Residential New Construction

Baseline Study of Building Characteristics

Homes Built After 2001 Codes

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Executive Summary

ES.1 Introduction

This executive summary summarizes the findings of the 2003 Residential New Construction Baseline Study conducted by Itron, Inc. under Pacific Gas & Electric (PG&E) management.[1] KEMA-Xenergy conducted the on-site surveys. The RNC baseline study investigates energy efficiency in newly constructed single family homes throughout California. The study's primary purpose is to provide information to residential new construction (RNC) program managers across the state, thereby allowing them to assess and address the effect of recent energy code changes on these programs.

The remainder of this Executive Summary includes a review of the project's objectives, the approach taken, and the key findings from the study including baseline characteristics, compliance analysis, a comparison of these results to the results of the 2001 RNC Study,[2] and the results of telephone interviews with Title 24 Consultants and builders relating to construction practices used under the new 2001 Standards.

ES.2 Study Objectives

The primary objective is to examine the status of Title 24 compliance for a representative sample of California residences as constructed (as-built). The study results were used to develop a baseline to determine the average building practices in the RNC sector by region. These results will help RNC program managers assess the energy savings potential for new programs.

This project also involved conducting interviews with Title 24 consultants and builders. These interviews were designed to collect data on not only baseline construction/compliance practices, but also to gain insight into the changes in practices due to changes in Title 24 standards and feedback on existing utility RNC programs.[3]

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1 The detailed results of this study can be found in *Residential New Construction—Baseline Study of Building Characteristics—Homes Built After 2001 Codes.* Itron, Inc. September 2004. Prepared for Pacific Gas & Electric.

2 Regional Economic Research, Inc. *2002 Statewide Residential New Construction Energy Efficiency Baseline Study: Second-Year Report.* Prepared for PG&E. 2003.

3 The results of these surveys were also used for the California ENERGY STAR New Homes Program Evaluation, which can be found in *Evaluation, Measurement and Verification of the 2002 California Statewide energy star New Homes Program -- Phase 1 Report.* RLW Analytics. 2004.

ES.3 Overview of Approach

The approach to meet the project objectives included the following elements: develop the sample design, update the RNC Interface to analyze the new fields added to the on-site survey form and the new measures/credits included in the new Standards, identify baseline characteristics, and complete the MICROPAS compliance analysis of the 600 single family homes. Further, to gain insight into how the 2001 Standards affected builders, Title 24 consultants and builders when interviewed. Each of these steps is discussed in this section.

On-Site Sample Design

For this study, Itron obtained 2002 new housing starts from the Construction Industry Research Board (CIRB). The CIRB data contain the number of single-family homes built by building department. This allowed Itron to calculate total housing starts by RMST Climate Zone and IOU.

As shown in Figure ES-1, there are 16 CEC climate zones in California. These zones were collapsed into five regions. The criterion for combining the climate zones was that the Title 24 requirements across these climate zones be the same or vary in only one component. Using this approach, climate zones were aggregated as follows.

- RMST Climate Zone 1 (CZ1) North Coast encompasses CEC Climate Zones 1 – 5.
- RMST Climate Zone 2 (CZ2) South Coast encompasses CEC Climate Zones 6 and 7.
- RMST Climate Zone 3 (CZ3) South Inland encompasses CEC Climate Zones 8 – 10.
- RMST Climate Zone 4 (CZ4) Central Valley encompasses CEC Climate Zones 11 – 13.
- RMST Climate Zone 5 (CZ5) Desert and Mountain encompasses CEC Climate Zones 14 – 16.

Figure ES-1: CEC Climate Zones

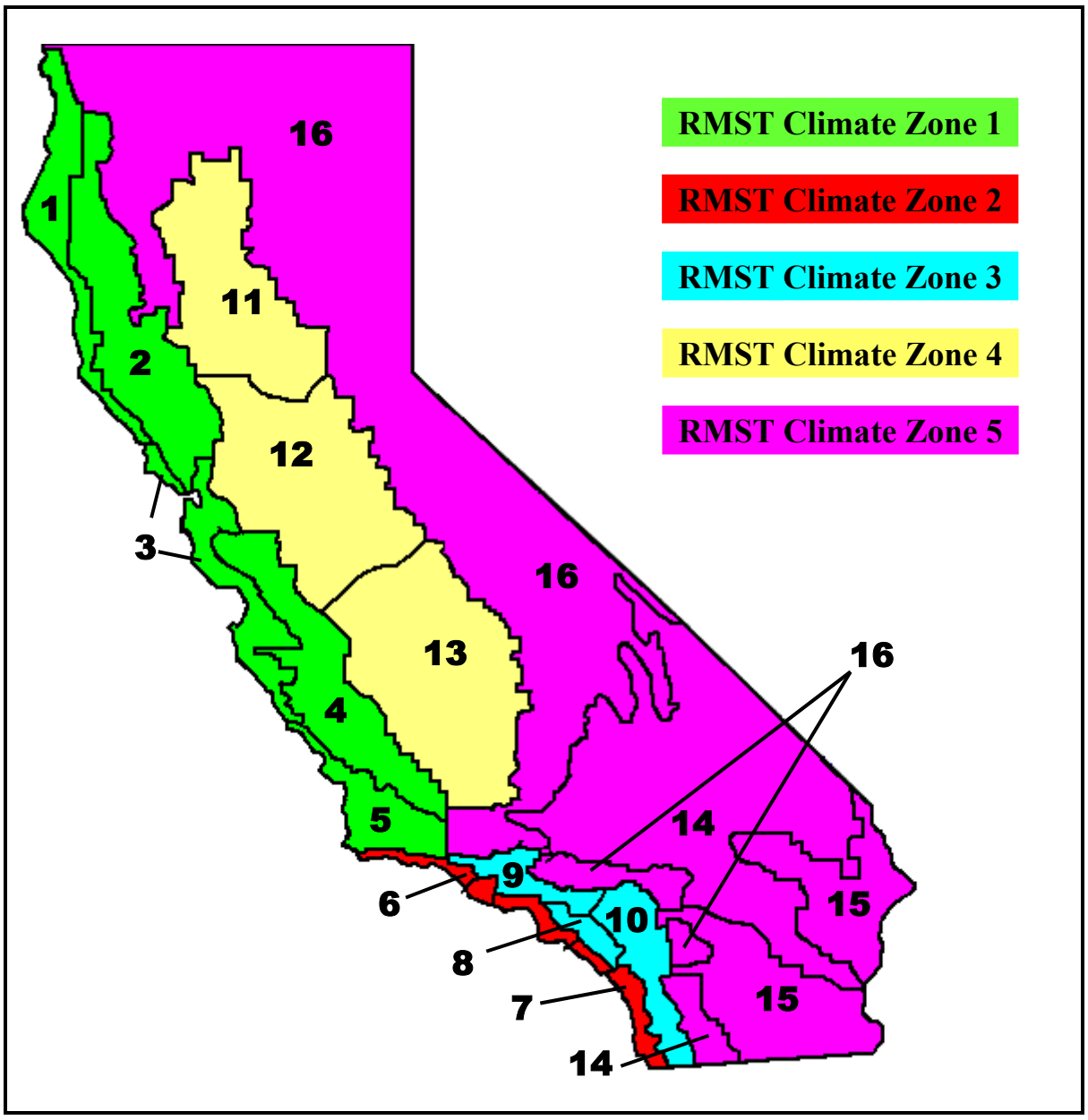

Table ES-1 presents a distribution of the completed on-site surveys of newly constructed single family detached homes by RMST climate zone and number of stories. As shown, 604 homes were surveyed. Since the objective of this study was to develop a baseline, 19 homes were not included in the analysis because they were California ENERGY STAR new homes. Another 10 homes were excluded; 6 were mobile or manufactured homes and 4 were excluded for other reasons.

Table ES-1: Completed On-Site Surveys

	Overall	RMST CZ1	RMST CZ2	RMST CZ3	RMST CZ4	RMST CZ5
Single Family Detached Homes						
1 story	189	7	8	29	126	19
2 story	364	29	72	91	150	22
3 story	22	6	8	7	1	0
Used in Analysis	**575**	**42**	**88**	**127**	**277**	**41**
ENERGY STAR Homes	19	14	5			
Single Family Other (Mobile/Manufactured Home)	6	1	2		2	1
Other Omitted Sites	4	2	1	1		
Total	**604**	**59**	**96**	**128**	**279**	**42**

Baseline Characterization

Baseline characteristics were developed using on-site survey data of the 575 nonparticipant single family homes mentioned above. Detailed data including equipment sizes and efficiencies, size and types of windows, and building shell characteristics were collected during the on-site surveys. These data were then entered into the RNC database, developed during the first year of the Statewide RNC Baseline Study in 2000. The RNC database contains the building characteristics of approximately 2,200 homes built between 1998 and 2003. Average building characteristics were weighted using 2002 housing starts by city and developed using SAS.

Compliance Analysis and the RNC Interface

Itron developed a software tool, the RNC Interface, during the first year of the Statewide RNC Baseline Study. The primary purpose of the RNC Interface is to generate MICROPAS[4] compliance runs, which are then used to examine the compliance status for each residential building and to explore the energy conservation potential of some key energy saving technologies. Since the RNC Interface was initially developed, it has been updated and upgraded during the two subsequent RNC baseline studies and for various other works relating to California's Title 24 Low-Rise Residential Energy Standards, the California

[4] MICROPAS was chosen as the compliance tool because it is the tool of choice among energy consultants for performing low-rise residential compliance analysis. Interviews with MICROPAS developers indicate that more than 75% of energy professionals use their product. Further, two subsequent studies by Itron indicate that more than 90% of energy compliance documentation was completed using MICROPAS.

ENERGY STAR New Homes Program, and the statewide energy savings potential in constructing more energy efficient residential buildings.

The RNC Interface uses the data collected from on-site surveys to create a MICROPAS input file. This is accomplished by first manipulating the data,[5] then "writing" it to a file in the required MICROPAS input format. The RNC Interface then passes the input file through MICROPAS. The interface produces results in the same format as the C-2R forms used for compliance documentation. A copy of a C-2R form is contained in Appendix A.

The interface was initially designed to batch process many sites at one time. During the first year of the project (2000), 800 on-site surveys of low-rise residential buildings were conducted. Instead of using the MICROPAS interface to develop each input file by hand, one at a time, a decision was made to automate the process. The system that was developed became extremely useful during the last few months of the project when the focus changed to include analyzing the then upcoming 2001 Standards. Without the RNC Interface, it would have been necessary to manipulate each MICROPAS input file one at a time to run under the new version of MICROPAS. Similarly, over the last four years requests have been made for new types of analysis that would have been either impossible or extremely costly to conduct without the many capabilities of the interface. Specifically, the interface was designed to do the following:

- Translate the on-site survey data into MICROPAS input files,
- Run MICROPAS in a batch mode,
- Facilitate the use of either MICROPAS 4.5, 5.1, 6.0, or 6.5 (1995, 1998, 2001, 2005 Standards, respectively)
- Extract the MICROPAS compliance results, and
- Provide a platform for the technical potential analysis, and
- Conduct several other "what if" analyses.

The RNC Interface was used to develop the compliance results for each of the 575 single family homes. SAS was then used to calculate the weighted average compliance margins by region.

Builder and Title 24 Consultant Surveys

Telephone surveys were conducted with 77 builders and 41 Title 24 Consultants throughout California in 2003. The objective was to gain an understanding of building and compliance practices of single family new home builders as they relate to the current 2001 Title 24 energy efficiency standards. Specifically, respondents were asked about the efficiency of the

[5] For information on how the RNC Interface manipulates the data, please see Appendix E, subsection "Developing MICROPAS Inputs from the RMST On-Site Survey Data."

measures that they installed/specified in homes built under the 2001 Standards, changes in construction practices because of the 2001 Standards, and their knowledge of and participation in the California ENERGY STAR® New Homes program and differences in the design and construction of ENERGY STAR homes relative to non-ENERGY STAR homes

ES.4 Summary of Findings

The following are key findings from the 2003 residential new construction baseline study.

Baseline Characterization

Current building practices for single family homes are summarized below. In particular, findings on efficiency levels and key differences in construction practice among regions, and project years are highlighted.

- ***Average HVAC equipment efficiencies in detached single family homes are slightly above the minimum equipment efficiency standards.*** The average efficiency of gas furnaces installed in detached single family homes is 81% AFUE, versus the 78% AFUE Standard value. The average efficiency of central air conditioners installed in detached single family homes is 10.9 SEER, versus the 10 SEER Standard value.
- ***The predominant cooling system is air conditioning.*** Approximately 55% of detached single family homes have a higher than standard efficiency air conditioner (>10 SEER) and 5% have a SEER greater than 12.
- ***A large number of homes do not have cooling equipment.*** About 73% of single family homes in RMST Climate Zone 1 and 30% of single family homes in RMST Climate Zone 2 do not have a cooling system. The number of houses without cooling systems is 13% at the state level.
- ***Efficiency levels of water heating systems are generally above the Minimum Efficiency Standards.*** The average energy factor (EF) of water heating systems installed is 17% higher than required by the Minimum Efficiency Standards for detached single family homes.
- ***Dual-paned vinyl-framed windows are the most commonly installed window type.*** The predominant window type in detached single family homes is a vinyl-framed, dual-paned, low-E glass window.
- ***Use of metal-framed windows varies significantly by climate zone.*** While 6% of windows statewide were metal framed, the percent of metal-framed windows ranges significantly from 2.5% in RMST Climate Zone 5 to 12.5% in RMST Climate Zone 2.

- ***Ceiling and wall insulation levels vary by climate zone.***[6] For residences where ceiling and wall insulation R-values were obtained, a majority of homes in RMST Climate Zones 1, 2, and 3 were either higher performing or equal to the prescriptive values, while a majority of homes in RMST Climate Zones 4 and 5 were lower than the prescriptive values.

Comparison of Homes Built in 1999, 2000, and 2003

Below is a brief comparison of the baseline characteristics of the homes analyzed during the three years of this project. In general, while construction practices did not change significantly from 1999 to 2000, there were changes between the homes constructed in 2000 and those in 2003. With the exception of types of windows installed, most of the changes on a statewide level were moderate. However, there were also a couple significant changes in the more extreme regions of the state.

- ***Fenestration.*** The average U-value of windows decreased from 0.59 in 2000 to 0.42 in 2003. This is largely explained by the transition from clear glass to the more efficient Low-E coated glass. Furthermore, the average glazing percentage statewide dropped from 17% to 15.7% from 2000 to 2003. For example, the average glazing percentage for homes in RMST Climate Zone 5 has decreased from 18% to 15%.
- ***Space Heating Systems.*** The average AFUE of gas furnaces did not change much between 1999 and 2003. The statewide average AFUE was 80.4 in 1999 and 81.4 in 2003. However, in RMST Climate Zone 1 average AFUE increased from 80.3 to 85.3.
- ***Space Cooling Systems.*** A larger percent of new homes are being built with air conditioners. In 1999, approximately 20% of detached single family homes were built without cooling equipment installed, compared to just 13% in 2003. Homes in RMST Climate Zones 2 and 5 had the largest percentage increase in homes with cooling equipment. The average SEER of air conditioners installed in the homes surveyed increased slightly (10.6 to 10.9).

Analysis of Compliance

Analysis of the MICROPAS results on a *non-compliant*/*compliant* criterion was not appropriate due to on-site measurement error,[7] characterized by the error band discussed in

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6 The prescriptive values, the minimum values allowed by Prescriptive Package D in the 2001 standards, for both ceiling and wall insulation vary by CEC climate zone.

7 On-site measurement error is described as items estimated during or after the on-site survey that can not always be verified or exact. Examples include using mapped U-values and SHGC values for fenestration since these can not be recorded during the on-site survey due to removal of window stickers after the occupant moves in; and using default wall R-values due to the inability to always obtain wall insulation values as the surveyor is not allowed to drill a hole in the wall.

Section 2.4. As a result, a third "compliance group" would have been added to characterize the compliance runs (*indeterminate*). However, because of the interest in RNC programs, an additional group was formed (*high efficiency*).[8] As shown below, this high efficiency group, includes homes with a % Compliance Margin greater than 19%.[9] As such, four compliance groups were used as the basis for analysis of the MICROPAS results.

- ***Non-Compliant.*** This category includes sites that, based on the analysis, are not compliant with Title 24 code. In particular, these sites have a % compliance margin less than the lower end of the error band (i.e., <-5%).
- ***Indeterminate.*** This category includes sites that have a % compliance margin within the error band (-5% to 4%). As such, it is indeterminate as to whether these sites comply with the Title 24 codes.
- ***Compliant***. This category includes sites that, based on the analysis, are compliant with Title 24 code. In particular, these sites have a % compliance margin greater than the upper end of the error band (i.e., > 4% and < 19%).
- ***High Efficiency.*** This category includes sites that, based on the analysis, are high efficiency with Title 24 code. In particular, these sites have a % compliance margin greater than 19%. This category was created to account for the share of homes that would meet the existing ENERGY STAR New Home construction requirements, given the error band. (*Note that these are not actually California ENERGY STAR New Homes. While the program requires that participating homes comply with at least a 15% margin over the 2001 Standard, it also requires verification of measures installed. The homes in this group meet the requirement of being at least 15% overly compliant, given the error band, but did not apply for, nor could be verified as, a participating home.)

Below is a summary of the results from the compliance analysis.

- ***Approximately 27% of sites are identified as non-compliant.*** The results from the RNC Interface compliance analysis indicate that 27% of all homes built in the study period were non-compliant. Thirty-four percent of homes fell within the compliant group, while 13% fell in the high efficiency group. Figure ES-2 summarizes the distribution of sites by % Compliance Margin and compliance group for single family homes.

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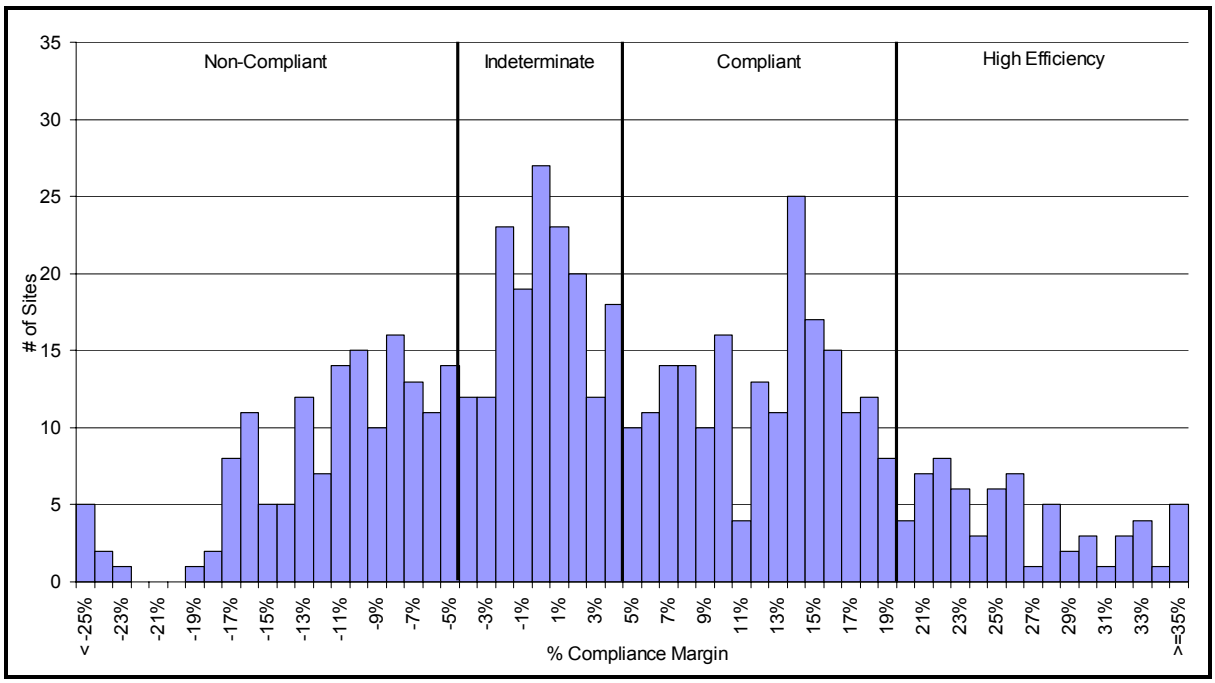
[8] Note that homes in this group were not ENERGY STAR New Homes participants as all participants were removed from the baseline. This group simply includes homes that, as-built, would have qualified to be ENERGY STAR New Homes.

[9] ENERGY STAR requires that a home use 15% less energy than the maximum allowed. The error band, discussed in Section 2.4, was then put around the 15%, which results in the 19% shown as the cut-off for this group.

Figure ES-2: MICROPAS Results Summary – Detached Single Family Homes



- ***The percent glazing area has a substantial impact on compliance.*** Homes with large glazing percentages tend to be non-compliant, while homes with small glazing percentages tend to be compliant or high efficiency.
- ***RMST Climate Zone 2 (South Coast) has the highest percentage of compliant homes.*** Approximately 95% of sites in RMST Climate Zone 2 fall into either the compliant or high efficiency groups. In fact, RMST Climate Zone 2 is the most compliant of the RMST climate zones with an average % compliance margin of 17.5%. Only 1% of sites in RMST Climate Zone 2 fall in the non-compliant group and only 4% fall in the indeterminate group.
- ***RMST Climate Zone 5 (Desert and Mountains) has the highest percentage of non-compliant homes.*** Approximately 39% of sites in RMST Climate Zone 5 fall in the non-compliant group and 31% are indeterminate. In fact, RMST Climate Zone 5 is the most non-compliant of the RMST climate zones with an average % compliance margin of -5.3%.

Compliance Variations among Climate Zones across Project Years

As seen in Table ES-2, the average % compliance margins for detached single family homes in the RMST climate zones changed significantly between homes built from July 1999 to June 2000 (2000 homes) and those built between January 2003 and June 2003 (June 2003) homes. Are the changes in average % compliance margin attributable to changes in building practices or to changes in the Standards?

Table ES-2: Average % Compliance Margin by Year and RMST Climate Zone

	Overall	RMST CZ1	RMST CZ2	RMST CZ3	RMST CZ4	RMST CZ5
Homes Built in 2000 –1998 Stds.	6.2%	11.4%	14.7%	6.1%	4.1%	-6.2%
Homes Built in 2003 –2001 Stds.	3.8%	19.2%	16.0%	9.4%	-2.9%	-5.7%
Difference	-2.4%	7.8%	1.3%	3.3%	-7.0%	0.5%

To answer these questions accurately, it is not enough to simply look at the differences in the % compliance margins from the two years. The 2000 homes were analyzed using MICROPAS 5.1, which uses the 1998 low-rise residential building standards. Homes used in the second year of the project were analyzed using MICROPAS 6.5, which uses the 2000 low-rise residential building standards. Therefore, the compliance of the homes used for the second year of the project was analyzed using MICROPAS 4.5. These results were then used in two comparisons to highlight the differences in the results between Project Year 2000 and Project Year 2003, by RMST climate zone.

- ***"Homes built in 2000: 1998 Standards" vs. "Homes built in 2003: 1998 Standards" results.*** Comparing the % compliance margins between these sets of results makes it possible to analyze how the differences in building practices between the two project years affected the average % compliance margin.
- "***Homes built in 2003: 1998 Standards" results vs. "Homes built in 2003: 2001 Standards" results.*** Comparing the % compliance margins between these sets of results makes it possible to analyze how the changes in the standards affected the average % compliance margin.

Changes in Building Characteristics between 2000 and 2003

Table ES-3 presents the average % Compliance Margin for homes built in 2000 and those built in 2003 under the 1998 low-rise residential building standards. As shown, the average % Compliance Margin for homes built in 2003 is 14.6%, which is higher than the 6.2% average for homes built in 2000. The average % Compliance Margins in each RMST Climate Zone increased. These results imply that there were changes in average building characteristics across RMST climate zones and that these changes increased the average compliance in each zone.

Table ES-3: Average % Compliance Margin by Year and RMST Climate Zone – 1998 Standards

	Overall	RMST CZ1	RMST CZ2	RMST CZ3	RMST CZ4	RMST CZ5
Homes Built in 2000 –1998 Stds.	6.2%	11.4%	14.7%	6.1%	4.1%	-6.2%
Homes Built in 2003 –1998 Stds.	14.6%	23.9%	17.6%	21.7%	8.8%	9.4%
Difference	8.4%	12.5%	2.9%	15.6%	4.7%	15.6%

The following are the primary reasons for the differences in compliance margins shown above.

- ***Changes in window characteristics affect compliance levels.*** The percentage of homes with low-E windows increased significantly between homes built in 2000 and those built in 2003 from 10% to 83%. Reductions in the glazing percentages can also have a significant impact on compliance; homes with less glass area inherently more compliant. The glazing percentage reductions for homes built in 2000 vs homes built in 2003 for RMST Climate Zones 3 and 5 were 3.5% and 2.4% respectively.
- ***The efficiency of HVAC and water heating units can also have a large impact on compliance.*** The average SEER value in RMST Climate Zone 5 increased from 10.5 to 11.5, while the average AFUE in RMST Climate Zone 1 increased from 80.7 to 85.3. Also, the average water heating % above standard increased in every climate zone, and the statewide average increased from 15.6% to 16.7%.

Changes in Building Standards Between 1998 and 2001

Table ES-4 shows that homes built in 2003 have a lower average % Compliance Margin using the 2001 standards than they do using the 1998 standards. This is most apparent in RMST Climate Zones 3, 4, and 5 (inland regions) where the average % Compliance Margin decreased at least 10%. What changes in the standards caused these RMST climate zones to have a much lower average % Compliance Margin under the 2001 standards than the 1998 standards, while RMST Climate Zones 1 and 2 have only a slightly lower average % Compliance Margin? The following discussion is broken out by end-use—water heating, space cooling, and space heating—in an attempt to answer these questions.

Table ES-4: Average % Compliance Margin by RMST Climate Zone – Homes Built in 2003

	Overall	RMST CZ1	RMST CZ2	RMST CZ3	RMST CZ4	RMST CZ5
Homes Built in 2003 –1998 Stds.	14.6%	23.9%	17.6%	21.7%	8.8%	9.4%
Homes Built in 2003 –2001 Stds.	3.8%	19.2%	16.0%	9.4%	-2.9%	-5.7%

The following are the primary reasons for the differences in compliance margins shown above.

- ***Water Heating.*** There were no changes in how the water heating budgets are calculated between the 1998 and 2001 Standards. The average water heating margins are the same when comparing the water heating results for 2003 homes analyzed under both the 1998 and 2001 Standards.
- ***Space Cooling.*** Since the 2001 Standards were focused on reducing peak energy, it is not surprising that the cooling budgets were the hardest hit. The new Standards resulted in smaller space cooling Standard budgets in RMST Climate Zones 1, 3, 4, and 5. A reduction in the Standard budget signifies that the "allowed" energy usage for cooling has decreased. On the other hand, the proposed space cooling budgets have increased in every RMST climate zone. This increase reveals that the 2001 Standards, due to the changes in calculations, now estimate that the same proposed home uses more energy for space cooling. The combination of these changes results in the space cooling margin decreasing, therefore makes the home less compliant or non-compliant.
- ***Space Heating.*** The average space heating standard and proposed budgets increased in each of the RMST climate zones. These changes resulted in the average space heating margins decreasing in each climate zone. However, since the decreases in space heating margins are relatively small, it does not affect the overall compliance as much as the decrease in the space cooling margins.

