Residential ZNE Market Characterization

Final Report

CALMAC Study ID PGE0351.01

February 27, 2015

Submitted to:
Pacific Gas & Electric Company

On behalf of:

Southern California Edison

San Diego Gas and Electric Company

Southern California Gas Company

Submitted by:

TRC Energy Services
11211 Gold Country Blvd. #103
Gold River, CA 95670
Phone: (916) 962-7001
website: www.trcsolutions.com

Abhijeet Pande; Marian Goebes, PhD; and Stephanie Berkland, et al.

Marjorie McRae,
Mersiha McClaren, et al.
research into action inc

Debra Little
See A Home Like Yours

CIC Research

TABLE OF CONTENTS

1. ACKNOWLEDGMENTS 6
2. EXECUTIVE SUMMARY 7
2.1. Introduction and Methodology 7
2.2. Synthesis of Findings 9
2.3. Summary of Conclusions and Recommendations 15
3. INTRODUCTION 20
3.1. Study Purpose and Background 20
3.2. TRC Team Introduction 20
3.3. Study Limitations 21
3.4. Terminology Used in this Report 22
4. METHODOLOGY 28
4.1. Collaboration with Stakeholders 28
4.2. Initial Data Collection 28
4.3. Market Actor Feedback and Market Size Estimates 29
5. SYNTHESIS OF FINDINGS 34
5.1. ZNE-type Home Market Size Estimates 35
5.2. Characteristics of ZNE-type Homes 47
5.3. Awareness of ZNE 55
5.4. ZNE Terminology Interpretations 57
5.5. Messaging of ZNE-type Homes 61
5.6. Owners' Home Purchasing Criteria 65
5.7. Cost and Value of ZNE-type Homes 69
5.8. Home Satisfaction for Owners 76
5.9. ZNE-Related Policies 78
5.10. Drivers and Barriers for Market Actors 81
5.11. Opportunities Identified by Market Actors 92
6. CONCLUSIONS AND RECOMMENDATIONS 95
6.1. ZNE Market Transformation Initiative 101
6.2. ZNE-Related Policies 110
6.3. ZNE Research Priorities 112

6.4. Concluding Statement 114

7. APPENDIX A: ZNE-TYPE HOME EXAMPLES 116

8. APPENDIX B: BIBLIOGRAPHY 122

9. APPENDIX C: SUMMARY OF DATA COLLECTION RESULTS 131

9.1. High Performance Builder Interviews 131

9.2. Utility Program Manager Interviews 136

9.3. Appraiser Interviews 138

9.4. Lender Interviews 140

9.5. Building Official Discussion 142

9.6. Planner Discussion and Interviews 143

9.7. Interviews with ZNE-type Owners 144

9.8. Forum with ZNE-type owners 148

9.9. Surveys with Energy Efficient Owners 149

9.10. Forum with Code-built Owners 152

9.11. Impact of TDV on Policies and ZNE-type Homes 154

TABLE OF FIGURES

Figure 1. Home Energy Performance Classifications 8
Figure 2. Summary of Data Collection 9
Figure 3. Estimate of Market Size for ZNE-type Homes from Different Sources 10
Figure 4. Market Size Estimates under Different Definitions of "ZNE-type" 10
Figure 5. ZNE-type Homes as a Percent of the Total Permits, by Year 11
Figure 6. Summary of Drivers and Barriers to ZNE-type Homes 15
Figure 7. Summary of Recommendations 19
Figure 8. Home Energy Performance Classifications 23
Figure 9. Study Classification of ZNE and Other Energy Performance Terms 24
Figure 10. Summary of Primary Data Collection 30
Figure 11. Data Sources for Homes in Owner Data Collection Activities (Interviews, Surveys, Forums) 31
Figure 12. Data Sources for Homes in Market Size Estimates 32
Figure 13. Summary of Data Sources 33
Figure 14. ZNE-type Home Market Size Estimates Provided by RFI Respondents 36
Figure 15. Market Size Estimates under Different Definitions of "ZNE-type" 38
Figure 16. Estimate of Market Size for ZNE-type Homes from Different Sources 39
Figure 17. Number of ZNE-type Homes Compared to Single-family Housing Starts by Year 41
Figure 18. ZNE-type Homes as a Percent of Total Permits by Year 42
Figure 19. GreenPoint Rated ZNE-type Homes by Year 43
Figure 20. Number of Homes Reported Built in the Past 3 Years by Builders Interviewed 43
Figure 21. Home Energy Performance Distribution (PG&E, SCE, and SDG&E CAHP, and NSHP Data) 46

Figure 22. Home Energy Performance Distribution (SoCalGas CAHP Data) 46

Figure 23. Penetration of PV Relative to Energy Efficiency Level 47

Figure 24. ZNE-type Home Characteristics (CAHP and RFI Data) 48

Figure 25. Zip Codes of ZNE-type Homes by California Income Quintiles (CAHP / NSHP / RFI Data) 49

