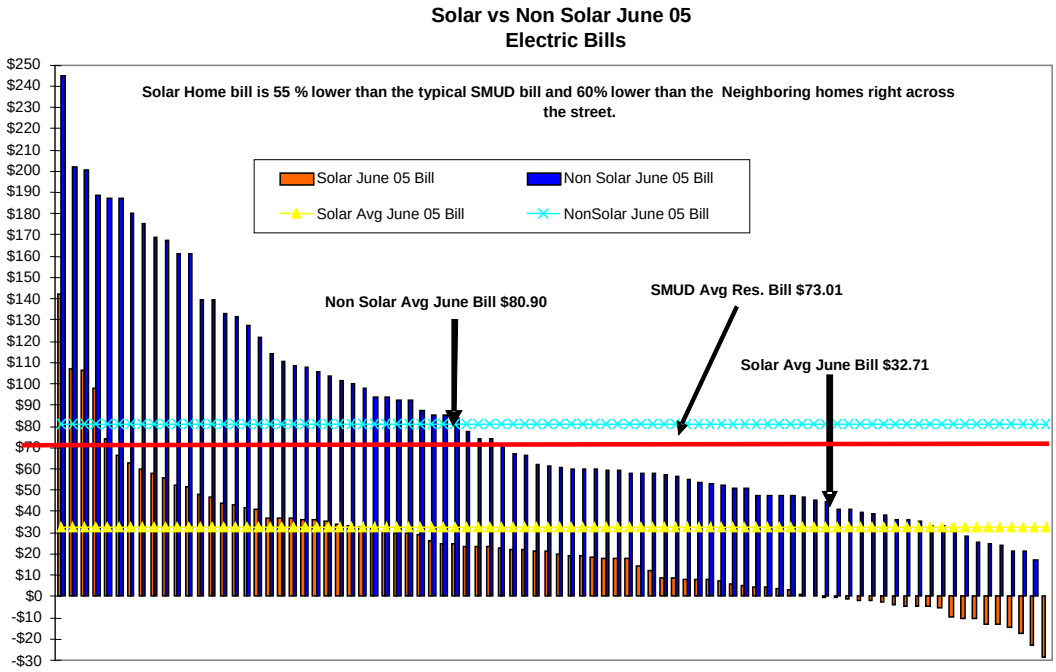

Figure 44: June 2005 Electric Bill Comparisons

More and more energy-related stories appear in the press and it is important for us to help feed the market pull with a stream of generic articles on the benefits of PVs coupled with real life stories. Developing a consumer media list will be an important first step. Home sections of major newspapers as well as monthly new home guides are always looking for a new twist on an old story.

In the end, it is critical to develop a market sustainability plan that promotes and ZENH approaches and business models to other new homebuilders and developers.

A market sustainability plan for targeted builders will include:

- Assurance product will be available
- Pictures of BIPV
- Cost Analysis
- Turn-key product offering and menu of features
- Step By Step Guide for Builders
- Builder sales materials
- Builder media list
- Builder success stories
- Availability
- Issues with city
- Production schedule
- Issues with utility agreement to tie to the grid
- Rebates
- Sales agent training

- Public relations
- Press events
- Green rooms
- Buyers' questions and enthusiasm or lack there of
- Warranty
- Home owners' manuals
- Call backs
- Training procedure for building officials
- Implement preferential local building department point system for entitlements
- Training procedure for installers

A market sustainability plan for buyers will include:

- Focus group with some PV owners, some junior high kids (They ask tough questions.)
- Develop clear market message
- Create consumer media list
- Develop buyer collateral
- Maintenance
- Clear picture of return on investment
- Homeowner Manual
- Press
- Benefits of PV coupled with real life stories

1.1.22. 3.6.2 Market ZENH Homes

The goal this section is to develop a marketing strategy to promote and sell ZENHs in California by building brand recognition, awareness, and education of the benefits of ZENHs.

Under this task, SunPower, new home builders, and external marketing professionals worked together to develop an effective sales and marketing approach for ZENHs that many leading national builders have adopted in their sales practices. SunPower has and continues to work extensively with its builder partners to obtain critical feedback that is used to improve the marketing collateral.

Builders often remark that they will build what buyers demand. As a result, SunPower has focused much of its marketing effort on the secondary homeowner market, with the ultimate goal of driving demand for ZENHs. As demand increases, additional builders will offer solar as a standard feature until the supply of ZENHs has penetrated the entire new home market.

Until the day when solar is standard on all homes in California, builders will benefit from a competitive differentiator that will help them to sell homes faster. This, in turn, will drive further builder adoption of solar.

SunPower developed a "New Home Builder Sales Kit" (discussed below) with the goal of assisting new home builders to sell and promote ZENHs to prospective homebuyers, to help them sell more solar homes, and to do so faster than the non-solar competition. By putting the builder's brand first whenever possible, allowing the builder to benefit from name-recognition

among consumers. SunPower's marketing materials have furthered the goal of increased solar adoption among both consumers and home builders.

SunPower has taken a comprehensive view on marketing materials for solar-efficient communities. Rather than list features, we have worked alongside builders to tell integrated stories that cohesively explain the features and benefits of living in a solar and energy efficient home.

This starts with the builder's branding and its key messaging. Often with help from SunPower, builder partners will create brands around solar-efficient homes. SunPower and builders then develop co-marketing campaigns that focus on these brands. SunPower trains its sales staff based on tenets of the brand, and it develops point of sale materials to complement those efforts. The integrated marketing pieces become fundamental to the builder sales process. They are used frequently by builder sales agents to enhance consumer understanding of solar-efficient homes.

An effective marketing package and a quality product become more important as the homebuilding market becomes softer. With homebuilders reducing marketing staff and budgets on a regular basis, the SunPower team has had more marketing demands from builders. The Energy Commission plans to launch the statewide promotional campaign for new solar homes beginning in Spring 2008, which we anticipate will help with the adoption of ZENHs.

The following sections contain a description of the copyrighted materials that constitute SunPower's standard New Home Builder Sales Kit.

The marketing campaign implementation tasks are described in section 3.6.3, "Increase Homeowner Demand".

1.1.22.1 *3.6.2.1 Marketing Collateral*

The standard marketing materials that SunPower and the builder develop consist of the following copyrighted items:

- "How Solar Works" mural
- SunPower Solar and Builder DVD
- "Solar Powered Home" poster
- Monitoring kiosk with iMac display
- Inverter and computer signage
- Paper collateral
- "Now is the time for SunPower" handout
- Frequent Questions sheet
- SunTile® product sheet

SunPower also provides builders with copy and image assistance for customized collateral for brochures and builder websites, SunPower video clips, community listings on SunPowercorp.com, and grand opening and media event planning. SunPower asks builders to provide a room in each community's model home complex for materials displays. If space is

available in the sales office, SunPower works with the builder to install small teaser or informational displays that direct the customer to the solar-efficient room. SunPower also asks builder to provide their solar and energy efficiency feature lists, wall dimensions for the mural, an Internet connection, a television and DVD player.

SunPower provides a "Guide to my ZENH" handout to buyers at closing. The homeowner manual is described later in this deliverable and is intended to set expectations and ensure customer satisfaction by answering many questions about the solar system.

"How Solar Works" Mural

SunPower develops murals for each builder partner, customized to each community. The murals contain information on how solar works, with brief descriptions of the components of a solar system, and descriptions of the other energy efficiency and environmental features in the homes. Figure 44 and Figure 45 show two examples of banners. Figure 46 shows an example of banners installed in model homes.

Figure 45: Lennar SOLAR*plus* Banner

Figure 46: Grupe Green Banner

Figure 47: Installed Banner Examples

SunPower Solar and Builder DVD

SunPower has produced and distributed custom DVDs for our builder partners. The builders use the DVDs for a variety of purposes, including television airing, solar room displays to educate potential buyers, and to educate their sales agents. The DVDs cover these four main topics: How it Works, Technology, Design, and Savings. To view the custom Lennar DVD, visit www.lennarsolarplus.com. Figure 47 shows an example of the DVD playing in a Lennar model home display room.

Figure 48: Lennar DVD Display

"Solar Powered Home" Poster

SunPower developed the poster displayed in Figure 48 for builders to easily show buyers the components and the benefits of a solar system. This poster is often used by builders in the interim period before customized co-marketing materials are developed. SunPower takes copies of the poster to events and conferences when an informal display is required.

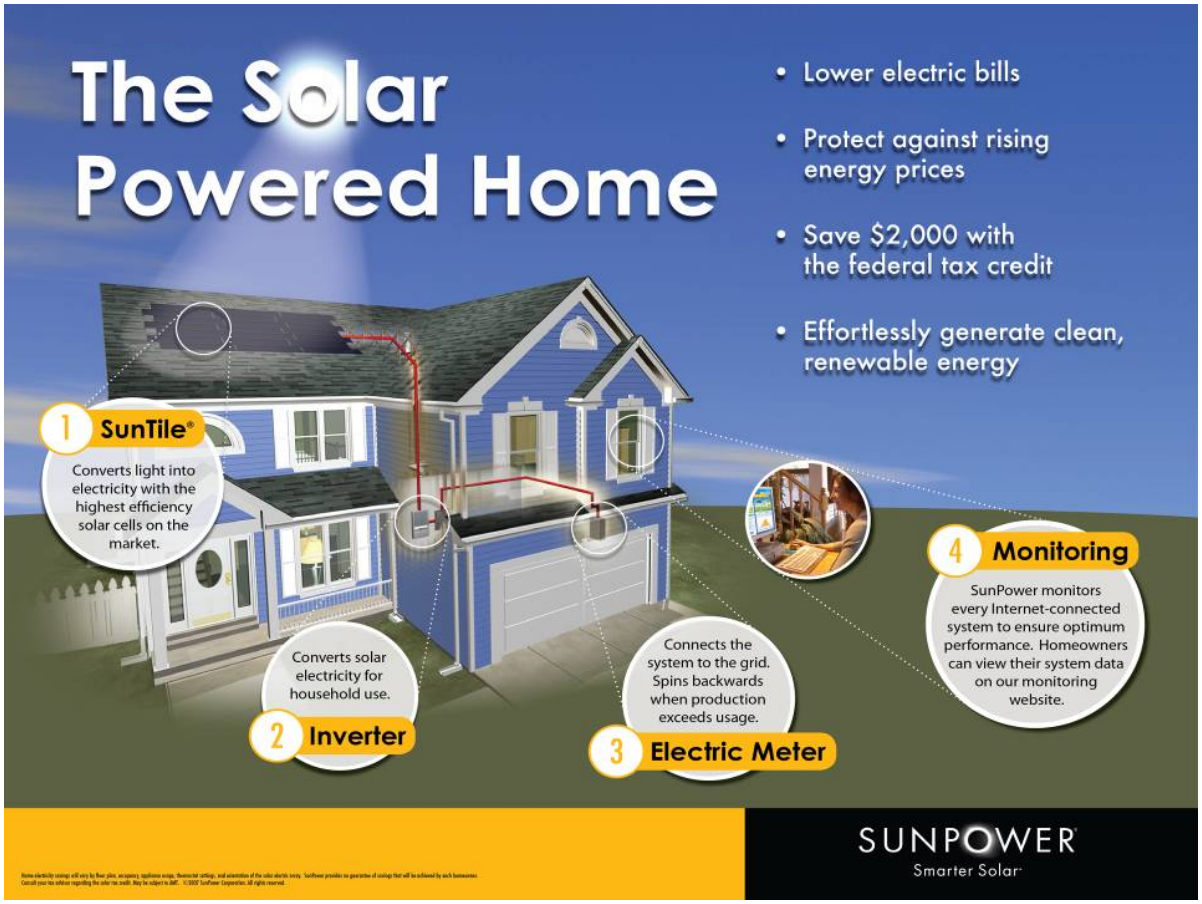

Figure 49: "Solar Powered Home" Poster

Monitoring Kiosk with iMac Display

SunPower provides an education kiosk that is sited within a model home at each community. The education kiosk contains information on the benefits of ZENHs for buyers, typically on a wall display and take-away sales collateral. A main feature of the kiosk is the iMac that has a real-time display of a sample home with a SunPower PV system and the online performance and consumption monitoring. The homebuyers can view the amount of electricity consumed and generated by the sample home by hour in the current day, daily for the past month, and monthly for the past 12 months.

The iMac has been programmed to show live performance monitoring data immediately upon start up. Sales agents are not required to perform any maintenance or have technical knowledge to operate the kiosks. This is important to ensuring that kiosks are online and working when potential customers visit the sales office or solar/EE room.

Figure 49 shows examples of education kiosks that SunPower has developed in conjunction with builders and external marketing professionals for Lennar and Grupe Homes.

Figure 50: Examples of Education Kiosks in Display Rooms

Inverter and Computer Signage

SunPower works with the builders to develop signage for all of the solar components in the display room. Many of the display rooms contain an inverter, a performance monitor display, and a SunTile® mock-up. SunPower ensures that all of the signs are consistent with the builder brand and that the benefits of the system are effectively communicated.

Figure 50 shows examples of the inverter and computer signage that SunPower created for Lennar and Meritage Homes.

Figure 51: Example Inverter and Computer Signage in Display Rooms

"Now is the time for SunPower" Handout

SunPower provides each of the builders with the option of using the flyer shown in Figure 51 as sales collateral for homebuyers. The builders that are early in the process of integrating solar into their communities are more likely to use this general brochure. Once builders have a better understanding of the solar technology and the benefits that are specific to their region and communities, most builders opt to develop their own customized brochures with the assistance of SunPower.

Figure 52: SunPower Handout

Frequent Questions Sheet

SunPower provides each of the builders with the handout shown in Figure 52 to answer homebuyer questions. While the sales agents are trained on this information, SunPower wants to ensure that no homebuyer leaves a community with unanswered questions. SunPower encourages sales agents to call SunPower staff whenever they are asked a question that they cannot answer.

SUNPOWER

FREQUENT QUESTIONS

SOLAR BASICS

How do I turn the SunPower system on?

The system turns on and off automatically every day.

How do I know if my system is working properly?

Check for a green light on your inverter during daylight hours, or check the SunPower Performance Monitoring Website (sunpowermonitor.com).

Will my system work at night?

At night, your home draws electricity from the local utility and the inverter displays that it is offline. Sunlight must be present for the system to generate electricity.

Will my system work on cloudy days?

Yes, though it will produce less electricity depending upon the thickness of the cloud cover.

Will my system work during blackouts?

