



Occupied Home Evaluation Results

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Task 12.E.2 Occupied Home Evaluation Results

Project Overview

Executive Summary

In 2004, Premier Garden's near-Zero Energy Homes (ZEHs) and Cresleigh Rosewood's non-ZEHs were built side-by-side, providing BIRA the opportunity to evaluate two large scale communities of occupied single-family homes. The non-ZEHs surpass California's building code, designed to save 30% on summer cooling energy, while the near-ZEHs represent Building America ZEHs. With at least one year of electric and gas use data for each community, totaling almost 200 homes, BIRA compares the benefits of near-ZEHs compared to non-ZEHs finding a 44% reduction in whole house energy use.

Additionally, BIRA investigates and identifies the benefits of near-ZEHs for homebuilders, homebuyers, the Sacramento Municipal Utility District, and other stakeholders to understand the collective benefits near-ZEHs offer.

BIRA evaluated the actual energy performance of Premier near-ZEHs against estimates using the simulation tools and best assumptions that were available at the time of construction. Equipped with updated information, models were revised to more closely simulate as-built and customer use information. BIRA found that electricity use was within 2% of expectations, while actual gas use was over estimated by 25% using Micropas and Building America benchmark assumptions for appliance, lighting, and miscellaneous energy use.

Based on the success of the Premier Gardens near-ZEH community for reducing source energy and peak electricity use, Premier Homes has again partnered with BIRA to design new homes for a community in the Sacramento area called Lakeside, aimed at further energy and peak savings. As modeled, these Lakeside homes suggest savings of more than 50% beyond the BA benchmark.

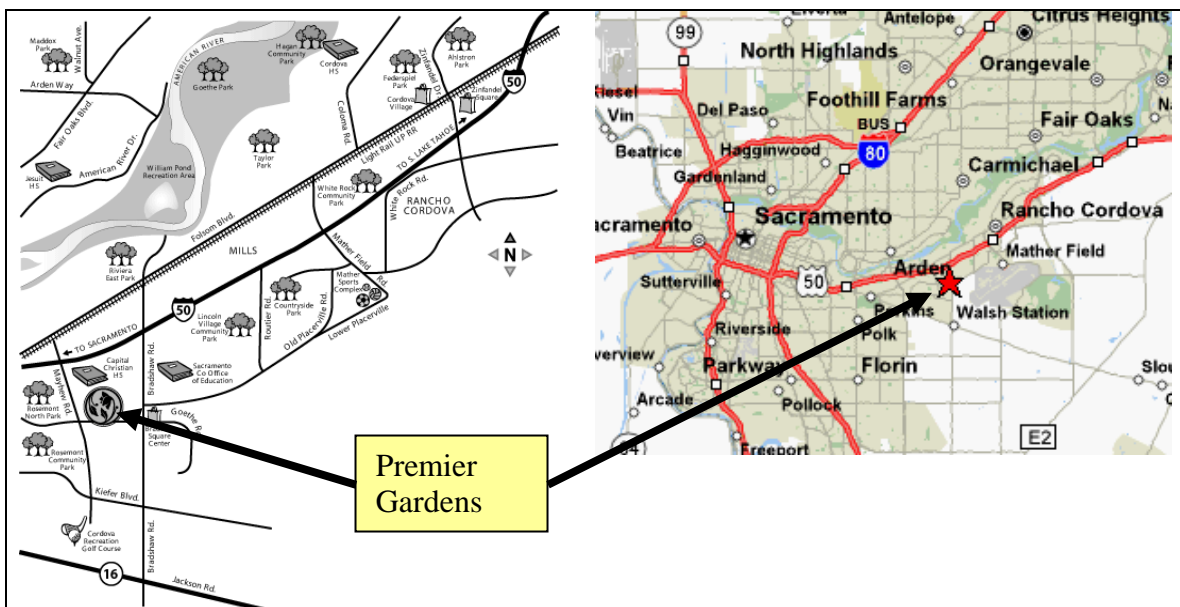
This Occupied Home Evaluation Report serves as both an empirical overview of the Premier Gardens project, but also a look forward leveraging the lessons learned and success of Premier Gardens. With the collective benefits better understood for all stakeholders, the Premier Gardens experience can serve as a platform for the next level of Zero Energy Home technical and commercial success.

Introduction

Given the large sample of near Zero Energy Homes and control homes combined with the amount of data collected, Premier Gardens and Cresleigh Rosewood offers a unique opportunity to evaluate the large scale impacts of Zero Energy Homes. BIRA and the Sacramento Municipal Utility District (SMUD) have evaluated these homes from many perspectives. This report will serve as both a brief overview of what has been done, an overview of the benefits for all stakeholders, and a look forward on how Premier Gardens can serve as a platform for future near-ZEHs aimed at Building America Program (BAP) goals of reaching 50% whole house energy savings.

Background

In 2004 and 2005, Premier Homes and Cresleigh Homes undertook a business agreement to divide the development of a plot of land in Rancho Cordova, CA. Rancho Cordova is located on the east edge of Sacramento, as shown below.



**Figure 1: Premier Gardens & Cresleigh Rosewood
Located in Rancho Cordova on the East Edge of Sacramento, CA.**

The resulting community consists of 95 Premier homes on the west side of the property, and 98 Cresleigh homes on the east. Many of the homes are right next to each other, as shown in Figure 2.

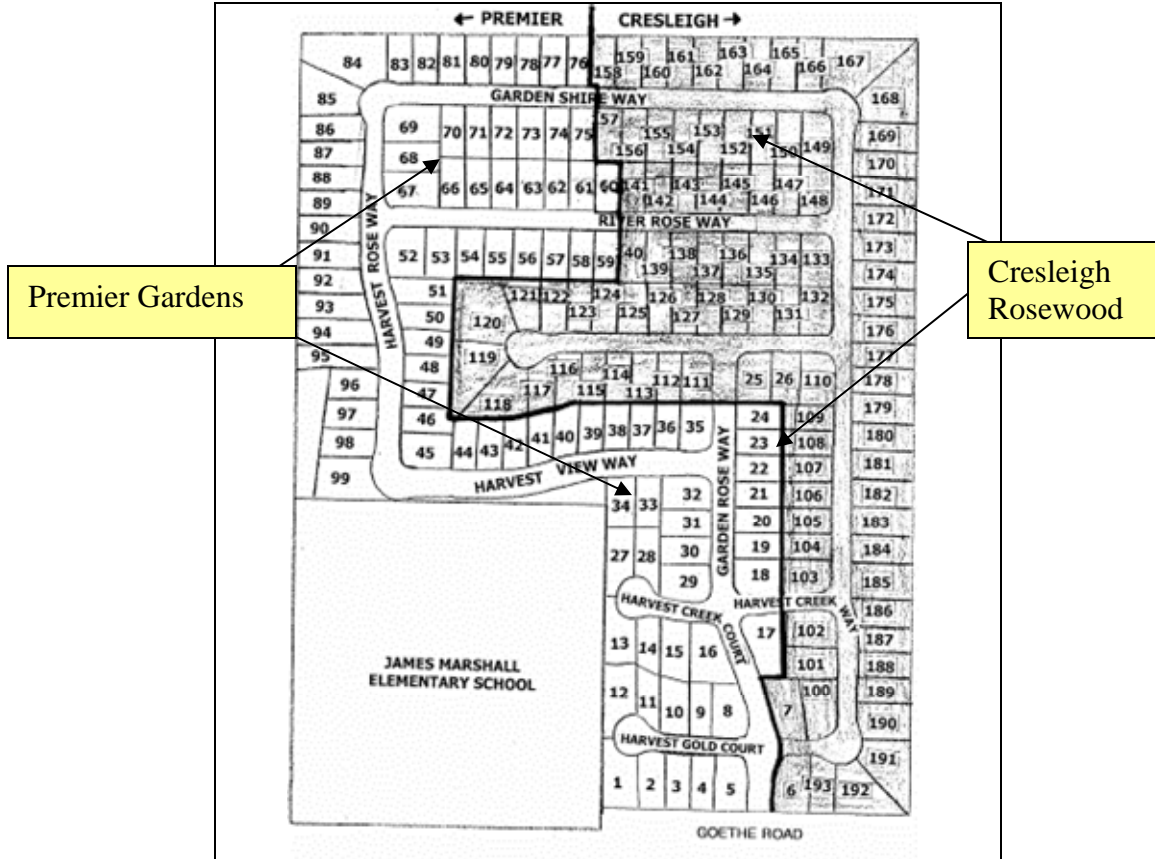


Figure 2: Premier Gardens and Cresleigh Rosewood Side-By-Side



Figure 3: The Entrances to the Two Adjacent Developments

Buyer Demographics

Research funded by and in support of the Department of Energy's Building America Program was conducted by RAND Corporation for the purpose of beginning to understand "the differences in homeowners' preferences for energy efficiency at the time of purchases, and what may account for these differences."¹ The research consisted of a study of prior research and a series of focus group discussions with homeowners in Premier Gardens and Cresleigh Rosewood in October of 2005.

RAND cautions that "limitations of our qualitative research approach and the small sample size in our study, our results should be considered as preliminary, and our conclusions as tentative.... This report is a "working paper" intended to share preliminary findings, invite comment, and continue progress made on better understanding the issues surrounding home buying decisions."

The following was learned of the near-ZEH homebuyers relative to the non-ZEH homebuyers:

- Near-ZEH homebuyers are younger
- Near-ZEH homebuyers earn less household income
- Near-ZEH homebuyers are more educated (2:1 hold advanced degrees)
- Near-ZEH homebuyers viewed more homes before purchasing (more than 2:1)

Detailed Description of Homes

The homes built in both of these developments are approximately the same size. The energy features are different in several notable ways. Premier Homes, working with support and encouragement from SMUD and BIRA, developed the first full-scale Near Zero Energy Community in the Sacramento area on their half of the development. On the other half, Cresleigh built homes participating in the SMUD Advantage Program intended to reduce summer cooling by 30% and meeting the California Title 24 requirements in effect at the time of construction. The Premier Garden's homes are significantly more energy-efficient and include a 2.0 kW AC photovoltaic (PV) system on each house. The table below compares the as-built energy features of the two developments.

¹ RAND Working Paper "The Role of Energy Efficiency in Homebuying Decisions: Results of Initial Focus Group Discussions" Mark Hanson and Mark Bernstein

Community	Premier Gardens	Cresleigh Rosewood
Energy Program	ComfortWise	SMUD Advantage
Square Footage of Each House Plan	2,248	2,384
	1,846	2,024
	1,625	2,000
	1,503	1,850
	1,285	1,720
	1,610	
PV	2kW AC GE	None
AC	14 SEER	10 SEER
Heating	92% AFUE	80% AFUE
Water Heating	Tankless 0.82EF	40 Gallon 0.60EF
Ceiling	R-38	R-30
Walls	R-13 + 1in foam w/Stucco	
Windows	Vinyl Low E	
Lighting	Fluorescent	Incandescent
Ducts	Sealed, Tested, Buried	Sealed, Tested

Table 1: Comparisons of Premier Gardens and Cresleigh Rosewood.

Energy Analysis

Methodology and Notes

SMUD has been an active partner in both collecting and analyzing data. Without their support this analysis would not be possible. Also, recently Pacific Gas & Electric (PG&E) has agreed to share the gas data for all the homes in both communities. This allows BIRA to examine the whole energy picture, which is of great value. In the future, BIRA hopes to gather gas data for other projects.

If not otherwise stated, the Cresleigh homes will be labeled as “Non-ZEH,” and the Premier homes as “Near-ZEH.”

This case study is beneficial for many reasons, one of which is the similar size of the homes across the communities. Although similar, there is a notable difference in the average home’s square footage between Premier and Cresleigh. The table below displays that the average Cresleigh Home is 10.5% larger.

Premier Plans by Sq Ft	# of Homes Built Per Plan	Total Square Feet/Plan
1285	13	16705
1503	20	30060
1625	13	21125
1848	18	33264
2248	31	69688
Premier Average Square Footage		1798
Cresleigh Plans by Sq Ft	# of Homes Built Per Plan	Total Square Feet/Plan
1610	12	19320
1720	15	25800
1850	16	29600
2000	19	38000
2042	11	22462
2384	25	59600
Cresleigh Average Square Footage		1988
Cresleigh Homes are 10.5% larger on Average		

Table 2: Average Square Footage of Homes

When interpreting one home's particular energy consumption for space heating and cooling the average square footage is unimportant; however, when averaged, the energy usage per community corresponds to the above averages. This factor or multiplier is not used in the analysis but is worth considering in understanding the energy usage across the communities.

Micropas is the main tool used to simulate heating, cooling, and domestic hot water energy use. For estimating all other loads, California's Title 24 and Building America's benchmark were used, depending on the situation. California or Title 24 load assumptions regarding lighting, appliances, and miscellaneous energy use come from both the BA benchmark and 1997 PG&E published data. All simulated results included in this analysis are labeled accordingly. As each of the five Premier plans was modeled separately, BIRA weighted each plan's simulated energy use based on the percent distribution in the community, as was done to calculate average square footage.

When BIRA and SMUD first began analyzing the energy use in this project only a portion of the homes were occupied. Below is a look at the number of occupied homes by month.

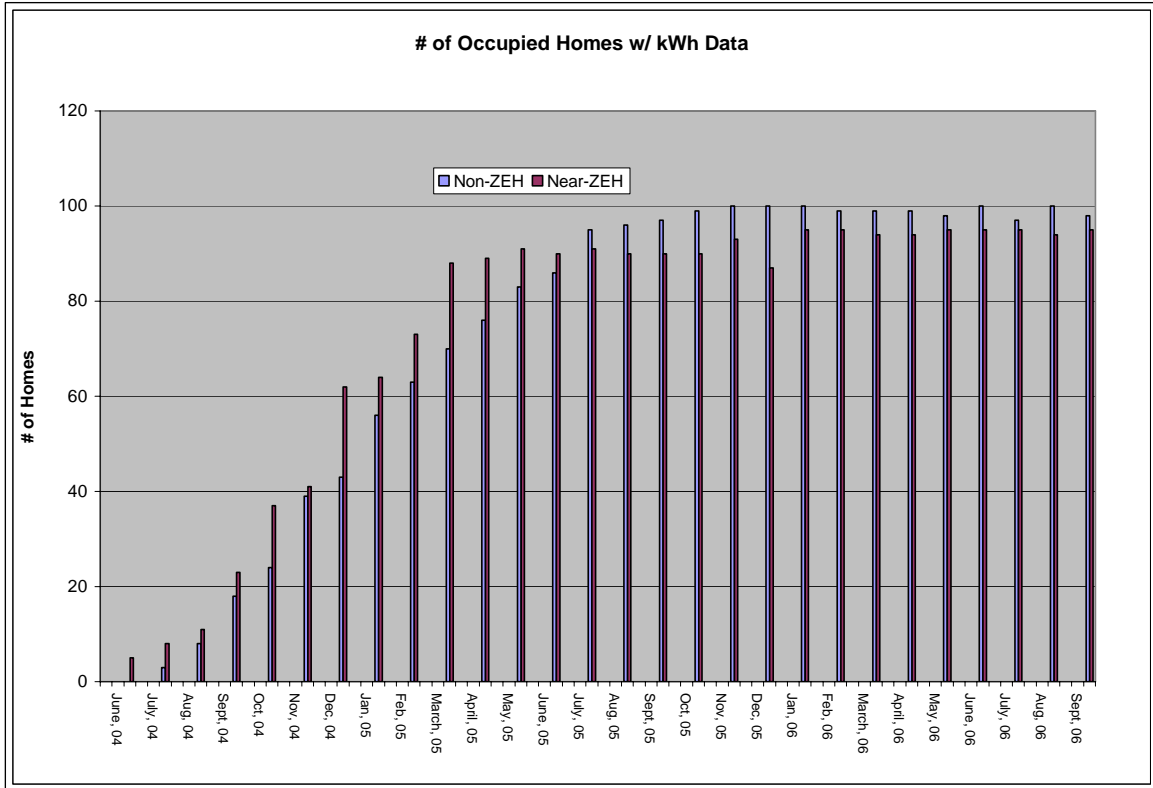


Figure 4: Number of Occupied Homes with kWh Data

Now that BIRA has access to more monthly electrical data, this report will only analyze data beginning when the majority of the homes were occupied, March 2005.

Electricity Use

Before interpreting the electricity consumption, it is important to understand the differences between the near-ZEHs and the non-ZEHs. The most notable difference is the PV systems on the near-ZEHs, this difference can easily be seen in the following graphs. Beyond that, the near-ZEHs have a higher R-value ceiling insulation, higher SEER-rated A/C with TXV, florescent vs. incandescent lighting, and buried ducts.

The analysis will begin by looking at the average monthly electricity use for each community from March 2005 to September 2006. This represents 19 months, and two summers.

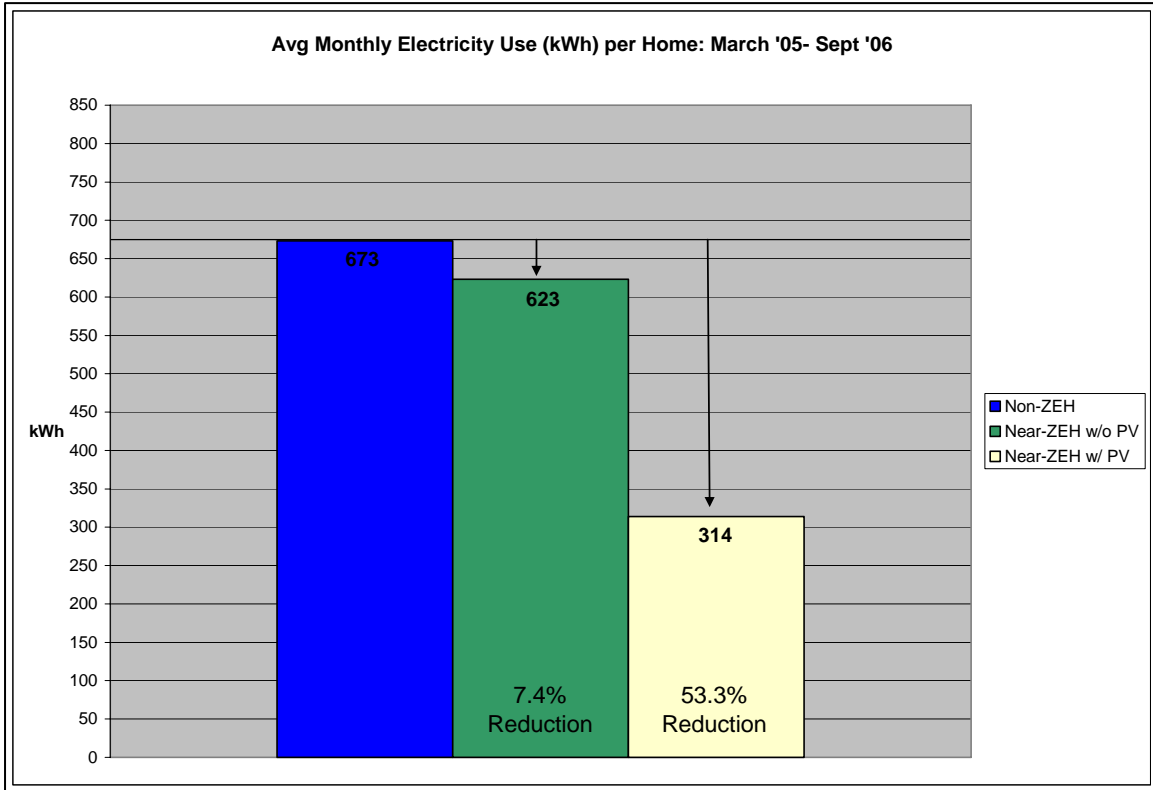


Figure 5: Avg Monthly Electricity Use (kWh) per home: March '05- Sept. '06

Before the PV electricity consumption is factored in, the electricity use across the communities is very similar, especially considering that the Cresleigh homes' are 10.5% larger. Although BIRA would like to see a larger savings before PV production is factored in, given Cresleigh homes meet the nation's most stringent energy code, Title 24, and were built to reduce cooling bills by 30%, it is not surprising.