Figure 26. Location of Energy Efficient and ZNE-type Homes, based on CAHP/ NSHP / RFI Data 50

Figure 27. Location of ZNE-type Homes – GPR Data 52

Figure 28. ZNE-type homes Compared to Total Housing Starts by Climate Zone 53

Figure 29. ZNE-type Homes Characteristics by Builder and Location (CAHP and RFI Data)..... 54

Figure 30. Number of Distinct Cities, Zip Codes, and Builders of ZNE-type Homes 55

Figure 31. Self-Reported Owner Awareness of the Term "ZNE" 56

Figure 32. Owner Self-Reported Source of ZNE Awareness 57

Figure 33. Owner Interpretations of ZNE 59

Figure 34. Labels and Programs Used by Builders for ZNE-type Homes (Multiple Reponses Allowed) 63

Figure 35. Home Purchasing Criteria for Owners of Different Home Types 66

Figure 36. Most Important Home Purchasing Criteria Reported by Owners of Different Home Types 66

Figure 37. Level of Importance of ZNE-type Home Features in the Home Buying or Design Process, n=43 68

Figure 38. Program Managers' and Builders' Estimates of Incremental Cost to Build a ZNE Home 71

Figure 39. Builders' Responses of Homebuyers' Willingness-to-pay for ZNE Homes 73

Figure 40. ZNE-type Owners' Expected Increase in Sales Price of Current Home vs. Willingness-to-Pay Premium, n=32 74

Figure 41. Energy Efficient Owners' Expected Increase in Sales Price of Current Home vs. Willingness-to-Pay Premium (n=112) 75

Figure 42. Summary of Market Drivers 82

Figure 43. Summary of Market Barriers 83

Figure 44. Builders' Drivers to Pursue ZNE-type Homes 84

Figure 45. Builders' Barriers to Pursue ZNE-type Homes 85

Figure 46. Owners' Drivers to Buying ZNE-type Homes 89

Figure 47. Owners' Barriers to Buying ZNE-type Homes 92

Figure 48. Summary of Recommendations 100

Figure 49. Description of Builders Interviewed 132

Figure 50. Number of Homes Reported Built in the Past 3 Years by Builders Interviewed 133

Figure 51. Barriers to ZNE Identified by Builders 136

Figure 52. Description of ZNE-type Owners Interviewed 144

Figure 53. Home Features Considered by ZNE-type Owners When Purchasing Their Home 145

Figure 54. Level of Importance of ZNE-type Home Features in the Home Buying or Design Process, n=43 146

Figure 55. Home Features Influencing Energy Efficient Owners' Purchasing Decision (Multiple Responses Allowed) 150

Figure 56. TDV Concept: "Flat" Valuation versus TDV for Electricity Use 155

Figure 57. Installed PV, and PV Needed for ZNE under Different Definitions of ZNE (Source: HMG 2012) 156

Figure 58. Key Assumptions in 2016 TDVs (Based on E3 2014) 157

Figure 59. Summary of Energy Demand Forecasts Embedded in Various Regulatory Efforts as of 2013 158

Figure 60. Comparing Average 2013 and 2016 TDVs for Residential Buildings 159

1. ACKNOWLEDGMENTS

The TRC team would like to thank the individuals who contributed to the development of this market characterization. Without their support and assistance, this report would not have been possible.