Since there is a chance that the SunPower system could feed electricity into the electric grid, safety requirements prohibit the system from producing electricity during blackouts. The system will restart automatically when power is restored.

Should I limit shading from trees?

Yes, if possible. Panels must receive full sunlight to work at their peak efficiency. If any portion of a panel is shaded, the entire panel's electrical output—even those sections still exposed to sunlight—decreases.

How long will my SunPower system last?

Because they have no moving parts and are made of inert materials, SunPower SunTile and Solar Panels are inherently durable. Their cells are backed by a 25-year power output warranty, and the related system components are designed to last for many years without incident.

Are solar electric systems good for the environment?

Energy created through the SunPower system produces no pollutants. By offsetting peak electricity demand, SunPower systems reduce the need for oil and gas-fired power plants. Over a thirty-year period, a 2.3 kWp system typically offsets the same amount of greenhouse gases as 30 acres of trees.*

What are solar cells and solar panels?

A solar, or photovoltaic (PV), cell is the smallest element of a system that converts sunlight into electricity. Each cell is made of silicon, which is the same material found in computer chips. Silicon in photovoltaic cells is treated so that it generates a flow of electricity whenever it is exposed to light. A series of solar cells are wired together to form solar panels.

*Source: EPA EGRID2000 database

www.sunpowersolarhome.com

Figure 53A: FAQ Handout

Are solar cells new technology?

Modern solar cells were invented in the early 1950s and were used to power satellites. In the 1970s, they were used for remote telecommunications and navigational aids. In the 1980s, they were used for roadside emergency telephones and traffic signs. Now in the 21st century, they help power your home.

Are solar electric systems safe?

Yes. Solar cells are mostly silicon, the primary component of sand. Solar electric systems produce no exhaust or toxic materials. The electricity coming through the inverter is like the electricity coming from household wall sockets. Homeowners should use the same care they do with any electricity. All components are approved for utility interconnection and are installed according to the best construction practices.

What maintenance is required?

No maintenance is required. The system turns on automatically in the morning and turns off automatically at night.

Can I increase the size of my system? Why isn't the system larger?

Homeowners cannot increase their system size. Your system has been optimized for your inverter, roof layout, and home. It is designed to be cost effective, offsetting your home's most expensive electricity consumption.

ELECTRICITY

Can I generate heat for my home with a residential solar electric system?

Not usually. Solar electric systems are designed to provide electricity to operate lights, appliances and other electric devices in the home, which may include electric heating systems.

Does my SunPower system make hot water?

No. SunPower Solar Panels and SunTile convert sunlight directly into electricity to operate appliances, light fixtures, televisions, and other electronic devices.

What is a kilowatt-hour (kWh)? How many kWh does my home consume?

A kilowatt-hour is a measure of electricity. It is the amount of power (kilowatts) used over a period of time (hours). A 60-watt light bulb that is illuminated for one hour uses 60 watt-hours of electricity, or .060 kilowatt-hours. If it is illuminated for a half-hour, the bulb will consume .030 kWh of electricity, or half as much. The average home consumes about 20 kilowatt-hours of electricity per day, or 600 kWh per month. Depending on size, time of year, and weather, SunPower systems produce from 1 kWh to more than 10 kWh per day.

THE LOCAL UTILITY AND INTERCONNECTION

Can my system produce enough energy to meet all of my electricity needs?

Not usually, but solar electric systems do not need to provide all of a home's electricity to be of significant value to homeowners. Cutting electricity usage by 40 to 50 percent is typically the most cost-effective approach for home solar power.

Can I be completely independent from the utility? Can I store my electricity?

No, though homeowners can purchase a backup storage system, which SunPower neither provides nor sells. The SunPower system credits any surplus electricity with the utility at market rates. The utility essentially acts as your storage system.

How do I sell my surplus electricity back to the utility?

At certain hours and on certain days, homes with solar electric systems will often produce more electricity than they consume. Through a "net metering" arrangement with the local utility, your surplus electricity is credited against your bill.

What else can I do to reduce my energy costs?

Homeowners can increase their savings by making wise energy decisions. This includes turning off lights and appliances when not in use and selecting Energy Star appliances, including refrigerators, dishwashers, washing machines, and dryers.

Printed on recycled paper

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Figure 53B: FAQ Handout

SunTile® Product Sheet

Occasionally builders encounter more technical homebuyers that ask for detailed information on the solar array specifications. SunPower provides the builders with the following product sheet that describes the features and benefits of SunPower's solar cells and modules.

SUNPOWER

FEATURES & BENEFITS

More Power
Cells deliver up to 50% more power than conventional technology

No Shading
Optimal solar cell placement reduces shading from upper roof tiles

Roof Integrated
Unique all-black roof tiles blend seamlessly into all Flat and S-Tile roofs

No Maintenance
Features robust solid-state technology with no moving parts

Safe & Reliable
Withstands up to 110 mph wind-driven rain and UL® Class A fire rated

SUNPOWER SUNTILE®

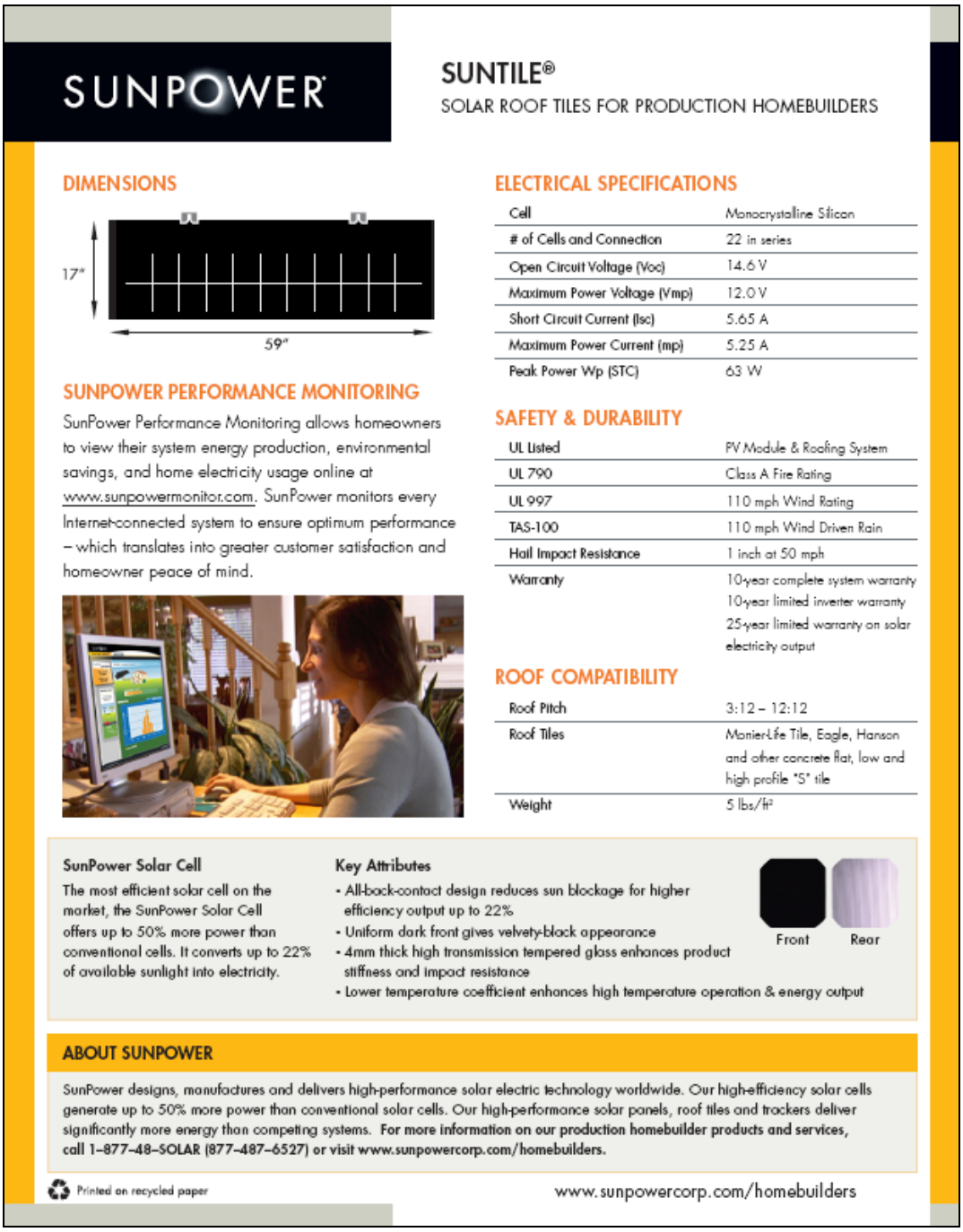
SUNTILE®

SOLAR ROOF TILES FOR PRODUCTION HOMEBUILDERS

SunPower SunTile® is a high-efficiency, roof-integrated solar tile for new production home communities. SunTile blends seamlessly into flat and S-Tile roofs while generating clean, renewable energy. Its unique, all-black appearance complements the design of any home.

www.sunpowercorp.com/homebuilders

Figure 54A: SunTile® Product Sheet



SUNPOWER

SUNTILE®

SOLAR ROOF TILES FOR PRODUCTION HOMEBUILDERS

DIMENSIONS

17"

59"

SUNPOWER PERFORMANCE MONITORING

SunPower Performance Monitoring allows homeowners to view their system energy production, environmental savings, and home electricity usage online at www.sunpowermonitor.com. SunPower monitors every Internet-connected system to ensure optimum performance – which translates into greater customer satisfaction and homeowner peace of mind.

ELECTRICAL SPECIFICATIONS

Cell	Monocrystalline Silicon
# of Cells and Connection	22 in series
Open Circuit Voltage (Voc)	14.6 V
Maximum Power Voltage (Vmp)	12.0 V
Short Circuit Current (Isc)	5.65 A
Maximum Power Current (mp)	5.25 A
Peak Power Wp (STC)	63 W

SAFETY & DURABILITY

UL Listed	PV Module & Roofing System
UL 790	Class A Fire Rating
UL 997	110 mph Wind Rating
TAS-100	110 mph Wind Driven Rain
Hail Impact Resistance	1 inch at 50 mph
Warranty	10-year complete system warranty 10-year limited inverter warranty 25-year limited warranty on solar electricity output

ROOF COMPATIBILITY

Roof Pitch	3:12 – 12:12
Roof Tiles	Monier-Life Tile, Eagle, Hanson and other concrete flat, low and high profile "S" tile
Weight	5 lbs/ft²

SunPower Solar Cell

The most efficient solar cell on the market, the SunPower Solar Cell offers up to 50% more power than conventional cells. It converts up to 22% of available sunlight into electricity.

Key Attributes

- All-back-contact design reduces sun blockage for higher efficiency output up to 22%
- Uniform dark front gives velvety-black appearance
- 4mm thick high transmission tempered glass enhances product stiffness and impact resistance
- Lower temperature coefficient enhances high temperature operation & energy output

Front Rear

ABOUT SUNPOWER

SunPower designs, manufactures and delivers high-performance solar electric technology worldwide. Our high-efficiency solar cells generate up to 50% more power than conventional solar cells. Our high-performance solar panels, roof tiles and trackers deliver significantly more energy than competing systems. **For more information on our production homebuilder products and services, call 1-877-48-SOLAR (877-487-6527) or visit www.sunpowercorp.com/homebuilders.**

Printed on recycled paper

www.sunpowercorp.com/homebuilders

Figure 54B: SunTile® Product Sheet

Community Listings on SunPowercorp.com

SunPower lists all of the new home communities with SunPower solar on the main SunPower website[40]. See Figure 54. As the SunPower brand permeates the market through primary

[40] *www.sunpowercorp.com/For-Homes/Homebuilders/New-Home-Communities.aspx*

marketing channels such as print, radio, and television advertising, more potential buyers will be driven to the SunPower website, providing added value to builders.

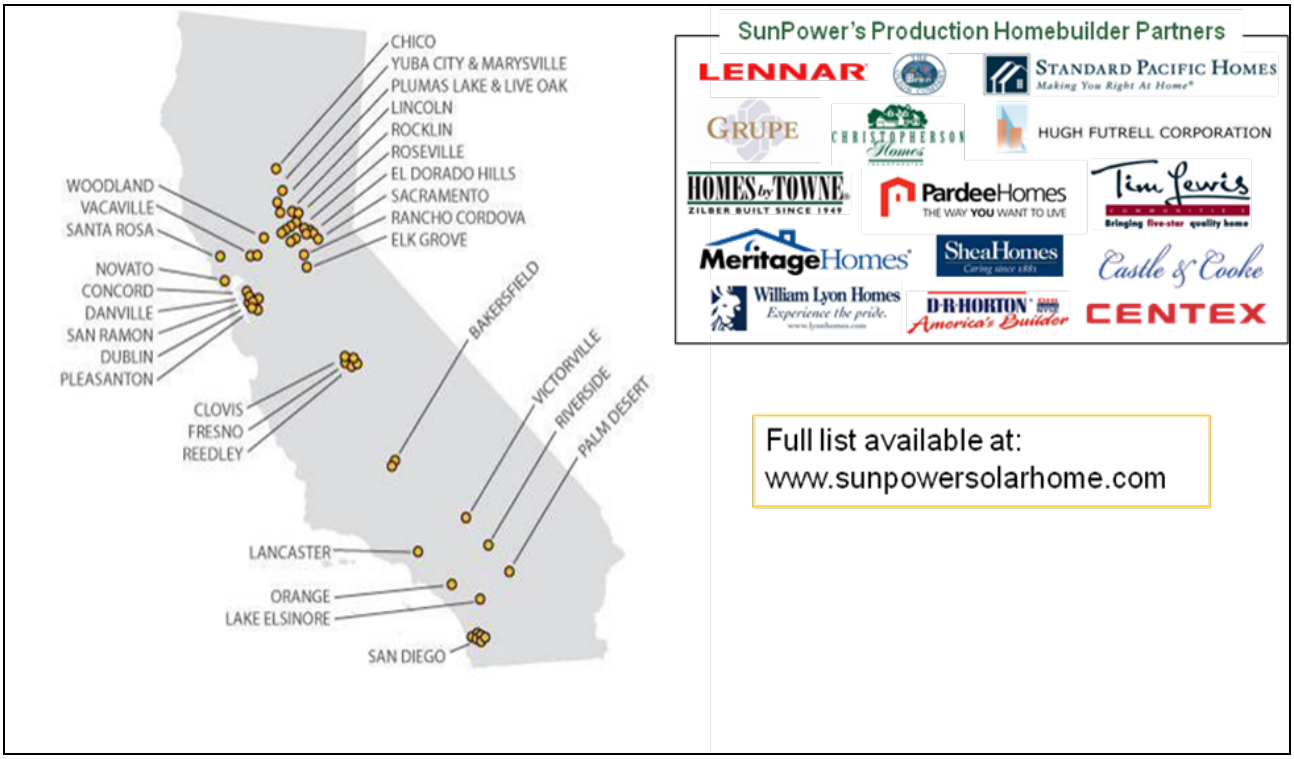


Figure 55: Community Listing on SunPower Website

Builder "Brand Building" around Solar and Energy Efficiency

Figure 55 displays a number of the brands that builders have developed around their solar and energy efficient offerings. Builders are capitalizing on the heightened cultural interest in being "Green" by promoting the homes as environmentally friendly.

