Residential ZNE Market Characterization

Final Report

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1. ACKNOWLEDGMENTS

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2. EXECUTIVE SUMMARY

2.1. Introduction and Methodology

2.1.1. Purpose and Scope

The joint California Investor Owned Utilities (IOUs) contracted a team led by TRC Energy Services (the "TRC team") to conduct a market characterization of Zero Net Energy (ZNE) new construction homes in California. The study's objectives were to:

- Characterize the residential ZNE-type new construction market by estimating the market sizes and exploring trends for ZNE and ZNE-type homes;
- Assess residential energy rating systems and financing opportunities for ZNE-type homes; and
- Assess drivers, barriers, and opportunities to messaging, building, financing, and purchasing residential ZNE-type new construction.

Overall, this study found that ZNE-type homes – and ZNE homes in particular – are in the innovator stage of market adoption. All told, over 50 builders have constructed ZNE-type homes in over 130 California cities. We identified approximately sixteen ZNE homes and over one thousand ZNE-ready and near ZNE homes based on this study's interpretation of this term. This indicates that while ZNE is nascent in the residential new construction market, it is possible, and some market actors are achieving it. In addition, the diversity of builders and locations of ZNE-ready, near ZNE, and ZNE homes indicates that this type of construction is feasible under different contractor business models and in different climates. Furthermore, because California is at the beginning stage of this market transformation, this is likely the most difficult stage, when the required cost and effort are highest.

Despite this vibrant activity among the emerging ZNE-type market, the study also found various indicators that the market is not currently poised to achieve a ZNE homes 2020 aspirational goal, including a lack of consumer demand, a lack of qualified building professionals, early adopters' misperceptions about the ZNE concept, questions regarding the cost effectiveness of ZNE-type homes, and various barriers (real and perceived) to adoption of ZNE-type homes. Energy efficiency Program Administrators (PA) – particularly the Investor Owned Utilities (IOUs), as well as the California Public Utilities Commission (CPUC), the California Energy Commission (CEC), and other entities are conducting various efforts to reach the State's ZNE goals. This includes having improved the electric efficiency of regulated loads in residential buildings by approximately 40% since 2005 through Title 24 (Part 6) building energy standards.[1] Results indicate, however, that current efforts are insufficient to reach the goal of all ZNE residential new construction by 2020. To achieve this goal, the PAs, CPUC, CEC, and others will need to expand activities, significantly increase financial incentives, design assistance and workforce education efforts, and take risks with new programs and policies.

If meaningful progress toward the 2020 ZNE goal is to be achieved in the next five years, it would require a ZNE Market Transformation Initiative that transcends the current regulatory framework for PA program

[1] Based on impact analysis for 2013 Title 24, http://energy.ca.gov/2013publications/CEC-400-2013-008/CEC-400-2013-008.pdf, homes built to the 2013 Title 24 standard use 36% less electricity, 40% less peak demand, and 7% less natural gas on average compared with homes built to the 2008 Title 24. Similarly, based on impact analysis for 2008 Title 24, http://www.energy.ca.gov/title24/2008standards/rulemaking/documents/2007-11-07_IMPACT_ANALYSIS.PDF, homes built to 2008 Title 24 use 23% less electricity, 8% less peak demand, and 10% less natural gas compared with 2005 Title 24. The savings from the two standards are not directly additive, and 40% is likely an underestimate of total electricity and demand savings.

delivery. In addition, the ZNE-type home community will need to work collaboratively across various stakeholder groups—both within and beyond California—to encourage the market to meet ZNE residential new construction goals.

2.1.2. Study Terminologies and Methodology

In general, the TRC team views energy performance as a continuum, with ZNE at the low end of a net energy use scale. Figure 1 illustrates this concept, and introduces the broad categories of energy performance used in this study: Code-built, Energy Efficient[2], ZNE-ready, near ZNE, and ZNE homes. As shown in the figure, this study uses the term, "ZNE-type homes" to refer collectively to ZNE-ready, near ZNE, and ZNE homes.

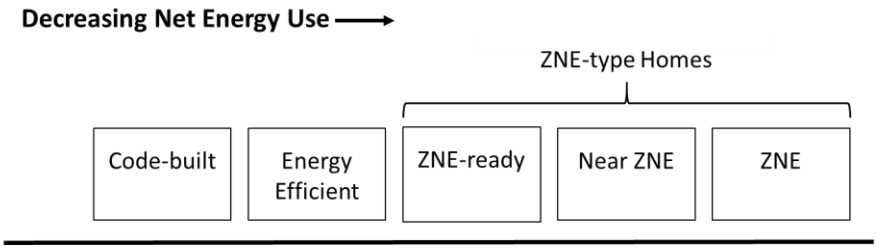


Figure 1. Home Energy Performance Classifications

While California policy has defined ZNE, it has not defined ZNE-ready or near ZNE homes. This study classified homes as ZNE-type if energy modeling showed them to be any of the following:

- ZNE-ready: highly efficient without distributed generation;
- Near ZNE: highly efficient with some distributed generation, generally solar photovoltaic (PV); or
- ZNE: produce as much energy as they consume annually.

In market actor interviews, the TRC team did not provide a quantitative threshold for "highly energy efficient," but instead relied on the market actors' interpretation of this term. However, for market size estimates, the TRC team identified a "ZNE-type" home as one that was at least 40% more efficient than Title 24 (based on energy modeling).[3] The team identified this 40% threshold based on the literature review and a review of ZNE-type home case studies.

The TRC team conducted an initial research effort, which included a literature review, interviews with utility program managers, and a Request for Information (RFI) of ZNE-type home practitioners. These initial findings shaped the remainder of data collection, which focused on collecting feedback from market actors experienced with ZNE-type homes. Because the number of ZNE-type homes is small, the TRC team also gathered feedback where necessary from market actors with high performance homes (a broader category that refers to a ZNE-type or Energy Efficient home), or homes with PV. Figure 2 summarizes data collection activities.

[2] This study uses the term Energy Efficient home to refer to a home that is 15-39% above Title 24 – i.e., more efficient than a Code-built home, but not as efficient as a ZNE-type home.

[3] For near ZNE homes, TRC also included homes modeled to use at least 80% less energy than a Code-built home.

Market Actor	Data Collection Activity
Builders of ZNE-type homes	19 interviews (16 builders – 8 custom and 8 production, and 3 industry experts)
Program Managers	6 interviews with 9 staff
Appraisers with high performance home[4] experience	11 interviews
Lenders with high performance home experience	6 interviews
Building Officials with high performance home experience	1 discussion with 6 officials
Planners with high performance home experience	1 discussion with 4 planners, and 4 interviews (8 planners total)
CEC staff involved with ZNE and TDV efforts	3 staff
ZNE-type Owners	43 interviews (27 production and 16 custom); 1 forum with 4 near ZNE owners (all production)
Energy Efficient Owners[5]	112 surveys (109 production, 3 custom)
Code-built Owners	1 forum with 10 owners (all production)

Figure 2. Summary of Data Collection

2.2. Synthesis of Findings

This section synthesizes findings by drawing on the results from the various data collection activities. Because the TRC team targeted market actors with ZNE-type home experience, the findings from interviews, surveys, and forums likely do not reflect feedback from the broad market.

2.2.1. Market Size Estimates

2.2.1.1. ZNE-type Home Market Size Estimates

The TRC team used several methods to identify the number of ZNE-type homes. Figure 3 summarizes results. Note that the column showing "RFI estimates" provides the summary of RFI respondents' estimates to the questions of the number of ZNE-ready, near ZNE, and ZNE homes built in California (i.e., a top-down estimate). In contrast, "RFI Data" refers to ZNE-type homes identified by RFI respondents, which the TRC team added to homes in the California Advanced Home Program (CAHP) and New Solar Homes Partnership databases by counting the number of homes (i.e., a bottom-up approach). As shown, there were large variances in the ZNE-type home market sizes estimates from different data sources. This may be because different market actors have different interpretations of these terms, and because none of the data sources for identifying ZNE-type homes was comprehensive.

[4] The TRC team did not identify enough market actors with ZNE-type home experience for some data collection activities. For these activities, the TRC team targeted market actors with experience with high performance homes, a broader category that encompasses ZNE-type or Energy Efficient homes, or homes with distributed generation.

[5] Owners of homes projected to exceed Title 24 by at least 15%, but by less than 40% (the minimum threshold for ZNE-type, as classified by this study).

Home Type	Summary of RFI Estimates	Interviewed Builders' Self-Reports	Count from CAHP / NSHP/ RFI Data	Count from GPR Database[6]	Utility Program Managers' Estimates
ZNE-ready	> 1000	Not asked	164	98 ZNE-ready / near ZNE homes	Not asked
Near ZNE	> 500	Not asked	944		Not asked
ZNE	Ranged from 1-20 to > 1000	31[7]	16	6	10
Total ZNE-type homes[8]	**Not asked**	**Not asked**	**1,124**	**104**	**Not asked**

Figure 3. Estimate of Market Size for ZNE-type Homes from Different Sources[9]

As described in Section 2.1, the TRC team identified homes as ZNE-ready if modeling predicted they were at least 40% more efficient than Title 24 and—for near ZNE homes—they had distributed generation that offset some, but not all, annual energy use. Under this interpretation, the study identified 1,124 total ZNE-type homes that have been constructed from 2004 to 2014. However, there is no clear efficiency threshold for a ZNE-ready or near ZNE home. If this study had identified the threshold as 30% above Title 24, which would align with the New Solar Home Partnership Tier II incentive levels, the study would have identified over 10,000 ZNE-type homes, with more ZNE-ready homes (6,490) than near ZNE homes (4,040). The number of ZNE homes would have stayed the same – i.e., 16, because only the definition of ZNE-ready and near ZNE would have changed.

Figure 4 summarizes the difference in results of ZNE-type home market size estimates under different interpretations of ZNE-ready and near ZNE homes using CAHP, NSHP, and RFI data.

ZNE-type Home	ZNE-type ≥ 30% above Title 24	ZNE-type ≥ 40% above Title 24
ZNE-ready	6,490	164
Near ZNE	4,040	944
ZNE	16	16
Total ZNE-type homes	**10,546**	**1,124**

Figure 4. Market Size Estimates under Different Definitions of "ZNE-type"

2.2.1.2. ZNE-type Homes as a Relative Fraction of the Market

Figure 5 shows the number of ZNE-type homes (based on ZNE-type homes in the CAHP and NSHP databases and homes identified through the RFI) as a percent of California single-family housing permits.[10] Because of data gaps in the various sources used for this figure (detailed in Section 5.1), the data for 2008 through 2013 is the most accurate. As shown, compared to total California housing permits, the number of ZNE-type

[6] The Green Point Rated (GPR) data provided to the TRC team did not distinguish between near ZNE and ZNE-ready homes, although BIG staff reported that most of these projects were near ZNE.

[7] Many of the "ZNE" homes self-identified by builders were categorized as near ZNE by the TRC team for the CAHP / NSHP/ RFI Data estimate.

[8] This row shows "Not asked", because the TRC team did not ask RFI respondents, builders, or utility program managers to estimate the total number of ZNE-type homes in California.

[9] The GPR data provided to the TRC team did not distinguish between near ZNE and ZNE-ready homes, although BIG staff reported that most of these projects were near ZNE.

[10] California Building Industry Association (CBIA) data.

homes was approximately 0.2 - 0.4% for 2008 - 2013. For 2014, the peak year so far for ZNE-type homes, ZNE-type homes were on track to comprise approximately 1% of the market.

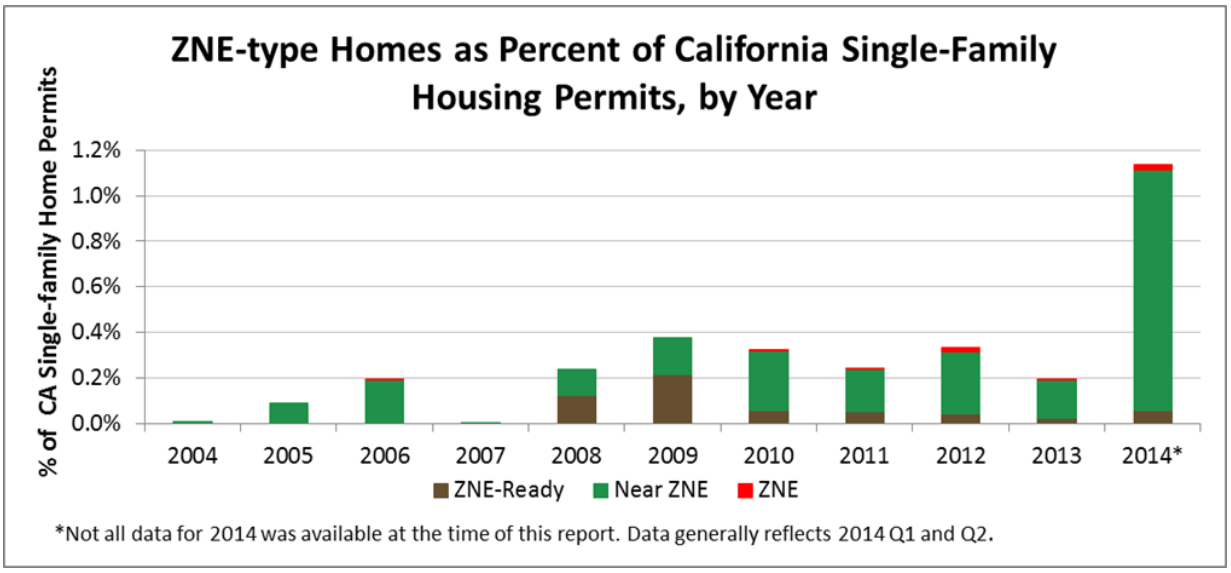


Figure 5. ZNE-type Homes as a Percent of the Total Permits, by Year

The diffusion of innovations curve identifies market penetration up to 2.5% as innovators (Roger 1962). Thus, although this analysis identified over one thousand ZNE-type homes, the market still resides at the innovator stage of market diffusion. In addition, most of the ZNE-type homes are near ZNE; the number of ZNE homes reflects only approximately 0.01% of the market. The findings in Figure 5 also align with feedback from builders interviewed in this study; those builders who were selected for interviews because they have delivered ZNE-type homes reported that the vast majority (over 99%) of the homes they have built in the past three years have been above code, but that only a small fraction (0.3%) have been ZNE.[11]

2.2.1.3. Trends in Energy Efficiency and PV Penetration

TRC team analysis indicates that most CAHP homes are modeled at 15-24% above Title 24, a significant fraction are between 25-39%, and very few are at least 40% above Title 24. The TRC team also found that the prevalence of PV increases with greater energy efficiency, and that most homes modeled at least 40% above Title 24 had PV.

2.2.2. Characteristics and Geographical Distribution of ZNE-type Homes

In terms of home characteristics, ZNE-type homes span a range of sizes, numbers of bedrooms, and PV system sizes. Comparing custom and production ZNE-type homes, these home types had similar numbers of bedrooms (median of three for both) and compliance margins (median of 44% above Title 24 for both). However, custom ZNE-type homes are larger (median of 2,902 and 2,049 square feet for custom and production, respectively) and may have larger PV systems than production ZNE-type homes.

The TRC team conducted an income analysis of ZNE-type homes to investigate trends in ZNE-type home adoption across income levels. Most ZNE-type homes are primarily in zip codes with income levels in the third quintile, followed by the fourth and second income quintiles. This generally aligns with the location of homes with host-owned and third-party-owned PV identified in a study by Navigant (2014a).

[11] The TRC team did not ask builders to provide estimates of the number of ZNE-ready or near ZNE homes they have constructed.

Over 50 builders have constructed ZNE-type homes in over 130 cities: Based on CAHP, NSHP, and RFI data, ZNE-type homes are present throughout California, although the highest number of ZNE-type homes are in the San Francisco Bay Area, the Sacramento area, and the Los Angeles area. Compared to the number of housing permits, the Sacramento area has a particularly high number of ZNE-type homes; this may reflect early ZNE-type home program efforts in this area by Sacramento Municipal Utility District (SMUD) and Pacific Gas and Electric Company (PG&E), and it may indicate peer pressure among builders in this area to construct ZNE-type homes. The Sonoma / Napa area also has a high number of ZNE-type homes compared to total housing permits. GPR data also supports the finding that various developers are delivering ZNE-type homes across California.

2.2.3. Awareness and Interpretation of ZNE

California policymakers clearly defined a "ZNE Code Building" using a Time Dependent Valuation-based metric in the 2013 Integrated Energy Policy Report (IEPR – CEC, 2013).[12] However, construction of ZNE-type homes began in California before publication of the 2013 IEPR. Consequently, this study investigated different market actors' awareness and interpretations of the term ZNE, and identified any areas of misalignment in their expectations.

All of the builders and almost all of the appraisers, lenders, and local officials interviewed in the study were aware of ZNE. Builders generally provided a site-based interpretation of ZNE. Most builders consider all fuels for ZNE, but three builders interpreted a ZNE home as an all-electric home, or a home where the builder only offsets the electricity. As noted in 2.1, these results may not reflect the broader market, because the TRC team specifically targeted market actors with ZNE-type home experience.

Most custom ZNE-type owners, about one-third of production ZNE-type and Energy Efficient owners, and no Code-built owners were aware of the term ZNE. Among the ZNE-type and Energy Efficient owners aware of ZNE, the most common interpretation was a home that produces as much or more energy as it uses (39% of owners). However, one-third had a misinterpretation of ZNE as either a home with no energy bills (23%) or not consuming energy from the utility (11%). This finding is surprising because these owners represent early adopters, whom the TRC team would expect to be much more informed about ZNE than the broader home buying market.

2.2.4. Energy Performance Messages

Builders most commonly use the term ZNE when marketing ZNE-type homes. Builders market energy performance of ZNE-type homes, but cautiously, and use strategies such as disclaimers regarding future energy bills to manage expectations. Builders reported using a variety of labels and programs for ZNE-type homes, including, ENERGY STAR® Homes, CAHP, GreenPoint Rated (GPR), Leadership in Energy and Environmental Design [LEED], Passive House[13], and others. Appraisers suggested that the number of labels used may create confusion in the market. Owner feedback also supported the finding that there are various descriptions and labels used for ZNE-type homes and for Energy Efficient homes.

Half of builders interviewed use the Home Energy Rating System (HERS) as a homebuyer communication tool. Those that do not use HERS reported that it is confusing for homebuyers. All appraisers interviewed

[12] According to the CEC (2013): "The TDV concept, first used in the 2005 California Building Energy Efficiency Standards, is based on the forecasted seasonal and hourly costs for generating, transmitting, and distributing electricity, and producing and distributing natural gas and propane."

[13] The TRC team uses the term "Passive House" to refer to homes built under either the Passivhaus Institut (PHI) or Passive House Institute U.S. (PHIUS) standards, which work separately in the U.S.

were aware of the HERS index, but none use it in their daily work. Most ZNE-type and Energy Efficient owners could not recall much information about an energy rating, but many reported it was helpful at the time of home purchase.

2.2.5. Home Purchasing Criteria

In open-ended questions, most custom ZNE-type owners identified energy features like efficiency, PV, or low bills as purchasing[14] criteria, and many identified a particular energy feature as the most important criterion. Production owners identified location, home size, and price as the most important purchasing criteria, and they generally viewed energy features as attractive bonuses. Production owners had similar purchasing criteria, regardless of energy performance (i.e., ZNE-type, Energy Efficient, or Code-built). The difference in criteria between custom and production owners may be because these owner types have different priorities and because custom owners have often selected a lot and identified a target price range and general home size before detailed design begins.

In prompted questions, ZNE-type owners ranked comfort, indoor air quality, and low energy bills as medium or high priorities, although few mentioned these as purchasing criteria in the open-ended questions.

Most (74%) ZNE-type and just under half (49%) of Energy Efficient owners would put a high priority on purchasing a ZNE-type home with their next home purchase if it were in the right location. Of the remaining ZNE-type and Energy Efficient owners interviewed, most ranked purchasing a ZNE-type home as a medium priority for their next home purchase.

Most owners preferred owning, rather than leasing a PV system, and Code-built owners expressed confusion over the PV leasing process.

2.2.6. Incremental Cost and Willingness-to-pay for ZNE-type Homes

2.2.6.1. Cost and Value of ZNE-type Homes

The TRC team asked high performance builders for their estimate of the incremental cost of building a 2,500 square foot ZNE home compared to a Code-built home. Eleven of the builders interviewed provided incremental cost estimates, and their responses ranged from 5-15% or $15,000 to $50,000. The TRC team did not ask about the incremental cost to build ZNE-ready or near ZNE homes. While the number of builders that provided an estimate is small, these results generally aligned with findings from the literature (Davis Energy Group 2012, BIRAenergy 2013).

While appraisers reported the value of features in ZNE-type or high performance homes is site-specific, five appraisers estimated the incremental value of a high performance home, and these varied from 5-15%. This agrees with Kok (2012), which found that single-family homes in California with a green label like ENERGY STAR Homes, GPR, and LEED sold for 9% more than a similar home without the label. In addition, studies have found that homes with PV sell for a premium compared to homes without distributed generation (e.g., LBNL 2013b, LBNL 2011, and ConSol 2008).

2.2.6.2. Willingness-to-Pay for ZNE-type Homes

The TRC team asked builders whether they believe that owners are willing to pay more for a ZNE home. Builders were split evenly between reporting that homebuyers are willing to spend more, that a very small

[14] For all questions regarding purchasing, the TRC team asked many custom owners about design criteria rather than purchasing criteria, because many custom owners had already committed to purchasing the home during the design phase.

fraction of homebuyers will pay more, and that homebuyers will not pay more for ZNE. The TRC team did not ask builders about owners' willingness-to-pay for ZNE-ready or near ZNE homes.

Based on the ZNE-type and Energy Efficient owner interviews and surveys, these owners reported they were willing to pay more for their next home to be ZNE-type. ZNE-type owners would pay 10% more on average for a ZNE-type home, with custom owners reporting a higher willingness-to-pay than production owners. Among Energy Efficient owners, 27% reported they would pay 1-5% more, and about half (53%) reported they would pay at least 11% for a ZNE-type home. Thus, many ZNE-type and Energy Efficient owners reported a willingness-to-pay that is in line with incremental cost estimates for ZNE homes from builders.[15]

The TRC team also asked ZNE-type and Energy Efficient owners if they expected their homes to sell for a premium, and if so, to estimate that sales increase. Most owners, particularly those with PV, expected their homes to sell for more. In addition, ZNE-type and Energy Efficient owners' willingness-to-pay increased with their perceived increased value of their current home. However, these ZNE-type and Energy Efficient owners represent early adopters, and their responses may not represent the views of the broader home buying market.

2.2.7. Home Satisfaction

All owner groups were satisfied with their homes, but energy performance and comfort contributed to ZNE-type and Energy Efficient owners' satisfaction, whereas Code-built owners liked their homes regardless of energy performance. Most (69%) ZNE-type and most (79%) Energy Efficient owners reported that their expectations for their homes had been met. Most of the remaining ZNE-type and Energy Efficient owners reported that their expectations had been somewhat met, and only a few reported their expectations had not been met. These expectations included low energy bills and a comfortable home. In contrast, while Code-built owners reported they were generally satisfied with their homes because of the location and family-friendly neighborhood, many reported dissatisfaction with high energy bills and poor temperature balancing. For their next home purchase, most ZNE-type and Energy Efficient owners would put a high priority on purchasing a ZNE-type home. Code-built owners would consider PV, efficiency, and buying a smaller home.

2.2.8. ZNE-Related Policies

While planners indicated that they are aware of ZNE, most reported that their jurisdictions are "waiting and seeing" what happens at the state level for ZNE-related policies. Many jurisdictions have adopted Reach Codes, and a few have adopted PV ordinances. These PV-only ordinances indicate a misalignment with the State loading order; currently, energy efficiency should occur before distributed generation**.**

Several builders reported that owners are confused about net metering, which other studies (e.g., Navigant 2014a) have also documented. The CEC is currently updating the 2016 Time Dependent Valuations (TDVs), and their updates to the 2019 TDVs will require further investigation into the effect of a 50% Renewable Portfolio Standard[16] and higher penetrations of distributed generation.

[15] The TRC team provided Energy Efficient owners with coded response options, and thus cannot calculate a mean value of these responses.

[16] Inaugural Address, Governor Edmund G. Brown Jr., January 5, 2015, Retrieved from: http://www.gov.ca.gov/news.php?id=18828

2.2.9. Drivers and Barriers

Figure 6 summarizes the top drivers of, and barriers to, different market actors for pursuing ZNE-type homes.

Market Actor	Primary Driver(s)	Primary Barrier(s)
Builders	Marketing differentiation, desire to innovate	Lack of consumer demand, incremental cost to build ZNE-type homes
Appraisers	Fulfillment of responsibilities and keeping up with market	Data availability
Lenders[17]	Marketing differentiation	Lack of consumer demand and additional resources
Building Officials	Fulfillment of responsibilities and keeping up with market	Additional resources, training needs (for builders and subcontractors)
Planners	Sustainability goals	Incremental cost to local builders for building ZNE-type homes, and challenges in meeting CEC incremental cost tests
Homebuyers	Energy savings, improved comfort, and improved indoor air quality (IAQ)	Incremental cost, misperceptions of ZNE (including expectations that misalign with policy), availability of ZNE-type homes, and confusion over PV policies and procedures

Figure 6. Summary of Drivers and Barriers to ZNE-type Homes

The results in Figure 6 are based on information that the TRC team collected directly from the market actors. The homebuyer drivers and barriers are those identified by the homeowners in this study's interviews, surveys, and forums. The TRC team also gathered secondary opinions by asking program managers for their opinions of drivers and barriers to builders, and asking program managers and builders for their opinions of homebuyers' drivers and barriers. These secondary opinions generally aligned with the data provided by the builders and owners themselves. However, direct owner feedback indicated that they may be less motivated by sustainability concerns than some builders and program managers believe: None (0 of 24) production ZNE-type owners and only 17% (3 of 18) of custom ZNE-type owners identified sustainability or a low energy footprint as a driver for purchasing their home.

2.3. Summary of Conclusions and Recommendations

Figure 7 summarizes the study recommendations. These recommendations focus on the IOUs and other PAs because they are the primary intended audiences of this report, and the CEC and CPUC, because they regulate the PAs. However, many market actors must support these recommendations, including builders, appraisers, lenders, realtors, raters, and local government officials.

Although this study's findings indicate that the California market is not currently ready to embrace a ZNE mandate for all residential new construction, the evidence also demonstrates that there is vibrant activity among the emerging ZNE-type home market.

[17] This figure summarizes barriers to lenders for providing financing that is specific to high performance homes, including Energy Efficient Mortgages.

Category	Subcategory	Supporting Conclusion	Recommendation	Lead	Support	Action Plan Goal (s)
ZNE Market Transformation Initiative	*Encourage Builders further down the EUI Continuum*	6.1.1.1	Expand programs targeting ZNE, and for ZNE-ready and near ZNE homes, particularly within 5-10% of the incremental cost compared to a code-built home.	PAs	CPUC, CEC	1, 4
		6.1.1.2	Continue programs for Energy Efficient homes as a stepping-stone for ZNE, but target builders that have been non-participants to date.	PAs	CPUC, CEC	1, 4
		6.1.1.3	Transition to a single market transformation program for energy efficiency and distributed generation.	PAs	Legislature, CPUC, CEC,	5
		6.1.1.4	Because different organizations track ZNE-type homes using different metrics, develop a central repository of ZNE-type homes or (at a minimum) consistent tracking metrics for tracking progress towards ZNE goals.	PAs	CEC, US DOE, California HERS Providers	1, 3
	Expand Market Actor Training and Collaboration	6.1.2.1	Continue and expand education efforts for builders and their contractors and trades regarding code compliance and above code building practices.	PAs	CEC, building departments	2
		6.1.2.2	Support real estate agents and lenders by holding symposiums for builders, appraisers, lenders, and realtors with interest and training in ZNE-type homes; bringing together ZNE-type homebuilders and Energy Efficient Mortgage (EEM) lenders;	PAs	CEC, CPUC, CalBRE[18], BREA[19]	1, 4

[18] California Bureau of Real Estate

[19] California Bureau of Real Estate Appraisers

		investigating a model through which a facilitator handles the additional paperwork of an EEM; providing a platform for connecting lenders with appraisers trained on ZNE-type homes; and providing training for realtors on how to recognize and promote ZNE-type home features.			
Expand Marketing of ZNE-type Homes with Consistent Messaging	6.1.3.1-6.1.3.2	Work with builders to develop clear and consistent messaging for the 2013 IEPR's ZNE definition that builders are comfortable promoting, and expand the reach of ZNE-type demonstration homes.	PAs	CEC	1, 2
	6.1.3.3	Provide educational toolkits to help builders address homebuyers' concerns about the re-sale value of ZNE-type homes, by promoting study results showing higher resale values of Energy Efficient and solar homes.	PAs	CEC	1, 4
	6.1.3.4	Once the State agencies update net-energy metering and other policies, work with these agencies, builders, and PV installers to educate homebuyers on how these policies affect them.	PAs	CEC, CPUC	1, 6
	6.1.3.5	Reframe the incremental cost paradigm by providing additional incentives and technical assistance to builders that meet the following challenge: using an identical budget for your non-ZNE home, how would you build a ZNE home that is as comparable as possible?	PAs	CEC, CPUC	2, 4
	6.1.3.6	Support builders in highlighting comfort benefits of ZNE-type homes through customer testimonials.	PAs		1
	6.1.3.7	Address homebuyers concerns about managing high tech features by providing template homeowner orientations to builders.	PAs		2

		6.1.3.8	Based on customers' satisfaction with PV displays, encourage builders to install home energy monitoring systems.	PAs		1, 3
	Research Natural Gas Appliances in ZNE-type Homes under an Evolving Grid	6.1.4	Investigate consumer preferences, greenhouse gas emissions, and cost effectiveness impacts (to the owners and the utilities) of equipment with different fuel sources, under an evolving grid.	PAs		6
ZNE-Related Policies	*Identify Consistent Metric(s) for Tracking ZNE-type Homes*	6.2.1	To address the difficulty of tracking progress towards ZNE under a Title-24 based metric, identify an EUI-based metric for tracking projects in energy efficiency and distributed generation programs.	CEC	PAs	4
	Assign Value for Distributed Generation in TDV	6.2.2	Finalize policies for how TDV will account for PV generation in the CEC's TDV-Lifecycle cost update process.	CEC		5
	Develop Equivalencies for Distributed Generation	6.2.3	Because not all homes can feasibly achieve ZNE on their own (e.g., due to lack of roof space for PV), develop equivalencies for the distributed generation aspect of ZNE.	CEC	PAs and local jurisdictions	6
	Consider Short-term, Voluntary ZNE Provisions	6.2.4	Work with planners to develop short-term voluntary provisions, with carrots for ZNE-type construction.	CEC	Local jurisdictions	6
	Encourage Energy Use Disclosures	6.2.5	To address appraisers' challenges from the lack of sales data for ZNE-type homes, work with the National Association of Realtors and the California Bureau of Real Estate (CalBRE) to encourage realtors to provide energy use disclosures.	CEC	CalBRE, National Association of Realtors	4

ZNE Research Priorities	*Develop Ranges of Actual Home Performance*	6.3.1	Because owners may interpret ZNE based on actual rather than modeled energy performance, collect performance data from occupied ZNE-type homes to: (1) understand how occupant behavior can affect energy use, (2) develop ranges of energy use based on actual ZNE-type homes, and (3) improve energy modeling.	PAs	CEC, CPUC	3
	Use and Improve the Energy Performance Categories	6.3.2	In future ZNE-type home studies, use and improve the catalog of energy performances developed in this study.	CEC	PAs	3
	Develop an Evaluation Plan to Support ZNE	6.3.3	Develop an evaluation research plan to support the State's ZNE goals including a full market baseline study that gathers feedback from the broader market, a market transformation study around 2018, and a market characterization of multifamily homes.	PAs, CEC, CPUC		1
	Research Barriers and Opportunities for Community-Scale Distributed Energy Resources	6.3.4	The lack of market actor experience with renewable energy resources beyond rooftop PV demonstrates the need to understand barriers and opportunities for community-scale Distributed Energy Resources (DERs) options for ZNE-type homes.	PAs, CEC, CPUC		5
	Evaluate Operational Challenges for Homebuyers	6.3.5	Track operational issues with ZNE-type homes so that builders can improve construction practices to address actual homebuyer concerns and develop messaging to address perceived concerns.	CEC	PAs	1, 2, 5

Figure 7. Summary of Recommendations

3. INTRODUCTION

Pacific Gas & Electric (PG&E), on behalf of the joint California Investor Owned Utilities (IOUs) contracted a team led by TRC Energy Services (TRC) to provide a market characterization of Zero Net Energy (ZNE) homes. The overall goal of the market characterization study was to provide a deeper understanding of opportunities for overcoming identified barriers to residential ZNE-type new construction in California.

3.1. Study Purpose and Background

The research priorities for this study flowed from the findings of the Road to ZNE: Mapping Pathways to ZNE Buildings in California (HMG 2012, abbreviated henceforth as the "Road to ZNE"), a policy and market analysis of the ZNE new construction goals set forth by California's energy agencies. The California Public Utilities Commission (CPUC) established ZNE goals in their 2008 California Long Term Energy Efficiency Strategic Plan (CPUC 2008), and the California Energy Commission (CEC) established similar ZNE goals in their 2007 Integrated Energy Policy Report (IEPR) (CEC 2007). The goals seek ZNE for all new residential construction by 2020 and for all new commercial construction by 2030.

The Road to ZNE and the Technical Feasibility of Zero Net Energy Buildings in California (Arup 2012) were deliverables for PG&E's Zero Net Energy Pilot program completed during the 2010-12 Energy Efficiency Program Cycle. PG&E managed both projects with co-funding support from the other California IOUs. Taken together, the studies' central finding was that, while the ZNE goals may be technically feasible—particularly so for residential new construction—there are considerable market and policy barriers to overcome. The goal of this market characterization study was to provide a deeper understanding of opportunities for overcoming identified barriers to ZNE residential new construction in California.

The TRC team hypothesized that the number of ZNE homes is extremely small, which was supported by the findings of this study, as described in Section 5.1. Consequently, the TRC team expanded the objectives to research ZNE-type homes (which include ZNE-ready, near ZNE, and ZNE homes, as defined in Section 3.4) because: (1) there would have been a lack of data for this study, i.e. very few market actors with "true ZNE" experience, and few ZNE homes for characterizing trends; and (2) the TRC team hypothesized that the drivers and barriers to ZNE generally apply to ZNE-type homes as well, which was supported by feedback from market actors.

To that end, the study's three main objectives were to:

- Characterize the residential ZNE-type new construction market by estimating the market sizes and exploring trends for ZNE-type homes;
- Assess residential rating systems and financing opportunities for ZNE-type homes; and
- Assess drivers, barriers, and opportunities to messaging, building, financing, and purchasing residential ZNE-type new construction.

3.2. TRC Team Introduction

To achieve the study's objectives, TRC assembled a team with diverse expertise:

- TRC, an energy efficiency research firm, provided coordination and oversight, served as the point of contact with PG&E, led the market-size estimates research, and led the analysis and reporting.
- Research into Action, an energy efficiency program evaluation and market research firm, led the builder, ZNE-type owner, and appraiser interviews; the ZNE-type and Code-built owner forums; and managed the surveys of Energy Efficient owners.

- Ann Edminster, an environmental and ZNE consultant, served as a liaison with ZNE-type home practitioners, particularly builders and designers, and provided guidance throughout the project.
- Debra Little, a sustainability consultant and certified residential appraiser, provided guidance on the financing and appraising aspects of the project and provided contacts for these interviews.
- CIC Research Inc., an economics, marketing, and survey research firm, conducted the surveys with Energy Efficient owners.

This report refers to this group as the "TRC team."

In addition, Cadmus conducted and analyzed the lender interviews for this study and provided draft recommendations from these findings under a separate contract with PG&E. PG&E requested that Cadmus conduct this portion of the study because of this firm's experience in this area and its existing relationships with lenders.

3.3. Study Limitations

The TRC team notes the following limitations of this study based on the specific research questions that drove the research design:

- This study is an exploratory analysis of a nascent market. The TRC team used purposive sampling to target specific slices of the market. In most cases, the TRC team targeted the early adopters in the residential ZNE space. For owner feedback through interviews, surveys, and forums, the TRC team also targeted other segments of the market, such as a small sample of Code-built owners and entry-level Energy Efficient owners. Results from this analysis are intended to be directional, not definitive, and to provide a deeper understanding of opportunities for overcoming barriers to residential ZNE new construction in California.
- Readers should note that in all cases except for the Code-built owner forum, the TRC team specifically sought market actors with ZNE-type home experience. For example, builder interviews reflect the perspectives of high performance builders. Similarly, the TRC team targeted other market actors (e.g., appraisers, lenders, local government officials) that have experience with or awareness of high performance or ZNE-type homes. This approach was necessary to collect the perspectives of early adopters of ZNE-type homes to achieve the study's objective of identifying the drivers, opportunities, and barriers to ZNE-type homes. Consequently, the interview and discussion results are likely biased because they reflect a small, targeted segment of the broad market of all builders, appraisers, lenders, and local government officials in California. The familiarity of these market actors with ZNE terminology and ZNE-type home practices may not reflect the broader market. Moreover, all incremental measure cost estimates from builders and willingness-to-pay estimates from Energy Efficient owners and ZNE-type homes may not reflect the broad market.
- The study's intention is to be a market characterization and not a market segmentation study.
- This study did not address the impact of ZNE-type homes on the grid, IOU business models, or ratepayers.
- This was a study of new construction, single-family homes. The market may include ZNE-type multifamily developments, and ZNE-type retrofits, but those were outside of this project's scope.
- This study gathered quantitative information on current ZNE-type home penetration, and qualitative information regarding the future adoption of ZNE-type homes, but it was beyond the scope to conduct a full market baseline or to develop normal market adoption (NOMAD) curves.

- The TRC team interviewed several of the critical market actors involved in ZNE-type homes. Other types of market actors participate in the ZNE-type home process, including architects, energy raters, subcontractors, and other project team members, but it was beyond the scope to interview these additional market actors.
- The TRC team used the CEC and CPUC interpretation of ZNE articulated in the 2013 Integrated Energy Policy Report[20] (CEC 2013), and categorized homes that follow the state loading order with both energy efficiency and distributed generation as ZNE-type homes. Consequently, the study did not consider homes with only distributed generation as ZNE-type, although the TRC team recognizes that homes may meet some ZNE definitions with only distributed generation.
- Owners provided self-reported willingness-to-pay data, which were not based on actual purchases. Although these owners had purchased a ZNE-type or Energy Efficient home, they typically were not presented with the home they purchased or the exact same home in the same location but without the energy features. Consequently, the TRC team presented a hypothetical question regarding willingness-to-pay.

3.4. Terminology Used in this Report

One motivation for the study was to identify different terms for ZNE-type homes in the market and different market actors' interpretations of ZNE. While the TRC team did not wish to elevate one set of terms over another, the team needed to develop a set of terms for describing homes in this report and for data collection purposes. This section describes the terminology and interpretations used in the report.

3.4.1. Approach to Categorizing ZNE-type Homes

One of the study goals was to understand awareness of ZNE among different types of market actors and their interpretations of the term. Consequently, the TRC team used as broad an interpretation of ZNE as possible in interviews, surveys, and discussions. For example, when collecting feedback from market actors, the TRC team generally asked the market actor if they had heard of the term "Zero Net Energy." If so, the team would ask for his/her interpretation of the term and add, "There are no right or wrong answers here" to encourage the market actor to speak freely on his/her interpretation.

In certain data collection activities, the TRC team provided the team's definitions of ZNE or other terms in subsequent questions, so that respondents would interpret these questions consistently. For example, the TRC team asked ZNE-type home experts for their definition of ZNE; later, the team asked these experts for their estimates of the number of ZNE-ready, near ZNE, and ZNE homes in California based on the TRC team's classifications of these terms (described in Section 3.4.2). Similarly, the TRC team asked owners about their awareness of ZNE and their interpretation of the term; later, the team provided its interpretation of ZNE and asked for the respondent's willingness-to-pay for a ZNE-type home.

For the market size estimates, the TRC team developed quantitative criteria for home energy performance based primarily on data in IOU residential new construction program databases. The TRC team developed these criteria based on compliance margins relative to Title 24 (defined in Section 3.4.2), because the IOU databases currently track energy performance in this manner.

The next section provides more detail on the study classifications of these categories.

[20] Senate Bill 1389 requires that the CEC adopt and transmit to the Governor and Legislature a report of findings every two years. That report is called the Integrated Energy Policy Report (IEPR).

3.4.2. ZNE Terminology and Home Energy Performance Categories

In general, the TRC team views energy performance as a continuum, with ZNE at the low end of a net energy use scale. Figure 8 illustrates this concept, and introduces the broad categories of energy performance used in this study: Code-built, Energy Efficient, ZNE-ready, near ZNE, and ZNE homes. As shown in the figure, this study uses the term "ZNE-type homes" to refer collectively to ZNE-ready, near ZNE, and ZNE homes.

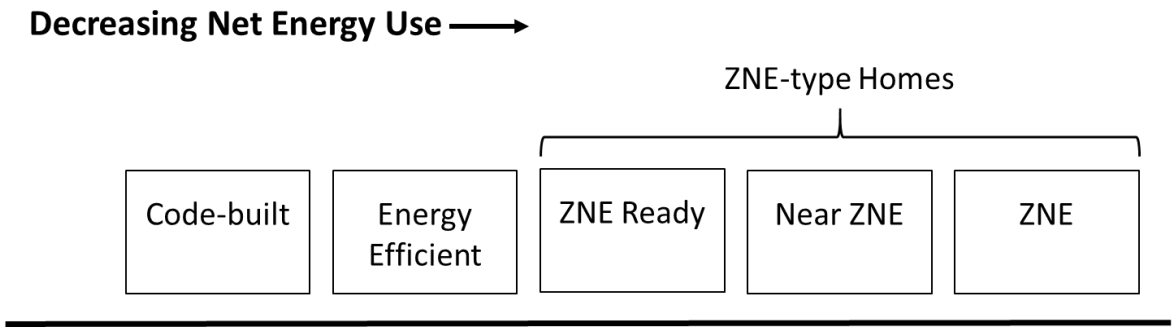


Figure 8. Home Energy Performance Classifications

Figure 9 presents the study classifications for each of these home performance categories. As shown, when describing a ZNE-type home to market actors, the TRC team provided a qualitative description of "very energy efficient." For the market size estimates, the TRC team identified 40% above Title 24 as a minimum for ZNE-type homes because this represented the top tier of homes. The TRC team identified the 40% cut-off based on the literature review. While research studies and example projects illustrate different energy performance levels for ZNE and ZNE-type homes, several studies support a threshold of 40% above Title 24. SMUD Zero Energy Home (ZEH) program established a target of 30-40% above Title 24, a review of case studies found that many ZNE-type homes are modeled to exceed Title 24 by at least 40%, and the U.S. DOE Zero Energy Ready homes are intended to be at least 40%-50% more efficient than code. Consequently, the TRC team selected a 40% compliance margin as the threshold for a ZNE-type home.

Broad Category	Home Performance Category	Study Classification, provided in market actor interviews, surveys, and forums[21]	Title 24[22] Compliance used for market size estimates	Distributed Generation
Non-ZNE homes	Code-built	A newly constructed code-built home	Meets Title 24, or exceeds it by < 15%	Maybe
	Energy Efficient	Modeled to be more energy efficient than a code-built home	Generally exceeds Title 24 by 15% - 39%	Maybe
ZNE-type homes	ZNE-ready	Highly energy efficient with no onsite renewable generation	Generally exceeds Title 24 by ≥ 40%	No
	Near ZNE	Highly energy efficient with insufficient onsite renewable generation to annually offset consumption	Exceeds Title 24 by ≥ 40%; OR net energy use is ≥80% less than a Title 24 compliant home[23]	Yes, but not enough to offset annual consumption
	ZNE	Highly energy efficient with sufficient onsite renewable generation to annually offset consumption[24]	Generally exceeds Title 24 by ≥ 40%	Yes, enough to offset annual consumption

Figure 9. Study Classification of ZNE and Other Energy Performance Terms

The TRC team provides the following notes on these home performance classifications:

- These definitions use projected energy use/energy modeling rather than actual energy use based on performance. Occupancy, resident behavior, weather, and other factors may cause actual energy performance to differ from projected energy performance.
- The TRC team followed the energy loading order, as described by the 2013 IEPR (CEC 2013), meaning energy efficiency first, followed by distributed generation to offset the remaining energy use. While it is possible for a code-built home or a home with minimal energy efficiency with large amounts of distributed generation to offset its projected annual energy use, the TRC team did not interpret these homes as ZNE in this report, as discussed further in Section 3.3.
- For the market actor feedback, the TRC team did not differentiate between the various definitions of ZNE (TDV, site, source, energy cost, etc.). Where appropriate, the TRC team identified if particular market actors specified one version of the ZNE definition over another. For example, as discussed in more detail in Section 9.1.1, most builders reported building to a site-based ZNE definition. For the market size estimates, the TRC team used a site-based definition of ZNE, because this is how the program databases and RFI respondents have generally tracked home performance.

[21] As described in this section, the TRC team would first ask market actors for their interpretation of the term Zero Net Energy. The TRC team would provide the classifications shown in this table in later questions if needed (such as for questions on market size or willingness-to-pay), so that all market actors would interpret these subsequent questions consistently.

[22] The TRC team did not specify a version of Title 24 for these definitions. Most of the homes represented in this study were built under the 2005 Title 24 or 2008 Title 24.

[23] Projects that met this near ZNE classification (i.e., net energy use ≥ 80% less than a Title 24 compliant home) were identified by RFI respondents. There may be additional near ZNE projects that meet this threshold that the TRC team did not identify.

[24] The TRC team did not further differentiate between the various definitions of ZNE (TDV, site, source, energy cost etc.) for the purposes of this report. Where appropriate, the TRC team identified if particular market actors prefer one version of the ZNE definition to the other.

- According to both California policy (i.e., the 2013 IEPR) and the interpretations of most market actors in the study, the term "ZNE" includes all energy loads. Consequently, in a ZNE home, energy efficiency and distributed generation will reduce and offset, respectively, all energy loads regulated by Title 24 (e.g., heating, cooling, and water heating) and loads not regulated by Title 24 (e.g., appliances, plug loads).

For brevity, the TRC team also uses the term "high performance home" as a broader category that refers to a ZNE-type or Energy Efficient home.

3.4.3. Other Terminology

While there are various definitions of the following terms, we define them as follows for the purpose of this report:

Home types:

- **Custom home:** A home built with a specific owner in mind. Based on owner interviews, the owner is typically involved in the design process.
- **Spec home:** A home built individually, or as part of a very small group of homes, without a specific owner in mind.
- **Production home:** A home that is part of a development in which a builder or developer builds many homes together with similar floor plans and features. In some cases, if the home is not yet constructed, the owner can purchase options from a list of additional features. In other cases, an owner may purchase a home after construction is complete.

Builder types:

- **Custom builder:** A builder of custom or spec homes
- **Production builder:** A builder of production homes

Owner types:

For brevity, this study uses the following terms to describe owners of different home types.

- **Code-built owner:** An owner of a Code-built home per Figure 2
- **Energy Efficient owner:** An owner of a home that is Energy Efficient per Figure 2
- **ZNE-type owner:** An owner of a ZNE-type home that is ZNE-ready, near ZNE, or ZNE, per Figure 2
- **Custom owner:** An owner of a custom home
- **Production owner:** An owner of a production home

The study also combines terms to describe specific types of owners, such as "custom ZNE-type owners" to describe owners of custom, ZNE-type homes.