- Derek Jones, Pacific Gas & Electric Company (PG&E), served as project manager on behalf of the California Investor Owned Utilities (IOUs).
- Anna LaRue, Resource Refocus LLC, provided guidance to the TRC team on behalf of PG&E.
- Jesse Emge, Southern California Edison (SCE); Chuck Berry, San Diego Gas & Electric Company (SDG&E); Corinne Sierzant, Southern California Gas Company (SoCalGas); and Caroline Chen, consultant to Southern California IOUs, provided guidance to the TRC team.
- Cathleen Fogel, California Public Utilities Commission (CPUC); Martha Brook, California Energy Commission (CEC); Farakh Nasim (CEC); Bill Pennington (CEC); and Ken Keating (CPUC consultant) provided guidance and a review of data collection instruments.
- California Advanced Homes Program Managers – Conrad Asper (PG&E), John Morton (SCE), Chuck Berry (SDG&E), and Darrell Brand (SoCalGas); Amy Dryden (Build It Green); Alex Araiza, Sacramento Municipal Utility District (SMUD); Le-Quyen Nguyen (CEC); and the U.S. Department of Energy (DOE) provided data and other assistance.
- Project Advisory Group (PAG) members and others who provided project guidance. Those not mentioned previously included: Randall Higa (SCE), Peter Turnbull (PG&E), Chip Fox (SDG&E), Reuben Schwartz (San Francisco Department of Environment), Meg Waltner (Natural Resources Defense Council), Bob Raymer (California Building Industry Association), Mike Hogdson (ConSol), Ralph DiNola (New Buildings Institute), Mark Meyers (City of Clovis), Sharon Block (Bright Green Strategies), Bronwyn Barry (Passive House California), Rob Hammon (BIRAenergy), Smita Gupta (Itron), Mindy Craig (Blue Point Planning), Luke Morton (Pete Moffat Construction) and Iain Walker (Lawrence Berkeley National Laboratory).
- PG&E staff working on energy efficiency financing initiatives, including Alfred Gaspari, John Ku, and Andy Fessel, for their guidance on lender interviews, and IOU analysts Atul Kane (PG&E), Anh Nguyen (SCE), Emilio Samartin (SoCalGas) and other IOU staff for technical support.
- High performance builders for providing feedback, including One Sky Homes, KB Homes, DeYoung Properties, Meritage Homes - Vacaville, Lennar Fresno, Inc., Wathen Castanos Hybrid Homes, Inc., Granville Homes, Grupe Homes, Clarum Homes, Carmel Building and Design, ZETA, ForStrategy Consulting, Shea Homes, MGM Construction, Testorff Construction, and Marrone & Marrone.
- Industry market actors—appraisers, lenders, rating system experts, planners, and building officials – for providing their experience on high performance homes efforts and financing options.
- Participants in owner interviews, surveys, and forums, for sharing their experiences, and the property management companies for assisting with the organization of these forums.
- Respondents to the Request for Information for providing their estimate of ZNE-type homes in California, case studies, ZNE-related literature, and recommendations of interviewees.
- The late Michael Kyes, former Sebastopol Mayor, who provided feedback on the PV ordinance in the City of Sebastopol. Michael was passionate about forwarding the cause of PV and high performance homes, and his loss is felt by the entire ZNE community.

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.

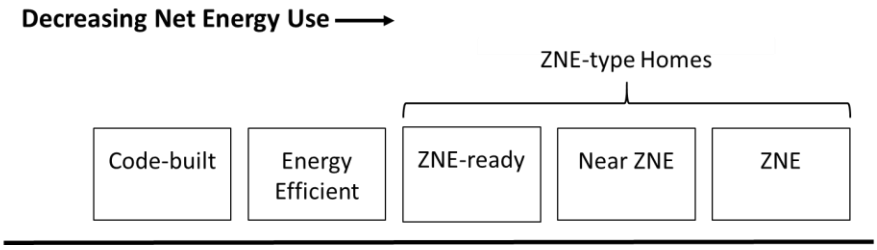

Figure 1. Home Energy Performance Classifications

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.

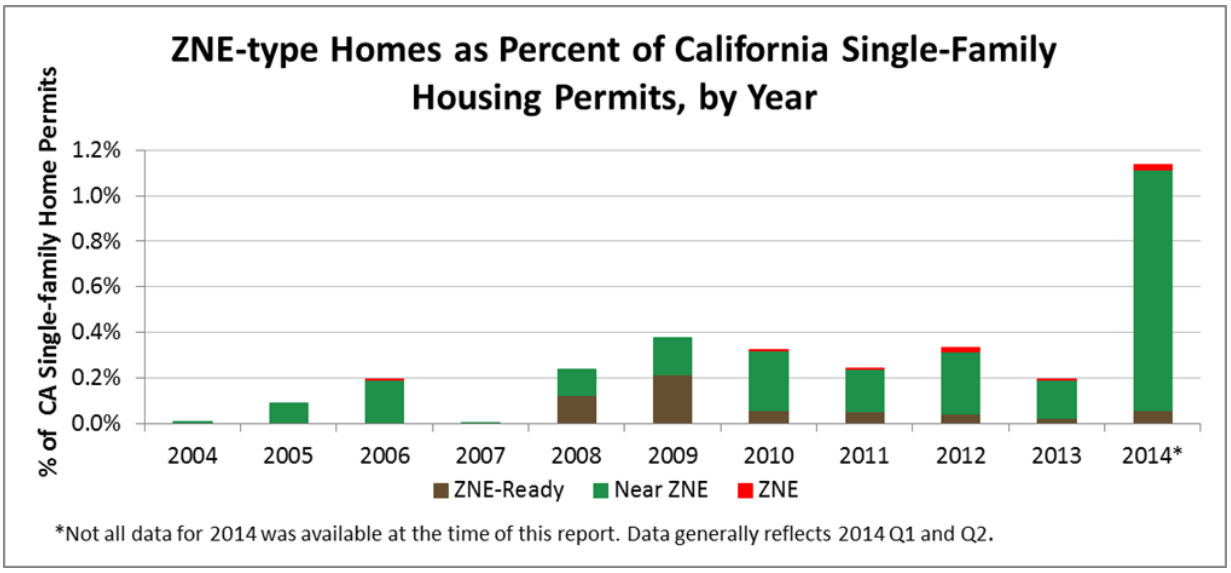

Figure 5. ZNE-type Homes as a Percent of the Total Permits, by Year

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