One Year of Electricity Use

Below is the electricity use for each community for one year, including all 12 months from March 2005 to February 2006.

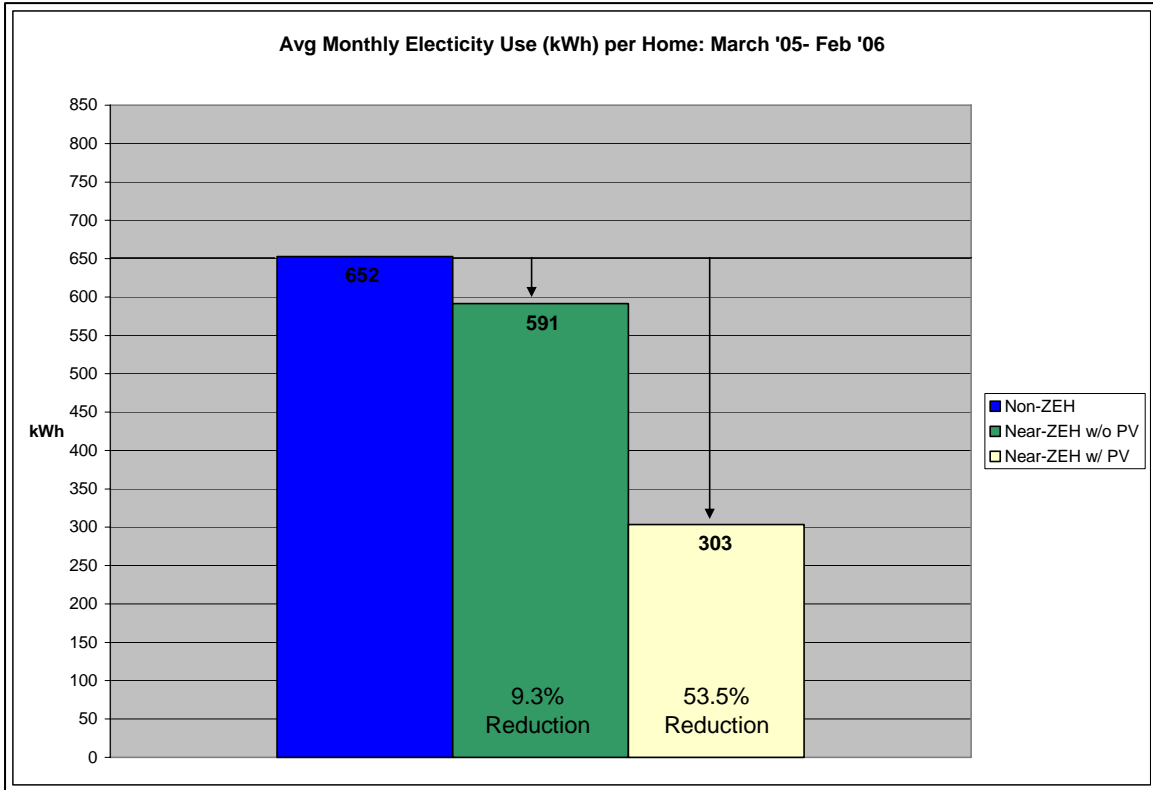


Figure 6: Avg Monthly Electricity Use (kWh) per home: March '05- Feb. '06

For analyzing the individual monthly results, it is useful to reference the average reductions per month.

Individual monthly electricity use between March 2005 and February 2006 show that the near-ZEHs perform better March through August as compared to the winter months versus Cresleigh. September through February use is similar where Cresleigh homes actually consume less on average in December and February. Likely this is because there is little to no electricity savings from the buried ducts and an improved A/C compressor during the non-cooling months.

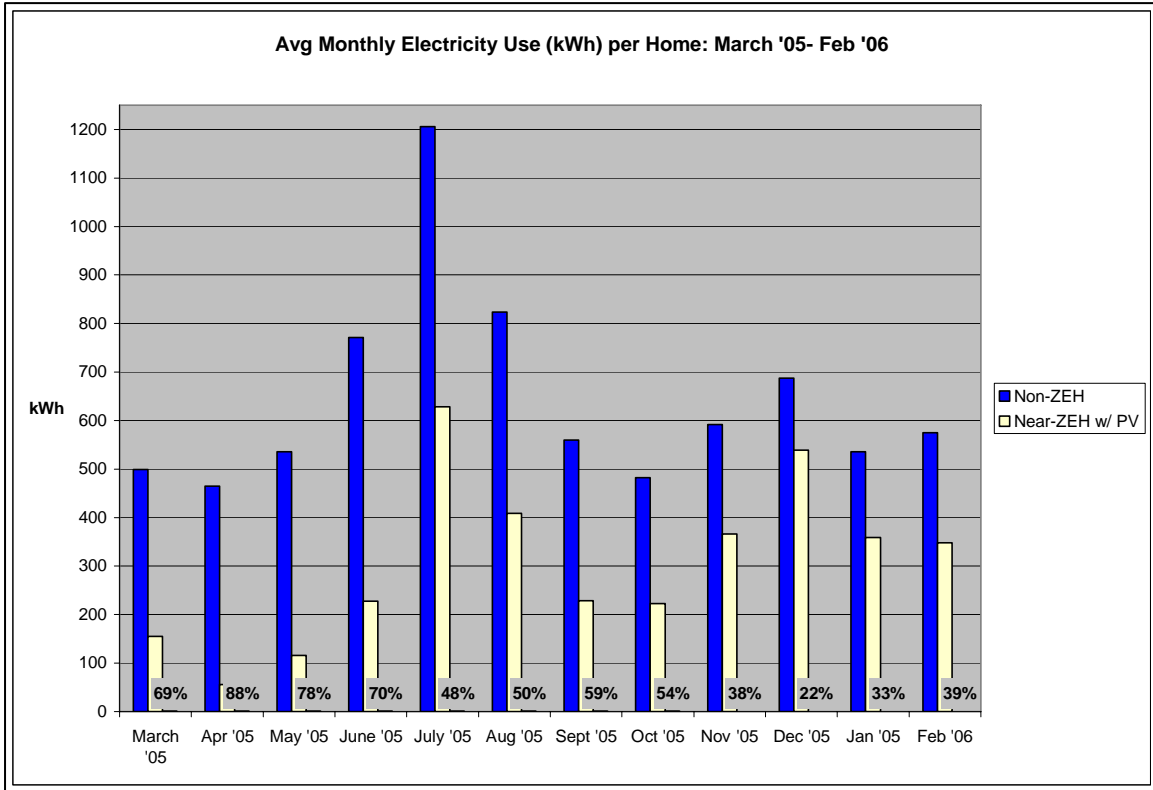


Figure 7: Each Month's Avg Electricity Use (kWh) per home: March '05- Feb. '06 (w PV)

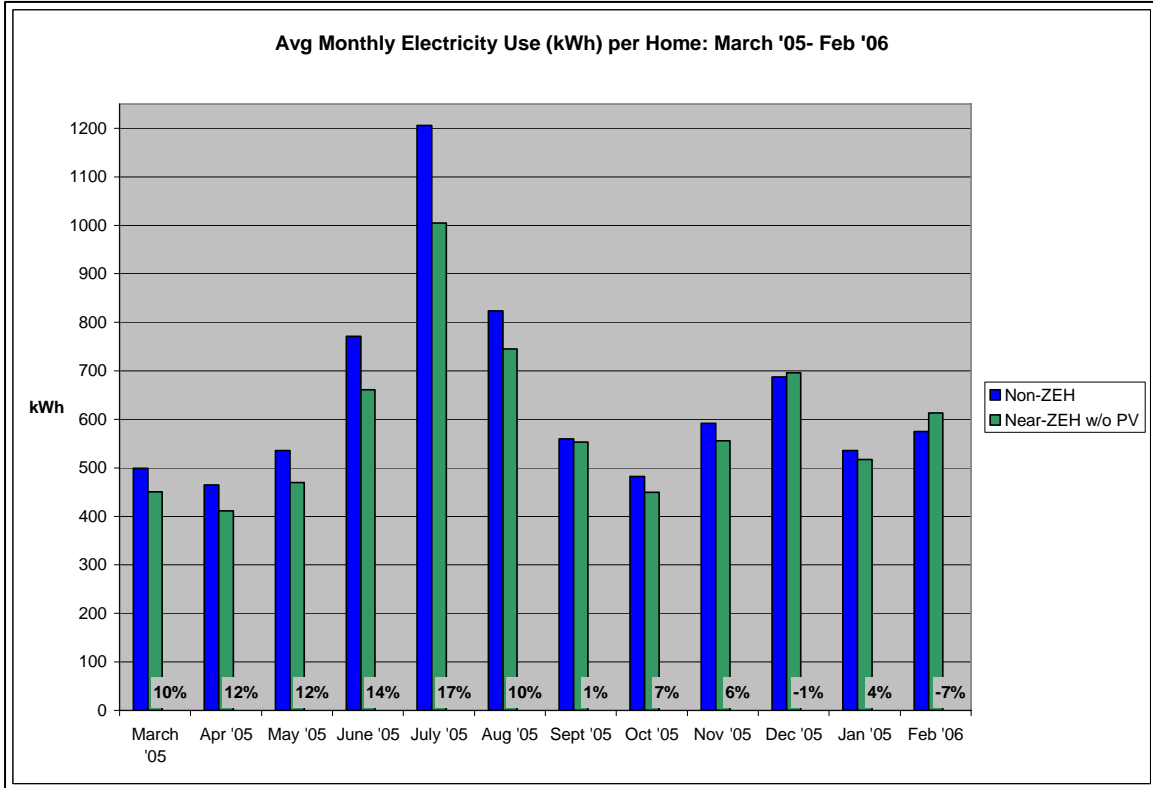


Figure 8: Each Month's Avg Electricity Use (kWh) per home: March '05- Feb. '06 (w/o PV)

Results from the 2005 and 2006 Summer Cooling Season

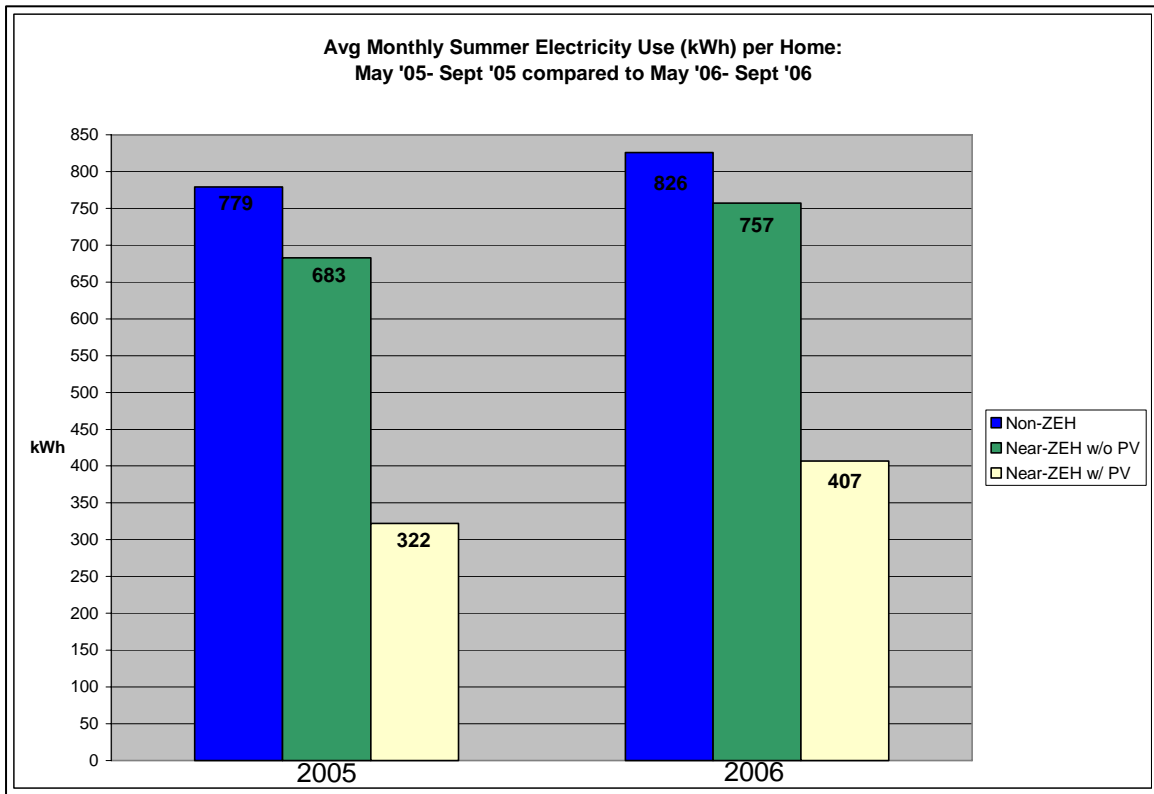


Figure 9: Avg Monthly Summer Electricity Use (kWh) per Home: May '05- Sept. '05 compared to May '06- Sept. '06

Both Premier and Cresleigh homeowners used more electricity from 2005 to 2006. However, Premier homes used 9.7% more electricity compared to Cresleigh's 5.7% increase.

The explanation for the increase across communities could be as simple as thermostat set points, or perhaps something more profound. Table 3, displays the average high temperature for each month of the 2005 and 2006 cooling season.

2005 and 2006 Summer Monthly Avg High			
Month	2005	2006	% of 2005
May	78.0	81.0	104%
Jun	83.0	90.0	108%
Jul	96.0	96.0	100%
Aug	94.0	89.0	95%
Sep	84.0	86.0	102%
Oct	77.0	75.0	97%
The 2006 Summer Cooling Season Avg High was 1% higher			

Table 3: 2005 and 2006 Summer Monthly Avg High

Table 3 shows that the summer 2006 cooling season average high was 1% higher than 2005, not a drastic difference. This likely contributed to somewhat higher cooling loads, but by how much is difficult to say

Electric Bills Show Savings, Variability

Figures 10 and 11 represent electricity bills for both near-ZEH and non-ZEH homeowners. Figure 10 represents a winter bill, while Figure 11 represents a summer bill.

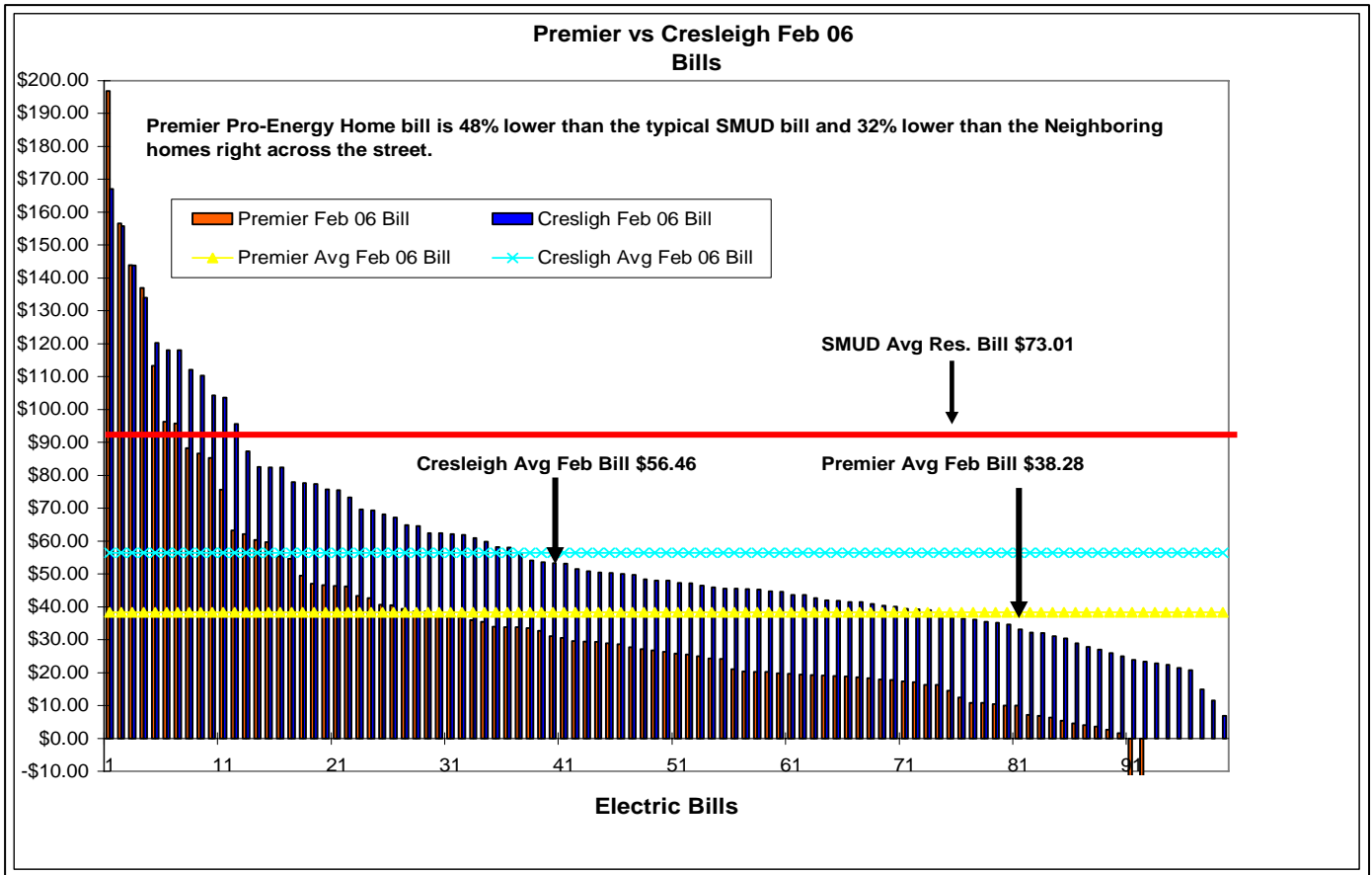


Figure 10: Premier vs. Cresleigh Feb 06 Bills (courtesy of SMUD)

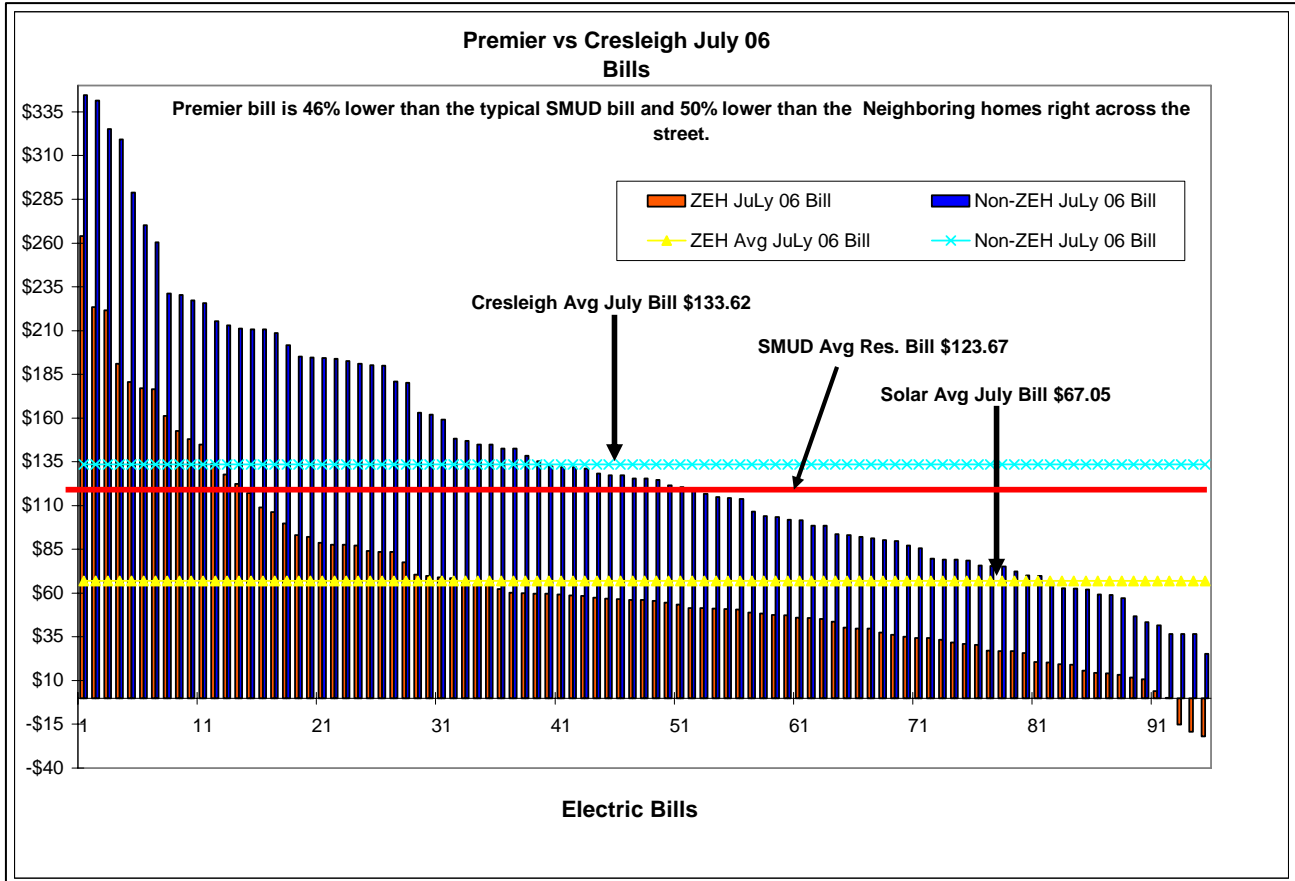


Figure 11: Premier vs. Cresleigh July 06 Bills

The primary feature of the above figures is the dollar savings of Premier homeowners over both neighboring Cresleigh, and the average SMUD residential bill. A common theme among Premier owners is their happiness when they open their summer electric bills. While their highest near-ZEH bill may be 60 dollars, their old smaller home's bill was over 200 dollars².