Solar and energy efficiency are more than a capital materials investment. They significantly improve the comfort and the quality of the home, they reduce the environmental impact, and they attract people that want to integrate energy and environmental awareness into their lifestyle. Builders that have built brands around these features are ahead of the market; they will benefit the most from the growing awareness of green and environmental issues.

Depending on the builder, SunPower will fully develop a solar and energy efficiency brand for use at the builder's solar/EE communities.

Figure 56: Builder Brands around Solar and Energy Efficiency

1.1.22.2 *3.6.2.2 Conclusion*

SunPower has developed a comprehensive set of materials with builders and external marketing professionals to sell and promote ZENHs. The marketing effort to date has been successful, measured by the increasing adoption rate of new solar homes in California. SunPower will continue to work with the relevant parties to adapt the sales and marketing approaches as the market evolves. It is clear that builders will build what buyers demand. Therefore, SunPower plans to focus our future marketing on driving consumer demand to increase the adoption rate of ZENHs. (See section 3.6.3.) This future marketing will consist of a more informational approach with information to substantiate savings claims, while not losing focus of the main need: increasing basic consumer awareness of solar homes.

1.1.23. 3.6.3 Increase Homeowner Demand

In order to increase homeowner demand SunPower assisted new home builders to drive demand for ZENHs among potential homebuyers. SunPower conducts co-marketing campaigns with all of its builder partners. While the specific content and distribution channels of the campaigns varies by builder and region, the basic focus of the campaigns remains the same – to promote ZENHs in the California home buying market.

This section contains a summary of the types of marketing initiatives that SunPower has conducted.

1.1.23.1 *3.6.3.1 Marketing*

SunPower's marketing efforts to new home buyers are essential to the continued success of new solar homes in California. Through our co-marketing efforts with our builder partners, we identify and capitalize upon opportunities for marketing and promotion of solar, energy efficient homes.

Depending on builder need, SunPower either provides materials or helps customize them for the builder's re-use. SunPower adapts its work in whatever way will help leverage the builder's large capital investment and produce additional and faster sales. To that end, SunPower has conducted new solar home marketing initiatives with a variety of media outlets, such as newspapers, radio, online, and trade shows; produced brochures, DVDs, and other collateral for builders' own use; and encouraged the re-mixing and re-use of content for educational and marketing programs as they present themselves.

SunPower has created structures and content that enables its builders to explain their solar, energy efficient homes to new home buyers in simple and clear terms. Builders can reuse SunPower content and infrastructure as necessary as new media and advertising opportunities arise, or as they expand their solar programs across divisions and regions.

In all of these materials, SunPower is sure to position itself as an "ingredient" in the builder's program. In this way, new home buyers will more often remember the builders' brands (rather than SunPower), which in turns leads to greater sales compared to the non-solar competition.

The initiatives for each of these mediums are described below.

Talking Points for Builders

SunPower provides builders with customized talking points for television or radio interviews. The talking points help builders to concisely convey the benefits of their solar + energy efficiency offering by explaining some key topics, such as why builders are adopting solar, the federal tax credit, advances in solar technology, and grid interconnection. The generic talking points that SunPower customizes and provides to builders are:

- ***Background for Interviewer***
  - [*Builder*] has made the decision to build [x] communities in [region] with solar and energy efficiency features
  - *[Builder's]* brand for homes with solar and EE is *[builder solar and EE brand]*
  - Focus on *[builder solar and EE brand]* Homes, with SunPower as an ingredient brand.
  - Focus the discussion on *new* solar and energy efficient homes, and ***not*** solar as a retrofit for existing homes.

- ***Why has this division of [builder] decided to offer solar electric as a standard feature?***
  - *[builder]* wants to provide their buyers with the best in class homes on the market, with the highest quality features as standard
  - People looking to buy a new home are starting to look and ask for these features
  - The cost is much less if done during construction (e.g., volume pricing, smaller system requirements, done while the home is being built)
  - Energy costs are increasing, solar will protect our customers from rising energy costs
  - Rebates from the California Energy Commission pay for 30 percent of the system cost
  - New homes sales data shows that solar communities are selling faster than non-solar communities

- ***So [builder] is not just including solar on all homes for marketing appeal?***
  - Not at all - these homes are built to higher standards along with featuring solar
  - *[builder]* has an effective package in *[builder solar and EE brand]*
  - *[builder]* is forward-thinking across the board - they realize solar and energy efficiency are the future of home construction
  - They are not just putting solar on homes, they are also making them extremely energy efficient, 30-35 percent better than code requires.

- *[builder]* selected SunPower panels, the most advanced technology and aesthetically pleasing in the world for new homes

➢ ***What are the benefits of buying a new solar home over a non-solar new home?***

- Significantly lower utility costs (average $1,000 to $1,500 savings per year, or 40-60 percent)
- Higher resale value
- One-time $2,000 federal tax credit
- Protect against rising utility costs by freezing electric bill, resulting in an increased value of system and savings over time
- Generating clean, renewable, and reliable energy is good for the environment (part of the solution)
- *[builder solar and EE brand]* homes are more comfortable with the energy efficiency features
- Homeowners exchanging daytime excess power for future energy needs
- House remains connected to the electric utility at all times, so any power needed above what the solar system can produce is simply drawn from the utility (grid acts as battery)

➢ ***Is there something new about solar technology that has led to such rapid inclusion in new home construction?***

- Most of what we are doing today is what we call "building integrated". Most new homes in [region] are built with concrete flat tile roofs. SunPower's SunTile product simply replaces concrete roof tiles. They end up looking like roof tiles, they perform the same functionality as roof tiles, it just so happens they also produce electricity.
- If fact, most people do not even notice these systems on the roof when they pass by because they look so much like the rest of the roof.

➢ ***Do these homes cost a lot more than comparable non-solar homes?***

- Surprisingly, the answer is no. Because new solar homes have been selling faster than non-solar homes, *[builder]* is able to offer these features standard at no additional cost.

➢ ***Are there many new solar home communities available in the [regional] area to choose from?***

- *[builder]* has made the decision to build 100 percent of their new homes in the region with solar and energy efficiency as standard features
- Right now we have [x] new home communities that will be 100 percent solar

➢ ***How can our listeners find out more about [builder] and where to find all these new solar home communities?***

Television and Online Advertising

SunPower has recently embarked upon an enhanced co-marketing campaign with a ZENH demonstration community partner, Lennar Corporation. The goal of this enhanced co-marketing campaign is to assist Lennar with developing a scalable, successful and repeatable marketing program in order to drive sales of their solar and energy efficient home offering (homes featuring SOLAR*plus*).

News10, the ABC-affiliate in the Sacramento area, was selected as the media outlet for the television campaign. They were selected because of their high rating in the area, and because they are launching an environmental education campaign called 'Living Green'. The Living Green campaign provides News10 viewers with information on environmentally friendly alternatives.

The campaign has television, online, and solar educational seminar components that are described below.

- Television Spots
    - 30 second Lennar SOLAR*plus* promotional commercials (24 spots/month)
    - Live 6-minute appearances on Sacramento & Co. (Six per year)
- Web Advertising on News10 website
    - Web banners on rotating pages advertising SOLAR*plus* communities
    - 5 second pre-rolls on streaming web videos
- Microsite featuring Lennar's SOLAR*plus* offering (www.lennarsolarplus.com). See Figure 56, below.
- Content developed by SunPower and approved by Lennar
- Linked from Living Green website
- Hosted by Lennar
- Content includes
    - SOLAR*plus* DVD
    - List of SOLAR*plus* communities, linking to Lennar website
    - Calendar of SOLAR*plus* community events

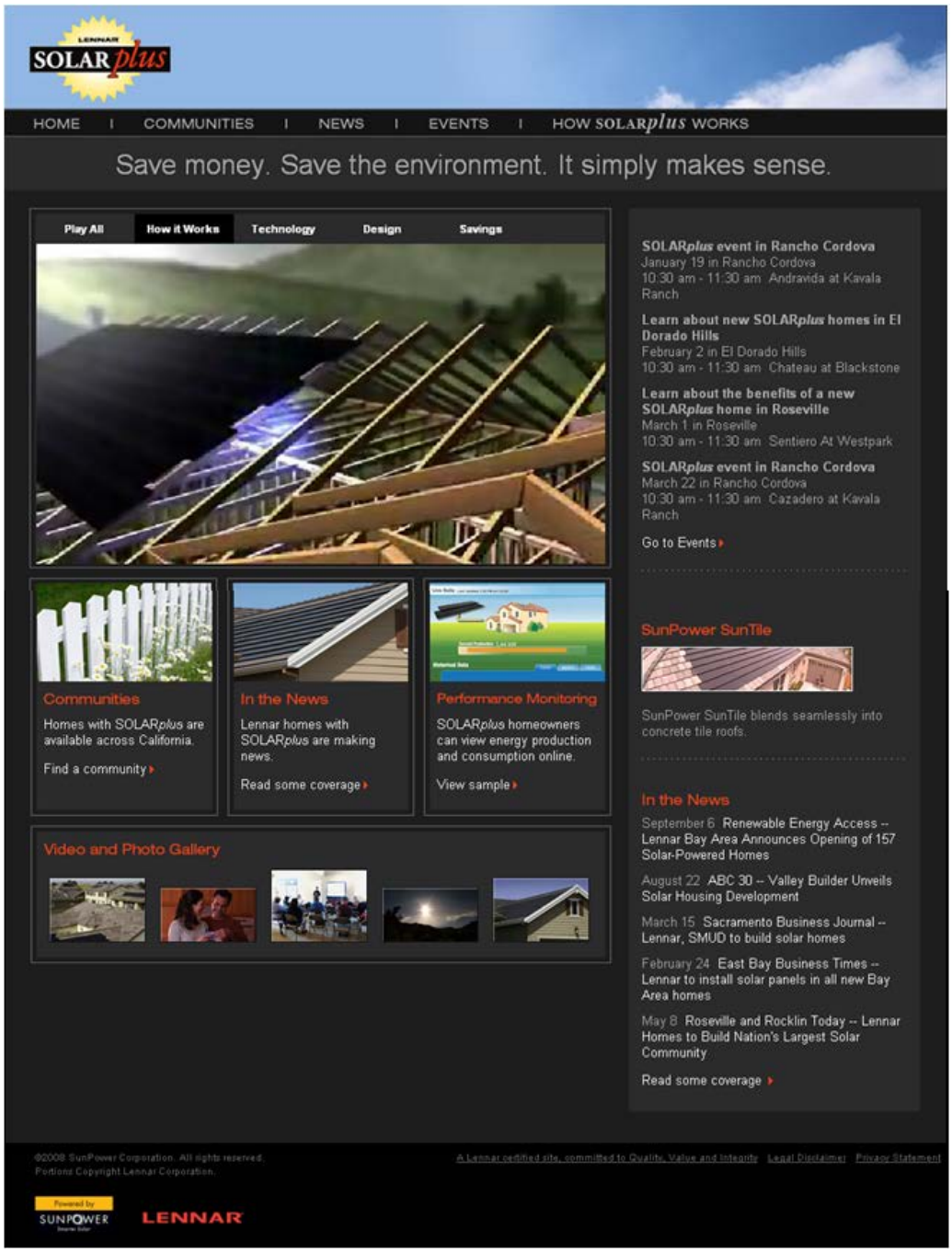


Figure 57: Lennar SOLAR*plus* Microsite – Front Page Screen Capture

Community Events

SunPower currently hosts monthly SOLAR*plus* community events as part of the Lennar enhanced co-marketing campaign. These events are designed to educate potential homebuyers and new homeowners about solar and energy efficiency in order to increase sales and improve customer satisfaction. The events currently rotate to different communities in Sacramento, and occur on Saturdays in the late morning or early afternoon in a model home. Up to three

SunPower staff will attend each event. SunPower provides a 1 to 1.5 hour presentation on the following topics:

- SOLAR*plus* features and benefits
  - The *plus* of SOLAR*plus* - Energy efficiency
  - How solar electric systems work
  - SMUD billing
  - Federal Tax Credit
- What other solar homeowners and the media are saying
- SunPower Online Performance Monitor
- Warranty and Service
- Q&A

Web Marketing

SunPower's main website contains information targeted to new home buyers that are interested in solar communities in California. The SunPower website contains a map of California with links to all new home communities with SunPower solar as shown in Figure 57. SunPower has a broad-based marketing campaign aimed at raising awareness of the SunPower brand, which drives customers to the SunPower website.