Why are Coastal Homes so Compliant?

Homes in RMST Climate Zones 1 and 2 (CEC Climate Zones 1-7) are, on average, high efficiency. In fact, approximately 58% would have qualified for the California ENERGY STAR New Homes program[10]. Below are several reasons for the disparity in compliance between coastal and inland homes.

[10] While these homes met the requirement of being at least 15% overly compliant, the program also requires verification of measures installed. Therefore, these homes are not actual California ENERGY STAR New Homes.

- ***The new 2001 Standards.*** Because the new Standards focused on reducing peak demand, typically air conditioning loads, homes in the inland regions had a more difficult time complying.
- ***Changes in building practices along the coast.*** Over the past several years, builders have begun installing more low-E windows. Since builders need to install these windows in some inland areas in order to comply, they install the same windows in their costal homes.
- ***The California ENERGY STAR New Homes Program.*** Builders who were program participants for other projects built many of the nonparticipating homes surveyed. Therefore, a spillover effect is likely, and, in fact, approximately two-thirds of builders said that they changed construction practices because of their participation in the program.

Builder Survey Results

Telephone surveys were conducted with 77 builders throughout California in early 2003 with respect to the standard specification practices for new detached single family homes. Thirty of the 77 builders indicated that they build homes in 2002 that qualified for the ENERGY STAR program (the "participants").

- ***Efficiency measures varied across regions.*** Builders of homes in the Inland and Desert regions reported, on average, higher efficiency HVAC equipment, a greater percentage of homes with radiant barriers, and more frequent duct testing. Also, low-E glass and vinyl-framed windows are more prevalent in the South Inland, Desert, and Central Valley regions.
- ***Tract builders typically specify the same package of measures for each model of a development.*** High volume builders of ENERGY STAR homes reported that their general compliance strategy is to choose the type of equipment and windows based on the combination of measures that makes the least complying model meet code.
- ***Adjustments to the 2001 Standards varied with region and builder size.*** Overall, builders rated the adjustment to the 2001 Standards to be "somewhat difficult." Builders in the South Inland regions, where the requirements are more stringent than along the coast, rated the adjustment to the Standards most difficult. Also, the average difficulty rating by small builders (with fewer than 25 homes completed) was the lowest. This result is significantly different than the average rating of larger builders who found the adjustments slightly more difficult.

Comparison with On-Site Surveys

The following compares the results of the telephone surveys with nonparticipant builders and the on-site surveys of single family detached homes.[11]

- ***Space Heating.*** According to self-reports by builders, the statewide average AFUE for space heating furnaces was 81.2, slightly lower than the results of the on-site survey (81.4). The greatest difference in furnace efficiencies between builder self-reports and the on-site surveys was in the North Coast (RMST CZ1). In the North Coast, the average efficiency rating of builders' self-reports was 81.6 AFUE, but the on-site average was 85.3 AFUE.[12]
- ***Space Cooling.*** The self-reported efficiencies of air conditioners installed by builders were very close to the average efficiencies found during the on-site surveys conducted. The results differed by no more than 0.3 SEER for each RNC climate zone.
- ***Window Types.*** The results of the on-site and telephone surveys demonstrate that, statewide, the predominant window characteristics are dual-paned, vinyl-framed, low-E glass windows. Although the results of the builders' survey reported a slightly larger percentage of windows with metal frames and a slightly smaller percentage of windows with low-E glass, these differences are not significant.
- ***Radiant Barrier Installation.*** The number of builders statewide who reported installing radiant barriers (5.4%) is not significantly different from the number of homes surveyed (4.0%). The greatest difference in the number of observed and reported radiant barriers occurred in RMST Climate Zone 5, where the builders reported installing radiant barriers in 86% of homes, and the on-site survey found 21% saturation.

Overall, builders are fairly knowledgeable about the efficiencies of measures being installed in the homes that they build. However, previous interviews have shown that they are not as knowledgeable about new energy efficiency measures or the Standards.

Title 24 Consultants

Title 24 Consultants have a strong familiarity and understanding of energy-related characteristics of new homes, as well as builder specification strategies to comply with Title 24 Standards. The survey and in-depth interviews, conducted with 41 Consultants in early 2003, provided insight into how the 2001 Standards impacted compliance practices, as well as the differences between homes that just meet Title 24 and those that qualify for the ENERGY STAR program. The following are key findings.

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[11] Note that the on-site survey results include only nonparticipant homes.

[12] While it appears that the average efficiency, as reported by builders, in the Desert (85.7) was much higher than the average found during the on-site surveys (80.8), these results can not be directly compared because the on-site results include homes built in the High Deserts and Mountains.

- ***The impact of the 2001 Standards varied by region.*** The Standards had the greatest impact on building practices in the Desert and High Desert regions (CEC Climate Zones 14 and 15), followed by the South Inland and Central Valley regions (CEC Climate Zones 8-13).
- ***Measures requiring third party verification are specified only as a last resort for Title 24 compliance.*** According to Title 24 consultants, the additional cost, potential disruption to the construction schedule and potential insurance risk associated with measures requiring third party verification create a significant disincentive for specification of such measures.

Comparison with On-Site Surveys

The following compares the results of the Title 24 consultant interviews and the on-site surveys for single family homes.

- ***Insulation Levels.*** Although the Title 24 consultants reported that increased roof and wall insulation levels occurred in 66% of the "standard" homes, the on-site analysis of single family homes revealed that only 5% of homes had higher performance (greater than prescriptive) ceiling installation levels and only 6% had higher performance wall insulation. This was the greatest discrepancy between the reported and observed results.
- ***Window Types.*** The percentage of homes actually installing high performance windows (dual-paned, vinyl-framed, low-E glass) was higher (79%) than the percentage reported by the Title 24 consultants (66%).
- ***Heating and Cooling Equipment.*** Title 24 consultants reported that 13% of non-participant homes had heating equipment with efficiencies greater than 90% AFUE. This is fairly close to the percentage of homes surveyed that actually had higher efficiency units (11%). Title 24 consultants also reported that more homes (43%) had higher efficiency air conditioning units (greater than 12 SEER) than actually did (6%). However, it is interesting to note that 36% of homes surveyed have air conditioners that are greater than 11 SEER. Note that there is room for interpretation since each Title 24 consultant was asked about high efficiency and not a specific SEER rating. Therefore, if some of the Title 24 consultants surveyed consider anything over 11 SEER high efficiency, their self-report is close to the saturations found on-site.
- ***Radiant Barriers.*** The number of sites statewide with radiant barriers installed was 4%, less than the consultant reports of 10%. There were fewer sites with radiant barriers than were reported for every climate zone, with the greatest discrepancy in the desert and mountain regions (RMST CZ 5).

ES.5 Residential Standards Issues

The following are some suggestions and observations designed to highlight issues that might be important to Title 24 consultants and agencies that design/revise the Standards.

- ***A new baseline for single family attached and multifamily buildings is needed.*** The most recent baseline study of multifamily buildings was conducted several years ago and analyzed buildings built in 2000 under the 1998 Standards. A baseline must be developed to accurately determine savings from the California ENERGY STAR New Homes Program for these building types. A new baseline study would also provide data on whether multifamily builders are switching to low-E windows and other trends seen in single family detached homes.
- ***A billing analysis of MICROPAS and EnergyPro results is needed.*** In order to better develop kWh and therms savings estimates, it would be useful to conduct a billing analysis of both the 2001 and 2005 compliance software. This will be especially important under the 2005 Standards since the time dependent valuation (TDV) version will predict peak demand and TOU usage.

1

Introduction

1.1 Overview

The work presented in this report is the third year of the Statewide Residential New Construction Baseline study conducted by Itron, Inc. under Pacific Gas & Electric (PG&E) management. KEMA-Xenergy conducted the on-site surveys. This report, similar to the two previous residential new construction (RNC) studies conducted by Itron, investigates energy efficiency in newly constructed single family homes throughout California.[1] The study's primary purpose is to provide information to RNC program managers across the state, thereby allowing them to assess and address the effect of recent and impending energy code changes on these programs.

Section 2 describes the development of the RNC Interface, the tool used to complete the compliance analysis. Section 3 summarizes the baseline construction characteristics of low-rise residential buildings built between January 1, 2003 and June 30, 2003 in California, while Section 4 presents the results of the Title 24 compliance analysis[2] of these homes. Sections 5 and 6 present the results of interviews with single family home builders and Title 24 Consultants. Section 7 summarizes the key results. This section reviews the objectives of this project, discusses the approach taken along with key findings from each of the various sections of this report, and briefly discusses the next steps in the project.

1.2 Objectives

The primary objective of the study is to examine the status of Title 24 compliance for a representative sample of California residences as constructed (as-built) using the MICROPAS Title 24 computer compliance tool using on-site survey data of 600 newly constructed single family homes. The study results will be used as a baseline to determine

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1 *Residential New Construction Study.* Regional Economic Research, Inc. September 2001. Prepared for Pacific Gas and Electric.
Residential New Construction Study – Year 2. Regional Economic Research, Inc. September 2002. Prepared for Pacific Gas and Electric.

2 As described in detail in Section 2, MICROPAS 6.5, the compliance software used to perform compliance analysis under the 2001 low-rise residential standards, was used to develop the results in Section 4.

the average building practices in the residential new construction sector by region. This will assist residential new construction program managers in developing and maintaining effective energy efficiency initiatives and assessing the energy savings potential for new programs.

This project also involved conducting interviews with Title 24 consultants and builders. These interviews were designed to collect data on not only baseline construction/compliance practices, but also to gain insight into the changes in practices due to changes in Title 24 standards, and feedback on existing utility RNC programs.[3]

1.3 Overview of Approach to Assess Baseline Building Practices and Title 24 Compliance in the Residential Sector

The objective of this phase is to describe common building practices and analyze Title 24 compliance for single family homes. To accomplish this, Itron developed a software tool that allows the data from on-site surveys to be translated into a MICROPAS input file. MICROPAS processes these input files and the results are made available in a number of formats, including C-2Rs and an Access database. Itron then analyzed these results, together with the detailed on-site data, to ascertain common building practices and to complete the Title 24 compliance analysis. The major elements included in the approach are to review the on-site survey database, update the RNC interface to analyze the new fields added to the on-site survey form and the new measures/credits included in the new Standards, complete the MICROPAS compliance analysis of the 600 single family homes, identify baseline characteristics, and analyze the compliance results.

1.4 Organization of the Report

The remainder of the report is organized as follows.

- Section 2 presents an overview of the development and testing of the RNC Interface to MICROPAS.
- Section 3 summarizes the current building practices in single family homes.
- Section 4 discusses the analysis of Title 24 compliance in single family homes.
- Section 5 summarizes the findings of the interviews with Title 24 Consultants.
- Section 6 discusses the in-depth interviews with the builders.

[3] The results of these surveys were also used for the California ENERGY STAR New Homes Program Evaluation, which can be found in *Evaluation, Measurement and Verification of the 2002 California Statewide energy star New Homes Program -- Phase 1 Report. RLW Analytics. 2004*

- Section 7 presents the key findings of the project and comments on issues that are relevant to residential new construction program planners, and Title 24 compliance.
- The following appendices are included:
  - Appendix A: Sample C-2R form,
  - Appendix B: On-Site Survey Form,
  - Appendix C: Title 24 Consultant Telephone Survey,
  - Appendix D: Title 24 Consultant In-Depth Survey, and
  - Appendix E: Builder Survey.

2

The RNC Interface

2.1 Introduction

This section briefly describes the development and testing of the RNC Interface. The RNC Interface was first developed in 2000, during the first year of the Statewide RNC Baseline Study. The primary purpose of the RNC Interface is to generate MICROPAS[1] compliance runs, which are then used to examine the compliance status for each residential building and to explore the energy conservation potential of some key energy saving technologies. Since the RNC Interface was initially developed, it has been updated and upgraded during the two subsequent RNC Baseline studies and for various other work relating to California's Title 24 Low-Rise Residential Energy Standards, the California ENERGY STAR New Homes Program, and the statewide energy savings potential in constructing more energy efficient residential buildings.

The following sections provide an overview of the RNC Interface, a brief description on how the RNC Interface was tested, and a discussion of the RNC Interface error band developed for use in analyzing the compliance of individual surveyed residences and modifications made over the last four years.

2.2 Overview of the RNC Interface

The RNC Interface uses the data collected from on-site surveys to create a MICROPAS input file. This is accomplished by first manipulating the data,[2] then "writing" it to a file in the required MICROPAS input format. The RNC Interface then passes the input file through MICROPAS. The interface produces results in the same format as the C-2R forms used for compliance documentation. A copy of a C-2R form is contained in Appendix A.

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1 MICROPAS was chosen as the compliance tool because it is the tool of choice among energy consultants for performing low-rise residential compliance analysis. Interviews with MICROPAS developers indicate that more than 75% of energy professionals use their product. Further, two subsequent studies by Itron indicate that more than 90% of energy compliance documentation was completed using MICROPAS.

2 For information on how the RNC Interface manipulates the data, please see Appendix E, subsection "Developing MICROPAS Inputs from the RMST On-Site Survey Data."

The interface was initially designed to batch process many sites at one time. During the first year of the project (2000), 800 on-site surveys of low-rise residential buildings were conducted. Instead of using the MICROPAS interface to develop each input file by hand, one at a time, a decision was made to automate the process. The system that was developed became extremely useful during the last few months of the project when the focus changed to include analyzing the then upcoming 2001 Standards. Without the RNC Interface, it would have been necessary to manipulate each MICROPAS input file one at a time to run under the new version of MICROPAS. Similarly, over the last four years requests have been made for new types of analysis that would have been either impossible or extremely costly to conduct without the many capabilities of the interface. Specifically, the interface was designed to do the following:

- Translate the on-site survey data into MICROPAS input files,
- Run MICROPAS in a batch mode,
- Facilitate the use of either MICROPAS 4.5, 5.1, 6.0, or 6.5 (1995, 1998, 2001, 2005 Standards, respectively)
- Extract the MICROPAS compliance results, and
- Provide a platform for the technical potential analysis, and
- Conduct several other "what if" analyses.

MICROPAS Version 4.5, 5.1, 6.0, and 6.5

It was recognized early on that the RNC Interface needed to be able to generate results for two versions of MICROPAS: MICROPAS4 (v4.5) for the 1995 Standards and MICROPAS5 (v5.1) for the 1998 Standards. The Residential Standards are normally revised on a three-year cycle. However, during the first year of the project, emergency revisions were made to the Standards under AB 970.[3] Therefore, the capability to generate results for a third version of MICROPAS, MICROPAS6 (v6.0), was added to the interface. The current standards are the AB 970 Standards, which were implemented in January 2002 for all low-rise residential homes and superceded the 1998 Standards. Then, in order to evaluate the proposed 2005 Standards, the RNC Interface was again upgraded to generate results using MICROPAS6 (v6.5).

Developing MICROPAS Inputs from the On-Site Survey Data

The on-site survey database contains detailed information on HVAC and water heating equipment and building envelope characteristics. Some of these data were taken directly out of the database and written to the MICROPAS input file. However, the on-site survey did not collect all of the information needed to create a valid MICROPAS input file. Where

[3] Assembly Bill 970 is a measure passed by the California State Legislature in January 2001. *Contractor's Report 2001 Update Assembly Bill 970. CEC Volume 1 – Summary.* November 2000.

possible, changes were made to the survey instrument for Project Year #2 (2001) and Project Year #3 (2003) to collect additional information in order to limit the number of defaults required. Even with the changes, some of the information needed to create the input file was not able to be collected at some sites or had to be manipulated in order to be utilized in the MICROPAS run. As such, the transformation of survey data to MICROPAS inputs can be characterized in the following three categories.

- ***Direct Inputs.*** These values, types, etc., are mapped directly from the survey database into the MICROPAS input file. Examples of direct inputs include square footage, heating and cooling equipment efficiencies, and roof and wall insulation values.
- ***Default Inputs.*** These values, types, etc., are required MICROPAS inputs, including MICROPAS run parameters, for which no equivalent direct or indirect survey data value exists. Examples of default inputs include slab thickness and thermal performance characteristics.
- ***Direct Defaults.*** These are defaults for direct values that are required MICROPAS inputs, but for which no value was entered on the survey form (missing data). Examples of direct defaults include roof insulation, wall insulation, and HVAC and water heating equipment efficiencies.

Direct inputs are inserted directly into the MICROPAS input files. The methods and sources used to develop *default inputs* and *direct defaults* include the use of algorithms and mapping tables, the MICROPAS User's Guide, consultation with industry experts, building department C-2R forms, and on-site survey data. Each input type is used by the RNC Interface to generate the MICROPAS input files.

Features of the RNC Interface

The ability to do batch compliance runs for a large number of sites from outside MICROPAS, and to be able to easily extract the results for these runs, is critical to performing the runs efficiently. The RNC Interface controls the execution of each MICROPAS run, then imports the run results into an Access database table automatically as each run is completed. In addition to performing batch runs, the RNC Interface has several other useful capabilities:

- Select individual or multiple sites,
- Select the version of MICROPAS (4.5, 5, 6, or, 6.5),
- Select whether to run a Cardinal,[4]
- Select the weather data set to use – FullYear or ReducedYear,[5] and

[4] A Cardinal run is actually four runs—a run is performed for the home facing each of the four cardinal directions (North/East/South/West) and compliance is determined by the run with the smallest margin.

- Specify the source input database (this feature was used for the testing phase and during the Statewide Multifamily Study to read in building department C-2R data).

2.3 Testing the RNC Interface

Considerable effort was made in 2000 to ensure that the RNC Interface produced accurate MICROPAS simulation results given the limitations of the available data and the design of the RNC Interface. A testing procedure was developed to evaluate the default parameters, underlying algorithms, and structure of the RNC Interface. Building department compliance forms (C-2Rs) were collected for a sample of the sites surveyed and the data was mapped to the 2000 on-site database.[6] These data then were passed through the RNC Interface. The error band used in 2000 was calculated by comparing the compliance margins from these runs to the compliance margins from the C-2R forms.

Since the second year on-site survey form was changed to improve data availability, it was necessary to re-implement the testing procedure. Data from the Project Year #1 C-2Rs were mapped to the Project Year #2 on-site survey database. Additional fields from the C-2Rs, such as roof area and overhangs, could be mapped since these fields were added to the Project Year #2 on-site survey. The error band for Project Year #2 then was calculated in the same manner as Project Year #1. Since collecting C-2Rs during the third year of the project (2003) was not included in the scope of work due to budget restrictions, the error band developed in 2001 was used in 2003.

2.4 RNC Interface Error Band

This section explains how the error band was developed during the first two years of the project (2000 and 2001). Note that the error band developed in 2001 was used again for the current study (2003).

Establishing the error band for the RNC Interface was necessary because there is uncertainty in the compliance runs generated by the RNC Interface. As such, it is problematic to determine compliance/non-compliance from the results of the RNC Interface runs. Therefore, a margin of error for the estimated % Compliance Margin was developed using data from the test phase of the project. This error band is ultimately used to define three compliance categories:

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5 "MICROPAS can be run using full-year weather data (365 days) or reduced-year data (42 days). The reduced-year run performs only one-eighth of the calculations of the full-year run. Because of the reduced calculation time, the reduced-year weather data is used for most compliance work … Very small differences in results may occur between reduced and full year calculations." *MICROPAS4 User's Manual.*

6 For details on the testing procedure, please see Appendix E.

- Non-compliant,
- Indeterminate, and
- Compliant.

The error band for the compliance margins is developed using the difference estimator method described below. Using the comparison of the test sites, an error band of -5% to +4% around the RNC Interface compliance estimates was calculated. This implies that if the RNC Interface compliance run using the on-site data for a single site estimated a 12% compliance margin, then there is 90% confidence that the "true" compliance margin is between 6% and 16% (12% - 5% = 7%, 12% + 4% = 16%).[7]

Difference Estimator Method

The difference estimator method was used to develop an error band for the % Compliance Margin from the RNC Interface. This was accomplished by comparing the compliance runs from the RNC Interface and the building department C-2R data for the test sites. In particular, the difference estimator (DE), the average difference of the two versions, and the standard deviation of the difference estimator were calculated. Specifically, % Compliance Margin as calculated for the building department C-2R compliance data (% Compliance Margin_{BD}) and for the RNC Interface compliance runs (% Compliance Margin_{RNC}) was determined as follows:

$$\%\,Compliance\ Margin_{i,BD} = \frac{Standard\ Design_{i,BD} - Proposed\ Design_{i,BD}}{Standard\ Design_{i,BD}}$$

where

$Standard\ Design_{BD}$ = Total energy use (space heating, space cooling, and water heating) for a home with Prescriptive Package D features (standard design) from the building department compliance records (*BD*).

$Proposed\ Design_{BD}$ = Total energy use (space heating, space cooling, and water heating) for home *i* with proposed construction plan features (proposed design) from the building department compliance records (*BD*).

and

[7] Note that all test sites used to calculate the Error Band are detached single family homes.

$$\%\ Compliance\ Margin_{i,RNC} = \frac{Standard\ Design_{i,RNC} - Proposed\ Design_{i,RNC}}{Standard\ Design_{i,RNC}}$$

where

$Standard\ Design_{i,RNC}$ = Total energy use (space heating, space cooling, and water heating) for a home with Prescriptive Package D features (standard design) from the RNC Interface (*RNC*).

$Proposed\ Design_{i,RNC}$ = Total energy use (space heating, space cooling, and water heating) for home *i* with proposed construction plan features (proposed design) from the RNC Interface (*RNC*).

The difference estimator (*DE*) is defined as:

$$DE = \frac{\sum_i \%\ Complaince\ Margin_{i,RNC} - \%\ Compliance\ Margin_{i,BD}}{n}$$

The standard deviation (*StdDev*) of the difference estimator is defined as:

$$StdDev\ (DE) = \sqrt{\frac{\sum (\%\ Complaince\ Margin_{BD} - (\%\ Complaince\ Margin_{RNC} + DE))^2}{(n-1)}}$$

Error Band Analysis and Results

A summary of key parameters in the error band analysis is presented in Table 2-1. In particular, the difference estimator is -0.29%, which implies that, on average, the % Compliance Margins generated from the RNC Interface are 0.29% lower than the % Compliance Margin generated from the building department C-2R forms. The standard deviation of the difference estimator is calculated as 0.029 – slightly lower than Year #1. To compute the 90% confidence interval, the standard deviation is multiplied by 1.645, which is 0.0476 or 4.76%. Lastly, since the RNC Interface compliance runs are, on average, 0.29% lower than the building department C-2R compliance runs, 5.17% is both added and subtracted from -0.29% to define the error band. As mentioned above, the resulting error band is -5% to +4%.

Table 2-1: Summary of the RNC Interface Error Band Analysis

Statistic	Year #1	Year #2
Difference Estimator	0.73%	-0.29%
Standard Deviation	0.0314	0.0289
90% Confidence Interval	± 5.17%	± 4.76%
Lower Error Band	-4.44%	-5.05%
Upper Error Band	5.90%	4.47%

2.5 Other Uses

The RNC Interface has proved useful in many applications other than those it was developed for. Its batch processing and technical potential capabilities have allowed for quick "what if" analysis that could otherwise not have been possible. Some of these "what if" scenarios are mentioned in Section 4.

3

Current Building Practices for Residential Detached Single Family Homes

3.1 Introduction

This section discusses current building practices for residential detached single family homes. In particular, on-site survey data from 575 homes, which were first occupied in 2003, were used to establish current building practices for building shell, HVAC systems, and water heating equipment.

The remainder of this section provides an overview of the on-site sample design, a discussion of the prescriptive requirements of Title 24, and a discussion of current building practices by climate zone.

3.2 Overview of On-Site Survey Sample Design

This section presents an overview of the sample design. The overview includes a discussion on the sample frame, sample plan, sample selection, and sample weights.

RMST On-Site Sample Frame

In the first two RNC Studies[1], the sample design and weights were based on the new construction sample frame developed using customer frame data provided to Itron by California's investor-owned utilities (IOUs). For this study, Itron again received customer frame data from the IOUs; however, the data was not sufficient to develop the sample design. Therefore, 2002 new housing starts, obtained from the Construction Industry Research Board (CIRB), were used to calculate the number of new homes that were permitted to be built in late 2002 and early 2003. Further, the CIRB data contains the number of single family homes built by building department, which allowed Itron to calculate total housing starts by RMST Climate Zone and IOU.

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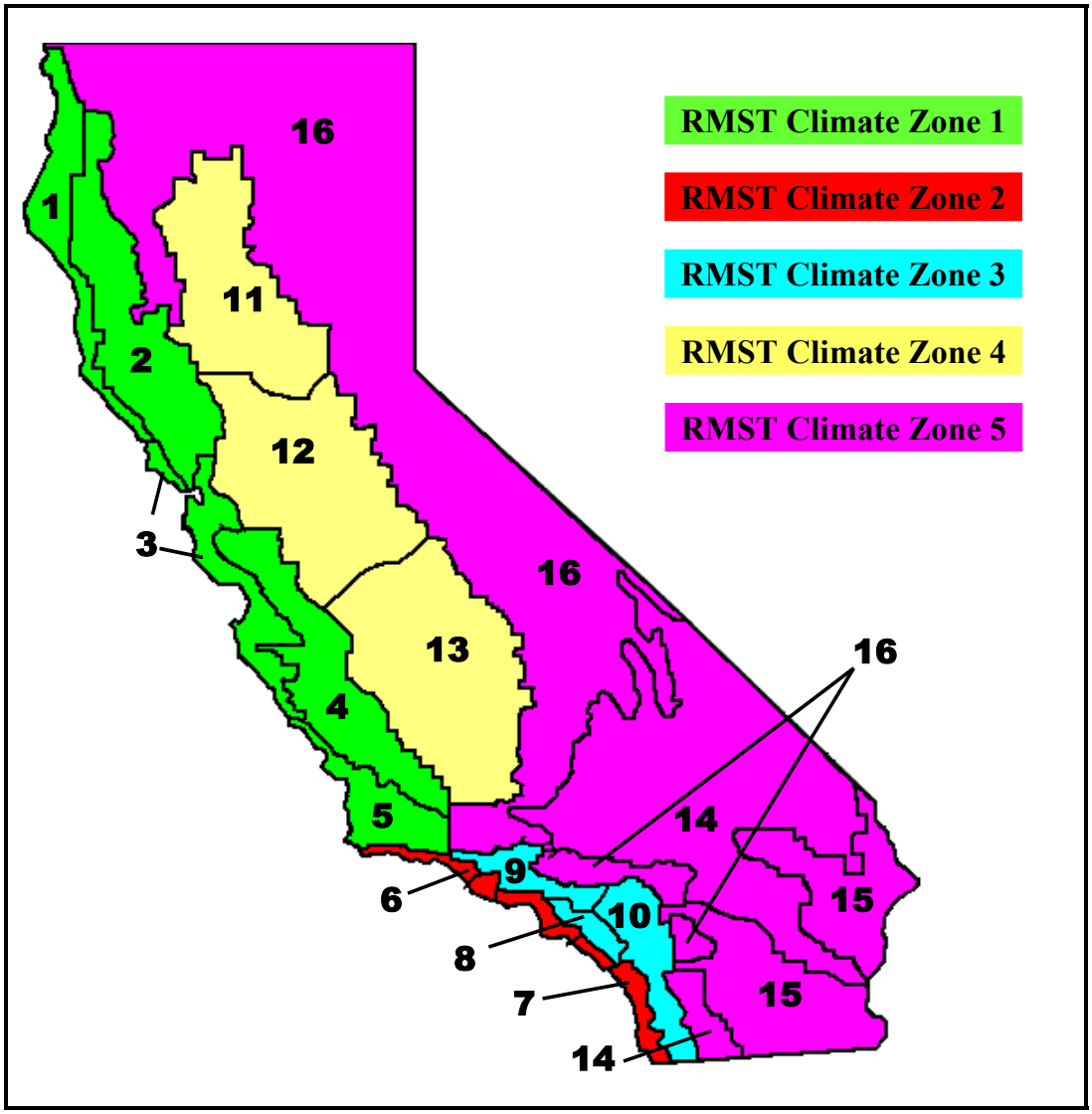
[1] RER, Inc. 2001 Statewide *Residential New Construction Energy Efficiency Baseline Study.* Prepared for PG&E.
RER, Inc. 2002 Statewide *Residential New Construction Energy Efficiency Baseline Study: Second-Year Report.* Prepared for PG&E.