The secondary feature is the variability shown from the highest to lowest bills. For both Cresleigh and Premier percent variability far out weighs the percent variability in home size. These figures highlight that which is already known, there is tremendous variability in energy use dependent on resident behavior.

One important thing to note while interpreting the bill data is the tiered-rates that SMUD offers.

² Ibid.

Summer (May-Oct.)			
All-electric and gas-heated homes			
	Tier 1	Tier 2	Tier 3
Kilowatt-hours (kWh)	0-700	701-1,000	1,001+
Rate (cents per kWh)	8.66	15.1	16.83
SMUD Residential Rates 2006			
Winter (Nov.-April)			
	Tier 1	Tier 2	Tier 3
Gas-heated homes kWh/mo	0-620	621-825	826+
Rate (cents per kWh)	7.98	14.13	15.37

Table 4: SMUD Residential Electric Rates (courtesy of SMUD)

SMUD heavily encourages conservation as evidenced by the significant rate increase from tier 1 to tier 2, representing over a 60% increase for both summer and winter. This bucketed rate system favors the near-ZEH homeowners, for much of the marginal electricity consumed above their total by Cresleigh falls outside tier 1.

Gas Use

Gas Savings for Premier Garden’s homes are derived from their buried ducts, higher efficiency furnace, improved ceiling insulation, and tankless water heater.

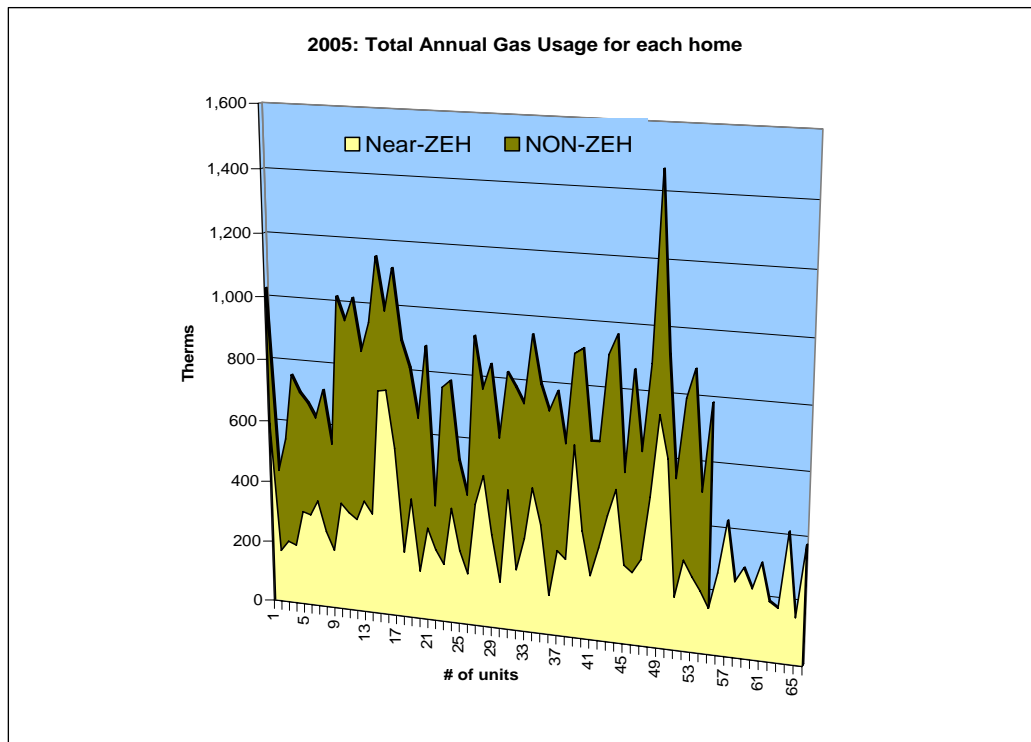


Figure 12: Total Annual Gas Usage for 2005 for Each Home

Figure 12 shows the total annual gas usage for all the homes in both communities. The near-ZEH homes consistently use less gas than their non-ZEH counterparts across the street. With so many homes of varying sizes, Figure 12 illustrates the apparent benefit of the added near-ZEH features.

Figure 13 illustrates the average 2005 gas usage for each community. This further illustrates the overall benefit of energy efficiency measures between both communities.

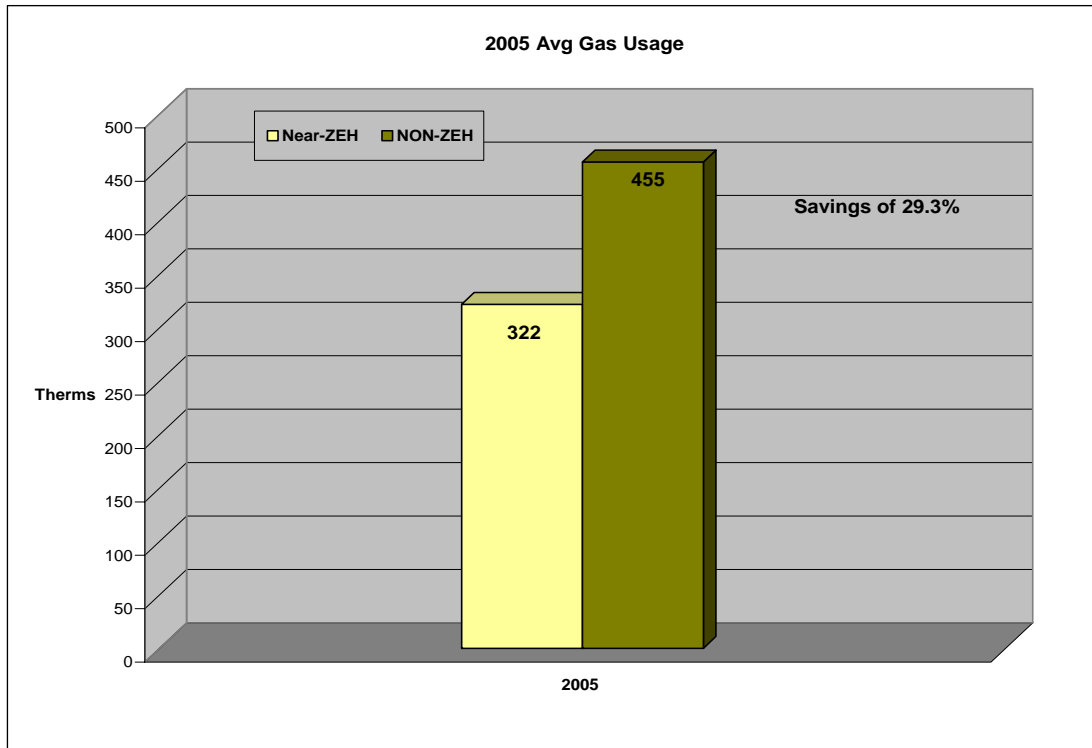


Figure 13: Average Gas Usage by Month, by Community

Figure 13 indicates that in 2005, the near-ZEH community used an average of 322 therms, a savings of 29.3% over the 455 therms used by the non-ZEH community.

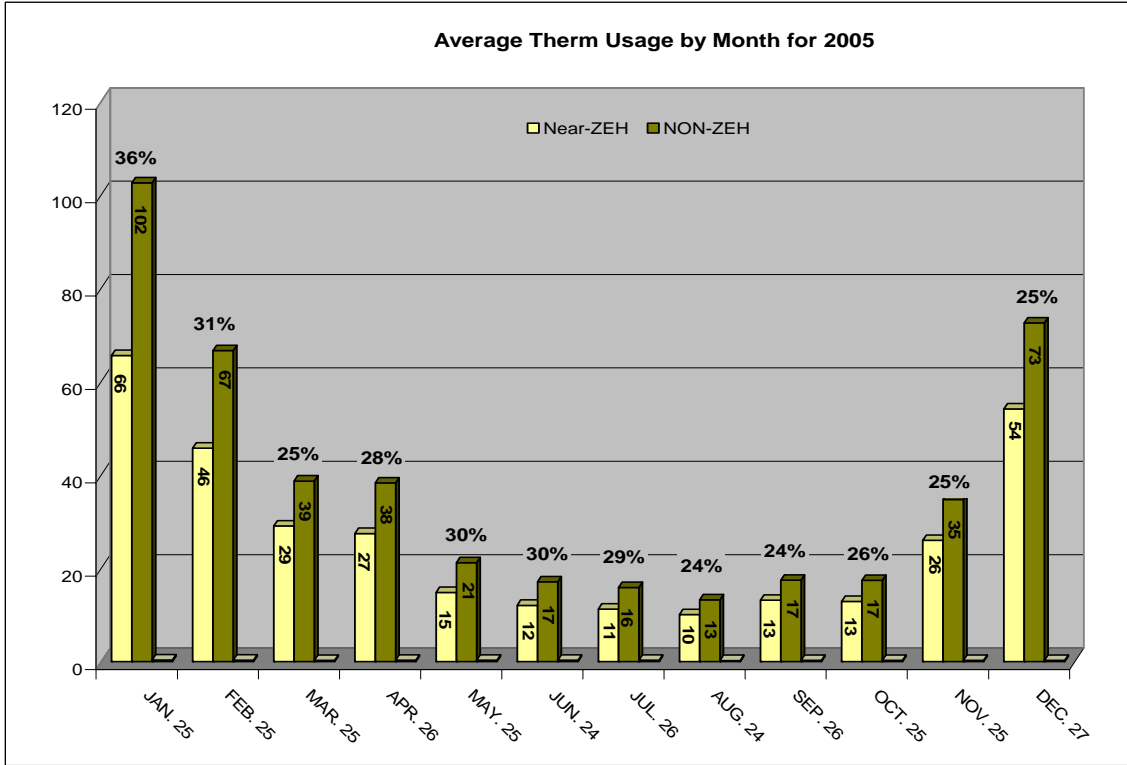


Figure 14: Actual Average Gas Usage by Community

Figure 14 shows the actual average gas usage for both communities by month.

Total Energy Savings

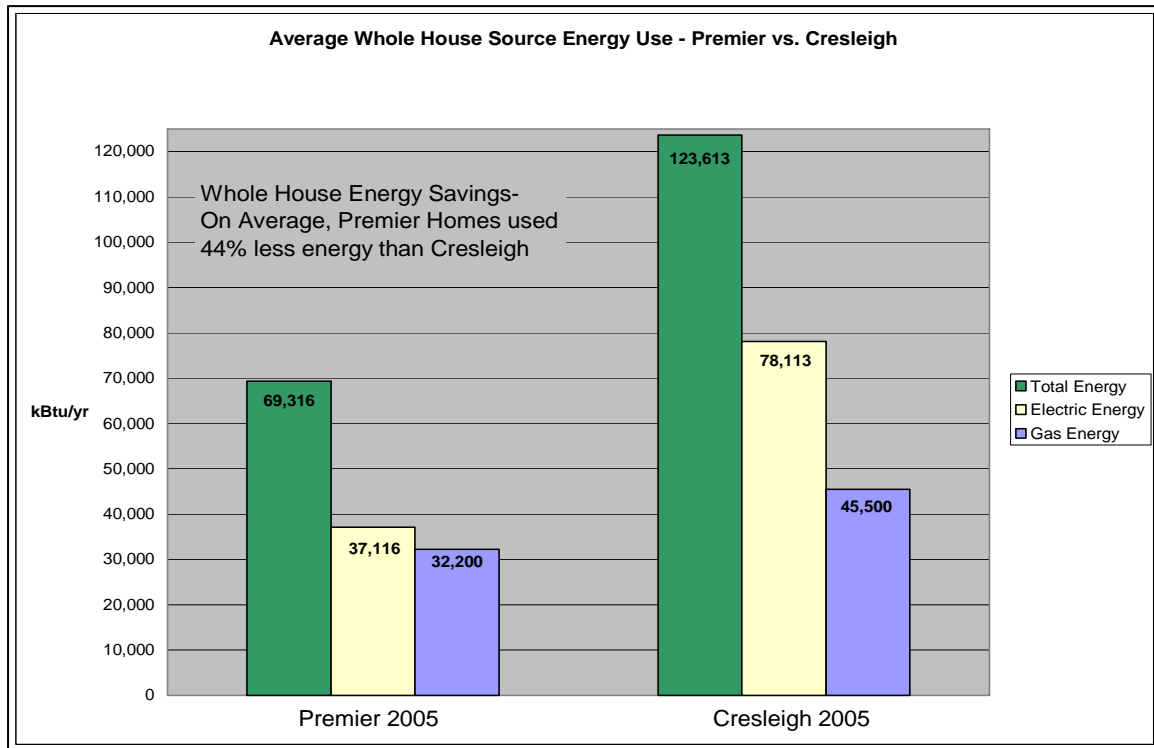


Figure 15: Average Whole House Source Energy Use- Premier vs. Cresleigh

On average, Premier Homes used 44% less source energy than their neighbors in Cresleigh Homes. As displayed in Figure 15, Premier used similar amounts of source gas and electric energy, while Cresleigh used 42% more source electric energy than gas, largely because Premier homes have electric solar generation.

When compared to an energy-efficient SMUD Advantage Home built by Cresleigh, Premier's near-ZEH still used 44% less source energy. It is safe to say that these homes are performing well. Next BIRA will examine the actual energy use versus simulated use for the near-ZEHs.

Simulated vs. Actual Energy Use

Now that BIRA has at least one year of electricity and gas data for the near-ZEH homes it will be valuable to compare these actual results to the predicted values. Through this, BIRA will evaluate both the simulation tools and the assumptions inherent within.

Electricity: Actual vs. Simulated

Below are the results from the near-ZEHs including actual and simulated results using both California and the Building America benchmark assumptions.

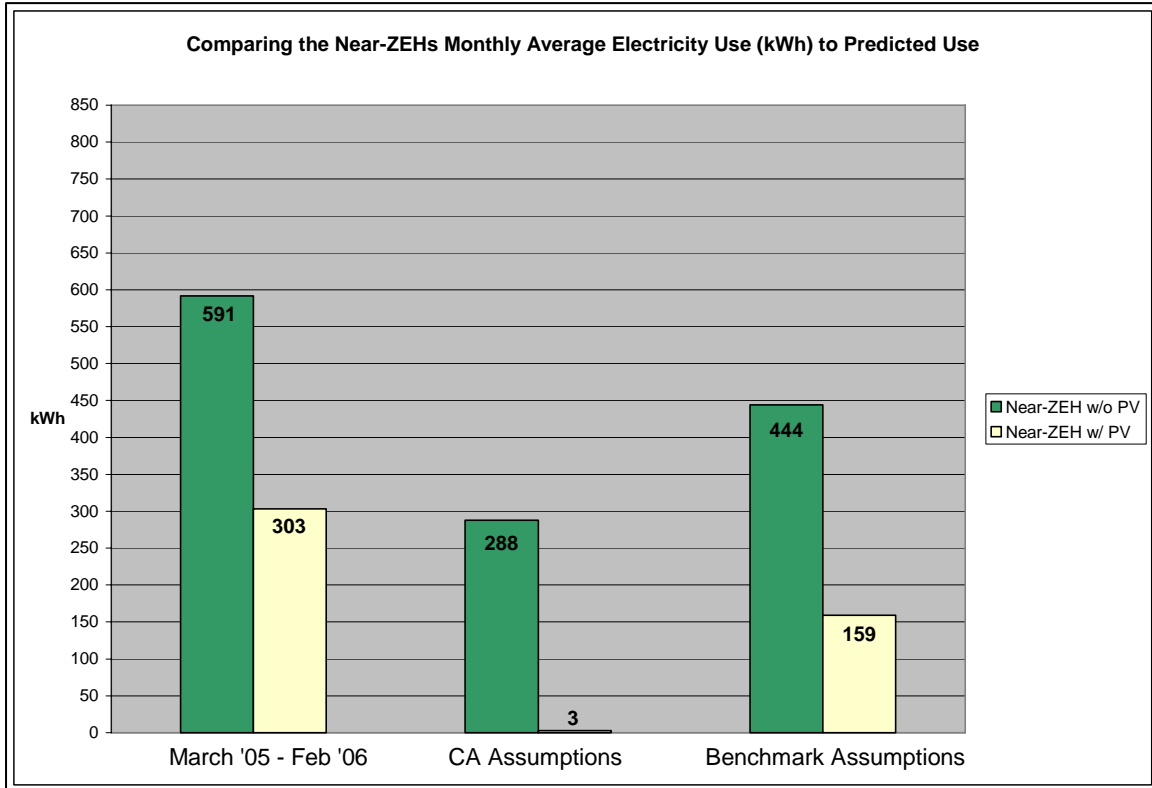


Figure 16: Comparing the Near-ZEHs Monthly Average Electricity Use (kWh) to Predicted Use

As seen in Figure 16, the actual consumption was considerably higher than expected. There are several explanations for this.

One very positive feature of this analysis is that the assumptions made for PV kWh production were right on. Based on GE solar data, BIRA estimated that on average the PVs would produce 285 kWhs a month. Compared to the actual 288 kWhs that were produced, the difference between actual and estimated is only 1%.