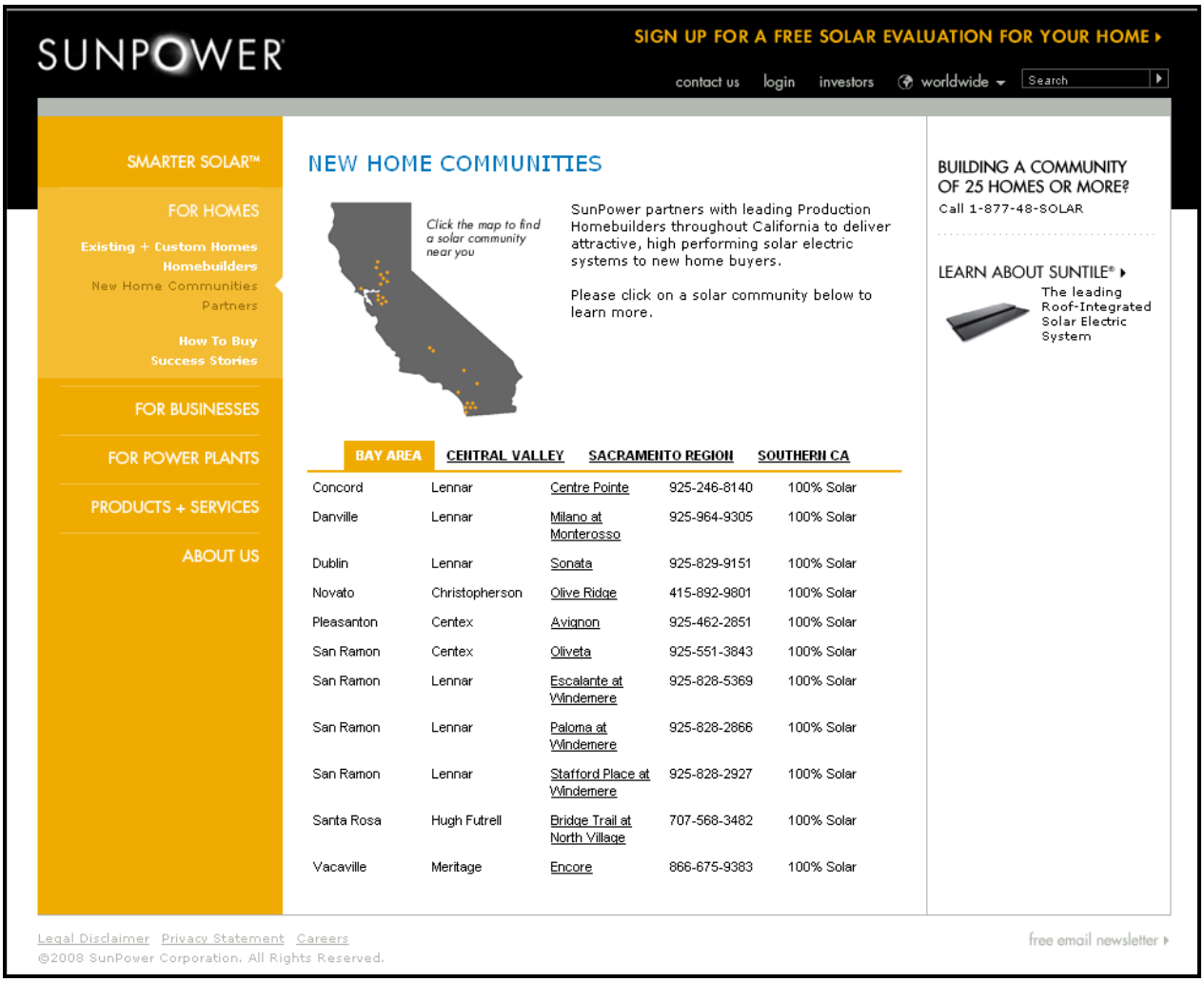


Figure 58: SunPower Corporation Website

Print Advertising

SunPower has not directly advertised in any newspapers or magazines. However, it frequently reviews and provides copy for builders to use in print ads. Examples of this work have included ads with the Olson Company, Lennar, and Meritage Homes Corporation.

Radio

SunPower frequently capitalizes upon radio opportunities to promote solar, energy efficient homes. For example, on January 30, 2008, SunPower's PR team secured an interview for one of builder partners, Shastan Homes, on the KPAY station out of Sacramento, CA.

In 2007, SunPower's Sacramento Region New Homes Account Manager was a guest on the Brett Gove show, a local Sacramento show on real estate. The audience for the Brett Gove show is new home buyers. During the show, Brett and SunPower's representative discussed the benefits of new solar homes, how people could learn more about solar, where new solar homes are available, among other solar topics.

SMUD recently produced radio ads to promote a solar event that SunPower hosted at a new Lennar solar community in Rancho Cordova.

Trade Shows

SunPower attends and presents information on the benefits of solar new homes at key conferences that target home builders. Conferences that SunPower's new homes team have attended include:

- PCBC 2005, 2006, and 2007 – booth and presentation
- BIS '07– booth and presentation
- Solar Power 2007 – booth and presentation

SunPower is also exploring ways in which it can work with builder partners to promote new solar homes at homeowner-focused expos and events.

1.1.23.2 *3.6.3.2 Public Relations*

SunPower's Public Relations team works directly with builders to promote new solar home communities. Our PR team can work independently or alongside a builder's existing agency. As with our marketing programs, SunPower offers flexible solutions and assistance to fit a builder's particular region, demographic, and PR requirements.

To date, the primary focus of our PR efforts has been grand opening events in which we invite featured speakers, the press, and solar homeowners to celebrate the opening of 100 percent solar communities. As markets develop and solar communities proliferate, SunPower's PR efforts on behalf of builders transition to local media pitches to newspapers, television, and radio stations. We seek lifestyle articles and features on solar communities that will help drive continued traffic to our builder partners' communities.

Events

SunPower frequently arranges, directs, or assists with grand opening events for new solar home communities. Most PR efforts begin with a Media Day for the press, often during the week, and a grand opening event the following weekend. Media Days drive press coverage, which in turn drives homeowner traffic for the grand opening event.

Both events are primarily designed to educate customers and build awareness whether through the press or directly, of ZENH features and availability. SunPower assists builders with setting up on-site solar demonstrations and media outreach, and often presents information on the solar and energy efficiency benefits of the community at both the Media Days and grand openings. Our representatives answer questions, conduct demonstrations, and assist builder salespeople during this important launch period.

Figure 59: Grand Opening Events at ZENH Communities

Other Press Coverage

SunPower writes press releases and arranges for press coverage for other significant milestones throughout a community's sales stages. A sampling of the press that SunPower has assisted with is listed below:

Press Releases

- Lennar Wins 2007 SEPA Award for Solar Business Achievement
- Meritage Homes' 'Zero Energy' New Home Community Combines Solar Power and Energy Efficiency
- Hugh Futrell Corporation Opens First Solar Home Community in Sonoma County

Print

SunPower builder partners have been featured in the following major newspapers as a result of its combined marketing and PR efforts:

- New York Times
- Wall Street Journal
- San Francisco Chronicle
- Sacramento Bee
- LA Daily News
- Fresno Bee
- C|Net News.com

Television

SunPower's new home builder partners have received television coverage from the majority of the national and local media outlets. Below is a sampling of the television stations that have run stories on SunPower solar in the new home communities.

- CBS Evening News
- Good Morning America
- ABC 7 in Bay Area
- New York Times Online Video
- ABC News 10 in Sacramento
- News 17 in Fresno

1.1.23.3 *3.6.3.3 Conclusion*

SunPower has assisted new home builders to drive demand for ZENHs among potential homebuyers using a variety of media outlets. SunPower is fully committed to supporting builders during the downturn in the housing market, as advertising budgets are slashed, by increasing marketing assistance to builders. SunPower's corporate marketing team recently dedicated additional resources to the new homes marketing effort, amounting to over $100,000 for the year.

1.1.24. 3.6.4 After Sales Support

1.1.24.1 *3.6.4.1 Introduction*

SunPower understood early on in the development of the ZENH offering that high homeowner satisfaction would be critical to the adoption of solar in the new home market. As a result, SunPower has allocated significant resources to post-sales support and customer service in order to drive customer satisfaction higher. The goal of this task is to develop a plan to support customers who have invested in ZENHs and to facilitate referrals for builders. This section describes SunPower's effort to support customers with SunPower solar systems on their new homes.

1.1.24.2 *3.6.4.2 Dedicated Post-Occupancy SunPower Team*

SunPower developed an in-house customer service team dedicated solely to support new solar home buyers. This primary goal of this team is to respond to customer correspondence in a timely manner. The team has representation in multiple regions in the state in order to resolve issues within a short time frame.

The goal of the team is to respond to all emails and calls within three hours and to have all issues resolved within 72 hours. The customer service team provides a hardcopy of the "Solar Basics Homeowner Manual" (see: to all new homeowners upon move-in. The manual was designed in order to make solar ownership a positive and enjoyable experience by educating the homeowner. (The manual content is described in section 3.3.4, Tailored Maintenance, Warranty and Customer Service, page 161.)

SunPower Performance Monitor

The SunPower Performance Monitor is a web portal that contains system information for new homeowners, including both system performance data and customer-service related tools. On page 230, see Figure 59: Performance Monitor Guide and the following web portal screenshots that follow.

The portal and its components allow homeowners to interact with their system in a way that is not possible with the current generation of solar electric system components (e.g. simplistic inverter and wireless displays). The software is configurable and allows SunPower to add new features and customer service programs as the company receives user feedback and develops new performance parsing technologies.

As shown in SunPower Online Performance Monitor features four sections with the following information to support homeowners:

- *Home* – Provides production and consumption graphs in daily, monthly, and annual formats to show that solar system is working correctly.
- *Solar Basics* – Provides overview of system benefits. Homeowners can download the solar manual (a hardcopy is also provided upon move-in). Provides information on interconnection, utility billing, federal tax credit. Contains links to IRS and utility interconnection forms (where necessary). Lists all frequently asked questions and responses to these questions.
- *Service* – This section contains a service request form with an area to describe possible issues with the system. SunPower responds to all service requests from the portal within a 1 business day.
- *My Account* – Allows homeowner to enter personal contact information for SunPower to use to contact them in the event of a system issue. Using this contact information, SunPower has been able to contact homeowners after downtime events – including power outages and tripped breakers – to help restore system functionality.

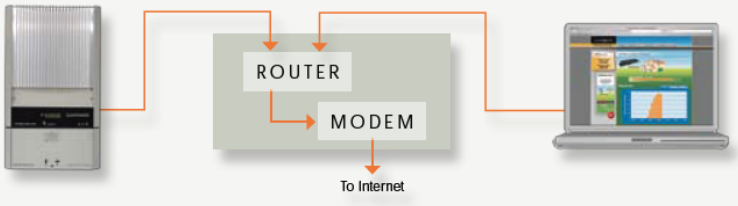
SUNPOWER

PERFORMANCE MONITORING SETUP

SUNPOWER PERFORMANCE MONITORING

24 Hour Peace of Mind — Absolutely Free

- Connect to SunPower's 24-hour solar monitoring system
- 10 years of solar monitoring is included with the purchase of your solar system, compliments of your home builder
- Maximize your potential energy savings by monitoring your home energy use
- Predict your utility bill before it arrives – a great way to manage expenses
- It's fun and educational – Share with your friends and teach your children about solar electricity
- To add performance monitoring to your solar system, follow the steps below or call **1-877-344-6637** to set up a service apppointment.



CONNECTING YOUR SYSTEM TO PERFORMANCE MONITORING IS EASY AS 1,2,3

1 Connect the Solar Cable

Locate your home's structured wiring hub, either in your garage or master bedroom closet. The solar cable is inside the wiring hub.

Plug the solar cable into an open network port on your Internet router or modem.

2 Record the Inverter Number

Locate your home's solar power inverter in your garage. The inverter number is under the barcode and begins with the letter "B". You will need this number to complete step 3.

3 Register Online

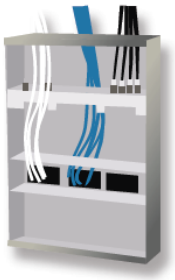
Visit **sunpowermonitor.com** and follow the online instructions. Once completed, you can begin monitoring your energy production and usage immediately. Return any time, using your email and password, and watch your solar system's performance-24 hours a day!

Figure 60A: Performance Monitor Guide

SUNPOWER

LOCATING THE INVERTER NUMBER

Your system's unique identification number, required for online registration, is located on the inverter in your home's garage. Look for the label on top of the inverter. The number, which starts with the letter "B," is located under the barcode in the above diagram. The identification number is nine characters long (e.g. B12345678).



STRUCTURED WIRING HUBS

A structured wiring hub is a feature in many homes that allows Internet, telephone, and cable television wires to be routed to any room in your house, enabling multiple computers in different rooms to share the same Internet signal. The telephone, cable, or DSL service enters the house at the hub. Typically, a router splits Internet connections into several network signals that are sent to other rooms. In most houses, the structured wiring hub is located in the master bedroom closet or the garage.

ROUTERS AND MODEMS

To take advantage of structured wiring features—including SunPower Performance Monitoring—you should install your Internet modem (cable or DSL) and home networking router in your home's structured wiring hub. If a technician installs your Internet service, be sure to tell them to take advantage of your home's structured wiring capability by placing your modem and router in the structured wiring hub.

CUSTOMER SERVICE

For a service appointment to assist with monitoring setup, call 1-877-34-HOMES.