Geographic descriptions: For this study's data collection activities, including owner interviews and estimates of market size, the TRC team uses the following terms:

- **Northern California:** Homes in PG&E and SMUD territories
- **Southern California:** Homes in SCE, SDG&E, and SoCalGas territories

Programs:

California Advanced Home Program (CAHP): The whole house performance program for residential new construction offered by the California IOUs, which provides incentives to builders for delivering energy efficient homes.

California Solar Initiative Program (CSI): A statewide program that provides financial incentives to customers of California's three major electric IOUs for the installation of PV systems. With a $2.4 billion budget over a ten-year period, CSI has a goal of installing 1,940 megawatts (MW) of distributed PV capacity in the IOU service territories by the end of 2016.[25] The general market component of CSI is the primary component of the CSI program and has a goal of installing 1,750 MW. CSI also includes low income subprograms, research and development, and other components. The CSI general market program is funded by the ratepayers in each of the respective service areas.

GreenPoint Rated (GPR): A voluntary labeling program for California homes that meets requirements for energy efficiency and green measures, operated by Build it Green (BIG).

New Solar Home Partnership (NSHP): The California Energy Commission's New Solar Homes Partnership (NSHP) is part of the comprehensive statewide solar program, known as the California Solar Initiative. The NSHP provides financial incentives and other support to homebuilders encouraging the construction of new, energy efficient solar homes that save homeowners money on their electric bills and protect the environment. More information is available at: http://www.gosolarcalifornia.org/about/nshp.php.

Additional Terms

Compliance margin: The percent by which a home is projected (based on energy modeling) to exceed the energy performance of a code compliant home – i.e., the percent by which a home is projected to exceed the energy performance predicted under Title 24.

Distributed generation (DG): Energy generators interconnected to the grid to reduce the amount of power they purchase from the utility.[26] For the purposes of this study, the generators would be located on the premise or within the boundaries of a development. In almost all homes discussed here, the type of distributed generation employed was rooftop solar photovoltaic (PV). However, one appraiser had valued a home with wind turbines, and one planner discussed the possibility of community-scale DG.

Energy Efficient Mortgage (EEM): A mortgage through the Federal Housing Administration that helps homebuyers or homeowners save money on utility bills by enabling them to finance the cost of adding energy efficiency features to new or existing housing.

Purposive sampling: A sampling methodology whereby the researcher intentionally develops a biased sample based on who they believe would be appropriate for the study, rather than a sample representation of the broad population.

Solar Photovoltaic (PV): This study generally uses the term "PV" to refer to solar photovoltaic to differentiate solar PV from other types of solar energy (e.g., solar thermal). However, this study uses the term "solar" to refer to PV, when quoting a market actor, because many owners described "solar homes," or when referencing a program name like the California Solar Initiative.

Time Dependent Valuation (TDV): According to the CEC (2013): "The TDV concept, first used in the 2005 California Building Energy Efficiency Standards, is based on the forecasted seasonal and hourly costs for generating, transmitting, and distributing electricity, and producing and distributing natural gas and

[25] http://www.cpuc.ca.gov/PUC/energy/Solar/aboutsolar.htm

[26] http://www.pge.com/b2b/newgenerator/distributedgeneration/

propane. TDVs are established for every hour of the year for each type of energy in each of California's 16 climate zones. The set of values considered under TDV are specific to the intent of the metric to recognize the premium utility costs that must be paid for energy consumed during peak conditions compared to the substantially lower costs during off-peak conditions."

Willingness-to-pay: The incremental cost that someone will pay for something. In the context of this report, customers provided willingness-to-pay estimates in response to the question of how much more they would pay for ZNE-type home compared with a code-built home.

4. METHODOLOGY

This section describes study collaboration and the major data collection activities, which included:

- Initial data collection;
- Market actor feedback through interviews, surveys, and forums; and
- ZNE-type Market size and ZNE-type home characteristics analysis.

This section then presents the data sources used for these data collection activities.

4.1. Collaboration with Stakeholders

The TRC team enlisted the input of a Project Advisory Group (PAG) to provide technical oversight and direction to this research. The PAG met twice—once at the beginning of the project to review and provide comment on the Study Work Plan, and the second time after the TRC team had collected and analyzed results to provide feedback on developing conclusions. In addition, the TRC team worked with the IOUs, the CPUC, and the CEC throughout the study. These groups provided feedback on the study work plan, data collection instruments, and initial findings. The TRC team also worked with these groups to document the 2016 TDV update process.

4.2. Initial Data Collection

The TRC team conducted an initial research effort, which included a literature review, interviews with utility program managers, and a survey of ZNE practitioners. These initial findings shaped the remainder of data collection, which focused on collecting feedback from market actors.

4.2.1. Literature Review

The TRC team identified an initial list of resources for review based on the various team members' knowledge of literature. The TRC team added to this list based on recommendations from various IOU staff, CPUC staff, PAG members, and others. Finally, the TRC team conducted an internet search using the California Measurement Advisory Council (CALMAC), American Council for an Energy Efficient Economy (ACEEE) publications, and U.S. DOE publications. When reviewing literature, the TRC identified ZNE-related information to guide the data collection efforts initially and to compare against the results of this study during analysis.

4.2.2. Request for Information (RFI) from ZNE Network

The TRC team gathered initial information regarding ZNE-type homes and recommendations for interviewees by conducting an RFI with professionals with ZNE expertise. To identify RFI respondents, the TRC team used its contacts within the ZNE community, and asked IOU staff to identify additional professionals with ZNE expertise. This RFI was a short online survey administered using Survey Monkey, which asked respondents to provide their interpretation of ZNE, identify ZNE-type projects, recommend market actors for interviews (e.g., builders of ZNE-type homes, appraisers with ZNE experience), and estimate the number of ZNE-ready, near ZNE, and ZNE homes in California.

4.2.3. Program Manager Interviews

The TRC team conducted interviews with nine staff involved with programs that encourage ZNE homes, primarily at the IOUs, but also at SMUD and Build It Green, a non-profit that manages the voluntary labeling

program, GreenPoint Rated (GPR). The TRC team collected information on ZNE home characteristics, the size of the ZNE market, and drivers for and barriers to achieving ZNE for program participants or program trade allies. The TRC program managers also recommended market actors for interview, particularly high performance builders.

4.3. Market Actor Feedback and Market Size Estimates

4.3.1. Overview of Market Actor Data Collection

Based on the initial data collection, the TRC team developed interview guides and a list of market actors for interviews, forums, and surveys. Note that this study used *purposive sampling* by targeting market actors with high performance home experience[27], rather than sampling market actors representing the broader population. The project scope did not allow for interviews reflecting a broad range of perspectives for each market actor group.

The TRC team also collected feedback from a variety of owners by conducting interviews and one forum with ZNE-type owners, surveys with Energy Efficient owners, and a forum with Code-built owners. Where schedule allowed, the findings from one data collection effort informed subsequent efforts. For example, the findings from the ZNE-type owner interviews informed the survey guide for the Energy Efficient owners.

Figure 10 summarizes the data collection efforts from various market actors.

[27] Where possible, the TRC team targeted market actors with ZNE-type home experience. However, because the number of ZNE-type homes is small, the TRC team was not able to find enough market actors with ZNE-type home experience in some cases; the TRC-team collected feedback from market actors with high performance home experience in these instances.

Market Actor	Data Collection	Target in Work Plan	Number Achieved
Builders of ZNE-type homes	Interviews	10 to 20 builders and 1-2 building industry experts	16 builders[28], and 3 industry experts
Program Managers	Interviews	4 to 6	6 interviews that included 9 staff
Appraisers with ZNE-type home experience	Interviews	6 to 8 ZNE-type experience, 3 with ZNE training but little ZNE-type experience	11, all had at least some experience with efficient and/or PV homes, but few had ZNE-type home experience; and 1 industry expert
Lenders with high performance home experience	Interviews	6 to 8	6 with energy efficiency and/or PV experience, 1 of which also had ZNE experience
Building Officials and Planners with high performance home experience	Group Discussions	1-2 small group discussions each group	1 discussion with 6 building officials; 1 discussion with 4 planners and 4 interviews (8 planners total)
CEC staff involved with ZNE and TDV efforts	Brief interviews	2-4 staff	3 staff
ZNE-type Owners	Interviews	40 (32 ZNE-ready and near ZNE, 8 ZNE)	43 (4 ZNE-ready, 34 near ZNE, and 5 ZNE)
ZNE-type Owners	Forums	2 forums	1 forum with 4 near ZNE owners
Energy Efficient Owners	Surveys	80-136 (roughly half in northern CA, half in southern CA)	112 (57 northern and 55 southern California owners)
Code-built Owners	Forum	0	1 forum with 10 owners

Figure 10. Summary of Primary Data Collection[29]

4.3.2. Data Sources

Figure 11 and Figure 12 present the data sources used for each data collection activity. As described in section 3.4.2, these figures represent modeled or predicted performance, not actual energy use, and this report does not include homes with distributed generation but only minimal efficiency.

In general, the TRC team used homes from the CAHP databases and identified through the RFI for the homeowner data collection activities, because the team did not have NSHP data at the time of these efforts. The team included NSHP data along with CAHP and RFI data for the market size estimates.

[28] Some builders did not respond to all questions because the builder did not feel he/she had enough experience to provide a response, and the interviewer skipped some questions to respect the builder's stated time constraints. The TRC team identifies the number of builder responses when presenting data from builder interviews.

[29] The original work plan also included interviews with two to three energy raters, to discuss the use of HERS as a messaging tool and challenges with the California HERS system being different from the national HERS. Initial interviews conducted for this study indicated that interviews with energy raters regarding these issues were not critical for the purposes of this project scope, because challenges and needs are generally known (e.g., need for a crosswalk between HERS systems). However, energy raters play a critical role in high performance homes, and the TRC team encourages future studies to gather energy raters' broad feedback on ZNE-type homes.

Home Type	Data Collection Activity	Homes Included
Code-built	Code-built owner forum	Newly constructed homes for which builders did not participate in energy efficiency programs or earn energy efficiency labels, to the owners' knowledge. To the best of the TRC team's knowledge, these homes met Title 24 requirements, but did not exceed them by a significant margin. A few owners of Code-built homes had PV.
Energy Efficient	Owner surveys	PG&E, SCE, and SoCalGas CAHP entry-level homes, meaning homes 15-20% more efficient than Title 24, some of which included PV. While the TRC team identified 39% as the upper limit of Energy Efficient (but not ZNE-type) homes, the team used 20% as the maximum for the Energy Efficient owner survey to have a large difference between the Energy Efficient and ZNE-type homes reflected in the Energy Efficient owner surveys and ZNE-type owner interviews.
ZNE-type	Interviews and ZNE-type owner forum	Three sources of data: • PG&E CAHP homes modeled as at least 40% more efficient than Title 24, with or without PV • SCE and SoCalGas CAHP homes modeled as at least 35% more efficient than Title 24 AND with PV, OR at least 40% more efficient than Title 24 with or without PV[30] • ZNE-type owners recommended by RFI respondents, including homes projected to have at least an 80% net energy reduction compared to Title 24 homes

Figure 11. Data Sources for Homes in Owner Data Collection Activities (Interviews, Surveys, Forums)

[30] The minimum Title 24 cut-off was different for the SCE and SoCalGas homes compared with PG&E homes, because there were not enough homes 40% above Title 24 for the Southern California owner sample.

Home Type	Data Sources	Homes Included
Energy Efficient	CAHP and NSHP databases	Homes modeled to exceed Title 24 by at least 15%, but by less than 40%.
ZNE-type	CAHP, NSHP, and RFI data	The TRC team subcategorized ZNE-type homes as follows: • **ZNE-ready**: Homes modeled to exceed Title 24 by at least 40% that did not have PV or other types of distributed generation, to the best of the TRC team's knowledge. The TRC team identified almost all of these homes through the IOU CAHP databases. • **Near ZNE**: Homes modeled to (1) exceed Title 24 by at least 40% that did have PV or other types of distributed generation—the TRC team identified almost all of these homes through the IOU CAHP and NSHP databases, or (2) have at least an 80% net energy reduction compared to Title 24 homes—the TRC team identified almost all of these homes through RFI responses. • **ZNE**: Highly energy efficient homes with distributed generation that were modeled or designed to produce as much energy as they consumed on an annual basis. The TRC team identified all of these homes through the CAHP program manager interviews and RFI responses, because the CAHP and NSHP databases do not currently track ZNE homes. The TRC team used a site-based definition of ZNE, because this was how the data sources tracked home energy performance.

Figure 12. Data Sources for Homes in Market Size Estimates

Figure 13 graphically illustrates the information presented in Figure 11 and Figure 12 and summarizes the data sources used.

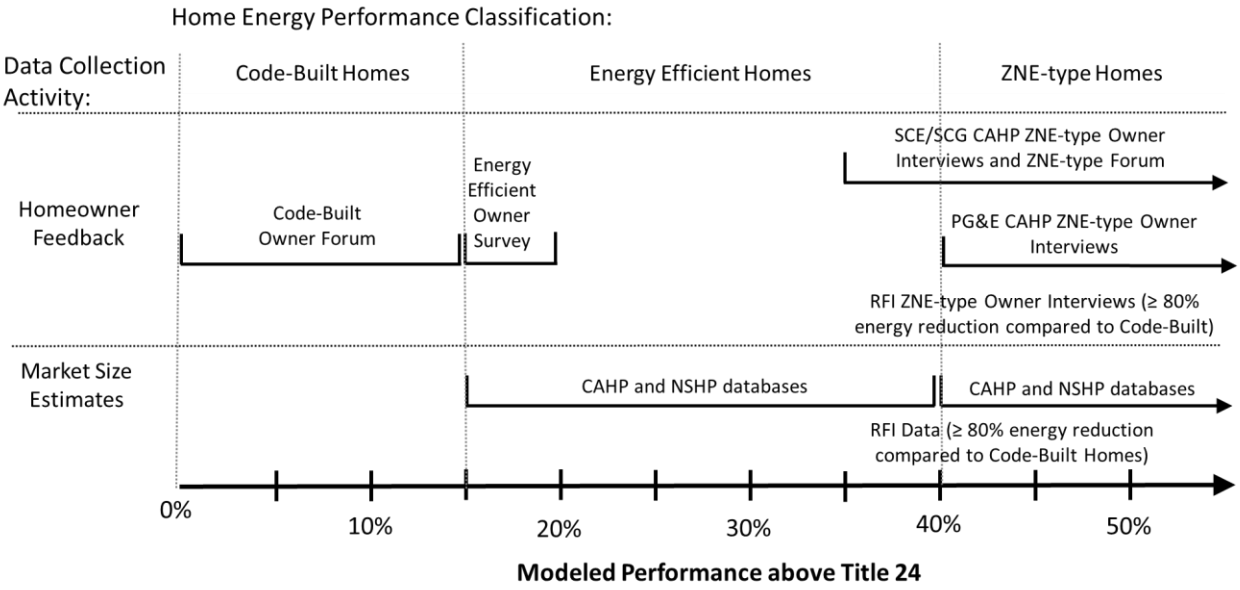


Figure 13. Summary of Data Sources

5. SYNTHESIS OF FINDINGS

This section synthesizes results by topic, based on the results from the various data collection activities. The TRC team provides a summary of primary data collection results organized by data collection activity in an appendix (Section 9). The TRC team presents the full data collection results in the report Attachment.

This section presents findings in the following order:

- Estimates of the number of new construction ZNE-type homes built since 2006
- Characteristics of ZNE-type homes and their geographical distribution, and how these compare to Energy Efficient and Code-built homes
- Awareness of the ZNE term among different market actors
- Interpretations of ZNE among different market actors
- The marketing messages that builders use when describing ZNE-type homes, the labels and descriptions recalled by owners for their high performance homes, and the value of energy rating systems and labels in marketing
- Home purchasing criteria identified by owners, and how these vary by owners of different home types (i.e., custom and production) and different energy performance (i.e., ZNE-type, Energy Efficient, and Code-built)
- Builders' estimated incremental cost to build ZNE-type homes, appraisers' valuation of high performance homes, owners' perceived value of high performance homes, and owners' willingness-to-pay for ZNE-type homes
- Areas of home satisfaction and dissatisfaction for owner groups with different energy performance
- Current ZNE-related policies, including local Reach Codes and PV ordinances, PV ratemaking reforms, and research questions for the 2016 and 2019 TDV updates
- Drivers and barriers to ZNE-type homes for the various market actors included in this study
- Opportunities for overcoming barriers, as identified by market actors

As described in Section 3.3, the market actor results primarily reflect the views of early adopters, and may not reflect the views of the broad market.

In general, in each subsection, the TRC team presents owner results in the following order:

- ZNE-type owners, consisting of those owning custom ZNE-type homes ("custom ZNE-type owners") and those owning production ZNE-type homes ("production ZNE-type homes"). The TRC team collected data from ZNE-type owners through phone interviews and one in-person forum.
- Energy efficient owners, of which almost all (97%) owned production homes ("Energy Efficient owners"). The TRC team collected data from Energy Efficient owners in phone surveys.
- Code-built owners, all of which were production owners ("Code-built owners"). The TRC team collected data from Code-built owners in one in-person forum.

5.1. ZNE-type Home Market Size Estimates

This section describes results of the market estimates of newly constructed ZNE-type homes in California, a comparison to the total number of housing permits in California, and analysis showing the relationship between PV and energy efficiency.

5.1.1. Estimates of the Market Size of ZNE-type Homes

The TRC team used multiple methods to estimate the market size of ZNE-type homes:

1. Estimates provided by the RFI respondents;
2. Self-reported data provided by builders interviewed in this study;
3. California Advanced Homes Program (CAHP) databases from all four IOUs—PG&E, SCE, SoCalGas, and SDG&E, combined with the New Solar Homes Partnership (NSHP) database, and with ZNE-type homes identified by RFI respondents ("RFI data"), abbreviated as CAHP / NSHP / RFI data; and
4. The GreenPoint Rated database for single-family homes, provided by Build It Green.

The TRC team provides results from each data source below. As described in Section 3.4, this study classified ZNE-type homes based on projected (i.e., modeled) energy performance, not actual energy use.

5.1.1.1. Request for Information Survey

Broad knowledge base was tapped for RFI: The TRC team solicited various market actors involved with ZNE-type homes (e.g., architects and designers, raters, IOU staff, government staff, non-profit staff, and others) for their estimate of the market size of ZNE-ready, near ZNE, and ZNE homes as part of the RFI. As described in Section 3.4, the RFI provided respondents with the following interpretations of these terms when asking for market size estimates:

- ZNE-ready: highly energy efficient with no onsite renewable generation[31]
- Near ZNE: highly energy efficient with insufficient onsite renewable generation to annually offset consumption
- ZNE: highly energy efficient with sufficient onsite renewable generation to annually offset consumption

For ZNE homes, the TRC team did not specify a site-based, TDV-based, or other definition for ZNE, but instead allowed respondents to make their own interpretations.

RFI respondents estimated more ZNE-ready than near ZNE homes: The RFI provided the same multiple-choice options (0, 1-20, 21-50, 51-100, 101-50, 501-1000, or over 1000 homes) for each category of ZNE-type homes. Respondents provided a large range of market size estimates. As seen in Figure 14 below, there was no majority opinion on the number of ZNE homes; estimates ranged from 1-20 to over 1000 homes. However, the most common estimate of ZNE homes was between 21-59 homes. The majority of respondents estimated there are over 500 near ZNE, with respondents evenly split between 501-1000 and over 1000 homes. The majority of respondents estimated over 1000 ZNE-ready homes. Thus, RFI respondents generally estimated a higher number of ZNE-ready homes than near ZNE homes.

[31] This report the term "distributed generation", because this is the technically correct term. However, the TRC used the term "onsite renewable generation" in the RFI, because this term is more understandable to the market.

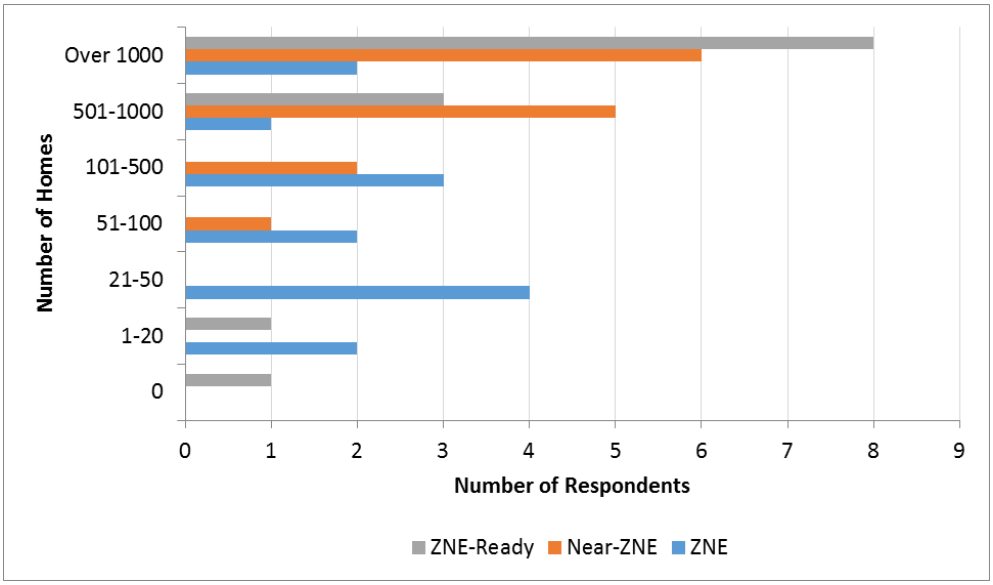


Figure 14. ZNE-type Home Market Size Estimates Provided by RFI Respondents

5.1.1.2. Self-Reported ZNE Homes from Builder Interviews

Builders reported 31 ZNE homes, but many met the study definition of "near ZNE": As part of the builder interviews, the TRC team asked builders to estimate the number of ZNE homes they had built in the past three years. Overall, the 16 builders interviewed reported that they had built, in total, 31 ZNE homes. However, these numbers were self-reported, and builders used their own interpretation of ZNE when providing these estimates.

The TRC team reviewed information on the "ZNE projects" identified by the builders to reclassify some of these homes. Overall, many of these homes met the study definition of near ZNE (not ZNE) homes. The TRC team included the homes identified by builders in the estimates developed using CAHP / NSHP / RFI data (see section 5.1.1.3).

To stay within the time limits of the interview, the TRC team did not ask builders to estimate the number of ZNE-ready or near ZNE homes that they had constructed.

5.1.1.3. Estimates from CAHP, NSHP, and RFI Data

CAHP, NSHP, and RFI data yield 1,124 total ZNE-type homes, of which 16 are ZNE: The TRC team developed a bottom up estimate of ZNE-type homes using the CAHP and NSHP databases and ZNE-type homes identified through the RFI, including projects identified by SMUD staff, builders, and PAG members. As described in section 9.2.2, the CAHP and NSHP databases currently do not distinguish between ZNE-ready, near ZNE, and ZNE homes, and they have historically tracked performance relative to Title 24; however, in support of the move towards ZNE, the CAHP program is moving towards an energy use intensity (EUI) metric (a *CAHP score*).

For the CAHP database analysis, the TRC team used the four IOUs' CAHP databases to identify homes that exceeded Title 24 by at least 40%. Of these, the TRC team identified homes that the CAHP program labeled as receiving a PV incentive as near ZNE, and homes that did not as ZNE-ready. The team also removed duplicate ZNE-type homes within the IOU CAHP databases – e.g., duplicates between SoCalGas and SCE. Using information from the CAHP program managers, the TRC team identified some of these CAHP homes

as ZNE. The TRC team identified 454 ZNE-type homes total – 164 ZNE-ready, 279 near ZNE, and 11 ZNE homes – using the CAHP data.

The NSHP database includes single-family and multi-family homes. Based on input from the NSHP program manager, the TRC team assumed that all affordable units were multifamily and removed these from the analysis. The NSHP database also includes a field showing CAHP participation; the TRC team removed these homes as well, to avoid double-counting homes that were already included in the CAHP databases. The remaining homes represented single-family homes that did *not* participate in the CAHP program; of these homes, the TRC team identified those that were at least 40% above Title 24 as near ZNE. The TRC team identified an additional 182 ZNE-type homes, all of which the team categorized as near ZNE homes, from the NSHP database.

The TRC team also reviewed on-line information for "RFI data", which included homes that were:

1. Identified by RFI respondents,
2. Provided by SMUD staff,
3. Found in the literature review, and
4. Shown on the Passive House websites (i.e., Passive Haus, and U.S. Passive House[32]) or the DOE Zero Energy Ready[33] website.

The TRC team classified these as ZNE-ready, near ZNE, or ZNE, based on the interpretations provided in section 3.4. For homes identified through RFI data where the address was available, the TRC team removed duplicates between the RFI data and the CAHP and NSHP databases. The TRC team identified an additional 488 ZNE-type homes total – 483 near ZNE and 5 ZNE homes – using RFI data.[34]

Based on CAHP, NSHP, and RFI data, there are a total of 1,124 ZNE-type homes, the vast majority of which are near ZNE. By classification, the TRC team estimated 164 ZNE-ready, 944 near ZNE, and 16 ZNE homes.

Interpretation of "ZNE-type" significantly affects market size estimates: While California policy has defined ZNE, it has not defined ZNE-type homes, including ZNE-ready or near ZNE homes. If this study had used 30% more efficient than Title 24, which corresponds to the NSHP Tier II threshold and the SMUD definitions for ZNE, the estimate would be 10,546 ZNE-type homes, an order of magnitude higher than the estimate based on a 40% threshold. Also, under a 30% greater than Title 24 definition, there are more ZNE-ready homes (6,490) than near ZNE homes (4,040). The number of ZNE homes remains at 16. Figure 15 illustrates the different analyses under the two different energy efficiency thresholds for a ZNE-type home—30% vs. 40%. Both estimates also count homes as near ZNE if they have a net energy use modeled as at least 80% lower than a Code-built home.

[32] The TRC team uses the term "Passive House" to refer to homes built under either the Passivhaus Institut (PHI) or Passive House Institute U.S. (PHIUS) standards, which work separately in the U.S.

[33] The DOE only recently began the ZNE Energy Ready program, and the predecessor program (Builder Challenge) did not have a database of California homes that would meet the needs of this activity. Consequently, the TRC team obtained only a few ZNE-type homes from the DOE.

[34] The majority of these homes were either SMUD homes, or homes that were constructed prior to the years for which the TRC team had CAHP data. Consequently, the large number of ZNE-type homes found through RFI data does not indicate that many ZNE-type homes are not participating in the IOU CAHP programs.

ZNE-type Home	ZNE-type ≥ 30% above Title 24	ZNE-type ≥ 40% above Title 24
ZNE-ready	6,490	164
Near ZNE	4,040	944
ZNE	16	16
Total ZNE-type homes	**10,546**	**1,124**

Figure 15. Market Size Estimates under Different Definitions of "ZNE-type"

5.1.1.4. Estimates Based on GPR Data

GPR data yield 6 ZNE, and 104 ZNE-type homes: Some builders interviewed, particularly custom builders, reported that they do not participate in the CAHP program, but that they sometimes participate in a voluntary labeling program. Consequently, the TRC team requested databases from several voluntary programs, including Build It Green (BIG), which manages the GreenPoint Rated (GPR) labeling program; the U.S. Green Building Council (USGBC), which manages the LEED labeling program; and CHEERS, a California HERS provider. While the USGBC and CHEERS were not able to provide data in the format needed for this analysis, BIG was able to provide data for homes that had participated in the single-family new construction program. Specifically, BIG provided a list of homes that met the study interpretations of ZNE-type homes--meaning those at least 40% more efficient than Title 24 for a near ZNE or ZNE-ready home—and projected to consume as much energy as it produces annually for a ZNE home. BIG did not provide PV data, so the TRC team presents ZNE-ready and near ZNE homes as one group. However, BIG staff reported that the majority of these homes have PV, so this study would categorize most as near ZNE. In addition, BIG staff reported that, while the majority of the ZNE-type homes reported here are single-family detached units, there may be some single-family attached units in this data. BIG provided the list of homes with project addresses removed, for confidentiality reasons. Consequently, the TRC team presents the GPR data separately from the CAHP / NSHP / RFI data, because there may be some duplicates between ZNE-type homes in the CAHP/ NSHP / RFI data and GPR data.

The data identified 104 ZNE-type homes total in the GPR database. Of these, 98 are ZNE-ready or near ZNE homes, and six are ZNE.

5.1.1.5. Program Manager Estimates

Program managers estimated ten ZNE homes: As part of the program manager interviews, staff provided estimates of the number of ZNE homes in their territory. Collective information from the CAHP program managers puts the market size of ZNE homes (based on a site ZNE definition) in the IOU CAHP programs at approximately ten. The GPR staff member also estimated ten ZNE homes in California, some of which may be homes that participated in CAHP.

Market size estimates reported here were higher, because of custom homes identified through the RFI: As described in Sections 5.1.1.3 and 5.1.1.4, using the CAHP and NSHP databases and projects identified through the RFI, the TRC team estimated 16 ZNE homes from the CAHP / NSHP / RFI data, and 6 ZNE homes from the GPR data. Thus, the estimates of ZNE homes provided by the CAHP and BIG program managers were within a factor of two of the results found using the database analysis.

- The difference between the market size estimates developed using CAHP / NSHP / RFI data and CAHP program managers' estimates was because the TRC team identified additional ZNE-type homes through the RFI that had not participated in CAHP, including custom homes and homes in SMUD territory.

- The difference between the GPR data analysis result and BIG staff member's estimates may be because the GPR staff member estimated how many ZNE homes were in California, not just the ZNE home that had participated in GPR. Also, the GPR staff member provided a top-down estimate of ZNE homes, but did not count specific homes for this estimate.

5.1.1.6. Summary and Comparison of Market Size Estimates from Different Sources

In Section 5.1.1.6, the TRC team summarizes the estimates of market size using different sources. Note that:

- The "RFI estimates" provides the summary of RFI respondents' estimates to the questions of the number of ZNE, near ZNE, and ZNE ready homes have been built in California, or a top-down estimate.
- The "RFI Data" refers to ZNE-type homes identified by RFI respondents, which the TRC team added to CAHP and NSHP projects by counting the number of homes using a bottom-up approach.[35]

Home Type	Summary of RFI Estimates	Interviewed Builders' Self-Reports	Count from CAHP / NSHP/ RFI Data	Count from GPR Database	Utility Program Managers' Estimates
ZNE-ready	> 1000	Not asked	164	98 ZNE-ready / near ZNE homes	Not asked
Near ZNE	> 500	Not asked	944		Not asked
ZNE	Ranged from 1-20 to > 1000	31	16	6	10
Total ZNE-type homes[36]	**Not asked**	**Not asked**	**1,124**	**104**	**Not asked**

Figure 16. Estimate of Market Size for ZNE-type Homes from Different Sources[37]

There were large variances in the ZNE-type home market sizes estimates from different data sources: The different approaches yielded different estimates for ZNE, near ZNE, and ZNE-ready homes. In particular, the number of ZNE-ready and ZNE homes varied greatly among the data sources.

RFI respondents estimated more ZNE-ready than near ZNE homes, but CAHP and RFI data showed the opposite trend: In general, RFI respondents estimated more ZNE-ready homes than near ZNE homes. However, both the CAHP databases and RFI data identified far more near ZNE homes than ZNE-ready homes. GPR staff also reported that, in general, homes with a high compliance margin (i.e., at least 40% above Title 24) typically have PV.

Builders reported "ZNE" homes that the TRC team interpreted as "near ZNE": The number of ZNE homes reported by builders was roughly twice the number estimated using CAHP / NSHP / RFI or the number in the GPR database. However, many of the projects identified by builders did not meet the study definition of ZNE, but instead met the study definition of near ZNE. For a few projects identified as ZNE, builders did not

[35] In other words, an RFI respondent could have provided an estimate of the number of ZNE-ready, near ZNE, and ZNE homes, which the TRC team presents in the second column; and the respondent could have identified a ZNE-type project, which the TRC team incorporated into the fourth column. As described above, the TRC team presents the GPR data separately, because there may be duplicates between GPR and CAHP projects.

[36] This row shows "Not asked", because the TRC team did not ask RFI respondents, builders, or utility program managers to estimate the total number of ZNE-type homes in California

[37] The GPR data provided to the TRC team did not distinguish between near ZNE and ZNE-ready homes, although BIG staff reported that most of these projects were near ZNE.

provide any documentation for these projects, so the TRC team could not check that these homes met the study definitions; the TRC team did not include these homes in the CAHP / NSHP / RFI count.

The CAHP / NSHP / RFI and GPR estimates likely undercount ZNE-type homes: While the estimates based on CAHP / NSHP / RFI data and the GPR data may appear to be more reliable because the TRC team developed them with actual numbers, both of these are likely to be underestimates. This is because:

- **There are likely near ZNE homes that the TRC team did not count:** For the CAHP / NSHP/ RFI estimate, the TRC team used two methods for identifying near ZNE homes:

  1. Homes modeled to exceed Title 24 by at least 40%, with distributed generation, and
  2. Homes modeled to have a net energy use at least 80% less than a Title-24 compliant home.

  The TRC team primarily identified near ZNE homes using the first method, because the CAHP and NSHP databases and most RFI respondents tracked the Title 24 compliance margin, but not the net energy use. The TRC team identified several ZNE-type homes, including some developments in SMUD territory, using the second method, by working with contacts involved with these homes. Many of the homes that met the definition of near ZNE under the second method did not meet the first—the compliance margin was less than 40%. There were thousands of homes in the CAHP and NSHP databases, and it was beyond the project scope for the TRC team to investigate which of these may have met the second method for qualifying as a near ZNE home. Thus, there may be additional homes in the CAHP / NSHP / RFI data that met the near ZNE definition under the second method.

- Based on the builder interview responses, not all high performance builders use CAHP, NSHP, or GPR for all of their ZNE-type homes.[38] The RFI helped identify additional ZNE-type homes. However, it is likely that the TRC team missed some of the ZNE-type homes that did not participate in CAHP, NSHP, or GPR.

5.1.2. ZNE-type Homes as a Relative Fraction of the Market

Given fluctuations in the housing market, it is important to consider not just the absolute number of ZNE-type homes, but also this number compared to the overall housing market.

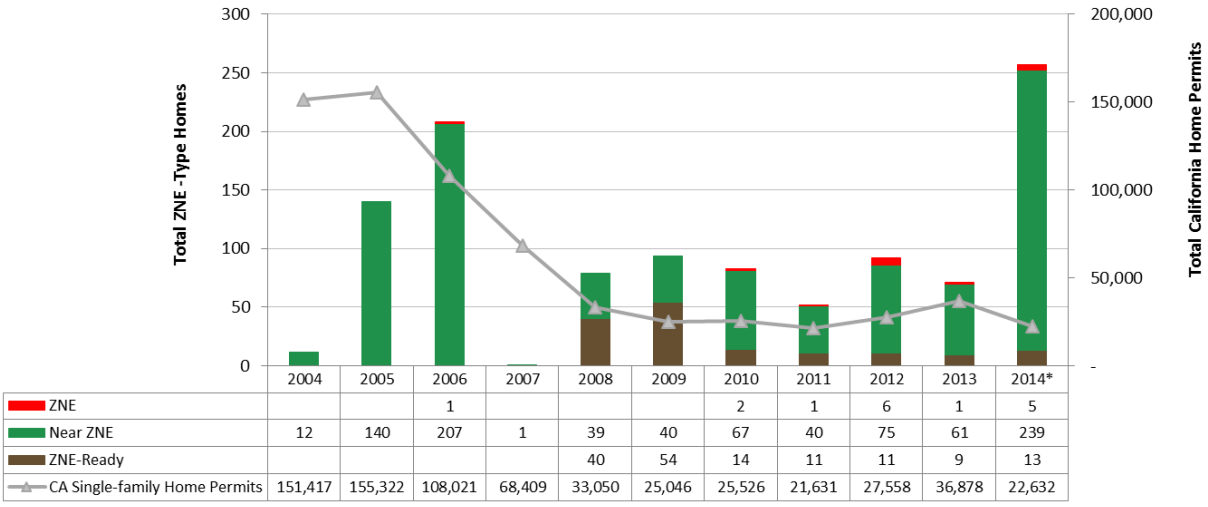
Figure 17 compares the total number of ZNE-type homes based on CAHP / NSHP / RFI data with the number of new, single-family housing permits in California from 2004 through part of 2014. Figure 18 shows the number of ZNE-type homes as a percent of total housing permits. In Figure 18, the values shown on the primary y-axis in Figure 17 are divided by the values shown on the secondary y-axis in Figure 17.

Data for 2008-2013 is more accurate than prior years or 2014: The reader should view these values as general levels, due to several data gaps: PG&E CAHP data reflect 2007 - May 2014, SCE CAHP data reflect 2007 - June 2014, SDG&E CAHP data reflect 2010 - July 2014, SoCalGas CAHP data reflect 2010 - June 2014, and NSHP data reflect 2006 - December 2014. Total single-family housing permitted units from CBIA reflects 2004 - July 2014. Consequently, the percent of the market represented by ZNE-type homes is likely an underestimate for 2004-2007, because the TRC team used incomplete data for CAHP and NSHP for these

[38] In the coded question to builders regarding their use of labeling programs for ZNE-type homes, the TRC team did not ask builders specifically if they had participated in the NSHP program. However, the team asked if they participated in other programs – beyond the coded list – for ZNE-type homes. One builder identified NSHP in response.

years.[39] In addition, because the TRC team collected data for this project in 2014, 2014 data generally reflects the first two quarters of that year.

The market fraction consisting of ZNE-type homes is small (0.2% - 1%) but growing: Figure 17 shows that builders constructed over 100 near ZNE homes in 2005 and 2006 through several near ZNE developments, although Figure 18 shows that this represented a fairly small (0.1-0.2%) of the total housing market. ZNE-type home construction then dropped along with the broader housing market in 2007. From 2008 through 2013, builders constructed between 50 and 100 ZNE-type homes annually, representing 0.2 to 0.4% of the market. Data available for 2014 shows that builders have increased ZNE-type home construction, both on an absolute scale -- over 250 ZNE-type homes – and relative to the overall housing market – approximately 1% of the market. Overall, ZNE-type homes have comprised a relatively small fraction of the total market—typically 0.2% to 0.4% for 2008-2013 — but this number appears to have grown in 2014.



	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014*
ZNE			1				2	1	6	1	5
Near ZNE	12	140	207	1	39	40	67	40	75	61	239
ZNE-Ready					40	54	14	11	11	9	13
CA Single-family Home Permits	151,417	155,322	108,021	68,409	33,050	25,046	25,526	21,631	27,558	36,878	22,632

*Not all data for 2014 were available at the time of this report. Data generally reflects 2014 Q1 and Q2 of 2014.

Figure 17. Number of ZNE-type Homes Compared to Single-family Housing Starts by Year

[39] It is likely that this analysis slightly underestimates market size for 2008 and 2009 as well, because SDG&E and SoCalGas did not provide data for 2008 or 2009. However, the SDG&E CAHP program has historically had significantly lower participation than PG&E CAHP, SCE CAHP, and NSHP, in part because SDG&E territory is much smaller than the areas served by the other programs. Most homes in the SoCalGas CAHP program have participated in the SCE or PG&E CAHP program, so the TRC team would have captured these homes through analysis of the PG&E and SCE databases.

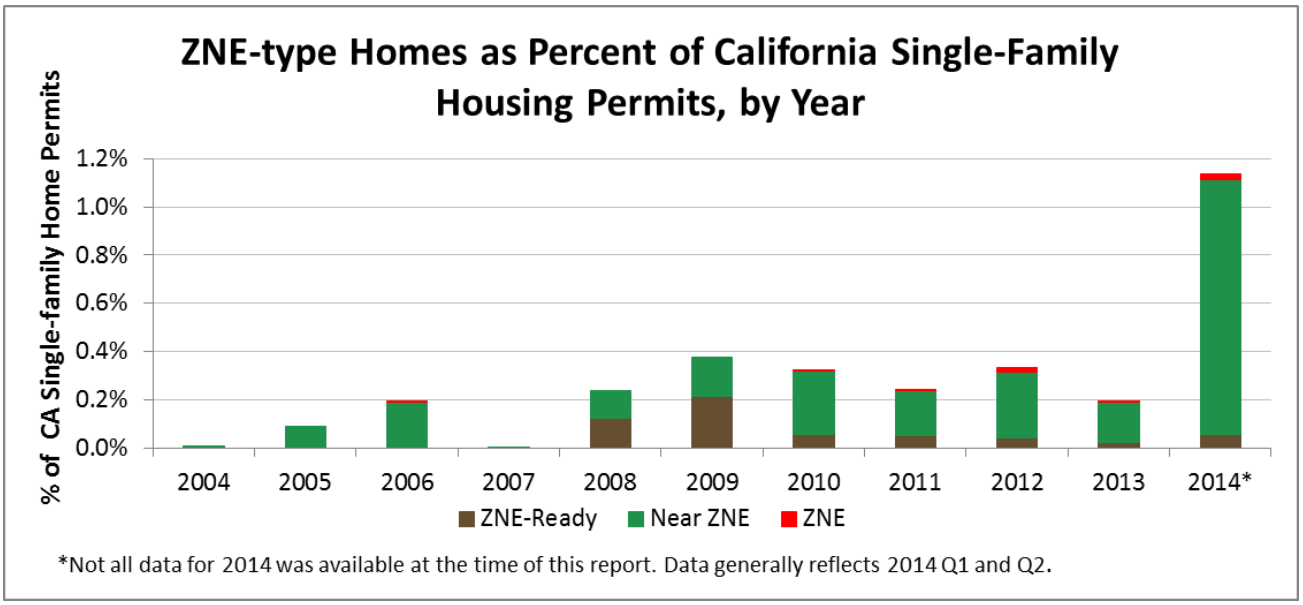


Figure 18. ZNE-type Homes as a Percent of Total Permits by Year

GPR data supports that there are few ZNE-type homes: The TRC team also presents the number of ZNE-type homes from the GPR database based on the year in Figure 19. As described in section 5.1.1.4, the GPR data that BIG provided to the TRC team did not include PV data, but BIG staff reported that most GPR-certified homes that are at least 40% above Title 24 have PV. Consequently, the TRC team combined ZNE-ready and near ZNE homes into one category (ZNE-ready / near ZNE), but believe that most would be categorized as near ZNE.

As shown in Figure 19, since 2009, builders have delivered between 10 and 25 ZNE-type homes annually through the GPR program. Builders have delivered a small number of ZNE homes, in 2013 and 2014.

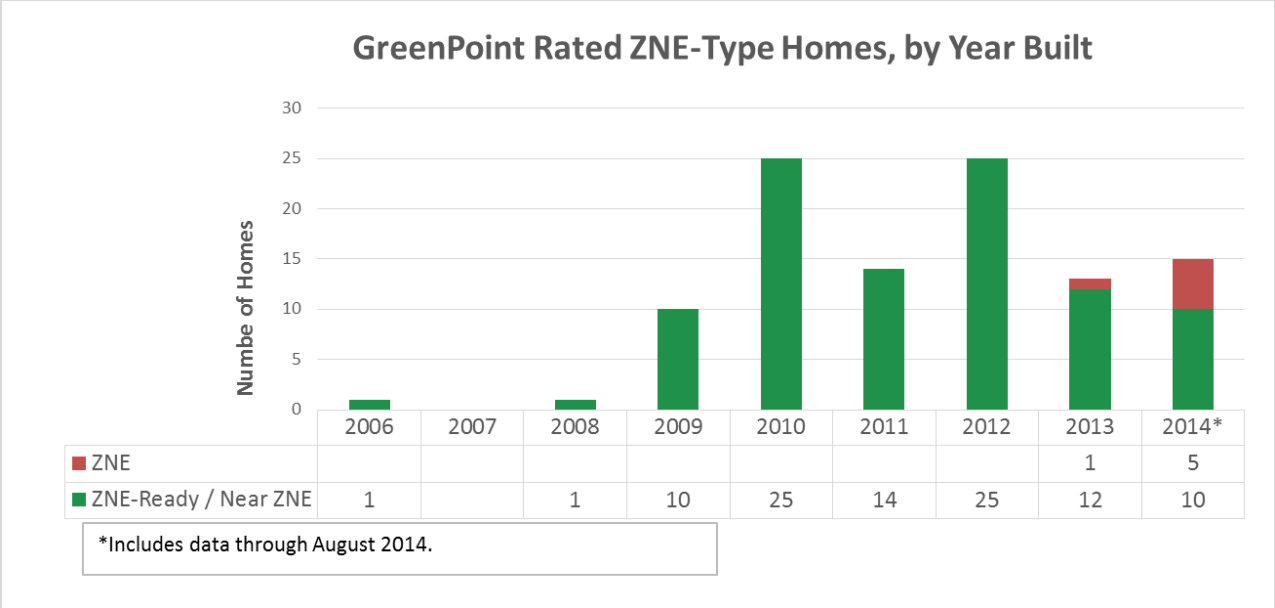


Figure 19. GreenPoint Rated ZNE-type Homes by Year[40]

Builders interviewed have built thousands of efficient homes, but not many ZNE homes: As part of the builder interviews, the TRC team asked each builder for an estimate of the number of homes his/her organization had built, the number of these that exceeded code, and the number of these that were ZNE homes. For interview time constraints, the TRC team did not ask specifically about ZNE-ready or near ZNE homes. Figure 20 presents results aggregated by different builder groups. Overall, these high performance builders reported that the vast majority (> 99%) of the homes they have built have been above code, but that only a very small fraction (< 1%) have been ZNE. Also, as described in Section 5.1.1.2, some of the homes that builders self-described as ZNE were categorized by the TRC team as near ZNE.

Builder Group	Total Homes Built	Number of Above-code Homes Built	% of Total	Number of ZNE Homes Built[41]	% of Total
Custom total	67	49	73%	17	25%
Production total	9169	9169	100%	14	0.2%
Northern CA total	3620	3602	99.5%	25	0.7%
Southern CA total	1266	1266	100%	3	0.2%
Statewide total	4350	4350	100%	3	0.1%
Grand Total	**9236**	**9218**	**99.8%**	**31**	**0.3%**

Figure 20. Number of Homes Reported Built in the Past 3 Years by Builders Interviewed

[40] Due to data limitations, Build It Green was unable to provide which homes have PV. Therefore, all homes were classified as ZNE-ready / Near ZNE.

[41] Some of the homes identified as ZNE by builders did not meet the study's classification of ZNE. The TRC team reviewed information from the builders and on-line for the ZNE homes that builders identified. The TRC team reclassified some homes as ZNE-ready or near ZNE, (based on the study classifications of these terms) for the study's market size estimates.

In addition, of the 11 appraisers interviewed, all had at least some experience valuing Energy Efficient homes and/or homes with PV, but only one reported valuing a ZNE-type home, specifically a near ZNE home. As described in Section 4, the TRC team targeted appraisers with ZNE-type and high performance home experience for interviews. This serves as another indicator that the number of ZNE-type homes is small.

ZNE-type homes are still in the innovator stage: Overall, the CAHP / NSHP/ RFI data, GPR data, and builder interview results indicate that the number of ZNE-type homes is small relative to the total number of California housing permits. Although this analysis identified approximately one thousand ZNE-type homes using CAHP / NSHP/ RFI data, this analysis indicates that the number of ZNE-type homes still represents the innovator stage of market diffusion. For 2014, the peak year so far for ZNE-type homes, ZNE-type homes represented approximately 1% of the market. The diffusion of innovations curve identifies market penetration up to 2.5% as innovators, which is followed by the early adopter phase (Roger 1962). In addition, most of the ZNE-type homes are near ZNE and ZNE-ready. The number of ZNE homes represent a very small fraction of the total market.

Interviews support the upward trend in ZNE-type homebuilding, which will be driven by homebuyer demand: In general, builders and appraisers reported that the number of ZNE-type homes appears to be growing. Most market actors interviewed (builders, program managers, building officials) reported that the major driver for increasing the number of ZNE homes in the future will be homebuyer demand. Most builders expect the demand for ZNE-type homes to increase in the next five years. Twelve of 16 builders reported that demand will increase, and 11 of those builders plan to increase the number of ZNE-type homes that they build. While appraisers did not comment on the increase in ZNE-type homes, one appraiser indicated that several large builders were installing PV at every home they built prior to the financial downturn in 2007 and that this trend is reemerging.