Determining why Electricity Consumption was Higher than Expected

Some insight can be gained through a survey of these two adjacent communities conducted by SMUD. In this survey, SMUD found that the majority of occupants of both developments have electric cloths dryers. In addition, many, if not most of the kitchens are all-electric (the standard offering), rather than gas, as originally modeled. Another difference that SMUD found that contributes to this unexpected electricity use is thermostat set points for cooling. In the computer analyses 78 degrees was used. In SMUD's survey most were considerably lower than 78 degrees. The highest temperature used for the cooling set point was 77 degrees with 75 degrees typical. Furthermore, the prediction assumes that the homeowner uses their setback thermostats to raise the set point five degrees at night, whereas the homeowners reported that they set their thermostats and left them alone.

In the focus groups conducted by RAND researching the buying decisions and customer satisfaction of the home owners in these two communities, it was determined that 50% of the participants representing the near-ZEH group have a second refrigerator in their home. The second refrigerators are most likely older less efficient models further exacerbating the problem.

Given these findings, BIRA revisited the simulated results. Remembering that each home is modeled individually, BIRA added electric ranges to 80% of the homes, electric dryers to 70% of the homes, and a second refrigerator to 50% of the homes.

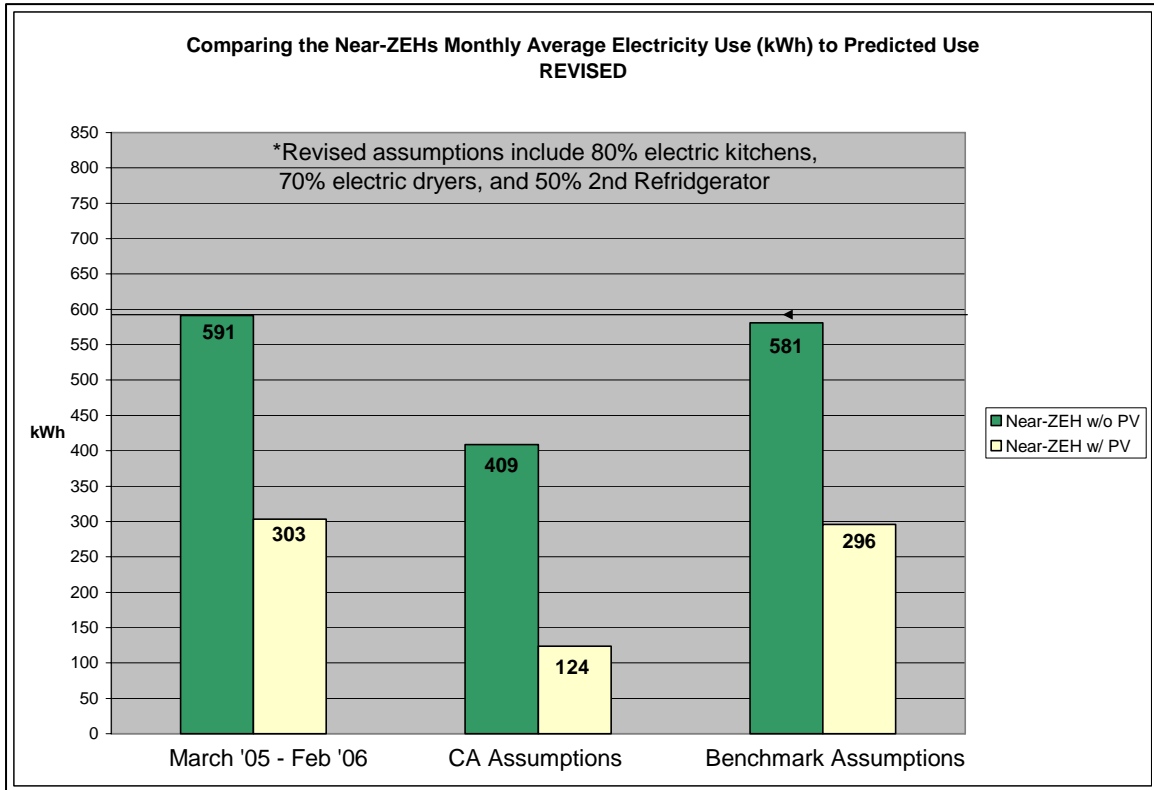


Figure 17: Comparing the Near-ZEHs Monthly Average Electricity Use (kWh) to Predicted Use REVISED

When assumptions were revised, the benchmark simulated energy performance is very similar to the energy performance indicated in the actual utility bill data. The California assumptions, which are a combination of PG&E and benchmark data, are still considerably lower than the actual results.

The one element left out of Figure 17, is the lower cooling thermostat set points and failures to set temperature back at night, which would further raise each simulated result.

Gas: Actual vs. Simulated

Figure 18 represents the actual average yearly gas use of the near-ZEHs compared to both California and benchmark assumptions.

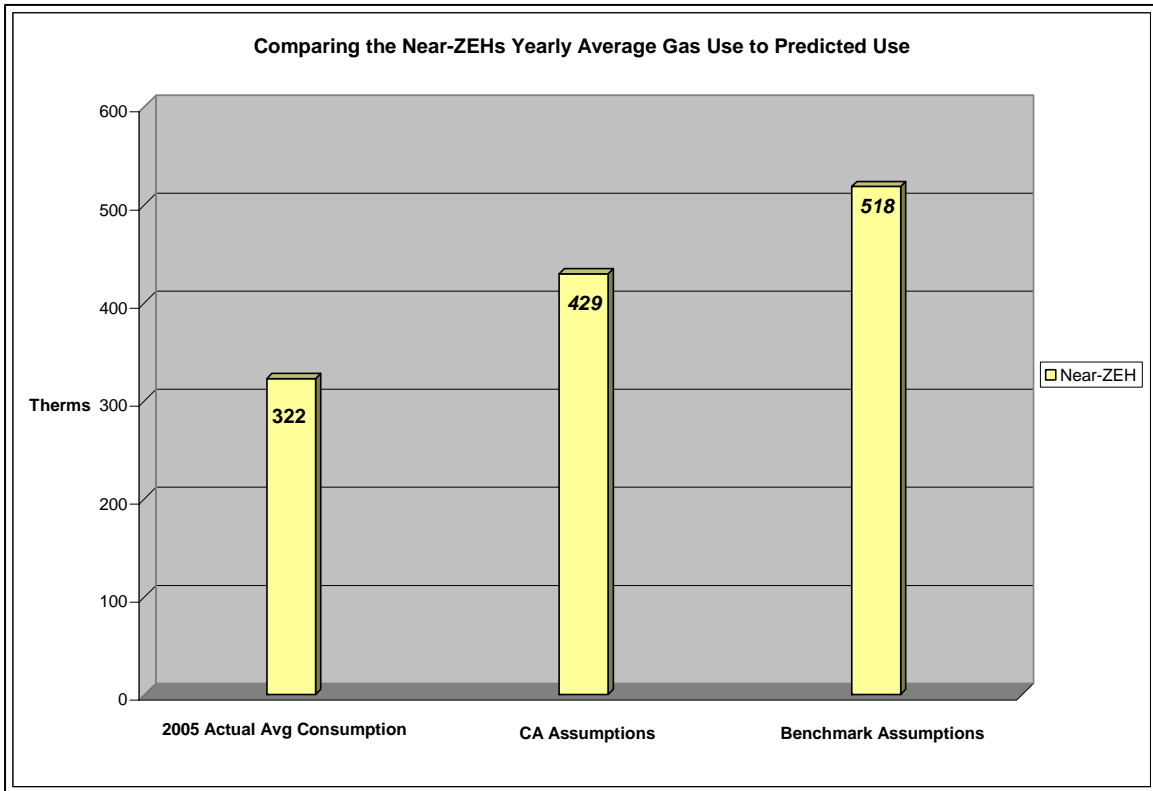


Figure 18: Comparing the Near-ZEHs Yearly Average Gas Use to Predicted Use

The gas use simulations over estimated in the same way that electricity use estimates were underestimated. The revised assumptions draw both estimates closer to the energy performance indicated in the actual utility bills. Across all near-ZEH plans, the BA Benchmark predicts an average of 72 therms of gas for clothes drying, and 78 therms for cooking. California assumptions for the same are 35 and 44 therms, respectively. The total increase across both uses is 71 therms. This contributes significantly to the total 89 additional therms the benchmark predicted above California.

The below figure represents the revised models to include reduced gas cooking and clothes drying from 100% penetration to 20% and 30% respectively. The second refrigerators do not affect this category.

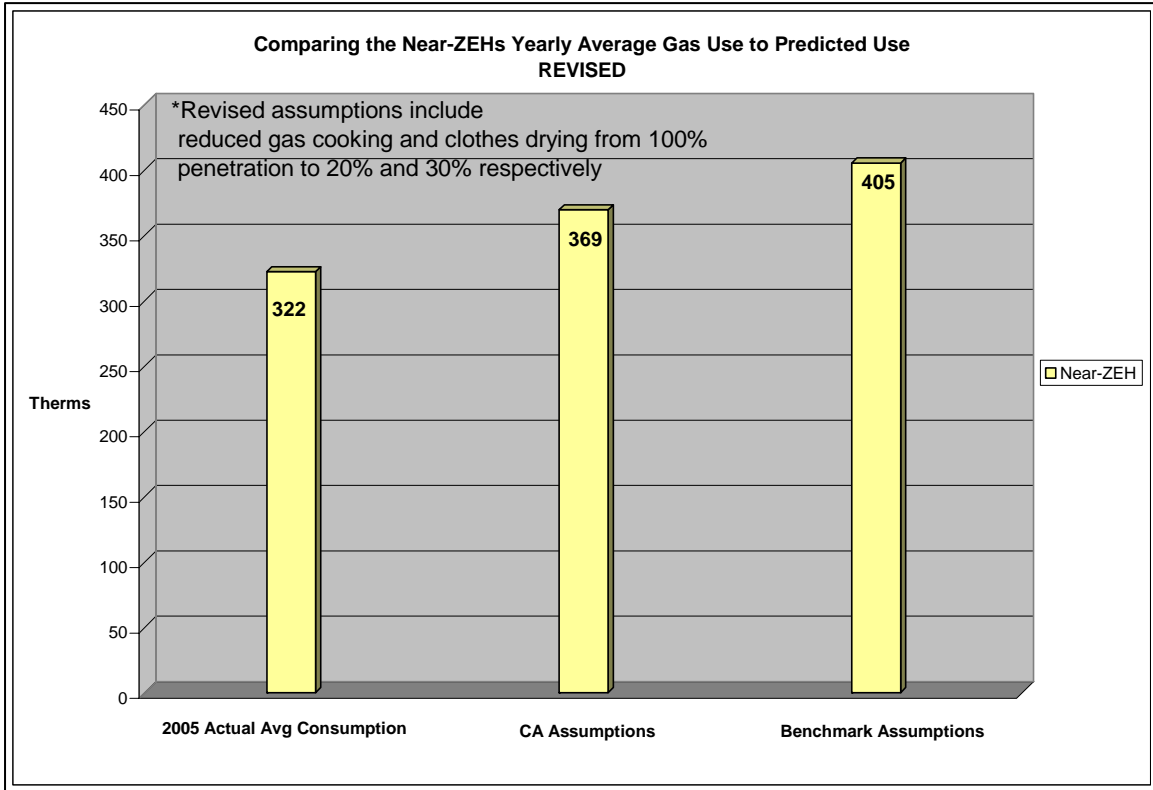


Figure 19: Comparing the Near-ZEHs Yearly Average Gas Use to Predicted Use REVISED

Although both simulated models grew closer to actual gas usage, the actual consumption is still 14.6% lower than California assumptions estimated and 25.7% lower than the benchmark. One possible reason for this could be a milder winter. Below are the monthly average temperatures as modeled by Micropas and actual 2005 temperatures. Micropas uses TMY2 weather data, which is an average for the last 30 years. As can be seen below in Table 4, the 2005 winter seasons were 4% warmer than the model where every month was warmer.

2005 Weather Compared to Modeled Weather			
Month	TMY2	Actual	% Difference
Jan	45.0	46.0	102%
Feb	50.0	53.0	106%
Mar	53.0	55.0	104%
Apr	57.0	57.0	100%
May	64.0	65.0	102%
Jun	70.0	69.0	99%
Jul	72.0	80.0	111%
Aug	72.0	77.0	107%
Sep	68.0	69.0	101%
Oct	62.0	63.0	102%
Nov	53.0	55.0	104%
Dec	46.0	49.0	107%
The 2005 Winter Seasons Were 4% Warmer than Modeled			

Table 5: 2005 Weather Compared to Modeled Weather

Even with the warmer winter, the assumptions still seem high. However, BIRA does not have any other potential mitigating factors for this. It might be behavior, or perhaps the models and assumptions are incorrect.

Benchmark vs. California Assumptions

The benchmark is 25.7% higher than the actual average gas use by the near-ZEHs. Even with variability, it may be prudent to investigate the assumptions the benchmark uses for gas consumption.

The Whole Energy Story: Actual vs. Simulated

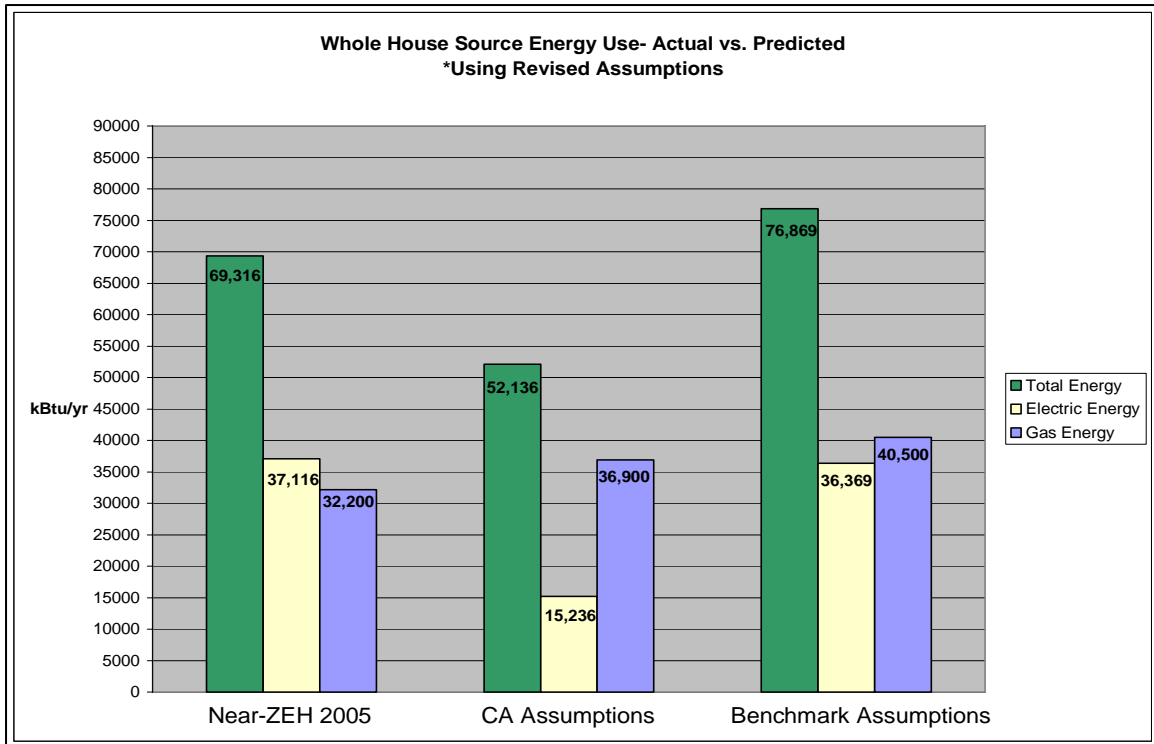


Figure 20: Whole House Source Energy Use- Actual vs. Predicted *Using Revised Assumptions

Whereas the benchmark assumptions were closer to reality for electricity, the California assumptions proved to be closer for gas.

Peak Analysis

System peak demand is a serious concern for SMUD, many other California utilities, and utilities across the country. To study the impacts that near-ZEHs have on peak, SMUD designed a monitoring experiment using the Premier Gardens and Cresleigh Rosewood communities. The methodology for the monitoring experiments can be found in Appendix II.

As seen in the figure below, the average home’s kW draw follows a similar curve to SMUD’s system draw.

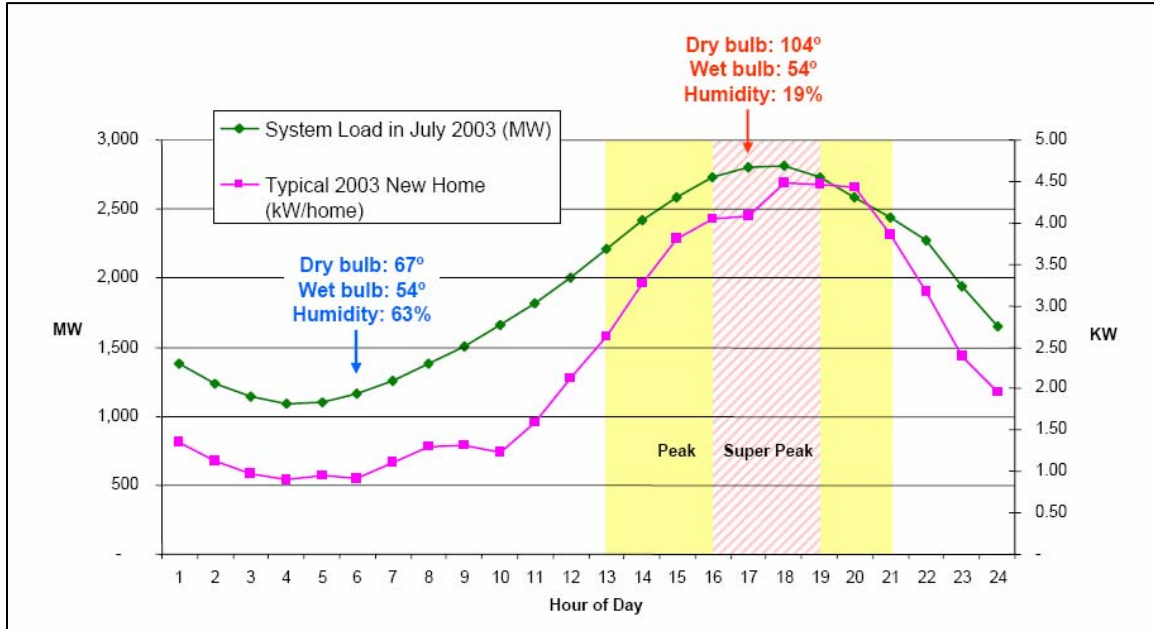


Figure 21: SMUD System Load in July 2003 vs. Typical 2003 New Home (courtesy of SMUD)

The initial monitoring results have been very positive, and have prompted further evaluation and emphasis for near-ZEHs due to peak benefits. The heat storm experienced July 2005 is still the best opportunity we have to monitor the homes' influence on peak.

July 2005

July 2005 was one of the hottest months in Sacramento weather history dating back to 1877, providing an excellent opportunity to test the effectiveness of the near-ZEH for reducing peak demand. The average daily high of 98 degrees was about 4 degrees higher than the "normal" daily high, and the daily low temperature of 65 degrees was the highest in Sacramento history. As a result, the average customer used about 13% more electricity in July 2005 when compared to July 2004. More importantly, SMUD set a new system peak demand. A new system peak of 2,959 MW was set at 5 pm on July 15th, and represented a 5% increase from the previous peak of 2,809 MW set on July 22, 2003. SMUD's new peak demand occurred on the fourth 100 degree plus day of a seven day "heat storm" in which new peak demand records were set on three consecutive days, July 13-15, 2005.