For further information about your SunPower Solar Electric System or help with monitoring, please refer to your homeowner manual, email us at residentialservice@sunpowercorp.com, or call 1-877-34-HOMES (1-877-344-6637).

sunpowermonitor.com

Printed on recycled paper

Figure 60B: Performance Monitor Guide (page 2)

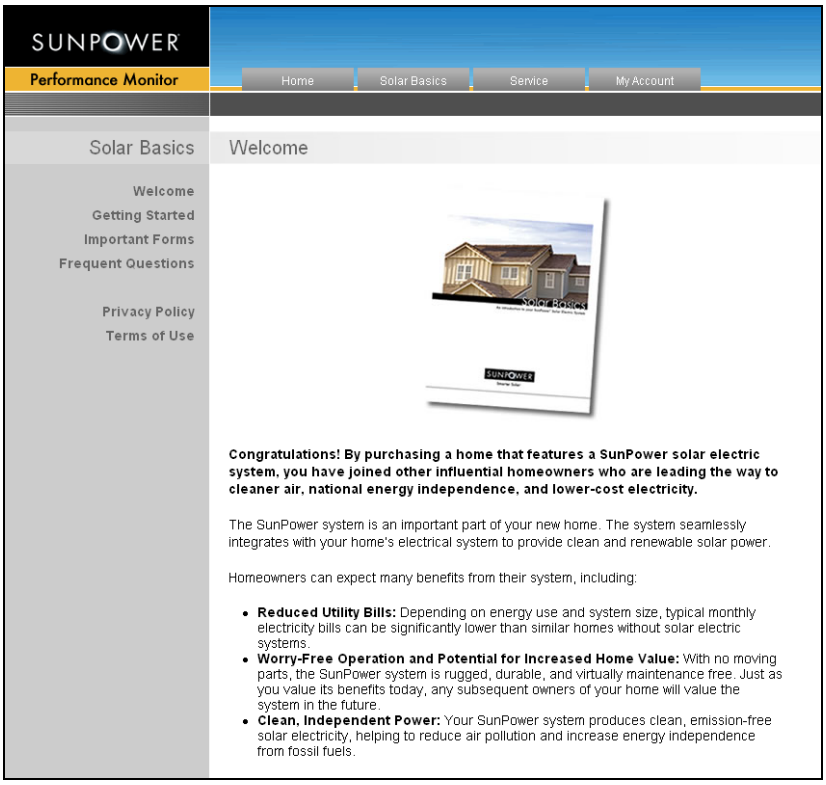


Figure 61: Online Portal "Solar Basics" Tab

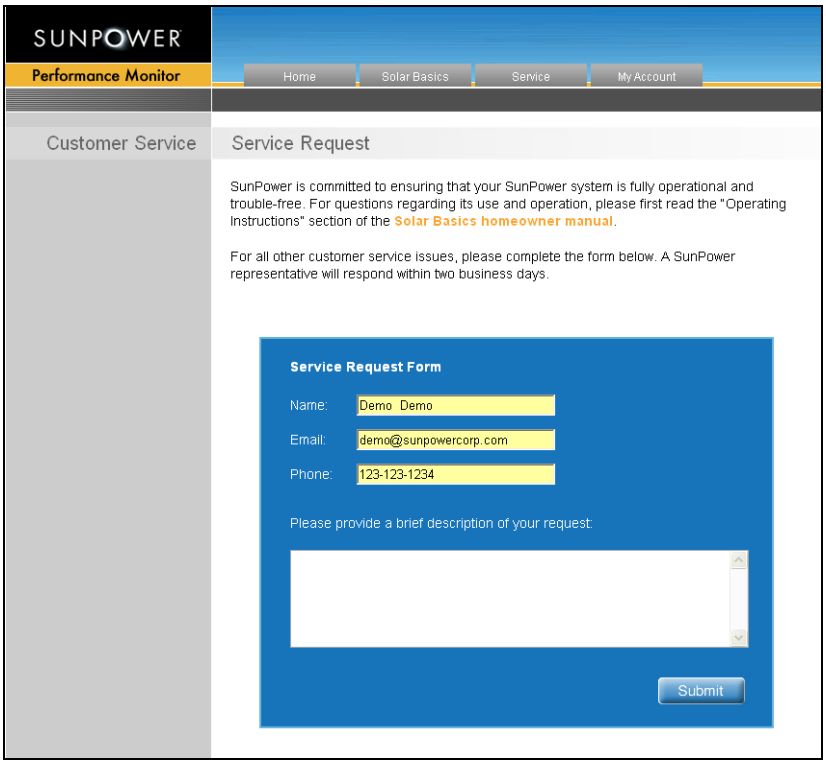


Figure 62: Online Portal "Service" Tab

1.1.24.3 *3.6.4.3 Pre-emptive Response*

SunPower's web-based monitoring infrastructure not only reports system performance to homeowners, but also reports performance to SunPower to ensure optimum system performance. SunPower has developed a robust toolset for interpreting system data. The downtime reports, alerts, and performance benchmarking metrics enable our field technicians to recognize system downtime, inverter issues, and other performance inhibitors before a homeowner is aware she has an issue with her system.

Once SunPower is aware of a potential issue, we schedule an appointment, diagnose, and resolve the issue within our standard timeframe. SunPower's system awareness greatly increases system uptime and homeowner savings compared to traditional systems. With standard solar electric technology, homeowners might not know that their inverter is offline or that their system has been disconnected until they have received their electric bill, and even then, many homeowners might not realize the problem or call for service until many months after a system issue presents itself.

1.1.24.4 *3.6.4.4 Connection*

SunPower believes that Performance Monitoring is critical to customer satisfaction and service. To encourage uptake by homeowners, we are developing a suite of educational tools that smooth system connection and registration. Early examples include:

- www.SunPowersolarhome.com/basis – A developing website with instructions for connecting and registering for monitoring.
- SunPower Performance Monitoring Setup sheet – A piece of paper collateral with instructions for connecting and registering for monitoring.
- SunPower Solar Basics Homeowner manual (discussed further in section 3.3.4, Tailored Maintenance, Warranty and Customer Service).

1.1.24.5 *3.6.4.5 Customer Care Agents*

New homeowners require basic information about their solar system at or before move-in in order to prevent confusion and reduce the number of initial service calls. All builders provide new buyers with a walk-through of their new home upon move-in. SunPower trains these agents on the critical information to transfer to homeowners, such as information for connecting their monitoring system, on expectations from their solar system, cleaning and maintenance, etc. SunPower also developed laminated cards that all agents receive and use during the final walk-through to reference the appropriate information (Figure 62). SunPower has developed unique cards for various regions and utility districts.

PG&E ORIENTATION REFERENCE CARD

Before Orientation

1. Confirm that the inverter is operating – call SunPower if any concerns
2. Bring copy of Solar Basics homeowner manual

Customer Orientation

1. Introduce how the system works
2. Provide Solar Basics homeowner manual
3. Homeowner will receive two statements from PG&E – added together, they make up the monthly charges
4. Performance Monitoring is free – connect system to Internet service in the home's structured wiring panel
5. Federal tax credit – apply during first year of home ownership

Answers to Frequent Questions

- The system is **maintenance free** and does not require cleaning.
- The system is connected to the grid and **contains no batteries**. At night, **your home draws power from the grid**. During blackouts, the system shuts down as a safety precaution.
- The system **does not produce hot water** and will not affect natural gas bills. Other features in your home will help to reduce natural gas bills.
- SunPower offers industry-leading technology: SunPower cells are **the most efficient on the market**. They are 50% more efficient than conventional solar cells and up to 100% more efficient than thin film solar cells.
- SunPower has **sized your system appropriately** for your home. It has been **designed to offset the most expensive electricity** while fitting within the community's roof design and exposure constraints.
- **The SunPower warranty covers system components for 10 years and solar cell output for 25 years.**

Contact SunPower Customer Service

1.877.34.HOMES | residentialservice@sunpowercorp.com

Figure 63: Example Walk-Through Reference Card

1.1.24.6 *3.6.4.6 Homeowner Orientations*

SunPower provides builders with the option of hosting solar orientations, targeted at both potential homebuyers and new homeowners. The builders develop the invite lists for the events and SunPower provides all the content for the presentation. The events are typically held within a model home at a solar community. The agenda for one of the Lennar presentations is shown below.

The primary goal of these events is homeowner orientation. In addition to homeowner education, we also try to solve homeowner issues following the orientation session. If a

homeowner has a problem with their system, a SunPower customer service agent is usually present to answer questions or schedule an appointment – often directly after the event.

As a secondary goal, these events can help build enthusiasm for solar, energy efficient homes. We have found that when homeowners and potential buyers attend the same event, the current solar homeowners help sell the benefits of solar to buyers by providing live testimonials, lending credibility to SunPower's solar benefits claims.

The homeowner attendees have been overwhelmingly satisfied with their systems, and this comes through at the events. We have received very positive feedback from the event attendees, who are eager to learn about solar and surprised to receive personalized responses to their questions.

- SOLAR*plus* features and benefits
    - The *plus* of SOLAR*plus* - Energy efficiency
    - How solar electric systems work
    - SMUD billing
    - Federal Tax Credit
- What other solar homeowners are saying
- SunPower Online Performance Monitor
- Warranty and Service
- Q&A

Figure 64: Example Solar Event Flyer for a Lennar Community

Figure 65: December 2007 Solar Orientation at Lennar Wayfarer at Westpark Community

Figure 66: December 2007 Solar Orientation at Lennar Laureate at Westpark Community

1.1.24.7 *3.6.4.7 Conclusion*

Each day, it becomes clearer that high homeowner satisfaction is critical to the adoption of solar in the new homes market. SunPower is committed to ensure high satisfaction for our builder clients, and the company continues to identify ways to maintain satisfaction. SunPower strives to increase the level of satisfaction until all customers are completely satisfied with their systems, and all new home buyers demand solar systems as a standard feature on their home.

3.7 Refine Residential BIPV

The goal of this task is to develop several key residential BIPV system enhancements to improve performance and reduce its delivered cost.

At the commencement of the ZENH program, PowerLight – a separate entity from SunPower – was PV agnostic as it sought out the best products for the best designs in BIPV. As such, the

original intent of the work in this section was to work with a multitude of different PV manufacturers. Work began and the following report was written but, shortly thereafter, PowerLight was acquired by SunPower. With readily available access to the most efficient PV cell technology in the marketplace, the need to work with multiple PV manufacturers was obviated.

The work documented herein recounts the efforts and accomplishments SunPower achieved in designing, building and rolling out market leading BIPV products.

- Develop Alternate PV Laminates 240
- Enhance PV Designs 242
- BIPV Design Lessons Learned 247

1.1.25. 3.7.1 Develop Alternate PV Laminates

This report summarizes the research that PowerLight conducted to investigate the feasibility of utilizing PV laminates from various manufacturers in order to allow for greater product flexibility, increase cost competitiveness, and maximize performance. The ultimate goal of this task was to provide the greatest flexibility to PowerLight and its builders to enhance ZENH market sustainability by providing a PV manufacturer-neutral BIPV product.

1.1.25.1 *3.7.1.1 Results*

PowerLight had a longstanding strategy of designing products which could accommodate cells or modules from a variety of different manufacturers. This approach was also taken with SunTile®. While the initial product release used 125 mm quasi-square SunPower® cells, the physical size of the laminate was such that other cell sizes could be used.

The technologies investigated included the following three options:

- A low cost, low efficiency polycrystalline cell technology;
- A mid-efficiency, monocrystalline cell technology; and
- A high efficiency monocrystalline cell technology packaged as a Class A laminate (detailed in section 3.7.3 BIPV Design Lessons Learned)

In the course of this task, we requested quotes from several 3rd party module and cell manufacturers and undertook economic analyses of the resulting modules. Because SunPower® cells are high efficiency, the lower rated power of other cell technologies significantly impacted their economic viability. Other considered factors included the relatively low temperature coefficient of SunPower® cells and their superior aesthetics.

Additionally, for this type of BIPV, cell size has a significant impact on annual energy production due to inter-module shading. The modules have a fixed aperture width due to the row spacing of concrete tiles. The use of smaller cells results in more “dead” area in the module but this design is less susceptible to shading. While the use of larger, less efficient cells can result in an equivalent nameplate rating to smaller, more efficient cells, annual energy output is negatively impacted by shading.

Therefore, these modules needed to be significantly lower in price on a $ / W basis to be economically viable.

Of the options considered, the mid-efficiency, monocrystalline cell option was the most attractive. This option involved the use of 3rd party cells. Therefore, SunPower® designed the module package in-house. Initial quotes were promising and SunPower® was in the process of selecting a modco to produce these modules for us.

During the modco selection process in early 2007, PowerLight was acquired by SunPower® Corporation. Since SunTile® was originally developed to accommodate SunPower® cells, the alternate PV laminate option purchased from a 3rd party cell manufacturer was significantly less attractive to the combined, vertically integrated company. While the research that SunPower® performed under this task demonstrated that it was straightforward to produce an alternative laminate product on a technical basis, a business decision was made to discontinue development of the 3rd party version of SunTile®.

1.1.26. 3.7.2 Enhance PV Designs

This section summarizes the changes that SunPower made to its existing BIPV product in order to increase the market acceptance of the product by minimizing implementation cost and maximizing ease of installation through additional pre-fabrication.

The product development team met with the ZENH design team, the installation team, builders, roofing contractors, and the manufacturing team to obtain input for the recommended product improvements. The product development team also considered the output from the long-term performance monitoring task**.** This report summarizes the design changes that were made in response to the research.

Another part of this task was to submit any improved design to UL for listing. This issue is also discussed in this report.

1.1.26.1 *3.7.2.1 Approach*

Even as SunTile was being brought to market, SunPower recognized that further improvements were possible and desirable. The work in section 3.7.2 made it possible to explore potential design improvements and assess their feasibility.

Critical to this process was feedback from the customer and early installations, as detailed in the Design Lessons Learned Report (section 3.7.3). Also crucial was data obtained from the Long-Term Performance Evaluation subtask, particularly the performance monitoring portion (the advanced materials portion was not undertaken).

The main areas of improvement that were identified include:

- Improved ventilation
- Lower assembled cost
- Improved or eliminated grounding.

- ***Ventilation***

Improved ventilation is desirable as it lowers module operating temperatures, thus improving energy yield. Since BIPV is typically installed flush to the roof, operating temperatures are higher than with conventional technologies. The goal of improving ventilation is to reduce the performance penalty of the BIPV configuration. As outlined in the Developmental System Monitoring Report (D-8.5.4), our research indicated that significant reductions in operating temperature, about 7.5°C, were possible with optimum venting. As a result of this optimum venting, average power output increased by 4.59 percent, thus leading to increased yearly energy production. This demonstrated a performance advantage to increased venting, and further analysis was performed to ascertain the economic value of this advantage. A primary challenge, however, was to improve ventilation while still maintaining a Class A roof fire rating. This has proven to be extremely challenging.

- ***Assembly***

The current design consists of an assembly of many parts. To reduce costs, it is desirable to reduce part count and assembly steps. This results in a lower product cost. Additionally, any new design must accommodate improved cell technologies, as efficiency is a powerful cost driver on a $ / Watt basis.

- ***Grounding***

Finally, improving or eliminating grounding is desired to reduce installed costs.

To this end, SunPower focused on two primary paths:

The first approach, which we termed a "unibody" design, is based on the current design philosophy of using a standard laminate and protecting it with a frame structure that prevents ignition in the fire test. Unlike the current design, however, this approach minimizes part count by relying on high volume, automotive style sheet metal fabrication techniques. This design approach significantly reduces part count and assembly steps.

The second approach, the (Flame Retardant) FR laminate design, as indicated depends on the PV laminate itself built as a fire resistant structure. This opens the design envelope, allowing for significantly increased ventilation and lowered part count through simplified design. Under this scenario, we also explored the use of polymeric frame materials to achieve a one-part molded frame design.

The design team considered the FR laminate option to be the most elegant solution since it significantly reduced the amount of the material used in the frame structure, and the FR laminate was an enabling technology to allow a high-volume, polymeric molded product concept. Moreover, a major PV manufacturer (and key supplier at the time) Sanyo was well advanced in developing a Class A module using a glass backsheet construction. Working with this PV manufacturer, the PowerLight team observed a Class A module fire test and validated that it was technically feasible in a BIPV format. Unfortunately, the cost of a FR BIPV module from this manufacturer proved to be prohibitive. Our internal analysis showed that material costs were not driving the pricing, but the manufacturer was unwilling to negotiate a mutually acceptable price. This setback led the team to pursue the unibody approach.