The literature supports the upward trend: The general upward trend found in this study aligns with results from the literature. When ZNE experts were asked to estimate how the North American ZNE home market (retrofits and new construction) will grow in the next five years, a majority of respondents (65%) said the growth will be about 5% per year, and another 6% of the respondents said that growth would exceed 10% per year (Net Zero Energy Home Coalition 2012). However, note that the Net Zero Energy Home Coalition question was broader than the scope of this study, because it applied to retrofits and new construction and all of North America, not just California.

This study identified more ZNE-type homes in recent years, even though these homes were more efficient due to study definitions: The growth in ZNE-type homes is particularly impressive, because of the way that the TRC team classified ZNE-ready and near ZNE homes for the market size estimates. The team classified homes as ZNE-ready and near ZNE if they were modeled as at least 40% more efficient than Title 24. The version of Title 24 used for each home depended on when the builder constructed the home, and the majority of homes counted in this study were built under the 2005 Title 24 or 2008 Title 24 versions. The ZNE-ready and near ZNE homes in later years should be more efficient than the ZNE-ready and near ZNE homes in earlier years, because the 2008 Title 24 (effective January 1, 2010) required a higher level of efficiency than the 2005 Title 24.

This study classified homes as ZNE-ready and near ZNE based on Title 24 compliance margins, because the CAHP and NSHP databases track projects based on this metric. However, because the code becomes more efficient, there is no baseline to benchmark homes for the purposes of identifying a comparable efficiency level for ZNE-type homes across all years. This is one reason why the TRC team recommends moving towards an Energy Use Intensity (EUI)-based metric in the future, as described in Section 6.2.1.

5.1.3. Trends in Energy Efficiency and PV Penetration

The following analysis compares the number of ZNE-type homes with the number of Energy Efficient homes, and considers trends in the prevalence of PV compared with different levels of energy efficiency.

5.1.3.1. Number of Homes by Energy Efficiency Level

CAHP and NSHP have historically provided incentives to homes that are modeled to exceed Title 24 by at least 15%.[42] The following figures show the distribution of CAHP and NSHP homes' modeled energy performance compared to Title 24. (These figures do not include RFI data, because the team did not have compliance margin data for most homes identified through the RFI.) Figure 21 includes data from PG&E CAHP, SCE CAHP, SDG&E CAHP, and NSHP for the timeframes described in Section 5.1.1.3. As described in Section 5.1.1.3, for the NSHP data, the TRC team removed homes labeled as "affordable" because the team assumed that most of these homes were multifamily, and removed homes marked as participating in the CAHP program to avoid duplicates with the CAHP data.

The TRC team presents the SoCalGas CAHP data (for the timeframe described in Section 5.1.1.3) separately in Figure 22, because many of these homes are in the SCE and PG&E CAHP databases. There were thousands of homes in these databases and removing the duplicates was beyond the project scope.

Very few CAHP and NSHP homes have a compliance margin at least 40% above Title 24: As shown in Figure 21, the largest number of CAHP and NSHP homes is at the entry level for these programs – between 15 and 19% above Title 24. However, there are significant fractions of homes in each energy efficiency bin from 20% to 39%, with a particularly high number of NSHP homes in the 35-39% range. A small fraction are at least 40% above Title 24. The SoCalGas CAHP data presented in Figure 22 illustrates similar trends, although this program shows a more steady decrease in participation relative to compliance margin.

[42] Under the 2013 Title 24, which took effect on July 1, 2014, the CAHP programs require a CAHP score of at least 84 – roughly equivalent to 16% more efficient than a Code-built home. NSHP allows homes built to the 2013 Title 24 standard to participate, but provides escalating incentives for homes built to 15%, and another level for 30%, above Title 24. Almost all homes in this study's analysis were built under the historical CAHP and NSHP requirements of 15% above 2005 or 2008 Title 24.

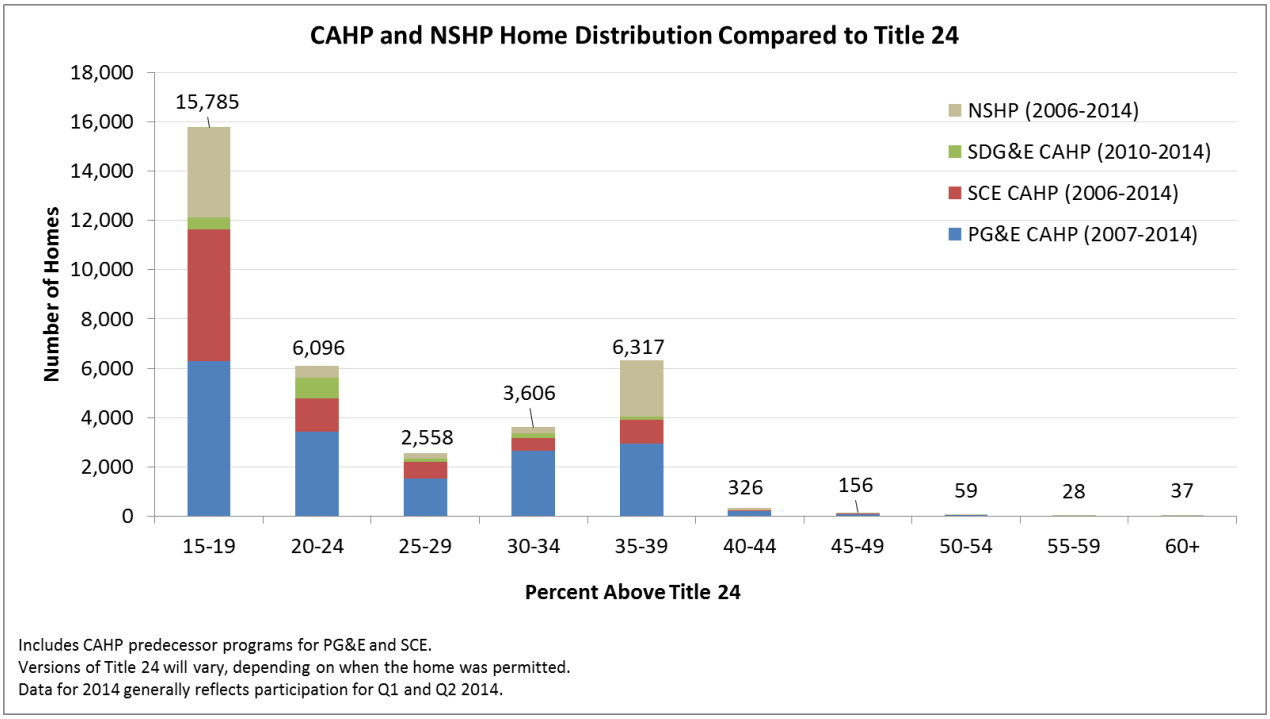


Figure 21. Home Energy Performance Distribution (PG&E, SCE, and SDG&E CAHP, and NSHP Data)

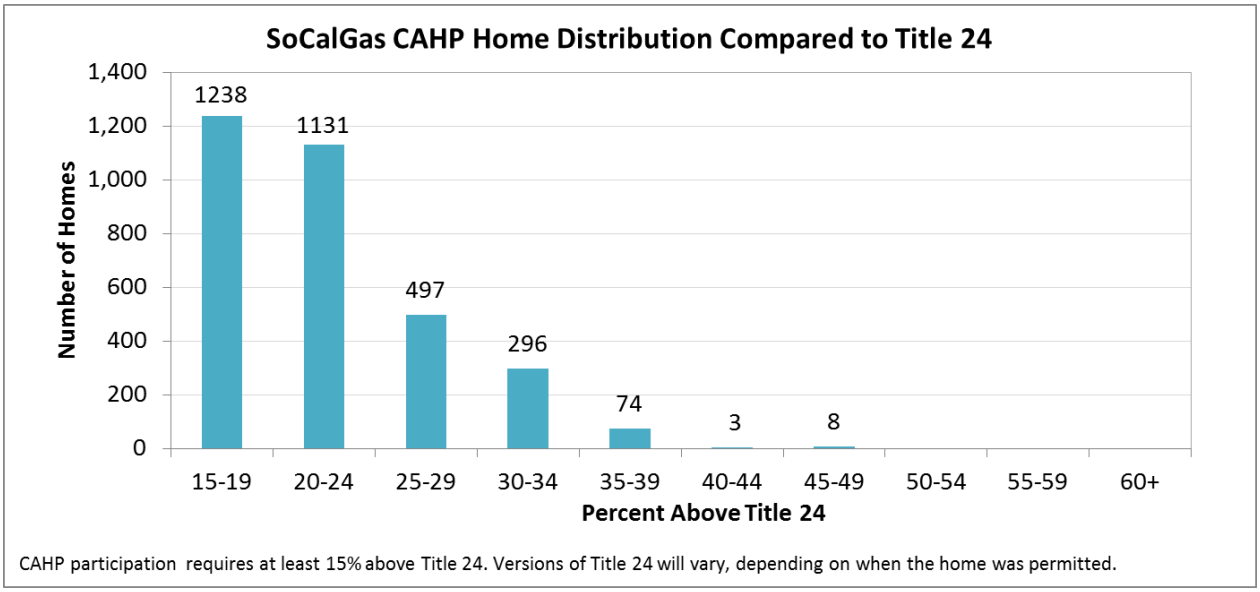


Figure 22. Home Energy Performance Distribution (SoCalGas CAHP Data)

5.1.3.2. Relationship between Energy Efficiency and PV

Prevalence of PV increases with greater energy efficiency: Figure 23[43] presents the penetration of PV compared with energy efficiency (i.e., projected performance relative to Title 24), using homes in the CAHP databases, for the timeframes described in Section 5.1.1.3. Overall, homes with PV represent a small portion of CAHP qualified homes. However, this figure shows that homes with higher levels of efficiency are more likely to have PV. Less than 20% of homes with compliance margins of 39% or lower have PV, but over 80% of homes with compliance margins at least 45% have PV.

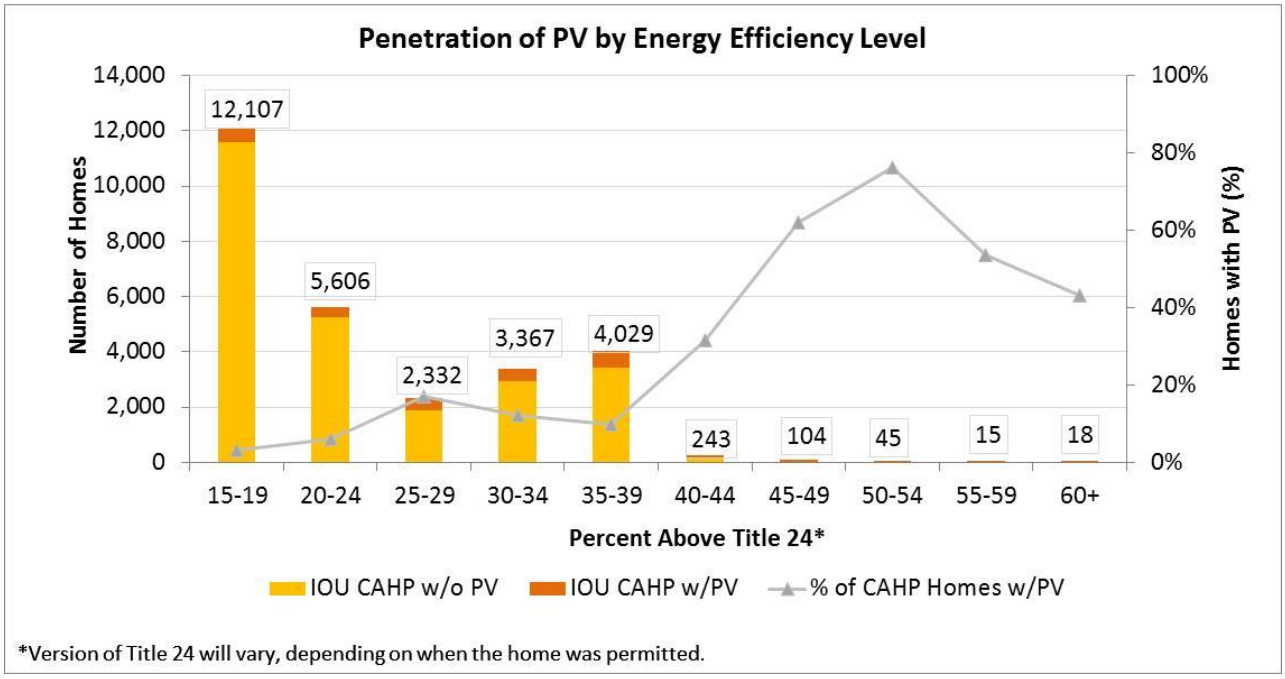


Figure 23. Penetration of PV Relative to Energy Efficiency Level

5.2. Characteristics of ZNE-type Homes

5.2.1. Key Characteristics of ZNE-type Homes

The TRC team identified several key characteristics of ZNE-type homes based on CAHP, RFI data, and GPR data (where available), and summarized them in Figure 24 below. The TRC team did not have data for these characteristics for ZNE-type homes obtained from the NSHP database.

Because TRC used a variety of sources, the number of homes used to develop results - i.e., the count (n) varied. Because custom homes may represent a different market than production homes, the TRC team tabulated results for these home types separately.

Custom ZNE-type homes are larger and may have larger PV systems than production ZNE-type homes: Figure 24 shows that custom and production ZNE-type homes are similar in terms of median bedrooms, although custom ZNE-type homes are larger and span a larger range in home size. The custom ZNE-type

[43] Figure 21 shows fewer homes than the total number of ZNE-type homes identified based on CAHP /NSHP/ RFI data, presented in Section 5.1. The difference (in order of significance) is because: a. Some homes met the definition of near ZNE because they were projected to have at least 80% net energy reduction compared to Title 24, but exceeded Title 24 by less than 40%. TRC did not have PV information for all homes. Almost all of these homes were obtained from RFI data (not CAHP or NSHP homes); b. The figure does not include homes from the SoCalGas CAHP database.

homes analyzed here tended to have larger PV systems with a median value of 8.8 kW for custom, compared with 2.4 kW systems for production homes. This could be because the TRC team did not have PV system size for many custom ZNE-type homes, and the results may not be representative of the larger population of custom ZNE-type homes. Another possible reason for the discrepancy is that the custom ZNE-type owners may be more affluent and willing to purchase larger PV systems.

The overall range of PV systems agrees with what builders reported in interviews for ZNE homes: 1.8 kW to 10 kW. The TRC team did not ask builders to estimate a PV size for near ZNE homes.

Custom and production ZNE-type homes had similar energy efficiency levels: Median energy efficiency compliance margins were similar for custom and production homes, at 44% above Title 24 for both.

	PV (kW)			Bedrooms			Square Footage			Compliance Margin (% above T24)		
	Min	Max	Count (n)	Min	Max	Count (n)	Min	Max	Count (n)	Min	Max	Count (n)
Custom	3	27	6	1	4	18	443	7680	62	40	90	49
Median		**8.8**			**3**			**2902**			**44**	
Production	1.89	6	395	2	6	335	550	4986	798	15	65	705
Median		**2.4**			**3**			**2049**			**44**	

Figure 24. ZNE-type Home Characteristics (CAHP and RFI Data)

ZNE-type homes span a range of sizes, architecture, and other characteristics: Section 7 provides more detail on specific examples of ZNE-type homes. Overall, the minimum and maximum values in Figure 24 and the example projects in Section 7 illustrate that ZNE-type homes span a range of sizes, architecture, and other characteristics.

5.2.2. Income Analysis of ZNE-type homes

The TRC team conducted an income analysis of ZNE-type homes to investigate trends in ZNE-type home adoption across income levels. To conduct the analysis, the TRC team identified an income level for each ZNE-type home from the CAHP / NSHP / RFI data using the median household income level for that ZNE-type home's zip code, based on census data – the 2013 American Community Survey (ACS). The TRC team then summed the total number of ZNE-type homes with an income level within each California household income quintile level.[44] The TRC team also analyzed custom and production ZNE-type homes separately to investigate possible differences. The TRC team notes three limitations with this approach:

1. The TRC team based this analysis on the approach used by Navigant (2014a), which used zip code data for its income analysis of PV owners and PV leaseholders in California, so that readers could compare results. However, as noted by Navigant (2014a), "any given zip code can include people of fairly disparate incomes, and the distribution of actual annual incomes can vary widely around a reported median."

[44] The TRC team developed the zip code income level for each ZNE-type home using 2013 ACS data, but the income quintiles using 2011 ACS data, because 2013 ACS quintiles were not available. The California median household income was $57,287 in the 2011 ACS and $60,190 in the 2013 ACS (i.e., an increase of $2,903.) For sensitivity analysis (results not shown), the TRC team added $2,903 to each 2011 ACS quintile to estimate 2013 ACS quintiles; ZNE-type homes shifted slightly into lower quintiles (i.e., there were more homes in the second quintile, and fewer in the fourth).

2. On average, California owners have higher median incomes than renters do. This analysis presents income levels for ZNE-type homes, all of which were owner-occupied (based on the owner interviews and surveys), and compares their income levels to those of all California households of both owners and renters. The TRC team compared ZNE-type income levels to all household income levels, because quintile-based income levels for homeowners only were not available.
3. This analysis is based on a fairly small number (1120) of ZNE-type owners[45], and these results may not persist as the number of ZNE-type homes increases.

Most ZNE-type homes are in zip codes with moderate income levels: As shown in Figure 25, for both production and custom ZNE-type homes, approximately half (51%) are in the third income quintile ($48,217 - $77,358). For production ZNE-type homes, the remainder are approximately evenly split between the second and fourth quintiles, with a very small fraction in the fifth quintile. For custom-ZNE-type homes, the remainder are primarily in the fourth and fifth quintiles, with a small fraction in the second quintile. The results did not identify any homes in zip codes with the lowest quintile. This analysis also found that 63% of ZNE-type homes are in zip codes with incomes above the California household median income of $60,190.

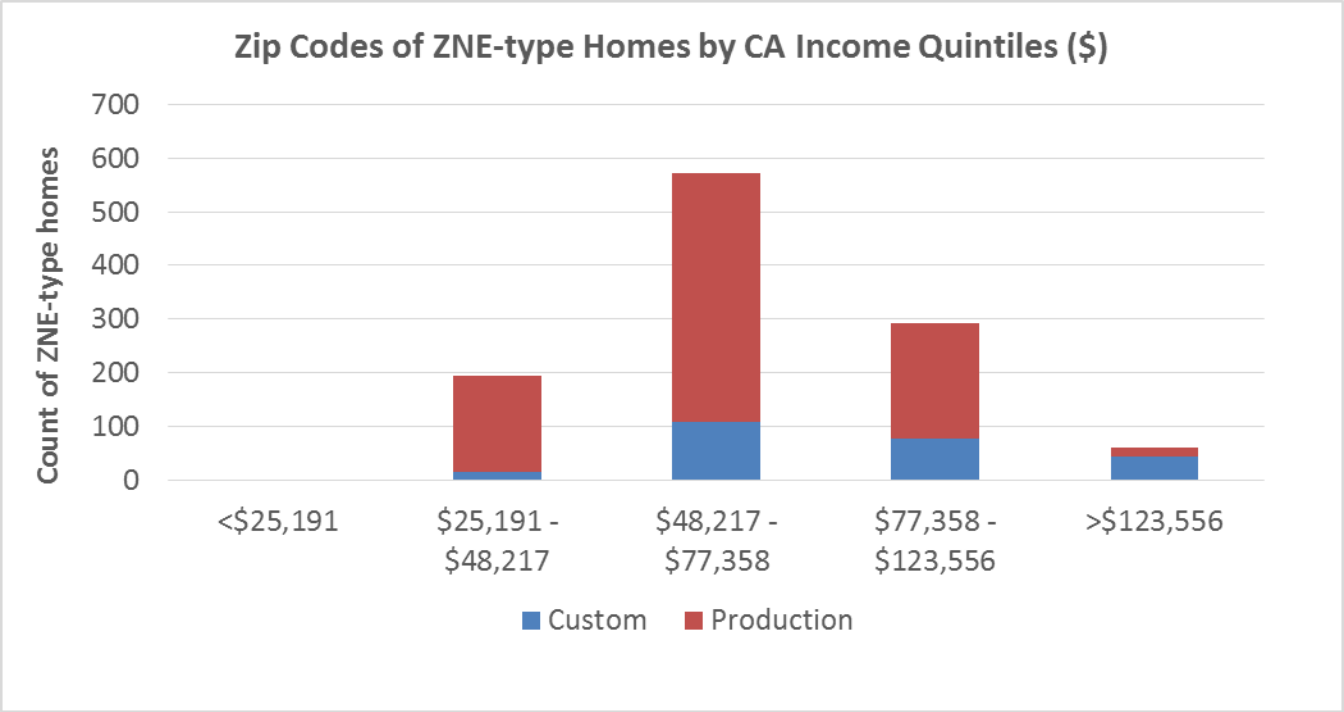


Figure 25. Zip Codes of ZNE-type Homes by California Income Quintiles (CAHP / NSHP / RFI Data)

Income results for ZNE-type homes generally align with CSI results, although CSI had a larger presence in higher income zip codes than ZNE-type homes. The preponderance of ZNE-type homes in the middle quintiles agrees with the location of existing homes that added PV through the California Solar Initiative (CSI) General Market Program, both host-owned and third-party-owned (TPO) (Navigant 2014a). However, Navigant (2014a) found a greater percentage of existing homes (both-host owned and TPO) in the fourth quintile than what was found here for ZNE-type homes. In addition, Navigant (2014a) found significant numbers of existing homes with host owned and TPO PV systems in the fifth income quintile, while this study found only 5% of ZNE-type homes in this quintile.

[45] The TRC team did not have the zip code for four ZNE-type homes identified through the RFI.

5.2.3. Maps of ZNE-type Homes

The TRC team mapped the location of Energy Efficient and ZNE-type homes across California based on various data sources. This section presents results.

ZNE-type homes (based on CAHP / NSHP / RFI data) are present throughout California: Figure 26 shows the location of Energy Efficient (15-39% above Title 24) and ZNE-type homes across California, based on CAHP and NSHP data and projects identified through the RFI. As shown, Energy Efficient (not ZNE-type) homes comprise the majority of homes participating in the CAHP programs. The highest number of ZNE-type homes are in the Sacramento area, San Francisco Bay Area, and Los Angeles area, although this analysis found ZNE-type homes in many areas of California. There are also a high number of custom ZNE-type homes in the San Diego area.

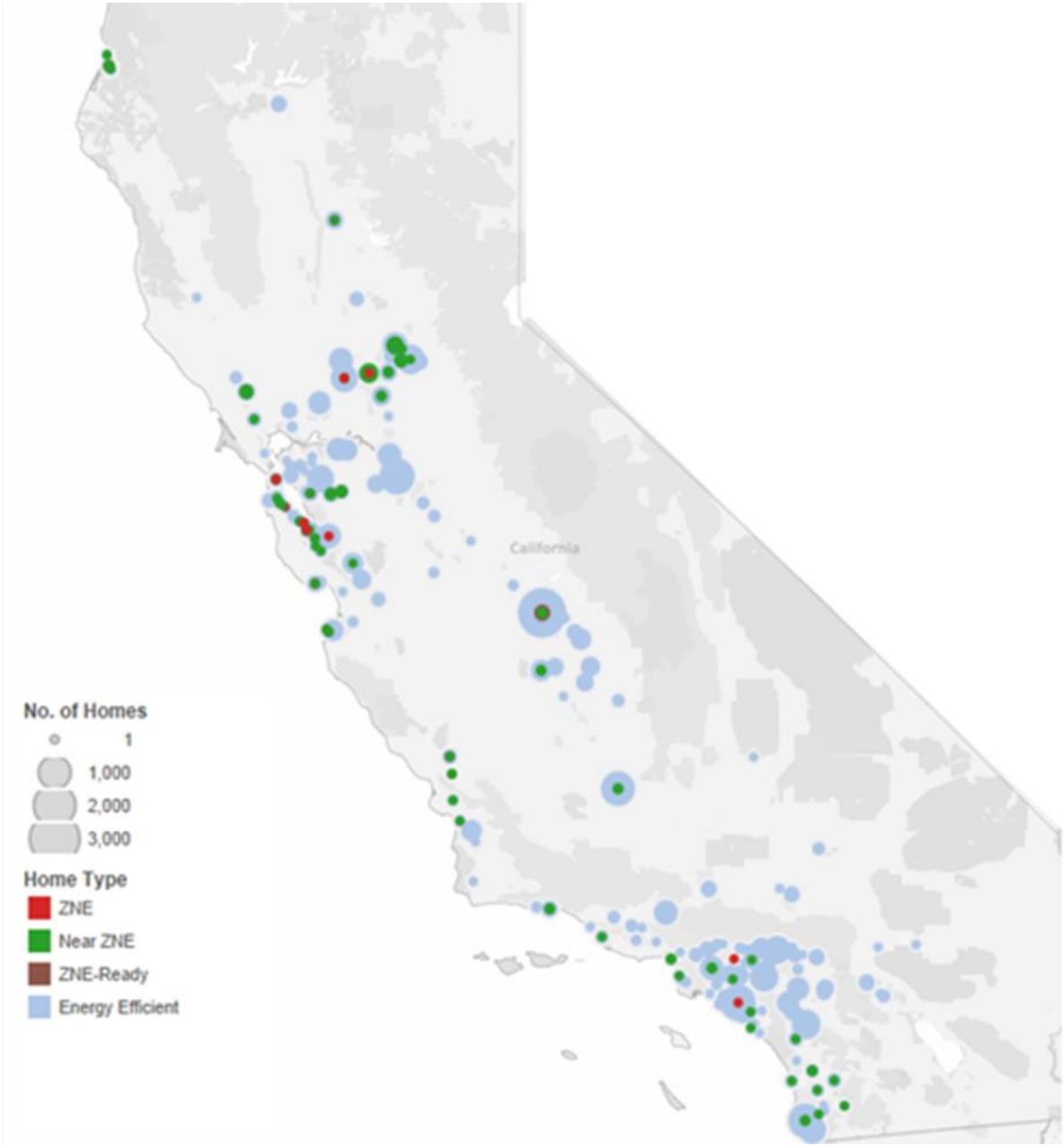


Figure 26. Location of Energy Efficient and ZNE-type Homes, based on CAHP/ NSHP / RFI Data

GPR ZNE-type homes have a higher presence in Northern California: Figure 27 presents the location of ZNE and ZNE-ready/near ZNE homes in the GPR database of single-family, new construction homes. As described in Section 5.1.1.4, data on PV was not available, but BIG staff reported that the majority of the GPR-certified ZNE-ready/near ZNE homes have PV, which this study would categorize as near ZNE. In addition, BIG staff reported that, while the majority of the ZNE-type homes reported here are single-family detached units, there may be some single-family attached units included in Figure 27.

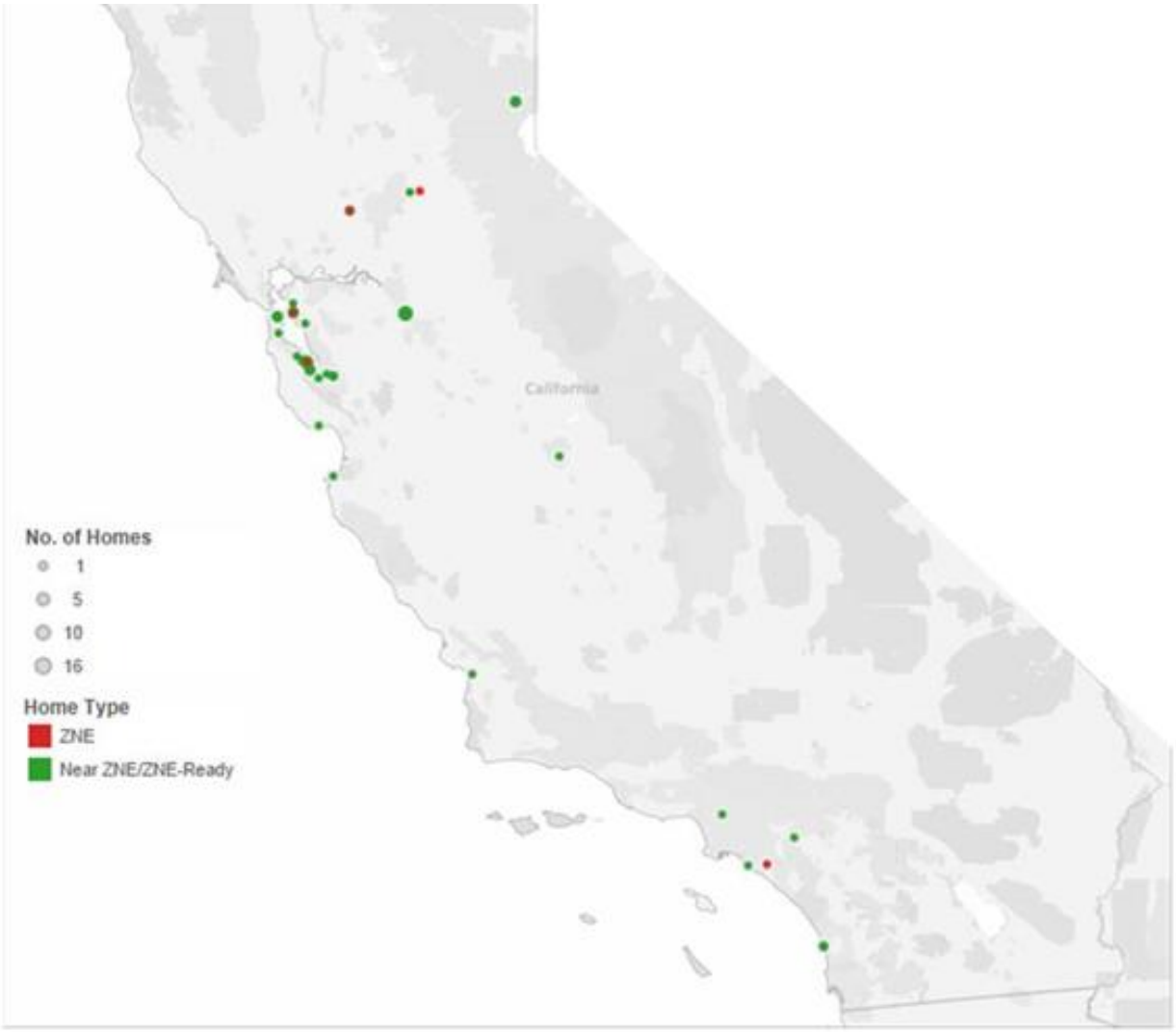


Figure 27. Location of ZNE-type Homes – GPR Data

Both Figure 26 and Figure 27 indicate a prevalence of ZNE-type homes in the San Francisco Bay Area. However, the GPR data in Figure 27 does not show the concentration of ZNE-type homes in Sacramento or the Los Angeles area, or as many homes in Southern California in general, compared to the CAHP and RFP data (Figure 26). Build it Green is based in the Bay Area, which may partially explain the higher number of ZNE-type homes in Northern California.

None of the data sources are comprehensive: A comparison of Figure 26 with Figure 27 also shows that the CAHP / NSHP/ RFI data include many ZNE-type homes not included in the GPR data, and that the GPR data includes several ZNE-type homes not in the CAHP/ NSHP / RFI data. The non-correspondence of the two maps indicates that none of the data sources is comprehensive.

Location of ZNE-type homes does not follow general housing construction trends: Using CAHP / NSHP / RFI data, the TRC team compared the distribution of ZNE-type homes across the state to the overall housing starts in the state. Figure 28 shows the percent of ZNE-type homes by California climate zone (primary y-axis) and the percent of total housing starts by California climate zones (secondary y-axis),

both for 2010-2014.[46] For example, for California climate zone 12, the TRC team found that 37% of all ZNE-type homes were located in this climate zone and that 17% of total housing starts were in that climate zone. This indicates that, after normalizing for total home construction, climate zone 12 has experienced more than twice as much ZNE-type home construction compared to the state average.

As Figure 28 shows, builders have constructed ZNE-type homes across the state in most of the climate zones. There are certain climate zones where builders have constructed a majority of ZNE-type homes, such as 2, 12, and 13. This is because builders have constructed several ZNE-type developments (homes with >10 homes) in these climate zones.

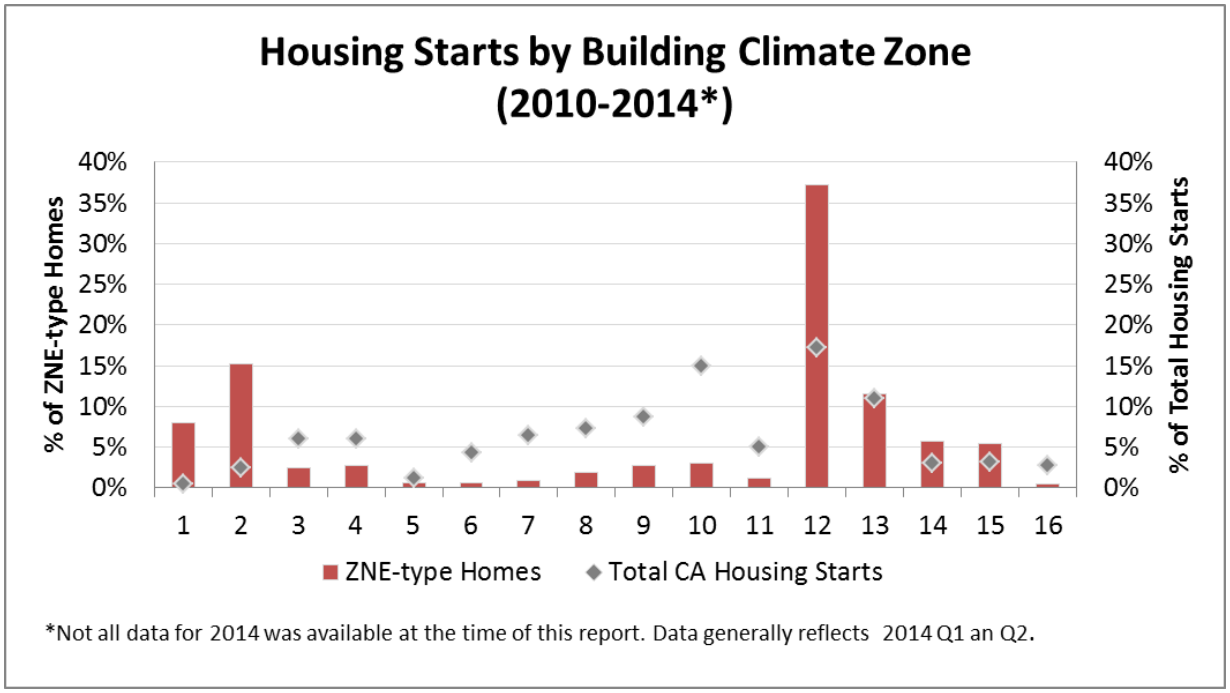


Figure 28. ZNE-type homes Compared to Total Housing Starts by Climate Zone

Sacramento area and Sonoma / Napa valleys have a higher number of ZNE-type homes, particularly compared to total housing starts: Climate zone 12 includes the Sacramento area, and Figure 28 shows that this climate zone has the most ZNE-type homes, both on an absolute scale and relative to total housing starts. Climate zone 12 includes several ZNE-type home developments in both SMUD territory and the surrounding areas of Sacramento in PG&E territory. A few of these ZNE-type developments in both SMUD and PG&E territory are homes that have a compliance margin lower than 40% above Title 24, but meet this study's near ZNE definition, because they are modeled to use at least 80% less energy than Code-built homes. (As described in Section 5.1.1, the TRC team identified homes meeting the 80% definition of near ZNE through the RFI and a literature review.) The high number of ZNE-type homes in climate zone 12 likely reflects SMUD's early and continued programs to encourage ZNE-type home construction and PG&E's efforts in this geographic area, and it may indicate peer pressure among builders in this area to construct high performance homes.

Climate zone 2 also has a high fraction of the state's ZNE-type homes (15%) compared to the fraction of the state's housing starts in that area (2%). This climate zone includes one large near ZNE development

[46] The TRC team presents data for 2010-2014, because all four California IOUs had provided CAHP databases for these years (generally through Q2 of 2014). The team did not have CAHP data from all IOUs for years prior to 2010.

in Santa Rosa and several custom near ZNE homes in Sonoma and Napa counties. This climate zone also includes Sebastopol, which passed an ordinance in 2013 requiring all new homes to install PV. However, this ordinance did not require energy efficiency measures beyond Title 24, and the TRC team identified only a few ZNE-type homes in Sebastopol.

5.2.4. Distribution of ZNE-type Homes by Geography and Builder Type

The diversity of builders and locations of ZNE-type homes extends to ZNE-ready, near ZNE, and ZNE homes: Figure 29 shows the number of ZNE-type homes, builders, and cities represented by different categories of ZNE-type homes, based on CAHP and RFI data.[47] In this table, a single ZNE-type home occurs only once in the table – i.e., as a ZNE-ready, near ZNE, or ZNE home; and as either a custom or production home. However, the same city may appear in multiple rows of the table if it includes, for example, both near ZNE and ZNE homes, or both custom and production ZNE-type homes. Similarly, the same builder may appear in multiple rows if the builder has delivered near ZNE and ZNE homes. However, the TRC team classified builders as either custom or production, so there are no duplicates in builders between these two categories. Also note that the "production" ZNE-type homes refer to those delivered by production builders. These production builders delivered some of these homes – including most of the ZNE-ready and near ZNE homes – in multi-home developments, but others – including all of the ZNE homes – as single ("one-off") homes. Overall, the table supports the findings of the market maps that ZNE-type homes of all types—ZNE-ready, near ZNE, and ZNE—have been built in a variety of cities by a variety of builders. In addition, the finding that the production builders interviewed have constructed five ZNE homes total indicates that they have only built demonstration (or "one-off") ZNE homes so far, rather than multi-home ZNE developments.

	ZNE-type Home	Number of Homes	Number of Builders	Number of Cities
Custom	ZNE-ready	35	10	20
	Near ZNE	39	9	33
	ZNE	11	11	9
Production	ZNE-ready	129	11	12
	Near ZNE	723	20	24
	ZNE	5	5	5

Figure 29. ZNE-type Homes Characteristics by Builder and Location (CAHP and RFI Data)

Over 50 builders have constructed over 1000 ZNE-type homes in over 130 cities: In Figure 30, the TRC team removed duplicates among all rows to provide the number of distinct builders of ZNE-type homes, and the number of distinct cities with ZNE-type homes. The TRC team also added NSHP data for the number of ZNE-type homes and cities. (The team developed its "builder" analysis using CAHP and RFI data, because NSHP did not provide builder data.) In addition, the TRC team added a column for all values based on the GPR data. As shown, the CAHP / NSHP / RFI data identified 136 distinct cities with ZNE-type homes, and 57 builders – 31 production and 26 custom builders – that have delivered at least one ZNE-type home.

[47] The TRC team did not include NSHP data for this analysis, because NSHP did not provide builder data.

	CAHP / NSHP / RFI Data	GPR Data
Total Number of ZNE-type Homes	1,124	104
Total Number of Distinct Cities	136	45
Total Number of Distinct Builders (for CAHP and RFI Data) or Developers (for GPR Data)	57	78

Figure 30. Number of Distinct Cities, Zip Codes, and Builders of ZNE-type Homes

GPR data also indicates a diversity in ZNE-type home location and developer: The GPR data tracks developers, rather than builders. Eight of the developers of ZNE-type projects shown in the GPR data also appear as builders in the CAHP database. The TRC team found that 46 of the ZNE-type developers only delivered ZNE-type homes in the GPR database, not the CAHP databases. This may be because of the different tracking systems (e.g., builder vs. developer), or because some developers participated in GPR but not CAHP.

5.3. Awareness of ZNE

This section briefly discusses the awareness of building professionals – builders, appraisers, lenders, and local government officials – of the term ZNE, and then discusses owners' awareness of the term. Results reflect unaided responses, in which the researcher (e.g., interviewer, surveyor, or forum facilitator) asked the respondent whether he/she had heard of the term "Zero Net Energy or ZNE" without explaining the term.

Most builders, appraisers, lenders, and local officials in the study were aware of ZNE, but this awareness may not reflect the broader market: All of the program managers, planners, and builders; most of the appraisers (nine of 11); and all lenders interviewed were aware of ZNE. However, the TRC team specifically sought market actors with ZNE awareness or experience, such as planners that had attempted to incorporate Reach Codes, high performance homebuilders, and appraisers with experience valuing ZNE-type homes. It is likely that the ZNE familiarity of the market actors in this study does not reflect the broader market.

Most custom ZNE-type owners, about one-third of production ZNE-type and Energy Efficient owners, and no Code-built owners were aware of the term ZNE: Figure 31 shows the percent of owners that reportedly were aware of the term Zero Net Energy or ZNE. Because of the small number of participants in the ZNE-type forum, for the ZNE-type production owner results, the TRC team combined the results of the forum with results of the ZNE-type interviews. In general, owners' familiarity with ZNE varied with the level of efficiency in their homes and based on home type (i.e., custom vs. production). Nearly all custom ZNE-type owners and about half of the production ZNE-type owners were familiar with ZNE. Most of the owners in the ZNE-type forum had heard of ZNE, although they did not consider their homes to be ZNE. Among the Energy Efficient owners surveyed, almost all of which were production owners, one in four (28%) had heard of ZNE. None of the owners in the Code-built forum had heard of ZNE, although their homes were within the same development as some near ZNE homes.

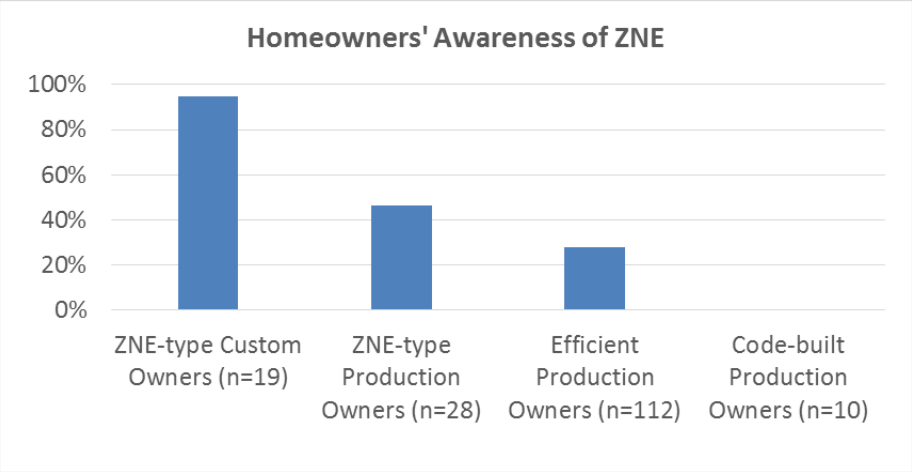


Figure 31. Self-Reported Owner Awareness of the Term "ZNE"[48]

Owners reported hearing about ZNE from a variety of sources: The TRC team asked owners who reported they were aware of ZNE for their source of awareness of the term. Figure 32 summarizes their responses. The figure also includes responses from owners who initially reported they were not aware of ZNE, but who reported they were aware once the surveyor provided them with a description of ZNE. Overall, there was no clear primary source of ZNE awareness—owners reported they had heard about ZNE from a variety of sources, including a friend or family member, a builder, a showcase home, the media, and the internet.

[48] Almost all homes represented in the Energy Efficient owner survey were production, but three were custom.

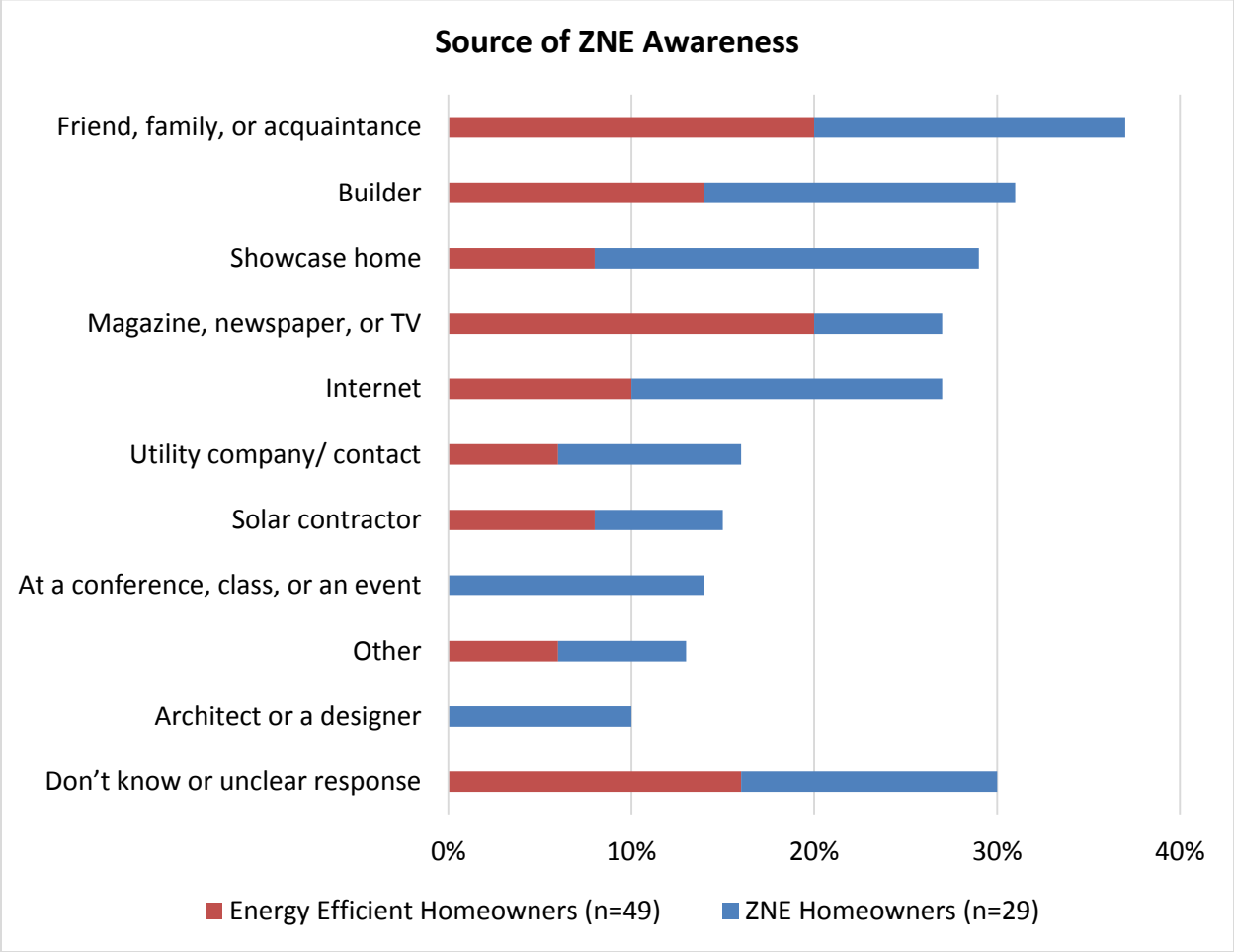


Figure 32. Owner Self-Reported Source of ZNE Awareness

5.4. ZNE Terminology Interpretations

ZNE has different meanings and expectations, both between different market actor groups – e.g., state agencies, builders, and owners define ZNE differently from owners; and within each group – e.g., different owners provided different definitions of ZNE. This section presents results of different market actors' interpretations of the term.