As shown in Figure 3-1, there are 16 CEC climate zones in California. These zones were collapsed into five regions. The criterion for the aggregation of the climate zones was that the Title 24 requirements across these climate zones be the same or vary in only one component. Using this approach, climate zones were aggregated as follows.

- RMST Climate Zone 1 North Coast encompasses CEC Climate Zones 1 – 5.
- RMST Climate Zone 2 South Coast encompasses CEC Climate Zones 6 – 7.
- RMST Climate Zone 3 South Inland encompasses CEC Climate Zones 8 – 10.)
- RMST Climate Zone 4 Central Valley encompasses CEC Climate Zones 11 – 13.
- RMST Climate Zone 5 Desert and Mountain encompasses CEC Climate Zones 14 – 16.

Figure 3-1: CEC Climate Zones



Source: California Energy Commission.

Sampling Plan

Next, Itron developed the sampling plan for the on-site survey. The sample was stratified by CEC climate zone and utility. Sample targets were allocated proportionally with some over sampling for the SDG&E service territory, for a total completed sample size of 600. With the sampling plan complete, Itron randomly selected the primary and secondary members of the sample-by-sample stratum. In all, 604 sites were surveyed.

Table 3-1 presents a summary of the 2002 CIRB housing starts and the completed sample for the IOU territories, by RMST climate zone.

Table 3-1: On-Site Survey Sample Frame and Completed Targets

Climate Zone	PG&E		SCE & SCG[2]		SDG&E	
	Sample Frame	Completed Targets	Sample Frame	Completed Targets	Sample Frame	Completed Targets
CZ1	12,233	44	6	1		-
CZ2		-	3,480	25	7,058	66
CZ3		-	28,757	119	2,618	18
CZ4	49,071	260	1,930	27		-
CZ5	1,164	3	14,423	39	873	2
Total	**62,468**	**307**	**48,596**	**211**	**10,549**	**86**

Table 3-2 presents the distribution of the 604 surveyed sites by RMST climate zone and number of stories. Since the goal of this project was to develop baseline building characteristics, the 19 ENERGY STAR® homes that were surveyed were not included in the analysis. An additional 10 homes were omitted because they either were mobile homes, had insufficient window data, or were remodeled homes. The remainder of this report presents the results of the remaining 575 homes.

[2] Results for the homes surveyed in Southern California Gas (SCG) territory were combined with those in Southern California Edison's (SCE) territory for two reasons: 1) their service territories overlap, and 2) there were not enough homes surveyed inside SCG's territory to show results by RMST climate zone.

Table 3-2: Completed On-Site Surveys

	Overall	RMST CZ1	RMST CZ2	RMST CZ3	RMST CZ4	RMST CZ5
Single Family Detached Homes						
1-story	189	7	8	29	126	19
2-story	364	29	72	91	150	22
3-story	22	6	8	7	1	0
Used in Analysis	**575**	**42**	**88**	**127**	**277**	**41**
ENERGY STAR Homes	19	14	5			
Single Family Other (Mobile/Manufactured Home)	6	1	2		2	1
Other Omitted Sites	4	2	1	1		
Total	**604**	**59**	**96**	**128**	**279**	**42**

RMST On-Site Survey Expansion Weights

Expansion weights were developed to expand the on-site data to represent to the total number of homes permitted to be built within the four IOU territories in 2003. The expansion weights are based on the number of households in each utility service area and RMST climate zone shown in Table 3-3.

Table 3-3: New Homes Built – 2003

Climate Zone	PG&E	SCE & SCG	SDG&E	Total
RMST CZ 1	13,412	6		13,418
RMST CZ 2		3,584	6,807	10,391
RMST CZ 3		32,555	2,852	35,407
RMST CZ 4	50,869	1,977		52,846
RMST CZ 5	1,199	16,921	858	18,978
Total	**65,480**	**55,043**	**10,517**	**131,040**

Specifically, expansion weights were calculated as follows:

$$Weight_{i,U,CZ,HT} = \frac{N_{U,CZ,HT}}{n_{U,CZ,HT}}$$

where

$N_{U,CZ,HT}$ = the total number of houses built in 2003, by utility and climate zone, and

$n_{U,CZ,HTA}$ = the number of completed sample points for houses built between 2003, by utility and climate zone.

3.3 Reference for Evaluating Energy Efficiency Building Characteristics and Practices

The following sections provide a description of the prescriptive requirements of Title 24 and the different bases that can be used to analyze the data—statewide, CEC climate zones, RMST climate zones, and utility service areas. These reference points provide a backdrop for the analysis of typical building characteristics and practices in the residential new construction sector. Further, as will be discussed in Section 4, the statewide, utility, and climate zone breakouts provide useful insights for the compliance analysis.

Building Shell Prescriptive Requirements by CEC Climate Zone

Prescriptive Package D values[3] for construction features affecting energy efficiency are presented in Table 3-4 for the 16 CEC climate zones. These values provide a basis for evaluating the current construction practices. Values are given for ceiling insulation, wall insulation, glazing percent (versus total conditioned floor area), minimum glazing U-values, and maximum allowable Solar Heat Gain Coefficients (SHGC) for the 2001 Standards. Also provided in the table are those CEC Climate Zones where Prescriptive Package D requires a radiant barrier and/or TXVs. Please note that under Prescriptive Package D, duct sealing is required in all CEC Climate Zones.

[3] *Contractor's Report 2001 Update Assembly Bill 970. CEC Volume 1 – Summary*. November 2000.

Table 3-4: Prescriptive Package D Requirements by CEC Climate Zone

CEC CZ	Ceiling R-Value	Wall R-Value	Radiant Barrier	TXV	Glazing Percent	Glazing U-Value	SHGC
1	38	21			16	0.65	
2	30	13	Required	Required	16	0.65	0.40
3	30	13			20	0.75	
4	30	13	Required		20	0.75	0.40
5	30	13			16	0.75	
6	30	13			20	0.75	
7	30	13			20	0.75	0.40
8	30	13	Required	Required	20	0.75	0.40
9	30	13	Required	Required	20	0.75	0.40
10	30	13	Required	Required	20	0.65	0.40
11	38	19	Required	Required	16	0.65	0.40
12	38	19	Required	Required	16	0.65	0.40
13	38	19	Required	Required	16	0.65	0.40
14	38	21	Required	Required	16	0.65	0.40
15	38	21	Required	Required	16	0.65	0.40
16	38	21			16	0.60	

Windows. Two values are used to rate window performance: U-value and SHGC. U-value is a measure of a window's thermal performance. The lower the U-value, the greater a window's resistance to heat flow and the better its insulating value. SHGC measures how well a product transmits sunlight. SHGC is the fraction of incident solar radiation admitted through a window, both directly transmitted and absorbed and subsequently released inward. The lower a window's SHGC, the less heat transmitted.

Since U-values and SHGCs were not observed during the on-site visits, the analysis of window efficiency focuses on the types of windows installed. After reviewing every possible combination of window type, Itron found seven types of windows in the RMST database. These seven window types, listed below, are the focus of the analysis presented here.

- Low-E glass, double pane, vinyl frame.
- Low-E glass, double pane, metal frame.
- Low-E glass, double pane, other frame.
- Clear glass, double pane, vinyl frame.
- Clear glass, double pane, metal frame.
- Tinted glass, double pane, vinyl frame.
- Tinted glass, double pane, metal frame.

Equipment Minimum Standards

The parameters used to measure energy efficiency and the current energy efficiency standards for furnaces, air conditioners, water heaters, and windows are presented below.

Furnaces

The energy efficiency of furnaces is expressed as a percentage of Annual Fuel Utilization Efficiency (AFUE). Equipment AFUEs increase as energy efficiency increases. The federal minimum AFUE standard for furnaces is 78%.[4,5] Units must have at least a 90% AFUE to qualify for the ENERGY STAR label.

Air Conditioners

The cooling efficiency rating used to rate central air conditioners is the Seasonal Energy Efficiency Ratio (SEER). The higher the SEER rating, the more efficient the cooling equipment. SEER ratings range from 10 to over 16. Standard efficiency for central air conditioners is 10 SEER.[6,7] To qualify for the ENERGY STAR label, central air conditioners must have at least a 12 SEER.

Water Heaters

The energy efficiency of water heaters is expressed as an energy factor rating (EF). Water heater EFs vary by storage tank size and fuel type.[8] Therefore, to standardize for tank size, the standard efficiency was calculated for each gas water heater in the sample. To conduct an analysis of water heater efficiencies, Itron computed the percent-above-standard for each water heater observed from the on-site surveys. The formula used for these calculations is:

$$\%AboveStd_i = \frac{(Eff_i - StdEff_i)}{StdEff_i}$$

where

Eff_i = Actual efficiency rating of unit i, and
$StdEff_i$ = $0.62 - (0.0019 \times (TankVolume_i))$.[9]

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4 Code of Federal Regulations. Title 10, Chapter II, Subpart C, Part 430, Section 430.32.

5 Required efficiency for residential central gas furnaces that are less than 225 kBtu/hr.

6 Required efficiency for residential central air conditioners that are less than 65 kBtu/hr.

7 Code of Federal Regulations. Title 10, Chapter II, Subpart C, Part 430, Section 430.32.

8 Ibid.

9 This standard efficiency equation is applicable for residential gas water heaters with a tank size of more than or equal to 20 gallons and an input rating of less than or equal to 75,000 Btu/hr.

Using this approach standardizes for tank size and eliminates the need to conduct the analysis by tank size.

Region/Climate Zone Basis Options for Comparison of Construction Practices

The most straightforward way to examine current building practices and compliance is to use a statewide average for all parameters. However, due to variations across the state in weather, local building code requirements, wages, customer preferences, influence of existing RNC programs, and other issues, looking at construction techniques on only a statewide average basis would be inadequate. Therefore, both the statewide and climate zone averages are presented to allow these regional differences to be sorted out. Possible region/climate zone breakouts for use in evaluating and analyzing energy efficiency are described below.

- ***CEC Climate Zones.*** These 16 standard climate zones defined by the CEC are utilized for all compliance calculations, as shown in Figure 3-1. This would be the most detailed breakout to use. However, because the RMST sample for some of these climate zones is quite thin (not many new homes built in several climate zones), meaningful trends could not be discerned for those climate zones.
- ***RMST Climate Zones.*** The RMST climate zones were used to develop the RMST survey sample. These subgroups are based on CEC climate zones with similar prescriptive performance characteristics, regional proximity, and utility service areas.
- ***Utility Service Areas.*** This would be the most difficult to use as the basis for analysis because the utility service areas for the IOUs (PG&E, SCE, and SDG&E) span multiple CEC climate zones and overlap in some areas.

For continuity with the RMST study, results for this report are presented on a statewide and RMST climate zone basis. However, other regional bases are used as needed to further examine a particular building practice or compliance issue.

3.4 Current Building Practices in the Residential Sector

In this section, "typical construction practices," as reflected in the RMST survey data, are compared wherever possible to Prescriptive Package D values and minimum equipment efficiencies from the Residential Standards. These comparisons are made at the state and RMST climate zone level in order to discern regional variations in construction practices. Current construction practices for the following features are summarized below.

- Square footage, number of stories, and equipment saturations,
- Fenestration,
- Space heating systems,

- Space cooling systems,
- Multiple HVAC systems and thermostat controls,
- Water heating, and
- Building shell features.

Note that for some equipment and shell characteristics, information based on observed data as well as data for the entire sample are presented. The data for the entire sample can include default data developed for use in the Title 24 compliance analysis.

Square Footage, Number of Stories, and Equipment Saturations

Table 3-5 presents a summary of the square footage, number of stories, and equipment saturations by RMST climate zone. Homes vary in size from an average of approximately 2,400 square feet in RMST Climate Zone 5 to 2,900 square feet in RMST Climate Zone 2. Not surprisingly, almost all of the water heaters and central furnaces are natural gas or propane. Further, the saturation of central air conditioners is much higher in the hot dry RMST Climate Zones 3, 4, and 5.

Table 3-5: Square Footage, Number of Stories, and Equipment Saturations

Analysis Parameter Description	Statewide	RMST CZ1	RMST CZ2	RMST CZ3	RMST CZ4	RMST CZ5
Average Square Footage	2,579	2,542	2,902	2,717	2,473	2,467
Average Number of Stories	1.7	2.0	2.0	1.8	1.6	1.5
Heating Equipment Saturation						
Central Furnace	98%	95%	99%	96%	100%	100%
Wall Furnace	0%	3%	-	1%	-	-
Other	1%	-	1%	3%	-	-
Cooling Equipment Saturation						
Central Air Conditioner	87.4%	27.5%	70.4%	90.6%	99.2%	100.0%
No Air Conditioner	12.6%	72.5%	29.6%	9.4%	0.8%	-
Water Heater Saturation						
Gas	95.6%	87.5%	100.0%	99.2%	94.4%	95.8%
Propane	4.4%	12.5%	-	0.8%	5.6%	4.2%

Fenestration

Fenestration construction practices, as represented by percent glazing and window types, are discussed in this section.

Percent Glazing

Percent glazing refers to the total glazing area of a home expressed as a percent of the total conditioned floor area. The Residential Standards use two values: 16% and 20%.[10] Average percent glazing values are presented in Table 3-6 by RMST climate zone. The following observations can be made from these tables.[11]

- The average glazing percentage is approximately 15.7%, down from the 17.4% recorded in 2000.
- The average glazing percentage for homes is less than the prescriptive value in RMST Climate Zones 2, 3, 4, and 5.
- Statewide, the percentage of homes with percent glazing values less than the prescriptive value (higher performance) increased from 58% to 68% compared to homes surveyed in 2000.
- RMST Climate Zones 1 and 4 have the largest number of homes with percent glazing values more than the prescriptive value (lower performance).

Table 3-6: Percent Glazing

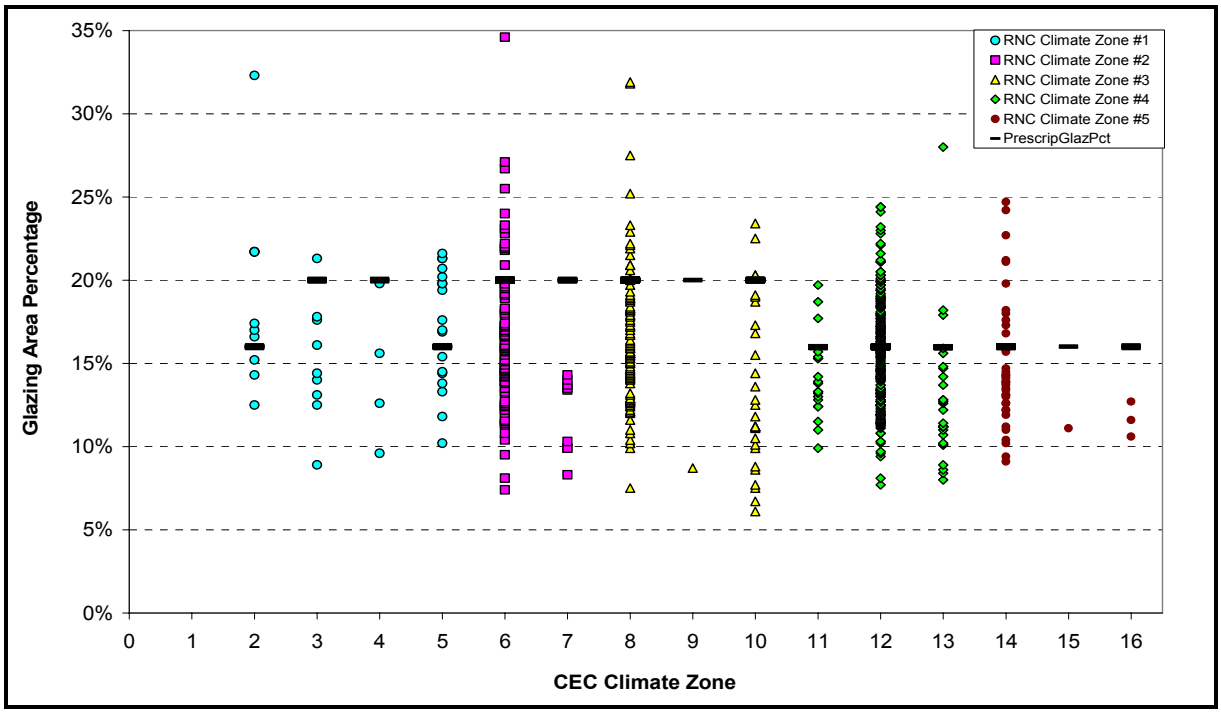
Analysis Parameter Description	Statewide	RMST CZ1	RMST CZ2	RMST CZ3	RMST CZ4	RMST CZ5
Higher Performance	68%	50%	85%	84%	59%	68%
Equal to Prescriptive	1%	-	-	2%	1%	2%
Lower Performance	31%	50%	15%	14%	41%	29%
Prescriptive		20% & 16%	20%	20%	16%	16%
Average % Glazing	15.7%	17.6%	16.3%	15.6%	15.4%	15.0%

Figure 3-2 offers a more in-depth look at percent glazing values. Percent glazing values for all sites are presented versus CEC and RMST climate zone.

[10] See Table 3-4 for more information.

[11] Note that for this third year of the project the on-site surveyors were given different protocols when gathering glazing information in order to improve the accuracy of their measurements, including measuring, in inches, each accessible window.

Figure 3-2: Percent Glazing Values by CEC and RMST Climate Zone



Window Types

Typical construction for window types—frame type, glass type, and number of panes—is presented in Table 3-7. The following results are shown.

- Statewide, and in each RMST climate zone, the predominant window type is vinyl-framed, dual-paned, Low-E glass. They are installed statewide in 79% of homes.
- Nearly all homes in RMST Climate Zone 5 have dual-paned vinyl Low-E windows (95%).
- Statewide, the percentage of homes with clear glass dropped from 89% to 16% (from 2000 to 2003).

Table 3-7: Distribution of Window Types

Window Types (# of panes, frame type, glass type)	Statewide	RMST CZ1	RMST CZ2	RMST CZ3	RMST CZ4	RMST CZ5
2-paned Vinyl, Clear Glass	14.3%	27.5%	27.8%	24.7%	5.5%	2.5%
2-paned Metal, Clear Glass	2.0%	0.0%	9.5%	2.9%	0.4%	2.5%
2-paned Vinyl, Low-E	78.6%	60.0%	55.8%	70.4%	87.4%	95.0%
2-paned Metal, Low-E	3.9%	7.5%	3.0%	1.2%	6.4%	0.0%
2-paned Other, Low-E	0.4%	2.5%	0.0%	0.0%	0.4%	0.0%
2-paned Vinyl, Tinted	0.6%	2.5%	3.9%	0.0%	0.0%	0.0%
2-paned Metal, Tinted	0.2%	0.0%	0.0%	0.8%	0.0%	0.0%

Fenestration Average U-Values

The following tables use average U-values obtained from the MICROPAS compliance runs. These results give a more comprehensive look at fenestration (as opposed to just windows). Table 3-8 provides a reference against which to evaluate the average U-values presented in Table 3-9, which presents the average U-value of the windows, installed in the homes surveyed by RMST climate zone. As explained above, a window with a lower U-value and/or a lower SHGC value is more efficient than one with higher values. As shown below, a vinyl-framed, low-E glass window is more efficient than a metal-framed, clear glass window.

Table 3-8: Default Window Thermal Performance Values

RMST Survey Fields and Descriptions				Default Values	
Frame Type	Number of Panes	Glazing Type	Grids/ Muntins	U-Value	SHGC
Vinyl	2	Clear	Yes	0.60	0.65
Vinyl	2	Tinted/Refl	Yes	0.60	0.53
Vinyl	2	Low-E	Yes	0.37	0.41
Metal	2	Clear	Yes	0.75	0.70
Metal	2	Tinted/Refl	Yes	0.75	0.59

The following results are shown in Table 3-9.

- The average U-value is approximately 0.42, down from 0.59 in 2000. U-values currently range from 0.39 to 0.49 across RMST climate zones.
- Statewide, only 1% of windows are below prescriptive standards (lower performance).
- The percentage of homes that have glazing that exceeded prescriptive requirements (higher performance) increased from 68% to 100% in RMST Climate Zone 4 from 2000 to 2003.

Table 3-9: Average Window U-Values

Analysis Parameter Description	Statewide	RMST CZ1	RMST CZ2	RMST CZ3	RMST CZ4	RMST CZ5
Higher Performance	98%	100%	94%	96%	100%	98%
Equal to Prescriptive	1%	-	5%	4%	-	-
Lower Performance	1%	-	1%	-	-	2%
Average U-Value	0.42	0.46	0.49	0.45	0.40	0.39
% of Sites w/Metal Frames	6.2%	7.5%	12.5%	4.8%	6.8%	2.5%
% of Sites w/Low-E Glass	82.9%	70.0%	58.9%	71.6%	94.1%	95.0%

Space Heating Systems

A summary of space heating systems characteristics for units installed in newly constructed homes is discussed in this section. These characteristics include average system efficiencies, system type, and duct location. Note that efficiency results focus exclusively on gas-fueled systems because there are so few electric systems in the sample (< 1%).

Equipment Type and Location

A distribution of the space heating system equipment types and locations are presented in Table 3-10. Results are as follows.

- Space heating systems in single family detached homes are predominantly furnaces (98%).
- Hydronic and radiant heat units did not appear in the homes surveyed in 2003, but were 1.6% and 0.2% respectively in 2000.

Table 3-10: Space Heating Equipment Type and Location

Analysis Parameter Description	Statewide	RMST CZ1	RMST CZ2	RMST CZ3	RMST CZ4	RMST CZ5
Equipment Type						
Central Furnace	98%	95%	99%	96%	100%	100%
Wall Furnace	0%	3%	-	1%	-	-
Other	1%	-	1%	3%	-	-
Equipment Location						
Attic	76%	55%	80%	73%	79%	86%
Garage	11%	13%	8%	7%	13%	10%
None	5%	8%	6%	10%	2%	2%
Other	8%	25%	6%	10%	6%	2%

Equipment Efficiency

Table 3-11 presents a summary of gas space heating system efficiencies. Key findings are highlighted below.

- The average statewide and RMST climate zone efficiencies are above the minimum standard efficiency of 78% AFUE. The statewide average is approximately 81% AFUE.
- Penetration of high efficiency space heating units (>90% AFUE) grew from 3% to 11% from 2000 to 2003. RMST Climate Zone 1 has the largest percentage of homes with high efficiency space heating units (46%).

Table 3-11: Gas Space Heating System Efficiency

Analysis Parameter Description	Statewide Average	RMST CZ1	RMST CZ2	RMST CZ3	RMST CZ4	RMST CZ5
Average Efficiency (AFUE)*	81.4	85.3	82.0	80.0	81.4	80.8
>= 78% and <= 80% AFUE*	86%	50%	84%	97%	87%	93%
> 80% and <= 90% AFUE*	3%	4%	-	3%	2%	3%
> 90% AFUE*	11%	46%	16%	-	10%	4%
% of sites with observed data	54%	68%	36%	59%	46%	65%
% of sites with default values	46%	33%	64%	41%	54%	35%
Default AFUE	82.1	88.5	82.0	80.0	82.2	81.9
Average AFUE including defaults	81.7	86.4	82.0	80.0	81.8	81.2

* Of observed data.

Space Cooling System

Space cooling systems characteristics for units installed in newly constructed homes are discussed in this section. These characteristics include average system efficiencies, system type, and unit locations.

Equipment Type and Location

A distribution of the space cooling system equipment types and locations is presented in Table 3-12. Key findings are highlighted below.

- The predominant space cooling system is a conventional central air conditioner (87%). However, 13% of the homes do not have air conditioning.
- The percentage of homes without air conditioning increased in RMST Climate Zone 1 from 54% in 2000 to 73% in 2003, but remained stable at about 13% on a statewide basis.
- Space cooling equipment is typically installed in the attic (70%).
- Nearly all homes in RMST Climate Zones 4 and 5 have air conditioning units (99% and 100%, respectively).

Table 3-12: Space Cooling Equipment Types

Analysis Parameter Description	Statewide	RMST CZ1	RMST CZ2	RMST CZ3	RMST CZ4	RMST CZ5
Equipment Type						
Central Air Conditioner	87%	28%	70%	91%	99%	100%
No Air Conditioner	13%	73%	30%	9%	1%	-
Equipment Location						
Attic	70%	23%	64%	68%	78%	86%
Garage	9%	3%	1%	7%	13%	10%
None	13%	73%	30%	9%	1%	-
Other	8%	3%	5%	15%	8%	4%

Equipment Efficiency

Results for cooling system efficiencies are presented in Table 3-13. Results are highlighted below.

- Statewide and RMST climate zone average efficiencies are higher than the minimum efficiency of 10 SEER. The statewide average is nearly 11 SEER.
- Statewide, 51% of homes have higher than standard efficiency cooling systems.
- The average SEER in RMST Climate Zone 5 increased the most between 2000 and 2003 (10.5 to 11.5).

Table 3-13: Central Air Conditioner Efficiency

Analysis Parameter Description	Statewide	RMST CZ1	RMST CZ2	RMST CZ3	RMST CZ4	RMST CZ5
Average Efficiency (SEER) *	10.9	10.5	10.3	10.5	10.9	11.5
<= 10 SEER*	49%	50%	67%	50%	55%	25%
> 10 and <= 11 SEER*	15%	30%	20%	35%	2%	8%
> 11 and <= 12 SEER*	31%	20%	13%	12%	37%	54%
> 12 and <= 13 SEER*	4%	-	-	2%	3%	13%
> 13 and <= 14 SEER*	1%	-	-	-	2%	-
> 14 SEER*	0%	-	-	1%	-	-
% of sites w/ observed efficiency	95%	91%	87%	98%	93%	98%
% of sites w/ default efficiency	5%	9%	13%	2%	7%	2%
Default SEER	11.0	10.5	10.0	10.5	11.2	12.0
Average SEER including defaults)	10.9	10.5	10.3	10.5	11.0	11.5

* Of observed data.