Unibody Design Process

The unibody design process was started by engaging an automotive sheet metal stamping expert and explaining our design goals and constraints. Using this resource, we were able to draft several design concepts. After completing these draft designs, the BIPV design team and our stamping consultant visited several large tool and die shops in the Grand Rapids, MI area. These shops typically serve the automotive, aerospace, and metal furniture industries. This visit gained extremely valuable feedback on the design, as well as manufacturing process options. This resulted in a final design concept.

Simultaneously, the design team engaged a current manufacturing partner in sheet metal fabrication. This manufacturer utilizes a unique fabrication process, a CNC panel bender. This technology allows for geometries that cannot be achieved on stamping dies or standard bending techniques, and allows a throughput rate significantly higher than standard bending. Working with this manufacturer, the BIPV design team was able to fabricate two full-size prototypes.

Both manufacturing approaches resulted in similar geometries in terms of the overall physical envelope and amount of venting. This allowed the BIPV design team to create dimensional prototypes by assembling current production parts and some simple custom parts.

Using these prototypes, the team set out to validate the designs. First, the prototypes were installed at the test bed site adjacent to standard product. The purpose of this installation was to quantify reductions in operating temperature and increases in energy production.

Second, the design team tested the prototypes at Underwriters Laboratories to ascertain if the improved venting impacted the ability of the design to pass the Class A fire test.

This testing showed that while the new design was capable of passing the Class A spread of flame test, it did not pass the burning brand test. This presented a significant obstacle.

Simultaneously, the prototypes did not demonstrate a measurably lower operating temperature than the current design. As ventilation in this prototype was not completely unobstructed, there was room for improvement; however, as the fire test demonstrated, the amount of ventilation provided was still not consistent with passing this test.

This setback was tempered, however, by information from a key vendor that an encapsulant material with FR properties was nearing commercialization.

In parallel, dramatic ongoing cost reduction of the commercialized product was eroding the cost advantage of the unibody design. In combination with the high cost of tooling required to stamp these large parts, it became clear that this approach would not be the highest internal rate of return (IRR) option to pursue, even if the technical obstacles – which appear formidable – could be overcome.

With the unibody avenue appearing sub-optimal, the team was hopeful that the proposed FR encapsulant material would allow for a lower-cost FR module construction and again enable a more elegant design approach.

Laminate Design Process

The BIPV design team elaborated several concepts based on an FR laminate, both grounded and non-grounded. As the designs progressed, a detailed economic analysis was developed to support decision making among the options. This process pointed us towards a single-piece design molded from polymeric material.

Significant work then began to ascertain the requirements for such a material in this application, including fire resistance, weatherability, and certification requirements. The BIPV design team engaged several major suppliers of engineering polymers to help develop these requirements. This process proved to be complex and as the material choices were in flux, the design team elected to delay weathering testing until clear options emerged.

Included in the ongoing design work was small-scale wind-driven rain testing. This testing allowed the design team to down-select and validate among strategies to allow for maximum ventilation, while minimizing wind-driven rain penetration below the roof system. This testing successfully identified a promising strategy. With the physical characteristics of the product now well-defined, we have a product design that is ready to be prototyped.

Unfortunately, as time went by it became clear that the FR encapsulant vendor had encountered significant roadblocks in commercializing the material. To date, the material still has not been commercially released. Other options for creating a FR module were also explored. Prior to the combination of PowerLight and SunPower, PowerLight was independently engaged in early-stage development of FR laminate constructions under a DOE program. With the SunPower merger, we were able to fabricate small-scale coupon laminates using various FR constructions. This allowed the BIPV design team to perform small-scale fire testing on some of the FR laminate designs under consideration. Doing so allowed the team to guide the module group towards the most promising constructions for the BIPV application. However, commercialization of these laminate designs will require a significant amount of R&D time and effort.

1.1.26.2 *3.7.2.2 Results*

The work done under this task has led to an enormous amount of learning. Under this task, we have achieved the following:

- Quantified the value of improved venting based on measured data.
- Determined that increased ventilation is inconsistent with Class A fire rating if a conventional laminate is used in a metal-shielded design.
- Incorporated high volume sheet metal stamping expertise into our design team.
- Determined key characteristics for engineering polymers in PV module frames.
- Down-selected from the literally thousands of relevant polymeric materials to a few leading candidates for PV applications. We can't go there.
- Identified and engaged material weathering consultants to assist in further validation of these candidates.
- Created design concepts for a next-generation SunTile with a focus on a low cost, enhanced performance solution that can be manufactured in high volume. The leading design concept is ready to be prototyped once FR laminate technology is sufficiently advanced.

- Researched many techniques for producing FR laminates, validated several possible approaches in small-scale testing, and are currently tracking and / or further developing these technologies outside of this program.

1.1.26.3 *3.7.2.3 Conclusion and Recommendations*

SunPower's conclusion is that development of a next-generation product that is a significant improvement over the current state of the art is both possible and desirable. However, the successful implementation of FR laminate technology is a key enabler.

SunPower is continuing to work on FR laminate development under the Solar America Initiative. The work done under this task will significantly accelerate the introduction of a next-generation BIPV product based on FR laminate technology.

1.1.27. 3.7.3 BIPV Design Lessons Learned

1.1.27.1 *3.7.3.1 Introduction*

This report summarizes the research that SunPower conducted to increase the market acceptance of the BIPV product by minimizing implementation cost and maximizing ease of installation through additional pre-fabrication.

The research consisted of numerous meetings with the BIPV product development team, the ZENH design team, the installation team, builders, roofing contractors, and the manufacturing team in order to obtain the required input for the recommended product improvements. The product development team tested different product enhancements to understand the relative performance increases and the potential cost reductions. This report summarizes the different options and approaches that were considered for product improvements, including the limitations and obstacles to the approaches. The design changes that were made in response to the research are summarized in the following section, the Advanced Design Enhancement Report.

1.1.27.2 *3.7.3.2 Approach*

PowerLight kicked off this work in August, 2005 following a successful Critical Project Review with the Energy Commission. Commercial installations commenced immediately thereafter.

This report details lessons learned from the commercial roll-out, which proceeded quite rapidly. Over 3,500 systems have been installed to date throughout the state.

The BIPV product development team worked closely with the ZENH design team and the installation team, especially during the early installations. In addition, the team solicited feedback from roofers and builders – often during the installation process with "on-roof" discussions.

The product development team also worked very closely with manufacturing, including both assembly and upstream component manufacturers, to ensure that design for manufacturability was a key driver for product improvement.

Additionally, feedback from the installation and ZENH design teams has continually come in to the product development team over the last two years.

Using this information, we identified a number of improvements to the product both in the short term (incremental product improvement) and long term (new product development).

- ***Incremental Improvements:***
  - Cost reduction.
  - Installation (incl. wire management, packaging).
  - Fit and finish.
  - Proof of performance.

- ***Long Term:***
  - Eliminate grounding.
  - Improve ventilation.
  - Further cost reduction.

1.1.27.3 *3.7.3.3 Results*

Cost Reduction

PowerLight and SunPower have achieved a 73 percent reduction in product cost (exclusive of PV laminate) since the initial introduction. This was accomplished through implementing design changes to facilitate manufacturing of components and assemblies, sourcing strategies, and ramping into volume production.

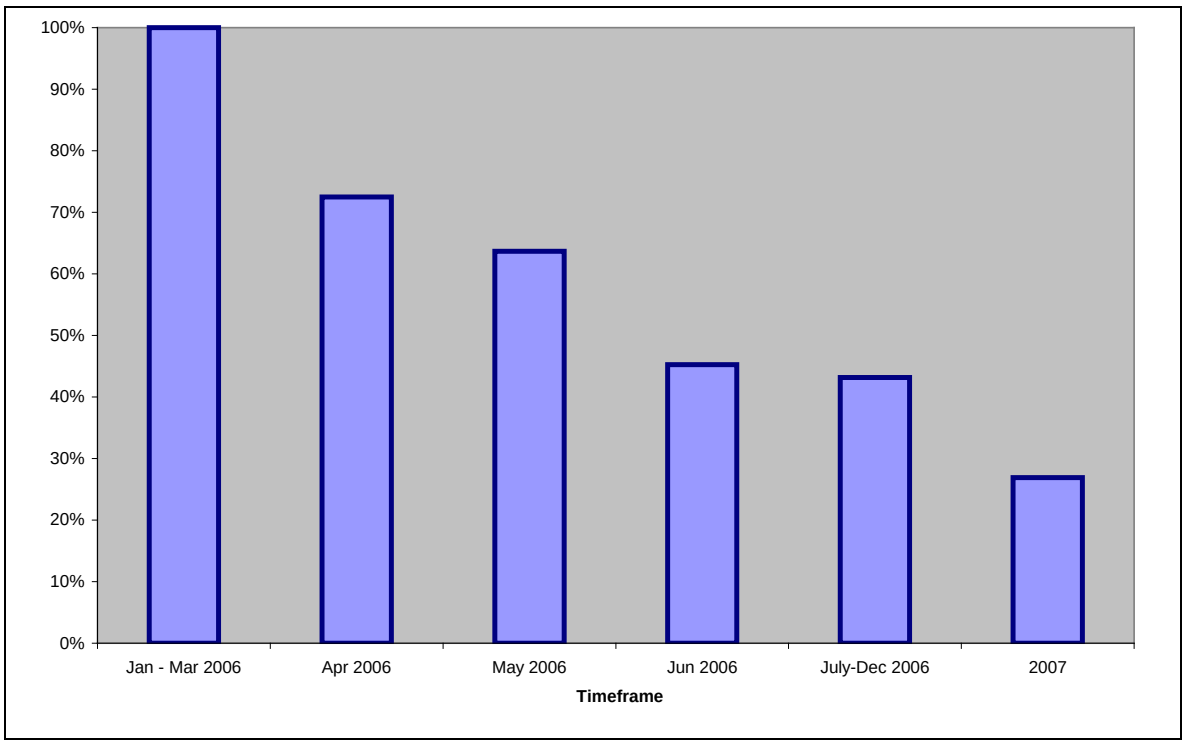


Figure 67: SunTile Cost Reduction Trend

Installation

A number of minor changes were implemented quickly after observing installations and getting installer feedback.

Installers had issues with wires falling into the box and getting tangled as the modules were moved around the roof. Wire management was improved by adding wire clips to the design so that they could be secured in position during shipping and handling.

Another issue was that the butyl sealing tape used to weatherproof screw penetrations was initially provided separately from the modules. This proved awkward to handle in the field, so the tape was added to the product BOM and now is part of the assembly.

One significant issue is that modules were initially packed in boxes of four. This proved to be too heavy to readily move around the roof. The packages also needed to be loaded using a Pettibone or forklift. By packaging modules in 2-packs, we are able to load the roof using a ladder lift and moving the boxes around on the roof is much easier.

Finally, a small design change was made for improved compliance to handle roof irregularities. The modules are designed to lock together on the roof using tongue and slot features, and in this case the dimensions of the slot were opened up slightly to improve fit.

Since these changes were made in an early design revision, few installation issues have been reported.

Fit and Finish

In addition to installation issues, initial units required some fine-tuning with regards to fit and finish. This involved redesign of some parts to reduce unnecessarily wide tolerances, create a more robust "feel" when picked up, and improve appearance.

Proof of Performance

Initial feedback, particularly from roofers and builders, was skepticism that the product would perform adequately as roof – particularly in regards to waterproofing. Although many aspects of the design had benefited from input from roofers and the watershedding features were nearly identical to concrete tile, many stakeholders were not comfortable with assurances. They wanted proof.

To fulfill our goal of gaining an ICC-ES Evaluation Report under this program, extensive testing was carried out to validate SunTile's performance as a roofing material. Evidence of this testing has proven invaluable in demonstrating SunTile's performance as a roofing product and an ICC-ES Evaluation Report will serve to provide further validation.

Long Term

A number of opportunities, identified prior to the start of this contract, were validated by installation experience and field testing.

In the long term, elimination of grounding is a desirable feature. Although grounding in SunTile is streamlined significantly as compared to standard modules, eliminating this step entirely would provide further savings. Based on installation experience to date, we estimate about $0.02 / W incremental savings in eliminated parts and labor for SunTile.

Improved ventilation leads to increased performance. This is particularly important in a Performance Based Incentive scenario. This will be discussed in more detail in the Advanced Design Enhancement report.

Further cost reduction is, of course, always valuable. As detailed in the Advanced Design Enhancement report, we identified several areas of cost reduction that could be achieved with a substantial product re-design.

1.1.27.4 *3.7.3.4 Conclusion and Recommendations*

Most of the early feedback from installation and manufacturing was very quickly implemented in an early design revision, resulting substantial reductions in product cost and installation time. These lessons will certainly also be applied to future designs, in conjunction with improvements that require a more substantial re-design or a different design approach.

3.8 Broaden the Application of BIPV

This section documents how SunPower worked to broaden the application of residential BIPV beyond previously existent systems.

1.1.28. 3.8.1 Ensure ICC Compliance

The goal of this task was to achieve an evaluation report from International Code Council (ICC) ICC Evaluation Service (ICC-ES).

ICC-ES is a leading source of technical information on building products and building technology for code compliance. ICC-ES performs technical evaluations of building products, components, methods and materials. The evaluation process culminates with the issuance of reports on compliance with the major U.S. building codes. ICC-ES thoroughly examined SunPower Corporation's BIPV SunTile® product information, test reports, calculations, quality control methods and other factors to ensure the product is code compliant. Building officials, architects, contractors and others utilize the ICC-ES Evaluation Reports to provide a basis for using or approving the product in construction projects.

SunPower performed the following work under this task:

- Worked with the International Code Council (ICC) to identify any pre-existing standards that were applicable to BIPV
- Assisted ICC-ES with the development of a BIPV standard
- Obtained feedback from ICC on product improvements from the standpoint of building code issues
- Prepared documentation for ICC evaluation
- Submitted the BIPV system to ICC for evaluation

This document contains a copy of the final International Code Council evaluation report on SunPower Corporation's BIPV SunTile® product, dated January 1, 2008. The report, ESR-2194, can be downloaded from www.icc-es.org by mid-January 2008.

1.1.28.1 *3.8.1.1 Results*

ICC-ES has certified SunTile® as a roofing product, comparable to all other clay and concrete roof tile products that have an ICC-ES report. This evaluation report makes SunPower's SunTile® the first ever BIPV product on the market with this very rigorous certification.