Peak Demand data compiled from the Premier Garden's ZEHs and adjacent non-ZEH homes show that ZEHs can have a significant impact on a home's peak demand. The graphs that follow show average 15-minute interval peak demand from the Premier Garden's ZEHs and adjacent non-ZEH homes for the month of July and July 15th.

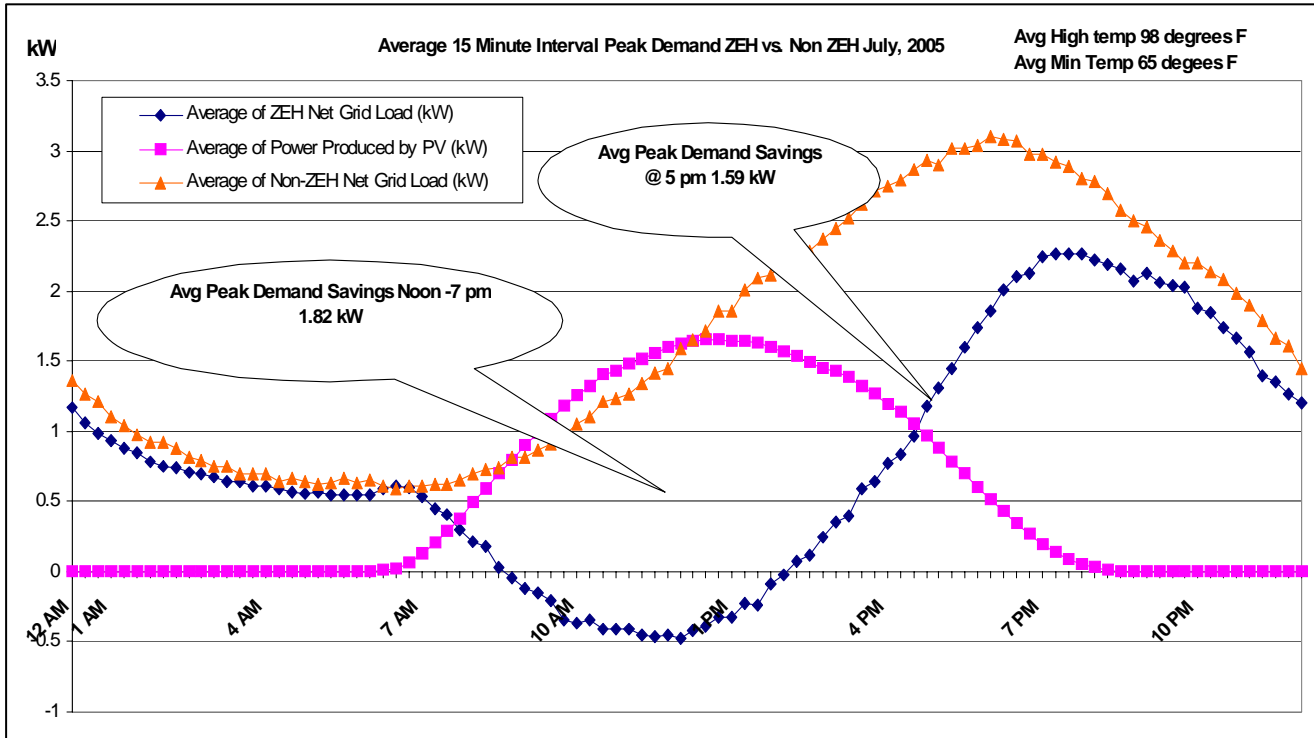


Figure 22: Average 15 minute Interval Peak Demand Near-ZEH vs. Non-ZEH July, 2005

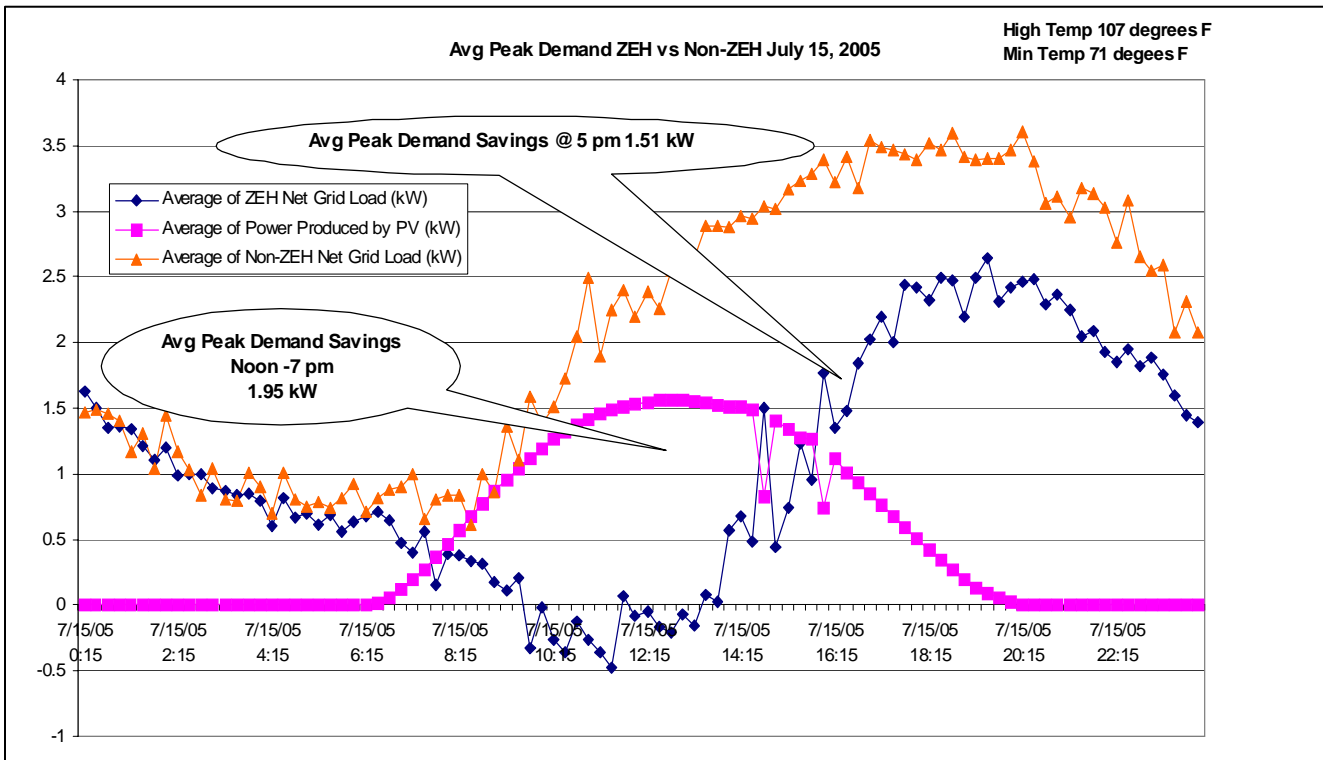


Figure 23: Average Peak Demand Near-ZEH vs. Non-ZEH July 15, 2005

As the graphs show, the near-ZEH peak demand was demonstrably lower than the adjacent, non-ZEH homes. This is especially significant as the non-ZEH homes were SMUD Advantage Homes designed to use at least 30% less cooling energy than homes built to the Title-24 cooling energy standards. It is further significant in considering that 11 of the homes in the sample, 28% face east and had no role in reducing peak demand. For the month of July, the ZEHs' peak demand at 5 pm was 59% less than the non-ZEH homes (1.3 vs. 2.9 kW). The ZEH peak demand was 43% lower on the peak day, July 15th. Average peak demand savings from noon-7pm were also significant, as seen in the below table.

Noon-7pm Avg. Peak Demand Savings			
Date	ZEH	Non-ZEH	% Lower
July	.69 kW	2.51 kW	73%
July 9-15	.63 kW	2.51 kW	75%
July 15	1.14 kW	3.09 kW	63%

Table 6: Average Peak Demand Savings (courtesy of SMUD)

Designing PV for Optimal Peak Reductions

In previous reports, BIRA analyzed the power production of the PV systems on the near-ZEHs to better understand when power is being produced. Since PV arrays can be oriented to maximize total production or peak production, it is important to look at PV performance as a function of orientation.

Eighteen homes in Premier Gardens are being monitored for power usage and PV production.

Orientation of PV Systems at Premier Gardens				
	Actual of all 95		SMUD's Sample of 18	
	#	%	#	%
SW	1	1%		
S	54	57%	11	61%
E	23	24%	5	28%
W	17	18%	2	11%
Total	95		18	

Table 7: Orientation of All 95 and 18 With 15 Minute Monitoring

It was found that total kWh production on an annual basis was best when facing south, about 5% better than west or east for July 16, 2005. However, there was a more significant difference between orientations for time of production, which is most important for peak. Below is a graph of total PV production during SMUD's peak hours for east, south and west facing PV.

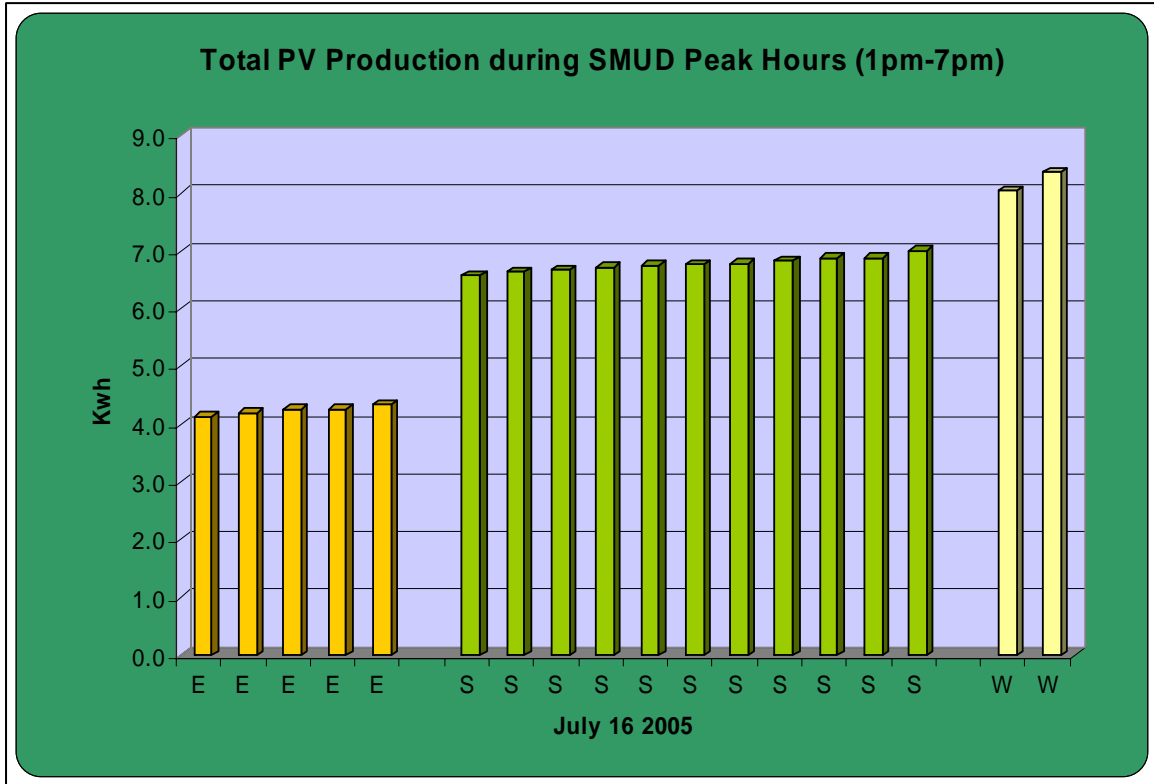


Figure 24: PV Production during Peak Hours vs. Orientation

To address peak load, PV orientation needs consideration during the design process. If total production were a priority, a south facing PV would be the choice. However, this analysis shows west-facing is best for production during peak hours.

To illustrate this point further all home’s were modeled as if they all had west facing PV. This is shown relative to actual results in the below graph.

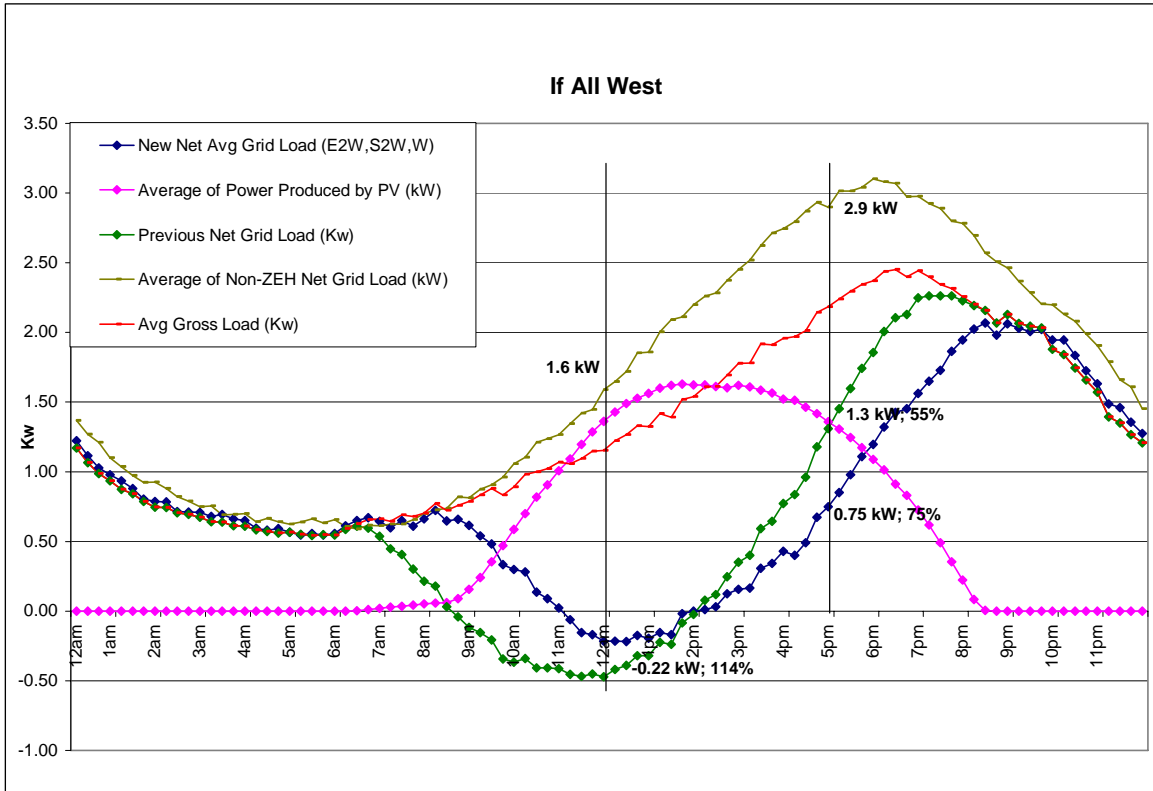


Figure 25: Simulated Impact of All West-Facing PVs

The impact of orientation optimized to address peak demand is shown in Figure 25. This analysis shows that had the Premier Gardens development been designed to maximize westerly facing PV’s, the net grid load could be shifted almost three hours. Additionally, the average demand at 5pm would have reduced from 1.3 kW as-built, to 0.75 kW with all westerly facing PV.

Moving Forward

After building and experiencing significant marketing/sales successes with both Premier Gardens and Premier Oaks, Premier Homes has made a pledge to build more ZEH communities. Currently, Premier is working with the California Energy Commission (CEC), Powerlight, and ConSol to build a community of Zero Energy New Homes (ZENH), California’s equivalent to the ZEH.

California’s ZENH must provide similar energy savings to a ZEH, but also reach only 1 kW during peak. These homes are being designed to save kWhs and kW at the most important, and difficult, time of day. As seen in Figure 21, home’s draw most of their electricity during the afternoon on hot summer days. This makes it especially challenging, and important to reduce new homes’ peak demand. The following analysis will look at techniques that Premier is considering to lower both kWh, and peak kW draw.

Premier Lakeside

The reason that the Lakeside project is being highlighted in this report is simple; it is the next step toward Zero Energy Homes highlighting the peak reducing power of energy efficiency and solar electric generation. Premier will be building in Lincoln, CA, which is on the north side of Sacramento. Also, the home design will build on the success and lessons learned from Premier Gardens to reach higher levels of energy efficiency and peak reduction. Premier Gardens showed that it is possible to build homes that drastically reduce whole house energy use and electrical peak demand. BIRA/ConSol is working closely with Premier to design these homes to achieve new levels of efficiency and peak reductions.

Saving kWh and kW, Moving towards Zero Energy Homes by 2020

As BIRA began work with Premier to design the Premier Lakeside homes it found that when going past 40% savings in the Sacramento area, energy saving features become peak shaving features as well. Many of the logical next steps toward greater whole house savings also reduce peak.

Note on Analysis

All analysis was done using Micropas, modeled in California climate zone 12, like Premier Gardens, using Building America benchmark assumptions.

Base Zero Energy Home

The table below displays all the features that are included in the base ZEH designed for Lakeside to meet the CEC ZENH requirements. Notably, the PV faces west on all homes to produce energy later in the day to mitigate for the home's kW draw in the afternoons during system electrical peak demand.

Premier Homes "Lakeside" 3,182 SQ FT (Largest Model + Worst Case Orientation)			
ENVELOPE: (Insulation R-Values)		HVAC SYSTEM:	
Roof (attic)	38	HVAC SYSTEM: Tonnage	3.9 Ton
Roof (at furnace)	19	Furnace: AFUE	0.90
Wall (2x4 Exterior)	13+1" Foam (R-4.2)	A/C: SEER	14 SEER TXV (12 EER)
Wall (2x6 Exterior)	19+1" Foam (R-4.2)	NightBreeze System	No
Wall (2x4 Garage)	13	Duct Insulation / Location	R-4.2 (buried)
Wall (2x6 Garage)	19	Duct Testing	Yes
Floor (Above Garage / Cantilever)	30	ACCA Manual D	Yes
Housewrap (Tyvek)	Yes	WATER HEATING:	
Attic Radiant Barrier	Yes	Water Heater Size	Tankless
Low Air Infiltration	Yes	Energy Factor	0.82
Quality Installation of Insulation Credit	Yes	Distribution Type	Pipe Insulation
GLAZING:		Solar Hot Water Heating	No
	IWC	PV SOLAR ELECTRIC (2.3 kW DC)	
<i>U-Factor</i>		PV Solar Electric System	Yes
Slider (horz)	0.35		West
Slider (vert)	0.35	MISCELLANEOUS	
Fixed	0.33	3rd Party Inspections and Testing	
Patio	0.34	Gas dryer stub	
French	0.37	Lighting (All Fluorescent)	
		Appliances (ENERGY STAR / Gas Dryer)	
SHGC			
Slider (horz)	0.33		
Slider (vert)	0.33		
Fixed	0.36		
Patio	0.33		
French	0.28		

Table 8: Premier Lakeside Base ZEH Features

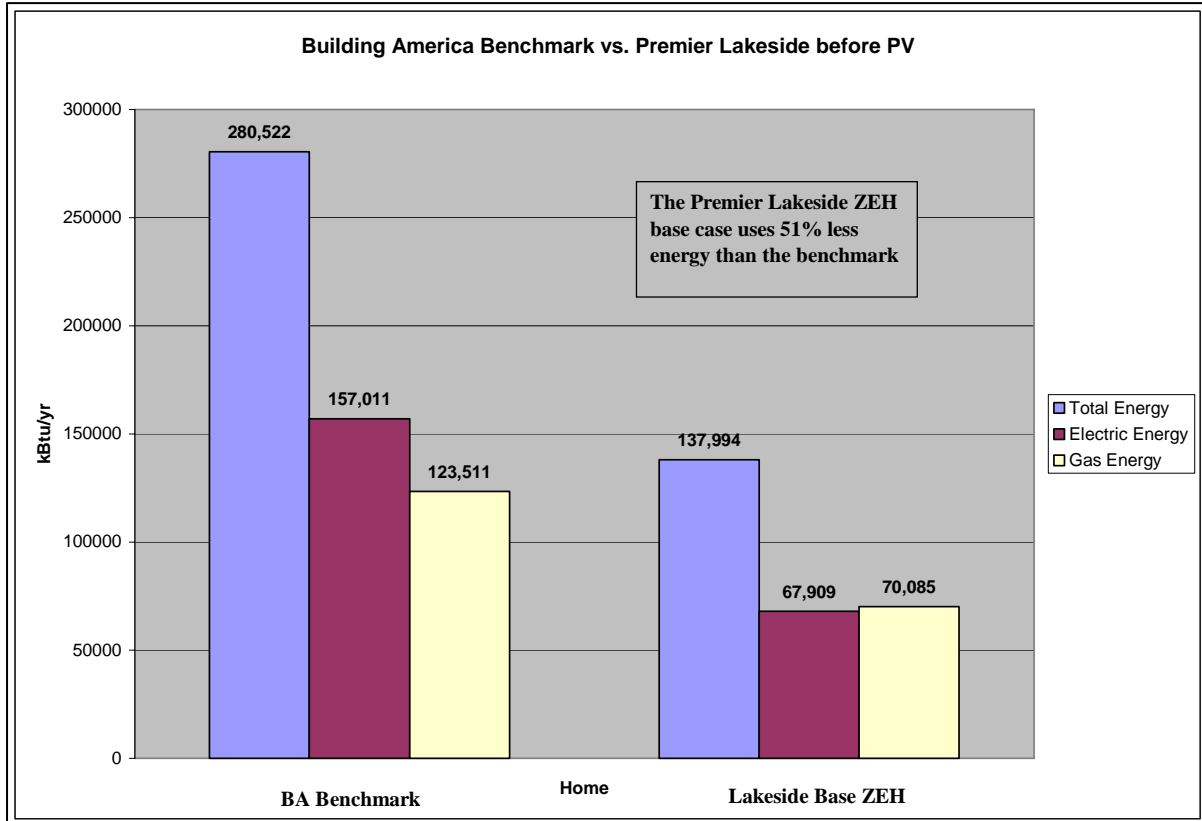


Figure 26: Building America Benchmark vs. Premier Lakeside before PV

As displayed in Figure 26, the Premier Lakeside ZEH base case simulated energy use is 51% lower than the BA benchmark. There are multiple features that contribute to its high energy savings.