Multiple HVAC Systems and Thermostat Types

Multiple HVAC systems and thermostat type can have a significant impact on energy use. A summary of the percent of homes with multiple units and thermostat types is presented in Table 3-14. Results are highlighted below.

- Approximately 28% of homes have two or more HVAC units.
- Digital thermostats are the most common thermostat type (97% statewide). The percentage of electromechanical thermostats decreased from 5% to 1% (2000-2003).

Table 3-14: Multiple HVAC Systems and Thermostat Types

Analysis Parameter Description	Statewide	RMST CZ1	RMST CZ2	RMST CZ3	RMST CZ4	RMST CZ5
Number of HVAC Systems						
1	72%	73%	63%	62%	85%	59%
2	28%	25%	37%	37%	15%	41%
3	0.5%	2.5%	-	0.8%	-	-
Thermostat Types						
Digital	97%	98%	98%	91%	100%	98%
Electromechanical	1%	3%	-	2%	-	-
None	3%	-	1%	7%	-	2%

Water Heating

A summary of water heating equipment characteristics for units installed in newly constructed homes is discussed in this section. These characteristics include average system efficiencies, system types, and fuel types.

Equipment Type, Fuel Type, and Use of Recirculation Pumps

Distributions of water heating equipment types and the use of recirculation pumps and fuel types are presented in Table 3-15. Key findings are highlighted below.

- The conventional storage-type water heater is the most predominant system type (99%). Natural gas-fueled units are most common (95%), followed by propane (4%).
- Statewide, 17% utilize recirculation pumps in their water heating systems. Recirculation pumps are used primarily in RMST Climate Zones 1 and 2 (35% in both zones).

Table 3-15: Water Heating Fuel Type and Presence of Recirculation Pumps

Analysis Parameter Description	Statewide	RMST CZ1	RMST CZ2	RMST CZ3	RMST CZ4	RMST CZ5
Style/Fuel Type						
Storage/Standard – Natural Gas	95%	85%	99%	98%	94%	96%
Storage/Standard – Propane	4%	10%	-	1%	5%	-
Instantaneous – Natural Gas	1%	3%	-	2%	-	-
Instantaneous – Electric	0%	3%	-	-	0%	-
Systems w/Recirculating Pumps	17%	35%	35%	24%	8%	9%

Equipment Efficiency

A summary of water heating system efficiencies is presented in Table 3-16. Note that the efficiency results are presented relative to "minimum efficiency" rather than actual average efficiency values because the minimum efficiency varies by tank size and fuel type. In addition, for those few systems where no information other than fuel type could be gathered due to water heater blanket or earthquake straps, the CEC default water heater data were used. Key findings from these data include the following.

- The average % above minimum efficiency for sites with actual data is approximately 17%.
- Statewide, 4% of homes did not have accessible water heaters; therefore the CEC default was used.

Table 3-16: Gas Water Heater Efficiency

Analysis Parameter Description	Statewide	RMST CZ1	RMST CZ2	RMST CZ3	RMST CZ4	RMST CZ5
Average % above standard*	16.7%	18.1%	17.1%	16.5%	16.4%	16.5%
% sites w/actual data	81%	83%	70%	73%	84%	95%
% sites w/default values	14%	18%	24%	17%	13%	5%
% sites w/CEC default values	4%	0%	6%	10%	3%	0%
Average % above std inc. defaults	15.3%	17.6%	14.3%	14.2%	15.3%	16.5%

* Of observed data.

Building Shell Characteristics

Current building practices for ceiling insulation, wall insulation, radiant barrier, and metal framing are discussed and summarized below.

Ceiling Insulation

Current ceiling insulation practices are summarized in Table 3-17. Note that these results are presented with respect to performance versus prescriptive values (higher performance, equal to prescriptive, lower performance). Note also that the Residential Standards require a minimum of R-19 ceiling insulation to be installed. Key findings are summarized below.

- Statewide, approximately 46% of homes have ceiling insulation levels that are lower than the prescriptive values.
- Only 5% of the homes statewide have ceiling insulation levels that exceed the prescriptive values, most of these are located in RMST Climate Zone 1.

Table 3-17: Ceiling Insulation

Analysis Parameter Description	Statewide	RMST CZ1	RMST CZ2	RMST CZ3	RMST CZ4	RMST CZ5
Average R-Value*	31.8	31.8	29.6	30.2	32.6	33.3
Average Prescriptive R-Value *	34.4	30.0	30.0	30.0	38.0	38.0
Higher Performance	5%	40%	-	2%	0%	-
Equal to Prescriptive	50%	48%	99%	98%	17%	24%
Lower Performance	46%	13%	1%	1%	82%	76%
% of sites w/actual data	49%	73%	38%	42%	52%	42%
% of sites w/default values	51%	28%	62%	58%	48%	58%
Average R-Value (of sites w/ defaults) [12]	30.5	35.8	30.0	30.0	30.0	30.9

* Of homes with observed data.

[12] Default ceiling insulation R-values are based on the average observed R-values by CEC climate zone. In some RMST climate zones, the average default and the average observed R-value may appear to be different, but this is due to a change in the distribution among the CEC climate zones within the RMST climate zone.

Wall Insulation

Wall insulation practices are summarized in Table 3-18. The Residential Standards require a minimum of R-13 wall insulation and there is limited space for insulation in a 2×4 stud frame. Key findings are summarized below.

- The average R-Value of wall insulation decreased from 15.9 in 2000 to approximately 14.0 in 2003.
- RMST Climate Zone 1 had the highest R-Value (15.8) while RMST Climate Zone 5 had the lowest (13.5).

Table 3-18: Wall Insulation

Analysis Parameter Description	Statewide	RMST CZ1	RMST CZ2	RMST CZ3	RMST CZ4	RMST CZ5
Average R-Value*	14.0	15.9	14.3	13.6	13.6	13.5
Average Prescriptive R-Value*	17.2	13.0	13.0	13.0	19.0	21.0
Higher Performance	6%	48%	10%	3%	-	-
Equal to Prescriptive	41%	50%	90%	96%	8%	-
Lower Performance	52%	3%	-	1%	92%	100%
% of sites w/actual data	49.3%	72.5%	48.8%	26.2%	52.8%	66.1%
% of sites w/default values	50.7%	27.5%	51.2%	73.8%	47.2%	33.9%
Average R-Value (of sites w/ defaults)[13]	13.4	16.8	13.0	13.0	13.3	13.8

* Of observed data.

Radiant Barrier and Framing Practices

Radiant barriers and framing materials can also have a significant impact on energy use. A summary of this information is included in Table 3-19. Key findings are summarized below.

- Radiant barriers are installed in only 4% of homes statewide. RMST Climate Zones 1 and 5 have the highest penetration of radiant barriers (14% and 21%).
- Metal framing is used in only 1% of homes statewide.

[13] Default wall insulation R-values are based on the average observed R-values by CEC climate zone. In some RMST climate zones, the average default and the average observed R-value may appear to be different, but this is due to a change in the distribution among the CEC climate zones within the RMST climate zone.

Table 3-19: Radiant Barrier and Framing Practices

Analysis Parameter Description	Statewide	RMST CZ1	RMST CZ2	RMST CZ3	RMST CZ4	RMST CZ5
Radiant barriers installed						
No	96%	86%	100%	100%	98%	79%
Yes	4%	14%	-	-	2%	21%
Framing						
Wood	99%	98%	100%	100%	98%	100%
Metal	1%	-	-	-	2%	-
Other	0%	3%	-	-	-	-

3.5 Summary of Current Construction Practices

Current building practices in the detached single family residential sector are summarized below. Table 3-20 provides a high-level summary of the results found in the third year of the RNC project.

Statewide

The following is a summary of construction practices that appear to be statewide practices (i.e., independent of region).

- The average AFUE of space heating systems installed in homes is approximately 81, which is slightly higher than required by the Minimum Efficiency Standards. The average SEER of the space cooling systems is also higher than required by the Minimum Efficiency Standards at 10.7.
- The average EF of water heating systems installed is 17% higher than required by the Minimum Efficiency Standards.
- The predominant window type is vinyl-framed, dual-paned, Low-E glass (79%).

Regional Construction Practices

A number of differences in building practices among RMST climate zones were detected during the analysis. Table 3-20 summarizes some of the key characteristics, by RMST climate zone.

- Ceiling and wall insulation is usually below prescriptive values in those climate zones with the most extreme prescriptive values. Wall insulation of R-13 is usually used.

- Approximately 13% of homes statewide do not have a cooling system. Specifically, 73% of homes in RMST Climate Zone 1 and 30% in RMST Climate Zone 2 do not have a cooling system.

Table 3-20: Summary of Key Characteristics by RMST Climate Zone

	Overall	RMST CZ1	RMST CZ2	RMST CZ3	RMST CZ4	RMST CZ5
Building Shell						
Average Square Footage	2,579	2,542	2,902	2,717	2,473	2,467
Average Number of Stories	1.7	2.0	2.0	1.8	1.6	1.5
Windows						
Average % Glazing	15.7%	17.6%	16.3%	15.6%	15.4%	15.0%
Prescriptive % Glazing		20% & 16%	20%	20%	16%	16%
Average U-value	0.42	0.46	0.49	0.45	0.40	0.39
Air Conditioners						
Average SEER of Observed Data	10.9	10.5	10.3	10.5	10.9	11.5
> 10 SEER	51%	50%	33%	50%	45%	75%
% of sites w/No Air Conditioner	13%	73%	30%	9%	1%	-
Gas Furnaces						
Average AFUE of Observed Data	81.4	85.3	82.0	80.0	81.4	80.8
> 80% AFUE	13.5%	50.0%	16.1%	2.7%	12.7%	7.0%
Gas Water Heaters						
Avg. % Above Std Energy Factor	16.7%	18.1%	17.1%	16.5%	16.4%	16.5%
% of sites w/Blankets	18%	30%	39%	24%	12%	2%
Radiant Barriers						
% of sites w/ a Radiant Barrier	4.0%	13.8%	-	-	1.7%	20.9%

Building Characteristics

Percent Glazing

The average glazing percentage for all building types is less than the prescriptive values. RMST Climate Zones 2 and 3 have the largest number of sites with percent glazing values less than the prescriptive value, but also have the largest prescriptive value (20%).

Window Types

The predominant window type for all building types is vinyl-framed, dual-paned, Low-E glass. In 2000, only 10% of homes had Low-E glass. In 2003, Low-E glass was the predominant glass type in nearly 83% of new homes.

Space Heating Systems

Space heating systems are predominantly central gas furnaces with efficiencies slightly above 80% AFUE. Penetration of high efficiency (≥90%) space heating units is low for detached single family homes (11%). High efficiency units are the most prevalent in RMST Climate Zone 1 (46%).

Space Cooling Systems

Space cooling systems are predominantly central air conditioners. A large number of new homes do not have air conditioners (13%), primarily in RMST Climate Zones 1 and 2. Penetration of high efficiency (>11 SEER) space cooling units is approximately 36% statewide. These units are concentrated in RMST Climate Zone 5 (67%).

Water Heating Systems

Standard practice water heaters are already more efficient than the Appliance Standards minimums (average 17% higher). This percentage is fairly consistent across RMST climate zones. This is because high efficiency water heaters are cost-effective, readily available, and offer better performance (hence fewer customer complaints).

Building Shell Characteristics

Almost half of homes (46% statewide) are constructed using ceiling insulation with efficiency levels that are lower than the prescriptive values, while only 5% of homes use above-prescriptive ceiling insulation levels. The results for wall insulation were slightly worse; only 52% of homes have wall insulation below the prescriptive level.

Miscellaneous Practices

Number of HVAC Systems. Of detached single family homes, 28% have multiple (two or more) HVAC units. These are primarily in RMST Climate Zones 2, 3, and 5 where homes are bigger (CZ 2 and 3) and where there is high cooling demand (CZ 5).

Thermostat Type. Digital thermostats are now the most common thermostat type (97%).

Radiant Barriers. Radiant barriers are installed in approximately 4% of homes statewide. RMST Climate Zones 1 and 5 have the highest penetration of radiant barriers (14% and 21% respectively).

3.6 Comparison of Homes Built across Standards

Table 3-21 and Table 3-22 provide a summary of the results reported in the first, second, and third year of the RNC project by RMST climate zone. In addition, Table 3-23 provides a high-level comparison of key building characteristics between Project Years #1, 2, and 3. Note that the homes used in the analysis for Project Year #1 were built between July 1, 1998 and June 30, 1999 (most built under the 1995 Standards), while the homes used in the analysis for Project Year #2 were built between July 1, 1999 and June 30, 2000 (built under the 1998 Standards). In this section, these groups of homes will be referred to by the latest year they were built, in other words: 1999 (Project Year #1), 2000 (Project Year #2), and 2003 (Project Year #3 – current report).

Below is a brief comparison of the baseline characteristics of the homes analyzed during the three years of this project. In general, construction practices did not change significantly from 1999 to 2000. However, there were moderate changes in building practices from 2000 to 2003.

Fenestration

The average U-value of windows decreased from 0.59 in 2000 to 0.42 in 2003. This is largely explained by the transition from clear glass to the more efficient Low-E coated glass. Furthermore, the average glazing percentage statewide dropped from 17% to 15.7% from 2000 to 2003. For example, the average glazing percentage for homes in RMST Climate Zone 5 has decreased from 18% to 15%.

Space Heating Systems

The average AFUE of gas furnaces did not change much between 1999 and 2003. The statewide average AFUE was 80.4 in 1999 and 81.4 in 2003. However, in RMST Climate Zone 1 average AFUE increased from 80.3 to 85.3.

Space Cooling Systems

A larger percent of new homes are being built with air conditioners. In 1999, approximately 20% of detached single family homes were built without cooling equipment installed, compared to just 13% in 2003. Homes in RMST Climate Zones 2 and 5 had the largest percentage increase in homes with cooling equipment. The average SEER of air conditioners installed in the homes surveyed increased slightly (10.6 to 10.9).

Water Heating Systems

There was not much change in the efficiencies of the gas water heaters installed in new homes between 1999 and 2003.[14] The statewide average % above standard remained at around 17%. The use of water heater blankets has decreased from 32% to 18%.

Radiant Barriers

The percentage of radiant barriers installed has remained constant between 1999 (2.3%) and 2003 (4%). Radiant barriers have the highest concentration in Climate Zones 1 and 5 (14% and 21% respectively).

[14] Note that the homes used in the analysis for Project Year #1 were built between July 1, 1998 and June 30, 1999, while the homes used in the analysis for Project Year #2 were built between July 1, 1999 and June 30, 2000.

Table 3-21: Summary of Key Characteristics by RMST Climate Zone – 1999

	Overall	RMST CZ1	RMST CZ2	RMST CZ3	RMST CZ4	RMST CZ5
Building Shell						
Average Square Footage	2,232	2,324	2,353	2,436	1,952	2,179
Average Number of Stories	1.6	1.7	1.9	1.7	1.3	1.2
Windows						
Average % Glazing	17%	18%	19%	16%	17%	17%
Prescriptive % Glazing		16% & 20%	20%	20%	16%	16%
Average U-value	0.586	0.576	0.592	0.594	0.584	0.591
Air Conditioners						
Average SEER of Observed Data	10.53	10.39	10.19	10.17	10.95	10.87
> 10 SEER	65%	72%	45%	66%	66%	63%
% of sites w/No Air Conditioner	20%	51%	52%	1%	5%	9%
Gas Furnaces						
Average AFUE of Observed Data	80.39	80.28	80.05	80.22	80.81	80.35
> 80% AFUE	8%	4%	6%	7%	13%	12%
Gas Water Heaters						
Avg. % Above Std Energy Factor	16%	16%	16%	17%	15%	17%
% of sites w/Blankets	32%	22%	22%	30%	47%	19%
Ducts						
Average Leakage (cfm)	218	216	241	221	182	331
Average % Leakage	14%	14%	17%	12%	11%	19%
Radiant Barriers						
% of sites w/ a Radiant Barrier	2.3%	0.9%	-	-	6.2%	2.4%

Table 3-22: Summary of Key Characteristics by RMST Climate Zone – 2000

	Overall	RMST CZ1	RMST CZ2	RMST CZ3	RMST CZ4	RMST CZ5
Building Shell						
Average Square Footage	2,329	2,434	2,756	2,502	2,109	2,125
Average Number of Stories	1.5	1.7	1.9	1.7	1.4	1.2
Windows						
Average % Glazing	17%	18%	16%	18%	17%	18%
Prescriptive % Glazing		20% & 16%	20%	20%	16%	16%
Average U-value	0.595	0.583	0.589	0.592	0.604	0.598
Air Conditioners						
Average SEER of Observed Data	10.6	10.5	10.2	10.2	10.9	10.5
> 10 SEER	55%	71%	36%	41%	63%	37%
% of sites w/No Air Conditioner	14%	54%	34%	0%	1%	0%
Gas Furnaces						
Average AFUE of Observed Data	80.5	80.7	80.1	80.1	80.8	80.5
> 80% AFUE	8%	9%	8%	4%	10%	11%
Gas Water Heaters						
Avg. % Above Std Energy Factor	16%	14%	15%	16%	16%	16%
% of sites w/Blankets	34%	11%	34%	28%	53%	8%
Ducts						
Average Leakage (cfm)	210	288	237	212	164	141
Average % Leakage	13%	15%	12%	13%	14%	9%
Radiant Barriers						
% of sites w/ a Radiant Barrier	3.5%	-	1.9%	2.1%	6.8%	-

Table 3-23: Comparison of Key Characteristics by Year

	1999	2000	2003
Building Shell			
Average Square Footage	2,232	2,329	2,579
Average Number of Stories	1.6	1.5	1.7
Windows			
Average % Glazing	17%	17%	15.7%
Average U-value	0.59	0.60	0.42
Air Conditioners			
Average SEER of Observed Data	10.5	10.6	10.9
% of sites w/No Air Conditioner	20%	14%	13%
Gas Furnaces			
Average AFUE of Observed Data	80.4	80.5	81.4
> 80% AFUE	8%	8%	14%
Gas Water Heaters			
Avg. % Above Std Energy Factor	16%	16%	16.7%
% of sites w/Blankets	32%	34%	18%
Ducts			
Average Leakage (cfm)	218	210	N/A
Average % Leakage	14%	13%	N/A
Radiant Barriers			
% of sites w/ a Radiant Barrier	2.3%	3.5%	4.0%

4

Analysis of Title 24 Compliance for New Residential Construction

4.1 Introduction

This section discusses an assessment of the Title 24 compliance for new residential construction. The analysis is based on the MICROPAS simulation results using the on-site survey data. In particular, 575 homes were processed through the RNC Interface[1] and the % Compliance Margin was calculated for each home. The primary objective of the analysis is to establish key characteristics of buildings that are compliant and those that are not compliant with Title 24 standards. This was accomplished by examining the MICROPAS 6.5 results. Specifically, the Compliance Margin Groups, as defined in Section 4.3, were segmented and analyzed by RMST climate zones,[2] construction features, equipment types and efficiencies, and other building characteristics.

The remainder of this section summarizes the compliance data and presents an overview of the compliance groups used to characterize the results from the MICROPAS runs. Following this is a presentation of the compliance groups affected by RMST climate zone, end-use energy budgets, building shell features, fenestration, HVAC equipment, water heating equipment, and housing price.

4.2 Summary of Compliance Data

Compliance analysis was attempted for all 604 homes contained in the Residential New Construction (RNC) Study on-site database. Table 4-1 presents the status and disposition of the compliance runs for the 604 on-site surveys. As depicted, 10 of the surveyed homes were excluded from the MICROPAS compliance runs because they are manufactured or mobile homes. Additionally, 19 of the 594 valid MICROPAS homes are California ENERGY STAR New Homes and are therefore not included in this baseline analysis.

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1 The RNC Interface, as explained in Section 2, uses on-site survey data to generate a MICROPAS 6.5 input file. MICROPAS 6.5 is a software tool used to determine compliance under the 2001 Low-Rise Residential Building Standards.

2 A mapping of the California Energy Commission (CEC) climate zones to the five RMST climate zones used in this analysis is provided in Section 3.2.

Table 4-1: Status of On-Site Surveyed Homes for MICROPAS Compliance Analysis

Home Disposition	Number of Homes
Omitted Homes:	**29**
California ENERGY STAR Homes	19
Mobile/Manufactured Homes	10
Included Homes:	**575**
Total	**604**

Table 4-2 presents a distribution of the usable homes by RMST climate zone. RMST Climate Zone 4 has the largest number of homes (277). RMST Climate Zone 4 roughly corresponds to the Central Valley (this includes Sacramento, Fresno, and Red Bluff), while the smallest number of homes are in the north coastal region (RMST Climate Zone 1) and the mountains and deserts (RMST Climate Zone 5).

Table 4-2: Distribution of Usable Homes

	Overall	RMST CZ1	RMST CZ2	RMST CZ3	RMST CZ4	RMST CZ5
SF (detached single family)	**575**	**40**	**89**	**127**	**279**	**40**
1 story	189	7	8	29	127	18
2 story	364	27	73	91	151	22
3 story	22	6	8	7	1	0

4.3 Definition of Compliance Groups

Analysis of the MICROPAS results on a *non-compliant*/*compliant* criterion was not appropriate due to on-site measurement error,[3] characterized by the error band discussed in Section 2.4. As a result, a third "compliance group" would have been added to characterize the compliance runs (*indeterminate*). However, because of the interest in RNC programs, an additional group was formed (*high efficiency*).[4] As shown below, this high efficiency group, includes homes with a % Compliance Margin greater than 19%.[5] As such, four compliance groups were used as the basis for analysis of the MICROPAS results.

- ***Non-Compliant.*** This category includes homes that, based on the analysis, are not compliant with Title 24 code. In particular, these homes have a % Compliance Margin less than the lower end of the error band (i.e., <-5%).
- ***Indeterminate.*** This category includes homes with a % Compliance Margin within the error band (-5% to 4%). As such, it is indeterminate as to whether these homes comply with the Title 24 codes.
- ***Compliant.*** This category includes homes that, based on the analysis, are compliant with Title 24 code. In particular, these homes have a % Compliance Margin greater than the upper end of the error band (i.e., > 4% and < 19%).
- ***High Efficiency.*** This category includes homes that, based on the analysis, are overly compliant with Title 24 code. In particular, these homes have a % Compliance Margin greater than 19%. This category was created to account for the share of homes that would meet the existing California ENERGY STAR New Home construction requirements, given the error band. (*Note that these are not actually California ENERGY STAR New Homes. While the program requires that participating homes comply with at least a 15% margin over the 2001 Standard, it also requires verification of measures installed. The homes in this group meet the requirement of being at least 15% overly compliant, given the error band, but did not apply for, nor could be verified as, a participating home.)

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3 On-site measurement error is described as items estimated during or after the on-site survey that can not always be verified or exact. Examples include using mapped U-values and SHGC values for fenestration since these can not be recorded during the on-site survey due to removal of window stickers after the occupant moves in; and using default wall R-values due to the inability to always obtain wall insulation values as the surveyor is not allowed to drill a hole in the wall.

4 Note that homes in this group were not ENERGY STAR New Homes participants as all participants were removed from the baseline. This group simply includes homes that, as-built, would have qualified to be ENERGY STAR New Homes.

5 ENERGY STAR requires that a home use 15% less energy than the maximum allowed. The error band, discussed in Section 2.4, was then put around the 15%, which results in the 19% shown as the cut-off for this group.

Figure 4-1 shows the distribution of homes within each compliance grouping. As mentioned previously, these compliance groups form the basis against which construction features, equipment types and efficiencies, building characteristics, RMST climate zones, and energy budget results from the MICROPAS runs are characterized.

4.4 Compliance Analysis by RMST Climate Zone

This section studies the relationships between compliance groups and RMST climate zones by examining the distribution of homes by compliance groups and RMST climate zones, and examining the average % Compliance Margin by RMST climate zone.

Distribution of Homes by Compliance Groups and RMST Climate Zones

A distribution of homes by compliance groups and RMST climate zones is presented in Table 4-3 and Figure 4-1 through Figure 4-6. Key findings are summarized below.

- Nearly 47% of the homes (196 + 72) are identified as compliant (i.e., they are in the compliant or high efficiency compliance groups). Note that approximately 13% of the homes fall into the high efficiency group.
- Approximately 27% of the homes (155) are identified as non-compliant (i.e., they are in the non-compliant group).
- Slightly over 26% of the homes (152) are in the indeterminate group, which means they are within the error band. Homes in the indeterminate group should be thought of are those whose C-2Rs barely complied with Title 24.