PowerLight started the certification process with ICC-ES in early 2006. There was no standard to cover BIPV so PowerLight worked with ICC-ES to write the standard. This task took about one year to complete during which time SunPower performed rigorous testing and documentation of the product. Since then, SunPower has continued to work with ICC-ES to satisfy every concern they raised. The certification process culminated with a Quality audit of SunPower's manufacturing line, which passed with no concerns from ICC-ES. See Figure 67.

The performance tests that SunPower conducted included TAS 100 (110 mph) wind driven rain testing (Dade County, FL test standard), walk resistance testing, uplift testing, weather resistance and durability testing, UL Class A fire rating testing, and many more. SunPower achieved this and still maintained the industry-leading ventilation path on SunTile® that improves system performance and longevity.

ICC EVALUATION SERVICE, INC.
Evaluate ▪ Inform ▪ Protect

Los Angeles Business/Regional Office ▪ 5360 Workman Mill Road ▪ Whittier, CA 90601
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This evaluation report draft is not valid until published and distributed.

DIVISION: 07—THERMAL AND MOISTURE PROTECTION
Section: 07320—Roof Tiles

REPORT HOLDER:

ESR-2194
Issued January 1, 2008

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EVALUATION SUBJECT:

SUNTILE® BIPV ROOFING PANELS

1.0 EVALUATION SCOPE

Compliance with the following codes:

- 2006 *International Building Code®* (IBC)
- 2006 *International Residential Code®* (IRC)
- Legacy Codes (see Section 8.0)

Properties evaluated:

- Roof covering fire classification
- Wind uplift resistance
- Weather resistance

2.0 USES

SunTile BIPV roofing panels are building-integrated photovoltaic (BIPV) roof panels that are an alternate roof covering when installed in conjunction with code-complying asphalt shingles and concrete and clay tile roof covering systems. The BIPV panels are recognized for use where Class A roof coverings are required on new roofs,

Figure 68: ICC-ES Evaluation Report number ESR-2194

1.1.29. 3.8.2 Build Roof-Neutral Designs

The goal of this work was to increase the end-use flexibility of the design with modular elements that allow the PV system to be integrated with S-tile roofs, as well as SunPower's current flat tile product.

The resulting products enhanced ZENH Market Sustainability by providing a roof-neutral BIPV product.

1.1.29.1 *3.8.2.1 S-Tile Design*

SunPower recognized that a simple method to integrate the SunTile product with S-Tile type roofs would be advantageous, since many concrete tile roofs utilize S-shaped tile. SunTile is designed primarily to be installed with flat concrete tiles, and the interfaces with the flat concrete roofing material are not geometrically compatible with S-Tile.

In the roofing industry, it is common to utilize sheet metal flashings to accomplish waterproofed interfaces between roofing materials and other roof elements such as vents, chimneys, and skylights. These flashings are often fabricated on a job-by-job basis or sometimes standardized for a specific product, like a skylight.

The flashings had to accomplish a waterproof and aesthetically pleasing integration of SunTile into homes equipped with S-Tile roofs.

One challenge faced was that a single standardized flashing was not possible due to the large size and variable geometry of a PV array, but custom flashing would not be cost effective.

This was solved by the development of a standard set of modular, interlocking flashings that could be arranged to enclose any rectangular array. These consisted of top, bottom, and side flashings as well as corner flashings. Thus, a flashing set kit can be readily assembled from standard components based on the array geometry.

Another challenge was proving that these flashings accomplished their goal of providing a waterproofed interface. Geometrical constraints precluded compliance with all standard flashing design practices (such as those found in the *Concrete and Clay Roof Tile Installation Manual for Moderate Climate Regions* published by the Roof Tile Institute). Thus, proving that the flashings performed adequately was a key step to ensuring roofing industry acceptance of this approach.

To accomplish this, testing was carried out to the TAS-100 Wind Driven Rain standard and in addition, the flashing system was included in the ICC-ES Evaluation Report application. This latter step ensured scrutiny by ICC-ES of the flashings in regards to materials of construction.

Design of the flashings was followed by trial field installations, which resulted in some feedback on minor dimensional changes before drawings for mass production were finalized.

Conclusion and Recommendations

The flashing system was successfully designed and has been in volume production since late 2006. To date approximately 500 systems have been installed.

TAS-100 testing was successfully passed in 2006 and the ICC-ES Evaluation Report for SunTile, ER-2154, includes this flashing system.

Asphalt Tile Design

SunPower initially approached the task of developing an integrated asphalt shingle system by leveraging the work done for integration with S-Tile and developing a flashing system (see section 3.8.1, page 251, for details). Development of this flashing system was technically successful. The flashing system is included in the SunTile ICC-ES report and has been installed at several sites.

However, it became clear in the development process that adapting SunTile to asphalt shingle roofs was an expensive solution and aesthetics were not significantly approved.

Therefore, the team explored methods of achieving low-cost methods of mounting standard modules in an aesthetically pleasing manner.

Module mounting on residential roofs is typically accomplished with rack systems, consisting of rails mounted to stanchions with are bolted to structural members of the roof. PV modules are then attached to these racks.

Because PV modules are designed to withstand full code uplift loads, this results in a duplication of materials since module frames are adequately stiff and strong to resist loads on their own. The main reason racks are used is that modules generally are sized to maximize aperture area efficiency, rather than to fit with typical roof rafter spacing. Also, many roof rafters are not spaced consistently.

The goal then was to design a mounting system that could be secured to the roof without requiring that it be bolted to rafters. That is, the mounting device was to be secured to the roof deck, typically nominal ½" thick plywood or OSB sheathing. Because this material is significantly weaker than a rafter and there are multiple potential failure modes, this was challenging.

Another challenge was to ensure waterproofing. Attaching the mount directly to the roof shingles, even with a layer of sealant between the mount and the roof, was rejected as unreliable.

Because no rails are used, the small mounting feet need to be located very precisely on the roof surface so that the modules are assured to "land" on them correctly. Also, variations in the roof surface needed to be accounted for and mitigated.

Another goal was to eliminate the use of grounding lugs and wire as much as possible.

The solution SunPower developed, SMART Mount, accomplishes these goals.

The primary challenge, given the unorthodox approach of securing to sheathing, was working through the building codes and Allowable Stress Design rules for wood construction to establish allowable loads for the system. This was accomplished in partnership with a California Professional Engineer, who required extensive documentation of the system as well as physical testing. This rigorous process resulted in a PE Stamped calculation set documenting the allowable loading for the system.

Waterproofing was accomplished by developing a simple but effective flashing system that accomplishes a highly watertight interface between the mount and the roof. The approach was vetted by several roofers and extensive physical testing was carried out to validate it.

Proper layout of the array was accomplished by developing a layout tool. This is effectively a large, custom "L" square with recesses for the mounts and markings to assist in layout. It allows for fast and accurate system installation. Roof surface variations are accommodated with custom shim plates that allow the PV modules to be leveled.

Finally, the system is designed to work in conjunction with SunPower's IFF clip (developed previously) which provides both a method to secure the structure and grounding, thus eliminating the majority of ground lugs and wire that were required previously.

The system also provides a pleasing installation aesthetic, since it eliminates unsightly rails and standoffs which often have to be equipped with large conical flashings. The resulting arrays have a clean, uniform, low profile appearance.

Conclusion and Recommendations

The first prototype SMART Mount system was installed in July, 2006 followed by several beta installs in new home communities. Official production release followed by installation occurred in March, 2007. Separately from the ZENH contract, SMART Mount was released to SunPower Dealers for use in retrofit installations in February 2008 after validating that earlier installations were trouble-free.

SMART Mount meets its primary goal of reducing installation costs. Material costs are reduced radically compared to a standard rack system, and installation time is also reduced significantly.

Additionally, as mentioned, the aesthetics of the system are much better than standard rack systems and this has allowed for enthusiastic adoption in the New Homes channel, where aesthetics are paramount.

A single module installed on the SMART Mounts, which are laid out prior to module install. Note the amount of hardware needed compared to a standard rack install.

The same SMART Mount system after installation.

SMART Mount Installation.

SunTile installed with flashings on asphalt shingle roof.

CHAPTER 4:
Conclusions and Recommendations

SunPower's holistic approach to commercializing net zero energy new homes has fostered a deeper understanding of the challenges that remain, the risks that need to be addressed and the future steps necessary to succeeding in the marketplace. From the conclusions of this study, the stage is now set for expanding, scaling and enhancing the ZENH program. With the goal to drive up the adoption level of energy efficient, solar-powered new home communities, SunPower and its partners look forward to continuing to develop, apply and expand the reach of this study.

The following sections summarize the findings from each of these major task threads:

- Design ZENH Homes 261
- Develop ZENH Business Models 264
- Build ZENH Demonstration Communities 266
- Monitor and Evaluate ZENH Performance 267
- Ensure ZENH Market Sustainability 267
- Refine Residential BIPV 268
- Broaden the Application of BIPV 269

Embedded within each of the section summaries, formal conclusions, commercialization potential, recommendations and benefits to California are all cataloged.

The report concludes with a statement on the future outlook for commercializing ZENH and the prospects for additional work in this area.

4.1 Design ZENH Homes

1.1.30. 4.1.1 Design Charrettes

The design team developed a prioritized list of design features and practices to guide a discussion with the builders on how to increase efficiency. The team assessed the design features by taking into account the energy impacts, cost, and construction impacts, and worked with the builder to select the most effective features for the community. The design meetings helped the builders achieve Tier II program compliance for all communities in the ZENH Demonstration. While a goal of the design charrette was to influence the layout of the communities to improve solar access, this task was not accomplished for the demonstration projects since the construction process was too far along. Influencing the layout of communities needs to happen long before construction begins. It is SunPower's goal to develop strong relationships with our builder partners in order to be included in the planning stage of each community and to ultimately influence the community layout to maximize solar benefit for each home.

1.1.30.1 *4.1.1.1 Market Evaluation*

Five emerging technologies are presented in this report. These technologies have both benefits and risks for builders.

Table 7 summarizes key attributes of the five measures and provides an overall assessment of near term value to production builders.

Table 57: Measure Comparison

	Gas Tankless Water Heater	Quality Envelopes	Ventilation Cooling	Evaporative Condensers	Advanced Evap Coolers
Title 24 Recognition	Yes	Yes	2010 Likely	Yes	Jan 2010
Title 24 Credit	Significant	Moderate	Moderate	Significant	Significant
Builder Acceptance	Most	Some	Few	Few	None
Customer Acceptance	Most	Most	Some	Some	Few
Proven Reliability	Partial	Yes	Partial	No	No
Developed Infrastructure	Yes	Some	Some	Marginal	Marginal
Near Term Builder Value	High	High	Moderate	Moderate	Low

1.1.30.2 *4.1.1.2 Single Family Package Report*

Builders can apply technologies and design practices that are in common use to achieve energy savings that exceed Title 24 by 40 percent or more with minimal adjustments to their business practices. By applying appropriate incentives to reduce costs and using branding programs such as Energy Star, GreenPoint Rated, LEED, and Builders Challenge, builders can demand higher prices and turn homes over more quickly, making ZENH a strong value proposition for the builder. For the homebuyer, the decreased cost of ownership, improved home quality, and relative immunity from future hikes in utility rates is attractive, particularly given the current energy outlook. For the utilities, the peak load reduction offered by ZENH's means less pressure to provide and operate peaking plants, potentially decreasing their cost of providing service.

As production home industry standards rise to the levels described in this report, progressive builders looking for a market edge will need to continue to look to new and emerging technologies to maintain a strong market position. The need for technology will continue to be fed by the California Energy Commission's Public Interest Energy Research Program, the Department of Energy's Building Technologies program (including Building America), and utility emerging technologies programs.

1.1.30.3 *4.1.1.3 Single Family Design Report*

All of the homes in the three demonstration communities are Tier II participants, meaning that all homes are at least 35 percent above Title-24 and cooling is 40 percent above Title-24. This level of efficiency surpasses the 2005 ZENH energy performance goal of 25 percent above Title-24, and complies with the 2008 ZENH energy performance goal of 35 percent above 2005 Title-24.

The estimated annual electricity cost reduction for the typical plan in the three communities is between 61-80 percent using an E-1 rate. The ZENH cost reduction goal is 70 percent savings on the annual electric bill, which the Grupe community surpasses. E-1 is a tiered, non-TOU rate. Since peak solar production coincides with peak electrical demand, a TOU rate could be more beneficial for solar homeowners depending on their usage patterns, and increase their bill savings.

The modeled peak demand for the typical plan in the three communities varies from 1.4 to 1.9 kW, higher than the 2005 ZENH peak demand goal of 1.0 kW. However, the percentage reduction in demand relative to a home built to Title-24 varies from 54-64 percent, a significant reduction in peak demand. Alternative measures were explored with the builders to further reduce peak demand; however the other measures were not deemed to be cost effective and were not implemented.

1.1.30.4 *4.1.1.4 Multi-Family Package Report*

Achieving high levels of energy savings is more challenging for multi-family projects than for detached housing since space conditioning loads generally make up a smaller percentage of total energy use due to less envelope area per sq. ft. of floor area. Typically miscellaneous energy use is a larger component in multi-family projects and the builder has little or no control over that end use. Builders can however utilize technologies, design practices, and inspection procedures that are commonly available to achieve energy savings that exceed Title 24 by 25 percent, or more, with minimal adjustments to their business practices. By applying appropriate incentives to reduce costs and using branding programs such as Energy Star, GreenPoint Rated, LEED, and Builders Challenge, builders may be able to demand higher prices, making ZENH a strong value proposition for the builder. In addition, these energy efficiency strategies could lead to an increased ZENH market in affordable housing projects, if a mechanism exists for the developers to charge higher rents as a result of lower projected utility bills.

For the homebuyer or tenant, the decreased cost of ownership, improved construction quality, and higher insulation from future utility rate hikes is attractive, particularly given the current energy outlook. For the utilities, the peak load reduction offered by ZENH's represents a decentralized resource that contributes to reduce need for new generation facilities and infrastructure upgrades.

As the California Building Energy Standards rise to the efficiency levels described in this report, progressive builders looking for a market edge will need to continue to evaluate emerging technologies to maintain a strong market position. Technology development will continue to be fed by the California Energy Commission's Public Interest Energy Research Program, the Department of Energy's Building Technologies program (including Building America), and utility emerging technologies programs.