5.4.1. Policy (TDV-based) Definition of ZNE

Policy makers use a TDV-based ZNE definition: In July 2013, members of an Integrated Energy Policy Report (IEPR) workshop proposed a definition of ZNE that incorporated TDV. "A Zero Net Energy (ZNE) Code building is one where the net of the amount of energy produced by on-site renewable energy resources is equal to the value of the energy consumed by the building annually at the level of a single 'project' seeking development entitlements and building code permits, measured using the California Energy Commission's TDV metric. A ZNE Code Building meets an Energy Use Intensity value designated in the Building Energy Efficient Standards by building type and climate zone that reflect best practices for highly efficient buildings" (CEC 2013).

Utility program managers differed on whether TDV should be explained to owners: The utility program managers contacted for this study were aware of this TDV-based definition of ZNE. In general, program managers supported including TDV as part of the policy definition of ZNE, but some did not recommend

including TDV in the description of ZNE to owners. However, one program manager noted that there would be false expectations in terms of energy bills if TDV is included in the ZNE definition but not explained to homebuyers. Another program manager suggested explaining TDV together with demand response in discussions with owners.

5.4.2. Market Actor Interpretations of ZNE

This section presents results of different market actors' interpretations of the term ZNE.

None of the market actors provided a TDV-based definition of ZNE: Overall, none of the market actors interviewed—including builders, appraisers, and owners—provided a TDV-based definition when asked by the TRC team to provide their interpretation of ZNE.

Owners provided a variety of ZNE interpretations, and a site-based definition was the most common: Figure 33 summarizes how owners who initially indicated familiarity with the term ZNE interpreted this term. The most common interpretation was a site-based definition—that is, a home that produces as much or more energy as it uses (39%), followed by a home with no energy bills (23%). The "other" responses included one response each of the following: "distinct look and design of home," "appliances, lighting, construction materials, windows are more energy efficient and keep the heat and cool in," and "solar powered." It is noteworthy that almost all market actors discussed rooftop PV as the renewable energy resource for ZNE-type homes.[49]

[49] The two exceptions were: 1. One appraiser had valued a home with wind turbines, and 2. One planner described the feasibility challenges of installing rooftop PV on every home, because of shading or orientation. The TRC team asked if community-scale distributed generation could be used to mitigate this problem, and the planner reported that it could.

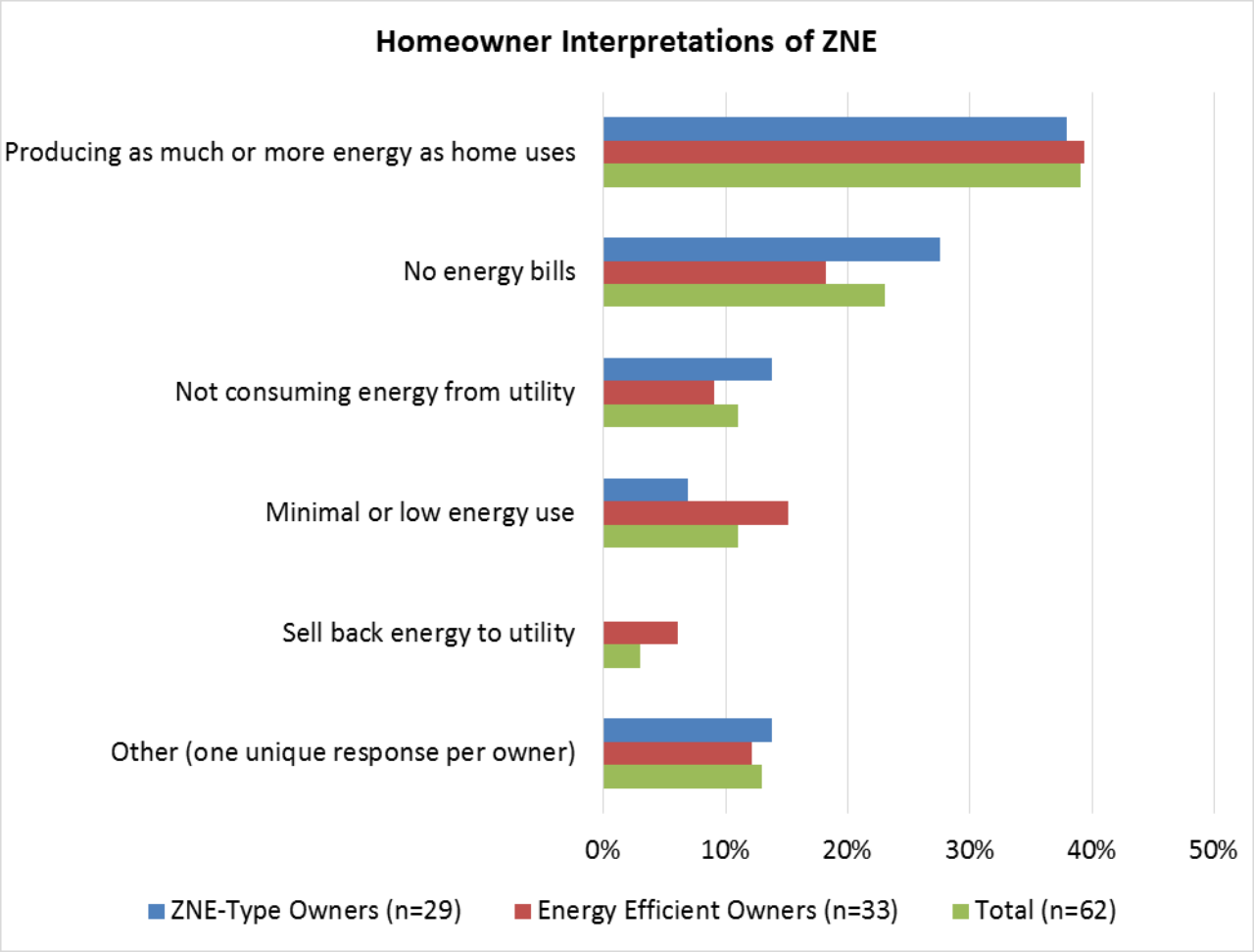


Figure 33. Owner Interpretations of ZNE

Below, we provide more detail on these interpretations by owners and by other market actors. The TRC team organizes results by ZNE definition, rather than by market actor.

5.4.2.1. Site-Based ZNE Definition

Builders and many owners have a site-based definition: A site-based ZNE building is one that produces as much energy as it consumes over the course of a year. This definition considers only the energy used and produced on-site and does not consider the additional energy used to generate or transmit energy to the building, as is captured by the TDV-based definition.

Of the 12 builders that responded to the question of how they interpreted ZNE, all provided a site-based definition. As shown in Figure 33, a site-based definition was also the most common interpretation by owners interviewed or surveyed in this study. A site-based definition also coincides with the New Building Institute definition of ZNE.[50]

Builders and owners may differ in interpreting ZNE based on "projected" vs. "actual" energy use: Builders and owners did not clarify whether their interpretation of ZNE refers to modeled or actual

[50]http://newbuildings.org/sites/default/files/ZNE_FAQ_v1.pdf

energy use. However, based on the interviews with ZNE-type owners[51], the TRC team believes it is more likely that most owners interpreted ZNE based on actual, not modeled energy use, whereas builders interpreted ZNE based on modeled energy use.

5.4.2.2. Zero Net "Energy" vs. Zero Net "Electricity"

Most programs and builders consider all fuels for ZNE, but some interpret ZNE as electric-only: While the IEPR definition interprets energy as encompassing electricity, natural gas, and other fuels, some market actors indicated that they interpret ZNE to refer to electricity only, as described below.

- Program Managers: All utility program managers identified ZNE as referring to all types of energy. However, BIG provides its ZNE credit based on electricity usage.
- Builders: Three of the twelve builders interpreted a ZNE home as an all-electric home, or a home where the builder only zeroes the electricity. (Section 9.1.1 provides more detailed results.) None of the builders specifically described producing more electricity than the home uses to offset natural gas or other fuel use. However, several of the builders interviewed have constructed ZNE homes with natural gas, such as the De Young house and Cottle house described in Section 7.

California energy goals and customer preferences indicate the important of including all fuels in ZNE: While some market actors have focused on electricity use when interpreting ZNE, current energy use in California illustrates the importance of considering other fuel types. Figure 57 in Section 9.11.2 presents the PV needed to offset energy use by different fuel types in residential buildings. The figure indicates that a substantial amount of home energy use is natural gas, and offsetting that natural gas use with renewable energy is critical to achieving ZNE. Including natural gas use in ZNE interpretations and ZNE-type home designs will be important to California's ZNE targets.

Energy Efficient owner surveys emphasized the importance of including natural gas in the ZNE definition: As described in Section 9.9.2, as part of the Energy Efficient owner survey, the TRC team asked owners if they were presented with a choice of fuel choice for appliances, and if so, what their preferences were. These owners indicated that when presented with a fuel choice option for appliances (e.g., stove, dryer, furnace and/or water heater) at the time of purchasing a home, the majority (88%) requested at least one natural gas appliance. Participants in the Code-built owner forum reported that they chose natural gas equipment and appliances because natural gas is inexpensive compared to electricity. These responses suggest that not all owners would prefer an all-electric home.

5.4.2.3. Zero Net Bills and Other Unrealistic Expectations

Concerns about unrealistic owner expectations appear justified, since one in three owners think ZNE equals zero bill or off-the-grid: While program managers and builders do not interpret ZNE in terms of energy bills, many program managers, builders, and other market actors reported concern that owners would interpret a ZNE home as a zero energy bill home, and be dissatisfied if the home had an energy bill. Similarly, a building official noted that he has concerns for the goal of all ZNE construction, because

[51] The TRC team asked ZNE-type owners to provide their interpretation of "Zero Net Energy" in an open-ended question, but the team provided Energy Efficient owners a coded-list of responses (based on the ZNE-type owner responses). Consequently, the TRC team can only draw this inference from the ZNE-type owners.

owners may interpret this term as zero energy bill, which could make him liable for permitting a ZNE home that may not perform as expected by the homebuyer.[52]

These concerns appear justified because, Figure 33 shows that almost one-quarter of these owners interpreted ZNE as a home with a zero energy bill, and approximately 10% interpreted ZNE as not consuming energy from the utility – i.e., off-the grid. Overall, 21 of 62 owners, or 1 in 3, expressed unrealistic expectations for ZNE. While these findings are based on a relatively small number of owners, these owners represent early adopters, whom the TRC team would expect to be much more informed about ZNE than the broader home buying market.

5.4.2.4. Considerations beyond Direct Energy Use

A few market actors believed that ZNE should consider water use: While this study focused on energy, the TRC team collected some limited information about other considerations, including water efficiency, and noted when market actors made comments about other features.

A few owners provided comments on water saving features. Two of the ten Code-built forum participants mentioned that the ZNE concept should extend to water conservation features, including using recycled or graywater for outdoor water needs, and one of the four participants in the ZNE-type forum stated that she was disappointed that her home did not include water recycling or irrigation conservation measures.

Several ZNE-type home case studies include water efficiency features, including the Double Zero House described in Section 7.

The literature raises considerations beyond direct energy use: Goldstein (2012) suggested expanding the definition of ZNE to include transportation energy (i.e., energy needed for building users to reach the building, including proximity to public transportation), embedded energy of materials, and embedded energy of water in the definition of ZNE. The TRC team provides conclusions and recommendations regarding additional energy uses – beyond energy directly used in the building – in Section 6.

5.5. Messaging of ZNE-type Homes

This section describes how builders market ZNE-type homes; perspectives from builders and appraisers, on the use of labels, programs, and energy rating systems for describing ZNE-type homes; and the usefulness of energy rating systems to homeowners.

5.5.1. Market Actors' Terms for ZNE-type Homes

ZNE is the most common marketing term: According to interviews with high performance builders, the term they most frequently use to describe ZNE-type homes is ZNE (eight of sixteen builders). Other terms used by builders and other market actors include:

- Zero electric or ZNE Electric: two builders, and one voluntary program manager
- Net zero energy (NZE): one non-IOU program manager
- Zero new energy: one builder

[52] The TRC team notes that a building permit does not result in a legally binding building performance for code-built homes, and would not expect different procedures for ZNE-type homes.

- Zero carbon home: one builder
- ZNE Ready: U.S. DOE
- Zero net cost: one ZNE owner
- Solar homes: owners in the ZNE-type forum

5.5.2. Energy Performance Messages

Builders market energy performance, but some are cautious: Most builders reported that they focus on the energy performance and resulting cost savings, and the increased comfort when promoting ZNE-type homes. Several builders reported that they are careful when describing expected energy performance, and may include a disclaimer or describe energy performance "as designed."

The literature reviews supported the finding that builders are marketing the energy bill savings of ZNE-type homes. One production builder that has developed a ZNE-type home development in midtown Sacramento promotes a zero electric bill over the course of the year, and describes these homes as Net Zero Energy.[53] The website advertises energy efficiency and describes some key efficiency features, emphasizes the downtown location and the benefit of a walkable lifestyle, and describes living in these homes as being "part of the solution" towards reducing greenhouse gas emissions and dependence on foreign oil. Another production builder that is developing ZNE-type communities advertises these homes as "The No Electric Bill Home".[54] The builder advertises these homes as energy wise, eco-friendly, well built, and healthy. Another national builder (not interviewed for this study) advertises low—but not zero –energy bills with billboards such as, "My energy bill is $5. What's yours?" (Rashkin 2014).

Builders use demonstrations to market ZNE-type homes, and results appear to be memorable to homeowners: Five builders suggested the use of home demonstrations, when asked in open-ended questions about reducing barriers to ZNE-type homes. Other results in this study indicate that demonstration or showcase homes may leave a lasting impression on homeowners. As shown in Figure 32, approximately one-third of ZNE-type owners and Energy Efficient owners reported that they learned about ZNE through a showcase home. In addition, three of the four owners in the ZNE-type forum reported that they toured a demonstration home prior to purchase. All three recalled specific elements of the demonstration, even though they had purchased their homes several years prior. One stated, "I could see what [the ZNE-type builders] were installing compared to other builders. I could see how much I would be saving. The physical demonstration was very influential."

Homeowners expect low energy bills: As part of the owner interviews and surveys, the TRC team asked what the owner's initial expectations for their home were, and whether these expectations have been met. Most of the ZNE-type and Energy Efficient owners expected low energy bills, and almost all reported that their homes met their expectations. However, a few ZNE-type and one Energy Efficient owners reported that their homes use more energy than they expected.

5.5.3. Use of Programs and Labels

Builders reported using a variety of labels and programs for ZNE-type homes: The TRC team asked builders what labels they use for ZNE-type homes. As shown Figure 35, builders use a variety of programs. Production builders reported using CAHP, ENERGY STAR Homes, and GPR for ZNE-type

[53] http://www.2500rmidtown.com/net-zero-energy-living/

[54] http://www.trilogylife.com/sheaxero/ The "SheaXero" option is available only in Washington and Florida.

homes, and custom builders reported using ENERGY STAR Homes, GPR, LEED for Homes, and Passive House for ZNE-type homes. Also, the number of total programs is roughly three times greater than the total number of builders that responded, indicating that builders have participated in a mix of different energy efficiency labels and programs for their ZNE-type homes.

	Custom (n=7)	Production (n=8)	Production/Custom (n =1)	All (n=16)
ENERGY STAR Homes	5	4	1	10
GPR	5	4	1	10
CAHP	2	6	0	8
LEED	5	1	1	7
Passive House	3	0	1	4
Other[55]	3	3	0	6
Total	23	18	4	45

Figure 34. Labels and Programs Used by Builders for ZNE-type Homes (Multiple Reponses Allowed)

Appraisers suggested the number of labels used may create confusion: The TRC team asked appraisers about their familiarity with different labels and the value of these labels on a home's valuation. The appraisers interviewed indicated that labels and certifications were largely meaningless to a home's valuation. Most appraisers were unaware of the different home labels, and had only seen ENERGY STAR applied to appliances. Three of the eleven appraisers mentioned LEED, with two describing it as the most common label, and the third noting that a LEED project sold quickly and for a premium. However, appraisers generally described labels as being a source of confusion, because there are so many labels, including builder-developed labels. Appraisers reported they generally do not have enough comparable homes with a specific label to support a higher value. However, as discussed in section 5.6, a study that compared thousands of home sales in California found that homes with green labels (e.g., ENERGY STAR Home, GPR, and LEED) sold for more on average than homes without a label (Kok 2012).

Owner feedback supports that various descriptions and labels are used for ZNE-type and Energy Efficient homes. The TRC team asked ZNE-type and Energy Efficient owners how their homes were described at the time of purchase. Most owners (for homes with PV installed) reported that their homes were described as "energy efficient" and "solar homes." A minority of owners (23% and 10% of ZNE-type and Energy Efficient owners, respectively) reported that their homes were described as "CAHP homes," although almost all owners in the survey had purchased a CAHP home. This is not surprising, because the CAHP program typically provides incentives to the builder, not the owner.[56] This finding generally indicates that builders are either not messaging the homes as CAHP homes to homebuyers; or that builders are messaging them as CAHP homes, but in a way that is not memorable to homebuyers.

Some ZNE-type owners also reported that their homes were messaged as ENERGY STAR homes, LEED homes, GPR homes, or Passive Houses. However, the TRC team did not have the databases for these programs to compare the labels reported by the owners with the actual labels awarded to these homes. Consequently, the TRC team could not draw clear conclusions regarding awareness of labels, or whether

[55] Other labels and programs included: DOE Zero Energy Ready Home, HERS Certified ZNE Home, Indoor airPLUS, Living Building Challenge, New Solar Homes Partnership, and WaterSense (one mention each).

[56] The exception to this if for owner-driven custom projects, where the homeowner is listed as the project contact. For these homes, the utilities provide the incentive directly the owner. However, these are a very small fraction of total projects.

builders properly describe homes when messaging them to homebuyers. The full results appear in Section 4 of the report Attachment.

Three of the four ZNE-type forum participants lived in LEED Homes, and all three indicated that they saw value in this label. One stated that "the LEED plaque went up before the photos of our kids," and the other stated that he keeps his LEED plaque in a safe place (his office) to be able to present at the time of re-sale. In contrast, none of the ten participants in the Code-built forum had heard of the LEED label. In addition, none of the participants in the Code-built forum had heard of the ENERGY STAR Homes label, although most were familiar with ENERGY STAR appliances.

5.5.4. Value of Home Energy Ratings

This section presents data on builders' use of home energy ratings, such as the Home Energy Rating (HERS), when describing energy performance to homebuyers, and homeowners' value of these energy ratings.

Half of builders interviewed use HERS[57] as a homebuyer communication tool: The TRC team asked builders about the use of the HERS index or other energy rating systems as a communication tool. The builders disagreed on whether it is a useful tool for describing the energy performance to a homebuyer. Half of builders interviewed (eight of sixteen) reported they discussed the HERS index with homebuyers, while the other half did not. Some builders reported that it is confusing for homebuyers, while others reported it is a useful tool for illustrating how the homes they have built compare to code-built homes. Some builders that do not use HERS as a communication tool reported that they simply describe how the home compares to code instead – i.e., a percent above Title 24. One builder reported that HERS could be a useful tool to create consumer awareness and that appraisers should use it during the valuation process, because it predicts financial savings.

No appraisers interviewed use HERS in their daily work: When asked about home energy rating systems, nearly all appraisers reported being familiar with the HERS index. However, none reported actively using it in their daily appraisal work.

Most owners could not recall much information about an energy rating, but reported it was helpful at the time of home purchase: Feedback from owners also showed a mix of responses on whether a home energy rating is valuable. Half (21 of 43) of the ZNE-type owners indicated receiving an energy rating score, or a description of their homes expected energy performance. Of these 21 owners:

- Eleven remembered what they received: Ten reported receiving a HERS rating and one reported receiving a Passive House performance spreadsheet. Of these eleven owners, three recalled details when asked what information was described in those materials.
- Ten could not recall the name or any detail about the energy rating material they received.

Similarly, 39% of Energy Efficient owners reported in surveys that they did not know if they had received an energy rating or description of their home's energy performance.

[57] The Residential Energy Services Network (RESNET) has long had a national HERS index that compares homes to a reference home based on the International Energy Conservation Code (IECC). California recently developed its own "California HERS" that compares homes to Title 24. When responding to questions regarding HERS, production builders (many of which operate nationally) primarily referred to their experience with the national HERS. Custom builders responded based on a mix of experiences with the national HERS, the HERS II for retrofits, and HERS for new construction. Overall, results were the same for the national and California HERS systems: some builders thought that HERS was a useful comparison tool, while others thought that it was too confusing for homeowners.

Of the 23% (26 of 112) of Energy Efficient owners that did recall receiving an energy rating:

- Over three-quarters (18 of 26) could not recall what they received. The remaining thirty-one percent remembered what they received (e.g., a HERS index).
- Most reported that the information was useful at the time of purchase: When asked to rate the usefulness of the energy rating information a 5-point scale (with 5 representing "very useful" and 1 representing "not useful"), the 26 owners that recalled receiving the information provided an average rating of 3.6.

Thus, among all ZNE-type owners and Energy Efficient owners, 7% recalled the information provided in the energy rating. But while most did not recall what they received, the majority of Energy Efficient owners reported the information was helpful at the time of home purchase.[58]

5.6. Owners' Home Purchasing Criteria

This section presents results of the criteria that homeowners reportedly used when purchasing their current home, and the purchasing criteria they plan to consider for their next home purchase. This section also presents feedback from owners on owned versus leased PV systems.

5.6.1. Criteria Based on Home type (Custom vs: Production) and Energy Performance

The TRC team asked ZNE-type owners (in interviews) and Energy Efficient homes (in surveys) two questions regarding their reasons for purchasing[59] their homes. The first was an open-ended question about what criteria the owner considered when purchasing a home (multiple responses accepted). The second question asked which of these criteria identified by the owner was the most important. A few respondents provided more than one response. Figure 35 presents results to the question of which criteria owners considered, and Figure 36 presents results of which of these criteria the owner thought was most important. Both figures distinguish responses from (1) ZNE-type custom owners, (2) ZNE-type production owners, and (3) Energy Efficient owners, almost all of whom owned production homes.

[58] The TRC team did not ask ZNE-type owners to rate the usefulness of this information.

[59] For all questions regarding purchasing, the TRC team asked many custom owners about design criteria rather than purchasing criteria, because many custom owners had already committed to purchasing the home during the design phase.

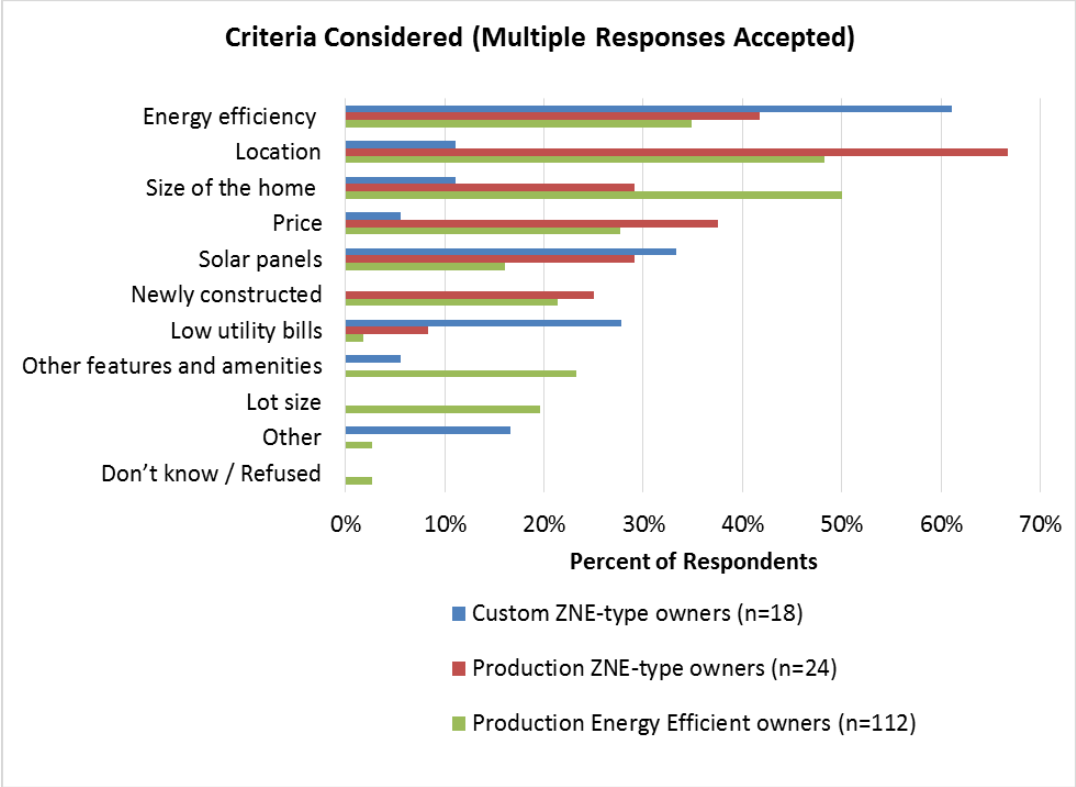


Figure 35. Home Purchasing Criteria for Owners of Different Home Types

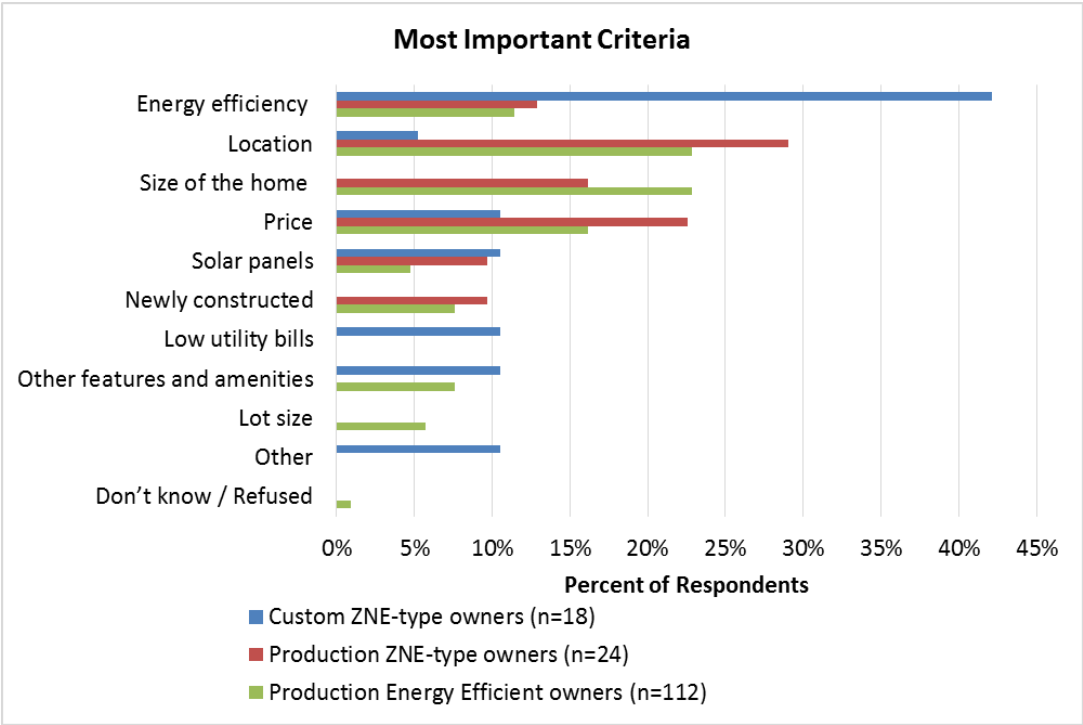


Figure 36. Most Important Home Purchasing Criteria Reported by Owners of Different Home Types

Most custom ZNE-type owners identified energy features (efficiency, PV, or low bills) as criteria, and many identified an energy feature as the most important criterion: As shown in Figure 35 and Figure

36, custom owners were more likely to identify energy features (efficiency, solar panels, low utility bills) as purchasing criteria or as the most important purchasing criterion, compared with production owners. Looking particularly at Figure 36, energy efficiency stands out as the criterion most often cited by custom owners as the most important, but it ranked fourth for production owners (both ZNE-type owners and Energy Efficient production owners). However, custom owners have often selected a lot and identified a target price range and general home size before detailed design begins, which may explain at least partially why they viewed energy features as more critical purchasing criteria than location, price, and home size.

Location, home size, and price were the most important criteria to production owners: The TRC team found that both production ZNE-type and production Energy Efficient owners identified location, home size, and price as the most important criteria. In contrast, few custom ZNE-type owners identified these as important criteria. However, as described above, many custom owners may have already identified a location, a general idea of home size and layout, and a target budget before they contracted a builder.

Energy features were not a priority, but were attractive bonuses to production owners: Participants in both the ZNE-type and Code-built forums—all of whom were production owners—identified the same major criteria for choosing a home as found with Energy Efficient and ZNE-type production owners: location (including access to quality schools), price, and floor plans. Two of the four ZNE-type forum participants indicated that the energy features, including PV, and resulting energy bill savings were highly influential in their home purchasing decision. The other two ZNE-type owners reported that factors not related to energy, such as location of the home and home layout, were more influential, and the energy features were a bonus. The Code-built forum participants differed in that they generally did not list energy efficiency or on-site renewable energy as a priority for home buying, although a few viewed energy efficiency or PV as a nice additional feature. All homeowners discussed rooftop PV as the only potential renewable energy resource for their homes.

Production owners had similar purchasing criteria, regardless of energy performance: Overall, production owners generally reported similar purchasing criteria, regardless of the energy performance of the homes -- i.e., ZNE-type, Energy Efficient or Code-built). In particular, Figure 35 and Figure 36 indicate that the production ZNE-type owners' responses more closely resembled those of production Energy Efficient owners than custom ZNE-type owners. One difference was in PV, where 29% production ZNE-type owners reported this as a purchasing criterion, compared with only 16% of production Energy Efficient owners. However, almost all ZNE-type owners, but only one-third of Energy Efficient owners, had purchased homes with PV. Consequently, the TRC team also compared results from the ZNE-type owners with only the Energy Efficient owners with PV. Of the 28 Energy Efficient owners who had purchased a home with PV, about two-thirds (61%) reported that the presence of PV (i.e., "solar panels") was a purchasing criterion.

New owners prioritized energy features: As part of the Energy Efficient owner survey analysis, the TRC team compared results from first-time owners (i.e., those that reported the Energy Efficient home was their first home purchased) with owners that had previously owned a home. For most survey questions, results were not different. However, first-time Energy Efficient owners reported energy related measures as the most important purchasing criterion more often than owners that had previously owned a home (29% and 8%, respectively). This difference was statistically significant (Z-Test of Proportions at $p<0.05$).

5.6.2. Prompted vs. Open-ended Feedback on Energy Features

ZNE-type owners ranked comfort, indoor air quality, and low energy bills as medium or high priorities: In addition to the open-ended questions described above, the TRC team later asked ZNE-type owners whether specific features of ZNE-type homes (identified by the interviewer) were a high, medium, or

low priority, or not a consideration at all in their home buying (for production owners) or design (for custom owners) process. Figure 37 presents results.

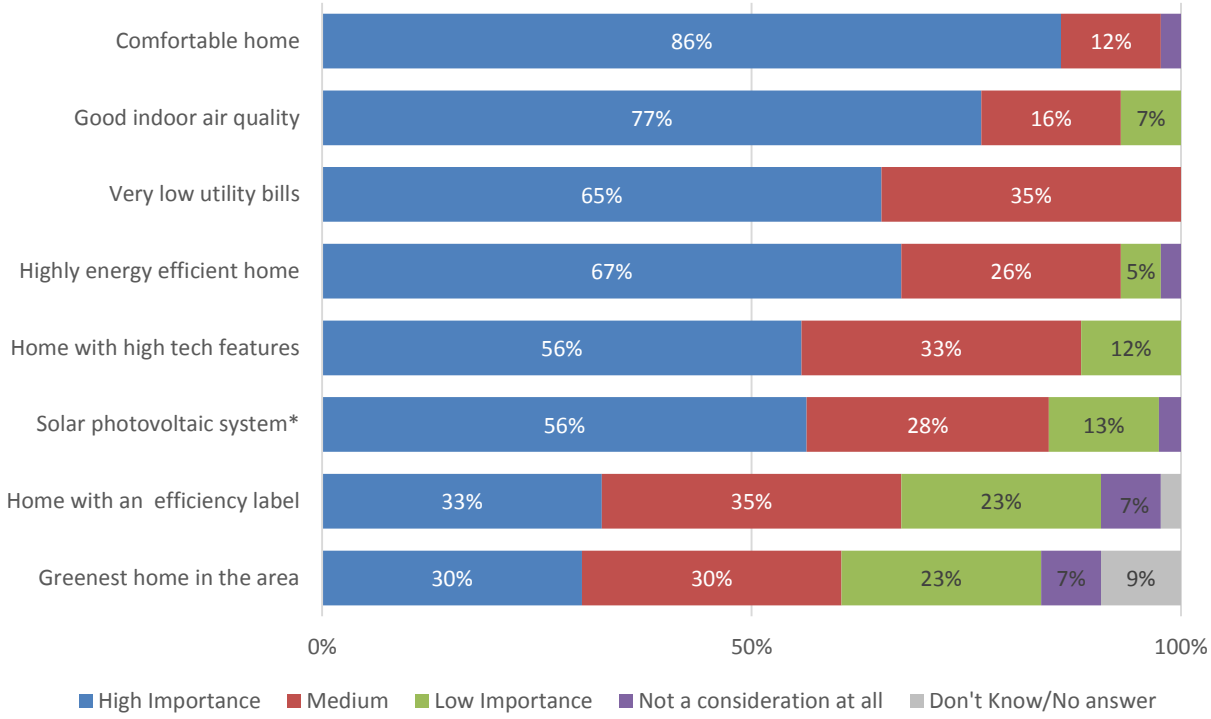


Figure 37. Level of Importance of ZNE-type Home Features in the Home Buying or Design Process, n=43[60]

ZNE-type owners' purchasing criteria differed from ZNE-type home feature ranking in prompted questions: As shown in Figure 37, ZNE-type owners most often identified the following as "high priority:" a comfortable home (86%) and good indoor air quality (77%). In contrast, very few of the ZNE-type owners or the Energy Efficient owners identified comfort or good indoor air quality as purchasing criteria in the open-ended questions shown in Figure 35.

Furthermore, all ZNE-type owners identified very low utility bills as either a high priority (65%) or a medium priority (35%) in the prompted question (99% total). These owners also reported that, of the most important features from the prompted list, they were generally equally split among a highly energy efficient home (9 owners), PV (9 owners), and very low utility bill (8 owners). However, few production owners (either ZNE-type or Energy Efficient) identified low utility bills as a purchasing criterion in the open-ended questions shown in Figure 35.

It is not entirely clear why owners rated comfort, indoor air quality, and low utility bills as high priorities in prompted questions, but did not identify these as purchasing criteria in open-ended questions. It is possible that owners expect a new home to be comfortable, have good indoor air quality, and have very low utility bills. It is also possible that owners did not think of these criteria on their own, but put a high value on them when the interviewer asked the owner to consider them.

[60] The number of owners rating "Solar photovoltaic system" was 39.

5.6.3. Future Purchasing Decisions

Most ZNE-type and Energy Efficient owners would put a high priority on purchasing a ZNE-type home: Of the ZNE-type owners interviewed, 31 of 42 reported they would place a high priority on buying a ZNE-type home in the future, and five identified it as a medium priority. Almost all Energy Efficient owners also reported they would place a medium (38%) or high (49%) priority on purchasing a ZNE-type home, if it were in the right location. Three of the four ZNE-type forum participants indicated that, if they were to move again, they would place a high value on the energy efficiency of their potential future home and would be interested in homes with PV. Thus, almost all ZNE-type and Energy Efficient owners indicated they would place a medium or high priority on purchasing a ZNE-type home with their next purchase.

Code-built owners would consider PV, efficiency, and buying a smaller home in their next purchase: The Code-built forum moderator asked participants how much priority they would place on buying a high energy-performance home in their next home purchasing decision. Several participants reported that they would consider efficient homes and homes with PV. A few also reported they would consider purchasing a smaller home as a way of reducing energy bills.

5.6.4. Feedback on Owned versus Leased PV

Most owners preferred owning, rather than leasing the PV system: Six of the forum participants (all four of the ZNE-type forum participants, and two of the Code-built participants) owned homes with PV, all of which were host-owned systems. Most forum participants with PV liked owning their systems, because they received the utility incentives, and some believed it would increase the resale value of their homes. However, one ZNE-type forum participant stated that he would prefer a leased system, because he currently has to pay to replace his PV inverter, which is expensive.

Forum participants expressed confusion over the PV leasing process: Most participants in the Code-built forum were not attracted to leasing PV, because they did not understand the leasing process. One owner in the ZNE-type forum and one owner in the Code-built forum expressed confusion over how PV would affect home resale. These findings generally agree with what Navigant (2013a) found in a large survey with owners with leased PV systems. Navigant (2013a) found that most residential owners with a third party owned system believe that system will increase their home's value, make it easier to sell, or have no significant impact. Navigant (2013a) further found that only 6% believed the leased system would make the home harder to sell, and 28% did not know what impact the leased system would have on their home sale.

5.7. Cost and Value of ZNE-type Homes

This section begins with builders' and program managers' responses to the question of how much it costs to build a ZNE home.[61] This section then summarizes appraisers' responses and literature review results regarding the value of ZNE-type homes. Finally, this section presents owners' responses to how much they would be willing to pay for their next home to be ZNE-type, and how much they believe their current home will sell for, compared to a Code-built home, because it is ZNE-type (for the ZNE-type owners) or because it is Energy Efficient (for the Energy Efficient owners).

[61] Due to interview time constraints, the TRC team did not ask builders for their estimated cost to build ZNE-ready or near ZNE homes.

5.7.1. Incremental Cost to Builders

The TRC team asked builders for their estimate of the incremental cost of building a 2,500 square foot ZNE home compared to a Code-built home. In addition, two IOU program staff provided incremental cost estimates for building a ZNE home. The TRC team presents results in this section.

Note that these incremental prices are broad-brush estimates, as described in Section 3.1.6 in the report Attachment. The TRC team notes two important limitations here:

- The TRC team asked interviewees to provide a response in either a percentage or a dollar value. The TRC team converted the percentage responses to dollar values based on average home sales prices in California.[62] Because home prices vary significantly by geographic region, the TRC team provides results as an average value (corresponding to the average sales price of a home in California), and as a range (corresponding to the range of home prices in California, which vary based on geography). However, in general, builders active in Northern California did not provide different incremental cost estimates than builders active in Southern California.
- The TRC team interprets the builders' responses to be somewhere between estimates based on actual construction experience and speculation. All but one of the builders who provided an incremental cost estimate had experience building ZNE homes. However, none of these builders had constructed one 2,500 square foot ZNE home and an identical code-built home; thus, these builders had to speculate to some degree on the incremental cost.

Builders' and program managers' incremental cost estimates for ZNE ranged from 5-15% or $15,000 to $50,000: Figure 38 summarizes builders and program manager responses. For builders, the TRC team notes whether responses came from a production or custom builder. While responses vary widely, most utility program managers and builders identified the incremental cost to build a ZNE home as between $15,000 to $50,000, or 5% to 15% of the average cost of a new 2,500 square foot house. Five of the builders interviewed, all of whom were production builders, recommended continued and increased utility incentives to bridge the incremental cost gap associated with ZNE homes.

[62] From CBIA, median home sale price is $379,800 in California, $91,200 for the lowest price area (Colusa / Glenn), and $806,500 for the highest price area (San Francsico / San Mateo / Redwood City). Downloaded August 27, 2014 from http://www.cbia.org/go/newsroom/housing-statistics/median-prices/

Market Actor (Response Count)	Estimated Incremental Cost to Build ZNE	Corresponding Value ($)
Custom builders with experience building ZNE homes (4), and building industry expert (1)	5%-10%	Average of $15,000 to $31,000 (range of 8,000 to $80,000)
Production builders with experience building ZNE homes (4)	$12,000-$34,000	$12,000-$34,000
Building industry experts (2)	$35,000-$40,000	$35,000-$40,000
Custom builder with experience building ZNE homes (1)	$37,500	$37,500
Production builder with experience building ZNE homes (1)	5% + $40,000 for PV	Average of $55,000 (range of $48,000 - $80,000)
Production builder with experience building ZNE-ready and near ZNE homes (1)	$10,000 -$15,000	$10,000 -$15,000
Custom and production builder with experience building ZNE homes (1)	15%	Average of $46,000 (range of $25,000 -$121,000)
Utility Program Manager (1)	$20,000-$50,000	$20,000-$50,000
Utility Account Executive (1)	$50,000	$50,000

Figure 38. Program Managers' and Builders' Estimates of Incremental Cost to Build a ZNE Home

Builder responses are comparable to literature review findings: The TRC team could not directly compare results of this study with the literature review results because the literature considered different questions. For example, as described below, Davis Energy Group considered energy efficiency only, and BIRAenergy considered a leased PV system. However, the responses found in this study were in the same general range as the following literature review findings:

- Davis Energy Group (2012) estimated that the incremental cost to achieve 40% reduction in thermal and lighting energy consumption is approximately $2-$8 for conventional upgrades per square foot. This translates into a range of approximately $4,000 - $23,000, based on the median size of custom and production ZNE-type homes (2,049 and 2,902 square feet, respectively) reviewed in this study (see section 5.2).
- BIRAenergy (2013) conducted cost analysis of the De Young ZNE home, and estimated the incremental cost for the efficiency upgrades as $13,093, with an additional $5,500 for a fully pre-paid lease for a 6 kW PV system.

5.7.2. Appraisal Value and Sales Premiums

Appraisers reported that the value of achieving ZNE-type is site specific: In general, appraisers reported that a ZNE-type home would sell for more than a similar Code-built home. However, most appraisers would not put a dollar value on a ZNE-type home or energy efficiency features, because they reported that the value of any feature is site specific, and because they look at the value of the "whole package" in determining their final valuation. Five appraisers did provide specific percentage estimates for the additional value they have seen applied to ZNE-type or highly energy efficient homes. These estimates were all between 5-15%, with three in the tighter 8-9% range.

PV may add more value than energy efficiency: Appraisers reported that PV typically adds more value than energy efficiency features, because PV is visible, and the impact of PV is generally easier to quantify than efficiency measures. One lender interviewed works with independent appraisers that the lender's

organization has trained to include PV using the Appraisal Institute's form, which has fields to report some data from the Sandia laboratory calculator for PV.[63] This lender reported receiving nearly dollar-for-dollar appraisals for PV systems. For instance, one recent PV system costing $43,000 increased the appraised value of the home by $41,000. Cadmus, which conducted the lender interviews, reported that this lender's efforts to obtain higher appraised values is not typical in the lending industry, and it may be more a reflection of this lender's commitment to energy-efficiency/PV lending.

The literature supports increased sales prices for homes with an energy efficiency label or PV: The literature provides some quantitative estimates of price increases for homes with energy features. Based on a large study of homes sold in California from 2007-2012, Kok (2012) found that single-family homes in California with a green label (e.g., ENERGY STAR Homes, GPR, and LEED) sold for 9% more (+/-4%) than a similar home without the label. In addition, the resale of seven ZNE-type homes in 2012 in a suburb of Sacramento, California and fourteen homes in neighboring comparable subdivisions suggested a 12% higher per square foot market valuation for the ZNE-type homes (Davis Energy Group 2012).

At a national level, based on sales prices in eight states of 22,822 homes, 3,951 of which had PV, the average premium for host-owned PV systems was approximately $4 per Watt, or approximately $15,000 for a typical PV system (LBNL 2015). Other literature also shows that homes with PV sell for premiums, on average, compared to homes without distributed generation (e.g., LBNL 2013b, LBNL 2011, ConSol 2008, and Colorado Energy Office 2013).

The increased value is within the range of incremental cost to build ZNE: Overall, builders estimated an increased cost to build ZNE of 5-15%. This was the same range provided by appraisers when estimating the additional value for a ZNE-type or highly efficient home (5-15%). Literature supports a sales increase of 9% for homes with an energy efficient label. Thus, the ranges of incremental cost for ZNE and incremental value for ZNE-type homes appear to overlap.

5.7.3. Perceived Value of ZNE-type homes to Owners

The following section presents builders' expectations of owners' willingness-to-pay for a ZNE-type home, followed by owners' self-reported responses to questions of how much they would be willing to pay for their next home to be ZNE-type. Owners also estimated how much of a sales premium they expect to receive because their current home is ZNE-type (for ZNE-type owners) or Energy Efficient (for Energy Efficient owners). Note that builder and owner results are not directly comparable; builders reflected on whether the general home buying market may be willing to pay, while the owners interviewed and surveyed in this study represented only the early adopters of ZNE-type homes.

5.7.3.1. Builders' Expectations of Owners' Willingness-to-pay

Builders' opinions differed as to whether homebuyers are willing to spend more for a ZNE home: Twelve builders responded to the question of whether homebuyers would pay more for a ZNE home, and Figure 39 presents their responses. As shown, these builders were evenly split in reporting that: (1) homebuyers are willing to spend additional money for ZNE homes; (2) only a small, select portion of the market is willing to pay more; and (3) homebuyers are not willing to pay more for a ZNE home. The TRC team asked specifically about ZNE homes and does not have similar data for ZNE-ready or near ZNE homes.

[63] http://energy.sandia.gov/energy/renewable-energy/solar-energy/photovoltaics/solar-market-tranformation/pv-value/

Number and Type of Builders	Opinion on Homebuyers' Willingness-to-pay
4 builders: 2 production, 1 custom/ production, and 1 custom	Homebuyers are willing to pay more for ZNE homes
4 builders: 1 production and 3 custom	A very small, select portion of homebuyers are willing to pay more for ZNE homes
4 builders: all production	Homebuyers are unwilling to pay more for ZNE homes

Figure 39. Builders' Responses of Homebuyers' Willingness-to-pay for ZNE Homes

Most builders were unsure how ZNE affects "days on market," although results from one subdivision show faster sales rate for ZNE-type homes: The TRC team also asked builders about the effect of ZNE on the speed of home sales (a.k.a. days on market)[64]. This metric is important to builders, because holding costs—the costs to keep and maintain the home—increase with increased time. Most builders were unable to predict if a ZNE home sells faster. Only three of sixteen builders reported that ZNE homes sell faster.

A study by Davis Energy Group (2012) based on one ZNE-type subdivision in California found that these homes sold faster compared to Code-built homes. Davis Energy Group (2012) found that the sales rate of the ZNE-type homes in the Carsten Crossings subdivision was 2.2 times higher than homes in competing subdivisions, resulting in a reduced sales time. Due to the small proportion of ZNE-type homes on the market, it is unclear whether this increased sales rate can be extrapolated beyond the population of ZNE-type early adopters to the general market.

From the literature, ZNE experts reported that homebuyers would spend $10,000 to $50,000 for ZNE: The TRC team did not ask the builders to quantify how much more consumers would spend for ZNE. However, a study by the Net Zero Energy Coalition asked ZNE experts for their opinion on consumers' willingness-to-pay for ZNE. In that report, most ZNE experts reported that consumers were willing to pay between $10,000 and $25,000 (40% of respondents) or between $25,000 and $50,000 (37% of respondents), although 19% reported consumers would spend below $10,000 (Net Zero Energy Home Coalition[65] 2012). The Net Zero Energy Coalition study did not ask similar questions for ZNE-ready or near ZNE homes.

5.7.3.2. Owners' Willingness-to-pay Compared to Incremental Sale Price

This section provides responses from the ZNE-type and Energy Efficient owners' willingness-to-pay for ZNE-type homes, and their expected incremental sales price for their current homes due to its energy features. As noted above, because these owners represent early adopters, their feedback, particularly on their willingness-to-pay, may not reflect the views of the broader home buying market. Also, note that the TRC team asked owners to speculate on their future willingness-to-pay for a ZNE-type home, rather than whether they actually paid more for their current ZNE-type or Energy Efficient home. This was because these owners were generally not presented with the option of buying the exact same home in the exact same location but without the ZNE-type or Energy Efficient features.

