

Are Zero Energy New Homes (ZENH) Good for the Builder, Good for the Buyer, and Good for the Electric Utility?

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ABSTRACT

The California Energy Commission's PIER Buildings Program is sponsoring research programs to develop new market models to promote the development of ZENHs in California. One project team proposed a market model in which electric utilities have a role in paying for or owning photovoltaic equipment on private residences. A key research question is the value that ZENHs provide to the utility. To answer this question, a proposed project was analyzed using building simulation software. Project goals are for each ZENH to be 25% more energy efficient than 2005 Title 24, reduce electricity cost by 70% and draw no more than 1 kW from the utility during the peak summer hours. The ZENHs will incorporate advanced energy efficient features with solar-electric systems. They will receive electricity from a different underground branch circuit than the one serving the non-ZENH homes. Southern California Edison will monitor energy usage to both groups of homes at the branch circuit level and use the information obtained to determine the benefits ZENHs provide to them. Additional monitoring equipment will be installed in 20% of the ZENH homes to evaluate the performance of individual homes.

Introduction

The California Energy Commission's PIER Program supports energy research, development and demonstration (RD&D) projects 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 PIER Program annually awards up to \$62 million to conduct the most promising public interest energy research by partnering with RD&D organizations including individuals, businesses, utilities, and public or private research institutions.

The PIER program is currently funding four research projects designed to demonstrate and develop a sustainable market for homes that combine state-of-the-art energy efficiency with on-site generation from solar photovoltaics, called Zero Energy New Homes (ZENHs). Each of the four ZENH projects has a slightly different focus, but all were selected because of their emphasis on not just the technologies for ZENHs, but particularly the development of markets for ZENHs. This paper focuses on the *Utility-Focused Market Model* ZENH project, awarded to Architectural Energy Corporation and in its first stages of implementation.

The paper will discuss the ZENH features analyzed on the proposed project in Santa Clarita, California. The specific builder for the proposed project has not yet been determined. This paper will also discuss the purpose of Southern California Edison (SCE) involvement in the project and their research efforts to determine whether there is financial value to the utility from having ZENH communities in their service territory.

California's Energy Challenges

California's electricity system, which fuels the world's sixth largest economy, is currently facing several critical challenges. Despite enormously successful energy efficiency programs, California's demand for electricity is growing with little sign of abatement. Even with efforts to develop new electricity supplies in the state, California increasingly relies on out-of-state electricity supplies to meet its summer peak demand. In addition, California's energy infrastructure is at a critical point, with the electricity transmission system becoming progressively stressed over recent years. Last year, transmission congestion and related reliability services cost California consumers over \$1 billion.¹

The residential sector is responsible for approximately 35 % of California's peak demand. At a rate of 100,000 new homes per year, California will add over 1.2 million new homes by the year 2017. Air conditioning from these new homes is expected to add another 2400 MW to California's system peak. Furthermore, a majority of this housing growth is expected to occur in California's urban areas and hot inland regions, where air conditioning loads are already higher than average and electricity congestion and demand management is an increasingly critical challenge.

California's Focus on ZENHs for all Four ZENH Contracts

These challenges provide a strong basis for the California Energy Commission's ZENH program. If California was able to meet just five percent of this demand for new homes with ZENHs, Architectural Energy Corporation estimates that the cumulative impact on the electrical system statewide in 2015 would be a demand savings of 176 MW and energy savings of almost 700,000 MWh.²

California has been a leader in the development of new energy standards and the development of markets for solar photovoltaic panels. California has further led the way in the development of homes that incorporate both energy efficiency and solar energy systems. By combining energy efficient building construction and state-of-the-art appliances and lighting systems with photovoltaics, these homes can become "zero energy" homes because the electricity generated through the PV system offsets the total electricity consumed by the home. ZENHs offer a number of benefits:

- They offload congested utility transmission and generation resources by reducing peak loads and reducing the need to purchase peak electricity from the grid.
- They save energy and reduce pollution.
- They insulate their owners against future increases in energy prices.

Despite these benefits, there remain two principal barriers to widespread adoption of ZENH development strategies: cost premiums and lack of information.

The overarching goal of the Energy Commission's ZENH program is to address these two barriers by demonstrating cost-effective ZENHs and developing new business models that help make ZENHs a mainstream part of California new home construction. A major focus of the

¹ 2005 *Integrated Energy Policy Report*, California Energy Commission, November, 2005

² Contract proposal to the California Energy Commission, response to RFP # 500-04-501, Architectural Energy Corporation, November 8, 2004

program is on the creation of partnerships among the critical market players that can develop creative cost effective approaches to ZENH construction and financing, and in so doing reduce the cost of ZENHs to homeowners.