1.1.30.5 *4.1.1.5 Multi-Family Design Report*

The design team developed a prioritized list of design features and practices to guide a discussion with the builders on how to increase efficiency. The team assessed the design features by taking into account the energy impacts, cost, and construction impacts, and worked

with the builder to select the most effective features for the project. The design meetings helped the builders achieve the 25 percent ZENH energy requirements in the MF Demonstration. Because the project was a gut rehab, influencing the layout of the project was not possible. It is SunPower's goal to develop strong relationships with our builder partners in order to be included in the planning stage of each community and to ultimately influence the community layout to maximize solar benefit for each home.

Based on the Villa Monterey apartment and 4-plex units, and the recommended efficiency measures and a 1.23 kWp PV system, the homes are anticipated to save approximately 40 percent in total annual energy costs compared to the Title 24 standard model. Average anticipated peak period demand reduction compared to Title 24 standard model for the peak, including PV contribution, is 0.75 kW depending on unit type. This is equivalent to offsetting a 1/2 to 1 ton AC system during system peak.

1.1.30.6 *4.1.1.6 Monitoring*

SunPower's monitoring tool provides an in-home and internet enabled system monitoring solution. The monitoring system is currently a web-based portal that displays production and consumption information in a daily, monthly, and annual format. SunPower monitors the production information and has automatic prompts for service calls when systems fall outside the quality control range.

4.2 Develop ZENH Business Models

1.1.31. 4.2.1 Turn-Key ZENH Offering

Without a successfully trained sales staff, adding benefits like solar and energy efficiency do little to differentiate one builder's product from another. The builder's commitment to add solar power to their project is simply the first step. The second, most important thing is for the builder to realize a positive return on his investment. This can come in several forms: greater sales, faster closing ratio, higher selling price, enhanced reputation, and/or higher customer satisfaction ratings. To help the builder achieve as many of these benefits as possible, SunPower works closely with builder employees to help them understand how to articulate the features and benefits to potential buyers.

1.1.31.1 *4.2.1.1 Alternative Financing*

Driving towards the objective of reducing the first-cost impact of purchasing a ZENH home, the goal of this work was to develop a financing mode that would allow homebuyers to pay little or nothing for their new energy efficient and PV powered home.

SunPower worked with key partners and advisors to map out the alternative system ownership and financing models, conducted feasibility studies and established goals and performance metrics for testing the concept with one of its ZENH demonstration partners.

The resulting business models were reviewed in the context of established ZENH goals decreasing reliance on PV subsidies over time, and an evolution of dynamic pricing tariffs and advanced metering initiatives currently underway in the State of California. From this work, the SunPower Access solar leasing program was born.

1.1.31.2 *4.2.1.2 Streamlined Permitting, Interconnection and Incentive Processing*

- ***Permitting***

No universal process for solar permitting currently exists in California and, as a result, requirements differ greatly between building departments. Such diverse and often stringent requirements have made it extremely challenging to develop a truly universal process or permit pack format. However through extensive dialogue with Building Departments and mutual education it has been possible to reach agreement on a generally acceptable format which allows flexibility to account for minor variations based on specific local requirements. This proactive approach taken by SunPower has been well received by building departments that in most cases are facing the challenge of high-volume plan checks and photovoltaic systems permitting for entire communities.

- ***Interconnection***

Undertaking a focused effort now to streamline and automate the interconnection application process for residential solar electric system installations will enable all stakeholders to realize significant benefits—and will not inhibit the growth of a vital industry.

Streamlining the interconnection process is a logical and necessary step in the process of growing the number of grid-connected solar electric systems in California, and ultimately throughout the country. The volume of documentation and the time taken for its completion as required currently constitute one of several barriers to the increased uptake of solar electric systems by new home builders and consumers.

Utilities such as PG&E that demonstrate a willingness to work with others such as builders and photovoltaic integrators are well positioned to reap the benefits of an expedited process—not the least of which will be enhanced profitability and improved customer satisfaction.

- ***Incentive Processing***

For installed solar to succeed in the long term, it will need the same certainty of economic returns as installing more efficient appliances. Streamlining the rebate process -- which in turn will encourage large-scale installation, reduce costs and promote additional PV investment-- will hasten the arrival of a rebate-less future in which solar is effortlessly integrated into mainstream production homes.

To accomplish this streamlining over the short term, the CEC should centralize and consolidate processes. Digital automation will be key to this process in the longer term.

In many ways, this requires a parallel application process different from the retrofit market. Since there are large relevant differences between the production home market and all others, trying to shoehorn that process into another is unadvisable. As we see here, combining both processes in one set of forms, while seemingly attractive, can be counterproductive to achieving program goals.

1.1.31.3 *4.2.1.3 Tailored Maintenance, Warranty and Customer Service*

SunPower's in-house customer service team has all the capabilities necessary to provide these critical support functions. To date, customer satisfaction has been high and SunPower is

continually striving to improve the process to increase satisfaction. Additional staffing of customer support positions requires a level of occupied homes before there is sufficient service demand to warrant dedicated resources. As SunPower installs solar at more new homes and expands our offering into different regions, the customer service team will proportionally increase to ensure that SunPower's customer service remains world class, and growing the industry through high customer satisfaction and increased demand for new solar homes.

- ***Service and Customer Satisfaction***

The results from SunPower's surveys indicate that solar can be used by production home builders to capture incremental home sales, drive word-of-mouth referrals, and impact future home buying trends.

The surveys were a valuable validation tool for the business plan SunPower presented to California builders. It clearly demonstrates that home buyers see the benefit when builders include a solar and energy efficiency package. There is a clear message that solar was a key component in buyer's decision making process. Once in the home buyers maintain their positive opinion of the solar system, and are happy with the experience.

Additionally, SunPower developed a comprehensive set of materials with builders and external marketing professionals to sell and promote ZENHs. The homebuilder partnerships that have been formed as a result of this work have been successful, measured by the increasing adoption rate of new solar homes in California. SunPower will continue to work with the relevant parties to adapt and expand our service and customer satisfaction reporting metrics.

4.3 Build ZENH Demonstration Communities

SunPower had built four official ZENH demonstration communities with more than 150 ZENH homes including both single- and multiple-family units. In addition, SunPower's ZENH-inspired homebuilding approach and lessons learned have helped SunPower's homebuilder partners develop more than 70 communities, constructing 3000+ energy efficient and solar homes throughout California.

In each of the homes, SunPower installed turn-key BIPV systems, included an in-home energy monitoring display, allowing customers to view their solar system energy production as well as their household energy consumption. System sizes were varied according to the energy analysis for each home. All installs were verified by 3rd party HERS raters and used as input for the design, construction and performance monitoring work discussed later in this report.

As an added service to the construction process, SunPower provides a comprehensive builder management orientation to homebuilders. It is used by SunPower to train builder sales staff and to facilitate the marketing, sales, and implementation of ZENHs. Many builders are including solar as a standard feature to differentiate their homes from the competition. By way of this program, SunPower has been able to train hundreds of builder employees across California. SunPower also provides the builder management team a summary of sales agent performance during the training to give the managers an idea of the benefits of the training.

4.4 Monitor and Evaluate ZENH Performance

Initial results of the program indicate that all demonstration community homes exceed Title 24 energy efficiency standards by nearly 40 percent. For reasons partly stemming from conservative solar system sizes and customer electricity usage behavior, peak energy demand was not capped at 1kW. However, net energy savings was about 60 percent less than comparable homes. Finally, with the recent (pilot) introduction of the SunPower Access leasing program, the incremental first-cost for these energy efficient and solar powered homes has been reduced to zero ($0).

4.5 Ensure ZENH Market Sustainability

1.1.32. 4.5.1 Transform the Marketplace

New home developers have resisted installing PV because of high initial costs, aesthetics, disruption to their production schedule and fear of the unknown or change. However, new products are now visually pleasing and by constructing the most energy efficient homes and then adding a right-sized PV system as standard, construction costs and disruption can be minimized. Incentives and other financing alternatives reduce the first costs. Innovators who have overcome the fear factor have discovered that their sales have happened quicker with less advertising and with incredible amounts of good will press. Additionally, continued support for a strong public policy for renewable energy will be very important to transforming the marketplace.

1.1.33. 4.5.2 Market ZENH Homes

SunPower has developed a comprehensive set of materials with builders and external marketing professionals to sell and promote ZENHs. The marketing effort to date has been successful, measured by the increasing adoption rate of new solar homes in California. SunPower will continue to work with the relevant parties to adapt the sales and marketing approaches as the market evolves. It is clear that builders will build what buyers demand. Therefore, SunPower plans to focus our future marketing on driving consumer demand to increase the adoption rate of ZENHs. This future marketing will consist of a more informational approach with information to substantiate savings claims, while not losing focus of the main need: increasing basic consumer awareness of solar homes.

1.1.34. 4.5.3 Increase Homeowner Demand

SunPower has assisted new home builders to drive demand for ZENHs among potential homebuyers using a variety of media outlets. SunPower is fully committed to supporting builders during the downturn in the housing market, as advertising budgets are slashed, by increasing marketing assistance to builders. SunPower's corporate marketing team recently dedicated additional resources to the new homes marketing effort, amounting to over $100,000 for the year.

1.1.35. 4.5.4 After Sales Support

Each day, it becomes clearer that high homeowner satisfaction is critical to the adoption of solar in the new homes market. SunPower is committed to ensure high satisfaction for our builder

clients, and the company continues to identify ways to maintain satisfaction. SunPower strives to increase the level of satisfaction until all customers are completely satisfied with their systems, and all new home buyers demand solar systems as a standard feature on their home.

4.6 Refine Residential BIPV

1.1.36. 4.6.1 Develop Alternate PV Laminates

PowerLight had a longstanding strategy of designing products which could accommodate cells or modules from a variety of different manufacturers. This approach was also taken with SunTile®. While the initial product release used 125 mm quasi-square SunPower® cells, the physical size of the laminate was such that other cell sizes could be used.

Of the options considered, the mid-efficiency, monocrystalline cell option was the most attractive. This option involved the use of 3rd party cells. Therefore, PowerLight designed the module package in-house. Initial quotes were promising and PowerLight was in the process of selecting a company to produce these modules for us.

During the company selection process in early 2007, PowerLight was acquired by SunPower® Corporation. Since SunTile® was originally developed to accommodate SunPower® cells, the alternate PV laminate option purchased from a 3rd party cell manufacturer was significantly less attractive to the combined, vertically integrated company. While the research that SunPower® performed under this task demonstrated that it was straightforward to produce an alternative laminate product on a technical basis, a business decision was made to discontinue development of the 3rd party version of SunTile®.

1.1.36.1 *4.6.1.1 Enhance PV Designs*

Development of a next-generation product that is a significant improvement over the current state of the art is both possible and desirable. However, the successful implementation of laminate technology is a key enabler.

SunPower is continuing to work on laminate development under the Solar America Initiative. The work done under this task will significantly accelerate the introduction of a next-generation BIPV product based on laminate technology.

1.1.36.2 *4.6.1.2 Document BIPV Design Lessons Learned*

This research consisted of numerous meetings with the BIPV product development team, the ZENH design team, the installation team, builders, roofing contractors, and the manufacturing team in order to obtain the required input for the recommended product improvements. The product development team tested different product enhancements to understand the relative performance increases and the potential cost reductions. This report summarizes the different options and approaches that were considered for product improvements, including the limitations and obstacles to the approaches.

Feedback from installation and manufacturing was very quickly implemented in an early design revision, resulting substantial reductions in product cost and installation time. These lessons will certainly also be applied to future designs, in conjunction with improvements that require a more substantial re-design or a different design approach.

4.7 Broaden the Application of BIPV

1.1.37. 4.7.1 Ensure ICC Compliance

The goal of this task was to achieve an evaluation report from International Code Council (ICC) ICC Evaluation Service (ICC-ES). ICC-ES is a leading source of technical information on building products and building technology for code compliance. ICC-ES performs technical evaluations of building products, components, methods and materials. The evaluation process culminates with the issuance of reports on compliance with the major U.S. building codes. ICC-ES thoroughly examined SunPower Corporation's BIPV SunTile® product information, test reports, calculations, quality control methods and other factors to ensure the product is code compliant. Building officials, architects, contractors and others utilize the ICC-ES Evaluation Reports to provide a basis for using or approving the product in construction projects.

Stemming from SunPower's work under this ZENH program, ICC-ES has certified SunTile® as a roofing product as comparable to all other clay and concrete roof tile products that have an ICC-ES report. This evaluation report makes SunPower's SunTile® the first ever BIPV product on the market with this very rigorous certification.

1.1.37.1 *4.7.1.2 Build Roof-Neutral Designs*

- ***S-Tile Design***

SunPower recognized that a simple method to integrate the SunTile product with S-Tile type roofs would be advantageous, since many concrete tile roofs utilize S-shaped tile. SunTile is designed primarily to be installed with flat concrete tiles, and the interfaces with the flat concrete roofing material are not geometrically compatible with S-Tile.

The flashing system was successfully designed and has been in volume production since late 2006. To date approximately 2000 systems have been installed.

TAS-100 testing was successfully passed in 2006 and the ICC-ES Evaluation Report for SunTile, ER-2154, includes this flashing system.

- ***Asphalt Tile Design***

SunPower initially approached the task of developing an integrated asphalt shingle system by leveraging the work done for integration with S-Tile and developing a flashing system. Development of this flashing system was technically successful. The flashing system is included in the SunTile ICC-ES report and has been installed at several sites.

However, it became clear in the development process that adapting SunTile to asphalt shingle roofs was an expensive solution and aesthetics were not significantly approved.

The team explored methods of achieving low-cost methods of mounting standard modules in an aesthetically pleasing manner and, as a result, the SMART Mount system was born.

The first prototype SMART Mount system was installed in July, 2006 followed by several beta installs in new home communities. Official production release followed by installation occurred in March, 2007. Separately from the ZENH contract, SMART Mount was released to

SunPower Dealers for use in retrofit installations in February 2008 after validating that earlier installations were trouble-free.

SMART Mount meets its primary ZENH goal of reducing installation costs. Material costs are reduced radically compared to a standard rack system, and installation time is also reduced significantly.

4.8 Future Outlook for ZENH

SunPower's holistic approach has fostered a deeper understanding of the challenges that remain, the risks that need to be addressed and the future steps necessary to succeeding in the commercialization of the ZENH marketplace. In brief, this Energy Commission sponsored PIER program to Commercialize Zero Energy New Homes was just the beginning; much work remains to be done.

At the conclusion of the program, with the imminent release of the Final Report and through new programs and business initiatives, SunPower looks forward to continuing to develop, apply and expand the reach of this study.