Table 4-3: Distribution of Homes by Compliance Group and RMST Climate Zone

Compliance Group	Totals	Percent	RMST CZ1	RMST CZ2	RMST CZ3	RMST CZ4	RMST CZ5
Non-Compliant	155	27.0%	1	1	14	117	22
Indeterminate	152	26.4%	2	5	21	113	11
Compliant	196	34.1%	18	55	71	46	6
High Efficiency	72	12.5%	19	28	21	3	1
# Homes in the Sample	575	100.0%	40	89	127	279	40
Overall Percentage	100.0%		7.0%	15.5%	22.1%	48.5%	7.0%

Figure 4-1: MICROPAS Results Summary—All Homes

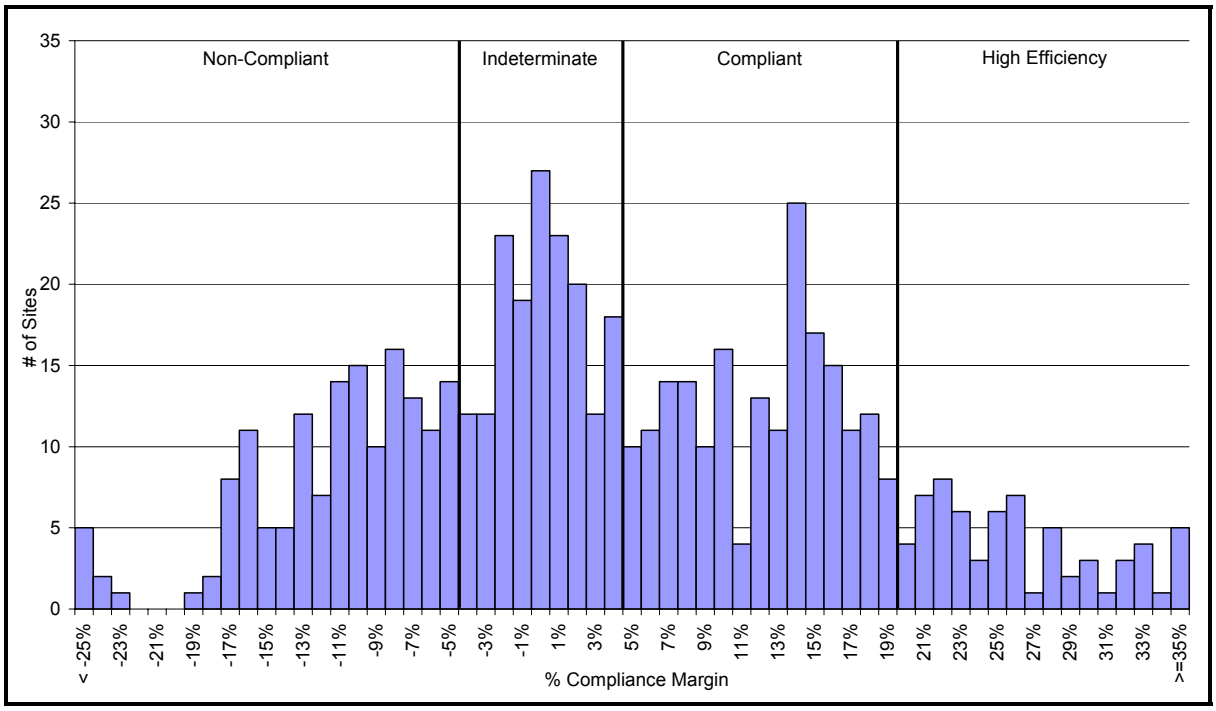


Figure 4-2: MICROPAS Results for RMST Climate Zone 1

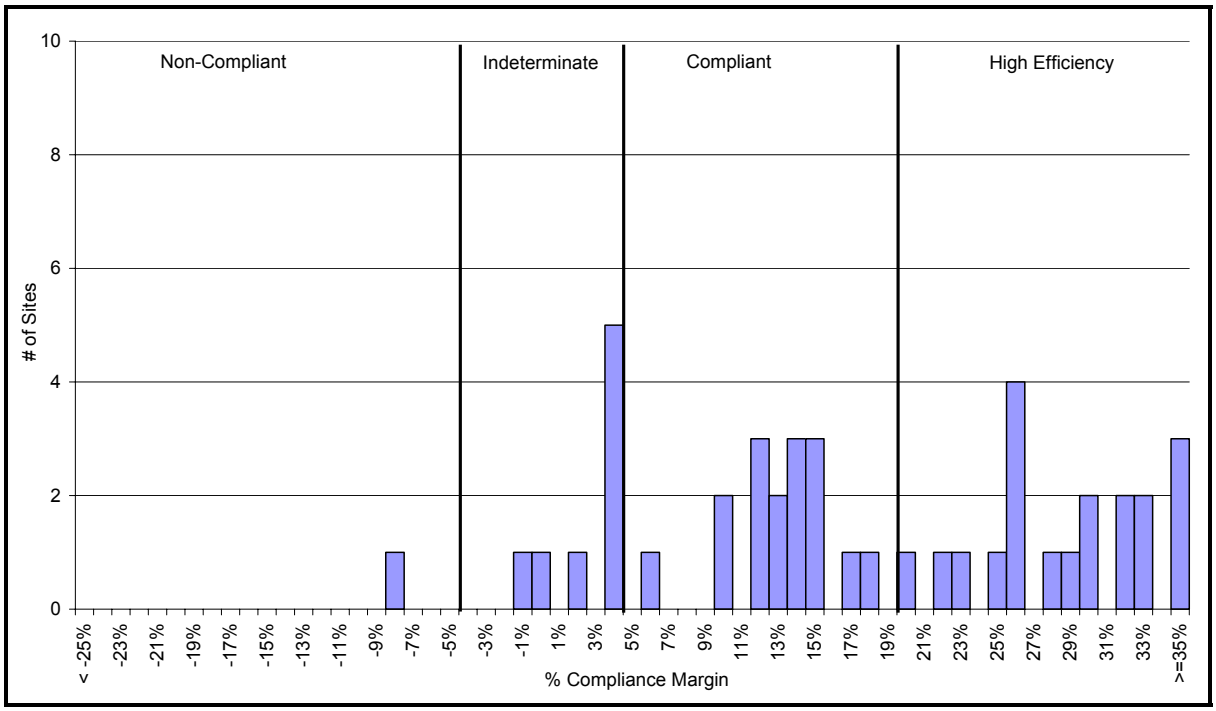


Figure 4-3: MICROPAS Results for RMST Climate Zone 2

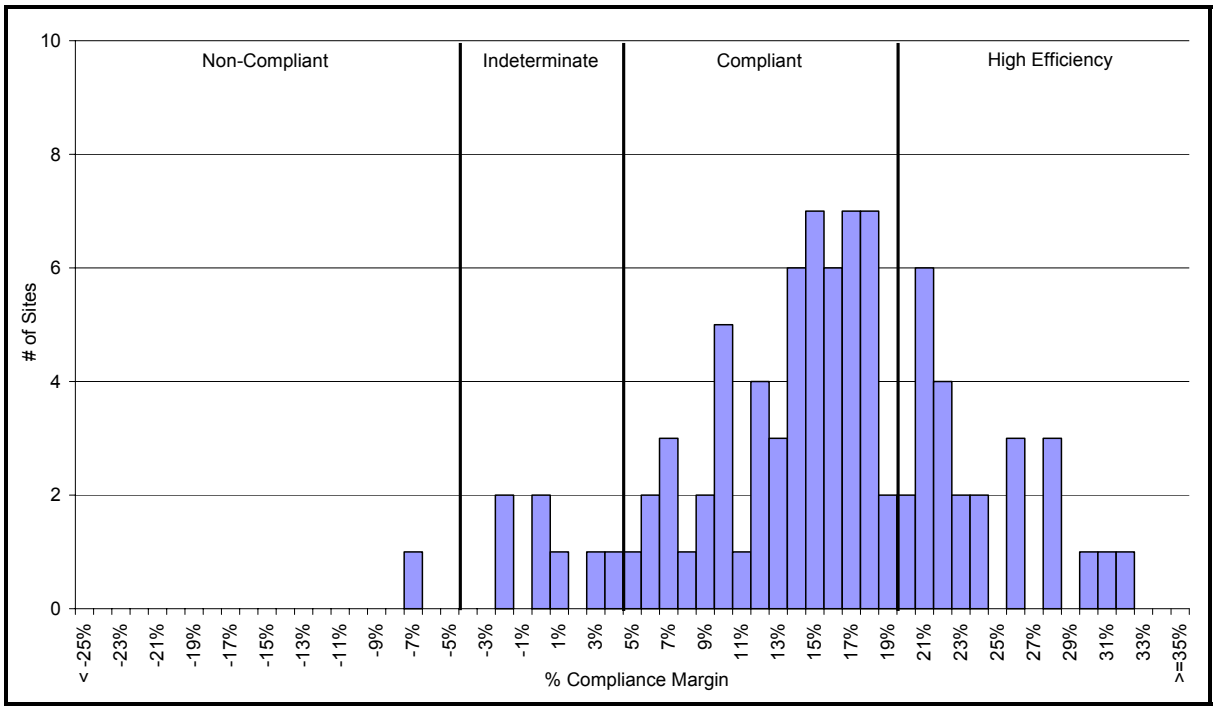


Figure 4-4: MICROPAS Results for RMST Climate Zone 3

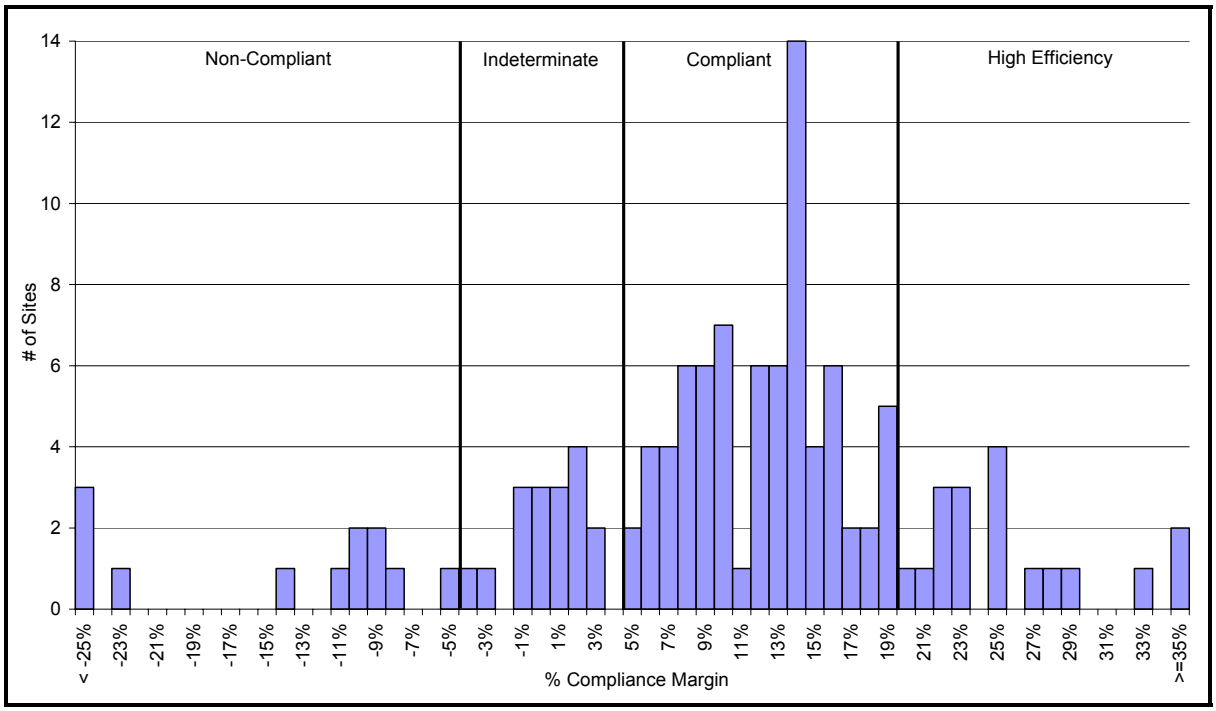


Figure 4-5: MICROPAS Results for RMST Climate Zone 4

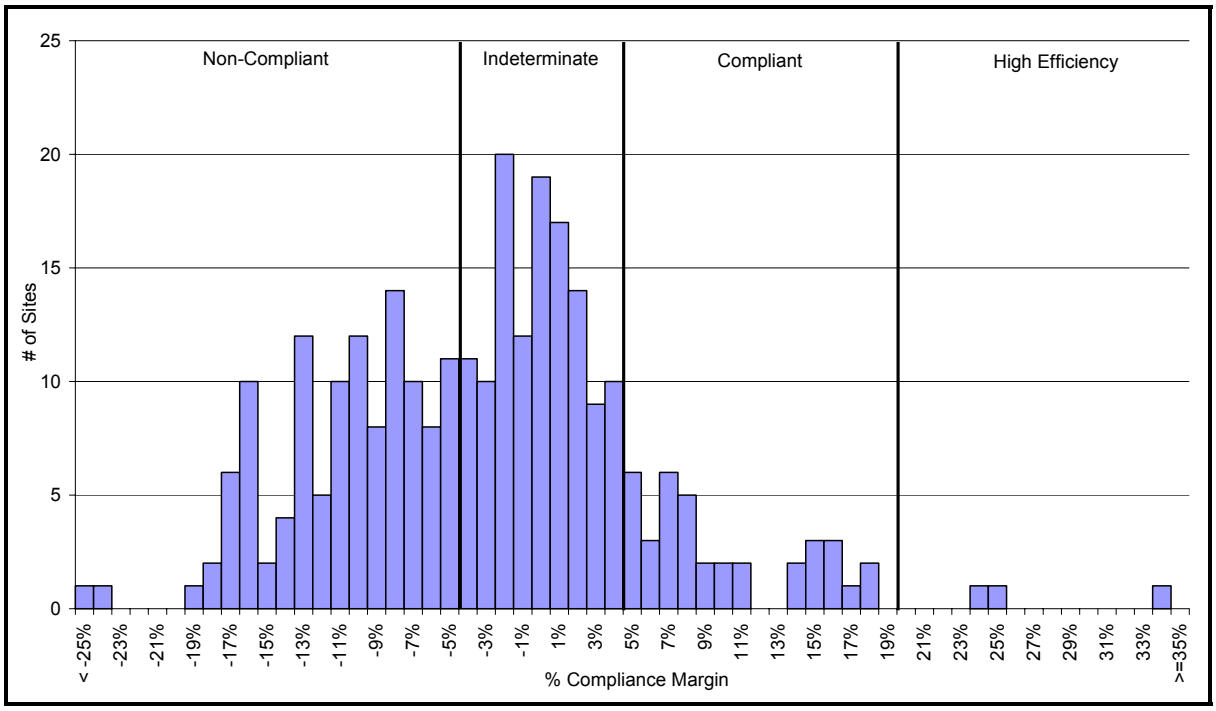


Figure 4-6: MICROPAS Results for RMST Climate Zone 5

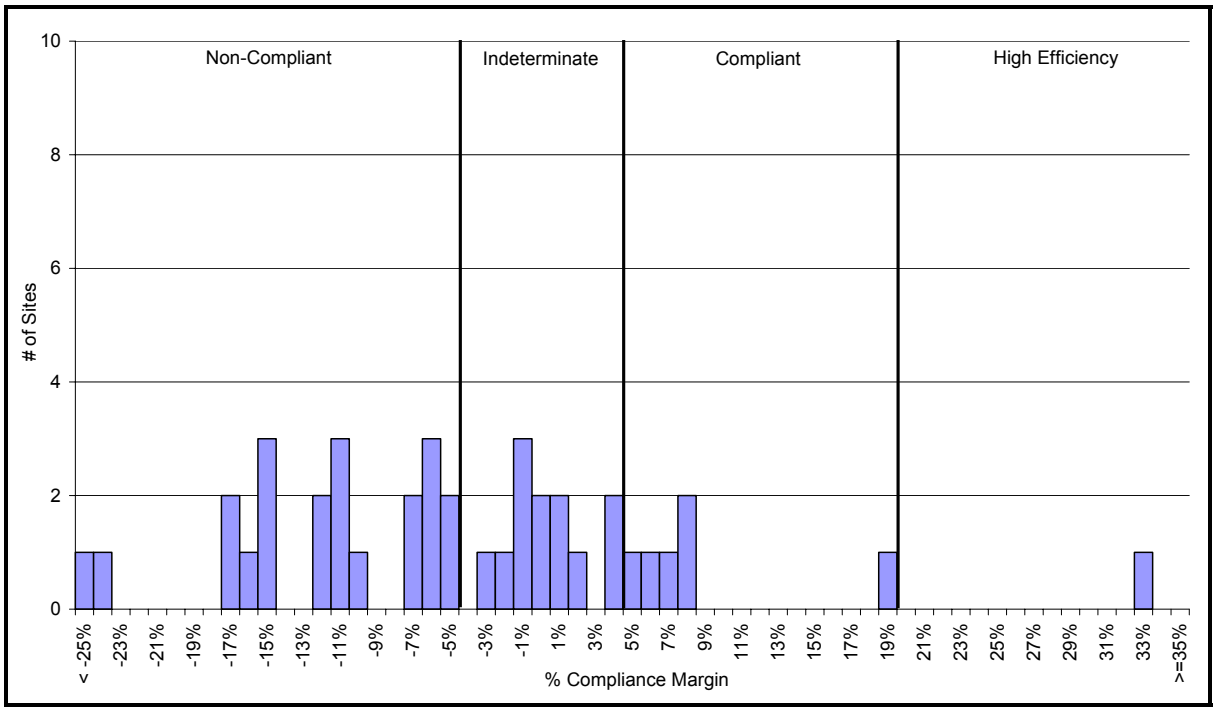


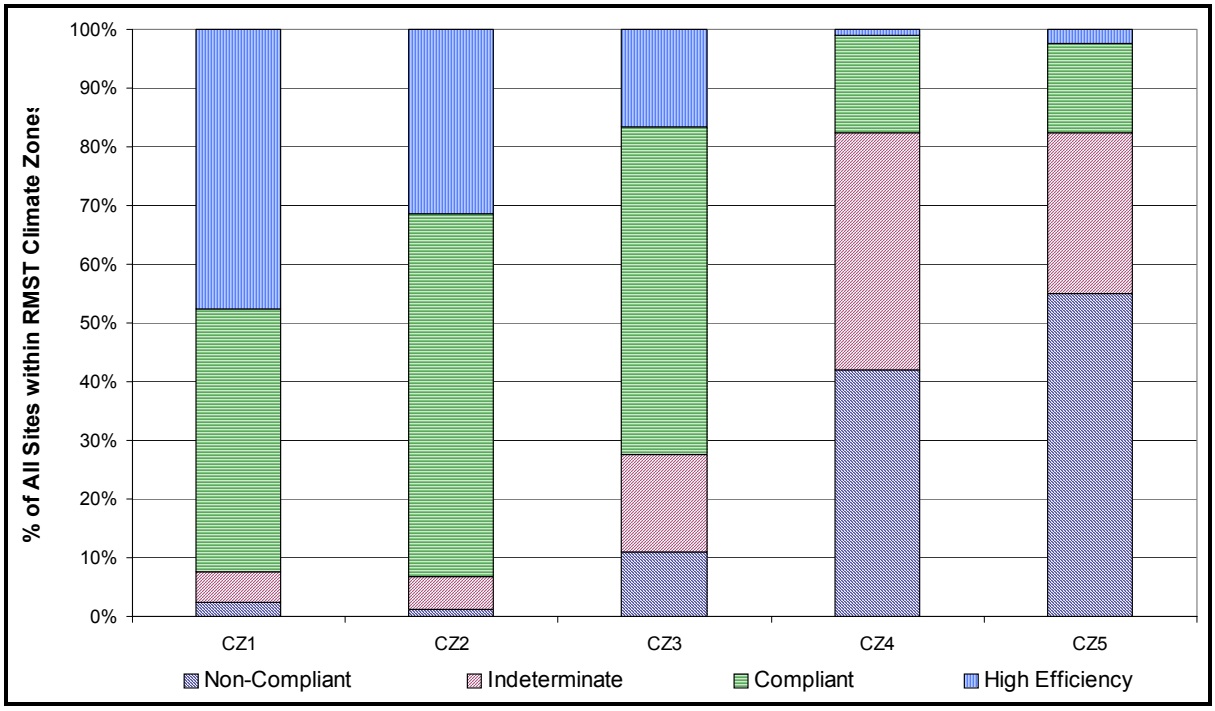
Table 4-4 and Figure 4-7 present the percentage of homes in each compliance group for each RMST climate zone. Analysis on this basis was performed to qualitatively assess the general compliance status of each RMST climate zone. Key findings are summarized below.

- Homes in RMST Climate Zones 4 and 5 appear to be the least compliant; most homes are either non-compliant or indeterminate (83%).
- Homes in RMST Climate Zones 1 and 2 appear to be the most compliant. In RMST Climate Zone 1, 48% are in the high efficiency group and in RMST Climate Zone 2, 31% are in the high efficiency group and only 7% are either non-compliant or indeterminate.

Table 4-4: Summary of Compliance Groups by RMST Climate Zone

Compliance Group	# Homes in Sample	RMST CZ1	RMST CZ2	RMST CZ3	RMST CZ4	RMST CZ5
Non-Compliant	155	3%	1%	11%	42%	55%
Indeterminate	152	5%	6%	17%	41%	28%
Compliant	196	45%	62%	56%	16%	15%
High Efficiency	72	48%	31%	17%	1%	3%
# Sites in the Sample	575	40	89	127	279	40

Figure 4-7: Distribution of Compliance Groups by RMST Climate Zone



Average % Compliance Margin by RMST Climate Zone

Table 4-5 summarizes the relationship between average % Compliance Margin and RMST climate zones. Section 4.12 discusses the differences in compliance performance across climate zones.

- RMST Climate Zone 1 has the highest overall average % Compliance Margin (18.5%).
- RMST Climate Zone 5 has the lowest overall average % Compliance Margin (-4.2%).
- Given that the 2001 Standards were developed to be much more stringent than the 1998 Standards, these high % Compliance Margins seem surprising. However, as explained later in this section, due to increased saturations of higher performance windows, homes along the coast are very compliant.

Table 4-5: Average % Compliance Margin by RMST Climate Zone

RMST CZ	CEC CZ	# of Homes Surveyed	Average % Compliance Margin
CZ1	1, 2, 3, 4, 5	40	19.2%
CZ2	6, 7	89	16.0%
CZ3	8, 9, 10	127	9.4%
CZ4	11, 12, 13	279	-2.9%
CZ5	14, 15, 16	40	-5.7%

Distribution of Homes by Compliance Group and Number of Floors

Table 4-6 summarizes the relationship between building types and compliance groups. Key findings are summarized below.

- Compliance tends to increase with the number of stories. One-story homes, which are inherently less compliant, represent only 17% of the high efficiency homes, despite being 33% of the sample. Furthermore, three-story homes represent 15% of the high efficiency homes, despite being only 4% of the sample.
- Custom-built homes tend to be more energy efficient. Despite being only 20% of the sample, custom-built homes represented 51% of the high efficiency homes.

Table 4-6: Distribution of Compliance Groups by Number of Floors

Analysis Parameter Description	Overall (575 Sites)	Non-Compliant (155 Sites)	Indeter-minate (152 Sites)	Compliant (196 Sites)	High Efficiency (72 Sites)
1 story	33%	35%	45%	28%	17%
2 story	63%	65%	55%	67%	68%
3 story	4%	1%	1%	5%	15%
Custom detached single family homes	20%	11%	10%	23%	51%

4.5 Compliance Analysis across HVAC and Water Heating Energy Budgets

Since compliance is determined by comparing the proposed energy usage to the maximum energy usage allowed by specific end uses, it is important to consider how each end use affects the home's compliance. This section summarizes how the relative share of the HVAC and water heating energy budgets affects compliance.

HVAC and Water Heating Budgets

HVAC and water heating energy use, as determined from the MICROPAS budget results, was examined by compliance group in two ways. First, the end-use proportions of the total energy budget were examined (standard budget), followed by energy intensities in kBtuh/ft^2/yr.

Standard Energy Budget by HVAC and Water Heating

Table 4-7 shows how the standard energy budget changes across RMST climate zones. RMST Climate Zone 2 (mild climate) has the lowest average total standard energy budget. RMST Climate Zones 1 and 3 have the next lowest average total standard energy budget, while the budgets for RMST Climate Zones 4 and 5 (more extreme climates) are double that of RMST Climate Zone 2.

Table 4-7: Average Annual End-Use Standard Budgets

Analysis Parameter Description	RMST CZ1	RMST CZ2	RMST CZ3	RMST CZ4	RMST CZ5
Water Heating Intensity					
Average Standard Budget	11.79	10.60	11.33	11.96	11.80
% of Total Standard Budget	36.5%	58.4%	46.6%	32.2%	26.5%
Space Heating Intensity					
Average Standard Budget	17.48	4.46	7.19	18.59	19.25
% of Total Standard Budget	54.2%	24.6%	29.6%	50.1%	43.2%
Space Cooling Intensity					
Average Standard Budget	2.99	3.09	5.77	6.58	13.50
% of Total Standard Budget	9.3%	17.0%	23.7%	17.7%	30.3%
Total					
Average Standard Budget	32.26	18.15	24.29	37.14	44.55

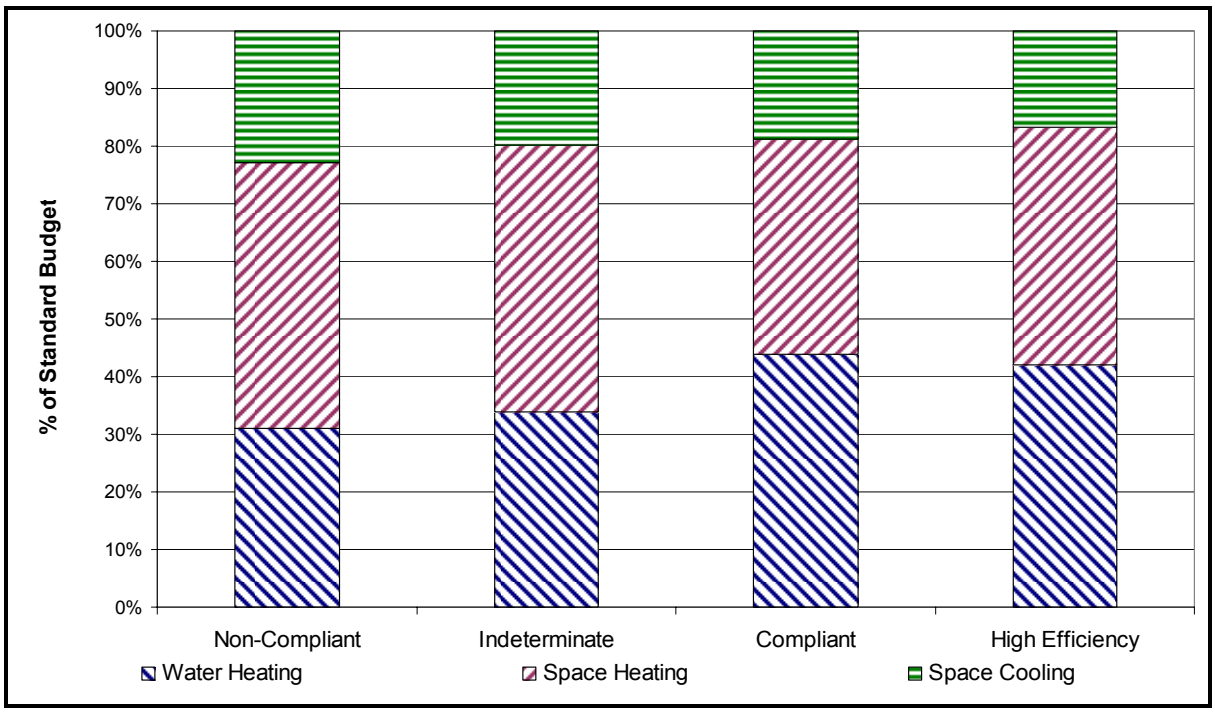
Table 4-8 and Figure 4-8 show the average proportion of each end use (space heating, space cooling, and water heating), as developed from MICROPAS Standard budget results, for each compliance group. Key findings are summarized below.

- The water heating budget as a percent of the total energy budget tends to increase across the compliance groups (31% in the non-compliant group to 42% in the high efficiency group).
- On the other hand, the space cooling budgets as a percent of the total energy budget tends to decrease across the compliance groups.

Table 4-8: Average Proportions of Standard Budget

Analysis Parameter Description	Overall (575 Sites)	Non-Compliant (155 Sites)	Indeter-minate (152 Sites)	Compliant (196 Sites)	High Efficiency (72 Sites)
Water Heating	37%	31%	34%	44%	42%
Space Heating	43%	46%	46%	37%	41%
Space Cooling	20%	23%	20%	19%	17%

Figure 4-8: Average HVAC and Water Heating Percentages of Standard Budget by Comparison Group



Standard vs. Proposed Energy Budgets by HVAC and Water Heating

Table 4-9 shows the average standard and proposed energy budgets by RMST climate zone and end use. As mentioned earlier, RMST Climate Zone 2 has the lowest average standard budget, while RMST Climate Zones 4 and 5 have the largest. Also shown is that RMST Climate Zone 1 has the largest total margin.

Water Heating. Each RMST Climate Zone has positive water heating margins.[6] Note that while RMST Climate Zone 1 has the largest water heating margin, RMST Climate Zone 2 has the largest water heating margin as a percent of the total standard budget. Since RMST Climate Zone 2 has small heating and cooling budgets, the positive water heating margin has a larger impact on overall compliance than the other RMST Climate Zones.[7]

[6] See Section 4.13 for a discussion on changes in the water heating budget between the 1995 standards and the 1998 standards.

[7] The differences amongst the RMST Climate Zones are discussed in more detail in Section 4.12.