The PIER ZENH program approach involves the following steps:

- Develop ZENH designs that optimize energy efficiency and on-site PV electricity generation
- Develop innovative business models to reduce the incremental cost of a ZENH to the homeowner
- Demonstrate these designs and business models in at least one 75+ unit development
- Monitor these homes to validate performance relative to the goals
- Initiate actions to ensure long-term sustainability in California.

The specific performance targets for the ZENH projects are as follows:

- Energy Goal: Improve building energy efficiency performance by at least 25% over the Title 24, Part 6, 2006 Building Energy Efficiency Standards.
- Peak Demand Goal: Reduce summer peak demand to no more than one kilowatt per housing unit.
- Cost Goal: Reduce the homebuyer's incremental first cost for a ZENH to no more than \$5,000 and reduce annual electricity bills by 70%.

Current PIER-Funded ZENH Projects

Four contracts have been awarded for a total program budget of approximately \$10 million. The four projects are:

1. Commercializing ZENH Communities – This contract, which has been awarded to PowerLight Corporation, is focused on the development of turnkey PV systems for builders and enhanced building-integrated photovoltaics (BIPVs). This contract will include the design, construction, and monitoring of both a single-family and a multifamily development in Northern California. Powerlight's team includes ConSol, RLW, GeoPraxis, Centex Homes and Premier Homes.
2. Affordable Multifamily Housing – This contract, awarded to the nonprofit group Global Green USA, is focused on the development of sustainable market models for multifamily and affordable housing ZENHs. For this contract, two multifamily affordable housing projects will be built and monitored in Southern California.
3. Utility-Focused Market Model – This contract, awarded to Architectural Energy Corporation (AEC), includes the construction a single-family housing development in Southern California. In addition to AEC, the project team includes Southern California Edison, ConSol, Consumer Powerline, Geltz Communications, a builder, and a PV manufacturer. This project will focus on the development of utility-focused partnerships as described below.
4. Affordable Zero Energy New Homes – This contract is currently under development, with the Sacramento Municipal District and San Diego Gas and Electric as the primary contractors.

The AEC-led Utility-Focused Market Model project is discussed in detail in the remaining sections of this paper. A major emphasis of the market model development process will be to explore the benefits that ZENHs provide for the electric utility and to develop market models in which the electric utility can serve as a major driver for reducing the cost to homeowners. Detailed analysis of the financial mechanisms and cash flows will be performed to construct models that will provide an overview of the risks and benefits to all stakeholders involved in ZENH development.

AEC is managing the project, which will be conducted over the next three years. The project will include the construction of 75 homes with ZENH-features standard. At least 15 of the ZENH-program homes will be monitored to evaluate the effectiveness of the installed features. Because the focus of this contract is on the involvement of the utility, this project will also be monitored to determine the impact on the utility distribution system.

Proposed Project in Santa Clarita, California

The proposed project analyzed in Santa Clarita, California consists of 75 ZENH homes (and 423 non-ZENH homes) with six plan types with conditioned floor areas ranging from 2697 to 3702 sq. ft. Each ZENH home incorporates super high energy efficient building features and a 2.0 to 2.2 kW DC building integrated PV (BIPV) system to achieve the program requirements of complying 25% above 2005 Title 24, reducing the annual electric bill by 70% and drawing no more than 1 kW from the utility during the system peak day (Southern California Edison’s (SCE) system peak day on August 11th at 4 PM). The CEC ZENH method for calculating the peak demand is calculated by averaging the four hour draws around the utility peak hour. The average incremental cost from Title 24 to ZENH is approximately \$8,000 including tax credits, rebates and incentives. Although this is more than the \$5,000 goal, it is close. The building features, estimated energy bills and kW drawn results below are analyzed using the California Energy Commission (CEC) and BESTEST-certified Micropas³ energy analysis software for building code compliance under the 2005 Residential Code standards. Note: results from Micropas software are similar to DOE2. The features for the proposed project are as follows:

Table 1. Proposed Project in Santa Clarita, California

	Features	Base T-24	ComfortWise	ZENH
1	Attic Insulation	R-30	R-30	R- 38
2	Wall Insulation	R-13 (2x4 and 2x6)	R-13 (2x4 and 2x6)	R-13+R-4.2 (2x4) R-19+R-4.2 (2x6)
3	Floor Insulation (Abv Grg/Cant)	R-19	R-19	R-30
4	Low Air Infiltration	No	Yes	Yes
5	Radiant Barrier	No	Yes	Yes
6	Quality Installation of Insulation	No	Yes	Yes

³ Micropas is a product of Enercomp, Inc.