Adding Options

In order to display and analyze where energy savings are coming from for additional options, each will be added one, or two at a time. Options will build on each other unless otherwise stated, so if new windows are added they will remain in for each new case.

Option 1

Add Milgard windows with SS glass (U-factor .35, SHGC .22) and replace batt with foam insulation in exterior wall cavities.

Option 2

Add Freus water-cooled air conditioner (SEER 19, EER 18)

Option 3

Remove Freus, replace with existing 14 SEER A/C and add Nightbreeze economizer

Option 4

Add exposed slab with tile or stained concrete replacing carpet to increase thermal mass

Energy Use for options 2 and 3 were remarkable similar with only a 32 kBtu/yr difference in electricity consumption. 32 kBtu/yr difference in electricity only represents a .06% difference in electricity use. BIRA opted to use the NightBreeze option as it saved 32 kBtu/yr and is climate appropriate.

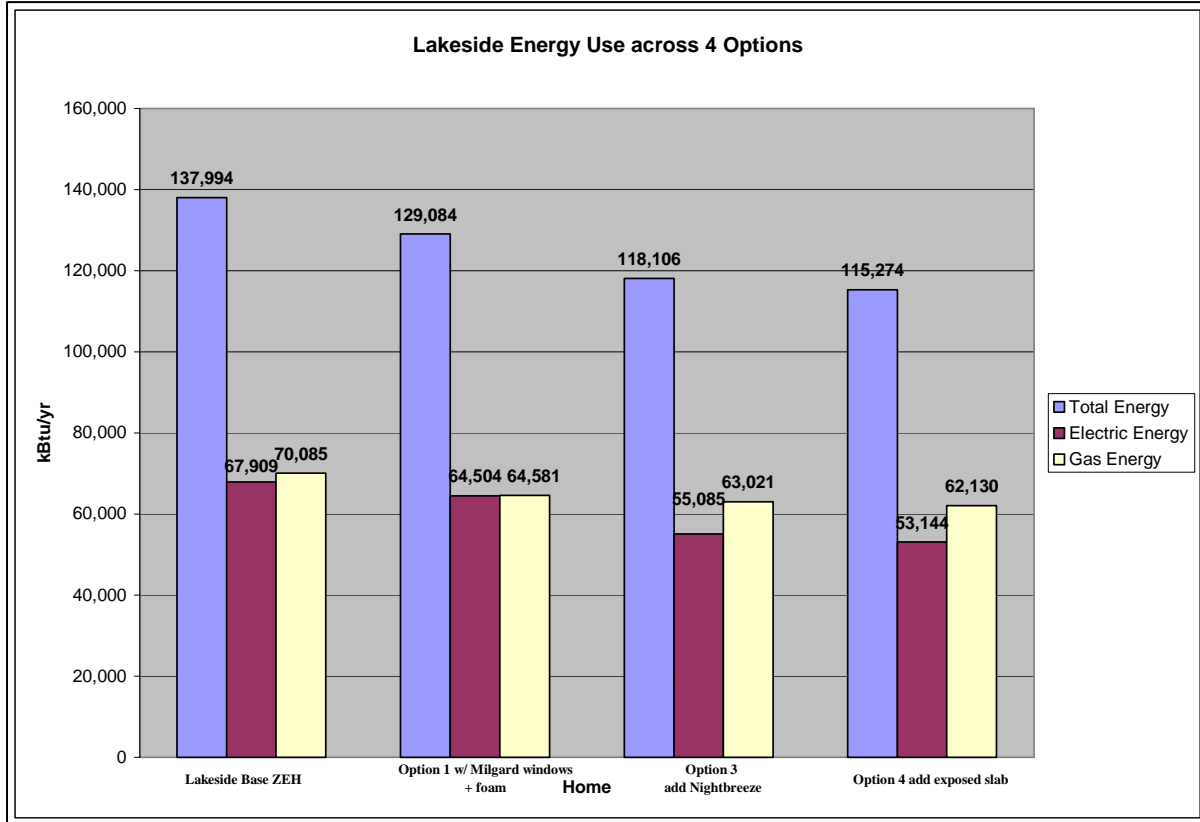


Figure 27: Lakeside Energy Use across 4 Options

Each energy feature contributed to the energy savings for the Premier Lakeside home. The largest difference was from the NightBreeze system, reducing total energy use by 9% from the previous option with the only variable being the NightBreeze system.

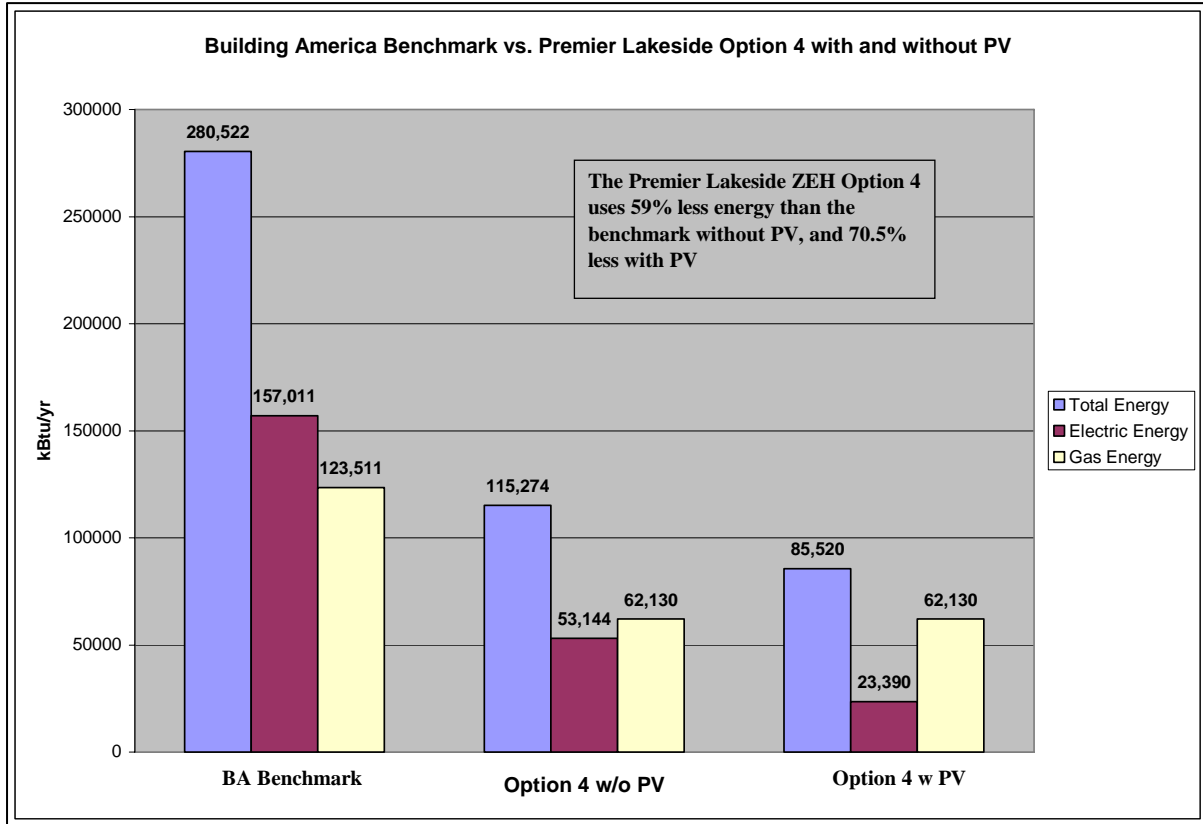


Figure 28: Building America Benchmark vs. Premier Lakeside Option 4 with and without PV

The Premier Lakeside ZEH Option 4 uses 59% less energy than the benchmark without PV, and 70.5% less with PV.

Peak Impacts

The peak impacts for these homes are as impressive as the energy savings. The “peak” used for analysis is PG&E’s current system peak, which is July 14 at 5pm. This was done with Micropas hourly draws for this day using TMY2 data. A complete analysis can be found in Appendix III. As shown, the peak for all options is below 1 kW and most are negative.

Options	Peak kWh draw
Base ZEH	.1 kW
Option 1	-.3 kW
Option 2	-.3 kW
Option 3	-.3 kW
Option 4	-.3 kW

Table 9: Premier Lakeside Base Peak kWh Draw

Energy Use by Sector

Another way to analyze energy consumption is by sector. The following figure identifies simulated energy use for the BA Benchmark and the Lakeside Option 4 ZEH.

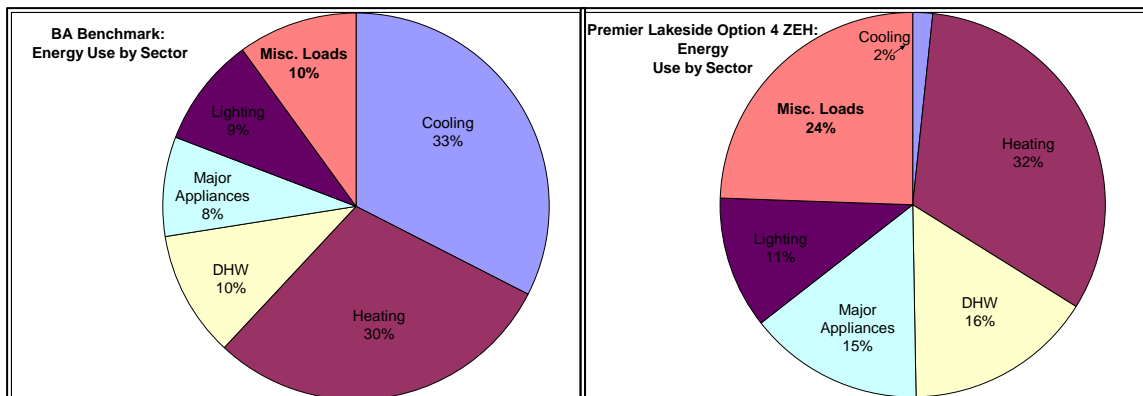


Figure 29: BA benchmark Energy Use by Sector vs. Premier Lakeside

The miscellaneous loads, although equal in absolute terms, increase in percentage from 10% in the benchmark to 24% in the ZEH. This represents an almost 150% increase as a percentage of whole house energy use. For the Lakeside home, the miscellaneous sector is the only one that remained constant from the benchmark. One option to reduce miscellaneous energy use is with an in-home energy feedback device.

In Home Energy Power Meter

There are several studies that show an average of 10% whole house electricity reductions from the installation of an energy power meter. These meters, of which several are available, simply display a home's energy draw (kW) in real-time. This allows the occupants to better understand how they consume energy, which in turn empowers them to better manage energy consumption. Currently, GE offers residential solar customers a meter that displays PV production (kW) and power use (kW) in real-time standard on most installations. However, most solar homes BIRA has consulted on do not contain these meters, including Premier Gardens. By simply installing these meters in all Building America solar homes, it is reasonable to expect 10% electricity reductions on average.

According to a Florida Solar Energy Center (FSEC) publication, "A compilation of available data on real-time feedback studies (Darby, 2000) suggests an average of 10-15% reduction in overall energy."³ Another study done by Hydro One released after the FSEC publication, installed meters in 500 homes and found that each home reduced total energy consumption by 7-10%.⁴

³ "How Much Energy Are We Using? Potential of Residential Energy Demand Feedback Devices" Danny Parker and David Hoak, Florida Solar Energy Center

⁴ "Monitors cut Energy Usage, Study Finds" 17 Dec. 2005 Technology Reporter authored by Tyler Hamilton.

As the BAP and BIRA move closer to true Zero Energy Homes it will be increasingly important to reduce miscellaneous end use. Although feedback meters do not specifically address one end use sector, they will certainly reduce miscellaneous end use and in a cost-effective manner.

A simple cost analysis shows that integrating these power meters, assuming 10% reductions in energy use, into solar homes is a low cost solution to reducing miscellaneous end use. As shown in the below figure, it is possible to increase the energy value of a PV system by 38% for 1/10th of the cost of adding additional PV generation. Therefore, a power meter either makes a home's PV system more cost effective, or makes it possible to install a smaller system to achieve similar energy savings.

Method	Energy Produced/Saved (kBtu/yr)	Cost	Cost Per kBtu/yr
PV system (2.2 kW)	29,746	\$13,547.00	\$0.02
Power Meter	11,527	\$500.00	\$0.002
Increase Energy Production/Savings of PV system by over 38% for 1/10th the Cost			
*Assuming 10% energy savings from meter, installed cost of meter at \$500 & 20yr life of PV			

Table 10: Energy Produced/Saved from PV generation and Power Meter with Cost

The power meter's cost is based on estimates from GE solar. For a GE system, the cost would only include labor and wiring, which is estimated at \$200. For any other system, it is assumed the meter would cost \$300, plus the \$200 installation cost. The cost estimates are conservative and likely would be lower.

Adding this power meter to the Lakeside Option 4 ZEH would further reduce the energy use.

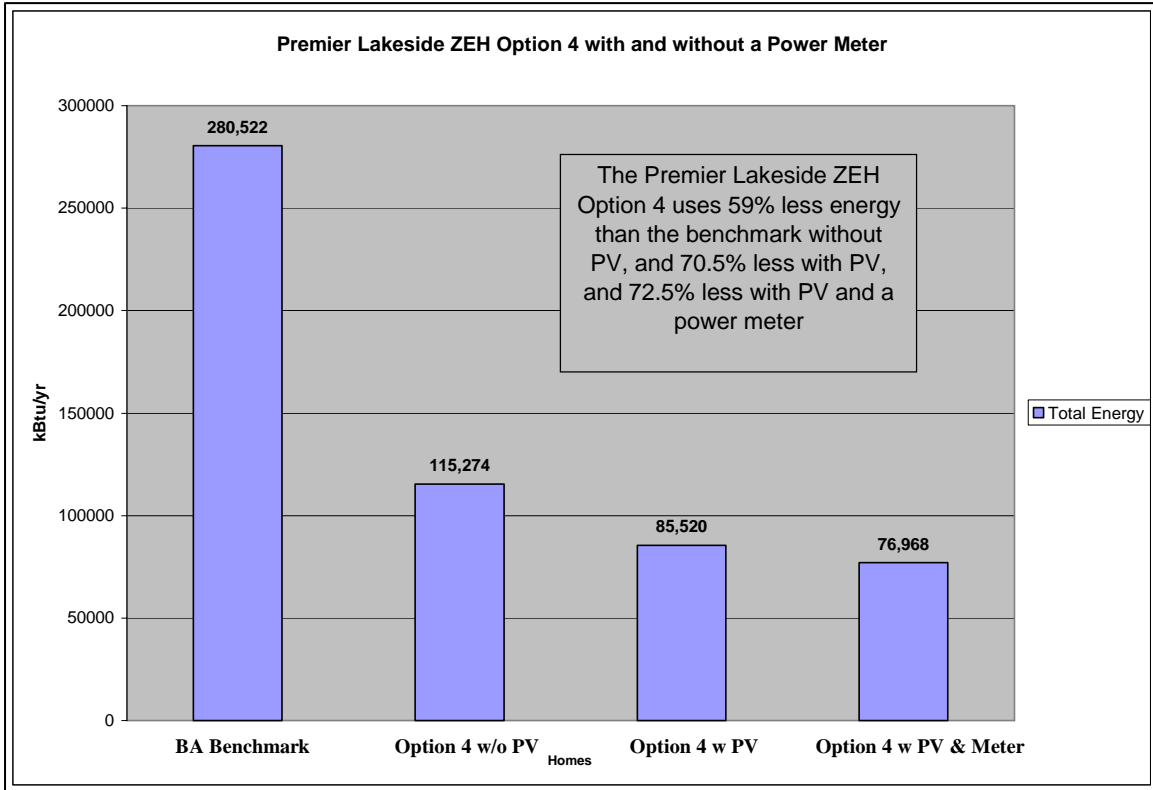


Figure 30: Premier Lakeside ZEH Option 4 with and without Power Meter

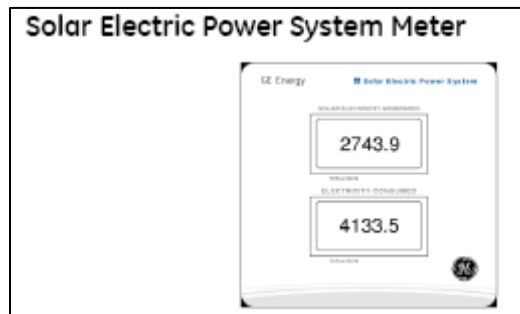


Figure 31: GE Solar Electric Power System Meter (courtesy of GE)

As seen in Figure 29, using a power meter can have a substantial impact. The Premier Lakeside Option 4 ZEH with a power meter uses 72.5% less source energy than the benchmark. It is important to note of course that this is simply an analytical exercise and BIRA is unsure what actual savings would be. However, this analysis is based on existing studies that suggest 10% whole house savings is a reasonable expectation for homes with a power meter. More work must be done to determine the effectiveness of power meters on ZEHs.

Builder Benefits

Background

Premier Homes builds an average of 70-90 homes a year in the Sacramento region. Prior to the Premier Gardens project, Premier had built only two homes with PV.