HVAC. As shown in Table 4-9, RMST Climate Zones 1, 3, 4, and 5 have negative space cooling margins. In fact, the large negative space cooling margins for RMST Climate Zones 4 and 5 is the reason these RMST climate zones have average % Compliance Margins that are negative. On the other hand, the positive space heating margins of RMST Climate Zones 1 and 3 help these climate zones have positive average % Compliance Margins in spite of the negative cooling margins.

Table 4-9: Average Annual End-Use Energy Intensities by RMST Climate Zone

Analysis Parameter Description	RMST CZ1	RMST CZ2	RMST CZ3	RMST CZ4	RMST CZ5
Water Heating Intensity					
Average Standard Budget	11.79	10.60	11.33	11.96	11.80
Average Proposed Budget	10.04	9.52	10.12	10.46	10.30
Average Margin	1.75	1.09	1.21	1.51	1.50
Space Heating Intensity					
Average Standard Budget	17.48	4.46	7.19	18.59	19.25
Average Proposed Budget	13.44	4.44	5.43	18.04	19.69
Average Margin	4.04	0.01	1.77	0.55	-0.44
Space Cooling Intensity					
Average Standard Budget	2.99	3.09	5.77	6.58	13.50
Average Proposed Budget	3.04	1.22	6.65	9.76	17.23
Average Margin	-0.05	1.87	-0.89	-3.17	-3.72
Total					
Average Standard Budget	32.26	18.15	24.29	37.14	44.55
Average Proposed Budget	26.52	15.18	22.19	38.25	47.22
Average Margin	5.73	2.97	2.09	-1.12	-2.66

Table 4-10 and Figure 4-9 present the average end-use (space heating, space cooling and water heating) energy intensities, as developed from MICROPAS budget results for each compliance group. Key findings are summarized below.

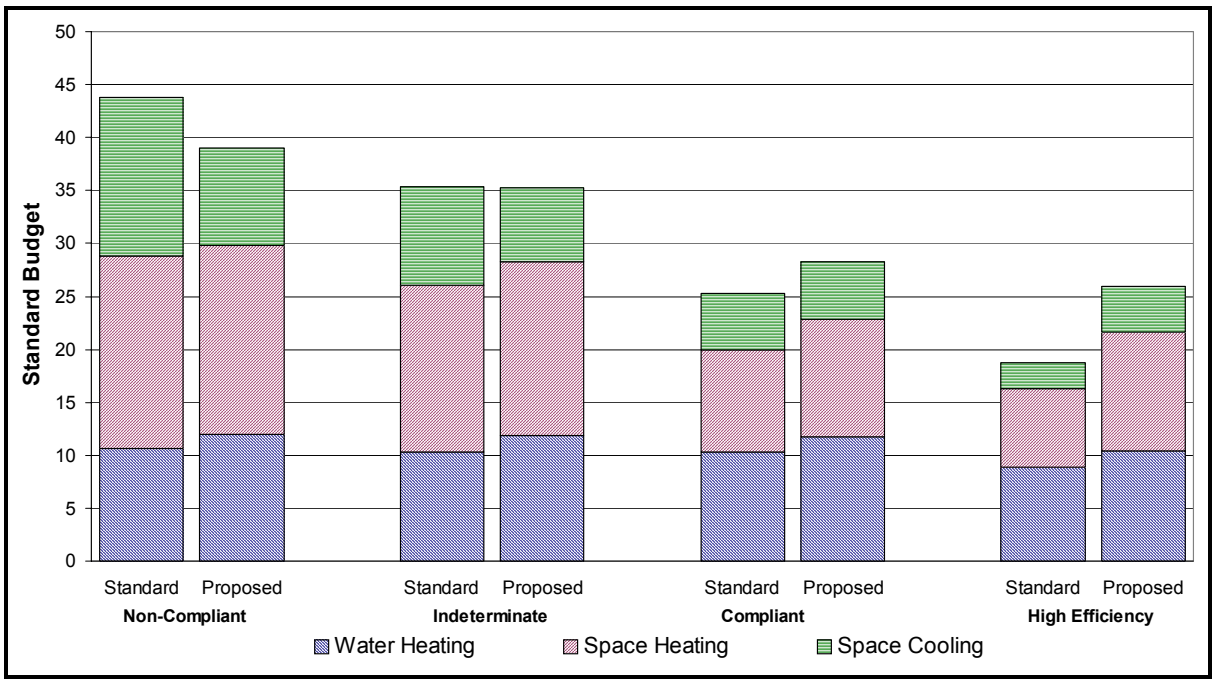
- The average standard space heating budget decreases from the non-compliant group to the high efficiency group (17.8 to 11.2). Likewise, the average standard cooling budget also decreases from the non-compliant group to the high efficiency group (9.2 to 4.2).

- Non-compliant sites are typically non-compliant because of their large negative cooling margins, while high efficiency sites are typically overly compliant because of their large positive cooling and heating margins.
- Water heating budgets remain relatively constant throughout the compliance groups. On average, sites in every group have a small positive water heating margin (average margins range from 1.33 to 1.53).

Table 4-10: Average Annual End-Use Energy Intensities by Compliance Group

Analysis Parameter Description	Overall (575 Sites)	Non-Compliant (155 Sites)	Indeter-minate (152 Sites)	Compliant (196 Sites)	High Efficiency (72 Sites)
Water Heating Intensity					
Average Standard Budget	11.64	11.96	11.81	11.70	10.45
Average Proposed Budget	10.23	10.63	10.35	10.28	8.92
Average Margin	1.42	1.33	1.46	1.42	1.53
Space Heating Intensity					
Average Standard Budget	14.37	17.81	16.41	11.17	11.21
Average Proposed Budget	13.32	18.18	15.73	9.71	7.40
Average Margin	1.05	-0.37	0.68	1.46	3.81
Space Cooling Intensity					
Average Standard Budget	6.72	9.21	7.05	5.35	4.24
Average Proposed Budget	8.63	14.98	9.31	5.25	2.37
Average Margin	-1.91	-5.77	-2.26	0.10	1.87
Total					
Average Standard Budget	32.73	38.98	35.27	28.22	25.90
Average Proposed Budget	32.18	43.79	35.38	25.24	18.70
Average Margin	0.55	-4.81	-0.12	2.98	7.20

Figure 4-9: Average Annual End-Use Energy Intensities (kBtuh/ft^2 per year)



4.6 Building Shell Analysis

This section reviews the relationships between compliance groups and building shell features, including ceiling insulation, wall insulation, and roof/wall/floor construction types.

Ceiling and Wall Insulation

Table 4-11 presents the relationship between ceiling insulation and compliance. Included in the table are the percentages of sites with higher/equal/lower than prescriptive insulation installed, the average ceiling R-value, average prescriptive R-value, and the percentages of sites with observed insulation levels—each by compliance group. The following observations can be made.

- Statewide, 46% of new homes were built with ceiling insulation values below the prescriptive requirements, with only 5% exceeding the prescriptive requirements.
- The percentage of homes with ceiling insulation below the prescriptive requirement decreases across compliance groups from 73% in the non-compliant group to 5% in the high efficiency group.

Table 4-11: Summary of Ceiling Insulation Levels by Compliance Group

Analysis Parameter Description	Overall	Non-Compliant	Indeter-minate	Compliant	High Efficiency
Higher Performance (>Presc)	5%	0%	1%	5%	22%
Equal to Prescriptive	50%	27%	32%	72%	73%
Lower Performance (<Presc)	46%	73%	67%	22%	5%
Average R-Value	31.1	31.1	31.1	30.6	32.8
Average Prescriptive R-Value	34.4	37.1	36.4	32.1	30.5
% of sites w/observed data	49%	48%	48%	46%	61%
Average R-Value	31.8	31.8	32.2	30.7	33.5
% of sites w/default R-values	51%	52%	52%	54%	39%
Average R-Value	30.5	30.4	30.0	30.6	31.7

Table 4-12 presents the relationship between wall insulation and compliance. Included in the table are the percentages of sites with higher/equal/lower than prescriptive insulation installed, the average wall R-value, the average prescriptive R-value, and the percentage of sites with observed insulation levels—each by compliance group. The following observations can be made.

- Just over half of the homes statewide have wall insulation that at least meets the prescriptive requirements (52%), but this varies across the compliance groups. Only 13% of homes in the non-compliant group have wall insulation that is at least equal to the prescriptive, while 95% of homes in the high efficiency group have insulation that at least meets prescriptive standards.
- There is a general pattern of wall insulation levels nearing and then exceeding the prescriptive values across compliance groups from non-compliant to compliant.
- For sites with observed data, the average wall R-value increases across compliance groups (13.2 for non-compliant to 15.7 for high efficiency).

Table 4-12: Summary of Wall Insulation Levels by Compliance Group

Analysis Parameter Description	Overall	Non-Compliant	Indeter-minate	Compliant	High Efficiency
Higher Performance (>Presc)	6%	0%	0%	5%	38%
Equal to Prescriptive	41%	13%	22%	73%	57%
Lower Performance (<Presc)	52%	87%	78%	22%	5%
Average R-Value	13.7	13.2	13.1	13.8	15.7
Average Prescriptive R-Value	16.6	18.9	18.1	14.7	13.4
% of sites w/observed data	49%	57%	43%	44%	60%
Average R-Value	14.0	13.2	13.2	14.1	16.5
% of sites w/default R-values	51%	43%	57%	56%	40%
Average R-Value	13.4	13.2	13.0	13.6	14.4

Roof, Wall, and Floor Construction

Table 4-13 shows the distribution of sites by Compliance Group and roof construction type. The following observations can be made regarding roof construction.

- Approximately 95% of the single family detached homes surveyed have a framed-with-attic (FAT) roof type. Homes with this type of roof are fairly evenly spread across the non-compliant, indeterminate, and compliant groups.
- There are more homes without attics in the high efficiency group than in the other compliance groups. One possible explanation is that some of these homes have ducts in conditioned space, which is a compliance credit under the Standards.

Table 4-13: Summary of Roof Construction Type by Compliance Group

Analysis Parameter Description	Overall	Non-Compliant	Indeter-minate	Compliant	High Efficiency
Framed w/Attic (FAT)	95%	100%	100%	97%	73%
Framed w/o Attic (FNO)	4%	0%	0%	2%	25%

Table 4-14 shows the distribution of sites by compliance group and wall construction type. The following observations can be made.

- Wood framing is the primary wall construction type statewide (99%).
- The percentage of metal-framed sites across compliance groups is extremely low, ranging from 0% to 1%.

Table 4-14: Summary of Wall Construction Type by Compliance Group

Analysis Parameter Description	Overall (575 Sites)	Non-Compliant (155 Sites)	Indeter-minate (152 Sites)	Compliant (196 Sites)	High Efficiency (72 Sites)
% Wood Framing	99%	99%	99%	99%	100%
% Metal Framing	1%	1%	1%	0%	0%

Table 4-15 shows the distribution of sites by compliance group and floor type.

- Statewide, approximately 97% of the sites have slab-on-grade floors.
- Statewide, only 2% of sites have raised floors (crawlspace). A larger percentage of sites in the high efficiency group have raised floors (8%).

Table 4-15: Summary of Typical Floor Construction Type by Compliance Group

Analysis Parameter Description	Overall	Non-Compliant	Indeter-minate	Compliant	High Efficiency
% Slab-On-Grade	97%	98%	99%	98%	85%
% Crawlspace	2%	1%	1%	2%	8%
% Other*	1%	1%	0%	0%	6%

* Other includes floors that are over a garage or an unheated basement.

4.7 Fenestration Analysis

This section summarizes the relationship between compliance and percent glazing and between compliance and the types of windows installed.

Percent Glazing

Percent glazing is a major indicator of a site's tendency to be compliant or non-compliant.

- The percentage of homes with higher than prescriptive percent glazing values (lower performance) is higher in the non-compliant group (58%) than in the compliant and high efficiency groups (17% and 23%).
- Homes in the non-compliant group have the largest average percent glazing (17%) while homes in the indeterminate group have the smallest average percent glazing (15%).
- When comparing glazing percent to compliance, it is important to compare it to the prescriptive glazing percent. Homes with glazing percentages higher than prescriptive are penalized while homes with lower than prescriptive percent

glazing are credited. Note that in non-compliant homes, the average glazing percentage, 17.2%, is greater than the average prescriptive value of 16.4%. On the other hand, homes in the high efficiency group have a much lower average glazing percent (14.8%) than the average prescriptive value (18.4%).

Table 4-16: Percent Glazing by Compliance Group

Analysis Parameter Description	Overall (575 Sites)	Non-Compliant (155 Sites)	Indeter-minate (152 Sites)	Compliant (196 Sites)	High Efficiency (72 Sites)
Higher than Prescriptive	31%	58%	24%	17%	23%
Equal to Prescriptive	1%	2%	2%	1%	0%
Less than Prescriptive	68%	40%	74%	82%	77%
Average Prescriptive % Glazing	17.5%	16.4%	16.8%	18.6%	18.4%
Average % Glazing	15.7%	17.2%	14.9%	15.3%	14.8%

Window Types

Table 4-17 presents the typical construction for window types (frame type, glass type, and number of panes) versus compliance group, as well as the average fenestration U-value. Table 4-18 provides a summary of window types installed by compliance group. Key findings are summarized below.

- The percentage of homes with higher performance fenestration is nearly 100% in each of the compliance groups.
- The average U-value ranges from 0.40 to 0.44. While there appears to be no clear trend when comparing U-values across compliance groups, the difference between the average U-value and the prescriptive value decreases across compliance groups (i.e., the difference increases from 0.22 to 0.31 from the non-compliant group to the high efficiency group).

Dual-paned windows were used in 100% of the single family detached homes surveyed. Furthermore, vinyl low-E windows have become the primary window type installed in homes (79%).

- The use of metal windows decreases across compliance groups from the non-compliant group (12%) to the high efficiency group (5%).

Table 4-17: Summary of Average Fenestration U-Values by Compliance Group

Analysis Parameter Description	Overall (575 Sites)	Non-Compliant (155 Sites)	Indeter-minate (152 Sites)	Compliant (196 Sites)	High Efficiency (72 Sites)
Higher Performance (<Presc)	98%	96%	99%	99%	98%
Equal to Prescriptive	1%	2%	1%	1%	2%
Lower Performance (>Presc)	1%	2%	0%	0%	0%
Average Prescriptive U-value	0.69	0.66	0.67	0.72	0.74
Average U-value	0.42	0.44	0.40	0.42	0.43
Sites with metal-framed windows					
% of compliance group sites	6%	12%	4%	4%	5%
Sites with dual-paned windows					
% of compliance group sites	100%	100%	100%	100%	100%
Sites with Low-E glass					
% of compliance group sites	83%	80%	90%	81%	80%

Table 4-18: Summary of Window Types by Compliance Group

Analysis Parameter Description	Overall (575 Sites)	Non-Compliant (155 Sites)	Indeter-minate (152 Sites)	Compliant (196 Sites)	High Efficiency (72 Sites)
2-paned Metal, Clear Glass	2%	4%	1%	2%	1%
2-paned Vinyl, Clear Glass	14%	16%	10%	16%	15%
2-paned Metal, Low-E	4%	8%	3%	2%	2%
2-paned Other, Low-E	0%	0%	0%	1%	0%
2-paned Vinyl, Low-E	79%	73%	87%	78%	78%
2-paned Metal, Tinted/Reflective	0%	0%	0%	0%	2%
2-paned Vinyl, Tinted/Reflective	1%	0%	0%	1%	2%

4.8 Space Heating and Space Cooling Equipment Analysis

This section examines the relationship between HVAC characteristics and compliance groups by showing average system efficiencies and duct locations by compliance group.

Space Heating Systems

Table 4-19 summarizes space heating system characteristics by compliance group, including average system efficiencies and the saturation of high efficiency gas furnaces. Regarding space heating efficiencies, the following observations can be made.

- The penetration of high efficiency gas furnaces increases from 1% in the non-compliant group to 30% in the high efficiency group.
- Overall as well as by compliance group, average AFUEs are fairly low, averaging just 81.7% AFUE.

Table 4-19: Space Heating System Efficiencies by Compliance Group

Analysis Parameter Description	Overall (575 Sites)	Non-Compliant (155 Sites)	Indeter-minate (152 Sites)	Compliant (196 Sites)	High Efficiency (72 Sites)
Average Efficiency (AFUE)	81.7	80.9	81.2	81.9	83.8
% of sites >= 90% AFUE	8.3%	0.9%	1.8%	11.4%	29.8%
% of sites w/observed data	54%	55%	48%	50%	73%
Average AFUE*	81.4	80.0	80.5	81.7	84.5

* Of observed data.

Table 4-20 shows the distribution of system types and duct locations by compliance group. The following observations can be made regarding space heating system types and duct locations.

- Central furnaces are the predominant heating system type for all compliance groups (98% overall).
- HVAC systems are most prevalently located in the attic (76% of homes statewide).

Table 4-20: Space Heating Equipment Types and Locations by Compliance Group

Analysis Parameter Description	Overall (575 Sites)	Non-Compliant (155 Sites)	Indeter-minate (152 Sites)	Compliant (196 Sites)	High Efficiency (72 Sites)
System Types					
Central Furnace	98%	99%	98%	97%	100%
Radiant Heat	0.3%	0%	0%	0.8%	0%
Wall Furnace	0.5%	0%	0%	1.4%	0%
Other	1.0%	1.2%	1.7%	0.7%	0%
HVAC Location					
Attic	76%	81%	78%	78%	56%
Garage	11%	12%	15%	6%	10%
None (non-ducted)	5%	1%	4%	7%	7%
Other	8%	5%	3%	9%	26%

Space Cooling Systems

Table 4-21 shows the average efficiency of the space cooling systems installed, as well as the percentage of homes that have an observed efficiency for their space cooling system. Key findings are summarized below.

- The average SEER varies minimally across compliance groups, with each compliance group being above the prescriptive value of 10 SEER.

Table 4-21: Space Cooling System Efficiencies by Compliance Group

Analysis Parameter Description	Overall (575 Sites)	Non-Compliant (155 Sites)	Indeter-minate (152 Sites)	Compliant (196 Sites)	High Efficiency (72 Sites)
Average Efficiency (SEER)	10.9	10.8	11.0	10.8	11.1
% of sites >= 12 SEER	36%	32%	41%	29%	51%
% of sites w/observed data	83%	91%	90%	80%	58%
Average SEER*	10.9	10.8	11.0	10.8	10.9

* Of observed data.

Table 4-22 shows the distribution of space cooling system types and duct locations by compliance group. The following observations can be made regarding space cooling system types and duct locations.

- The percentage of homes without air conditioning increases from non-compliant to high efficiency homes (from 3% to 40%, respectively). This is because homes in RMST Climate Zones 1 and 2 comprise most of the homes in the high efficiency group and they have the highest percentage of homes without space cooling.

Table 4-22: Space Cooling Equipment Types and Locations by Compliance Group

Analysis Parameter Description	Overall (575 Sites)	Non-Compliant (155 Sites)	Indeter-minate (152 Sites)	Compliant (196 Sites)	High Efficiency (72 Sites)
System Types					
Central Air Conditioner	87%	97%	93%	85%	60%
No Air Conditioner	13%	3%	7%	15%	40%
HVAC Location					
Attic	70%	80%	75%	68%	41%
Garage	9%	11%	14%	6%	3%
None	13%	3%	7%	15%	40%
Other	8%	6%	4%	11%	16%

4.9 Water Heating Equipment Analysis

Table 4-23 summarizes water heating system characteristics, including average system efficiencies and type of water heater by compliance group. Table 4-24 presents the distribution of sites by water heater fuel types, blanket/efficiency,[8] and compliance group.

Regarding water heating system efficiencies versus compliance groups, the following key findings are summarized.

- Statewide, 94% of the water heaters were higher performance, with little variance across compliance groups.
- Water heaters are, on average, 15% above the minimum energy factor (EF).[9]

[8] The relationship between the efficiency of a unit and whether a blanket was installed is important because, under the 1995 Residential Standards, credit for an external water heater blanket was given regardless of efficiency. This credit was dropped from the 1998 and 2001 Standards.

- The average percent above the minimum EF increases across compliance groups from 14.9% in the non-compliant group to 17.0% in the high efficiency group.

Table 4-23: Water Heating System Efficiencies by Compliance Group

Analysis Parameter Description	Overall (575 Sites)	Non-Compliant (155 Sites)	Indeter-minate (152 Sites)	Compliant (196 Sites)	High Efficiency (72 Sites)
Higher Performance	94%	94%	97%	93%	95%
Equal to Prescriptive	4%	5%	2%	7%	2%
Lower Performance	1%	2%	1%	1%	2%
Average Efficiency (% above Min. Energy Factor)	15.3%	14.9%	15.6%	14.9%	17.0%
% of sites w/actual data	81%	86%	82%	75%	83%
Average % above Standard	16.7%	16.3%	16.6%	16.6%	17.9%
% of sites w/RER default EFs[10]	14%	9%	15%	18%	14%
Average % above Standard	12.1%	7.7%	12.2%	13.2%	14.1%
% of sites w/CEC Standard water heater (=Min. Std EF)[11]	4%	5%	2%	7%	2%

Regarding water heater fuel types and blanket versus efficiency results by compliance groups, the following key findings are summarized.

- The high efficiency group has the largest percentage of water heaters with higher performance water heaters and external insulation blankets (24%), followed by the compliant group (17%).
- None of the homes surveyed had electric water heaters.

9 The averages listed here are for those sites where the efficiencies were collected.

10 Itron default efficiency values are higher than standard efficiency and were intended to represent typical construction practice. These values were developed from actual data and vary by tank size.

11 The CEC standard water heater is assumed when tank size and/or equipment type is not available.

Table 4-24: Water Heater Fuel Type and Blanket/Efficiency Level by Compliance Group

Analysis Parameter Description	Overall (575 Sites)	Non-Compliant (155 Sites)	Indeter-minate (152 Sites)	Compliant (196 Sites)	High Efficiency (72 Sites)
Gas/Propane Water Heater	100%	100%	100%	100%	100%
Electric Water Heater	0%	0%	0%	0%	0%
EF > Std. w/Blanket	14%	7%	14%	17%	24%
EF > Std. w/out Blanket	80%	87%	83%	75%	72%
EF = Std. w/Blanket	4%	3%	2%	6%	2%
EF = Std. w/out Blanket	1%	2%	0%	0%	0%
EF < Std. w/ Blanket	0%	0%	0%	0%	0%
EF < Std. w/out Blanket	1%	2%	1%	1%	2%

Housing Purchase Price

Table 4-25 compares compliance groups versus housing purchase price. Key findings are summarized below.

- The non-compliant and indeterminate groups have the highest percentage of homes that cost under $200,000 (both at 28%), while only 22% of homes in the high efficiency group cost under $200,000.
- The high efficiency group has the largest percentage of high-cost homes (over $800,000) at 21%.
- It is interesting to note that the average price of non-compliant homes is higher than that for indeterminate homes. However, this could be because some non-compliant homes are large custom homes with high glazing percentages.

Table 4-25: Housing Purchase Prices Versus Compliance Group

Analysis Parameter Description	Overall (575 Sites)	Non-Compliant (155 Sites)	Indeter-minate (152 Sites)	Compliant (196 Sites)	High Efficiency (72 Sites)
Under $100,000	16%	15%	18%	14%	22%
$100,000 - $200,000	8%	13%	10%	6%	0%
$200,000 - $400,000	32%	41%	45%	21%	12%
$400,000 - $600,000	20%	10%	11%	32%	29%
$600,000 - $800,000	14%	13%	10%	17%	16%
Over $800,000	9%	8%	5%	10%	21%
Average Home Price	$471,353	$414,789	$392,237	$513,048	$655,224

4.10 Summary of Compliance Results

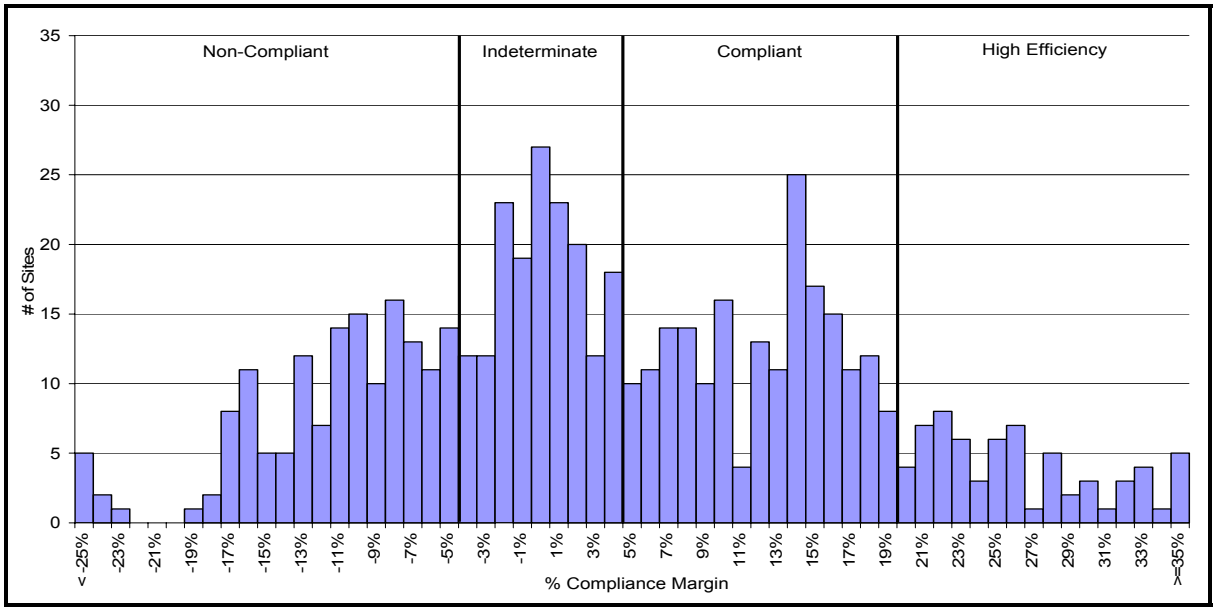
The following summarizes the key findings of this chapter. Results are organized into the following groups: statewide, regional (by RMST climate zone), and compliance groups.

General Compliance Results

A brief summary of the statewide compliance results follows.

- Approximately 27% of sites are in the non-compliant group.
- Approximately 13% of sites are in the high efficiency group.

Figure 4-10: MICROPAS Results Summary—All Sites



Regional Compliance Results

The following summarizes the compliance results by RMST climate zone. In addition, Table 4-3 shows the average % Compliance Margin for each RMST climate zone.

- ***RMST Climate Zone 1*** (North Coast) tends to be the most compliant with an average % Compliance Margin of approximately 19%. Of the sites in RMST Climate Zone 1, 93% fall in the compliant or high efficiency group, while approximately 8% are either indeterminate or non-compliant.
- ***RMST Climate Zone 2*** (South Coast) is the second most compliant of the RMST climate zones with an average % Compliance Margin of 16%. Only 1% of the sites fall in the non-compliant group and 6% fall in the indeterminate group.
- ***RMST Climate Zone 3*** (South Inland) tends to be compliant, as evidenced by an average % Compliance Margin of 9%. Approximately 17% of the sites fall in the high efficiency group, while 11% fall in the non-compliant group.
- ***RMST Climate Zone 4*** (Central Valley) tends to be non-compliant, which is evidenced by an average % Compliance Margin of -3%. In RMST Climate Zone 4, 42% of sites fall in the non-compliant group and 41% are indeterminate.
- ***RMST Climate Zone 5*** (Desert/Mountain) is the least compliant of the RMST climate zones with an average % Compliance Margin of -6%. In fact, 55% of sites fall in the non-compliant group and 28% are indeterminate. The main reason why RMST Climate Zones 4 and 5 are the least compliant can be directly attributed to the more stringent standards in these Climate Zones.