	Features	Base T-24	ComfortWise	ZENH
7	Glazing (U-factor and SHGC)	0.41 U-factor 0.41 SHGC	0.34 U-factor 0.33 SHGC	0.34 U-factor 0.33 SHGC
8	HVAC Efficiencies	80% AFUE 13.0 SEER 2 HVAC Systems	80% AFUE 13.0 TXV SEER 2 HVAC systems	90% AFUE 14.0 TXV SEER (12 EER) 2 HVAC systems
9	Tonnage Reduction		Up to 1 Ton from Title 24 to CW	Up to 1 Ton per system from Title 24 to ZENH
10	Duct Insulation / Location	R-4.2 @ Attic	R-4.2 @ Attic	R-4.2 @ Attic
11	Tight Duct and ACCA Manual D	Yes	Yes	Yes
12	Water Heater	75 Gal EF = 0.50	75 Gal EF = 0.76 w/ Recirculating system Temperature Timer Control	2 Tankless EF = 0.82 w/ R-4 pipe insulation on all major trunks
13	Lighting	2005 Package	2005 Package	2005 Fluorescent Lighting Package
14	Dryer	Electric	Gas	Gas
15	PV System Size	None	None	2.0 – 2.2 kW DC
16	Savings over T- 24 (Source Energy)	N/A	> 20%	> 40%
17	Annual Electric Bill Savings (PVs in ZENH only)	N/A	> 24%	> 70%
18	Total Peak Energy Draw	N/A	N/A	< 1 kW
19	Total Incr Cost (over T-24)	N/A	N/A	Approx. \$8,000
20	Estimated Annual Electric Bill	\$81.00	\$59.00	\$20.00 ⁴
21	Estimated Annual Electric and Gas Bill	\$123.00	\$100.00	\$51.00

Monitoring Plan by AEC and SCE

A major goal of this project is to determine whether there is a viable business advantage to Edison for encouraging ZENH communities in the future. This determination will require monitoring the impacts of the ZENH homes individually and collectively to understand how they perform and how they interact with the Edison distribution system. Further, assuming the ZENH homes provide a net benefit to Edison, this needs to be quantified such that a pilot ZENH

⁴ The estimated energy bills are calculated using the energy budgets (space heating, space cooling and water heating) from Micropas combined with the miscellaneous and lighting loads from PG&E's 1995 published data and from Building America assumptions. (Building America is an energy efficiency program sponsored by the US Department of Energy).

program can be developed and tested. This will include an evaluation of three different possible business models:

1. Current practice where the PV systems are owned and maintained by the homeowner and connected on the homeowner side of the meter;
2. The PV system is owned and maintained by Edison and connected on the homeowner side of the meter; and
3. The PV system is owned and maintained by Edison and connected on the Edison side of the meter.

To evaluate the performance of the ZENH homes and the different business models, Edison needs to monitor and evaluate the homes in the ZENH demonstration project. The original plan was to have a discrete population of 75 ZENH homes that would be on their own branch circuit and to monitor that circuit. The proposed project is planned to have approximately 500 homes, with the ZENH homes distributed throughout. Since the ZENHs will be mixed in with the non-ZENHs in the tracts, Edison metering will have to be done at the individual home level and not at the branch circuit level as originally conceived. This will require that all 75 ZENH and another 75 non-ZENH will be metered separately. Edison will then have to analyze all the data and determine the net effects on the Edison distribution system. The goal is to determine the implications of installing ZENH homes on a utility's electrical distribution systems. SCE will utilize this information so that it may be used for their business and economic evaluations, which consists of three aforementioned market models. Some of the evaluations to be performed include:

- Investigate and determine candidate circuits to evaluate electrical system impacts based on the potential benefit to the system. Collect data that will allow the benefits, principally peak shaving, to be evaluated by direct comparison.
- Determine prototypical residential circuit loading to be used as a baseline for tests. Coordinate with the builder and determine the circuit segment(s) to be utilized.
- Identify current or future "congestion" locations as they relate to benefits.
- Identify electrical system issues as they relate to the various candidates for ZENH development business models.

AEC will also install monitoring equipment in 15 homes and will monitor the end-uses (in 15 minute intervals).

Near-Term Opportunities for ZENH Communities

This ZENH program will identify near-term opportunities that can help enhance the market sustainability of the utility-sponsored Pilot Program. The near-term goal is to develop opportunities to reduce the cost of the ZENHs that can be implemented as soon as possible, optimally during the demonstration program. These results will feed directly into the development of the market model for the demonstration and will continue into the sustainable market model and they are described below.