Figure 40 shows responses from ZNE-type owners to two questions, both of which the TRC team asked as percentages:

[64] Due to interview time constraints, the TRC team did not ask similar questions regarding time on the market for ZNE-ready or near ZNE homes.

[65] The Net Zero Energy Coalition was the Net Zero Energy Home Coalition at the time of 2012 publication, but later changed its name (i.e., deleted "Home").

1) Their willingness-to-pay for their next ZNE-type home (x-axis), and
2) Their estimated increased sales price for their current ZNE-type home (y-axis).

The blue line is the response trend line. The red line identifies how owners would respond if they provided the same answer to both questions: i.e., if they reported that their expected incremental sales price for their current ZNE-type home is the same as their willingness-to-pay for their next ZNE-type home.

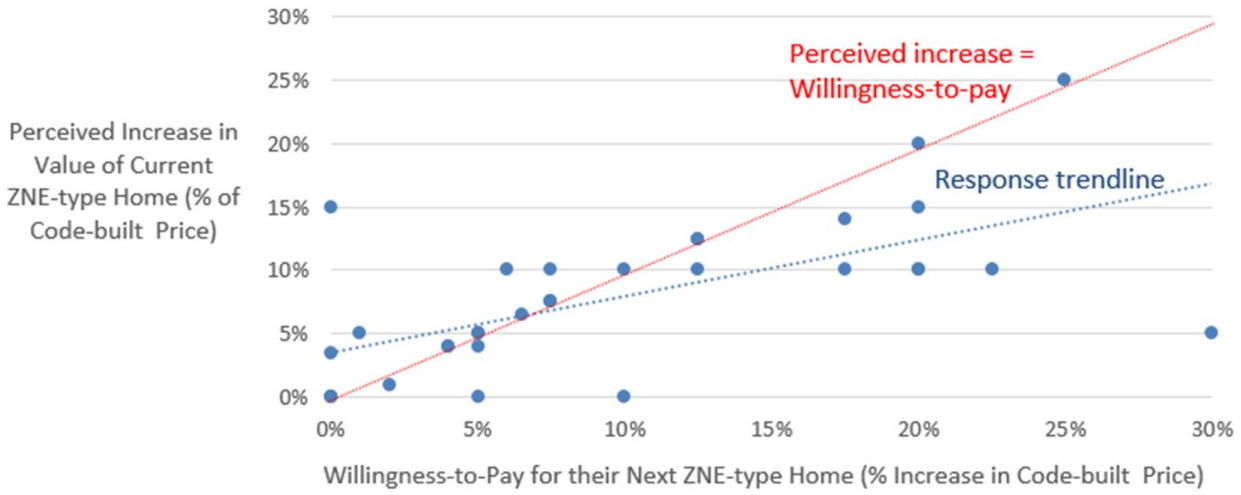


Figure 40. ZNE-type Owners' Expected Increase in Sales Price of Current Home vs. Willingness-to-Pay Premium, n=32

ZNE-type owners expect their ZNE-type homes to sell for more, and are willing to pay an even greater premium for their next ZNE-type home: Figure 40 shows that the majority of ZNE-type owners reported that they are willing to pay more for their next ZNE-type home than they expect to receive as an incremental sales price for their current ZNE-type home. This is indicated by the fact that the data-based trend line falls to the right of the red line. This finding suggests that owners appreciate the value of ZNE-type homes after living in one.[66]

On average, ZNE-type owners report they are willing to pay a 10% premium for their next ZNE-type home, with custom owners willing to pay more: In addition, these owners reported that their willingness-to-pay for their next ZNE-type home was 10% more on average and a median response of 8%. Custom owners were willing to spend 12% more on average, whereas production owners reported that they would be willing to spend 8% more. Figure 40 is based on data from the ZNE-type owner interviews. In the ZNE-type forum, one participant reported she would pay up to $30,000 for similar energy performance, while another stated he would need to see a payback time of less than ten years.

After explaining the concept of ZNE, the TRC team asked similar questions of willingness-to-pay and expected sales prices to Energy Efficient owners. Figure 20 presents the responses to these questions. Note that, for the Energy Efficient owners, the sales price question referred to their current Energy Efficient (but not ZNE-type) home, but the willingness-to-pay question referred to a ZNE-type home. Also, note that the surveyor asked Energy Efficient owners the willingness-to-pay question with coded

[66] Because the willingness-to-pay question was asked as a percentage, rather than an absolute dollar value, it should not matter if owners expect to buy a more or less expensive home with their next home purchase, compared to their current home.

responses (results shown on the x-axis), but asked about increase in sales price in an open-ended format (results shown on the y-axis). Consequently, the TRC team presents results for the Energy Efficient owners (Figure 41) in a different format than for the ZNE-type owners (Figure 40), for whom the team presented both questions in an open-ended format.

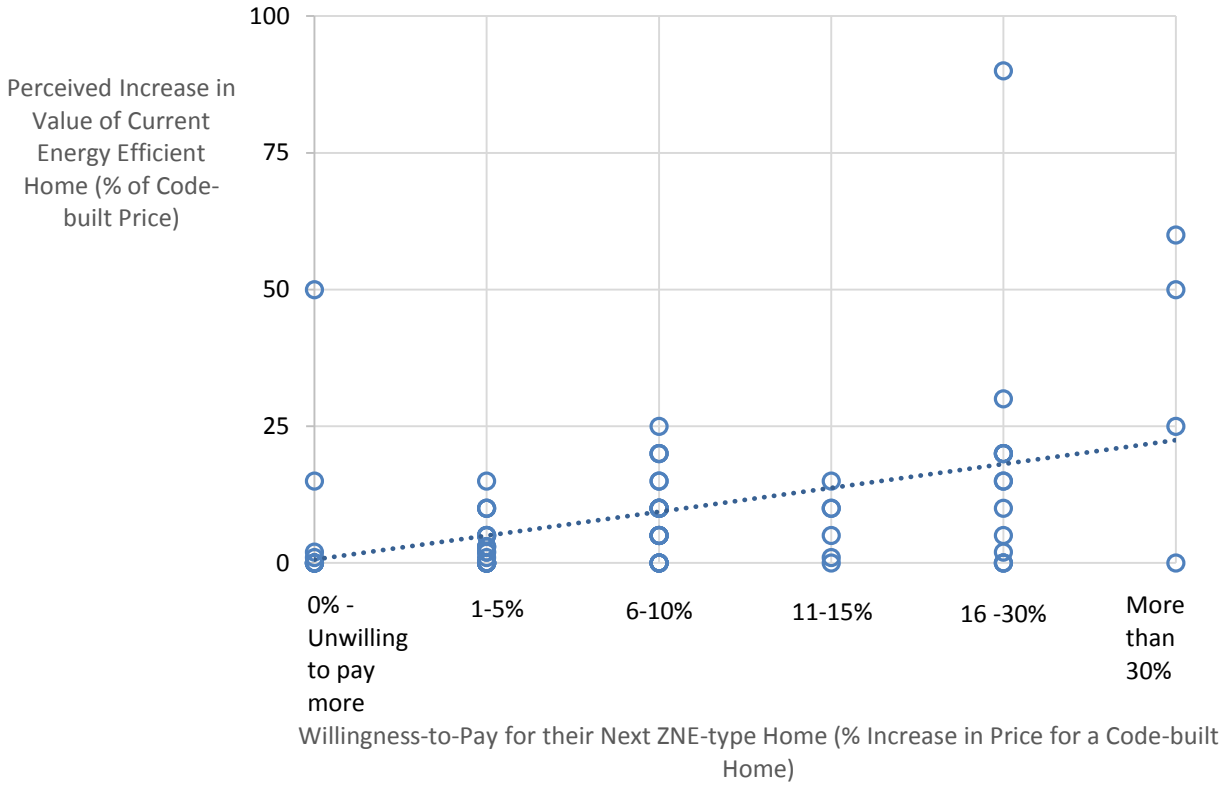


Figure 41. Energy Efficient Owners' Expected Increase in Sales Price of Current Home vs. Willingness-to-Pay Premium (n=112)

Most Energy Efficient owners, particularly those with PV, expect their homes to sell for more: Most Energy Efficient owners expect to receive an increase in sales price (i.e., a sales premium) because their home is efficient. In addition, the TRC team found that Energy Efficient owners with PV were more likely to report their home would sell for more compared to those without PV (91% of Energy Efficient owners with PV compared to 59% of Energy Efficient owners without PV).

Overall, based on responses from ZNE-type and Energy Efficient owners, the TRC team found the following:

- **Most ZNE-type and Energy Efficient owners expect their homes to sell for more because of their energy performance, and they expect to receive approximately the same premium:** A vast majority (36 of 42) of the ZNE-type owners interviewed expect their homes to sell for more because they are ZNE-type homes. Production ZNE-type owners generally provided a lower incremental price estimate than custom ZNE-type owners. Energy Efficient owners reported that the energy efficiency features of their homes would increase the value of their home by an average of 14% and a median of 10%. Thus, the Energy Efficient owners expect their homes to sell for about the same, or slightly more, than the ZNE-type owners. This indicates that the relative level of energy efficiency (i.e., energy efficient vs. very efficient) may not affect an owner's expected increase in the home sales price.

- **Most ZNE-type and Energy Efficient owners are willing to pay a premium for a ZNE-type home:** Overall, the data indicate that the majority of these ZNE-type and Energy Efficient owners are willing to pay more for their next home to be ZNE-type. This agrees with findings from the literature; Dakin (2008) found that most buyers reported that the efficiency and PV were good value, and that, if they were to purchase another home, they would select one with energy efficiency and PV features.
- **Willingness-to-pay increases with the owner's perceived increased value of his or her current home:** Figure 40 and Figure 41 both show an upward slope in the response trend line. This indicates there is a positive, linear relationship between owners' perceived value of energy efficiency features in their home and their willingness-to-pay for a ZNE-type home. In other words, the more value an owner attributes to his/her home's energy efficiency features, the more the owner is willing to pay for a ZNE-type home.
- **Many ZNE-type and Energy Efficient owners report a willingness-to-pay that is in line with incremental cost estimates:** The feedback from ZNE-type owners indicate that they are willing to pay approximately 8-12% more for their next home to be a ZNE-type home. Energy Efficient owners provided a broad range of responses for their willingness-to-pay for a ZNE-type home: 12% reported they would not pay more, 27% reported 1-5% more, and about half (53%) reported they would pay at least 11%.[67] Thus, many of these early adopters reported they are willing to pay a sales premium that is in the range of incremental cost estimates provided by builders (generally 5-15%).
- **ZNE-type and Energy Efficient owners represent early adopters, but many builders sell to the broader market.** The alignment noted above (between what ZNE-type and Energy Efficient owners are willing to pay for a ZNE-type home, and the incremental cost to build ZNE), is encouraging. However, ZNE-type and Energy Efficient owners represent early adopters, while many builders, including large production builders, build for the broader market. Because this study did not systematically investigate Code-built owners' willingness-to-pay for a ZNE-type home, the TRC team cannot state whether this alignment between homebuyers' willingness-to-pay and builders' estimated incremental cost would also be found for Code-built owners.

5.8. Home Satisfaction for Owners

The TRC team gathered feedback from the different owner groups on their general satisfaction, expectations, and feedback on specific energy features of their homes. This section presents the results. When reviewing results of the ZNE-type and Code-built forums, note that these results should be viewed as anecdotal rather than significant, because only four and ten owners participated in the ZNE-type forum and Code-built forum, respectively.

All owner groups reported their expectations were met or were generally satisfied with their homes: As described below, almost all ZNE-type and Energy Efficient owners reported that their overall expectations have been met for their homes. The owners in both the ZNE-type and Code-built forums were generally satisfied with their homes.

Energy performance and comfort contributed to ZNE-type and Energy Efficient owners' satisfaction, whereas Code-built owners liked their homes despite the energy performance: As described below,

[67] The TRC team asked the willingness-to-pay question as a coded question – i.e., with multiple-choice responses – so the team could not calculate a reliable median value.

most ZNE-type and Energy Efficient owners identified energy performance or specific energy features as a source of home satisfaction, while energy performance was a source of dissatisfaction for many Code-built owners.

Owners' areas of satisfaction included the following:

- ZNE-type owners in interviews: Based on responses to prompted questions:
  - 29 of 42 reported their homes have met their overall expectations, which generally included very low energy bills (26 of 42).
  - 15 of 42 stated comfort is what they like best about their home, followed by location (11 mentions) and low energy bills (8 mentions).
- ZNE-type owners in forum: Based on group discussion:
  - All (4) were very satisfied with their homes, and pointed to the energy features, particularly PV, as one reason for this satisfaction. Participants noted that they liked the ability to see the output of their PV systems, and the three owners with PV integrated into their roof liked this feature.
  - Participants were particularly pleased with their tankless water heaters, because it delivers hot water quickly, uses less space, and reduces water waste, and their "soy-based insulation" for its energy savings and noise reduction.
  - Two owners were pleased with the night ventilation system, which brings in outside air to meet heating or cooling needs when possible.
- Energy Efficient owners: Based on responses to prompted questions:
  - 79% reported their overall expectations have been met and 20% reported they have been somewhat met.
  - Most (71%) expected low energy bills and 23% expected a comfortable home.
- Code-built owners in forum: Based on responses to open-ended questions:
  - Owners were generally satisfied with homes, particularly the family friendly atmosphere of the neighborhood and home lay-out.
  - The two participants with PV noted that they liked the ability to see the PV system output, similar to the participants in the ZNE-type forum.

Owners' areas of dissatisfaction included the following:

- ZNE-type owners in interviews: Based on responses to open-ended questions:
  - Several disliked a certain energy or green feature, such as insufficient water pressure from low-flow faucets (6 mentions), a lot size that was too small (4 mentions), or difficulty managing high tech features (2 mentions).
  - Five reported dissatisfaction with general energy performance, including bills not as low as expected, or a large additional bill at the end of the year.
  - Two owners reported that their home was too big to clean.
- ZNE-type owners in forum: Based on group discussion, problems included:
  - Poor cellphone reception, which they attributed to their radiant barrier (3 mentions),

- High cost to replace a PV inverter (1 mention); that the night ventilation technology was too noisy or brings in polluted air (1 mention); and a lack of water conservation or efficiency features (1 mention).

- Energy Efficient owners: The TRC team did not ask these owners for areas of dissatisfaction. The 1 out of 112 owner who reported his home has not met his expectations reported that his energy bills were higher than expected.
- Code-built owners: Based on group discussion:
  - Several recalled being shocked by their first energy bills in their homes. In particular, they commented that their air conditioners are not as efficient as they would expect for a new home and have considered replacing them. One was upset that his winter bill is $400 per month and called this "outrageous."
  - Several reported problems with temperature balancing between floors.
  - Many reported that they had taken steps, both behavioral and/or measure-based, to reduce energy consumption or shift use to off-peak times.

While all owner groups reported areas of satisfaction and dissatisfaction, the positives outweighed the negatives as almost all owners reported general satisfaction with their homes.

5.9. ZNE-Related Policies

This section presents a description of responses from builders and planners regarding ordinances that local jurisdictions have used for promoting ZNE-type homes, the State's and market's loading order of energy efficiency compared with distributed generation, PV ratemaking reforms, and a summary of the TDV update process.

5.9.1. Reach Codes and PV Ordinances for Promoting ZNE-type Homes

Many jurisdictions have adopted Reach Codes and a few have adopted PV ordinances: Based on feedback from planners, Reach Codes and other types of ordinances have helped push jurisdictions towards greater energy efficiency and/or higher adoption of PV. Most planners participating in this study reported that their jurisdictions have adopted Reach Codes as part of a Climate Action Plan, or because of support from city council members. These Reach Codes included energy efficiency measures as well as requirements for solar pool heating and for solar ready construction.

The literature review indicated that some jurisdictions have instituted PV ordinances without requirements for energy efficiency beyond what is required under current Title 24. These examples include Sebastopol, Lancaster, and Davis, California (City of Sebastopol 2013, City of Lancaster 2013, and Cool Davis 2014).

Planners indicated that they are aware of ZNE, but that their jurisdictions are "waiting and seeing" what happens at the state level for ZNE: Most planners indicated that a requirement for ZNE construction would not be politically feasible for their jurisdiction at this time, and they would need to understand the impact of ZNE on cost effectiveness before trying to adopt a ZNE ordinance. Consequently, none of the planners reported that their jurisdictions currently have or have plans to adopt a ZNE ordinance; however, some jurisdictions have adopted PV-based ordinances, which some cities have described as ZNE requirements.

Two planners indicated that CALGreen may have delayed progress in their jurisdictions to some degree. Their jurisdictions did not want to develop ordinances, which could have been replaced by CALGreen, so

they did not implement a Reach Code or they suspended current Reach Codes until the CEC finalized CALGreen. These findings indicate that it will be important that state agencies clarify their plans regarding ZNE, so that jurisdictions do not delay their own implementation of Reach Codes or ordinances promoting ZNE-type homes.

Both mandatory and voluntary requirements have pros and cons: Planners provided mixed responses on whether mandatory, uniform requirements (such as Reach Codes) were better than voluntary requirements. On the one hand, uniform requirements are more equitable and can be easier to implement. However, as may be expected, some builders prefer voluntary requirements, and these may be politically easier to pass. Planners reported that jurisdictions can encourage builders to meet voluntary requirements by strategies such as waiving permitting fees.

5.9.2. California Loading Order of Energy Efficiency and Distributed Generation

The builders interviewed reported generally following the State loading order: The CPUC has called for a loading order that emphasizes energy efficiency first, followed by distributed generation. The builders interviewed for this study generally reported following that loading order. To meet their ZNE goals, nine builders interviewed specifically reported that they first focus on energy efficiency measures and then on PV to reduce costs associated with larger PV systems. The remaining builders did not discuss their preferred loading order. The TRC team notes there may be a self-selection bias in these responses, because the majority of builders were identified because of their participation in CAHP, a program encouraging energy efficiency.

Some market actors suggested revisiting the State loading order: As noted in Section 5.9.1, some jurisdictions have instituted PV ordinances without requirements for energy efficiency (beyond code), which run counter to the current State loading order. In an interview for this study, a Sebastopol city council member reported that his jurisdiction adopted a zoning ordinance requiring PV in residential and nonresidential new construction because of support from him and another council member. This city council member reported little resistance from the community, and attributed this to his jurisdiction's design of a "zero net cost" PV requirement.[68] When asked whether the city council considered an energy efficiency requirement, the city council member replied, "If a building meets code, code is efficient enough." Similarly, a building industry expert reported in an interview that based on his analysis of a home in California climate zone 4, if a home meets 2013 Title 24 requirements, PV is the next most cost effective strategy for reducing net energy consumption. In other words, for California climate zone 4, PV is more cost effective than energy efficiency measures beyond 2013 Title 24. The TRC team did not have access to these analyses and cannot comment on the analytical veracity of the respondents' views.

5.9.3. PV Ratemaking Reforms

Builders reported homebuyer confusion over net metering, supporting findings from previous studies: It was beyond the scope of this study to explore net metering issues in detail. However, in open-ended interview responses, four builders reported the need for greater clarity for how owners would be compensated for electricity that they supply back to the grid. This agrees with findings from the literature. Navigant (2014a) found that the overarching concern for the PV market lies in potential changes to net energy metering and retail rates enabled by AB 327. Navigant predicted these barriers to be more harmful to the residential PV market than the phasing out of CSI rebates. In a related study,

[68] Based on this council member's interview: Because first costs for PV are high, the jurisdiction's requirement calls for PV that roughly offset 75-80% of energy use. Based on this jurisdiction's solar incidence, which is very high, the council member reported that the cost of the PV system should break even at this system size.

Navigant found that substantial changes in net energy metering and rate structures could change the value proposition of customer-side PV or increase investors' perceptions of market risk, which could reverse progress made towards PV market transformation (Navigant 2014b). Navigant recommended that the California state agencies resolve the uncertainties regarding net energy metering and retail rate structure as quickly as possible, and reported that it will be important for the CPUC and other market actors (e.g., utilities, PV companies) to communicate the impacts of those changes to consumers (Navigant 2014a, Navigant 2014b).

The literature indicates that roofing maintenance can cause unexpected costs for PV systems: Navigant further noted the importance of providing resources to customers about PV benefits, costs, and risks due to their observation that customers did not fully understand the economics of PV, particularly third-party ownership arrangements such as leases (Navigant 2014b). These findings are consistent with the responses from code owners in this study's Code-built forum, who reported they did not find leasing panels attractive, because they were skeptical of the energy savings or did not understand the leasing process. Several Code-built forum participants remained undecided on whether they would install PV on their homes. Concerns included that they may not remain in the home long enough for the initial cost to pay back, and resale concerns.

In a related study, Navigant found that customers of both owned and leased PV systems need to be educated on the high likelihood that they will incur $3,500-$4,000 in re-roofing costs due to the lower lifetimes of roofs compared to PV systems (Navigant 2014c).

The consistency of this study's findings with the Navigant findings demonstrate the need to communicate PV benefits, costs, and risks carefully to prospective ZNE-type homebuyers.

5.9.4. 2016 TDV Update Process

Because the IEPR definition of ZNE is based on TDV, the TRC team investigated the TDV update and how it may affect ZNE-type homes. The TRC team presents full results in Section 9.11. Here, the team summarizes the TDV update and related research questions.

CEC is finalizing the 2016 TDV update: As of the time of this report, the CEC and its consultant, Energy and Environmental Economics (E3) are investigating several issues related to TDV as it applies to distributed generation. The key questions that they are addressing include:

- Do the same TDVs apply to renewable energy generated and consumed on site?
- Do the same TDVs apply to renewable energy exported to the grid?

Currently, the CEC has defaulted to assigning the same value for PV production and export as that for energy efficiency for the PV tradeoffs allowed in 2013 Title 24. The PV tradeoffs allow builders to trade off energy efficiency features with PV. While the CEC has not explicitly stated that PV production and export is the same value as energy efficiency (since the tradeoff is not calculated as such in the performance approach[69]), the practical impact is that PV is being equated to energy efficiency.

The 2019 TDV updates will require further investigation of the effect of increased renewables and higher distributed generation penetration: Looking further ahead to the 2019 TDV updates, there are several additional questions and considerations that the CEC will need to address, including the

[69] The PV performance is not directly calculated in the compliance software. Instead, the software models homes that have taken the PV tradeoff with the energy efficiency measures that the PV is deemed to have replaced/traded off. The input screens and software outputs including compliance forms will show the PV and not show the energy efficiency measures.

incorporation of renewable energy on capacity values in TDV, interconnection impacts of distributed generation, and how renewables will affect load profiles. Section 6.2.2 provides further detail on questions that the CEC should consider in the update process.

5.10. Drivers and Barriers for Market Actors

This section presents the drivers and barriers to several market actors key to the adoption of ZNE-type homes. The TRC team presents more detailed descriptions in Section 9.

Figure 42 and Figure 43 summarize drivers and barriers for ZNE-type homes and identified each as low, medium, or high in terms of their relative significance. When reviewing these figures, please note:

- As described in Section 3.3, this study collected market actor feedback using small sample sizes and primarily targeted market actors with ZNE-type and high performance home experience. The drivers and barriers identified here reflect those of early adopters, and may be different from the broader market.
- The drivers and barriers below are primarily those identified explicitly by market actors through open-ended questions. Some market actors may have identified additional drivers and barriers if the TRC team had provided them with a prompted list. For example, at least some appraisers and lenders may be motivated based on their personal or organization's sustainability goals, if asked about this motivation explicitly.
- For builders and owners[70], this section presents drivers and barriers identified directly by those market actors (i.e., by the builders and owners) and those identified indirectly by other market actors (e.g., what program managers believe are builders' drivers and barriers). In the subsections that follow these tables, the TRC team presents more detail on which market actors identified which drivers and barriers.
- Based on interviews with program managers, one of their goals is to increase the participation of ZNE-type homes that builders deliver through their programs. Program managers' drivers and barriers described here are reflective of this goal.

[70] For all other market actors, the TRC team only gathered data on the drivers and barriers directly from the market actors themselves. For example, the team asked planners about their drivers and barriers for adopting ZNE-type home ordinances, but did not ask other market actors (e.g., builders or appraisers) about their perception of planners' drivers and barriers.

DRIVER CATEGORY:	FINANCIAL CONSIDERATIONS		BUSINESS MODEL / MARKET CONSIDERATIONS			SUSTAINABILITY GOALS		CUSTOMER SATISFACTION
Market Actor	**Energy Savings**	**Resale Value**	**Marketing Differentiation**	**Desire to Innovate**	**Fulfillment of Responsibilities / Keeping up with Market**	**State Agency Goals**	**Personal / Organization's Goals**	**Improved Comfort and IAQ**
Builders			High	Medium		Low	Low	
Program Managers						Medium	Medium	
Appraisers			Low		Medium			
Lenders			Medium					
Building Officials					Medium			
Planners							Medium	
Homebuyers	High	Low					Low	Medium

Figure 42. Summary of Market Drivers

BARRIER CATEGORY:	FINANCIAL CONSIDERATIONS		MARKET CONSIDERATIONS			KNOWLEDGE / INFORMATION CONCERNS				TECHNICAL CONCERNS
Market Actor	**Incremental Cost or Additional Resources**	**Resale Value Concerns**	**Lack of Consumer Demand**	**Availability of ZNE-type Homes**	**Education / Training needs**	**Data Availability**	**Mis-perceptions of "ZNE"**	**Concerns for Managing High Tech Features**	**Confusion over PV Policies and Procedures**	**HVAC Equipment Needs and Ventilation Concerns**
Builders	Medium		High		Low		Low			Low
Program Managers	Medium		Medium			Low				
Appraisers	Low		Low	Low	Low	High				
Lenders	Medium		High		Low					
Building Officials	High				Medium		Low			
Planners	High		Low							
Homebuyers	High	Low		Medium	Low		High	Low	Medium	Low

Figure 43. Summary of Market Barriers

The following sections provide more detail on the information summarized in Figure 42 and Figure 43.

5.10.1. Builders

Figure 44 and Figure 45 present drivers and barriers to builders for constructing ZNE-type homes, in order of importance. The figures present drivers and barriers identified directly by the builders, and drivers and barriers that other market actors think may apply to builders. Note the TRC team interviewed only high performance builders (results are shown in the "Builder Identified" column), while the other market actors described drivers and barriers to the broader builder market (shown in the "Market Actor Identified" column).

Builders' Drivers to ZNE-type Homes (in order of importance)	Builder Identified	Market Actor Identified
Marketing Differentiation: Differentiate themselves from competitors and establish a competitive advantage.		Program Managers
Desire to Innovate: Attracted to the creativity and innovation required for ZNE-type building.	X	
Personal / Organization's Sustainability Goals: Reduce greenhouse gas emissions or meet other sustainability objectives for personal or organizational goals.	X	
State Agency Goals: Prepare for a ZNE code due to the State of California's sustainability goals.	X	Program Managers
Keeping up with Market: In rare cases, respond to customer requests for a ZNE-type home.	X	

Figure 44. Builders' Drivers to Pursue ZNE-type Homes

Builders' Barriers to ZNE-type Homes (in order of importance)	Builder Identified	Market Actor Identified
Lack of Consumer Demand: Lack of homebuyer demand for ZNE-type homes.	X	Program Managers, Building Officials
Incremental Cost: Incremental cost to build ZNE-type homes and the concern that customers will not pay this incremental cost.	X	Program Managers
Education / Training Needs: Identified several training or education needs, including: • Builder and subcontractor training for achieving above code construction, including high performance attics and installing ducts in conditioned space. • Building official training needs, to allow for permitting high performance homes without delay.[71]	X	Building officials (agreed that builder and subcontractor training is needed)
Misperceptions of "ZNE": Unrealistic expectations about ZNE from some homebuyers.	X	Program Managers
HVAC Equipment Needs: A few builders noted HVAC equipment and sizing concerns, such as a lack of HVAC systems small enough to meet the reduced loads in ZNE-type homes.	X	

Figure 45. Builders' Barriers to Pursue ZNE-type Homes

5.10.2. Program Managers

Top **drivers** to program managers for incentivizing ZNE-type homes in their programs include:

- Organization's sustainability goals: ZNE-type homes help meet organization's goals of reduced energy consumption.
- State agency goals: ZNE-type homes meet general statewide goals, particularly the goals for ZNE-type homes laid out in the California Energy Efficiency Strategic Plan.

Top **barriers** to program managers for incentivizing ZNE-type homes in their programs include (in order of importance):

- Lack of consumer demand: The lack of demand reduces the number of ZNE-type homes that builders deliver through programs.
- Incremental cost (to builders): Incremental cost reduces the number of builders that deliver ZNE-type homes through programs.
- Data needs:
  - In an ACEEE paper, the IOU CAHP program managers described the need for an Energy Use Intensity (EUI) metric to track progress towards ZNE because a Title 24-based metric only includes heating, cooling, and domestic hot water (i.e., ignores appliances, lighting, plug-

[71] Builders noted that permitting issues are decreasing as advanced building practices become more common.

loads), and because a percent-based metric does not indicate whether a home is ZNE (Christie et al. 2014).

- In interviews for this study, some program managers reported that the coordination of data between the energy efficiency and PV programs (i.e., CAHP and NSHP) was not always smooth, but noted that this has improved recently.

5.10.3. Appraisers

Appraisers reported that their top **drivers** for valuing ZNE-type homes and for gaining competency in the valuation of ZNE-type homes include:

- Fulfillment of responsibilities / keeping up with market: The Appraisal Foundation's Uniform Standards of Professional Appraisal Practice (USPAP), Fannie Mae, and Freddie Mac have directives related to the valuation of energy efficient features in homes. When appraising a home with energy features, it has already been established that appraisers are required to recognize these features and their potential contribution to value.
- Marketing differentiation: Related to the driver noted above, by obtaining training and/or experience valuing ZNE-type homes, an appraiser is able to conduct valuations on a larger range of projects.

Appraisers reported that their top **barriers** for valuing ZNE-type homes include, in order of importance:

- Data needs: These include:
  - A lack of comparable homes (i.e., data from sales of other ZNE-type homes).
  - Missing or inconsistent information regarding energy and high performance home features in Multiple Listing Service (MLS) databases.
- Additional resources: The typical time constraints and fees do not provide for the additional investigation and other efforts necessary for the valuation of ZNE-type high homes.
- Education / training needs: Appraisers noted a need for:
  - Lender education, to gain a general understanding of energy and high performance features.
  - Realtor training, to gain a general understanding of energy and high performance home features and their benefits, and for reporting these features.
- Lack of consumer demand and consumer education needs: Knowledgeable consumers are more likely to ask their realtors and builders about energy features, request homes with these features, and expect that these features will be valued appropriately.

5.10.4. Lenders

Lenders did not directly state what their **drivers** for ZNE-type financing are. However, the TRC team infers from the results:

- Marketing differentiation: By offering financing (beyond standard financing for a code-built home) for ZNE-type homes, lenders provide a product and service that can better serve their customers and potentially set themselves apart from other lending organizations.

Top **barriers** to lenders for providing financing (beyond standard financing for a code-built home) for ZNE-type homes are:

- Lack of consumer demand: Most lenders interviewed do not see enough current or potential demand to pay attention to EEMs or related financing products. Golden (2014) noted that the number of EEMs has dropped in the U.S., from 2,496 in 2010 to 601 in 2013, which supports this finding on the low use of EEMs. This was also supported by findings in this study: The TRC team asked ZNE-type owners whether they used an EEM to purchase their home, and none of the 47 owners reported they had.
- Additional resources: According to the lender interviews, because lenders make money on loan origination by standardizing the process, lenders perceive the occasional EEM and its additional paperwork, customer handholding, and other needs, as a hassle.
- Education / training needs**:** Lenders reported that:
  - Most homebuyers are not aware of EEMs. Also, owners that do learn about EEMs generally find out about them after they have chosen a home, so the EEM does not influence their purchasing decision.
  - There is a lack of appraisers who have the proper training in valuing energy efficiency or distributed generation.

5.10.5. Planners

The planners identified top **drivers** for adopting Reach Codes, ordinances requiring PV, or other types of ordinances for above code construction as:

- State agency goals: These ordinances help meet general statewide goals, reflected in Climate Action Plans.
- Organization's sustainability goals: These ordinances meet jurisdiction's general commitment for energy efficient and sustainable building practices.

Planners identified the top **barriers** for adopting Reach Codes or other types of ordinances for above code construction as:

- Incremental cost: The additional cost of building a ZNE-type home raises two challenges:
  - Reach Codes must pass the CEC's cost effectiveness test, which can be a challenge, particularly for jurisdictions in mild climates.
  - Local builders, city council member, and others can resist these ordinances over concerns that they will be too expensive for builders and their subcontractors.

5.10.6. Building Officials

Based on the building official discussions, top **drivers** to building officials for permitting or gaining training in permitting ZNE-type homes are:

- Keeping up with market: Some building officials reported that the prevalence of homes built above code or with PV has increased over the past five years.

Top **barriers** to building officials for permitting ZNE-type homes are:

- Additional resources: Building officials noted the need for more staffing support and budget resources for enforcement.
- Education /training needs: Building officials noted the need for training to address challenges with code built construction, as well as above code construction. Officials reported:

- Architects lack familiarity with energy codes, particularly because the energy codes are (to quote one official) "constantly updated."
- Builders and subcontractors do not always install measures according to code.
- PV contractors' installations sometimes deviate from plans.

5.10.7. Homebuyers

This section summarizes drivers and barriers to homebuyers for purchasing ZNE-type homes. Due to varying levels of familiarity with the ZNE concept, the TRC team did not ask all types of owners (i.e., ZNE-type, Energy Efficient, and Code-built) the exact same questions. Consequently, this section does not present the exact same information for all owner types. Also, Figure 46 and Figure 47 identify drivers and barriers identified by the owners, compared with drivers and barriers that other market actors (e.g., builders) think may apply to owners.[72]

In general, direct owner feedback indicates that energy savings, followed by comfort and improved indoor air, are the most significant drivers: Figure 46 summarizes top drivers to homebuyers for buying ZNE-type homes. Energy savings appear to be the main driver.

Owner feedback indicates sustainability less of a driver than expected: Overall, the findings presented here agree somewhat with those identified by a survey of ZNE experts (a mix of builders, program managers, industry experts, and others), who identified consumers' drivers as reduced operating costs (90% of respondents), followed closely by reduced environmental footprint (75% of respondents) (Net Zero Energy Home Coalition 2012). However, the ZNE experts and the builders and program managers interviewed here put a larger emphasis on sustainability as a driver than the TRC team found through direct owner feedback. In particular, as described in Section 9.1.5, six of the eight custom builders identified environmental concerns as homebuyer motivations, but less than one-fifth (three of the eighteen) of custom ZNE-type owners, and none of the production ZNE-type owners (zero of twenty-four), identified sustainability as a feature they considered.

Availability is a barrier. Of the Energy Efficient owners with homes without PV, 40% reported that they were not offered PV as an option.

[72] Note the TRC team collected feedback primarily from ZNE-type and Energy Efficient owners, while the other market actors described drivers and barriers to the broader homebuyer market.

Homebuyers' Drivers to ZNE-type Homes, in order of importance	Owner Identified	Market Actor Identified
Energy Savings: Various data indicate that the energy bill savings is the primary driver[73]: • In a prompted question, ZNE-type owners identified very low utility bills as a higher priority than energy efficiency and a PV system, although few owners identified low utility bills as their primary purchasing criteria in open-ended questions. • ZNE-type forum participants identified energy bill savings as a driver to purchasing their home and as a major source of satisfaction with their home. • Several Code-built forum participants reported they would place a higher priority on energy efficiency or PV with their next home purchase, because of their current homes' high-energy bills. • Builders and program managers reported that homebuyers are primarily motivated to purchase ZNE-type homes for financial benefits, particularly lower energy bills.	X	Builders, Program Managers
Improved Comfort and IAQ: Several data indicate that improved comfort (temperature balancing and acoustics) and improved IAQ are drivers: • In a prompted question, more ZNE-type owners identified comfort and IAQ as high purchasing priorities (86% and 77%, respectively) than identified very low utility bills (65%). However, no ZNE-type owners identified comfort and IAQ as purchasing criteria in open-ended questions. • One ZNE-type forum participant was particularly pleased with the improved acoustics of his home. • Code-built forum participants described poor temperature differences among rooms as a source of dissatisfaction. • Production builders believe that comfort, and custom builders believe that improved indoor air quality, are buyer motivations.	X	Builders
Sustainability: Personal concerns about sustainability is a driver for some owners: • 17% (3 of 18) custom ZNE-type owners, but none (0 of 24) of the production ZNE-type owners, identified sustainability or a low energy footprint as a driver for purchasing their home. • One Code-built forum participant liked the ZNE concept for reducing carbon footprints. • Program managers and builders reported that sustainability concerns may motivate some early adopters.	X	Builders, Program Managers
Resale Value: ZNE-type and Energy Efficient owners expect their home to sell for a higher price because of its energy features. Their willingness-to-pay for a ZNE-type home also increased with their expected sales price of their current home, indicating that increased resale value may motivate some homebuyers.	X	

Figure 46. Owners' Drivers to Buying ZNE-type Homes

[73] ZNE-type and Energy Efficient owners identified energy efficiency, PV, and low utility bills as important features. The data collected in this study does not clearly identify *why* energy efficiency and PV were drivers (e.g., energy savings, sustainability reasons, or other drivers).

Incremental cost is the most significant barrier: Figure 47 summarizes top barriers to homebuyers for buying ZNE-type homes, and shows incremental cost as the most significant.

Homebuyers' Barriers to ZNE-type Homes, in order of importance	Owner Identified	Market Actor Identified
Incremental Cost: • ZNE-type owners cited initial cost as their main barrier for purchasing a ZNE-type home. • Code-built forum participants expressed enthusiasm for the ZNE concept, but cited cost as the main barrier. • Builders and program managers reported that the main barrier for homebuyers is incremental cost, and that this premium must compete with costs for other additional features (e.g., granite countertops, swimming pool).	X	Builders, Program Managers
Misperceptions of ZNE and Efficiency: Feedback from owners indicated that they have misperceptions about ZNE-type homes and efficiency in general: • Builders, appraisers, and building officials indicated a need for owner education regarding the benefits of ZNE-type homes. • One-third of ZNE-type owners think ZNE means either no utility bill or off-the grid. • As described in Section 9.8.4, ZNE-type forum participants appeared to attribute most of their energy savings to PV, rather than energy efficiency, although the energy model results for these homes suggest that efficiency is primarily delivering the savings. Program managers and appraisers also noted the homebuyers typically value PV more than efficiency. This indicates the homebuyers could benefit from a greater understanding of the importance of efficiency. • Code-built forum participants described that a one-story home was more efficient or led to uneven temperature distribution, and that large foyers contributed to heat gain. This indicates misperceptions about energy performance. • Owners in both forums (the ZNE-type and Code-built) expressed confusion over how a leased PV system would be treated at the time of sale.	X	Builders, Program Managers, Appraisers, Building Officials
Availability of ZNE-type Homes: • Among Energy Efficient owners without PV, 40% reported one reason they did not purchase PV was because PV was not offered. • Several Code-built forum participants reported that energy efficiency features and PV were not offered as options, but they would have been interested in these features.	X	
Confusion over PV Policies and Procedures: • A few ZNE-type and Energy Efficient owners were surprised and frustrated by the annual true-up bill for their PV system. • Code-built owners did not understand the PV leasing process and were concerned about how PV would affect home resale. • Builders reported that owners' are confused regarding net metering policies.	X	Builders (reported confusion over net metering)

Resale Value: Some production owners reported they had initial concern about resale value at the time of home purchase. In prompted questions[74]: • Almost half of production ZNE-type owners, but only 11% of custom ZNE-type owners, identified resale value as an initial purchasing concern. • Over half (57%) of Energy Efficient owners, almost all of which owned production homes, reported that they were at least somewhat concerned with resale value when they initially purchased their home.	X	
Concerns for Managing High Tech Features: When asked in a prompted question, some owners reported they had concern at the time of home purchase over monitoring or maintaining PV panels, appliances, or other controls: • Approximately one-quarter (12 of 42) of ZNE-type owners reported concern about managing high tech features. • One-third of the Energy Efficient owners reported they were somewhat (26%) or highly (85%) concerned about managing high tech features. Owners with PV were significantly more like to report a concern than those without PV.	X	
Ventilation Concerns: When asked in a prompted question, some owners reported they had concern at the time of home purchase that their homes would not provide sufficient ventilation: • Almost half (9 of 19) of custom ZNE-type owners, but few (4 of 23) production ZNE-type owners reported this concern. • Almost half of Energy Efficient owners (almost all of which were production owners) reported they were either somewhat concerned (19% - 21 of 111) or highly concerned (27% - 30 of 111). One program manager reported that homebuyers have a concern regarding sufficient ventilation.	X	Program Manager

Figure 47. Owners' Barriers to Buying ZNE-type Homes

Some owner barriers may be perceived, not actual: As shown in Figure 47, some ZNE-type owners had initial concerns regarding resale value, their ability to manage high tech features, and that their homes would not provide sufficient ventilation. The TRC team cannot state whether concerns regarding resale value were justified, since the owners interviewed have not sold their ZNE-type or Energy Efficient homes. However, it is interesting to note that, after living in these homes, the majority of owners believe their homes will sell for a premium (as shown in Figure 40 and Figure 41 in Section 5.7.3.2). In addition, as described in Section 5.7.2, studies have found that ZNE-type homes generally sell for more than Code-built homes.

5.11. Opportunities Identified by Market Actors

The interviewed and surveyed market actors identified various opportunities for helping to overcome barriers to ZNE-type homes. The TRC team summarized these opportunities below. The TRC team incorporates many of these opportunities as recommendations in Section 6.

[74] As part of the ZNE-type owner interviews and Energy Efficient surveys, the TRC team asked owners whether they were "highly," "somewhat," or "not at all concerned" about several potential issues at the time of initial purchase.

5.11.1. Training and Education

Builder training: Building officials called for builder education regarding the new Title 24 requirements and how to meet them. One recommended mandatory training for contractors when renewing their license. One planner from a small jurisdiction reported that he individually works with local builders to educate them on how to build near ZNE homes in a cost effective manner, and recommended that other jurisdictions adopt this approach.[75]

Subcontractor training: Builders called for subcontractor training to deliver the high performance strategies used in ZNE-type homes. Building officials identified the need for increased knowledge of energy efficient building practices at all levels, including subcontractors, architects, and engineers.

Realtor education: Several appraisers and one lender recommended training for realtors on how to recognize and promote energy related features.

Appraiser training: While most of the appraisers interviewed here had taken some sort of training on energy efficiency or PV, about half reported difficulty finding training in their region, and the majority of appraisers would take additional training if available.

Lender education: Appraisers noted that lenders need education on the benefits of energy efficiency and PV and training on valuation methods that may be used with ZNE-type and high performance homes (summarized in Section 9.3.2 and described in more detail in Section 3.3.6 of the report Attachment).

Targeted building official education: When asked if there was a need for additional training for building officials, most building officials reported having access to sufficient training. However, one building official reported that building officials in the Central Valley could use additional training.

Homebuyer education: Builders called for increased consumer education and marketing. Program managers noted that homebuyers need to understand the profound impact that their behavior plays in their home's energy consumption. Appraisers indicated that consumers need more education about their energy use, energy efficiency, and the likeliness that energy costs will increase over time. The appraisers interviewed suggested that knowledgeable consumers are more likely to ask their realtors and builders about energy features and request homes with these features.

Demonstration homes: Two production builders and building industry experts recommended demonstration homes. As one described, it shows homebuyers "something tangible, beyond an academic concept."

5.11.2. Programs, Incentives, and Resources

Utility incentives: Several market actors, including builders and owners in the Code-built forum, recommended increased utility incentives for ZNE-type homes to help overcome cost barriers.

Improved program coordination: Some program managers recommended improved coordination between programs incentivizing energy efficiency and PV.

Resources for building officials: Building officials reported that they needed more resources and staff to assist in the code compliance process for both homes built to code and homes exceeding code.

[75] The builders interviewed here did not directly ask for more training. However, the TRC team only interviewed high performance builders. Also, questions on training can be difficult to interpret, because respondents "don't know what they don't know."

5.11.3. Data Needs

Data tracking: As described in their ACEEE paper, the CAHP program managers and PG&E CAHP implementer recommended that programs aligned with ZNE goals should evolve their core metrics and methods so that all building end uses are addressed, and so that energy efficiency is measured based on net energy use (Christie et al. 2014).

Data for ZNE-type home appraisals: Appraisers identified several tools that would be useful for the process of appraising ZNE-type and other high performance homes. These included access to anonymized energy bills, utility verified calculators to determine the value range for various energy related measures, and documentation and case studies of homes with reduced energy costs due to upgrades. The appraisers suggested that utilities could support or create a repository of data and statistics about the energy savings resulting from various energy upgrades. This repository would store information that the appraisers could contribute to and use as documentation when valuing homes.

5.11.4. Financing Needs

EEM facilitator model: Two lenders described a model that has evolved in the Sacramento area in which independent facilitators specialize in doing the extra work involved with an EEM. This minimizes the hassle for all involved (buyer, lender, and realtor) and avoids delaying the transaction. The lender may be the first to educate the customer about the availability of the program. The facilitator, rather than the lender, handles the additional work required for the EEM, and the facilitator's fee can be financed into the EEM.

Lender/ZNE-type builder collaboration: As several lenders pointed out in their interviews, there is little demand for financing products for ZNE-type homes, and a subsidy on a product for which there is little demand would not be of interest to them. However, when combined with marketing strategies to help generate focused demand, such as collaborating with production builders for ZNE-type or high performance homes, at least one lender expressed genuine interest. A UC Berkeley study supported this suggestion; Fuller (2009) found that financing programs with higher participation rates tended to have networks of engaged and informed contractors who use the financing program as a sales tool.

5.11.5. Policy Clarifications

ZNE definition clarifications: Several market actors requested clear messaging and consistent definitions for ZNE to set homebuyers' expectations.

Net metering clarifications: Builders requested policy clarifications for net metering for PV owners.

6. CONCLUSIONS AND RECOMMENDATIONS

In its Long-Term Energy Efficiency Strategic Plan, the CPUC set a goal for all new residential construction to be ZNE by 2020 (CPUC 2008). In an updated document, the CEC and CPUC provided an Action Plan Vision Framework, which provided goals towards achieving this ZNE target (CEC and CPUC 2013). These goals were to:

1. Create deep awareness of the value and benefits of ZNE with homebuyers and builders to spur demand and drive broader industry involvement.
2. Adopt a residential workforce sector strategy to increase participation in and improve the quality of education and training for industries related to planning, designing, constructing, and developing ZNE homes.
3. Ensure availability, effectiveness, and efficiency of technical tools for designing, modeling, constructing, and monitoring ZNE buildings.
4. Develop specific approaches and standards to quantify the value of ZNE homes, support a robust financing market, and ensure that ZNE homes are affordable.
5. Drive future grid infrastructure and technological improvements to support State distributed generation goals and a ZNE Building Future.
6. Align the development and implementation of regulations, policies, plans, incentives, and codes related to ZNE building.

This study provides specific findings and recommendations to pursue these goals, as depicted in Figure 48, with further detail on each conclusion and recommendation in the sections below. When reviewing these conclusions and recommendations, note that:

- Many of these conclusions are related, and many of the recommendations overlap and support each other.
- When referencing the PAs, the TRC team includes the IOUs; the Regional Energy Networks (RENs); the Community Choice Aggregators (CCAs); and the Publicly Owned Utilities (POUs), including the municipal utilities.

The TRC team also provides the following general recommendations.

Collaboration will be critical: In general, the TRC team notes that many of the barriers to ZNE-type homes will require actions by various stakeholders and market actors—not just the California regulatory agencies and the PAs—and that several of the issues and barriers are not specific to California. Consequently, the TRC team encourages the regulatory agencies and the PAs to continue to expand active engagement with industry groups and ZNE leaders, both at the state and national level. These collaborations should leverage existing initiatives that are promoting ZNE-type homes to achieve the rapid increase in knowledge and other market transformation steps that will be necessary for meeting California's aggressive ZNE goals.