Table 4-26: Average Compliance Margins by RMST Climate Zone

	Overall	RMST CZ1	RMST CZ2	RMST CZ3	RMST CZ4	RMST CZ5
Average % Compliance Margin	3.8%	19.2%	16.0%	9.4%	-2.9%	-5.7%

Compliance Groups

The following is a summary of the compliance results by compliance groups.[12]

Non-Compliant

- **Large Glazing Percentages.** The average percent glazing for non-compliant sites is 17%, slightly larger than for other compliance categories. In addition, on average, the homes in this group have higher than prescriptive glazing percentages.
- **RMST Climate Zone 5** (Desert and Mountain) is the least compliant of the RMST climate zones based on the average % Compliance Margin of -6%. In fact, 55% of

[12] See Section 4.1 for a detailed discussion of the compliance groups.

sites in RMST Climate Zone 5 fall in the non-compliant group, compared to only 1% of RMST Climate Zone 2 and 3% of RMST Climate Zone 1.[13]

Compliant and High Efficiency

- **Smaller Glazing Percentages.** The average percent glazing for high efficiency and compliant sites is 15%, which is nearly 3% less than the average prescriptive value for these homes (18%).
- **RMST Climate Zone 1** (North Coast) is the most compliant of the RMST climate zones based on the average % Compliance Margin of 19%. In fact, 48% of sites in RMST Climate Zone 1 fall in the high efficiency group, as opposed to only 1% of RMST Climate Zone 4 and 3% of RMST Climate Zone 5.[14]

4.11 Differences in Compliance Performance between Homes Built in 2000 and 2003 by RMST Climate Zone

As shown in Table 4-27, the average % Compliance Margins for detached single family homes in some RMST climate zones changed significantly between 2000 and 2003.[15] While the average % Compliance Margins in RMST Climate Zones 1, 2, 3, and 5 increased, it decreased in RMST Climate Zone 4. Overall, the average % Compliance Margin for detached single family homes decreased from 6.2% to 3.8% for homes built between July 1999 to June 2000 (2000 homes) and those built between January 2003 to June 2003 (2003 homes). Is this change in average % Compliance Margin attributable to a change in building practices or to the change in the Standards? Did the detached single family homes built in 2003 have less efficient measures installed than the 2000 homes, or are the differences between the 2001 standards and the 1998 standards the cause?

Table 4-27: Average % Compliance Margin by Year and RMST Climate Zone

	Overall	RMST CZ1	RMST CZ2	RMST CZ3	RMST CZ4	RMST CZ5
Homes Built in 2000 –1998 Stds.	6.2%	11.4%	14.7%	6.1%	4.1%	-6.2%
Homes Built in 2003 –2001 Stds.	3.8%	19.2%	16.0%	9.4%	-2.9%	-5.7%
Difference	-2.4%	7.8%	1.3%	3.3%	-7.0%	0.5%

In studying the compliance results further, several other questions arise.

[13] See Section 3.5 for a summary of key characteristics by RMST climate zone.

[14] See Section 3.5 for a summary of key characteristics by RMST climate zone.

[15] A significance test was conducted at the 95% confidence level.

1) Why is RMST Climate Zone 1 the most compliant and why did its average % Compliance Margin increase significantly?
2) Why did the average % Compliance Margin RMST Climate Zone 2 increase?
3) Why did the average % Compliance Margins in RMST Climate Zone 3 increase when the 2001 Standards were supposedly more difficult to comply with in the inland areas?
4) Did the average % Compliance Margin in RMST Climate Zone 4 significantly decrease because of the 2001 Standards?
5) Why did the average % Compliance Margins in RMST Climate Zone 5 increase slightly when the 2001 Standards were supposedly more difficult to comply with in the inland areas?

To answer these questions accurately, it is not enough to simply look at the differences in the % Compliance Margins from the two reports. Remember that the 2000 homes were analyzed with MICROPAS 5.1, which uses the 1998 low-rise residential building standards. In comparison, the 2003 homes were analyzed with MICROPAS 6.5, which uses the 2001 low-rise residential building standards. Therefore, before attempting to compare the compliance results of the 2000 and 2003 homes, the compliance of the 2003 homes was analyzed using MICROPAS 5.1. These results were then used in two comparisons to clarify the differences in the results between them, by RMST climate zone.

- ***"Homes built in 2000: 1998 Standards" results vs. "Homes built in 2003: 1998 Standards" results.*** Comparing the % Compliance Margins between these sets of results makes it possible to analyze how the differences in building practices between the two project years affected the average % Compliance Margin.
- ***"Homes built in 2003: 1998 Standards" results vs. "Homes built in 2003: 2001 Standards" results.*** Comparing the % Compliance Margins between these sets of results makes it possible to analyze how the changes in the standards affected the average % Compliance Margin.

The results of these comparisons are discussed below, followed by a conclusion section that answers the questions posed above.

Changes in Building Characteristics Between 2000 and 2003

Table 4-28 presents the average % Compliance Margin for homes built in 2000 and those built in 2003 under the 1998 low-rise residential building standards. As shown, the average % Compliance Margin for homes built in 2003 is 14.6%, which is higher than the 6.2% average for homes built in 2000. The average % Compliance Margins in each RMST Climate Zone increased. These results imply that there were changes in average building

characteristics across RMST climate zones and that these changes increased the average compliance in each zone.

Table 4-28: Average % Compliance Margin by Year and RMST Climate Zone – 1998 Standards

	Overall	RMST CZ1	RMST CZ2	RMST CZ3	RMST CZ4	RMST CZ5
Homes Built in 2000: 1998 Stds.	6.2%	11.4%	14.7%	6.1%	4.1%	-6.2%
Homes Built in 2003: 1998 Stds.	14.6%	23.9%	17.6%	21.7%	8.8%	9.4%

As mentioned earlier, the type of glazing and the glazing percentage play a large role in determining the compliance of a home. A change in the average glazing percentage within a climate zone could result in a significant change in the average % Compliance Margin. Table 4-29 shows that the percentage of homes with low-E windows increased significantly between homes built in 2000 and those built in 2003. The increased penetration of low-E windows is a major reason behind the increases in the average % Compliance Margins shown in Table 4-28.

Table 4-29 also shows that the average glazing percentage in RMST Climate Zone 5 for homes built in 2000 was 18.5%, which is more than the prescriptive glazing percentage of 16%. However, the average for homes built in 2003 is 15.0%, slightly less than the prescriptive value. This decrease in the glazing percentage is one reason that 2003 homes in RMST Climate Zone 5 tend to be more compliant than the 2000 homes. Similarly, the average glazing percentage in RMST Climate Zone 3 decreased from 18.0% to 15.6%. This decrease is one reason for the significant increase in the average % compliance margin shown in Table 4-28.[16]

Also shown in Table 4-29 are the average HVAC and water heating efficiencies by RMST climate zone. Depending on the breakout of the standard energy budget, the efficiencies of the space heating and cooling equipment in a home can also have a large impact on compliance. As shown, the average SEER value in RMST Climate Zone 5 increased from 10.5 to 11.5, while the average AFUE in RMST Climate Zone 1 increased from 80.7 to 85.3. These increases in HVAC efficiencies played an important role in why the 2003 homes have higher % Compliance Margins, under the 1998 Standards than the 2000 homes. The efficiency of the water heater in a home can also affect compliance. As shown below, the average % above standard increased in every climate zone. While the increases range across climate zones, the statewide average increased from 15.6% to 16.7%.

[16] A significance test was conducted at the 95% confidence level.

As discussed in Distribution of Homes by Compliance Group and Number of Floors on page 4-9, the number of floors also influences compliance, with two-story homes being inherently more compliant. Table 4-29 shows that the average number of floors increased slightly. As a percentage, more two-story homes were built in 2003 than in 2000.

Table 4-29: Average Building Characteristics by Year and RMST Climate Zone

	Overall	RMST CZ1	RMST CZ2	RMST CZ3	RMST CZ4	RMST CZ5
Average Glazing %						
Homes Built in 2000	17.4%	18.0%	16.5%	18.0%	16.8%	18.5%
Homes Built in 2003	15.7%	17.6%	16.3%	15.6%	15.4%	15.0%
% of Homes w/ Low-E Windows						
Homes Built in 2000	10%	8%	0%	1%	21%	0%
Homes Built in 2003	83%	70%	59%	72%	94%	95%
Average SEER						
Homes Built in 2000	10.6	10.5	10.2	10.2	10.9	10.5
Homes Built in 2003	10.9	10.5	10.3	10.5	10.9	11.5
Average AFUE						
Homes Built in 2000	80.5	80.7	80.1	80.1	80.8	80.5
Homes Built in 2003	81.4	85.3	82.0	80.0	81.4	80.8
Average Water Heating (% Above Std)						
Homes Built in 2000	15.6%	14.4%	15.5%	16.0%	16.0%	15.8%
Homes Built in 2003	16.7%	18.1%	17.1%	16.5%	16.4%	16.5%
Average # of Stories						
Homes Built in 2000	1.5	1.7	1.9	1.7	1.4	1.2
Homes Built in 2003	1.7	2.0	2.0	1.8	1.6	1.5

Changes in Building Standards Between 1998 and 2001

According to the above analysis, on average, homes have become more efficient over the last few years. However, since the 2001 Standards are more stringent in some climate zones, homes built in 2003 are not as compliant as shown in Table 4-28.

Background on 2001 Standards

In response to what the State of California described as "growth trends in electricity peak demand that have strained the adequacy and reliability of California's electricity system," the

State passed Assembly Bill 970 (AB 970) in September 2000.[17] Among other things, AB 970 directed the CEC to "adopt and implement updated and cost-effective standards…to ensure the maximum feasible reductions in wasteful, uneconomic, inefficient, or unnecessary consumption of electricity." The CEC considered amendments to the Standards that could be "quickly analyzed and justified, and which would have a clear and significant impact on peak energy demand." Subsequently, the AB 970 Standards were developed and adopted in January 2001. *Under these Standards, statewide annual source energy savings are estimated at 14% from the 1998 Standards, which includes a 39% or 155 MW reduction in cooling energy use on a statewide basis.*[18]

The major change to the Standards is that radiant barriers,[19] low solar heat gain fenestration,[20] duct sealing,[21] and TXV valves[22] for air conditioners (certified by a Home Energy Rating System (HERS) provider/rater) are now part of prescriptive component of the Standards for some climate zones. These added features also affected the performance calculations and made it much tougher to achieve compliance in several climate zones.

Differences in Average % Compliance Margins

Table 4-30 shows that homes built in 2003 have a lower average % Compliance Margin using the 2001 standards than they do using the 1998 standards. This is most apparent in RMST Climate Zones 3, 4, and 5 (inland regions) where the average % Compliance Margin decreased at least 10%. What changes in the standards caused these RMST climate zones to have a much lower average % Compliance Margin under the 2001 standards than the 1998 standards, while RMST Climate Zones 1 and 2 have only a slightly lower average % Compliance Margin? The following discussion is broken out by end-use—water heating, space cooling, and space heating—in an attempt to answer these questions.

17 CEC 2000.

18 CEC 2000.

19 A radiant barrier is a reflective foil or metal-coated surface usually placed on or against the underside of a roof.

20 Low solar heat gain fenestration products are typified by a dual-paned, vinyl-framed window with low solar/low emissivity (spectrally selective) glass.

21 Duct sealing involves actively testing and sealing a duct system with a "duct blaster" or equivalent apparatus.

22 Air conditioning system performance is dependent on proper refrigerant charge and airflow across the coil. TXVs mitigate the problems of improper refrigerant charge and airflow by making the system operate at its rated efficiency.

Table 4-30: Average % Compliance Margin by RMST Climate Zone – Homes Built in 2003

	Overall	RMST CZ1	RMST CZ2	RMST CZ3	RMST CZ4	RMST CZ5
Homes Built in 2003 –1998 Stds.	14.6%	23.9%	17.6%	21.7%	8.8%	9.4%
Homes Built in 2003 –2001 Stds.	3.8%	19.2%	16.0%	9.4%	-2.9%	-5.7%

Water Heating

There were no changes in how the water heating budgets are calculated between the 1998 and 2001 Standards. As shown in Table 4-31, the average water heating margins are the same when comparing the water heating results for 2003 homes analyzed under both the 1998 and 2001 Standards.

Table 4-31: Average Annual Water Heating Intensity (kBtuh/ft^2 per year) by RMST Climate Zone – Homes Built in 2003

Analysis Parameter Description	RMST CZ1	RMST CZ2	RMST CZ3	RMST CZ4	RMST CZ5
Homes Built in 2003 –1998 Stds.					
Average Standard Budget	11.79	10.60	11.33	11.96	11.80
Average Proposed Budget	10.04	9.52	10.12	10.46	10.30
Average Margin	1.75	1.08	1.21	1.50	1.50
Homes Built in 2003 –2001 Stds.					
Average Standard Budget	11.79	10.60	11.33	11.96	11.80
Average Proposed Budget	10.04	9.52	10.12	10.46	10.30
Average Margin	1.75	1.08	1.21	1.50	1.50
Differences					
Standard Budget	0.00	0.00	0.00	0.00	0.00
Proposed Budget	0.00	0.00	0.00	0.00	0.00
Margin	0.00	0.00	0.00	0.00	0.00

Space Heating and Space Cooling

While there were no changes in domestic hot water heating between the 1998 and 2001 Standards, the space heating and cooling requirements changed. In some climate zones, the

changes were drastic. As mentioned above, the main purpose of the changes were to reduce peak load, which in residential homes primarily comes from space cooling.

Table 4-32 shows that the changes in the Standards resulted in smaller space cooling Standard budgets in RMST Climate Zones 1, 3, 4, and 5. A reduction in the Standard budget signifies that the "allowed" energy usage for cooling has decreased. On the other hand, the proposed space cooling budgets have increased in every RMST climate zone. This increase reveals that the 2001 Standards, due to the changes in calculations mentioned above, now estimate that the same proposed home uses more energy for space cooling. The combination of these changes results in the space cooling margin decreasing, therefore making the home less compliant or non-compliant. (For example, on average, the homes built in 2003 in RMST Climate 5 would have easily complied under the 1998 Standards with a positive cooling margin of approximately 3 kBtu/ft^2 per year. However, those same homes, on average, do not comply under the 2001 Standards with a negative cooling margin (-3.73 kBtu/ft^2 per year).)

Table 4-32: Average Annual Space Cooling Intensity (kBtuh/ft^2 per year) by RMST Climate Zone – Homes Built in 2003

Analysis Parameter Description	RMST CZ1	RMST CZ2	RMST CZ3	RMST CZ4	RMST CZ5
Homes Built in 2003 –1998 Stds.					
Average Standard Budget	4.39	3.01	8.06	8.99	16.20
Average Proposed Budget	2.59	1.04	5.21	7.68	13.16
Average Margin	1.80	1.97	2.85	1.31	3.03
Homes Built in 2003 –2001 Stds.					
Average Standard Budget	2.99	3.09	5.77	6.58	13.50
Average Proposed Budget	3.04	1.22	6.65	9.76	17.23
Average Margin	-0.05	1.87	-0.88	-3.18	-3.73
Differences					
Standard Budget	-1.40	0.08	-2.29	-2.41	-2.70
Proposed Budget	0.45	0.18	1.44	2.08	4.07
Margin	-1.85	-0.10	-3.73	-4.49	-6.76

Table 4-32 presents the average standard and proposed space heating budgets for homes built in 2003 under both the 1998 and 2001 Standards. The average space heating standard and proposed budgets increased in each of the RMST climate zones. These changes resulted in

the average space heating margins decreasing in each climate zone. However, since the decreases in space heating margins are relatively small, it does not affect the overall compliance as much as the decrease in the space cooling margins.

Table 4-33: Average Annual Space Heating Intensity (kBtuh/ft^2 per year) by RMST Climate Zone – Homes Built in 2003

Analysis Parameter Description	RMST CZ1	RMST CZ2	RMST CZ3	RMST CZ4	RMST CZ5
Homes Built in 2003 –1998 Stds.					
Average Standard Budget	18.07	4.77	7.23	18.85	19.72
Average Proposed Budget	13.75	4.56	5.47	18.14	19.82
Average Margin	4.32	0.21	1.76	0.71	-0.10
Homes Built in 2003 –2001 Stds.					
Average Standard Budget	17.48	4.46	7.19	18.59	19.25
Average Proposed Budget	13.44	4.44	5.43	18.04	19.69
Average Margin	4.04	0.02	1.76	0.55	-0.44
Differences					
Standard Budget	-0.59	-0.31	-0.04	-0.26	-0.47
Proposed Budget	-0.31	-0.12	-0.04	-0.10	-0.13
Margin	-0.28	-0.19	0.00	-0.16	-0.34

Conclusions: Combining the Impacts of Changes in Building Charactersitics and Changes in Building Standards

As shown above, both building practices and changes to the standards were responsible for the changes in the average % Compliance Margins across RMST climate zones. In some RMST climate zones, the changes to the standards were primarily responsible for the significant decrease in the average % Compliance Margin. However, changes in construction practices, in most cases, did help the homes achieve higher % Compliance Margin than they otherwise would have. Below are possible answers to the RMST climate zone specific questions posed above.

1) Why is RMST Climate Zone 1 the most compliant and why did its average % Compliance Margin increase significantly?
   - The average AFUE value increased from 80.7% to 85.3% and the average water heater efficiency increased from 14% to 18% above standard. In addition, the percentage of homes with low-E windows increased from 8% to

70%. In turn, the average % Compliance Margin increased from 11.4% to 23.9%.

- Changes in the space cooling calculations used under the 2001 Standards caused the average cooling margin to decrease, thereby lowering the average % Compliance Margin slightly (23.9% to 19.2%).
- Changes in construction practices, specifically the increased penetration of low-E windows and higher efficiency furnaces and water heaters, explain the significant increase in the average % Compliance Margin (from 11.4% to 19.2%) and the reason that RMST Climate Zone 1 is the most compliant RMST climate zone.[23]

2) Why did the average % Compliance Margin RMST Climate Zone 2 increase?
   - The only significant change in building practices in RMST Climate Zone 2 is the increased saturation of low-E windows (0% to 59%), which caused the average % Compliance Margin to increase from 14.7% to 17.6%.
   - Changes in the space heating and cooling calculations used under the 2001 Standards caused the average cooling margin to decrease, thereby decreasing the average % Compliance Margin slightly (17.6% to 16.0%).
   - The average % Compliance Margin in RMST Climate Zone 2 did not change much. While the change in construction practices caused the average in increase, the changes in the Standards caused it to decrease slightly, resulting in a small increase from 14.7% to 16.0%.[24]

3) Why did the average % Compliance Margins in RMST Climate Zone 3 increase when the 2001 Standards were supposedly more difficult to comply with in the inland areas?
   - The percentage of homes with low-E windows increased from 1% to 72%, while the average glazing percentage decreased from 18.0% to 15.6%. In turn, the average % Compliance Margin increased from 6.1% to 21.7%.
   - Changes in the space cooling calculations used under the 2001 Standards caused the average cooling margin to decrease considerably. Since RMST Climate Zone 3 is warmer than RMST Climate Zones 1 and 2, changes to the cooling budgets are more pronounced, thereby decreasing the average % Compliance Margin significantly (21.7% to 9.4%).
   - The effect of increased penetration of low-E windows and the decrease in the average glazing percentage outweigh the effect of the more stringent Standards causing the average % Compliance Margin to increase slightly from 6.1% to 9.4%.

[23] Please see the section below for a more detailed look at why the coastal homes are so compliant.

[24] Please see the section below for a more detailed look at why the coastal homes are so compliant.

4) Did the average % Compliance Margin in RMST Climate Zone 4 significantly decrease because of the 2001 Standards?
   - The percentage of homes with low-E windows increased from 21% to 94%, while the average glazing percentage decreased slightly from 16.8% to 15.4%. In turn, the average % Compliance Margin increased from 4.1% to 8.8%.
   - Similar to RMST Climate Zone 3, the space cooling and space heating Standard budgets decreased due to the changes in the Standards which caused the average % Compliance Margin to decrease from 8.8% to -2.9%.
   - The more stringent Standards caused the average % Compliance Margin to decrease nearly 12%. This overshadows the small increase in compliance obtained from the higher penetration of low-E windows. The net effect is a decrease in the average % Compliance Margin (from 4.1% to -2.9%).

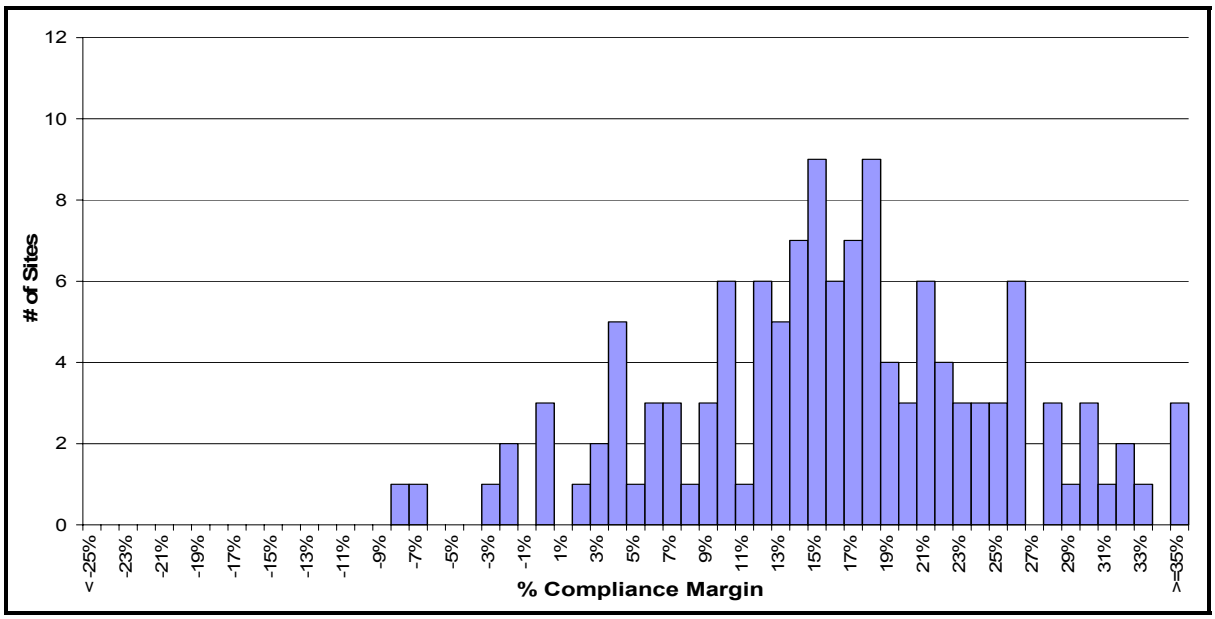
5) Why did the average % Compliance Margins in RMST Climate Zone 5 increase slightly when the 2001 Standards were supposedly more difficult to comply with in the inland areas?
   - The percentage of homes with low-E windows increased from 0% to 95%, while the average glazing percentage decreased from 18.5% to 15.0%. The average SEER also increased from 10.5 to 11.5. These changes in construction practices caused the average % Compliance Margin to increase from -6.2% to 9.4%.
   - Similar to RMST Climate Zone 3, the space cooling standard budget decreased and the proposed budget increased due to the changes in the Standards. Therefore, the average % Compliance Margin decreased from 9.4% to -5.7%.
   - Changes in construction practices found in the homes surveyed were enough, on average, to keep up with changes in the Standards. While the homes RMST Climate Zone 5 are still, on average, non-compliant, they are more compliant than the previous homes surveyed (-6.2% vs. -5.7%).

4.12 Why are Coastal Homes so Compliant?

As shown above, homes in RMST Climate Zones 1 and 2 (CEC Climate Zones 1–7) are, on average, overly compliant. In fact, of the homes surveyed along the coast, approximately 58% would have qualified for the California ENERGY STAR New Homes Program.[25] This may seem surprising, however as predicted in previous reports, the 2001 Standards did not make it much, if any, harder to comply along the coast. Instead, since the new Standards were focused on reducing peak demand, typically air conditioner loads, homes in the inland regions have found it much tougher to comply.

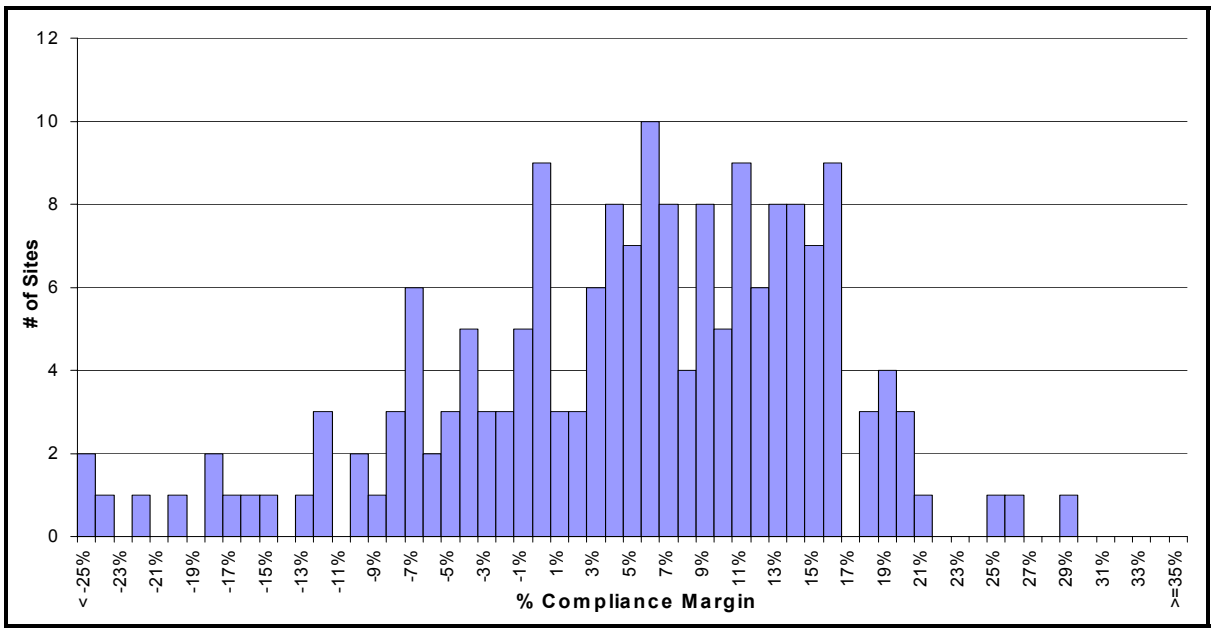
[25] Approximately 58% of homes surveyed in RMST Climate Zones 1 and 2 have compliance margins equal to or greater than 15%, the California ENERGY STAR New Homes requirement. However, when putting the error band around the 15%, at least 34% of the homes would have qualified.