There are a few important factors that may have contributed to Premier's success with this project that must be stated to understand the context in which Premier was able to achieve success at Premier Gardens. Given the lessons learned from past ZEH experiences, such as Shea Homes in San Diego, it was strongly recommended by BIRA that Premier build with PV as standard equipment. Past experience shows that selling electric solar as an option is difficult, and more costly. Premier agreed, and every home in Premier Gardens was equipped with standard PV systems. These systems were installed by a sister company that Premier Homes owns, which may have also aided them during installation.

Premier worked closely with BIRA, ConSol, and SMUD to design, build, and market the homes at Premier Gardens. As a median size builder having little experience with advanced home building, Premier did not have in-house experience or expertise to design and market Zero Energy Homes. ConSol works with production homebuilders and was able to advise Premier throughout the entire process. SMUD provided very important marketing support, and lastly, Premier's senior management was enthusiastic to build Premier Gardens, not only for business reasons but also ideological ones. This desire and commitment to Zero Energy Homes was important for there are always set-backs in home construction, and building ZEHs may compound this.

It is difficult to judge how all these factors contributed to the success of Premier Gardens, or how important they are for other builders.

Expectations vs. Reality

When Premier first decided to build Premier Gardens as a ZEH community, it stated goals for the project. These reasons were highlighted in a previous BAP task, and are as follows:

1. To differentiate themselves from all other builders
2. To promote innovative construction and energy efficiency and be energy conscious and doing good to the community
3. To attract attention, and hopefully provide faster sales
4. To continue to build with photovoltaic (PV) systems, which they have been doing for a few years, working with SMUD
5. To be competitive and have an advantage over Cresleigh Homes in the same development as well as other Sacramento builders
6. To take advantage of incentives from SMUD for building ZEH
7. To sell the ZEH homes with higher resale values
8. To offer ZEH homes as a standard package and make it affordable for entry level homebuyers while other builders only offer ZEH as a move up option.

In October 2006, BIRA revisited these goals with John Ralston, Premier Homes Director of Sales, and a driving force behind the Premier Gardens project. BIRA asked John to address each point on the list and evaluate the success of each. John, with little hesitation, stated that each goal was met and many were exceeded. John said that Premier received more media attention than was ever expected and that sales were remarkable. Although brisk sales would be expected during the 2004-2005 hot housing market, Premier Gardens began construction later and sold out earlier than neighboring Cresleigh Homes. Additionally, the Premier Gardens experience has prompted Premier to build more near-ZEHs, having built over 250 as of October 2006. The one goal that was difficult to access was whether Premier Garden's homes will appreciate faster than non-ZEHs. As more homes are resold, this question will be answered.

Organizational Benefits

Reputation

By building Premier Gardens and Premier Oaks, in near by Roseville, CA, Premier Homes has developed a reputation as a forward-thinking environmentally and energy wise builder. As evidenced by a 4:1 turn-out in favor of Premier Homes over Cresleigh for the RAND study, Premier homeowners are not only happy with their homes but seem to be interested in sharing the news of their ZEHs. Premier Garden's homeowners are more than willing to talk about their low energy bills and comfortable homes. Almost every Premier Garden's homeowner that Premier and BIRA have spoken with is excited to share their happiness with their homes and energy bills. This willingness to share their story has solidified Premier Homes as a homebuilder that cares about its customers and provides excellent customer service. As a small homebuilder, reputation is very important to John Ralston, and Premier Homes.

Premier Homes has also gained the respect of the homebuilding industry for its innovative designs and marketing success winning an Energy Value Housing Award, administered by the National Association of Home Builders Research Corporation and funded by DOE.

Premier will continue to build their reputation as an industry leading builder continuing to push the limits of quality, price, and energy efficiency.

Direction

The success of Premier Gardens encouraged Premier to become a ZEH builder. Although Premier has not committed to build only Zero Energy Homes, Premier's latest projects have all included solar and energy efficiency. Premier Garden's showed Premier that building ZEHs is not only good for the planet, but also good for the bottom line. Premier has decided that the value of differentiation and reputation offered by building ZEHs is worth the additional cost. Differentiation and reputation are atop John's list of important attributes for a homebuilder's success. One of Premier's main goals is to differentiate themselves from other homebuilders, and the ZEH concept has done that.

Lessons Learned

Through building and marketing Premier Gardens and other solar communities, Premier has learned how to build and market ZEHs more effectively. Premier estimates that when PV is sold as an option it costs 40% more to install than if built standard. Premier has also learned and crafted their marketing message based on what resonates with homebuyers. Both John and his sales personnel work to communicate the benefits of a ZEH to potential homebuyers. This mission is difficult and takes a clear and concise message. Premier Homes is now confident that they can sell cost savings through reduced energy bills as Premier Gardens has offered verifiable evidence.

Morale

Most Premier Homes employees are proud of what they have accomplished and believe that their homes enhance people's lives. Some Premier employees even own Premier ZEHs. This benefit is difficult to measure but non-the-less important for the people who work at Premier and for the organization as a whole.

Marketing and Sales Benefits

Public Relations

Before construction began, there were numerous articles about Premier Gardens in local newspapers and in home and garden magazines exposing the energy efficiency features. On April 21, 2004, Premier Homes completed three models and had their Grand Opening ceremony. They were interviewed and on the news of three Northern California television stations. Premier Homes felt this was a great success, and the media coverage provided good exposure of both Premier Homes and Premier Gardens to the community. In addition, the whole energy-efficient expert team was there including a guest speaker Robert Rivinius, CEO of the California Building Industry Association, who highly praised Premier Homes for voluntarily building the first ZEH community. Premier Homes received immeasurable benefits from the PR generated from the Premier Gardens Project. The exposure did not fade, and Premier executives continue to be interviewed and written about in national and regional new sources including Newsweek magazine.

It is difficult to value the news articles, television stories, and other PR but it certainly is valuable to selling homes. The media attention Premier Gardens received saved on advertising, and offered exposure Premier could otherwise not afford.

Interestingly, there is a downside to the national media attention Premier Homes received. As a regional builder, Premier gains little from media observed outside California. John Ralston says that he frequently receives calls from people all over the country asking if Premier can build homes in their area. The answer is no, but it still takes time for Premier employees to respond to all the requests. Although, John wouldn't have it any other way, and appreciates the free publicity, the national media attention is certainly more valuable for a national builder.

Selling a Zero Energy Home

Through speaking with John Ralston and Premier Sales personnel, BIRA has learned how Premier approaches communicating the benefits of a ZEH to homebuyers. Because Premier allows its sales people to create their own marketing message it is hard to understand exactly how they approach it, but there are common threads.

An important benefit of selling a ZEH is the element of differentiation. Most model homes in the Sacramento region look alike. Selling a home with solar makes Premier stand out, and it gets people in the door asking questions. The challenge is having the time and proper message to communicate the benefits of a Premier home. Much of the interest from homebuyers is derived from the opportunity to save money compared to their current utility bills. John Ralston believes the most effective way to communicate this is by showing a potential homebuyer a summer electric bill from a Premier Garden's house. Although it is a small thing, he thinks offering a \$40 electric bill is more powerful

then offering a 40% reduction in monthly utility bills. This is an important nuance that Premier has learned through selling Zero Energy Homes.

For Premier Gardens, the prices of the homes compared to Cresleigh were comparable. The main difference, minus the homes' layout, was Premier's standard ZEH features, and Cresleigh's standard granite countertops. The task is adequately communicating the value of a ZEH, and what that means for a homeowner.

Moving forward Premier values the ability to confidently communicate energy bill savings based on Premier Garden's results. As the building industry is not among the most trusted, Premier knows having verifiable bill savings from Premier Gardens is an asset for selling future ZEHs.

Differentiation vs. Cost

Currently Premier Homes are selling homes in two ZEH communities. Now that the housing market has cooled, other builders are dropping prices. Premier's margins are not as high as other builders because they competitively price their homes while spending more to integrate ZEH features, and thus cannot lower their prices to align with other builders. This makes it difficult to sell, as homebuyers are spending even less time in model homes. Premier's differentiation is the market is now increasingly valuable. When the housing market was hot in 2004 and 2005 people were buying homes because they were for sale. Now buyers are becoming more discriminating, but Premier must effectively communicate the value of a ZEH, and get past the gimmicks and price cuts that other builders are offering.

Home Owner Benefits

The benefits of the well-built Premier Zero Energy Homes are numerous. A professionally engineered and tested HVAC system provides better comfort and indoor air quality for occupants. Low-emissivity windows provide added comfort and protect furniture and fabric from fading and wear. Better insulation and testing provide more even temperatures throughout the home and better sound insulation from outside noise. All the ZEH features provide 44% whole house energy savings over a Cresleigh Rosewood home and make the home more affordable.

Energy Bill Savings

Electricity

Premier Garden's homeowners are saving money every month on their electric bills relative to both SMUD residential customers and neighboring Cresleigh homeowners. On average, between September 2005 and August 2006 Premier residents paid 55% less than the average SMUD customer and 52% less than the average Cresleigh resident. This amounts to an average savings per month of \$35.40 over Cresleigh homeowners. Also, given SMUD's tiered rate system, which penalizes high electricity use, Premier

homeowners almost always remain in the 1st tier, as Cresleigh residents pay higher 2nd and 3rd tier rates during high electricity use months such as the summer cooling season.

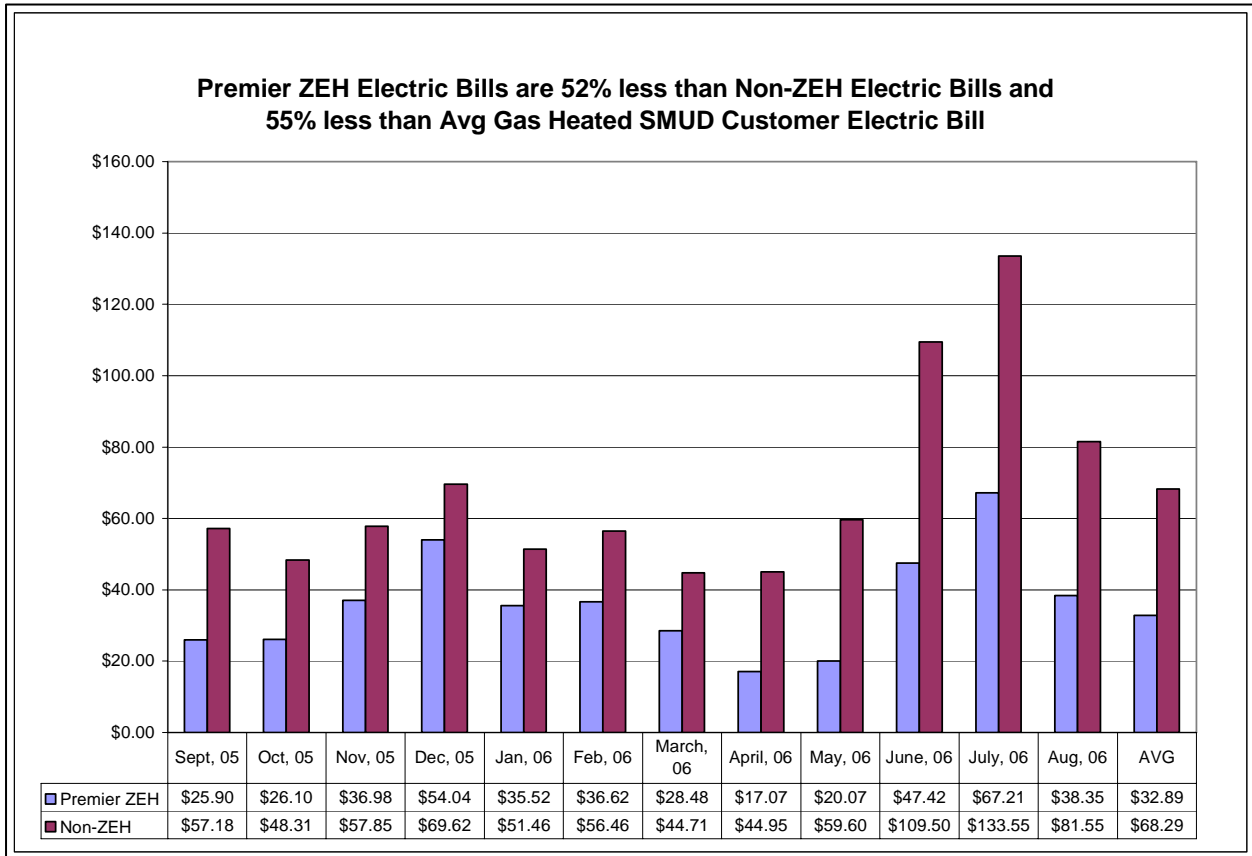


Figure 32: Premier Monthly Electric Bills vs. Cresleigh for 12 month period (courtesy of SMUD)

Additionally, Premier residents are able to create negative bills if they conserve energy. Every month there are a handful of Premier residents that experience negative bills creating a credit at the end of the year. In June 2005 more than 10% of Premier residents had negative bills.

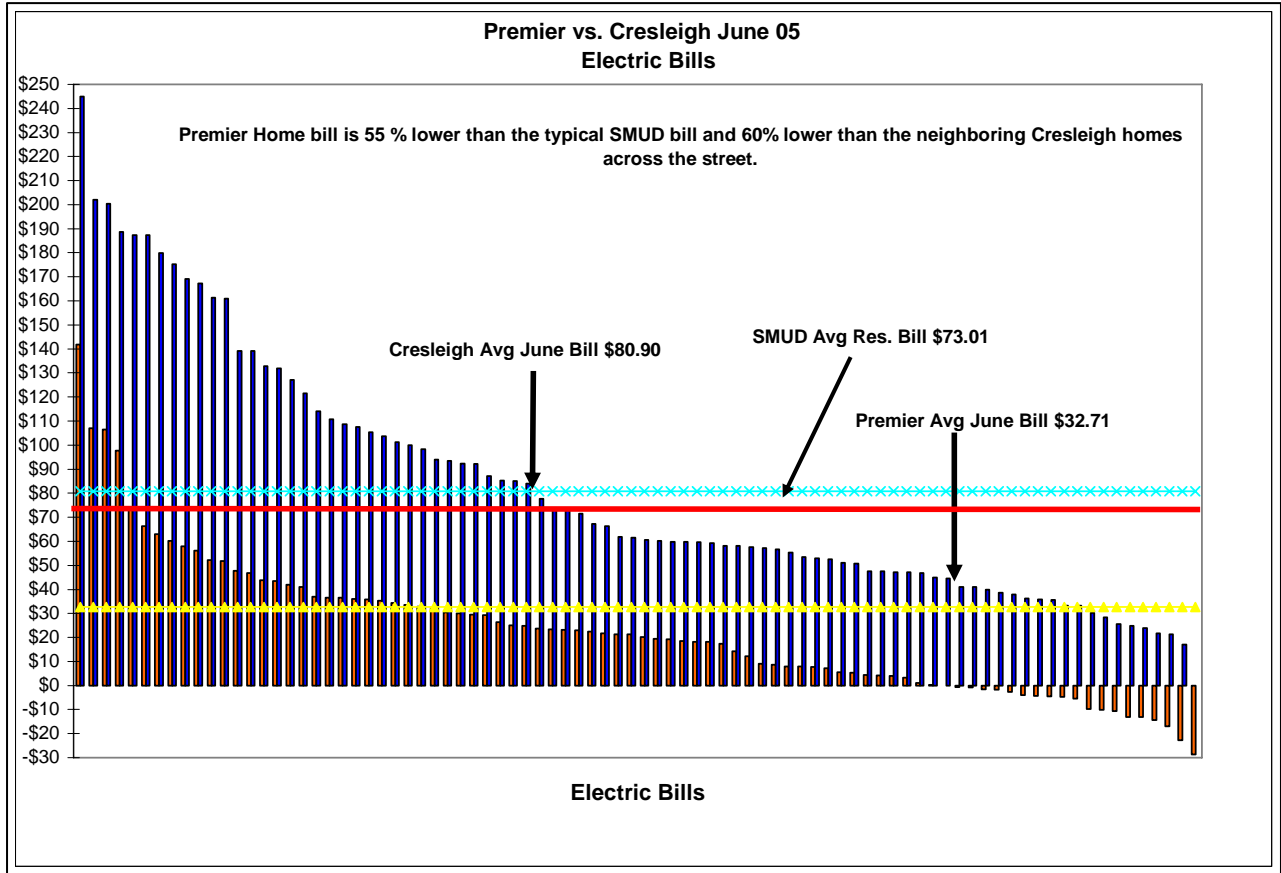


Figure 33: Premier vs. Cresleigh June 2005 Electric Bills (courtesy of SMUD)

Gas

Premier Residents also save on their gas bills. In 2005, Premier residents on average pay 30% less than Cresleigh residents, representing \$13.82 savings each month.

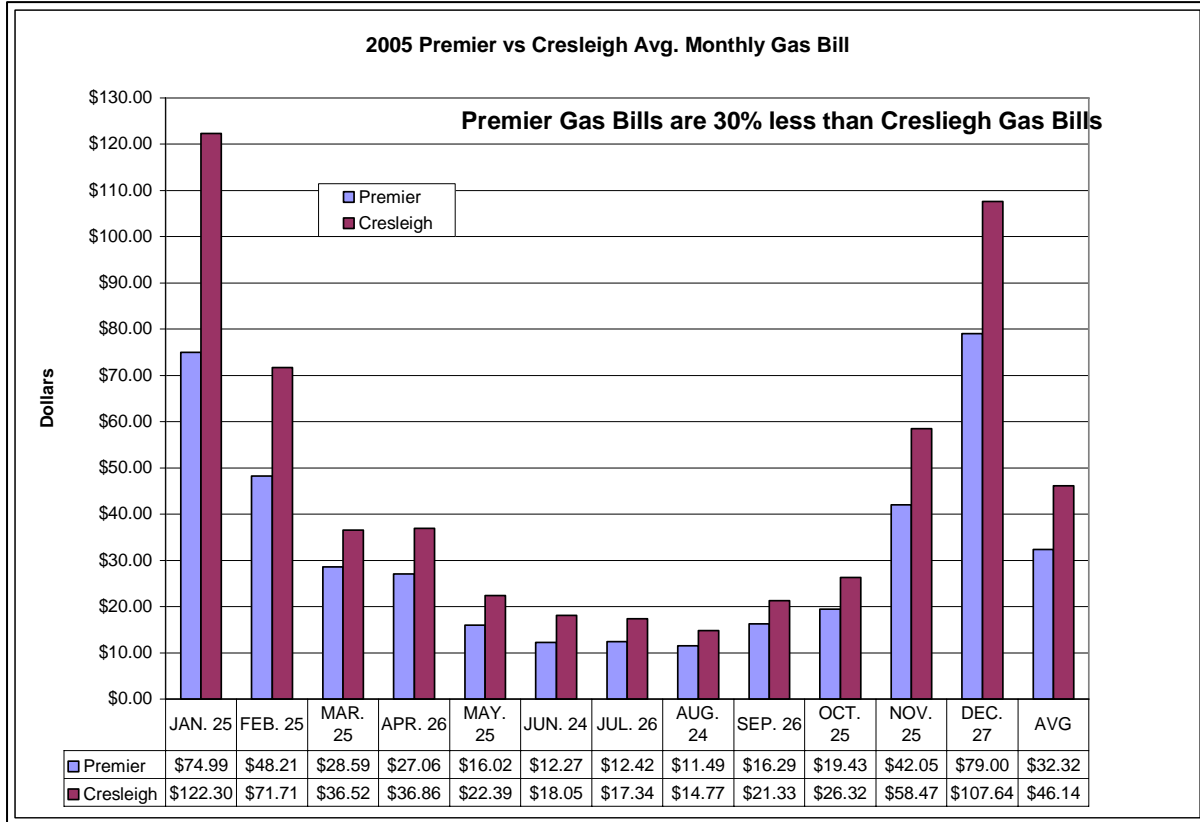


Figure 34: 2005 Premier vs. Cresleigh Avg. Monthly Gas Bills (courtesy of SMUD)

Total Energy Cost Savings

Premier homeowners save money on both gas and electric bills each month. The following table shows their savings over a 12-month period relative to Cresleigh.