ZNE residential new construction by 2020 will require a complete market transformation: While this study found that the penetration of ZNE-type homes has increased to approximately 1% for 2014 (up from 0.2-0.4% in previous years), this still represents the innovator stage of market adoption. In addition, ZNE homes comprise only ~0.01% of the market; the majority of ZNE-type homes found in this study are near ZNE. If California truly intends to achieve all ZNE new construction by 2020, the California agencies that set the ZNE targets and the PAs that support these strategies must markedly increase efforts to educate, train, and financially support the market towards adoption of ZNE-type homes;

expand efforts to market and message ZNE-type homes to increase consumer demand; prioritize ZNE-related research; and hasten the pace of ZNE-related policies. To move ZNE along the market adoption curve from the innovator stage in 2014 to being widely available and the industry norm in 2020, will require a market transformation in only six years.

Expand proven efforts, and test new approaches: The state agencies, PAs, and other collaborators are working to design and implement many of the solutions needed to reach the 2020 goals. However, to achieve the rapid market transformation necessary, these activities must be expanded and accelerated. In addition, the market transformation to ZNE that California has called for represents unchartered territory, which has not been accomplished elsewhere. Consequently, many of the recommendations provided below have not been tested before, but are based on the findings of this study.

Category	Subcategory	Supporting Conclusion	Recommendation	Lead	Support	Action Plan Goal (s)
ZNE Market Transformation Initiative	*Encourage Builders further down the EUI Continuum*	6.1.1.1	Expand programs targeting ZNE, and for ZNE-ready and near ZNE homes, particularly within 5-10% of the incremental cost compared to a code-built home.	PAs	CPUC, CEC	1, 4
		6.1.1.2	Continue programs for Energy Efficient homes as a stepping-stone for ZNE, but target builders that have been non-participants to date.	PAs	CPUC, CEC	1, 4
		6.1.1.3	Transition to a single market transformation program for energy efficiency and distributed generation.	PAs	Legislature, CPUC, CEC,	5
		6.1.1.4	Because different organizations track ZNE-type homes using different metrics, develop a central repository of ZNE-type homes or (at a minimum) consistent tracking metrics for tracking progress towards ZNE goals.	PAs	CEC, US DOE, California HERS Providers	1, 3
	Expand Market Actor Training and Collaboration	6.1.2.1	Continue and expand education efforts for builders and their contractors and trades regarding code compliance and above code building practices.	PAs	CEC, building departments	2
		6.1.2.2	Support real estate agents and lenders by holding symposiums for builders, appraisers, lenders, and realtors with interest and training in ZNE-type homes; bringing together ZNE-type homebuilders and Energy Efficient Mortgage (EEM) lenders;	PAs	CEC, CPUC, CalBRE[76], BREA[77]	1, 4

[76] California Bureau of Real Estate

[77] California Bureau of Real Estate Appraisers

			investigating a model through which a facilitator handles the additional paperwork of an EEM; providing a platform for connecting lenders with appraisers trained on ZNE-type homes; and providing training for realtors on how to recognize and promote ZNE-type home features.		
		6.1.3.1-6.1.3.2	Work with builders to develop clear and consistent messaging for the 2013 IEPR's ZNE definition that builders are comfortable promoting, and expand the reach of ZNE-type demonstration homes.	PAs	CEC	1, 2
		6.1.3.3	Provide educational toolkits to help builders address homebuyers' concerns about the re-sale value of ZNE-type homes, by promoting study results showing higher resale values of Energy Efficient and solar homes.	PAs	CEC	1, 4
	Expand Marketing of ZNE-type Homes with Consistent Messaging	6.1.3.4	Once the State agencies update net-energy metering and other policies, work with these agencies, builders, and PV installers to educate homebuyers on how these policies affect them.	PAs	CEC, CPUC	1, 6
		6.1.3.5	Reframe the incremental cost paradigm by providing additional incentives and technical assistance to builders that meet the following challenge: using an identical budget for your non-ZNE home, how would you build a ZNE home that is as comparable as possible?	PAs	CEC, CPUC	2, 4
		6.1.3.6	Support builders in highlighting comfort benefits of ZNE-type homes through customer testimonials.	PAs		1

		6.1.3.7	Address homebuyers concerns about managing high tech features by providing template homeowner orientations to builders.	PAs		2
		6.1.3.8	Based on customers' satisfaction with PV displays, encourage builders to install home energy monitoring systems.	PAs		1, 3
	Research Natural Gas Appliances in ZNE-type Homes under an Evolving Grid	6.1.4	Investigate consumer preferences, greenhouse gas emissions, and cost effectiveness impacts (to the owners and the utilities) of equipment with different fuel sources, under an evolving grid.	PAs		6
ZNE-Related Policies	*Identify Consistent Metric(s) for Tracking ZNE-type Homes*	6.2.1	To address the difficulty of tracking progress towards ZNE under a Title-24 based metric, identify an EUI-based metric for tracking projects in energy efficiency and distributed generation programs.	CEC	PAs	4
	Assign Value for Distributed Generation in TDV	6.2.2	Finalize policies for how TDV will account for PV generation in the CEC's TDV-Lifecycle cost update process.	CEC		5
	Develop Equivalencies for Distributed Generation	6.2.3	Because not all homes can feasibly achieve ZNE on their own (e.g., due to lack of roof space for PV), develop equivalencies for the distributed generation aspect of ZNE.	CEC	PAs and local jurisdictions	6
	Consider Short-term, Voluntary ZNE Provisions	6.2.4	Work with planners to develop short-term voluntary provisions, with carrots for ZNE-type construction.	CEC	Local jurisdictions	6
	Encourage Energy Use Disclosures	6.2.5	To address appraisers' challenges from the lack of sales data for ZNE-type homes, work with the National Association of Realtors and the California	CEC	CalBRE, National Association of Realtors	4

			Bureau of Real Estate (CalBRE) to encourage realtors to provide energy use disclosures.			
ZNE Research Priorities	*Develop Ranges of Actual Home Performance*	6.3.1	Because owners may interpret ZNE based on actual rather than modeled energy performance, collect performance data from occupied ZNE-type homes to: (1) understand how occupant behavior can affect energy use, (2) develop ranges of energy use based on actual ZNE-type homes, and (3) improve energy modeling.	PAs	CEC, CPUC	3
	Use and Improve the Energy Performance Categories	6.3.2	In future ZNE-type home studies, use and improve the catalog of energy performances developed in this study.	CEC	PAs	3
	Develop an Evaluation Plan to Support ZNE	6.3.3	Develop an evaluation research plan to support the State's ZNE goals including a full market baseline study that gathers feedback from the broader market, a market transformation study around 2018, and a market characterization of multifamily homes.	PAs, CEC, CPUC		1
	Research Barriers and Opportunities for Community-Scale Distributed Energy Resources	6.3.4	The lack of market actor experience with renewable energy resources beyond rooftop PV demonstrates the need to understand barriers and opportunities for community-scale Distributed Energy Resources (DERs) options for ZNE-type homes.	PAs, CEC, CPUC		5
	Evaluate Operational Challenges for Homebuyers	6.3.5	Track operational issues with ZNE-type homes so that builders can improve construction practices to address actual homebuyer concerns and develop messaging to address perceived concerns.	CEC	PAs	1, 2, 5

Figure 48. Summary of Recommendations

6.1. ZNE Market Transformation Initiative

The findings from this study indicate that it would require a tremendous effort to move the market from approximately one dozen ZNE homes in 2014 to 100% ZNE residential new construction by 2020. An effort of that magnitude would require substantial contributions from various market actors. From a programmatic perspective, the PAs would need legislative or regulatory direction to offer ZNE-related activities through a ZNE Market Transformation Initiative. This initiative could be akin to the California Solar Initiative (CSI), a market transformation initiative that has leveraged more than $2 billion over 10 years to help transform the PV industry (described in more detail in Section 6.4).

A ZNE Market Transformation Initiative is needed as soon as possible that will help transition the market through the following primary components:

- Programs that provide sufficient incentives and technical assistance to overcome barriers to ZNE-type home construction,
- Market actor training and collaboration, and
- Marketing and messaging.

The sections provide detail on each of these recommended components. Because the PAs manage programs, including market actor training, the PAs would lead many of these efforts. However, because only the legislature and CPUC have the authority to authorize spending on these efforts, they would need to provide both the authority for such an undertaking, and the financial support. The CEC would also play an important supporting role due to its development of codes and standards, code compliance activities, builder and rater support, management of the NSHP program, and other efforts.

The CEC and the PAs (through their Codes and Standards programs) have helped move the market towards ZNE by continually increasing the energy efficiency requirements in new versions of Title 24. Modeling predicts that the regulated loads of homes built under the 2013 Title 24 should require approximately 40% less electricity and peak demand and at least 10% less natural gas than homes built under the 2005 Title 24.[78] The CEC and PAs are working on 2016 Title 24 updates and will soon start working on 2019 updates to the regulated loads. However, the market still needs considerable assistance to reduce the energy use of both regulated and unregulated loads (e.g., appliances and plug-in loads), and to increase distributed generation, in order to reach ZNE goals.

6.1.1. Encourage Builders further down the EUI Continuum

6.1.1.1. Expand Programs for ZNE and Near ZNE Homes

Conclusion: As described in Section 5.1, this study identified 16 ZNE homes according to the CAHP and RFI data, representing 0.01% of total market share. However, this study found almost one thousand near ZNE homes (i.e., highly efficient with distributed generation), and it found that near ZNE homes represented approximately 1% of the market in 2014. The number of near ZNE homes also appears to be higher than the number of ZNE-ready (i.e., highly efficient without distributed generation) homes.

[78] Based on impact analysis for 2013 Title 24, http://energy.ca.gov/2013publications/CEC-400-2013-008/CEC-400-2013-008.pdf, homes built to the 2013 Title 24 standard use 36% less electricity, 40% less peak demand, and 7% less natural gas on average compared with homes built to 2008 Title 24. Similarly, based on impact analysis for 2008 Title 24, http://www.energy.ca.gov/title24/2008standards/rulemaking/documents/2007-11-07_IMPACT_ANALYSIS.PDF, homes built to 2008 Title 24 use 23% less electricity, 8% less peak demand, and 10% less natural gas compared with 2005 Title 24. Savings from the two standards are not directly additive, and 40% is likely an underestimate of total electricity and demand savings.

The prevalence of near ZNE home and the scarcity of ZNE homes indicates that the market may be more ready to embrace near ZNE construction than ZNE construction in the short term. Incremental cost is the biggest barrier to all ZNE-type home construction.

Recommendation: The PAs should expand programs targeting ZNE, ZNE-ready, and near ZNE homes, particularly within 5-10% of the incremental cost compared to a code-built home. The PAs should assist builders to build ZNE-type homes that are within 5-10% above the price of code-built homes. This range is within builders' reported incremental cost to build ZNE (i.e., 5-15%), and early adopters' reported willingness-to-pay for a ZNE-type home (1-12%). These efforts should include:

- Pilot programs for ZNE-ready and near ZNE homes, such as those explored by some utilities (e.g., SMUD). These should explore ways to cost effectively build ZNE-type homes within the 5-10% incremental cost range, particularly for subdivision developments—not single homes.
- Pilot programs for ZNE homes, such as those already explored by some PAs. These should serve as testing grounds or demonstrations of new technologies and approaches to build cost-effective ZNE homes.

For both of these ZNE-type programs, the PAs should:

- Provide higher incentives and technical assistance to builders.
- Provide a stipend to appraisers for valuing ZNE-type homes to offset the additional work required to assign value to the energy efficiency and distributed generation features.
- Offer owner incentives for participating in a high performance home feedback program, in which the owner:
  - Allows the PAs to use his/her energy bill data to develop estimates of actual energy use.
  - Provides the PAs with occupancy data and information on usage patterns (e.g., changes in occupancy or major purchases) to interpret energy bill data.
  - Has the opportunity to provide feedback on comfort or other benefits, which (if the customer agrees) should be included in a case study.

6.1.1.2. Continue Programs for Energy Efficient Homes

Conclusion: ZNE-type and energy efficient homeowners indicated that their willingness-to-pay for their next ZNE-type home increased with their perceived value of their current home. Consequently, once an owner purchases a ZNE-type or an energy efficient home, he/she may be more likely to pay for a ZNE home.

Recommendation: The PAs should continue programs for Energy Efficient homes as a stepping-stone for ZNE, but target builders that have been non-participants to date. These programs provide valuable high-performance home experience to various market actors (including builders, subcontractors, appraisers, lenders, and raters). The PAs should target builders that have traditionally produced Code-built homes (i.e., not participated in energy efficiency programs) to provide them exposure and experience with energy efficient construction practices.

In addition, because of these programs, more owners have experience living in energy efficient homes, which may increase their likelihood of purchasing a ZNE home in the future. However, it is unlikely that an owner buying a new home in 2015 will buy another house by 2020 that is ZNE. Thus, it is more important to capture the lessons learned and the benefits observed by owners in these efficient homes in future marketing and messaging platforms for ZNE-type homes. Combined with the next

recommendation about promoting lower net energy use, this will result in an increased awareness of ZNE-type homes and may spur greater demand for ZNE homes.

Recommendation: The PAs should provide escalating incentives for lower net energy use. As is done in the CAHP program, programs for energy efficiency and PV should provide builders with a higher incentive for delivering a home with a higher projected energy performance, to move builders further along the energy efficiency continuum and closer to ZNE. The programs should actively encourage builders currently participating in the programs to develop more efficient design and construction practices so that their homes approach ZNE.

6.1.1.3. Transition to a Single Market Transformation Program for Energy Efficiency and Distributed Generation

Conclusion: Currently, under most of the PAs' programs (including the IOU programs), builders use two different programs to receive all possible incentives for energy efficiency and PV (CAHP and NSHP), which is cumbersome. Also, some program managers reported the need for improved collaboration between these programs, including better data sharing. The TRC team concurred with program managers after reviewing the CAHP and NSHP databases and finding various differences in how these programs track projects. In addition, the previous PV kicker for some IOU CAHP programs required that all homes in a development have PV to receive an incentive.

Recommendation: Mid-term, the PAs and the CPUC should seek legislative support to merge or integrate new construction incentive programs for energy efficiency and distributed generation under the market transformation umbrella. Currently, the CPUC oversees cost effectiveness requirements and regulates IOU programs, including CAHP – which primarily incentivizes energy efficiency; whereas the CEC runs the NSHP program. While CAHP and NSHP programs should continue under the current administrators in the short term, they should increase their coordination to encourage deeper savings and renewable generation as a package.

The PAs and CPUC should seek legislative support to create a new program that merges energy efficiency and distributed generation; this program should begin when the CSI program expires in 2017. A single program would increase participants' awareness of incentives for, and the benefits of, both efficiency and distributed generation. It would also simplify the participation process for builders. For the PAs and the regulators, this merge also opens up possibilities of developing demand response, energy storage, and grid management offerings that can layer on top of energy efficiency and distributed generation. To merge energy efficiency and distributed generation into a single programmatic element will require the California Legislature, CPUC, CEC, and IOUs to collaborate to resolve policy and jurisdictional issues.

Recommendation: Short-term, the PAs should cross-promote energy efficiency and distributed generation and track projects using consistent metrics. PAs should ensure strong collaboration and cross-promotions between new construction energy efficiency (e.g., CAHP) and distributed generation programs (e.g., NSHP) through such approaches as incentive kickers. These programs should also align with state agency policies regarding the loading order for energy efficiency and distributed generation. As part of this effort, the PAs should encourage all homes in a development to include PV, but provide partial incentives for builders that install PV in only some homes in a development. In addition, the programs should improve consistency in data tracking so that researchers can more easily track which projects participate in both programs, and identify which developers or builders only participate in one program, representing a potential opportunity for the other program.

6.1.1.4. Develop Repository for Comprehensively Tracking ZNE-type Homes

Conclusion: There are various organizations working towards the ZNE goal, but they track homes using different metrics and database formats. This hinders the ability for any one organization to quantify the number of ZNE-type homes and track progress towards ZNE goals.

Recommendation: The PAs should work with the CEC to develop a central repository of ZNE-type homes or consistent tracking metrics. The PAs should collaborate with organizations that encourage ZNE-type homes including the CEC, the U.S. DOE, California HERS providers, and voluntary labeling programs to identify how they are tracking ZNE-type homes. If possible, the PAs should track ZNE-type homes in one location (e.g., an on-line platform where raters could upload data). If this is not feasible, the PAs should work with these organizations to identify metrics for tracking energy performance and discuss the possibility for periodically combining data for a comprehensive assessment of ZNE-type homes.

6.1.2. Expand Market Actor Training and Collaboration

6.1.2.1. Expand Contractor and Subcontractor Training for ZNE-type Home Practices

Conclusion: Builders reported that many subcontractors and builders of code-compliant homes do not have the knowledge needed to execute advanced building practices successfully. Building officials reported challenges in the code compliance process, both with homes built to code and those built above code.

Recommendation: Continue and expand education efforts for builders and their contractors and trades regarding code compliance, and above code building practices. Use a multi-pronged approach to help transform subcontractor practices:

- The PAs—including staff at their educational facilities, CEC, and building departments—should develop methods for expanding outreach to reach builders and contractors/trades. This should include:
  - On-line training for those builders and contractors/trades that cannot attend in-person trainings.
  - Training provided at the building departments. Building officials could identify and invite their local contractors and subcontractors, and the PAs could provide the training. As a benefit for participating, building departments could offer builders faster permitting times or lower permit fees for their next application, or another incentive. However, this should be balanced with the need for more building department resources (discussed in Section 5.10.6).
- The CEC could potentially require that certain energy efficiency features be installed or verified by trained and certified contractors/trades.
- The PAs should work with builders to identify best practices for installing high performance measures correctly. This investigation should consider:
  - Best practices under different subcontractor models (e.g., for builders that use their own crews, builders with preferred subcontractors, and builders that use a competitive bid process).
  - Motivations for subcontractors for learning and implementing these practices.

- Subcontractor scopes of work in these best practices, which the PAs could consider providing as examples to other builders and subcontractors.

6.1.2.2. Offer Appraiser, Lender, and Realtor Training and Collaboration

Conclusion: ZNE-type homes present a quandary to the lending community. Lenders need larger volumes of energy efficient or ZNE-type homes to make financing these products through EEMs or other mechanisms worth their while due to the increased paperwork and home rating requirement presented by EEMs. Lenders noted that most homebuyers are not aware of EEMs; if they are, they usually learn about them after they have identified a home for purchase, not during the decision-making stage. Lenders also noted that they have a shortage of appraisers with the necessary training to conduct valuations of ZNE-type homes.

Recommendation: The PAs should promote collaboration and networking events that bring together builders, appraisers, lenders, and realtors with interest and training in ZNE-type homes. The PAs should hold symposiums for these market actors with short training sessions and workshops, guided discussions, and networking opportunities. The PAs could garner interest in these efforts by providing evidence of the number of ZNE-type homes, data supporting the higher sales price of ZNE-type homes, and case studies of ZNE-type homes. The CEC and CPUC should provide support by working with agencies such as the California Bureau of Real Estate (CalBRE) and California Bureau of Real Estate Appraisers (BREA) to promote and plan the events.

As part of these events, participants should discuss:

- How to increase homebuyers' awareness of EEMs and other financing for ZNE-type homes during the home shopping and prequalification stage.
- What type of data are needed for appraisers to more easily value ZNE-type homes, what data lenders need to accept these valuations, and what data realtors need for marketing homes.
- How realtors could be encouraged to enter energy-related and high performance home data into the MLS databases.
- Potential methods or tools for appraisers to facilitate the process of recognizing high performance features in ZNE-type homes.

Conclusion: Lender interviews indicated that one partial solution to the lack of consumer demand for EEMs would be if they collaborated with production ZNE-type builders.

Recommendation: The PAs and CPUC should develop processes to connect builders of ZNE-type homes with EEM lenders. In addition to the larger symposiums, the PAs and CPUC should connect ZNE-type builders and lenders through programmatic approaches. The production builder could increase demand for EEMs for the lender, and builders and lenders could jointly develop marketing strategies.

Conclusion: Two lenders described success with EEMs using a facilitator model, in which an independent contractor (on the assessment side) handled the extra work involved with an EEM on behalf of the lender.

Recommendation: The PAs should work with lenders to investigate the facilitator model for financing energy efficient and ZNE-type homes. If appropriate, the PAs could provide incentives for the lenders to work with a facilitator.

Conclusion: Lenders reported difficulty in finding appraisers that are adequately trained to develop valuations for ZNE-type or high performance homes. Appraisers reported that some lenders will not accept appraisers' valuations of ZNE-type homes.

Recommendation: The PAs, CEC, and CPUC should encourage appraisers and lenders to gain competency in the valuation of ZNE-type homes. The PAs should support individual appraisers' training through incentives or stipends and the development of training programs. Because federal regulators oversee federally registered banks, the state regulating agencies do not have the same level of authority over many lenders as they do over realtors and appraisers. However, the PAs should work with lenders to understand their concerns of accepting valuations of high performance homes and facilitate a discussion with appraisers and lenders on how lenders' concerns can be addressed. The CEC and CPUC should work with BREA to mandate required competencies for appraisers and the Appraisal Management Companies, the middle-management entities that typically control the appraisal ordering and assignment processes for lending institutions.

Conclusion: While the lenders reported difficulty finding trained appraisers, the appraisers interviewed—all of whom had at least some level of training and experience with valuing high performance homes—reported they are rarely requested to provide a valuation of a ZNE-type home.

Recommendation: The PAs should provide a platform for connecting lenders with trained appraisers. As part of financing programs, the PAs (supported by the CPUC) should work with the BREA to support the facilitation of a directory of competent appraisers (e.g., an online resource), which would be accessible to the general public, including lenders and builders. At a minimum, the TRC team recommends the following training and competency needs for an appraiser to be listed as a "competent appraiser" for ZNE-type homes:

1. A comprehension of high performance elements and their benefits
2. A knowledge of best practices in areas of high performance building envelopes, mechanical systems, water management, materials, site design, orientation and distributed generation
3. Comprehension of whole-house integrated design and the impacts of quality installation and operations, including occupant behavior
4. Valuation considerations that include energy benefits and those beyond energy such as durability, quality, health/indoor air quality, comfort, and aesthetics

Conclusion: Appraisers and lenders reported the need for realtor training for better understanding and promoting the benefits of ZNE-type homes.

Recommendation: The PAs should provide training for realtors on how to recognize and promote energy related features and available financing. Real estate agents have continuing education requirements, which may offer a motivation for them to take training on the value of ZNE-type homes, and financing available, such as EEMs.

6.1.3. Expand Marketing of ZNE-type Homes with Consistent Messaging

6.1.3.1. Avoid Unrealistic Expectations through Consistent ZNE Messaging

Conclusion: Builders reported they have concerns that owners will misinterpret ZNE. This was supported by feedback from owners. Among owners that reported to be aware of the term ZNE, approximately one-third interpreted ZNE as either zero bill or a home that is off-the-grid. Two ZNE-type owners reported that "zero" is unachievable, and is a term that should not be used lightly.

Recommendation: The PAs should work with the CEC and builders to develop clear and consistent messaging for the 2013 IEPR's ZNE definition that builders understand and are comfortable promoting. While the TRC team does not recommend changing the IEPR definition of ZNE, the team recommends that the CEC work with builders to identify how ZNE homes should be described to homebuyers. As part of this messaging, homebuyers need to understand that their behavior can have a

large effect on their home's energy consumption and that a ZNE home will not result in zero bills or disconnecting from the grid.

The U.S. DOE uses the term "ZNE ready".[79] A term such as "ZNE-ready" or "ZNE capable" could imply some action on behalf of the occupant (i.e., "Your home is capable of ZNE", rather than "Your home is ZNE"). Using this nomenclature in messaging would reduce perceptions of risk associated with more declarative terms such as ZNE or even near ZNE.

6.1.3.2. Increase Model Home and Demonstration Projects

Conclusion: Builders and building industry experts recommended the use of demonstration homes. This was supported by reports from owners in the ZNE-type forum, who reported that the demonstration was influential in their purchasing decision and who could recall specific aspects of the demonstration years after touring it. In addition, approximately one-third of the ZNE-type and Energy Efficient owners that were familiar with the term ZNE reported that their source of awareness was a showcase home.

Recommendation: The PAs should work with builders to expand the reach of demonstration or model ZNE-type homes. As builders develop ZNE-type homes, the PAs should provide assistance to promote these homes. For example, the PAs could help advertise ZNE-type homes, develop case studies that include incremental cost and energy savings information, or work with builders to develop on-line videos of demonstration homes to reach a larger number of homebuyers.

6.1.3.3. Address Production Homebuyers' Concerns for Resale Value

Conclusion: About half of production ZNE-type owners and Energy Efficient owners reported they had concerns at the time of home purchase about resale value. However, studies have shown that homes with energy efficiency labels or PV sell for a higher value on average compared to Code-built homes (e.g., Kok 2012, LBNL 2013b, LBNL 2011, and ConSol 2008).

Recommendation: The PAs, supported by the CEC, should promote the results of studies showing higher resale values to owners through builders. The PAs, supported by the CEC, should provide these results as part of educational toolkits for ZNE-type homes, which builders can incorporate into messaging ZNE-type homes to homebuyers.

6.1.3.4. Communicate how ZNE-Related Policies Affect Homebuyers

Conclusion: Per the state's loading order established in the state's Energy Action Plan (CEC and CPUC 2013) and the CEC's 2013 IEPR, achieving ZNE residential new construction goals requires equitable promotion of energy efficiency and distributed generation measures to maximize the benefits of ZNE. Currently, there are several policies to promote distributed generation, such as rebates, tax credits and net energy metering policies. All of these policies are undergoing potential changes. Navigant (2014a-c) indicated that confusion in the market over net metering may hinder market adoption of PV. In this study, builders and program managers reported that consumers questioned how they will be compensated for energy supplied to the grid. (This study did not ask owners directly about their net metering concerns.) In this study, some owners with PV reported they did not expect the annual "true up bill" they received from their utility, and that this was a source of dissatisfaction.

Recommendation: Once the State agencies update net-energy metering and other policies, the PAs should work with these agencies, builders, and PV installers to educate homebuyers on how these

[79] In this study, the term "ZNE ready" refers to a home that is highly efficient but does not have distributed generation. In contrast, homes that the DOE describes as "ZNE ready" may have distributed generation.

policies affect homeowners. As described in Section 6.2, the State agencies are updating several policies that will affect how homeowners are compensated for energy supplied via distributed generation. While homeowners do not need a full understanding of these policies, they must understand how the result affects them. Critical components to communicate include the new compensation rate for exports, annual true up, utility-forecasted rate escalation, and the presence or absence of consumer protections.

Conclusion: Owners in this study expressed confusion over the PV leasing process. In addition, the literature indicates that roofing maintenance can cause unexpected costs for leased PV systems.

Recommendation: The PAs should work with builders and PV installers to develop accurate messaging to homebuyers on the potential benefits and costs of PV systems. These descriptions should include the benefits and risks of third party ownership arrangements and re-roofing costs.

6.1.3.5. Reframe Incremental Cost Paradigm for Builder and Homebuyer Messaging

Conclusion: ZNE is technically feasible, but the biggest barrier is incremental cost, and builders' concern that consumers may not pay this incremental cost. Based on interviews with high performance builders, building industry experts, and program managers, the incremental cost for a ZNE home is approximately 5-15% more than the cost to build a Code-built home. ZNE-type owners and Energy Efficient owners, reported they were willing to pay approximately 8-12% more, and 1-10% more, respectively, for their next home to be a ZNE-type home compared to a Code-built home.

Recommendation: The PAs, supported by the CEC and CPUC, should reframe the incremental cost messaging for builders and homebuyers. In developing programs and training materials, the PAs, CEC, and CPUC should consider presenting builders with a challenge: using an identical budget to your non-ZNE home design, how would you build a ZNE home that was as comparable as possible in all other respects? The PAs should provide additional incentives and technical assistance for builders that meet the goals of this challenge. Although the overall objective is for builders to develop homes that do *not* have an incremental cost, builders will still need a financial motivation for participating. This is a different paradigm and provokes a different response than the typical question of, what is the incremental cost of building a ZNE home compared to the identical code-built home? Similarly, builders should compare their ZNE-type homes to similarly priced code-built homes in marketing materials, such as "For the same price which would you rather have: (1) a quiet, comfort able home with extremely low energy bills; or (2) a home in the same neighborhood, with the same basic features, slightly larger rooms, but no energy-saving or comfort promoting features?" Although the IOUs have supported builders in designing and constructing a ZNE home with reduced incremental costs, these homes are still described in comparison to a Code-built home (e.g., the De Young home described in BIRA 2013).

6.1.3.6. Enhance Marketing with Customer Testimonials on Comfort Benefits

Conclusion: Comfort appears to be an important purchasing criterion for owners, and builders include comfort benefits in their messaging of ZNE-type homes. Based on the small number of owners in this study, ZNE-type and Energy Efficient owners indicated they were generally satisfied with the comfort provided by their homes, while several Code-built owners expressed dissatisfaction with the comfort of their homes.

Recommendation: The PAs should support builders in highlighting the comfort benefits of ZNE-type homes. New approaches could possibly include quotes from satisfied ZNE-type owners about their improved level of comfort. The PAs could collect testimonials through the high performance home feedback program, proposed in Section 6.1.1.1.

6.1.3.7. Provide Training to Owners for High Tech Features

Conclusion: About one-quarter (12 of 42) of ZNE-type owners and one-third (34 of 109) of Energy Efficient owners reported they had initial concerns about managing high tech features, including the monitoring or operation of PV systems, HVAC systems, or other measures. Owners of homes with PV were significantly more likely to report a concern managing high tech features at the initial time of purchase. This study did not rigorously explore whether these concerns were actual or perceived, although two ZNE-type owners mentioned that they do have difficulties managing high tech features.

Recommendation: The PAs should work with builders to provide or expand orientation for ZNE-type owners by developing example or template orientations, and encourage builders to discuss potential homebuyer concerns. The PAs should work with high-performance builders to understand current efforts to educate and orient owners, and develop template or example owner orientation materials as needed for ZNE-type homes. LEED for Homes and GPR promote owner orientations, and some owners in this study reported that builders or their representatives had provided some orientation; these existing orientations could be used as starting points. The PAs should require builders to provide owner orientation for ZNE-type pilot programs, and then gather feedback from owners to improve the orientation materials through the high performance home feedback program, proposed in Section 6.1.1.1. Builders should advertise the availability of this orientation as part of the sales process to reduce homebuyer concern regarding managing high tech features.

In addition, the PAs should work with builders (and their sales representatives) to discuss potential concerns with homebuyers during the purchasing process, and work to develop solutions to address these concerns.

6.1.3.8. Encourage Energy Monitoring Features

Conclusions**:** Several owners in this study described that they liked the in-home display feature of their PV system. In addition, many market actors pointed to the need for owners to be aware of the impact of their behaviors on their home's energy performance.

Recommendations: The PAs should encourage builders to install home energy monitoring and feedback systems. These systems should help occupants understand how their homes use energy and how their behavior affects energy use, and guide them towards reducing energy use or shifting its timing.

6.1.4. Research Natural Gas Appliances in ZNE-type Homes under an Evolving Grid

Conclusion: Owners indicated a preference for natural gas appliances. However, some builders consider ZNE to refer to electricity only (e.g., zero out electricity use only, or believe that a ZNE home must be all-electric), and one voluntary labeling program only considers electricity in its definition of ZNE. In addition, as the penetration of distribution generation and renewable energy increase, the cost effectiveness of, and greenhouse gas emissions from, electric appliances will change.

Recommendation: The PAs should research the role of natural gas in ZNE-type homes. This research should investigate consumer preferences, greenhouse gas emissions, and cost effectiveness impacts (to the owners and the utilities) of equipment with different fuel sources under an evolving grid with higher levels of renewable energy and distributed generation. When developing case studies of ZNE-type homes with natural gas (such as in the De Young and Cottle houses, described in Section 7), the PAs should investigate how efficiency can reduce natural gas use and how distributed generation can offset the remaining natural gas use.

6.2. ZNE-Related Policies

The following conclusions and recommendations pertain to ZNE-related policies, which the state agencies – i.e., the CEC and CPUC – should primarily lead.

6.2.1. Identify Consistent Metric(s) for Tracking ZNE-type Homes in California

Conclusion: CAHP program managers noted the difficulty for programs to track progress towards ZNE using a Title 24-based metric, because it does not include all energy loads, and it does not indicate a ZNE home. The TRC team concurs that this is a challenge after conducting market size analysis for this study.

Recommendation: **The CEC should work with the PAs to identify an EUI-based metric for tracking projects.** As part of the recommendation described in Section 6.1.1.4, the CEC and PA program should agree on an EUI metric, such as kBTU/sf/yr or a HERS design rating, for tracking projects that participate in programs for energy efficiency and distributed generation. This metric could be based on the output of the HERS report. Program staff should record this metric, in addition to or instead of performance relative to Title 24, for participating projects. Because total energy use, rather than energy use normalized by square foot, is necessary for tracking progress towards greenhouse gas emissions goals, program staff should also record the home size and number of bedrooms to allow future analysts to calculate (1) total energy use and (2) energy use on a per occupant basis.

6.2.2. Assign Value for Distributed Generation in TDV

Conclusion: While the state agencies continue to make progress on clarifying how TDV addresses energy efficiency, there is no clear policy on how distributed generation, and PV in particular, will be addressed.

With potential changes to net energy metering, it is important that the TDV metric keep pace with future changes. One risk of assuming status quo for PV valuation in the next round of TDV updates is that any changes in net energy metering or tax credits that are not captured in TDV will result in a disconnect between valuation in codes and valuation in the real world. This is especially true if TDV assigns higher value to PV exports than regulatory policies assign in the future. In an extreme scenario, TDV could require oversized PV systems that provide value to the owner on paper; but in reality, the owner does not capture that value in their levelized cost of energy paid for the system. On the other end of the spectrum, if TDV assigns a lesser value to PV exports than those assumed in net energy metering and other proceedings, codes could appear to be punitive to distributed generation.

Recommendation: The CEC, supported by the CPUC, should finalize policies for how TDV will account for PV generation in the CEC's TDV-Lifecycle Cost Update Process. Issues to address include:

- Should the same TDVs apply to renewable energy generated and consumed on site?
- Should the same TDVs apply to renewable energy exported to the grid?
- What values should be used for estimating the impact of distributed renewable energy on capacity values embedded in TDV?
- What are the interconnection impacts of distributed generation?
- What are the costs for integrating distributed generation into energy supplies?
- What is the increased penetration of renewables in the Renewable Portfolio Standards (RPS) scenarios?
- What is the impact of increased rooftop or distributed PV on generation, distribution and transmission systems?

- What are potential changes in load profiles due to increased renewables (e.g., reduced peaks during afternoons and higher peaks during late evenings)? This may likely impact energy savings estimates for measures like residential HVAC that are driven by peak savings.

6.2.3. Develop Equivalencies for Distributed Generation

Conclusion: One city planner noted that not every home can feasibly achieve ZNE on its own, due to lack of roof space or orientation. In addition, other researchers (e.g., Goldstein 2012) have pointed to the need to consider additional energy uses related to a home (e.g., embedded energy of water, proximity to public transportation or walkable neighborhoods) in the definition of ZNE.

Recommendation: The CEC should develop equivalencies for the distributed generation aspect of ZNE. The CEC should identify what energy uses should be considered and how energy equivalencies will be determined. For example, homes could earn credit for meeting urban planning goals (e.g., being an infill lot, proximity to public transportation) and/or water efficiency or water recycling goals. Similarly, as discussed in 6.3.4, developments could also earn equivalencies for community-scale distributed generation. These equivalencies could be based on carbon equivalents or other metrics that address AB 32 goals. The PAs and local jurisdictions could then develop strategies for encouraging or incentivizing these features, such as kicker incentives from the PAs (through CAHP points), or by incorporating these equivalencies into ZNE-type ordinances.

6.2.4. Consider Short-term, Voluntary ZNE Provisions

Conclusion: City planners reported that jurisdictions are aware of ZNE, but they generally do not see ZNE ordinances as politically viable or cost effective from builders' perspectives under current market conditions. In addition, most planners noted that their jurisdictions are "waiting and seeing" what happens at the state level for ZNE. Planners also noted that voluntary provisions can be politically easier to pass than mandatory requirements.

Recommendation: The CEC and planners should consider short-term voluntary provisions (with "carrots") for ZNE-type construction. Jurisdictions could develop voluntary provisions with benefits for building ZNE-type homes. These could including density bonuses[80], relaxed requirements for accessory dwelling units, or other benefits that are attractive for their particular jurisdiction (and preferably help meet AB 32 goals). These benefits could also include credits for distributed generation discussed in Section 6.2.3 or the distributed energy resources discussed in Section 6.3.4.

6.2.5. Encourage Energy Use Disclosures

Conclusion: Appraisers' most noted barrier is the lack of sales data for high performance homes. They further reported that another barrier is inconsistent reporting of high performance elements by realtors in the MLS databases.

Recommendation: The CEC should work with the National Association of Realtors and the CalBRE to encourage realtors to provide energy use disclosures. Currently, there are limited energy related disclosures in real estate transactions, and there is no specific information pertaining to projected energy consumption of new or newly upgraded homes. The TRC team encourages the CEC to continue engaging the real estate community to incorporate fields that capture energy use data in the MLS databases, to provide energy data at the time of home sale, and to present energy data in terms easily

[80] In a density bonus, the builder is allowed to build more units on the same parcel of land.

understood by homebuyers. The PAs and CPUC should support these activities through new homes programs and financing programs, respectively.

6.3. ZNE Research Priorities

Some of the recommendations above include research. Here, the TRC team presents recommendations that focus on research. The PAs, CEC, and CPUC all play important roles in planning, conducting, and funding research activities; thus, these recommendations are aimed at all of these entities.

6.3.1. Develop Ranges of Actual Home Performance

Conclusion: Based on interviews with ZNE-type owners, homeowners may interpret ZNE based on actual energy performance, but builders, policy makers, and the PAs currently interpret ZNE based on projected energy performance.

In addition, owners indicated that their primary driver for purchasing an Energy Efficient home or a ZNE-type home was reduced utility bills. However, builders are wary of making energy bill promises, because the actual performance can vary widely due to occupancy and behavior.

About half of builders indicated that they do not use HERS in discussions with owners because they think it is too confusing. This was confirmed by owners, who generally could not recall what information the HERS rating provided.

Recommendation: The PAs and CPUC should collect performance data from occupied ZNE-type homes and collaborate with the CEC to: (1) understand how occupant behavior can affect energy use, (2) develop ranges of energy use based on actual ZNE-type homes, and (3) improve energy modeling:

- The PAs and CPUC should collect actual energy performance data from ZNE-type homes, including through the high performance home feedback program described in Section 6.1.1.1.
- Using these data, the PAs and CPUC should work with the CEC to develop a range of expected home performance levels. The goal would be to create a range of expected energy bills from high occupancy/high usage to low occupancy/low usage, for each category of ZNE-type – i.e., ZNE-ready, near ZNE, and ZNE. This should be done through collaborative research so that the CEC, PAs, builders, and energy modelers agree on a methodology.
- Based on the results:
  - Builders could more confidently and accurately message the energy bill savings from ZNE-type homes.
  - The CEC should improve the HERS assumptions regarding various end uses that are dependent on occupant interaction. This will help make the HERS scale more accurate over time. Energy performance data could also provide useful information for incorporating emerging technologies, or other strategies used in ZNE-type homes, into compliance software.
- The CEC and PAs should also discuss with builders and raters how the HERS tool could be improved so that it is more understandable to homebuyers.

6.3.2. Use and Improve the Energy Performance Categories

Conclusion: This study developed a catalog of energy performances in Section 3.4.2, which included Code-built, Energy Efficient, ZNE-ready, near ZNE, and ZNE homes.

Recommendation: Future research on ZNE-type homes should use and improve the catalog of energy performances developed here. This study primarily relied on energy performance relative to Title 24 in cataloging homes. Future studies should use modeled EUI to categorize homes, once EUI data are more readily available. These home performance categories could be used by:

- The CEC and PAs to track progress towards ZNE goals.
- The CEC and PAs in developing ranges of home performance categories.
- Appraisers for developing valuations of homes with different energy performances.

6.3.3. Develop an Evaluation Plan to Support ZNE

Conclusion: This study had several limitations, including that the TRC team targeted ZNE-type market actors (rather than the broader market) for feedback, focused on the single-family homes market, and collected data at one point in time.

Recommendation: The PAs, CEC, and CPUC should develop an evaluation research plan to support the State's ZNE goals. This plan should include:

- A full market baseline study, focusing on non-ZNE market actors, including data collection from builders that primarily build to code, and a larger number of Code-built owners than was included in this study. The study should also develop market transformation indicators to track the market effects of the ZNE Market Transformation Initiative.
- A market transformation study in 2018. This study should identify the adoption level of ZNE-ready, near ZNE, and ZNE homes by 2018 relative to the baseline study to determine whether the market has been sufficiently transformed to warrant adoption of ZNE into Title 24, per the 2020 goal.
- A market characterization of multifamily homes.

6.3.4. Research Barriers and Opportunities for Community-Scale Distributed Energy Resources

Conclusions: The TRC team generally asked broad questions regarding distributed generation, but almost all market actors responded by discussing rooftop PV rather than community-scale distributed generation or other community-scale distributed energy resources (DERs). In addition, the ZNE-type home case studies reviewed by the TRC team did not use community-scale DERs.

Recommendation: Explore the barriers and opportunities for community-scale DER options for ZNE-type homes. The finding that market actors have generally not pursued community-scale DER installations in ZNE-type home developments suggests a need to investigate barriers and opportunities for such arrangements to achieve ZNE goals. Research efforts into community-scale DERs for residential and commercial customers should explore issues such as:

- Permitting requirements associated with siting and sizing the systems;
- Tariff frameworks that equitably allocate costs and generation to individual units;
- Potential DER voltage, frequency, and other impacts on the grid; and
- How the above variables interact and can be leveraged to forward ZNE goals. For example, research should explore whether community-scale DER installations sited close to the substation of the development's feeder could help to mitigate the grid impacts of the development's new load, while alleviating the need for locating DERs onsite to offset consumption. (This may

depend on the type of DER, and peaking characteristics of the development.) Research should also investigate how active utility community solar tariffs, such as PG&E's "Green Option" community solar program[81], could support achievement of the ZNE residential and commercial goals.

6.3.5. Evaluate Operational Challenges for Homebuyers

Conclusions**:** A study by the U.S. DOE (2011) found that the heavy focus on air sealing without designed ventilation provisions could negatively affect health, safety, and durability. Many owners, including production Energy Efficient owners and custom ZNE-type owners, reported that they had initial concerns (at the time of home purchase) regarding sufficient ventilation. Many ZNE-type and Energy Efficient owners also reported having initial concerns about operating their homes high-tech features. This study did not ascertain whether these concerns are perceived or actual.

Recommendation: The CEC and PAs should track operational issues with high-performance and ZNE-type homes. In addition to the repository of high-performance homes identified in section 6.1.1.4, the TRC team recommends ongoing surveys and data gathering on operational characteristics of ZNE-type homes that track any potential performance related issues. For example, there may be issues with air sealing, some devices may not perform as intended, or some owners may have difficulty operating some devices correctly. These lessons learned can help modify and improve construction practices and owner orientation. The PAs should also work with builders to develop messaging that addresses perceived (but not actual) concerns.

6.4. Concluding Statement

Results of this study indicate that ZNE-type homes are in the innovator stage of market adoption. This study identified approximately sixteen ZNE homes and over one thousand ZNE-ready and near ZNE homes based on this study's interpretation of this term. This indicates that while ZNE is nascent in the residential new construction market, it is possible, and some market actors are achieving it. In addition, the diversity of builders and locations of ZNE-ready, near ZNE, and ZNE homes indicates that this type of construction is feasible under different contractor business models and in different climates. Furthermore, because California is at the beginning stage of this market transformation, this is likely the most difficult stage, when the required cost and effort are highest.

There are various indicators that the market is not currently ready to embrace a ZNE mandate. These include a lack of consumer demand, a lack of qualified building professionals (contractors, subcontractors, appraisers, and others), early adopter misperceptions about the ZNE concept, questions regarding the cost effectiveness of ZNE, and various barriers to adoption of ZNE-type homes. The PAs, CPUC, CEC, and other entities are conducting various efforts to overcome these barriers. However, results of this study indicate that current efforts are not enough to reach the goal of all ZNE residential new construction by 2020. The PAs, CPUC, CEC, and others would need to expand activities, significantly increase financial incentives, and take risks with new programs and policies to achieve the 2020 goals.

The history of the California Solar Initiative (CSI) and its impact on the rooftop PV industry in California illustrates the impressive gains that can be possible with broad support and significant financial

[81] On January 29th, 2015 PG&E received permission from state regulators to offer electric customers a new clean energy program that will provide up to 100 percent solar power for a modest cost premium each month. PG&E expects to start enrolling customers in the fourth quarter 2015: http://www.pge.com/en/about/environment/pge/greenoption/index.page?WT.mc_id=Vanity_greenoption

incentives. In 2002, California established its Renewables Portfolio Standard Program to increase the percentage of renewable energy in the state's electricity mix. The CEC's 2004 Integrated Energy Policy Report (IEPR) recommended a goal of 33% renewables by 2020; Governor Schwarzenegger, the Energy Commission, and the CPUC endorsed this goal; and the Legislature adopted it into law through State Bill X1-2.[82] The California Solar Initiative (CSI) was developed in support of this legislation. The CSI General Market Program represents the largest component in the initiative with a $1.95 billion budget over a ten-year period and the goal of 1,750 MW of distributed PV capacity by 2016. Navigant (2014b) conducted a market transformation study and found that CSI has overcome the market barriers that program planners sought to address, and that CSI "got the market started" through its incentives and provided the basis for stable growth through its provision of reliable installation data.[83]

In contrast to the legislative support and substantial funding provided to promote rooftop PV on existing buildings through the CSI, the goal for all residential new construction to achieve ZNE by 2020 came from the CEC in its 2007 IEPR and the CPUC in its California Energy Efficiency Strategic Plan (CPUC 2008)[84], and the State of California has not directly specified funding targeting the residential ZNE goal. The funding for the CAHP and NSHP programs – the programs most closely aligned with the residential new construction ZNE goal – have been significantly lower than for CSI, and the primary focus of CAHP and NSHP have not been to achieve ZNE construction.[85] Consequently, simply expanding the CAHP and NSHP programs in their current forms is unlikely to reach the 2020 ZNE goal. However, a ZNE Market Transformation Initiative with broad support and substantial funding could stimulate market activities through incentives, technical assistance, training, and messaging to make ZNE-type practices more common. Incremental costs should drop as greater availability of the technologies and strategies behind these practices reduce costs, and these market effects would in turn decrease the need for financial support.

Although this study's findings indicate that the California market is not currently ready to embrace a ZNE mandate for all residential new construction, the evidence also demonstrates that there is vibrant activity among the emerging ZNE-type market. If meaningful progress toward the 2020 ZNE goal is to be achieved in the next five years, it would require a ZNE Market Transformation Initiative that transcends the current regulatory framework for PA program delivery. In addition, the ZNE-type home community will need to work collaboratively across various stakeholder groups—both within and beyond California—to encourage the market to meet ZNE residential new construction goals.

[82] http://www.leginfo.ca.gov/pub/11-12/bill/sen/sb_0001-0050/sbx1_2_bill_20110412_chaptered.html

[83] The study noted that, while it is possible that the PV industry would have achieved some level of market transformation without CSI due to other factors, including declining module prices, net metering, and federal tax credits, the transformation would likely have taken longer and not advanced as far (Navigant 2014b).

[84] The CEC has also endorsed similar goals (CEC 2007).

[85] The IOUs' CAHP programs have energy savings goals while the CEC's NSHP is charged with promoting rooftop PV installations on 50% of new homes by 2016 (360 MW).