Improve the entitlement process for ZENH communities. The land entitlement process is a process that a land developer will follow working with the affected local government to change the title of property to be buildable residential lots. This is often a contracted process spanning 5 – 15 years. The team will review this process to determine whether there are time-shortening or cost-reduction benefits that could be provided to ZENH-community developers. There is a similar task in the PowerLight ZENH project where that team is working with different local governments. These tasks in the two programs will be coordinated so as to not be duplicative. Some preliminary results from the PowerLight project will be presented at this conference.⁵

Improve ZENH reliability, decrease installation costs, and increase warranties. During the demonstration project the team will evaluate the process of specifying, designing, and installing the PV system to determine methods to improve the ZENH homes. Methods will be explored to simplify the entire process to decrease costs and improve reliability. This will include possible improvements in products and components, as well as their installation. A key factor in a successful utility-based ZENH program is that the energy impacts of the ZENH communities be predictable and reliable.

Improve ZENH designs and deployment; integrate improved PV systems and ZENH designs with potential deployment programs. Working with the builder and developer partners, the team will review opportunities for reduced risks and increased benefits of ZENH communities. This will include analyses of:

- potential mitigation factors for the increased costs of ZENHs
- methods to improve marketing & sales
- methods to improve value proposition to homebuyer and buyer
- methods to reduce maintenance and increase durability
- methods to improve materials and designs to improve value, cost, and reliability

Develop new mortgage concepts for ZENHs. The team will work with production-builder mortgage lenders to develop and implement finance packages designed to encourage greater implementation of ZENHs. Potential mortgage improvements for ZENH homes would be increased mortgage amounts, based on the present value of savings resulting from the ZENH improvements (similar to an Energy Efficient Mortgage), reduced fees, and a reduced interest rate. Preliminary discussions with primary lenders are encouraging that most or all of these improvements may be possible.

Create a marketing and branding strategy. The market participants range from PV manufacturers and installers, land developers, home designers and builders, home builder sales agents to local government (building departments, inspectors, assessors, etc.), construction and mortgage lenders, appraisers, and building trade associations to potential homeowners.

The marketing strategy will include:

- Market research before and during the demonstration project
- The creation of informative and persuasive marketing messages
- Expansion of the branding strategy

⁵ Private communication.

- A description of collateral tools and media placement
- Case studies and success stories

Identify needed training. Specialized training will be required for successful ZENH developments, including builders, subcontractors, and homeowners. This would include a training strategy informed by market research consisting of several different curricula geared toward the needs of each audience, supported by a strategy for training recruitment and support materials and for assessing the impact of training on participant knowledge.

Best Practices, Codes, and Standards Guidelines will be developed for future ZENH builders including the agreements, design guidelines, best practices, performance standards, and codes of conduct, that are needed to structure the utility-sponsored ZENH program with market participants.

ZENH Builder Guide. A how-to ZENH guide will be developed, including market assessment, sales and marketing evaluations and suggested improvements for sales and marketing of ZENH communities; suggested design and construction considerations. The team will also develop a strategy to disseminate the guide to additional builders and developers through CBIA and other venues.

Why SCE got involved

The Southern California Edison Company is a utility leader in developing and promoting energy efficient and environmentally friendly technologies. They see this demonstration project as a method to further understand the requirements necessary to make photovoltaic technology commercially viable. As a business they will evaluate business opportunities on both the customer and utility side of the meter. For example, if ZENH homes can reduce peak demand, SCE can save by reducing underground branch circuits. As a utility they hope to get a better understanding of the effects of photovoltaic technology on their distribution circuits. They will identify and quantify the benefits of reducing demand during peak periods on the circuits and the generation needs of the utility. They will also evaluate the power quality effects of the photovoltaic systems on the circuits in regards to power factor and harmonic distortion.

Conclusion

As found in the ZENH designs on the proposed project, the larger the homes and the harsher the climate zone, the harder it is to achieve ZENH requirements. The features analysis simulated on the proposed project are typical for the Santa Clarita climate zone 9 region. Features may vary depending on the sizes and locations of the homes. Once the ZENH builder and project is identified, ZENH features will have to be determined.

Through simulations, ZENH homes draw less than 1 kW, are 25 percent more energy efficient than typical Title 24 code homes and have an annual electric reduction of at least 70 percent. There is value here for the homeowner (comfort and low energy bill), builder (innovative product) and SCE (possible underground branch circuit reduction). However, actual performance of ZENHs will need to be measured and monitored by SCE and AEC to validate

these benefits. In addition, a demonstration project, sales absorption rates of these homes, construction lessons learned and further research are needed to identify whether ZENHs are good for buyers and builders.