Energy Bill Savings				
Community	Avg Gas Bill	Avg Electric Bill	Total Energy Bill	Yearly Energy Bill
Premier	\$32.32	\$32.89	\$65.21	\$782.52
Cresleigh	\$46.14	\$68.29	\$114.43	\$1,373.16
Savings (\$)	\$13.82	\$35.40	\$49.22	\$590.64
Savings (%)	30%	52%	43%	43%

Premier Residents save 43% on energy bills amounting to \$590.64/year

Table 11: Total Energy Bill Savings Premier vs. Cresleigh

Premier residents save 43% on energy bills over Cresleigh amounting to \$43.22 per month, and \$590.64 per year. These bill savings make the cost of home ownership cheaper for Premier residents.

Resale Value

It has been said that Zero Energy Homes have higher resale values. According to a National Renewable Energy Laboratory Technical Report, ZEHs built by SheaHomes in San Diego resold for 16.6% more than a comparable community.⁵ Unfortunately there have not been enough homes resold in Premier Gardens or Cresleigh Rosewood to judge whether the near-ZEHs will increase in value relative to non-ZEHs. As more homes are resold, this question can be answered.

Environmental Benefits

Of the 95 Premier Garden's homeowners, it is likely that some value the ability to decrease their impact on the environment. Premier's near-ZEHs offered homeowners the choice to buy a home that is less dependent on source energy, and therefore less polluting.

Residential buildings are the largest consumer of energy within the largest sector, buildings, consuming 21.5 percent of all energy produced within the United States in 2002.⁶ Likewise, residential buildings contribute 20.6 percent of total carbon dioxide emissions.

According to previous calculations, Premier Garden's homeowners use 44% less energy than Cresleigh homeowners. Therefore, Premier Garden's homes impact on the environment is about 44% less than Cresleigh's impact. Considering the impact residential buildings have on the environment, this savings is substantial. Near-ZEH owners can appreciate the positive impact they are having on environmental protection.

Quality of Life

Premier Garden's homeowners are genuinely satisfied with their homes. They find them to be comfortable, affordable, and easy to maintain. All research gathered suggests that Premier Garden's homeowners love their homes. As John Ralston said, we want our homes to enhance people's lives, and from all accounts these homes succeed.

⁵ "A Comparative Market and Utility Analysis of New High-Performance Homes in San Diego" B.C. Farhar and T.C. Coburn

⁶ EIA data

Other Stakeholder Benefits

Building Community

The Premier Garden's project has contributed significantly to the knowledge base for building high performance homes that deliver expected energy saving results. This case study has created evidence that shows building near-ZEHs is both technically and practically possible for production homebuilders. All stakeholders can reference actual energy use data from Premier Gardens to prove that ZEHs work serving multiple stakeholder goals.

Verifiable Results

Premier Gardens serves as a model for production level Zero Energy Homes that deliver verifiable results. This evidence provides a valuable tool for energy consultants, utilities, homebuilders, and other stakeholders to sell the ZEH concept to others. Premier Gardens has proven the ability of near-ZEHs to cut energy bills, energy use, and peak electrical use. These verifiable results likely contributed to the creation of SMUD's Zero Energy Homes program, CEC's Zero Energy New Home program, and Premier Home's Lakeside project.

Growing Evidence shows Zero Energy Homes are marketable

Profit driven production home builders are skeptical that consumers truly value the benefits that a Zero Energy Home provides. But as projects like Premier Gardens prove successful, the evidence is mounting that profitable homebuilders build Zero Energy Homes.

One key element for profitability in homebuilding is turning inventory. Homes are expensive to build, expensive to own, and expensive to sell so each day the homebuilder owns their homes costs them money. Homebuilders like Premier are showing that Zero Energy Homes sell faster. Clarum Homes, of California, also experienced brisk sales compared to industry averages with their Vista Montana project.

More recently, Grupe has been experiencing ZEH success, marketing their GrupeGreen homes in the Sacramento area. The GrupeGreen homes are part of a larger master planned community with multiple other builders. Although, Grupe is the furthest track of homes from the entrance and experiences less customer traffic, they have sold more homes than every other homebuilder.⁷

The evidence is mounting that in hot and cool housing markets the value of ZEH differentiation and value sells homes faster.

⁷ As of November 2006

Understanding Zero Energy Home Buyers

The RAND study evaluating the decisions made by Cresleigh and Premier buyers begins to explain how and why consumers buy Zero Energy Homes. Compared to Cresleigh buyers, Premier buyers were younger, earned less household income, were more educated, and visited twice as many homes before buying. Most homebuilders tell BIRA the key to selling ZEHs is education, customers must understand how a ZEH works and the benefits it offers. The fact that Premier buyers did more research would support this claim.

A white paper entitled “Energy in the Home Study” suggests that “If you have a product that is both energy efficient AND green, over two-thirds of the market are going to be interested in it. The appeal of a two-pronged attack is much wider.”⁸ This could be why GrupeGreen homes are selling so well compared to neighboring communities. This is also supported by an informal study done by ConSol of ZEH sales personnel from 15 communities across California. There were four themes that were repeated by the majority of interviewees: customers want homes that are good for the environment, save money (energy efficiency), customers need more solar education, and predominately men are interested in solar. Two-thirds of the near-ZEH RAND participants were male, supporting that men are interested in solar.

Commonalities across studies:

- Education is key to selling Zero Energy Homes
- Men are interested in PV
- Two-pronged approach most effective (good for the environment + energy efficient, which saves money)

Energy Analysts

The amount of information collected concerning gas and electricity use offered BIRA the opportunity to test the modeling tools and assumptions currently used to evaluate energy use in single-family homes. The large sample of homes equalizes the behavioral differences that exist from one home to the next. This offered a unique ability to compare expected results to actual results. As shown earlier, current models and assumptions worked reasonably well, but there is certainly room for improvement especially for gas use estimations. As additional years of data become available the variability from climate and other environmental factors will work with the large sample to further normalize actual results. The Premier Garden’s library of data can be used to judge new tools as well, such as BEopt, to compare its effectiveness not only to other simulation tools but also actual results.

⁸ “Energy in the Home Study” June 2002 Prepared by American LIVES, Inc. Oakland, CA

SMUD & Electric Utilities

SMUD Profile

- Electric Utility with 900 square mile service territory serving 1.3 million customers
- Heavily dominated by residential customers (515,000 residential meters, 65,000 commercial customers)
- More than 2,000 employees
- Peak Demand: 3,000 mW
- Load Factor- 40%

The Premier Gardens project has been as successful for SMUD as it has been for Premier Homes. The demonstrated ability of the near-ZEHs to cut peak electrical demand significantly over Cresleigh's SMUD Advantage Homes delighted SMUD officials. The success at Premier has prompted SMUD to create a Zero Energy Homes program to begin to leverage the peak shaving power of ZEHs. Much like the CEC's ZENH program, SMUD will look to leverage the success at Premier and build on those savings as shown by Premier's Lakeside home.

When speaking with Mike Keesee, Wade Hughes, or Bruce Cenicerros at SMUD, BIRA quickly learned their main object: cut peak demand, more specifically cut residential cooling demand. Wade Hughes said "It's all about A/C."⁹

Mike Keesee wrote, "In the past few years, Sacramento has seen record numbers of new homes built. This boom in new home construction is leading to increased demand for electricity, raising utility bills and taxing local electrical utility systems. Central air conditioning is a standard feature in all new homes built in Sacramento and a major factor in SMUD's peak electrical demand growth. SMUD is participating in the BAP because the District believes ZEH can reduce its peak demand while dramatically reducing new homeowners' utility bills."¹⁰ In a personal interview, Mike Keesee told BIRA that the Premier Garden's project was "precedent setting" and that an important goal was to "shift demand."¹¹

Bruce Cenicerros, SMUD's Principal Planner for New Construction Programs, believes SMUD needs to focus more on peak both for grid reliability and to reduce the marginal costs of peak electricity.

SMUD's need to shift peak demand is similar to most electric utilities. As shown in the Energy Analysis section, residential electricity demand follows a similar shape to the overall system load. At peak periods electricity is expensive to produce, buy, and distribute. Large capital investments are needed to provide electricity for very few hours

⁹ Personal Interview with Wade Hughes November 7, 2006.

¹⁰ Draft article, PREMIER GARDENS – SACRAMENTO'S FIRST ZERO ENERGY HOME COMMUNITY, by Mike Keesee, to be submitted to Home Energy.

¹¹ Personal Interview with Mike Kessee November 2006.

throughout the year. The ability to shift demand, and flatten the utility's load shape can significantly reduce the capital investments and marginal costs of energy creating lower prices for all consumers.

Pacific Gas & Electric

The benefits, or lack thereof, for gas retailers is difficult to gauge. PG&E provides gas to Premier and Cresleigh customers. By reducing Premier's gas consumption, potential revenues are lost for PG&E. For electricity providers the peak shaving benefits of ZEHs are significant enough to overcome lost revenues from conservation, but the benefits for gas providers is relatively unknown. The fact that natural gas is a finite resource means that decreasing demand will ensure future supplies. But the value of this for PG&E is unclear. As PG&E also sells electricity, one positive is the conservation of natural gas will help ensure the gas-powered electricity generators they source electricity from will continue to provide low cost electricity.

The impact of reducing gas consumption in ZEHs on natural gas retailers must be studied further to better understand the benefits ZEHs can provide them.

Conclusions

The Premier Gardens and Cresleigh Rosewood communities both represent well designed homes that exceed the best building code in the country, California's Title 24. Even so, Premier Garden's near-ZEHs use 44% less source energy than Cresleigh while significantly shaving peak electricity demand as well.

With all the information gathered and analyzed, this project represents an essential case study for designers, builders, and energy analysts interested in building high performance homes with predictable results. The benefits of the Premier Garden's homes are numerous and affect multiple stakeholders. Now that many ZEH benefits have been identified, the task for future near-ZEH projects will be to appropriately communicate and assign value to all affected stakeholders.

As the building industry moves forward, building in higher levels of efficiency, the lessons learned from Premier Gardens will continue to influence the next generation of Zero Energy Homes.

Appendix I - Energy Analyses Premier Gardens

Energy Analysis and Selection of Energy Features

ConSol reviewed the requirements of meeting the ZEH program. After many discussions and reviews, ConSol finalized and provided the ZEH features to Premier Homes. Premier agreed to build utilizing the energy features and recommended PV system for all of the homes in the Premier Gardens development. ConSol also compared the proposed ZEH homes to the BA benchmark. The spreadsheets on the following pages show energy analyses for each of the floor plans in this project in comparison to the BA benchmark. These energy analyses use the California Energy Commission (CEC) and BESTEST-certified Micropas¹² energy analysis software for building code compliance. The Building America features are as follows:

1. Wall insulation of R-13 batt with 1 inch foam insulation (1-coat stucco system)
2. Tight envelope with low air infiltration: Specific Leakage Area (SLA) = 3.5 or less (inspection and testing by ConSol's ComfortWise certified inspectors)
3. Dual pane vinyl frame with spectrally selective glass
4. Highly energy-efficient furnace of 0.91 AFUE
5. Highly energy-efficient AC of 14 SEER with Thermostatic Expansion Valve (TXV)
6. R-4.2 duct insulation buried in attic insulation, producing R-13 equivalent
7. Tight duct system designed by a licensed mechanical engineer using ACCA manual D
8. Tankless water heater with an Energy Factor (EF) of 0.82
9. R-4 pipe insulation on all major hot water trunks.
10. Gas dryer
11. Fluorescent lighting at all down lights
12. 2.0 kW AC PV system by GE (building integrated panels to blend in with roof tiles)

Plan #	Floor Area	% Energy Savings Compared to BA Benchmark wo/PV	% Energy Savings Compared to BA Benchmark w/PV
1503	1,503	38%	61%
1285	1,285	37%	63%
1625	1,625	37%	59%
1846	1,846	37%	58%
2248	2,248	39%	56%

¹² Micropas is a product of Enercomp, Inc.

Energy Analysis for Each Plan Type

Comparison of Total Energy Use

4 Bedrooms

Plan 1285

Base Case / BA Benchmark House			BA Prototype House - 40% Energy Savings (Upgraded Features, Fluorescent, Gas Dryer Stub, 2.4 kW PV and Tankless Hot Water)		
\		Dollars	Energy Use		Dollars
Therms	kWh	\$	Therms	kWh	\$
Energy Code Related					
Space Heating	278	\$ 208.17	152		\$ 114.30
Space Cooling	1,906	\$ 162.04		474	\$ 40.32
Water Heating	219	\$ 164.22	121		\$ 91.07
Other Uses					
cooking	78	\$ 58.50	78		\$ 58.50
clothes washer	123	\$ 10.41		123	\$ 10.41
dishwasher	240	\$ 20.42		240	\$ 20.42
electric or gas dryer	974	\$ 82.79	84		\$ 63.00
refrigerator	669	\$ 56.87		669	\$ 56.87
Miscellaneous (Appliances + Plug)	2,146	\$ 182.41		2,146	\$ 182.41
Lighting	1,833	\$ 155.81		477	\$ 40.55
reduce kWh by solar contribution	n/a	n/a		(3,420)	\$ (290.70)
Total use	575	\$ 1,101.63	436	709	387.14

Total Annual Energy Use

138,248 kBtu/yr

50,843 kBtu/yr

Reduction in Energy Use

24%

91%

65%

Total for Column in kBtu/yr

57,452 80,796

43,583 7,260

Total kBtu/yr for BA Benchmark House

138,248 kBtu/yr

Total kBtu/yr for Prototype House

50,843 kBtu/yr

Percent End Use Energy Savings

63%

Estimated Montly Energy Bill

\$ 91.80 /mo

\$ 32.26 /mo

Reduction in Energy Cost

35%

price of gas/therm

\$0.75

price of electricity/kWh

\$0.08500

Comparison of Total Energy Use

5 Bedrooms

PLAN 2248

Base Case / BA Benchmark House			BA Prototype House - 40% Energy Savings (Upgraded Features, Fluorescent, Gas Dryer Stub, 2.4 kW PV and Tankless Hot Water)		
\		Dollars	Energy Use		Dollars
Therms	kWh	\$	Therms	kWh	\$
Energy Code Related					
Space Heating	569	\$ 426.56	280		\$ 210.24
Space Cooling	3,052	\$ 259.40		696	\$ 59.16
Water Heating	265	\$ 198.95	164		\$ 122.74
Other Uses					
cooking	78	\$ 58.50	78		\$ 58.50
clothes washer	140	\$ 11.90		140	\$ 11.90
dishwasher	275	\$ 23.33		275	\$ 23.33
electric or gas dryer	1,113	\$ 94.61	96		\$ 72.00
refrigerator	669	\$ 56.87		669	\$ 56.87
Miscellaneous (Appliances + Plug)	3,754	\$ 319.10		3,754	\$ 319.10
Lighting	2,603	\$ 221.29		938	\$ 79.73
reduce kWh by solar contribution	n/a	n/a		(3,420)	\$ (290.70)
Total use	912	\$ 1,670.50	618	3,052	\$ 722.87

Total Annual Energy Use	210,033	kBtu/yr	93,044	kBtu/yr	
Reduction in Energy Use			32%	74%	57%
Total for Column in kBtu/yr	91,201	118,832	61,798	31,246	
Total kBtu/yr for BA Benchmark House	210,033	kBtu/yr			
Total kBtu/yr for Prototype House	93,044	kBtu/yr			
Percent End Use Energy Savings	56%				

Estimated Montly Energy Bill	\$ 139.21	/mo	\$ 60.24	/mo
Reduction in Energy Cost			43%	
price of gas/therm	\$0.75			
price of electricity/kWh	\$0.08500			

Appendix II - Peak Demand Monitoring Methodology

“To study the impact near ZEH homes have on peak demand, SMUD’s Pricing and Rules Metering Group designed a monitoring experiment comparing the peak demand of the ZEH homes to the non-ZEH homes that would achieve a 90% confidence interval with a +/- 10% margin of error. To achieve a 90% confidence level sample, 18 randomly selected homes in each subdivision are being monitored. As part of this sample, Pricing and Rates developed a random selection process based on comparably sized homes and their distribution in each subdivision to be used in selecting which homes to be monitored. The orientation of the PV systems found on the ZEH sample includes 11 south facing (61%), five-east facing (28%) and two west facing (11%) solar systems. The table below summarizes the sample distribution from each subdivision.

Premier Gardens		Adjacent Non ZEH Subdivision	
SqFt Category	# of Samples	SqFt Category	# of Samples
1285	2	1610	3
1503	4	1720	3
1625	2	1850	2
1846	4	2000	2
2248	6	2042	3
		2384	5
Total	18		18

Figure 35:Monitoring Sample Square Footage and Distribution (courtesy of SMUD).

SMUD’s Metering group installed and calibrated MV-90 recording meters at the designated sites to record 15-minute interval data for ZEH and non-ZEH energy use (kWh) and peak demand (kW), and for power produced by the ZEHs’ PV system (SMUD employs the MV-90 data monitoring system to analyze SMUD’s system loads). Data from the MV 90 recording meters is being collected by District meter readers as part of their monthly electric meter reads. Metering staff then compiles the 15-minute interval data into Excel spreadsheets that are easily manipulated into daily, weekly and monthly energy use, peak demand, and PV power production averages.

MV 90 recording meters were installed in April 2005 after the two subdivisions were fully occupied. The Metering group began downloading data in May 2005 and developing a data report format. The first complete energy use data reports were received in June 2005.

Appendix III - Lakeside Peak Analysis Methodology

Premier Homes (ZENH - Climate Zone 11) Plan 2916 (and Options) - Lakeside

PV Hourly Generation (Typical 20° roof pitch with PV facing West)		
day	time	PV output in kW AC
14-Jul	15	1.482 <i>(divided by 2)</i>
14-Jul	16	1.36
14-Jul	17	1.2
14-Jul	18	0.9
14-Jul	19	0.424 <i>(divided by 2)</i>

Non Cooling Energy use	
	kWh
Refrigerator	0.074 annual use 650 kWh/8760 hours in the year
Lighting	0.180 kitchen - 18w x 6 fixtures and bathroom - 18 w x 4 fixtures
Appliances &	
Plug Loads	0.205 annual use 1800 kWh/8760 hours in the year
Total	0.460

Peak hour based on PG&E is 5.00 pm on July 14th Micropas peak hour results		
day	time	Cooling enduse in kWh
14-Jul	15	0 <i>(divided by 2)</i>
14-Jul	16	0
14-Jul	17	0.931
14-Jul	18	2.133
14-Jul	19	0 <i>(divided by 2)</i>
Peak Hour		kWh
Cooling energy use		0.766
Non Cooling energy use		0.460
PV output		1.081 (2.2 kW DC PV)
Net Energy Consumption		0.1

Hourly House Energy for July 14th based on Micropas					
Hour	HEATFUEL (Btu)	HEATELEC (Wh)	COOLFUEL (Btu)	COOLELEC (Wh)	COOLELEC (kWh)
15	0	0	0	0	0
16	0	0	0	0	0
17	0	0	0	931	0.931
18	0	0	0	2133	2.133
19	0	0	0	0	0
Total	0	0	0	3064	3.064

Hourly PV Generation Based on a 2.2 kW DC PV per PV Watts (US Dept of Energy)		
	Hour	kWh
	1968, 7, 14, 15:00, 1482	1.482
	1968, 7, 14, 16:00, 1360	1.36
	1968, 7, 14, 17:00, 1160	1.16
	1968, 7, 14, 18:00, 851	0.851
	1968, 7, 14, 19:00, 424	0.424