7. Appendix A: ZNE-type Home Examples

This appendix presents examples of ZNE-type homes based on published case studies and websites.

Photo Credit: GBD Magazine

Project Name: Cottle House

City: San Jose

Builder: One Sky Homes

Certifications:

- LEED Platinum
- Passive House
- EPA Indoor Air Plus
- HERS Net Zero Energy Home
- First certified ZNE home in CA

Features:

- Designed to be ZNE
- 3,200 sq. ft., 4-bedrooms
- PV & hot water systems
- Electric vehicle charging

Website: http://oneskyhomes.com/

Photo Credit: De Young Properties

Project Name: Zero Net Energy Home

City: Clovis

Builder: De Young Properties

Features:

- Designed to be ZNE
- 2,064 sq. ft., 4-bedrooms
- PV (6 kW)
- LED lighting
- Advanced heat pump water heater
- Ducts in conditioned spaces

Website: http://www.deyoungproperties.com

Photo Credit: KB Homes

Project Name: Double Zero House 2.0

City: Lancaster (Dawn Creek Development)

Builder: KB Homes

Features:

- Designed to be ZNE
- Water recycling system and EPA WaterSense labeled
- 1,773-3,206 sq. ft., 3-5 bedrooms
- 2.5 kW PV System

Website:http://news.kbhome.com/

Photo Credit: Wathen Castanos Hybrid Homes, Inc.

Project Name: Artisan Ranch

City: Clovis (Artisan Development)

Builder: Wathen Castanos Hybrid Homes, Inc.

Features:

- Designed to be ZNE-ready
- 1,622-2,949 sq. ft., 3-6 bedrooms
- 40% better than Title 24

Website: http://wchomes.com/artisan

Project Name: Palo Alto Passive Home

Photo Credit: Clarum Homes

City: Palo Alto

Builder: Clarum Homes

Features:

- Designed to be ZNE
- 4,300 sq. ft., 5 bedrooms

Website: http://www.paloaltopassive.com/

Photo Credit: Clarum Homes

Project Name: Menlo Park Passive

City: Menlo Park

Builder: Clarum Homes

Features:

- Designed to be near ZNE
- 2,968 sq. ft., 4 bedrooms

Website: http://www.clarum.com/

Photo Credit: passivehousecal.org

Project Name: Carmel-by-the-Sea

City: Carmel

Builder: Carmel Building & Design

Features:

- Designed to be near ZNE
- 1,600 sq. ft., 2 bedrooms
- 61% better than Title 24

Website: http://www.carmelbuilding.com/

Photo Credit: mihomevstreet.com

Project Name: miHome V Street

City: Sacramento

Builder: Northwest Land Park LLC

Features:

- Messaged by developer as "Net Zero Electrical" and classified by TRC team as near ZNE
- 1,500 - 2,500 sq. ft., 2-5 bedrooms
- PV
- Multi-home development

Website: http://mihomevstreet.com/

Photo Credit: ktgy Architecture + Planning

Project Name: ABC Green Home & ABC Green Home 2.0

City: Irvine

Builder: ktgy Architecture + Planning, SCE, Green Home Builder Magazine

Features:

- Designed to be ZNE
- 1,695 - 2,380 sq. ft., 3 bedrooms
- PV

Website: http://www.ktgy.com

Photo Credit: Honda Smart Home

Project Name: Honda Smart Home

City: Davis

Builder: Honda, MAK Design + Build

Features:

- Designed to be ZNE
- 2,000 sq. ft., 2 bedrooms
- PV (9.5 kW)
- Electric vehicle charging station

Website: http://www.hondasmarthome.com/

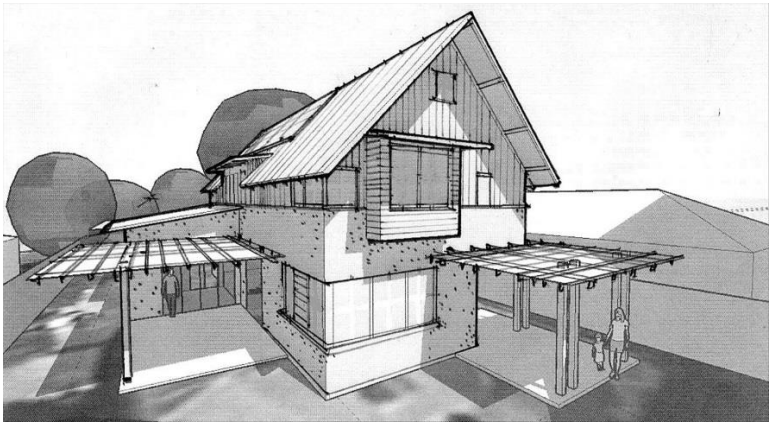


Photo Credit: Project Green Home

Project Name: Project Green Home

City: Palo Alto

Builder: Red Company, LLC

Features:

- Designed to be ZNE,
- LEED Platinum, Passive House
- 2,659 sq. ft., 3 bedrooms
- PV (4.2 kW)
- Electric vehicle charging station

Website: http://www.projectgreenhome.org/

Photo Credit: tahmahlah.com

Project Name: Tah Mah Lah

City: Portola Valley

Builder: MGM Construction

Certifications:

- LEED Platinum
- Living Building Challenge
- GreenPoint Rated

Features:

- Designed to be ZNE
- 5,600 sq. ft.

- PV (27 kW)
- Electric vehicle charging station

Website: http://www.tahmahlah.com/

Project Name: Carsten Crossings

City: Rocklin

Builder: Grupe

Features:

- Designed to be near ZNE
- LEED Certified
- 2,168 - 2,755 sq. ft.
- PV (2.4 kW)
- 35% better than Title 24
- Multi-home development (144)

Website: http://www.usgbc.org

8. APPENDIX B: BIBLIOGRAPHY

Below are the studies and other resources included in this report, including those in the full literature review presented in Section 2 of the report Attachment. Where possible, the TRC team provides links to these studies and resources.

This bibliography includes reports, articles, and presentations. For information obtained from websites, this report uses a footnote for the citation.

ACEEE 2011: What Have We Learned From Energy Efficiency Financing Programs?
Primary Author: Sara Hayes (ACEEE) et al.
Publication Date: September 2011
Publication Type: Report
Link: http://www.aceee.org/research-report/u115

ACEEE 2014: Engaging Small to Mid-Size Lenders in the Market for Energy Efficiency Investment: Lessons Learned from the ACEEE Small Lender Energy Efficiency Convening (SLEEC)
Primary Author: Casey Bell (ACEEE) et al.
Client: NREL, Argonne National Laboratory, and DOE
Publication Date: 2014
Publication Type: Report
Link: http://www.aceee.org/research-report/f1401

Architecture 2030 (2010): 2030 CHALLENGE Targets: U.S. Residential Regional Averages
Primary Author: Architecture 2030
Publication Date: 2006-2010
Publication Type: Survey Analysis
Link: http://www.architecture2030.org/files/2030_Challenge_Targets_Res_Regional.pdf

Arup 2012: The Technical Feasibility of Zero Net Energy Buildings in California
Primary Author: Arup
Client: PG&E
Publication Date: 2012
Publication Type: Energy Simulation Analysis
Link:
http://www.energydataweb.com/cpucFiles/pdaDocs/904/California_ZNE_Technical_Feasibility_Report_Final.pdf

Bell 2014: Engaging Small to Mid-Size Lenders in the Market for Energy Efficiency Investment: Lessons Learned from the ACEEE Small Lender Energy Efficiency Convening (SLEEC)
Primary Author: Casey J. Bell and Virginia Hewitt (ACEEE); Angela Ferrante (Energi, Inc.)
Publication Date: February 2014
Publication Type: Conference paper
Link: http://aceee.org/research-report/f1401

BIRAenergy 2013: PG&E ZNE Pilot Program: De Young Zero Net Energy Home
Primary Author: Rob Hammon (BIRAenergy)

Client: PG&E
Publication Date: December 2013
Publication Type: Final Report

Cadmus 2013: Comparative Regional Economic Impacts of Solar Ownership/Financing Alternatives
Primary Author: Cadmus, Meister Consultants Group, and Sustainable Energy Advantage
Client: Massachusetts Department of Energy Resources
Publication Date: September 30, 2013
Publication Type: Report

CEC 2007: 2007 Integrated Energy Policy Report
Primary Author: CEC
Publication type: Report
Link: www.energy.ca.gov/2007_energypolicy/

CEC 2013: Integrated Energy Policy Report 2013 IEPR
Primary Author: CEC
Publication type: Report
Link: http://www.energy.ca.gov/2013publications/CEC-100-2013-001/CEC-100-2013-001-CMF.pdf

CEC and CPUC, 2013: New Residential Zero Net Energy Action Plan
Primary Author: CEC, CPUC
Publication Date: October 14, 2013
Publication Type: Action Plan
Link: http://www.cpuc.ca.gov/NR/rdonlyres/D8EBFEE4-76A5-47AC-A8F3-6E0DAB3A9E5D/0/DRAFTZNE_Action_Plan_Comment.pdf

CMHC 2007: Approaching Net Zero Energy in Existing Housing
Primary Author: Abri Sustainable Design & Consulting
Client: Canada Mortgage and Housing Corporation (CMHC)
Publication Date: December 17, 2007
Publication Type: Report
www.affordablecomfort.org/sites/default/files/cmhc_nze_exisitng_henderson_full_2008_s60376_w_.pdf

Christie 2014: Moving beyond 'Better than Code': New Market Transforming Zero Net Energy Aligned Residential New Construction Programs
Authors: Matthew Christie (TRC), Conrad Asper (PG&E), John Morton (SCE), Chuck Berry (SDG&E), and Darrell Brand (SoCalGas)
Publication Date: 2014
Publication Type: Conference paper
Link: http://aceee.org/files/proceedings/2014/data/papers/2-1265.pdf

City of Lancaster 2013: CEC submittal
Primary Author: City of Lancaster
Publication Date: 2013

Link:
www.energy.ca.gov/title24/2013standards/ordinances/lancaster/Lancaster_Submittal_to_California_Energy_Commission.pdf

City of Sebastopol 2013: PV Ordinance
Primary Author: City of Sebastopol
Publication Type: City Ordinance
Link: ci.sebastopol.ca.us/sites/default/files/sbd/mandatory_photovoltaic_system_requirements.pdf

Coldham 2008: Making Choices Instead of Paying Premiums for Greener Buildings
Primary Author: Bruce Coldham
Publication Date: Fall 2008
Publication Type: Article (in Northeast Sun)

Colorado Energy Office 2013: The Impact of Photovoltaic Systems on Market Value and Marketability
Primary Author: Colorado Energy Office
Client: NA
Publication Date: May 2013
Publication Type: Report

ConSol 2008: Solar and Real Estate Values
Primary Author: Rob Hammon
Publication Date: 2008
Publication Type: Presentation

Cool Davis 2014: Council Approves Davis's PV Ordinance for New Single-family Home Construction
Primary Author: Alan Pryor (Cool Davis)
Publication Date: August 26, 2014
Publication Type: Article
Link: http://www.cooldavis.org/2014/08/26/be-present-on-aug-26th-as-council-considers-daviss-pv-ordinance-for-new-single-family-home-construction/

CPUC 2008: California Long-Term Energy Efficiency Strategic Plan
Publication Date: September 2008
Publication Type: Report
Link: http://www.cpuc.ca.gov/NR/rdonlyres/D4321448-208C-48F9-9F62-1BBB14A8D717/0/EEStrategicPlan.pdf

CPUC 2011: Energy Efficiency Financing in California
Primary Author: Harcourt Brown & Carey, Inc.
Client: CPUC
Publication Date: July 8, 2011
Publication Type: Report
Link: http://uc-ciee.org/downloads/EEFinanceReportCarey.pdf

Dakin 2008: Case Study: The Effectiveness of Zero Energy Home Strategies in the Marketplace
Primary Author: William Dakin (Davis Energy Group), David Springer (Davis Energy Group), and Bill Kelly (SunPower Corporation)
Publication Date: 2008
Publication Type: Conference paper
Link: https://www.aceee.org/files/proceedings/2008/data/papers/6_616.pdf

Davis Energy Group 2012: California Zero Net Energy Buildings Cost Study
Primary Author: Davis Energy Group
Client: PG&E
Publication Date: December 19, 2012
Publication Type: Report
Link: http://www.cpuc.ca.gov/NR/rdonlyres/2CDD0FB7-E871-47C0-97D0-A511F5683B57/0/PGECAZNECostStudy.pdf

Desert Sun 2014: Builder plans homes targeting 'net-zero' electric bills in Indio, Palm Springs
Primary Author: Dominique Fong (The Desert Sun)
Publication Date: February 2014
Publication Type: Article
Link: http://www.mydesert.com/article/20140204/BUSINESS0302/302040034/Net-Zero-neighborhoods-Indio-Palm-Springs?gcheck=1

DOE 2008: Zero Energy Buildings Database
Primary Author: U.S. Department of Energy (DOE)
Publication Date: Last updated June 2008
Publication Type: On-line building database
Link: http://zeb.buildinggreen.com/

DOE 2011: Challenges and Opportunities to Achieve 50% Energy Savings
Primary Author: DOE
Publication Date: July 2011
Publication Type: Compilation of national laboratory white papers
Link: http://energy.gov/sites/prod/files/2013/11/f5/ba_tech_roadmap_0.pdf

DOE 2012a: Sonoma House: Monitoring of the First U.S. Passive House Retrofit
Primary Author: Alliance for Residential Building Innovation (ARBI)
Client: DOE Building Technologies Program
Publication Date: December 2012
Publication Type: Report
Link: http://apps1.eere.energy.gov/buildings/publications/pdfs/building_america/sonoma_house.pdf

DOE 2012b: Long-Term Results: New Construction Occupied Test House, Urbana, Illinois
Primary Author: Stecher and Allison, IBACOS, Inc.
Client: DOE
Publication Date: October 2012
Publication Type: Report

Link:
http://apps1.eere.energy.gov/buildings/publications/pdfs/building_america/testhouse_urbana_il.pdf

DOE 2012c: The Role of Appraisals in Energy Efficiency Financing
Primary Author: Victoria Doyle (Building Industry Research Alliance)
Client: DOE
Publication Date: May 2012
Publication Type: Report
Link:
http://apps1.eere.energy.gov/buildings/publications/pdfs/building_america/appraisals_ee_financing.pdf

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Primary Author: DOE
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Link: www.energy.gov/eere/buildings/downloads/doe-challenge-home-california-program-requirements

E3 2013: Investigating a Higher Renewables Portfolio Standard in California
Primary Author: Energy and Environmental Economics, Inc. (E3)
Client: California Utilities
Publication Date: 2013
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Primary Author: Merrian Fuller
Publication Date: 2009
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Primary Author: Matt Golden (Efficiency.org)
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Publication Date: 2006
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Publication Type: Journal article, in The Appraisal Journal

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Primary Author: Geoffrey Klise (Sandia) and Jamie Johnson (Energy Sense Finance)
Client: Sandia National Laboratories
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Client: Office of Energy Efficiency and Renewable Energy and U.S. DOE
Publication Date: December 2013
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Primary Author: Mark Modera (Western Cooling Efficiency Center) and Michael Koenig (Honda)
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Primary Author: Stephen Frantz (SMUD)
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9. Appendix C: Summary of Data Collection Results

This section summarizes results from the primary data collection activities. Full results for each data collection effort are in an attachment. The TRC team used these results to develop the Synthesis of Findings, presented as Section 5.

In this section, the TRC team presents results in the following order representing the supply chain for ZNE-type homes:

- Builder interviews
- Program manager interviews
- Appraiser interviews
- Lender interviews
- Building Official discussion
- Planner discussion and interviews
- Owner feedback, presented in order of energy performance of their homes:
  - ZNE-type owners
    - Interview results
    - Forum results
  - Energy Efficient owner surveys
  - Code-built owner forum

After presenting these results, this section then presents:

- The impact of TDV on ZNE policies and ZNE-type homes

As described in Section 3.3, because of the small sample sizes, and because the TRC team targeted market actors with ZNE-type home experience, the market actor feedback collected here may not reflect the views of the broader market.

9.1. High Performance Builder Interviews

The TRC team developed a list of high performance builders representing the leading edge of energy efficient building in California using input from the California Advanced Homes Program (CAHP) managers, responses to a Request for Information (RFI) survey, and publicly available case studies of ZNE-type homes. The TRC team identified 25 builders, and completed interviews with 16. **Some builders did not respond to all questions**, so the number of builders that answered each question varies, as described in the results in Figure 49**:**

California Region Served	Builder Type			
	Custom	Production	Custom/ Production	Total
Northern	6	2	1	9
Southern	1	3	0	4
Statewide	0	3	0	3
Total	**7**	**8**	**1**	**16**

Figure 49. Description of Builders Interviewed

The TRC team also interviewed three building industry experts: representatives from BIRAenergy[86], the California Building Industry Association (CBIA)[87], and ConSol[88]. When presenting results, the TRC team combines results from both builders and industry experts, and describes the source (e.g., if builders or building industry experts provided the data).

9.1.1. ZNE Terminology Interpretations

Most builders interpreted ZNE as a site-based definition where home energy is zeroed out, but three provided a "ZNE electricity" interpretation: Of the twelve builders that responded to the question of how they interpreted ZNE, nine reported it is a home where the amount of energy consumed equals the amount of energy produced (i.e., where energy is zeroed out). One builder reported that ZNE is an all-electric home where electricity is zeroed out, a second reported it is a home where only the electricity is zeroed out, and the third reported a ZNE home could be either an all-electric home where the electricity is zeroed out or a home where only the electricity is zeroed out.

"ZNE" used most frequently in marketing: The most frequently reported marketing term used by builders to describe ZNE-type homes to homebuyers was "zero net energy" or a variation of that term (mentioned by eight of sixteen builders). Two production builders reported using their own proprietary terminology when describing homes. The builders interviewed also reported primarily focusing on energy performance and comfort when communicating the value of ZNE homes to buyers. However, the builders who reported marketing energy performance also explained that they have concerns about promising a specific performance and are careful with wording or often use a disclaimer.

Builders support a performance goal based on Title 24 compliance margins: Most builders reported that they would identify a target energy performance based on exceeding Title 24 by a specific percentage (eight mentions).

As described in section 9.2.2, CAHP had previously identified incentive levels using a Title 24 compliance margin, but recently switched to using a "CAHP score" that is an energy use intensity (EUI)-based metric. A CAHP staff member reported that, since the CAHP program switched to the CAHP score, most participating builders have switched to a CAHP score goal for their CAHP homes. Builders have not

[86] BIRAenergy provides a variety of technical support to promote ZNE-type communities including: integration of energy efficiency and renewable energy technologies; working with the US Department of Energy and National Renewable Energy Laboratory (NREL); and supporting builders and developers, utilities, and industry manufacturers across the United States.

[87] CBIA is a California trade association representing homebuilders, trade contractors, architects, engineers, designers, suppliers, and other industry professionals.

[88] ConSol provides research in systems and technologies to improve sustainability of new and existing residential developments.

delivered enough ZNE-type homes since the switch to the CAHP score to determine whether builders will use a CAHP score goal specifically for ZNE-type homes.

Some builders interpreted ZNE as electricity only: All 12 builders who reported to have built ZNE homes reported that offsetting the energy used by the home with roof mounted PV is a standard practice in ZNE home building. Among these twelve builders, nine did not specify which utility energy sources they offset in the home, whereas three mentioned offsetting electricity only. None of the builders interviewed mentioned the option of overproducing electricity to compensate for natural gas usage. However, the TRC team notes that at least some of these builders have compensated for natural gas usage based on published ZNE case studies. The industry experts interviewed reported that the goal of zeroing out energy use can be difficult for homes with natural gas.

Builders interviewed follow the IEPR loading order: To meet their ZNE goals, nine builders specifically reported that they first focus on energy efficiency measures and then on PV, to reduce PV system size due to costs associated with PV systems. Builders identified various strategies for achieving ZNE, including maximizing roof space for PV, reducing envelope leakage, reducing the HVAC size, and installing 2-10 kW PV systems.

9.1.2. ZNE Market Size

Builders interviewed have built thousands of efficient homes, but not many ZNE homes: The TRC team asked builders for their estimates of the total number of homes their organization has built in the past three years, how many of them were above code, and how many of them were ZNE. Builders used their own interpretations of ZNE when providing responses. Figure 50 presents total responses by different builder groups. The TRC team did not ask builders for their estimates of ZNE-ready or near ZNE homes.

Builder Group	Total homes built	Number of above code homes built	% of Total	Number of ZNE homes built[89]	% of Total
Custom total	67	49	73%	17	25%
Production total	9169	9169	100%	14	0.2%
Northern CA total	3620	3602	99.5%	25	0.7%
Southern CA total	1266	1266	100%	3	0.2%
Statewide total	4350	4350	100%	3	0.1%
Grand Total	**9236**	**9218**	**99.8%**	**31**	**0.3%**

Figure 50. Number of Homes Reported Built in the Past 3 Years by Builders Interviewed

While these builders reported that almost all of their homes exceed code, they reported that the number of ZNE homes[90] that they have built is small. Custom builders reported approximately one-fourth of their homes are ZNE, while production builders reported < 1% of their homes are ZNE.

[89] Some of the homes identified as ZNE by builders did not meet the study's classification of ZNE. The TRC team reviewed information from the builders and on-line for the ZNE homes that builders identified. The TRC team reclassified some homes as ZNE, near ZNE, or ZNE-ready (based on the study classifications of these terms) for the study's market size estimates.

[90] The TRC team probed specifically about ZNE homes and did not ask builder about the number of near ZNE or ZNE-ready homes they have built. In addition, the TRC team allowed builders to use their own interpretation of ZNE when responding to the question of market size. Finally, the TRC team asked builders to include homes built and underway.

9.1.3. Labels and Rating Systems

Builders use various labels and programs for ZNE-type homes: The TRC team asked builders whether they have participated in various programs for the ZNE-type homes they have built. Production builders reported that they have participated in CAHP most often, followed by ENERGY STAR Homes and Green Point Rated (GPR), while custom builders reported participating in ENERGY STAR Homes and LEED most often.

Builders provided mixed feedback on the value of HERS as a communications tool: Builders provided different feedback as to whether the Home Energy Rating System (HERS)[91] is a valuable tool for communicating home energy performance to the consumer. Half of builders (eight of sixteen) reported they discussed the HERS index to homebuyers, because it allows homebuyers to compare home performance. The other half did not, because they believe it can be confusing to buyers.

9.1.4. Incremental Cost and Willingness-to-pay

The following sections provides builders' responses to questions regarding the incremental cost of ZNE and homebuyers' willingness-to-pay for ZNE. Due to interview time constraints, the TRC team did not ask builders similar questions regarding ZNE-ready or near ZNE homes.

Builders estimated incremental cost for ZNE is 5% to 15%: The TRC team asked builders, "Compared to a new 2,500 square foot home build to current codes, what would you estimate is the incremental cost of building the same sized ZNE home?" Of the eleven builders that responded to this question, all reported that there is an incremental cost associated with building ZNE homes. While the value of the increase varied widely, most builders reported that the incremental cost to build a ZNE home is between $10,000 and $40,000, or 5% to 15% increase over the cost of the code-built home.

Builders have low expectations for homebuyers' willingness-to-pay: The TRC team asked builders whether homebuyers are willing to pay more for a ZNE home than a typical or code-built home. Of the 12 builders who responded to this question:

- One-third (4 of 12) reported that homebuyers are willing to pay for the incremental cost of a ZNE home;
- One-third reported that a very small, select portion of the market is willing to pay for ZNE; and
- The remaining third—all production builders—indicated that homebuyers are unwilling to pay the incremental cost.

In a separate question, the TRC team asked builders how quickly ZNE homes sell in comparison to code-built homes. Most builders (10 of 16) were unable to estimate whether ZNE homes sell faster.

[91] The Residential Energy Services Network (RESNET) has long had a national HERS index that compares homes to a reference home based on the International Energy Conservation Code (IECC). California recently developed its own "California HERS" that compares homes to Title 24. When responding to questions regarding HERS, production builders (many of which operate nationally) primarily referred to their experience with the national HERS. Custom builders responded based on a mix of experiences with the national HERS, the HERS II for retrofits, and HERS for new construction. Overall, results were the same for the national and California HERS systems: some builders thought that HERS was a useful comparison tool, while others thought that it was too confusing for homeowners.

9.1.5. Drivers

Builders seek a competitive advantage by building ZNE homes: In general, builders reported that they seek a competitive advantage (i.e., a marketing distinction) by building ZNE-type homes (8 of 16 builders). Additional motivations reported by builders included:

- Desire to innovate (six mentions);
- Concerns for the environment (three mentions);
- Homebuyer demand (two production builders); and
- Preparation for the upcoming regulatory "requirement"[92] for ZNE (two production builders).

Production builders identified financial benefits most often as homebuyer driver for ZNE: Of the eight production builders, they identified homebuyer motivations for ZNE as:

- The financial benefits, including energy bill savings (eight mentions), and
- Environmental concerns (six mentions).

Custom builders identified environmental concerns most often: Of the eight custom builders, they identified homebuyer motivations as:

- Environmental concerns (six mentions), and
- The financial benefits, including energy bill savings (one mention).

Some production builders identified comfort, and some custom builders identified indoor air quality: Of the sixteen total builders, they identified additional drivers as:

- Comfort (two production and one production/custom builder)
- Improved indoor air quality (three custom and one production/custom builder)

9.1.6. Barriers

Builders identified the following barriers to ZNE-type homes. Builders also identified opportunities, which the TRC team presents in Section 9.1.7.

Builders identified cost as the primary barrier: The TRC team asked builders to identify barriers to building ZNE homes. Nine of sixteen builders reported that the incremental cost associated with ZNE-type homes is a critical barrier for homebuyers, and most identified this as the biggest barrier. Figure 51 summarizes the barriers that builders identified to building ZNE homes, or to owners buying ZNE homes (which then serves as a barrier to builder in building ZNE homes).

[92] Currently, the California state agencies have not developed a requirement for ZNE, but they have presented it as a goal.

Barrier	Number of Responses	Market Actor Affected by Barrier (as inferred by the TRC team)
Incremental cost	9 builders	Owners and Builders
Homebuyers have little perceived value of ZNE homes	9 builders, 2 industry experts	Owners and Builders
Subcontractors often lack knowledge of the building techniques necessary for above code building	7 builders	Builders
The appraisal industry currently undervalues energy efficiency and distributed generation	6 builders	Owners and Builders
Issues associated with PV for homebuyers, including initial cost and confusion over how utilities will compensate them for excess electricity generation	6 builders	Owners and Builders
Knowledge gap for other builders who do not typically build above code	6 builders	Builders
ZNE-type homes primarily appeal to homebuyers who are more affluent	4 builders	Owners and Builders
Issues related to HVAC systems, including that the systems available are too large for ZNE home loads, or that small systems may not appeal to some homebuyers	3 builders	Owners and Builders

Figure 51. Barriers to ZNE Identified by Builders

9.1.7. Opportunities

Builders expect their ZNE production will increase, but need support: Despite the current barriers in the market, most builders and industry experts anticipate homebuyer demand and that the number of ZNE-type homes that they build will increase in the next five years. Builders offered a variety of suggestions on how to accelerate the ZNE market:

- Continued and increased incentives to bridge the incremental cost gap associated with ZNE homes (five builders).
- Improved homebuyer education would help drive the ZNE market, including simplified marketing materials and demonstration homes (five builders).
- A need for more ZNE demonstration homes (four builders).
- Clarifications for net metering policies (four builders).

9.2. Utility Program Manager Interviews

The TRC team interviewed the four IOU CAHP program managers (and the PG&E implementer), a SMUD program manager, and a Build It Green (BIG) staff member. (BIG administers the voluntary labeling program, Green Point Rated, or GRP.)

9.2.1. ZNE Terminology Interpretation

Market interpretations of ZNE vary: Multiple program managers reported that the most prevalent terms in the market for ZNE-type homes are ZNE Site, ZNE Source (which includes transmission costs), and ZNE Electric.[93] Program managers reported that builders are wary of marketing homes as ZNE because this can lead to unrealistic expectations of energy performance. Program managers further reported that homebuyers expect that ZNE means zero or very low energy bills (both electric and gas), or to be entirely off the grid. Finally, program managers reported that owners might not consider how their behavior can affect energy use. BIG uses a ZNE Electric definition for its GPR rating system, because (according to the BIG staff member) homes cannot directly offset natural gas consumption.

Managers held mixed views on using a TDV definition in marketing efforts: Program managers expressed different views on whether TDV should be explained to owners. Some program managers support including TDV as part of the policy definition of ZNE, but do not recommend including TDV in the description of ZNE to owners. (In other words, TDV may be "under the hood" if not described to the homebuyer.) On the other hand, one program manager noted that there will be false expectations in terms of bills if TDV is not explained to the owner.

9.2.2. ZNE Market Size

CAHP databases do not currently track ZNE: Currently, the CAHP databases do not distinguish between ZNE-ready, near ZNE, and ZNE homes. Reasons include that the CAHP databases have not consistently tracked PV installation historically, and the CAHP databases currently track a project's energy use compared to Title 24, rather than an energy use intensity or net energy use. BIG recently launched credits for ZNE and 80% ZNE, but few homes (if any) have earned these so far.

CAHP will use EUI going forward: In support of the move towards ZNE, CAHP is moving towards an energy use intensity metric (a "CAHP score"). The SMUD program manager reported that SMUD programs had been using a "percent better than code metric," but that SMUD programs are now using the CAHP score for their programs.

Program managers estimated ten ZNE homes so far: Collective information from the CAHP program managers puts the market size of ZNE homes (based on a site ZNE definition) in the IOU CAHP programs at approximately ten. Program managers believe that most of these ZNE homes are single site ("one off") homes, rather than multi-home developments. The GPR staff member also estimated ten ZNE homes in California, some of which may be homes that participated in CAHP.

ZNE is still in the testing phase: SMUD is currently working on six pilot homes to identify best practices and translate these findings into 200 homes that exceed Title 24 by at least 40%. Program managers reported that production homebuilders have generally adopted near ZNE home production for a model home or for small communities, but none has fully embraced ZNE.

9.2.3. Drivers

Market differentiation is the key driver for builders: Program managers reported the following drivers (in order of importance) for builders to build ZNE homes:

1. Builders typically use ZNE as a marketing tool and as a way to distinguish themselves from competition.

[93] ZNE Electric has two meanings; it can mean an all-electric home, or that a home does not account for offsetting gas usage.

2. Some builders are experimenting with ZNE construction techniques because they recognize that the energy portion of the building code is heading towards ZNE.

Energy bill savings is the key driver for homebuyers: Program managers reported that:

1. Energy bill savings will be the main motivation for the next generation of ZNE adopters.
2. Environmental concerns, including an increased awareness of climate change, will be a secondary driver. Similarly, early adopter homebuyers may want to display their home within their environmental networks.

9.2.4. Barriers

Program managers expect cost to be the primary barrier to builders and homebuyers: Program managers reported the following barriers (in order of importance) to ZNE:

- Builders and homebuyers see the most prevalent barrier as the upfront cost of a ZNE home.
- Most customers are not willing to pay the premiums for ZNE, or they would rather spend that incremental cost on visual features and improved appliances. Builders will only build ZNE homes on a large scale when there is customer demand.
- To facilitate wide adoption and customer demand for ZNE homes, there needs to be a clear and consistent market definition of ZNE.

9.3. Appraiser Interviews

The TRC team sought to interview appraisers with experience valuing energy-efficiency and/or distributed generation features present in homes built above code (including ZNE-type homes). The TRC team interviewed eleven appraisers, and one industry expert who was a member of the TRC team (the "TRC team industry expert").

9.3.1. ZNE Awareness and Terminology Interpretations

Appraisers were aware of ZNE and interpreted it as site-based: Most of the appraisers interviewed (9 of 11) had at least some familiarity with the term ZNE. These appraisers offered different definitions for ZNE, but generally described it as a home producing as much energy as it uses annually (i.e., a site-based definition).

Few appraisers had experience with ZNE-type homes: Overall, the appraisers had a mix of experience. All had at least some experience valuing Energy Efficient homes and/or homes with PV. Only one reported valuing a ZNE-type home (specifically, a near ZNE home). Most appraisers reported that less than 2% of the homes they appraise have PV. A few reported up to 10%, one of which worked with developers who build entire developments with PV.

9.3.2. Methods for Appraising Homes with Energy Features

Sales comparison is the most commonly used method: The appraisers interviewed reported using one or a combination of methods to value high performance homes. (The TRC team presents a description of each of these methods in the full description of results, in Section 3.3.6 of the report Attachment.) The appraisers reported that the sales comparison method is the most common method for valuing homes and required by underwriters. However, the appraisers reported that it is difficult to find sales of comparable homes with similar energy efficiency features.

Appraisers sometimes use the income approach, particularly for PV: Appraisers reported using the income approach for valuing high performance homes, and most commonly mentioned this method when discussing strategies for valuing PV in new construction. The TRC industry expert reported that appraisers can also use the income approach for valuation of energy efficiency in homes.

Some appraisers also reported using the survey method (i.e., an extended effort to discover market data from various local sources such as builders, realtors, peer appraisers, PV distributors, and/or owners) to provide support for a valuation.

9.3.3. Perceived Value

Valuation of energy features is site-specific: Appraisers explained that the value of any feature is site specific and depends on whether the owner can demonstrate savings for upgrades they made (existing homes) or the builder can demonstrate added value from previous sales (new construction). Thus, most of the appraisers interviewed would not provide a dollar value or percent increase for a specific energy efficiency or distributed generation feature.

PV tends to add more value than efficiency: While the value of any specific measure or a package of measures (i.e., a whole-house approach) is site-specific, appraisers reported that PV typically adds more value than energy efficiency features. Appraisers believe that owners view PV as a reliable strategy for reducing energy costs. In addition, appraisers reported that homebuyers value PV systems because they are visible, and their impact is generally easier to quantify than efficiency measures.

Appraisers estimated a range in additional value from energy features: While appraisers emphasized that the value of a home is determined as a whole, five appraisers offered specific percentage estimates for the additional value they have seen applied to ZNE-type or highly energy efficient homes. These estimates were all between 5-15%, with three in the tighter 8-9% range.

9.3.4. Labels and Rating Systems

Confusion over labels renders them largely meaningless to the appraisal process: Appraisers' discussion of home efficiency labels, certifications, and ratings suggest that these are largely meaningless in their valuation process. Appraisers explained that there are numerous labels, including custom labels created by individual builders, many of which have no recognition in the overall market.

Appraisers were aware of HERS, but none uses it regularly: The TRC team asked appraisers about their familiarity with the HERS index and their use of this tool in appraisals. Nearly all appraisers reported being familiar with the HERS index, but none reported actively using the HERS index in their daily appraisal work.

Appraisers use PV present value calculators and utility bills: Beyond the typical resources employed by appraisers such as MLS and data on comparable properties, the appraisers interviewed mentioned using energy-specific tools for calculating present value. The most commonly mentioned tool used by appraisers for energy features are calculators that determine the present value of a PV system's future energy production (several mentions). Interviewed appraisers indicated that they might also collect utility bills before and after energy saving upgrades to serve as documentation of energy consumption in existing homes.

9.3.5. Barriers

Appraisers described several barriers they face in appraising high performance homes or conveying these appraisals to lending institutions.

Lack of data is the biggest barrier: Appraisers identified the lack of data in general, and the lack of comparable properties specifically, as their biggest barrier. Appraisers elaborated that:

- Appraisers face difficulties with identifying comparable properties in part because many of the MLS databases do not contain information about energy features and performance.
- If an MLS database does contain energy related information, the data are often inconsistent because parties recording information in the MLS may record information differently.
- Real estate agents choose which information to enter into the MLS and may not offer much detail about energy related features.
- Without an industry standard for recording this information, other appraisers cannot find the data required for comparison homes to use in the sales comparison approach.

Appraisal timeline and fee does not allow for investigation of energy features: Appraisers also expressed concerns about the time and resources required to find the information needed to value energy features. The TRC team industry expert reported that an appraisal of a high performance home might take two to three times as much effort and time as a standard appraisal. Appraisers reported that lenders expect them to conduct appraisals quickly, and the fee provided may not cover the additional time required to perform the research and due diligence to produce a credible report.

Lenders may not accept adjusted values: As a related barrier, appraisers described several issues relating to the lending process. Appraisers indicated that only some lenders are knowledgeable about energy efficiency or PV, and that unknowledgeable lenders sometimes do not accept the value that appraisers place on these features. Appraisers also indicated that lenders generally prefer a standard approach. Multiple appraisers reported that lenders did not request a different approach for high performance homes.

9.3.6. Opportunities

Appraisers called for additional education and tools: Appraisers reported that education for all parties involved in the home buying and selling process is necessary to facilitate accurate appraisals and to influence lending for ZNE-type homes and other homes with energy efficiency or distributed generation features. The appraisers recommended education for realtors, lenders, and owners. The appraisers interviewed also asked for tools from the utilities, including local utility use data (based on aggregated or anonymized energy bills), utility verified calculators to determine the value range for various energy related measures, and documentation and case studies of homes with verified reduced energy costs due to upgrades.

Most appraisers had taken training on how to value energy features. However, about half of the appraisers reported difficulty in finding training focused on valuing energy features in their region. The majority of appraisers reported actively looking for additional training and would consider additional courses if available.

9.4. Lender Interviews

PG&E contracted Cadmus to conduct and analyze interviews with lenders for this study. Cadmus conducted interviews with six lenders, all of whom are active in providing financing for Energy Efficient or PV homes. Cadmus interviewed senior executives with broad lending responsibilities or senior managers responsible for sustainability initiatives and familiar with energy efficient mortgages (EEMs). This report provides a description of EEMs in Section 3.4.3 in the report Attachment.

The TRC team notes that many lenders described their experiences with existing homes in interviews even though the interviewer described the study focus as new construction. This is possibly because the volume of existing homes is much larger than new construction homes. However, Cadmus reported that the information is generally applicable to new construction.

9.4.1. ZNE Awareness

Lenders are aware of ZNE, but see no demand: All of the lenders interviewed were aware of the term ZNE, but only one had worked on a ZNE home. Most of these lenders indicated only limited demand for energy efficient lending products such as EEMs, and no demand for a special mortgage product just for ZNE homes. Since a standard mortgage or an EEM will work for a ZNE home, these lenders reported they have little incentive to create a special mortgage product for ZNE, for which there is minimal demand.

9.4.2. Barriers

Few owners are using or asking for EEMs: Homebuyers could use EEMs to purchase ZNE-type homes. However, most lenders do not see sufficient existing or potential demand to devote resources to EEMs. Lenders make money on loan origination by standardizing and operating efficiently, so these lenders viewed an occasional EEM more as a hassle than an opportunity. Lenders also reported that EEMs also create more work because the lender must fill out extra forms, ask the homebuilder or buyer for the HERS rating report, and help educate and guide the borrower through the EEM process. In addition, lenders reported that most homebuyers are not aware of EEMs, at least not in time to help steer them towards choosing an energy efficient home. Buyers may not contact a lender until after they have chosen a home, and those that do contact a lender beforehand (e.g., for pre-qualification) are unlikely to hear about EEMs.

Appraisers have not traditionally reflected energy efficiency and PV in valuations, although this practice is improving: Two lenders noted that some appraisers are starting to include PV and/or energy efficiency in their valuations, but there has been little adoption of these practices so far. However, one lender involved with the PowerSaver program works with independent appraisers who they have trained to value PV. This lender reported getting nearly dollar-for-dollar appraisals. For instance, one recent system costing $43,000 increased the appraised value of the home by $41,000. Cadmus reported that this PowerSaver lender's efforts to get higher appraised values is not typical in the lending industry, and it may be more a reflection of this lender's commitment to energy-efficiency/PV lending in general.

9.4.3. Opportunities

EEM facilitators streamline the EEM process: Two lenders in the Sacramento area described a model that has evolved in the Sacramento area in which independent facilitators specialize in doing the extra work involved with an EEM. Under this model, the facilitator handles the additional steps of the EEM (i.e., arranges for the HERS report, helps with forms.). The facilitator can develop some efficiency due to specialization, and the lender can pass the facilitator's fee on to the borrower. This minimizes the lenders' efforts, streamlines the transaction process for all parties, and avoids delaying the purchasing transaction. Thus, the facilitator model presents an opportunity for expanding the use of EEMs. One of the lenders may already be working to expand this model to other areas of California.

Lenders report success with PowerSaver retrofit loans: The one area where lenders have had some success with special energy efficiency and PV loans is with PowerSaver home retrofits. These loans from the U.S. Department of Housing and Urban Development (HUD) primarily help borrowers make energy improvements to the home they already own. Cadmus and the TRC team noted that PowerSaver, which is for retrofitting homes, could be used for newly constructed homes to add PV or energy efficiency.

Lenders expressed interest in working with ZNE-type builders: As several lenders pointed out, a subsidy on a product for which there is little demand would not be of interest. However, when combined with marketing strategies to help generate focused demand (including connecting lenders with ZNE-type homebuilders), at least one lender expressed genuine interest.

9.5. Building Official Discussion

The TRC team conducted one group discussion with six building officials, all of whom had at least some experience with ZNE-type or Energy Efficient homes, or homes with PV.

9.5.1. ZNE Awareness

Building officials were aware of ZNE: All building officials reported being familiar with the term Zero Net Energy and ZNE-type home related building practices. The TRC team notes that it targeted building officials with ZNE-type home experience, so the broad group of building officials may not have this level of awareness.

Homebuyer education will be critical to 2020 ZNE goal: When asked about their outlook on the upcoming 2020 ZNE goal, officials reported that homebuyer education could lead to an increased willingness of builders to build ZNE-type homes. One official expressed concern regarding the CPUC and CEC's 2020 residential ZNE goal because this would make him liable for permitting a ZNE home that may not perform as expected by the homebuyer. He reported that homebuyers must be educated that ZNE does not translate into zero utility bills.

Homes exceeding code and PV is increasing, but some builders are reluctant to build above code: Building officials offered differing opinions about the current prevalence of homes built to be more efficient than code. One official in the Central Valley reported that the prevalence of homes built above code has increased over the past five years, and that utility incentives have primarily driven this trend. Another official in the same region reported that builders are reluctant to build above Title 24, because they are not required to and may not want to adopt new building practices. All building officials who offered an opinion reported that the number of homes with PV has increased over the past five years.

9.5.2. Barriers

Officials reported challenges with homes meeting and exceeding code, although some challenges with PV are improving: All building officials reported experiencing challenges with the code compliance process for both homes built to code and those built above code. According to building officials, architects often do not ensure that their building plans are code compliant (which one attributed to architects' lack of training), and contractors do not always follow code (because of a general unwillingness among contractors to change outdated building practices). Two building officials reported encountering PV systems installed by unqualified installers, but they reported that this is becoming less of an issue.

9.5.3. Opportunities

Officials called for building industry training and greater enforcement resources: All building officials emphasized the general lack of knowledge and understanding of energy efficient building practices in the building industry at all levels (general contractors, subcontractors, architects, engineers) and suggested additional education and outreach be provided to these groups.

While building officials reported they themselves generally had sufficient training, they reported a need for more staffing support and budget resources for code enforcement.

Customers may have unrealistic expectations of above code homes: Building officials report that homebuyers do not understand the value of energy efficiency in homes, and they speculated that homebuyers do not demand them from builders. Additionally, these building officials reported that Code-built owners lack the knowledge to properly operate and maintain energy efficient features, which may cause owner frustration and higher than expected energy bills.

9.6. Planner Discussion and Interviews

The TRC team held one discussion with four planners. To gather feedback from a larger number of planners, the TRC team also conducted individual interviews with four planners that could not participate in the discussion due to scheduling constraints. TRC targeted these specific planners based on their experience with ZNE-type homes reach codes or local ordinances. These planners may not necessarily represent the views of the broader community of planners in the state.

9.6.1. ZNE Awareness

Planners were aware of ZNE, but generally did not have plans for ZNE ordinances: All of the planners interviewed were aware of the term ZNE. These planners indicated that a requirement for ZNE construction would not be politically feasible for their jurisdiction at this time, and they would need to understand the impact of ZNE on cost effectiveness. Planners also indicated that their jurisdictions are "waiting and seeing" what happens at the state level for ZNE. However, one exception was the representative from a jurisdiction that had adopted a requirement for PV installation on all new construction for residential and nonresidential buildings; this representative reported this as a ZNE ordinance.

The majority or jurisdictions represented had adopted a Reach Code ordinance: Most planners (six of eight) reported having an energy efficiency or PV ordinance in the area they represented. Among officials who reported having an ordinance in their area, all but one reported that the ordinance requires residential new construction to be a percentage above Title 24, ranging between 10% and 30%. The remaining official reported having an ordinance requiring all new commercial and residential buildings to have PV. Those officials who reported not having energy efficiency or PV requirements reported not doing so because of pushback from the building industry and local jurisdictions.

9.6.2. Drivers and Barriers

Climate action plans drove ordinances: Planners representing areas with energy efficiency or PV ordinances reported that climate action plans, local politics, and a general commitment to energy efficient and sustainable practices motivated their jurisdictions to adopt these ordinances.

Cost represented the primary barrier to adopting Reach Code or PV ordinances: Most planners (four of six) who have implemented energy efficiency or PV ordinances reported experiencing barriers to enforcing and implementing ordinances. The primary barriers related to cost. Planners explained that members of the local building industry had concerns about the profitability of high performance homes. One of the planners whose jurisdiction did not adopt a Reach Code explained that calculations showed that the payback time was too long. In addition, the Reach Codes must meet CEC cost effectiveness tests. Planners indicated some confusion over whether these cost effectiveness tests need to be redone after a new code is passed. For example, one planner described how his jurisdiction requires a 10% exceedance over Title 24, but another planner asked if the jurisdiction must recalculate the cost

effectiveness under the new (2013) Title 24. In addition, planners noted a lack of uniform code requirements and difficulty with plan checking.

Both mandatory and voluntary requirements have pros and cons: Planners provided mixed responses on whether mandatory, uniform requirements such as reach codes were better than voluntary requirements. On the one hand, uniform requirements are more equitable and can be easier to implement. However, some builders prefer voluntary requirements, and these may be politically easier to pass. Jurisdictions can encourage builders to meet voluntary requirements by strategies such as waiving permitting fees.

CALGreen delayed progress in some cases: Two planners indicated that CALGreen may have delayed progress in their jurisdictions to some degree. Their jurisdictions did not want to develop ordinances, which could be replaced soon by CALGreen, so they did not implement a Reach Code, or suspended current Reach Codes, until the CEC finalized CALGreen. One planner described how many local market actors collaborated to develop his jurisdiction's local Reach Code, but this was not the case for the adoption of CALGreen Tier 1.

9.6.3. Opportunities

Builders and the planning community need more training: Officials reported a general need for more training of builders on codes, and training for the planning community to assist in their understanding of the role that Reach Codes can have in meeting climate action goals.

9.7. Interviews with ZNE-type Owners

This section presents results from phone interviews with 43 ZNE-type owners. Figure 52 describes the types of owners that completed interviews.

Geography		Home Type		Energy Performance			Total
Northern CA	Southern CA	Custom	Production	ZNE-ready	Near ZNE	ZNE	
28*	15	16	27*	4	34*	5	43

Figure 52. Description of ZNE-type Owners Interviewed

*Responses indicate the one interview that was partially completed.

9.7.1. ZNE Awareness and Terminology Interpretations

Low awareness overall, but higher awareness among custom owners: Overall, less than one-third (28%) of these owners reported being familiar with the term "Zero Net Energy." Respondents' awareness of the term ZNE differed by home type. Nearly all custom owners (18 of 19) reported being aware of ZNE, whereas less than half (11 of 24) of production owners were aware of this term.

Owners held varying interpretations of ZNE: When asked in an open-ended question what ZNE meant to them, owners most commonly mentioned that a ZNE home is one that produces as much energy as the home uses (thirteen owners), followed by no energy bills (six owners), followed by minimal energy use (five owners), and off-the-grid (four owners). Overall, 41% interpreted ZNE to mean either no energy bill or off-the-grid, both of which are interpretations that are misaligned with the CPUC and CEC definition of ZNE. Figure 33 in Section 5.4.2 shows ZNE-type owner (as well as Energy Efficient owner) interpretations of ZNE.

Eight owners further explained that they think ZNE refers to both natural gas and electricity, and two expressed disbelief that a ZNE goal is attainable.

9.7.2. Purchasing Priorities and Drivers

Production homebuyers prioritized location, cost, and layout or size: The interviewer asked an open-ended question, "What home features or characteristics were critically important in your decision to buy this home?" For custom owners, the TRC team generally phrased questions as design decisions rather than purchasing decisions. Custom owners had generally already committed to purchasing a home, but influenced the design. The interviewer then asked, of these features identified by the owner, which was the most critical.

Figure 53 presents results. As shown, owners identified energy efficiency features, location, PV, price, and size or layout as important criteria, but the ranking varied for production versus custom owners. For example, 44% of custom owners identified energy efficiency features as the most important feature, but none identified size or layout as the most important feature. In contrast, production owners identified location, price, and home size as the most important features more often than energy features. One reason that custom owners may not have identified location, price, and home size as design criteria is that they often have decided these parameters (i.e., selected a lot, identified a target price range and general home size) before detailed design begins.

Most important home features (multiple responses allowed)	Features Considered			The most important features of those considered[94]		
	Custom or Spec Homes (n=18)	Production Homes (n=24)	All Homes (n=42)	Custom or Spec Homes (n=18)	Production Homes (n=24)	All Homes (n=42)[95]
Energy efficiency/ green features (insulation, tankless water heater, etc.) or energy efficient home design	11 (61%)	10 (42%)	21 (50%)	8 (44%)	4 (17%)	12 (29%)
Location	2 (11%)	16 (67%)	18 (43%)	1 (6%)	9 (38%)	10 (24%)
Price	1 (6%)	9 (38%)	10 (24%)	2 (11%)	7 (29%)	9 (21%)
Solar panels	6 (33%)	7 (29%)	13 (31%)	2 (11%)	3 (13%)	5 (12%)
Size of the home, layout, or structure	2 (11%)	7 (29%)	9 (21%)	0 (0%)	5 (21%)	5 (12%)
Newly constructed home	0 (0%)	6 (25%)	6 (14%)	0 (0%)	3 (13%)	3 (7%)
Living in a sustainable home/ low energy footprint home	3 (17%)	0 (0%)	3 (7%)	2 (11%)	0 (0%)	2 (5%)
Financial benefits (e.g., lower or no utility bills)	5 (28%)	2 (8%)	7 (17%)	2 (11%)	0 (0%)	2 (5%)
Automation/ being able to control equipment or appliances	6%	0%	1 (2%)	1 (6%)	0%	1 (2%)
Whole experience/ all the features	-	-	-	1 (6%)	0 (0%)	1 (2%)

Figure 53. Home Features Considered by ZNE-type Owners When Purchasing Their Home, n=42

[94] Some owners provided more than one response to this question. Consequently, the total number of responses is greater than the n-value

[95] One homeowner was not asked this question, because he had remodeled his home, making the question not applicable.

Ranked-choice of ZNE home features differ from purchasing criteria listed above: The TRC team also provided a list of specific features associated with ZNE-type homes, and asked owners to rate each feature as to whether it had a "high," "medium," or "low" level of importance or was "not a consideration at all" in their decision to buy their home. Figure 54 presents results. As shown, owners ranked comfort and good indoor air quality most often as a "high priority" (slightly higher than low utility bills, energy efficiency, PV, or other features). However, none of these owners identified these features in response to the open-ended questions. When asked which of these ZNE-features were the most important, more owners identified energy features (energy efficiency, PV, and very low utility bills – 21%, 21%, and 19%, respectively) than comfort (9%) or good indoor air quality (2%).

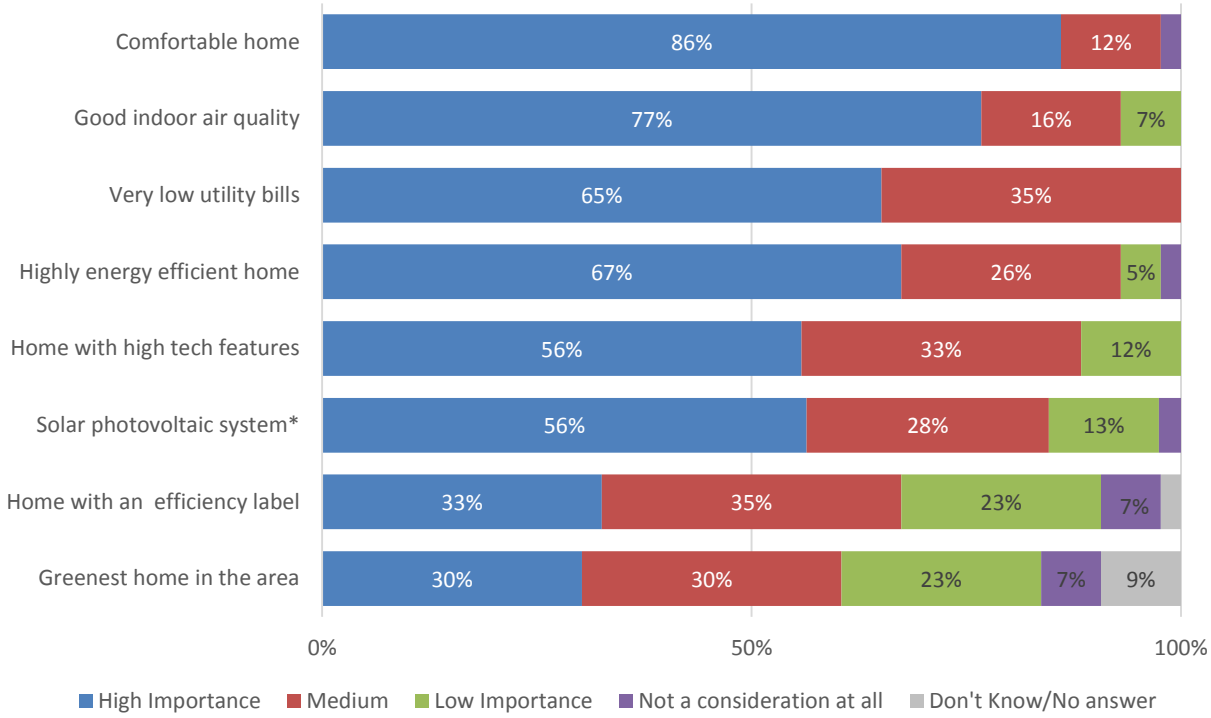

Figure 54. Level of Importance of ZNE-type Home Features in the Home Buying or Design Process, n=43[96]

9.7.3. Barriers

Cost was owners' main concern at time of Purchase: The TRC team asked owners whether they were "highly," "somewhat," or "not at all concerned" about several potential issues at the time of initial purchase. The majority of owners identified the initial cost of the home as the main concern.

Production owners held initial concerns regarding resale value, while custom owners held concerns over sufficient ventilation: Almost half (48%) of the production owners but only 11% of custom owners were concerned about resale value. Almost half (47%) of the custom owners but only 17% of production owners were concerned about sufficient ventilation.

Owners had initial concerns with managing high tech features: About one-quarter of both custom and production owners identified the ability to manage high tech features as an initial concern at the time of

[96] The number of owners rating this item was 39, because those who owned homes without PV did not rate it.

home purchase or construction. Specifically, three owners indicated either not understanding or needing additional training on how to use PV, a heat recovery ventilator, or other technologies.

9.7.4. Financing

No Energy Efficient Mortgages used: The TRC team asked these owners if they used an Energy Efficiency Mortgage (EEM) or other type of energy efficiency financing when they bought their home, and none reported that they had.

9.7.5. Labels and Rating Systems

Owners reported various labels: The TRC team listed several common energy efficiency programs and/or descriptions and asked owners if any were used to describe their home at the time of purchase. Owners most commonly recalled their home being described to them as a highly energy efficient house, a solar house, or an ENERGY STAR certified home. Some owners also reported that their home was described as receiving a label (besides ENERGY STAR), such as LEED or GreenPoint Rated, or another description, such as a Passive House or a CAHP Home.

Energy rating system recall was low: Twenty-one owners indicated that they received an energy rating score, or a description of their home's expected energy performance. Ten of these owners reported receiving a HERS rating; among those ten owners, only three recalled details when asked what information was described in those materials.

9.7.6. Experience Living in a ZNE-type Home

ZNE-type homes generally met owners' expectations: When asked what expectations they had for living in a highly efficient home, these owners primarily reported expecting low energy bills (26 mentions) and having a comfortable home (13 mentions). More than half (29 of 43) of owners reported that their expectations have been met. When asked what they liked the most about their home, owners cited comfort (15 mentions), location (11 mentions), and low energy bills (8 mentions).

Some owners expressed minor dissatisfaction: When asked what they liked the least about their home, six owners noted certain features associated with either energy efficient technologies (e.g., water pressure of low-flow faucets). Others disliked the small lot size (four mentions), home layout (three mentions), and the big annual utility bill (three mentions).

9.7.7. Perceived Value and Willingness-to-pay

Owners have a higher perceived value of their homes, because of ZNE-type features: Most (36 of 42[97]) owners reported that the energy features of their home would cause it to sell for more, compared to a home in the same location and of the same size but with standard energy performance. Their estimates generally ranged from 9-12% more, with an average of 9%.

Most are willing to pay more for ZNE-type features in their next home: When asked what priority they would put on purchasing a ZNE-type home in the future, most owners reported they would place a high priority on a ZNE-type home. They further reported that they would spend about 10% more on average for a ZNE-type home. Custom or spec owners were willing to spend 12% more on average, whereas production owners reported that they would be willing to spend 8% more. The TRC team found a positive, linear relationship between owners' perceived value of how much more their home would sell for and their willingness-to-pay for a ZNE-type home. In addition, the majority of owners reported they

[97] One homeowner that provided a partially completed interview did not respond to this question.

are willing to pay more for their next home to be a ZNE-type home than they expect to receive as an incremental sales price.

The TRC team presents the willingness-to-pay results in Figure 40 in Section 5.7.3.

9.8. Forum with ZNE-type owners

The TRC team recruited owners from two communities ("Community A" and "Community B") in the Sacramento area using an owner email distribution list and mailers. Collectively, these communities included approximately 200 near ZNE homes. Three near ZNE owners in Community A and one from Community B participated. Because the number of participants is small, readers should view results as anecdotal.

9.8.1. ZNE Awareness

Owners were aware of ZNE. All four of the forum participants reported being familiar with the term "zero net energy," but none connected the term to their home or had heard the term mentioned in connection with their homes. The TRC team did not probe for owner interpretations of ZNE.

9.8.2. Purchasing Priorities and Drivers

Energy features were a bonus, but not critical: The owners were not looking for a high performance home, but liked the layout and the neighborhood, and described the energy performance as a great bonus. Owners recalled touring the model home, and described specific elements of the hands-on demonstration of energy efficiency features. This recall was particularly impressive, because all owners had purchased their homes several years prior. One participant cited the demonstration home as the most influential source of information and explained: "[The demonstration] showed the thickness of the insulation. I could see what they were installing compared to other builders. I could see how much I would be saving. The physical demonstration was very influential."

9.8.3. Labels

Owners saw value in the LEED label: Three of the participants in Community A reported learning at the time of purchase that their homes met LEED program standards. They received LEED plaques for their homes, and all three indicated that they believed that the LEED certification carried some weight. For example, two keep the plaques in a safe place for resale.

9.8.4. ZNE-type Home Experience

Owners were generally happy with energy efficient features, but were more enthusiastic about PV: Participants had several positive and a few negative comments about energy efficiency features of their homes. They indicated that the soy-based insulation reduced outside noise, and that the radiant barrier in the attic keeps the temperature stable and comfortable. However, several participants reported that the radiant barrier reduced their cellphone reception and required them to purchase special equipment to use their phones. One participant reported being dissatisfied that the homes do not include any water recycling or water-saving irrigation features.

However, of all the included energy features these forum participants discussed, owners mentioned PV most often and most enthusiastically. Participants often referred to their homes as "solar homes." Three of the four forum participants indicated that the PV was very appealing when they were considering various homes.

PV warranties alleviated owners' concerns: Three participants (all from Community A, which had similar PV systems and contracts) reported not worrying about the potential cost of parts or maintenance for their PV system because their long-term warranties covered them. (Navigant 2014a found, based on a review of PV warranties, that the owner typically assumes most of the long-term risk of equipment malfunctions and system maintenance. The forum participants may have had misperceptions regarding their warranty, or their warranties may differ from the typical trends identified by Navigant.) These three participants reported that they preferred owning a PV system instead of leasing in part because of concern over how a leased PV system would be transferred if the home was sold. The fourth participant (in Community B) reported that his inverter needed replacing; he viewed this as a significant additional cost that was not included in his warranty and as a serious annoyance. This participant viewed a leased system as potentially more attractive than an owned system. All participants reported having a PV display and frequently checking it. All were aware of their system's typical output in terms of kW, and enthusiastically compared these numbers with other forum participants. The participants from Community A also liked that their PV was integrated into the roof, for aesthetic reasons.

9.8.5. Experience Living in a ZNE-type Home

Owners have had a very positive experience: Overall, participants appeared very pleased with their homes and reported that the experience of living in a ZNE-type home is positive and provides an improved quality of life compared to their previous homes. Benefits mentioned including lower bills, greater comfort, and reduced outdoor noise.

9.8.6. Perceived Value and Willingness-to-pay

Owners expressed a higher perceived value: All of the group participants indicated that they are confident that their home is worth more than a similar home without the energy features.

Owners are willing to pay more for ZNE features, particularly PV: Participants indicated that, if they were to move again, they would place a high value on the energy features of their potential future home. Three indicated they would place a high priority on PV. The fourth participant was the owner in Community B that needed to purchase a new inverter. He reported that his future purchasing decisions for PV or other features would depend on payback times, and that payback would need to be less than ten years. The owners also mentioned looking for energy efficiency, but PV appeared to be a higher purchasing criterion.

9.9. Surveys with Energy Efficient Owners

The TRC team conducted phone surveys with 112 Energy Efficient owners. The homes represented in this survey meet the entry-level for requirements for CAHP participation (i.e., 15-20% more efficient than Title 24), but are not so efficient as to be considered ZNE-type homes. Approximately one-third (30%) of the homes represented in the survey have PV, and almost all of the homes (109 of the 112) were production homes.

9.9.1. ZNE Awareness and Terminology

Low awareness of ZNE: Less than one-third (28%) of owners surveyed reported being familiar with the term "Zero Net Energy." Of those that were, owners interpreted ZNE to mean producing as much or more energy as the home uses (43%), no energy bills (19%), or minimal energy use/"saving energy in every way" (16%).

9.9.2. Purchasing Priorities and Drivers

Energy efficiency was important, but owners identified home size and location more often: The TRC team asked owners an open-ended question of which home features were critically important in their decision to buy their home, and which of these features (identified by the owner) was the most important in their decision. Figure 55 presents the results. Owners identified home size (50%), location of the home (48%), and energy efficiency (38%) as their top considerations. Taking all energy features together (energy efficiency, PV, and low utility bills), 53% of owners mentioned at least one. However, when asked which was the "most important" in their purchasing decision, owners identified size (23%) and location (23%) rather than energy features (16% for energy efficiency, PV, and low utility bills combined).

Important Features	Mentioned feature (*n*=112)		Percent Reporting Most Important Feature (*n*=106)
	Count	Percent	
Size of the home (# of bedrooms, sq. ft.)	56	50%	23%
Location of the home	54	48%	23%
Energy efficiency	39	35%	11%
Price of the home	31	28%	16%
Other home features and amenities[98]	26	23%	8%
Newly constructed home	24	21%	8%
Lot size	22	20%	6%
PV	18	16%	5%
Low utility bills	2	2%	0%
Other	3	3%	1%
Don't know or Refused	3	3%	--

Figure 55. Home Features Influencing Energy Efficient Owners' Purchasing Decision (Multiple Responses Allowed)[99]

Owners did not have a choice to purchase PV or viewed it as cost-prohibitive. About one-third (30%) of owners reported that their home is equipped with PV. Among owners with PV, most (28 of 33) reported that it was included with the home. The TRC team asked the owners without PV why they did not install PV on their home. Owners most commonly reported that PV was not an option (40%) or that the cost was prohibitive (31%). Among those owners indicating that PV was not a consideration, almost all (16 of 17) were Southern California owners.

Owners prefer at least one natural gas appliance if given the option: About two-thirds (61%) of Energy Efficient owners reported that they had at least some ability to customize or choose specific features for their home. Of those who did, about two-fifths (26 of 68) of owners reported they had the option to select a natural gas appliance over an electric appliance. The majority of owners (88%) who had a fuel

[98] Other home features and amenities included having a single story, flooring, high ceilings, roofing, large garage, quality workmanship, curb appeal, view, and floor plan.

[99] Three owners provided "don't know" responses.

option selected a natural gas appliance over an electric one for at least one appliance. Most owners (92%) who reported that they did not have a fuel choice reported that natural gas appliances were already installed in the home they purchased.

9.9.3. Labels and Rating Systems

Most owners were aware of efficiency, and some reported that labels were used to describe their homes: Nearly all owners (87%) reported being aware that their home was built to be more energy efficient than a typical home at the time of purchase. When the surveyor provided a list of seven common energy efficiency programs and descriptions, owners most commonly recall the use of "energy efficient house" and "ENERGY STAR certified home" to describe their home. PV owners also recalled their homes described as "solar homes." Some owners also reported that their home was described as LEED or GreenPoint Rated, or as a CAHP Home.

Owners had a low recall of energy rating systems, but those that remembered it described it as helpful: Over one-third of owners (39%) reported they did not know if they received an energy rating, score, or description of their homes' expected energy performance at the time of purchase. Less than one-quarter (23%) of owners reported they received one. When asked what energy rating, score, or description they received, about three-quarters (18 of 26) of owners reported they did not remember. For those owners that did recall what information they received, five owners mentioned the HERS Index. For those that received information on their home's energy performance, over three-quarters (18 of 26) reported the information they received was very useful (at least a rating of four on a five-point scale).

9.9.4. Energy Efficient Home Experience

Homes generally met owners' expectations: When asked about their expectations for their energy efficient home, owners most commonly reported expecting lower energy bills (62%) or a more comfortable home (20%). Nearly all (99%) owners reported that their expectations "have been met" or have been "somewhat met." The one owner whose home had not met their expectations reported expecting lower energy bills.

Initial cost and resale value were top initial concerns: Owners were asked, "When choosing your home, please let me know if you were 'not at all,' 'somewhat,' or 'highly concerned' about each of the following, because of the energy efficient features of your home?" The surveyor then provided a list of possible concerns that elicited the following responses:

- Owners identified resale value (57%) and initial cost (59%) most often as issues for which they were somewhat or highly concerned.
- Approximately half of owners identified initial concerns with efficiency items (e.g., not performing as expected; 52% were at least somewhat concerned).
- Almost half (46%) reported they were at least somewhat concerned that the home would not provide sufficient ventilation.
- Approximately one-third (31%) had initial concerns about managing high tech features, such as monitoring or maintaining PV panels, appliances or other controls. Owners with PV installed on their home at the time of purchase were significantly more likely to report being concerned with managing high tech features than those who did not have PV installed (46% and 26%, respectively; Z-Test of Proportions at $p<0.05$).
- Few had concerns that their home would not be comfortable.

9.9.5. Perceived Value and Willingness-to-pay

Owners perceive a higher value due to energy features, particularly PV: Two-thirds (66%) of owners expect their homes' energy features will result in a higher sale price than a code-built home in the same location and the same size, and the remaining reported that their home would sell for about the same amount. Comparing owners with PV and those without, the TRC team found that owners with PV were significantly more likely to report their home would sell for more compared to those without PV (91% compared to 59%, respectively, Z-Test of Proportions at $p<0.05$). In terms of how much more they expect their home to sell for, one-third (33%) of Energy Efficient owners reported the energy efficiency features of their home would increase the value of their home by 1% to 10%, with an average of 14% and median of 10%.

Owners were willing to pay more for a ZNE-type home: When asked how much of a priority they would put on purchasing a ZNE-type home in the future, about half (49%) of owners reported that having an energy efficient home would be a "high priority." Again, those owners with PV were significantly more likely to report placing a high priority on a high energy-performance home than those who did not have PV (70% compared to 42%, respectively). Half (50%) of the Energy Efficient owners reported they would be willing to pay 1% to 10% more to obtain a ZNE-type home. Of these owners willing to pay more, about half (or one-quarter of all respondents) reported they would pay 1 to 5% more, and the other half (or one-quarter of all respondents) reported they would pay 6-10% more. The TRC team asked the willingness-to-pay question as a coded question (i.e., with multiple-choice responses), so the team could not calculate a reliable median value.

Owners' willingness-to-pay increased with higher perceived value: There was a positive, linear relationship between owners' perceived value of energy efficiency features in their home and their willingness-to-pay for a ZNE-type home. In other words, the more value owners attribute to their home's energy efficiency features, the more they are willing to pay for their next home to be a ZNE-type home. This may indicate that they see an increased value to their home (based on their experience) and are willing to pay more for their next home to include high performance energy features.

The TRC team presents the willingness-to-pay results graphically in Section 5.7.3.2.

9.10. Forum with Code-built Owners

The TRC team conducted a forum of Code-built owners in a community near Sacramento, California. This same community included the majority of participants in the forum with ZNE-type owners (Community A). The community includes several hundred homes. The TRC team recruited owners using an email distribution list and offered cash for participation. The TRC team targeted Code-built owners (based on owners' self-reported information) that did not have PV. Ten owners participated, two of which owned homes with PV.

9.10.1. ZNE Awareness

Code-built owners had no awareness of ZNE, but expressed interest at the right price: The forum moderator asked participants if they had heard of the term "Zero Net Energy" and none reported any familiarity with the term. After the moderator offered a definition, all of the forum participants indicated that they found the ZNE concept appealing as long as the cost was reasonable. When the forum moderator asked participants about a future where ZNE-type homes with PV are the only option for new homes, many participants expressed concern over the cost.

9.10.2. Purchasing Priorities and Drivers

Energy features were a low priority: Similar to owners in the ZNE-type forum, the owners in the Code-built forum sought homes within their price range, in a desirable location (i.e., close to high quality schools and work), and with a floor plan they liked. Several Code-built forum participants indicated that they considered energy efficiency when looking to purchase a home, but that it was a lower priority than location or a family friendly atmosphere. A few participants indicated that they looked for a home with PV, but did not find one with the floor plan they wanted. For example, owners commented on looking for a home that was one-story, or a home with high levels of natural light.

Owners had low awareness of energy features: When asked about energy efficiency features, forum participants recalled that staff from the development told them about efficient windows, low-flow toilets, and efficient appliances. Only one of the participants spent time researching additional energy efficiency features that he could request during construction. No other forum participants reported being aware at the time of purchase of the potential to increase the efficiency of their home with optional add-on features. Several forum participants reported being dissatisfied with the energy performance of their homes and appliances, especially air conditioners.

Many owners did not find a home with PV that met their critical criteria: The forum participants without PV explained that builders did not offer them the option of PV, or that they had not found a home with PV in their price range or desired location. Of the two owners with PV, one reported that the PV was already installed at the point of purchase; this owner described the PV as a selling point, but not as the most important feature in their purchasing decision. The other participant installed PV later, because of high utility bills.

9.10.3. Labels

Owners had no awareness of home energy labels: None of the Code-built forum participants indicated that they were familiar with home energy labels. One participant had received a rebate for having an ENERGY STAR appliance, but none appeared aware of the ENERGY STAR Homes label or LEED.

9.10.4. Code-built Home Experience

Owners were satisfied, but not because of energy performance: Code-built forum participants indicated that they are generally satisfied with the experience of living in their homes. A few participants voiced small complaints about the layout, availability of natural lighting, or the orientation of their home. Participants did not typically mention energy related topics without prompting when asked about overall home satisfaction. When asked specifically about comfort and energy use, participants indicated that their large homes require a great deal of energy for heating and cooling, unexpectedly poor performance of some equipment (particularly air conditioners), and temperature balancing issues (i.e., some rooms are more difficult to heat/cool than others).

Some owners had energy bill shock: Several participants recalled being shocked by their first energy bills in their homes and have since taken steps (both behavioral and measure-based) to reduce their energy consumption or shift consumption to off-peak times. Participants indicated that they have learned how to set their thermostats to maximize comfort while minimizing their energy costs.

Some owners were skeptical of PV leasing: The participants without PV reported that companies offering leased PV systems frequently contact them. Most did not find leasing panels attractive because they were skeptical of the energy savings or did not understand the leasing process. Several participants remained undecided on whether they would install PV on their homes. Concerns included that they may not remain in the home long enough for the initial cost to pay back, and resale concerns.

9.10.5. Willingness-to-pay

Owners reported willingness-to-pay for PV: When asked about their purchasing criteria relating to energy features for their next home purchase, several participants indicated that they would consider PV. Of the two participants who had already installed PV, one indicated that they would definitely purchase PV for their next home and would purchase a larger capacity system. Participants also indicated that if they were to purchase another home, and if their family situation allowed, they would look for a smaller home—possibly one story—and a home with energy efficiency measures (e.g., several participants mentioned tankless water heaters).

9.11. Impact of TDV on Policies and ZNE-type Homes

The study sought to frame the role that Time Dependent Valuation (TDV) will play in the evaluation of ZNE homes and its impact on the marketing and metrics for ZNE homes.

9.11.1. Description of Time Dependent Valuation (TDV)

The value of energy changes by hour (for electricity) or month (for natural gas): The CEC uses the TDV metric to evaluate cost-effectiveness of proposed code change measures. According to the CEC (2013): "The TDV concept, first used in the 2005 California Building Energy Efficiency Standards, is based on the forecasted seasonal and hourly costs for generating, transmitting, and distributing electricity, and producing and distributing natural gas and propane. TDVs are established for every hour of the year for each type of energy in each of California's 16 climate zones. The set of values considered under TDV are specific to the intent of the metric to recognize the premium utility costs that must be paid for energy consumed during peak conditions compared to the substantially lower costs during off-peak conditions." Prior to 2005, the CEC used a flat value of source energy cost to evaluate the cost-effectiveness of measures. The CEC calculates TDVs separately for the three primary fuels used in buildings – electricity, natural gas and propane. Electricity values change by hour for each hour of the year while natural gas and propane values change by month.

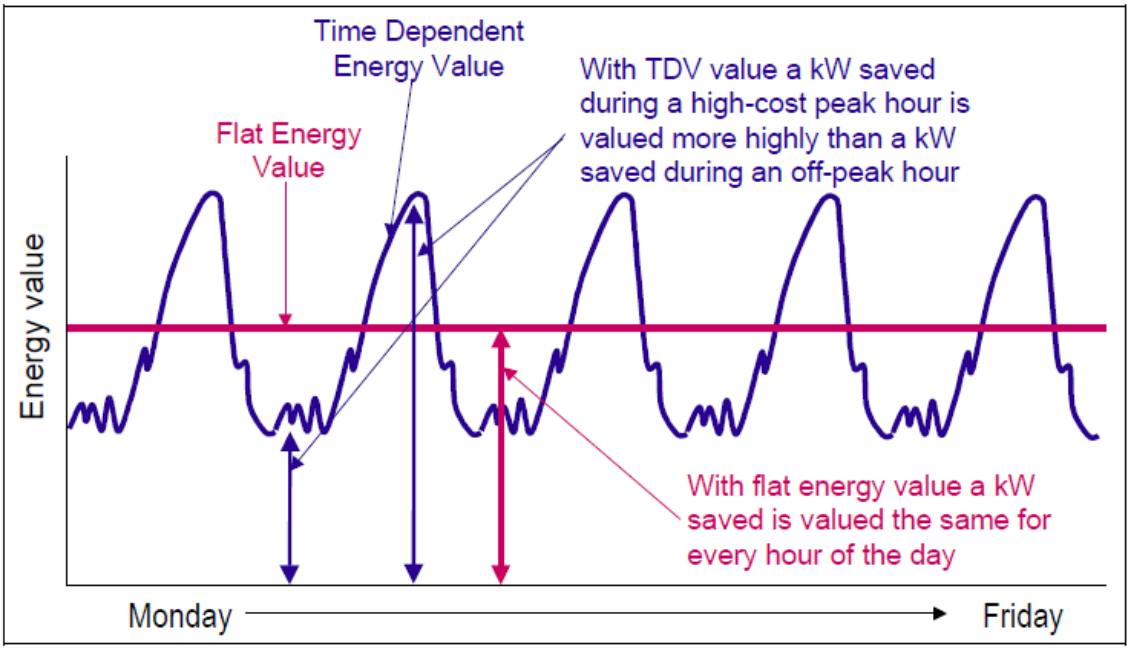

Figure 56. TDV Concept: "Flat" Valuation versus TDV for Electricity Use (Source: PG&E 2002)

Energy saved on-peak valued higher than energy saved off-peak: The TDV value of electricity savings is highest during summer peak periods when there is demand for additional generation resources. As a result, residential HVAC energy savings receive higher benefit under TDV (since HVAC usage coincides currently with system peak) and residential lighting savings receive lesser benefits since they typically occur at night.

9.11.2. Importance of TDV

TDV affects the energy equation for ZNE: The primary purpose of TDV is to guide the development of new code changes to the Title 24 building energy efficiency standards. As such, TDV is intrinsic to the "ZNE Code" definition outlined in the 2013 Integrated Energy policy Report (IEPR):

"A ZNE Code Building is one where the net of the amount of energy produced by on-site renewable energy resources is equal to the value of the energy consumed annually by the building, at the level of a single 'project' seeking development entitlements and building code permits, measured using the California Energy Commission's Time Dependent Valuation (TDV) metric. A ZNE Code Building meets an Energy Use Intensity value designated in the Building Energy Efficiency Standards by building type and climate zone that reflect best practices for highly efficient buildings." (CEC 2013)

As explained in the following section, TDV captures benefits to society beyond the benefits to IOU ratepayers. It captures the impacts of energy efficiency, demand response, and renewables on California in a holistic manner and provides a way to quantify the varying value of electricity and other fuels by time of day and season.

TDV-based definition of ZNE requires less renewable energy: Because TDV places a higher value on energy savings during summer peak than the traditional (flat) valuation, using the TDV-based "ZNE Code" definition requires the least amount of renewables on site to meet ZNE design standards. This results in lower costs to owners, the utilities, and society as a whole. Figure 57, excerpted from the "Road to ZNE" report[100], illustrates the TDV effect relative to other energy metrics. The three columns on the right in Figure 57 show the rooftop PV installations needed to meet statewide ZNE targets under different definitions of ZNE (site based, source based, and TDV-based). For context, these 2020 PV installation numbers are shown next to the total cumulative residential PV installations under the CSI and the NSHP from 2006 through 2012, and the additional rooftop PV installations required between 2012 and 2017 to meet the residential share (33%) of the statewide "million solar roofs" goal of 3,000 MW by 2017.[101] The error bars on the 2020 numbers represent uncertainty around new residential construction starts in 2020. The error bars reflect the 10th and 90th percentiles of the difference in new construction starts each year based on a linear fit of the historical trend.

[100] HMG, 2012. Heschong Mahone Group. *Road to ZNE: Mapping Pathways to ZNE Buildings in California.* Managed by PG&E for California IOUs. December 20, 2012. http://www.energydataweb.com/cpucFiles/pdaDocs/899/Road%20to%20ZNE%20FINAL%20Report_withAppendices.pdf

[101] The residential share of 33% was derived from the residential vs. commercial goals of the CSI program (CEC and CPUC 2012).

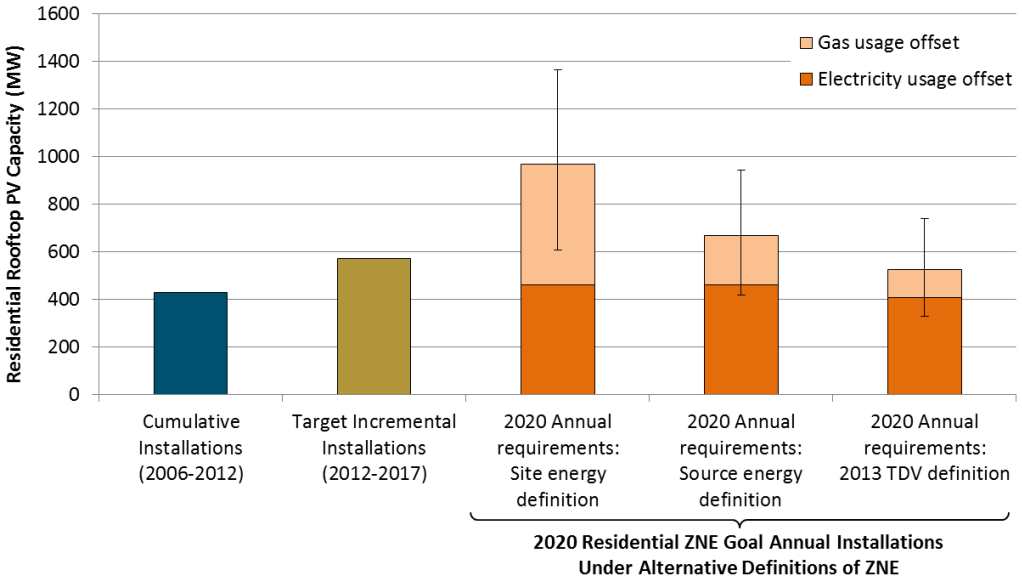

Figure 57. Installed PV, and PV Needed for ZNE under Different Definitions of ZNE (Source: HMG 2012)

As shown in Figure 57, the amount of PV needed to meet ZNE goals is less under the 2013 IEPR TDV definition than under a site or source energy definition. The site energy-based definition of ZNE would require approximately 970 MW of PV installed in 2020, based on a residential construction forecast of 150,000 new units, with an estimated range between 610 MW and 1,400 MW of PV in 2020 depending on the new residential construction starts. The 2013 TDV-based definition would require almost half as much PV as the site-energy definition: 530 MW of PV installed in 2020, with an estimated range of 330 MW to 740 MW depending on the new residential construction starts. The source energy definition would require a level of new PV capacity between those determined with the site energy and TDV-based definitions.

9.11.3. 2016 TDV Update Process

CEC (and E3) are updating TDVs for 2016 Title 24: The CEC contracted E3 to develop updated TDVs for the 2016 Title 24 updates. E3 presented preliminary results from their analysis at two workshops organized by the CEC. Below are key highlights from the 2016 updates to TDV as excerpted from the 2016 TDV Methodology Report (E3 2014):

"The economics for the 2016 Title 24 Building Energy Efficiency Standard TDVs, like those developed for the 2008 and 2016 T24 updates, are based on long-term (15- and 30-year) forecasts that reflect existing energy trends and state policies. The timeframe of the economic analysis used in the 2016 TDVs spans the years 2017 to 2046 for the 30-year analysis and 2017 to 2031 for the 15-year analysis. TDV NPV costs are reported in 2016 dollars, and are formatted to the 2009 calendar year and 2009 weather year file data."

E3 took the majority of its input assumptions for the 2016 TDV Update from the 2013 Integrated Energy Policy Report (2013 IEPR) and associated planning documents. To reflect current state policy, the 2016 Title 24 TDV factors include the costs and generation impacts of the Renewable Electricity Standard (requiring 33% renewables by 2020) as well as other policies around the state law AB 32, which requires a reduction in greenhouse gas (GHG) emissions to 1990 levels by 2020. Figure 58 describes the key assumptions included in the 2016 TDV numbers.

Input	Summary of Sources and Assumptions
Retail rate escalation	Based on average electricity rate forecasts from the 2013 IEPR. Compared to the rate forecast used for the 2013 TDVs, the new electricity rate forecast begins higher in the early years, but escalates at a lower rate than the 2013 values. The 2013 forecast escalated at 3.4%/yr. in nominal terms after 2020, compared to 2.9%/yr. for the 2016 forecast.
CO_2 price	Developed using the 2013 IEPR Mid Case, based on current Cap-and-Trade and Trade regulation continuing through 2020. Assumes a high probability that complementary policies reduce emissions through 2017, but that the availability of complementary policies diminishes after 2017.[102]
Renewable Portfolio Standard (RPS)	Assume that California will meet a 33% RPS by 2020. Renewable portfolio is based on 2012 Long-term Procurement Planning (LTPP) "Commercial" Scenario for R. 12-03-014.[103]
Energy Efficiency	Based on the 2012 California Energy Demand Forecast - Mid Demand case, including Additional Achievable Energy Efficiency Mid Case.[104]

Figure 58. Key Assumptions in 2016 TDVs (Based on E3 2014)

9.11.4. 2016 TDV Update Connected To Various Statewide Efforts

TDV update leverages other statewide efforts: CEC and E3 are developing the 2016 TDV update in concert with work already done for the 2013 IEPR. The Long Term Energy Procurement Plan (LTPP) and the California Independent System Operator (CAISO) Transmission Planning Process (TPP) intend to use similar analysis as the IEPR. The 2016 TDV update leverages each of the following:

- LTPP and TPP demand forecasts: The 2013 IEPR makes a conscious effort to tie the energy demand forecast for the IEPR with the energy demand forecasts used by the LTPP and TPP. The IEPR presents an overall Energy Demand Forecast based on the California Energy Demand Final Forecast 2014–2024 (the "CED 2013"). Traditionally these forecasts reflect committed energy efficiency and conservation efforts such as utility and public agency programs, codes and standards, legislation and ordinances that have final authorization, firm funding and a design that can be readily translated into characteristics that can be evaluated and used for estimating future impacts. The 2013 CED and thus 2013 IEPR continue these traditional forecasts, now called baseline forecasts.
- Additional Achievable Energy Efficiency (AAEE): New to 2013 forecasting efforts are AAEE savings scenarios that include several other energy efficiency potentials such as future emerging technologies, codes and standards not yet developed (but will be within the time frame of the

[102] Based on analysis presented in a report" Forecasting Supply and Demand Balances in California's Greenhouse Gas Cap-and-Trade Market" March 12, 2013. This reported was prepared by members of the Emissions Market Assessment Committee and the Market Simulation Group. The mid case scenario increase in price of 1.5 times the low energy consumption scenario is based on the Economic Analysis done in support of the regulations to implement the California Cap-and-Trade program. Appendix N, page N-13.

[103] See December 19, 2012 Joint California Energy Commission and California Public Utilities Commission staff Workshop on renewable resource portfolios for the California ISO Transmission Planning Process.

[104] California Energy Demand 2012-2022 Final Forecast. May 2012. CEC-200-2012-001-SF-VI

IEPR period of analysis), and projected naturally occurring energy efficiency and conservation efforts. These naturally occurring efforts reflect the broader energy efficiency and renewable energy policy goals such as ZNE; neither are legislative mandates nor have firm commitments in place.

- 2013 CED: The CED 2013 forecast contains three baseline cases (high, mid, and low) and five scenarios of additional achievable energy efficiency (high, high-mid, mid, low-mid, and low). The three middle AAEE scenarios all use the same economic, demographic, building stock, and price assumptions to provide consistent alternatives for planning purposes.
- 2013 Potentials, Goals and Targets (PGT) study: The AAEE forecasts are based on the 2013 CPUC PGT Study conducted by Navigant in 2012-2013. The PGT study provides specific recommendations for how the next phase of development for the IEPR, IOU program goals, LTPP, and TPP, and how tracking overall AB32 compliance should reflect various scenarios analyzed in the PGT study.

State agencies and the California Independent System Operator (CAISO) are working to align energy demand forecasts. There are several overlapping influences and references for each of these statewide efforts, which the TRC team summarizes in Figure 59 below. Solid lines in the figure represent direct reference and incorporation of data from one study to another (e.g. 2013 PGT Mid Case Forecast is used as the basis for setting 2015 IOU goals) while dotted lines indicate where the data from a study has influenced data in another study (e.g. 2013 PGT study Baseline Mid case is based on 2012 IEPR Mid Case with some differences). As shown in Figure 59, there is now a deliberate and concerted effort to align the energy demand forecasts in the various initiatives.

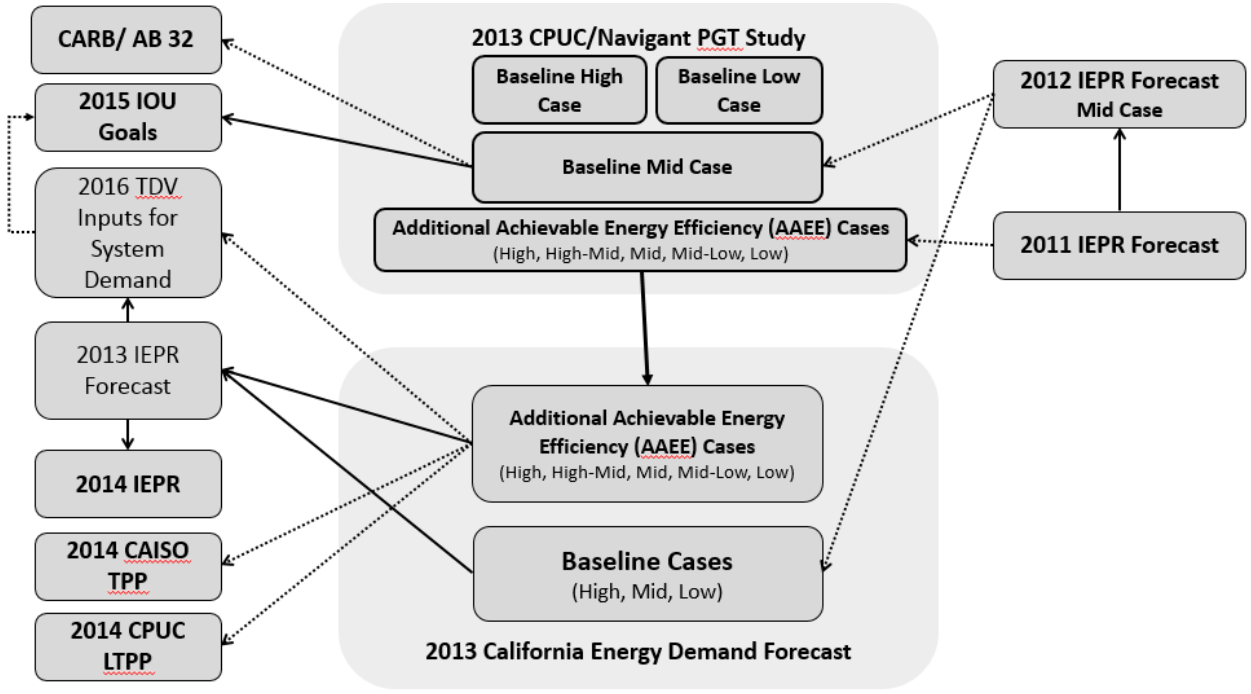

Figure 59. Summary of Energy Demand Forecasts Embedded in Various Regulatory Efforts as of 2013

9.11.5. Impact of 2016 TDV Updates

2016 TDVs similar to 2013 TDVs, with a higher and later peak: The 2016 TDV updates involved various changes that are highly technical, econometric in nature, and difficult to dissect on their own. However, the sum of the changes results in an overall TDV valuation that closely aligns with the overall TDVs for 2013 Title 24, with some small changes. These are illustrated in Figure 60, which shows current average TDVs compared to future average values for California climate zone 13. E3 conducted the analysis for four climate zones (3, 7, 11, and 13). Because the differences between 2013 TDV and 2016 TDV was similar for the different climate zones, the TRC team only shows result for climate Zone 13. The simulation supporting the 2016 TDV update is titled "2017" because the change would take effect in 2017.

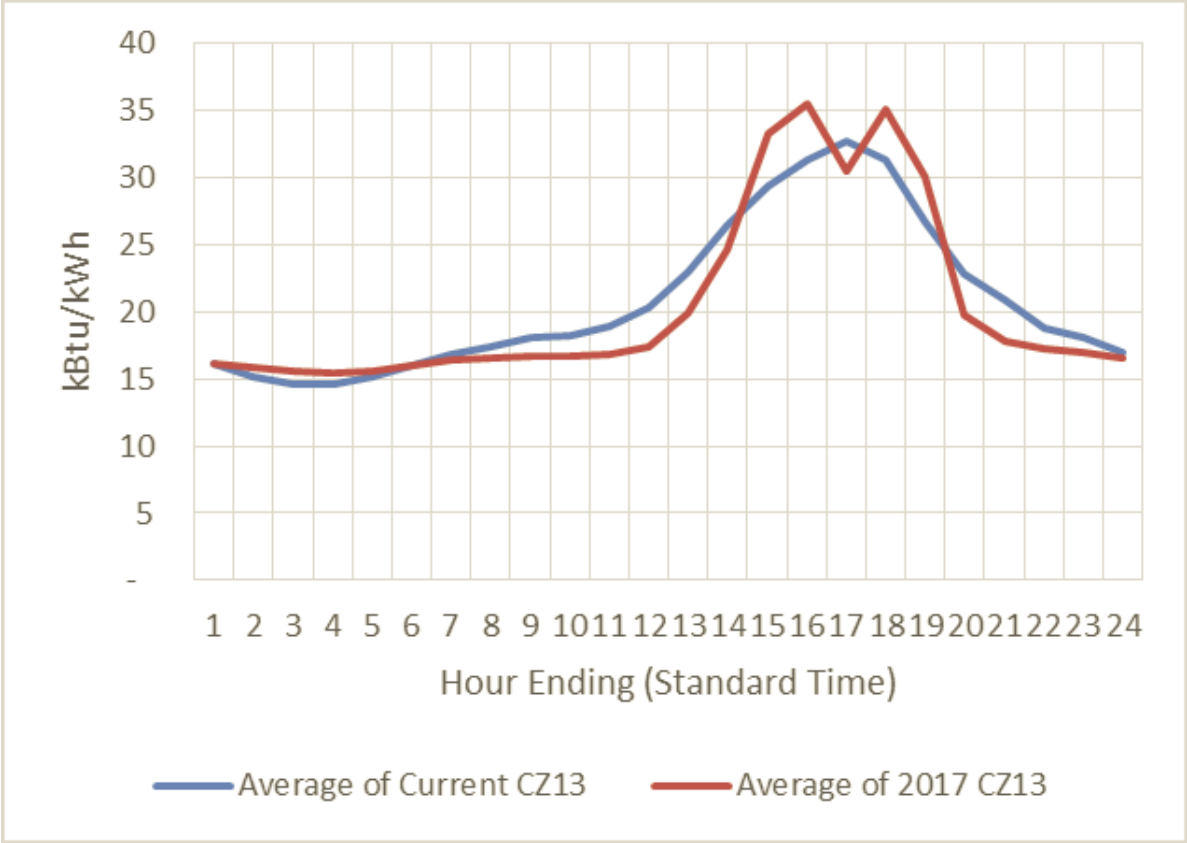

Figure 60. Comparing Average 2013 and 2016 TDVs for Residential Buildings (Source: E3 2014)

As seen in Figure 60, the 2016 values have stronger peaks than the 2013 TDVs, which will result in slightly higher energy savings and cost-effectiveness for measures that save energy during peak times. Figure 60 is based on an annual average, and the new double-hump shape of the TDVs around 4:00 pm is an artifact of averaging TDVs over multiple months for the purpose of this figure. When viewed for any individual day, there is generally only one peak, but this peak occurs at different times of the day depending on the month. The peak in September is higher and later in the day than the peak in July/August. This is primarily due to the weather files that have higher temperatures later in the day in September than the other summer peak months. As the penetration of PV increases on the grid (both utility-scale as well as rooftop), the peak will shift to later in the day. Overall, the impact of these TDV updates will be positive on the Title 24 development and will promote greater energy efficiency in buildings.