Figure 4-11: Homes Built in 2003, Compared to 2001 Standards – RMST Climate Zones 1 and 2 (134 Homes)



In the 2001-2002 RNC Study, homes built under the 1998 Standards were analyzed under both the 1998 and 2001 Standards. Results showed that these homes had an average compliance margin of approximately 12% when analyzed under the 1998 Standards and approximately 6% when analyzed under the 2001 Standards. While these results show that the 2001 Standards did become somewhat more stringent along the coast, the average home built in 2000 would have complied with the new Standards without changing any building practices.

Figure 4-12: Homes Built in 2000, Compared to 2001 Standards – RMST Climate Zones 1 and 2 (179 Homes)



However, average building practices along the coast did change between 2000 and 2003. The most dramatic change in the average building characteristics of coastal homes was the saturation of low-E windows. Over the last few years, builders across the state have started installing more low-E windows. During the interviews with builders, two reasons for this were discovered: 1) the incremental cost of low-E windows compared to clear glass windows has gone down, and 2) since builders need to install low-E windows in some inland areas in order to comply, they install the same windows in their coastal homes as well. Other changes in building characteristics in RMST Climate Zone 1 include the average AFUE increasing from 81% to 85%, and the saturation of radiant barriers increasing from 0% to 14%. These changes in building practices have resulted in the average % compliance margin being even higher.

Another possible reason for coastal homes being overly compliant could be due to the California ENERGY STAR Program. Builders who were program participants for other projects built many of the nonparticipant homes surveyed. Some builders might not have been able to have more projects participate because the program was so successful that Program Year (PY) 2002 funds ran out before the end of the year. Therefore, there could have been a spillover effect. Also, interviews have shown that being a program participant changes building practices for homes that did not qualify for the program. In the evaluation of the PY 2002 program, approximately two-thirds of builders said that they had changed construction practices as a result of participating in the program.

5

Builder Survey Results

5.1 Overview

As part of the 2003 PG&E Residential New Construction (RNC) Study, Itron conducted telephone surveys with 77 builders throughout California. The objective was to gain an understanding of the building and compliance practices of new home builders as they relate to the current 2001 Title 24 energy efficiency standards (Standards).[1,2] The survey obtained insight into the impact of the 2001 Standards in terms of 1) the incidence of various high efficiency measures specified in order to comply with the 2001 Standards, 2) the level of effort required to comply with the Standards compared to the 1998 Standards, and 3) changes in specification and design practices that are attributable to the 2001 Standards. These interviews helped to explain the differences seen in construction practices between the homes surveyed in 2000 (built under the 1998 Standards) and those surveyed in 2003 (built under the 2001 Standards).

Builders were also questioned about their knowledge of and participation in the California ENERGY STAR® New Homes program and differences in the design and construction of ENERGY STAR homes relative to non-ENERGY STAR homes.[3]

In addition to the telephone surveys, Itron conducted in-depth interviews with three "high-volume" builders of ENERGY STAR homes. This interview guide contained a subset of key questions from the telephone survey, enabling interviewers to concentrate on specification and design practices. Since the focus and structure of these in-depth interviews was quite different from the telephone survey, results from these interviews are reported separately throughout this report.

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1 California Energy Commission. *2001 Energy Efficiency Standards for Residential and Nonresidential Buildings*. August 2001.

2 The 2001 Standards were developed pursuant to California State Assembly Bill 970 (AB 970), enacted on September 6, 2000.

3 The results of these surveys were also used for the California ENERGY STAR New Homes Program Evaluation, which can be found in *Evaluation, Measurement and Verification of the 2002 California Statewide energy star New Homes Program -- Phase 1 Report. RLW Analytics. 2004*

This section includes the following subsections:

- General Builders Information,
- Construction and Compliance Practices of New Single Family Homes,
- General Specification Practices for ENERGY STAR New Homes Program, and
- Conclusions and Program Implications.

5.2 General Builder Information

Itron developed a contact database from 1) Itron's internal builder databases, 2) referrals from program managers, and 3) investor-owned utility (IOU) program databases.[4] The combination of these three sources yielded 2,138 contacts for 733 companies.

Seventy-seven builders of residential new construction throughout California were surveyed. These 77 completed surveys resulted after contacting builders over roughly a six-week period. The characteristics of the respondents and the companies they represent are summarized below.

Respondent Responsibilities

The nature of the survey, which included questions about the measures installed in homes that affect energy use and questions about the builders' participation in the California ENERGY STAR New Homes program, required that the respondent have the following qualifications:[5]

- Familiarity with the characteristics of the equipment installed in single family new homes,
- Responsibility for decisions about design features of new homes that affect Title 24 compliance (i.e., design of building shell, HVAC system, and water heating system),
- Responsibility for decisions about the selection and procurement of energy-using equipment for new homes, and
- The primary contact with respect to energy efficiency programs.

Forty percent of the respondents are Directors/Vice Presidents/Managers of Purchasing who oversee the procurement of equipment and materials for their company's housing developments. All other respondents have managerial status as a General Manager/Project Manager (14%), in the Construction (13%), Operations (7%), or the Development (3%)

[4] RLW, Inc. provided Itron with contact for program participants derived from IOU program records.

[5] Even though the majority of respondents were able to complete all sections of the survey, more than one respondent was required for a few builders.

departments. About 10% of the respondents were the company President, Owner, Chief Executive Officer, or Executive Director.

Design and Development Team

In addition to the respondents themselves, other individuals typically participate in the design and equipment specification for new homes. Interestingly, 45% of the respondents reported that a representative of their company's sales and marketing department participates in the design and specification decision process. One quarter of the respondents indicated that an architect is on the design team and about one-fifth of the companies have a member of the construction or development department participate in design decisions. Surprisingly, only about 10% indicated that a Title 24 or Energy Consultant is a member of the design team. Instead, the Title 24 consultant reviews the building plans and provides recommendations *after* the building plans and specifications have been developed.

Most builders (96%) use an outside consultant to conduct the Title 24 compliance analysis. The surveys and in-depth interviews conducted for this study confirm that a small number of firms conduct most of the compliance analyses for builders throughout the state.

Number and Location of Homes Built

The 77 builders who participated in the survey built 20,277 new single family homes statewide in 2002. On average, 97% of the homes built by the respondents in 2002 were detached single family. (Because the focus of this study is single family new construction, all builders who reported less than 20% of their homes as single family were removed from the analysis.) On average, 82% of the homes built by respondents were production homes.

Table 5-1 presents the regional distribution of homes built by survey respondents and the total single family new housing starts. Statewide, the builders surveyed represent 19% of all single family new homes built in California in 2002. The survey is fairly representative of the regional distribution of new homes, with the exception of the Mountain region. Just over 42% of homes built by the surveyed builders are located in the Central Valley region (CEC Climate Zones 8-10). The North Coast and South Inland regions each account for about one-fifth of the homes. According to the actual new housing starts in 2002, the Central Valley region has the highest rates of single family development in the state.

Table 5-1: Geographic Distribution of Homes Built in 2002

Region (CEC Climate Zones)	Builders	By Surveyed Builders		Total New Housing Starts	
		Single Family Homes[1]	*Percent*	Single Family Homes[2]	*Percent*
North Coastal (1 - 5)	21	3,845	*(19%)*	20,041	*(18%)*
South Coastal (6 - 7)	17	2,411	*(12%)*	11,180	*(10%)*
South Inland (8 - 10)	28	4,616	*(23%)*	24,027	*(22%)*
Central Valley (11 - 13)	31	8,665	*(43%)*	43,666	*(40%)*
Desert (14-15)	9	739	*(4%)*	7,113	*(7%)*
Mountain (16)	0	-	*(0%)*	2,442	*(2%)*
Total	**77**	**20,277**	***(19%)***	**108,468**	

1 Self-reports of survey respondents.
2 Construction Industry Research Board

Thirty of the 77 builders indicated they built homes in 2002 that qualified for the ENERGY STAR program; for this report, we consider these thirty builders to be "participants." The results presented below are segmented by program participants and nonparticipants to reveal differences in practices that might be attributable to the California ENERGY STAR New Homes program.

5.3 Construction and Compliance Practices – New Single Family Homes

The basic premise of this study is to support the development of a baseline characterization of single family new construction built under the 2001 Standards. Survey respondents were asked a series of questions to achieve this objective. Respondents were first asked, in an open-ended format, to describe their company's typical compliance strategy to make sure their homes meet the Title 24 requirements. Responses provided insight into each builder's overall strategies for ensuring that homes comply with Title 24 and their general perspectives with respect to the Standards. Respondents were then asked to provide detailed information regarding the efficiency rating of equipment and shell measures specified for the homes they built in 2002.

This section presents the following results:

- General Title 24 compliance strategies,
- The incidence of high efficiency measures in single family new homes, and
- Characteristics of specified versus installed equipment.

If relevant, differences between program participants and nonparticipants and differences between homes built across geographic regions are noted.

General Title 24 Compliance Strategies

Builders provided a broad range of responses when asked, *"What is your company's typical strategy to make sure your homes comply with the Title 24 Standards?"* Some builders responded by listing the high efficiency measures they used to comply, while others answered by explaining the "bigger picture" of how they deal with the Standards, including following the recommendations of their Title 24 consultant and changes in their strategies based on the climate.

Specific Measures

Table 5-2 summarizes the number of builders who mentioned specific measures and other general comments with respect to meeting the Standards. As shown, high performance windows (low-E glass and/or vinyl-framed) were the most common measure mentioned. According to some builders, installing higher efficiency windows in coastal regions is typically the only high efficiency measure needed for compliance. Several builders also mentioned upgrading insulation and central air conditioners. Measures requiring third party inspection were the least mentioned.

Table 5-2: Builder Compliance Strategies

Specific Measures	Number of Builders Mentioned
Windows, low-E glass	16
High efficiency HVAC	11
Upgrade insulation	7
Duct sealing/testing	3
TXV	2
Radiant barrier	2
ACCA manual D duct design	1
Other Comments	
Follows consultant recommendations	35
Always exceed standards	7
Do what is necessary to meet standards	6
Meet other program requirements	4
Use the same measures consistently	2
Meet ENERGY STAR program requirements	1

Compliance Strategies

Many respondents explained that they follow the recommendations of their Title 24 consultant to ensure that their homes comply with the Standards. Title 24 consultants typically review building plans and prepare a set of recommendations for meeting the Standards. One builder explained that they ask their consultant to prepare three sets of alternative recommendations for compliance. The builder can then choose the strategy that is most cost-effective and accommodates other design characteristics.

Forty percent of the builders indicated their overall strategies varied by project and 28% indicated their compliance strategy varied across different geographic regions. Builders attributed differences between projects to varying budgets, subcontractors, and homebuyer preferences. According to respondents, compliance strategies vary by climate zone due to temperature and geographic differentials. For example, one builder explained:

> *"In certain climate zones there may be a higher requirement for cooling, so we will improve the shell."*

During the in-depth interviews, the "high volume" builders of ENERGY STAR homes explained that they choose the efficiency of the equipment and type of windows based on the package of measures that makes the least complying model meet code. In a tract development, for example, the Title 24 consultant determines which measures need to be installed for the model that is most difficult to make comply. Those measures are then installed in each model, even if it causes some homes to exceed the minimum requirements. These builders emphasized that this was their strategy whether building "standard" homes or ENERGY STAR homes.

Other general responses from two large builders relating to their compliance strategies include the following:

> *"We have our own in-house energy program which goes above Title 24 and the California ENERGY STAR program. We upgrade all HVAC equipment above Title 24, perform duct blaster tests, and install low-E windows."*
>
> *"We don't necessarily use one specific set of measures in all our homes; we use the most cost-effective way to comply…we usually look at upgraded insulation or SEER. Then we consider TXV valves, then radiant barriers, then tested ducts. We're pretty much assuming low-E as standard these days …"*

Incidence of High Efficiency Measures in Single Family New Homes

To assess the incidence of various high efficiency measures in low-rise residential new construction, survey respondents were asked to provide average efficiency ratings and design characteristics of HVAC equipment, the duct system, and building shell measures of the homes their company built in 2002. This section summarizes these results by measure.

Furnaces

Table 5-3 provides the average AFUE of furnaces specified in single family new homes in 2002 by region. The statewide average AFUE rating was 81.7%.[6] The average efficiency of furnaces in homes built by participants of the ENERGY STAR New Homes program is slightly higher (82.2%) than those built by nonparticipants (81.2%), though the difference is not significant. The Desert region has the highest average AFUE rating for both participants and nonparticipants.

Table 5-4 presents the average percent of homes that have furnaces with an AFUE equal to 80%, greater than 80% and less than 90%, and greater than 90%, as reported by the builders surveyed. Statewide, 78% of the new homes in 2002 had furnaces with an AFUE equal to 80%. Surprisingly, just over 7% of homes built by nonparticipants had furnaces with an AFUE rating greater than 90%, while only 1.9% of the homes built by participants included these high efficiency units. However, given that the average AFUE of participants is greater than or equal to that of nonparticipants in every region shown in Table 5-3, nonparticipant respondents must be building more homes in the North Coastal and Desert regions than the participant respondents, thereby increasing their overall percentages.

[6] This finding is higher than the average AFUE of 80.4% reported in the 2001 RNC study (page 3-23).

Table 5-3: Average Furnace AFUE Ratings

Region	Average AFUE[1]		
	All	**Participants**	**Nonparticipants**
Statewide	81.7 *(0.48)* (n=61)	82.2 *(0.83)* (n=26)	81.2 *(0.56)* (n=35)
North Coastal	82.1 *(1.10)* (n=15)	82.5 *(1.74)* (n=7)	81.6 *(1.46)* (n=8)
South Coastal[2]	82.6 *(1.31)* (n=13)	83.9 *(1.78)* (n=9)	80.0 *(0.00)* (n=4)
South Inland	81.7 *(0.80)* (n=20)	82.6 *(1.65)* (n=8)	81.0 *(0.71)* (n=12)
Central Valley	81.2 *(0.65)* (n=28)	81.2 *(1.04)* (n=11)	81.2 *(0.86)* (n=17)
Desert	86.4 *(2.40)* (n=5)	86.7a *(3.31)* (n=3)	85.7 *(4.96)* (n=2)

1 Average AFUE are weighted means. Weighted standard errors are in parentheses.
2 The difference between the average furnace AFUE ratings of participants and nonparticipants is significant at the 95% level only in the South Coastal region.

Table 5-4: Distribution of Furnace Efficiency Ratings

AFUE	Average Percent of Homes[1,2]		
	All (n=62)	**Participants** (n=26)	**Nonparticipants** (n=36)
= 80%	78.0%	78.1%	78.0%
> 80% and ≤ 90%	17.1%	20.0%	14.7%
> 90%	4.9%	1.9%	7.3%

1 Average percentages are weighted means. Weighted standard errors are in parentheses.
2 The difference between participants and nonparticipants is not significant for any AFUE category.

Fifteen percent of the respondents reported that the AFUE ratings of furnaces varied across climate zones. Most of these builders indicated an overall average AFUE of 80% and indicated that only a small percentage of their homes exceeded this standard. Higher efficiency furnaces were specified for particular projects located in climate zones with higher heating demand. One builder particularly mentioned specifying higher efficiency furnaces in the North Coast region.

Central Air Conditioners

Table 5-5 and Table 5-6 present the average SEER rating for air conditioners and the distribution of central air conditioners by SEER rating, respectively. Statewide, the average SEER rating specified for single family new homes in 2002 was 10.7.[7] On average, air conditioners specified for homes built by program participants is higher (11.1) than those specified for homes built by nonparticipants (10.5). With the exception of the Central Valley region, results are consistent at the regional level.

Table 5-5: Average Central Air Conditioner SEER Ratings

Region	Average SEER[1]		
	All	Participants	Nonparticipants
Statewide[2]	10.7 *(0.12)* (n=71)	11.1 *(0.24)* (n=28)	10.5 *(0.11)* (n=43)
North Coastal[2]	10.8 *(0.23)* (n=17)	11.5 *(0.34)* (n=8)	10.3 *(0.17)* (n=9)
South Coastal	10.5 *(0.28)* (n=14)	10.9 *(0.43)* (n=9)	10.1 *(0.25)* (n=5)
South Inland[2]	10.8 *(0.26)* (n=27)	11.6 *(0.50)* (n=11)	10.2 *(0.17)* (n=16)
Central Valley	10.6 *(0.14)* (n=30)	10.6 *(0.27)* (n=11)	10.7 *(0.16)* (n=19)
Desert	11.9 *(0.34)* (n=9)	12.1 *(0.54)* (n=5)	11.7 *(0.41)* (n=4)

1 Average SEER values are weighted means. Weighted standard errors are in parentheses.
2 The difference between the average SEER of participants and nonparticipants is significant at the 95% level.

7 The statewide average SEER reported in the 2001 RNC study was 10.53 (page 3-27).

As shown in Table 5-6, about 65% of new single family homes have central air conditioners with a SEER of 10.0 to 10.9. Nonparticipants specified central air conditioners with a SEER of 10.0 to 10.9 in 74.7% of their new single family homes, while participants specified central air conditioners with a SEER of 10.0 to 10.9 in 52.7% of their new single family homes. Moreover, participants specified units of 12.0 SEER or higher for nearly half of their homes while nonparticipants specified high efficiency units for only about 25% of their homes. About two-thirds (63%) of the builders reported that SEER ratings varied across climate zones. The two largest of these builders specify 13 SEER units in the Central Valley and 10 SEER units in areas with less cooling demand.

Table 5-6: Distribution of Central Air Conditioner Efficiency Ratings

SEER	Average Percent of Homes[1,2]		
	All (n=69)	Participants (n=27)	Nonparticipants (n=42)
10.0 - 10.9	65.5%	52.7%	74.7%
11.0 - 11.9	0.8%	1.9%	0.0%
12.0 - 12.9	28.7%	36.0%	23.5%
13.0 - 13.9	1.1%	1.8%	0.6%
14.0+	3.9%	7.6%	1.2%

1 Average percentages are weighted means. Weighted standard errors are in parentheses.
2 The differences between participants and nonparticipants are not significant for all SEER categories.

Duct Testing

About 75% of builders statewide reported testing ducts of the single family homes they built in 2002. Table 5-7 and Table 5-8 summarize builder practices with respect to duct system testing. Statewide, builders reported testing an average of 52% of the homes they built in 2002. Seventy percent of the homes built by builders participating in the ENERGY STAR New Homes program had their duct system leakage tested, while 36% of the homes built by nonparticipants have been tested. At the regional level, the incidence of duct testing is highest in the Desert region (84%) and lowest in the Central Valley region (44%).

Most respondents began duct testing after January of 2000. About one-third of the builders began testing in 2000, 37% began in 2001, and 16% began in 2002. A small percentage began testing in the first half of 2003. Table 5-8 summarizes reasons for duct testing. Approximately two-thirds of the respondents cited Title 24 compliance or program requirements as their primary reason to begin duct testing, while about one-third of the builders test ducts to ensure they build better quality homes.

Table 5-7: Average Percent of Homes Tested

Region	Average Percent of Homes[1,2]		
	All	Participants	Nonparticipants
Statewide	52.0% *(.0474)* (n=74)	69.5% *(.0622)* (n=29)	36.3% *(.0607)* (n=45)
North Coastal	67.0% *(.0871)* (n=21)	91.0% *(.0898)* (n=9)	30.7% *(.0766)* (n=12)
South Coastal	48.6% *(.1114)* (n=17)	75.3% *(.1096)* (n=11)	3.1 % *(.0261)* (n=6)
South Inland	50.5% *(.0814)* (n=27)	64.0% *(.0899)* (n=11)	40.8% *(.1199)* (n=16)
Central Valley	43.8% *(.0695)* (n=29)	52.3% *(.0974)* (n=10)	38.6% *(.0940)* (n=19)
Desert	84.0% *(.1105)* (n=9)	82.9% *(.1394)* (n=5)	85.5% *(.2031)* (n=4)

1 Average percentages are weighted means. Weighted standard errors are in parentheses.
2 The differences between participants and nonparticipants are not significant in any region.

Table 5-8: Reasons for Duct Testing

"What prompted you to begin duct testing?"	% of Builders (n=50)
Credit for Title 24 Compliance	46.3%
Desire to build better quality homes	35.5%
Fulfill program requirement	18.6%
Do not know	3.4%
Avoid litigation	2.4%
Marketing advantage	0.4%

* Builders were allowed to provide more than one answer, therefore the percentages add up to more than 100%.

Duct Insulation

Table 5-9 shows the percentage of builders who specify duct insulation of various R-values. As shown, R-4.2 is most prevalent statewide, particularly by nonparticipants, while R-6.0 is specified by 23% of the builders. According to respondents, R-8.0 duct insulation is rarely specified because it is difficult to fit into the duct cavity.[8] Builders that upgrade duct insulation explained that R-6.0 is more practical. Table 5-9 also reveals that participant builders of homes in northern regions are slightly more likely to specify R-6 duct insulation than participant builders of homes in the southern regions of the state.

Table 5-9: Duct Insulation R-values

R-value	Percent of Builders Installing[1]		
	All	Participants	Nonparticipants
Statewide	(n=39)	(n=18)	(n=21)
R-4.2	76.8%	49.3%	99.0%
R-6	23.2%	50.7%	0.9%
R-8	0.0%	0.0%	0.1%
North[2]	(n=26)	(n=12)	(n=14)
R-4.2	75.4%	44.5%	99.9%
R-6	24.6%	55.5%	0.0%
R-8	0.0%	0.0%	0.1%
South[3]	(n=16)	(n=6)	(n=10)
R-4.2	80.3%	60.9%	96.7%
R-6	19.7%	39.1%	3.3%
R-8	0.0%	0.0%	0.0%

1 Percentages are weighted.
2 Includes the North Coast and Central Valley regions.
3 Includes the South Coast, South Inland, and Desert regions.

Window Types

Several combined features of a window assembly determine its overall performance in reducing heat transfer (heat gain and loss): frame type, glass type, and the number of panes. Table 5-10 and Table 5-11 include the average percent of new single family homes in which windows with various characteristics were specified in 2002. Statewide, the predominant window characteristics are dual-paned, vinyl framed, low-E glass windows. These results reveal that low-E glass is becoming the standard glass type, particularly in the inland region.[9]

8 In fact, only one builder specified R-8 duct insulation.
9 The 2001 Residential New Construction study found clear glass to be most prevalent.

Participants reported a larger percentage of homes with clear glass and metal frames. However, it is important to note that these differences are not significant, and that the largest builder surveyed reported building homes in the Coastal regions where compliance with Title 24 is achievable with lower performance windows.

Table 5-10: Window Characteristics – Statewide

"What percentage of homes you built last year had windows with the following characteristics?"	Average Percent of Homes[1,2]		
	All (n=76)	Participants (n=30)	Nonparticipants (n=46)
Single Paned	0.7%	0.0%	1.3%
Dual Paned	99.1%	100.0%	98.3%
Triple Paned	0.2%	0.0%	0.4%
Clear Glass	16.6%	19.5%	14.0%
Low-E Glass	83.4%	80.5%	86.0%
Tinted/Reflective Glass	0.0%	0.0%	0.0%
Metal Framed	14.2%	21.0%	8.2%
Vinyl Framed	85.4%	79.0%	91.1%
Wood Framed	0.4%	0.1%	0.7%

1 Average percentages are weighted means. Weighted standard errors are in parentheses.
2 The differences between participants and nonparticipants is not significant for any characteristic.

Table 5-11: Window Characteristics – All Respondents, by Region

"What percentage of homes you built last year had windows with the following characteristics?"	Average Percent of Homes[1,2]				
	North Coastal (n=21)	South Coastal (n=17)	South Inland (n=28)	Central Valley (n=30)	Desert (n=9)
Single Paned	0.0%	0.0%	2.9%	0.0%	0.0%
Dual Paned	99.9%	100.0%	96.8%	99.7%	100.0%
Triple Paned	14.7%	0.0%	0.3%	0.3%	0.0%
Clear Glass	30.8%	40.8%	22.8%	1.6%	0.6%
Low-E Glass	69.2%	59.2%	77.2%	98.4%	99.4%
Tinted/Reflective Glass	0.0%	0.0%	0.0%	0.0%	0.0%
Metal Framed	33.2%	41.5%	5.7%	2.5%	14.6%
Vinyl Framed	66.7%	58.0%	93.3%	97.4%	83.8%
Wood Framed	0.0%	0.5%	1.0%	0.1%	1.6%

1 Average percentages are weighted means. Weighted standard errors are in parentheses.
2 The differences between participants and nonparticipants is not significant for any characteristic.

Radiant Barriers

Radiant barriers are a prescriptive requirement in all but the coastal climate zones.[10] A radiant barriers is a reflective sheeting on the interior side of the roof that helps reduce summer heat gain and winter heat loss, thereby reducing air-conditioning cooling loads in warm climates.

Statewide, about 10% of the builders reported installing radiant barriers; the percent of participants (8.2%) is lower than nonparticipants (13.5%). Table 5-12 includes the average percent of homes in which radiant barriers were installed. Builders reported installing radiant barriers in an average of about 3% of their homes. Not surprisingly, a greater proportion of builders have adopted this practice in the Desert region than any other area in the state. Those who build in the Desert region install the material in approximately 40% of their homes, while builders in the North Coastal region use this measure in less than 1% of their units.

[10] Required when using Prescriptive Package D in CEC Climate Zones 2, 4, and 8 through 15.

Table 5-12: Average Percent of Homes with Radiant Barriers

Region	Average Percent of Homes[1]		
	All	Participants	Nonparticipants
Statewide	3.3% *(1.824)* (n=74)	1.1% *(1.606)* (n=30)	5.4% *(3.036)* (n=44)
North Coastal	0.0% *(.0617)* (n=19)	0.0% *(.0000)* (n=9)	0.1% *(.1493)* (n=10)
South Coastal	0.2% *(.3894)* (n=17)	0.0% *(.0000)* (n=11)	0.7% *(1.121)* (n=6)
South Inland	2.8% *(2.919)* (n=27)	3.0% *(5.428)* (n=11)	2.6% *(3.376)* (n=16)
Central Valley	2.7% *(2.012)* (n=30)	1.2% *(1.168)* (n=11)	3.8% *(3.233)* (n=19)
Desert	38.6% *(17.21)* (n=9)	3.2% *(8.773)* (n=5)	85.5% *(20.31)* (n=4)

1 The difference between participants and nonparticipants is not significant for any region.

Wall and Ceiling Insulation

The prescriptive wall insulation is R-13 (Climate Zones 2-10), R-19 (Climate Zones 11-13) or R-21 (Climate Zones 1 and 14-16). According to survey respondents, standard industry practice is to specify R-13 for 2×4 framed walls (limited space prohibits additional insulation) and R-19 for 2×6 and/or exterior walls. Table 5-13 shows that while most builders specify at least R-13 wall insulation, a small percentage use below-prescriptive levels. This practice seems to be most prevalent in the Coastal region by nonparticipant builders.

Table 5-13: Wall Insulation R-values

R-value	Percent of Builders Installing[1]		
	All	Participants	Nonparticipants
Statewide	(n=71)	(n=28)	(n=43)
R-11	4.4%	0.0%	7.7%
R-13	72.6%	62.4%	80.3%
R-15	21.8%	35.7%	11.3%
R-21+	1.2%	1.9%	0.7%
Coastal	(n=30)	(n=15)	(n=15)
R-11	14.2%	0.0%	25.8%
R-13	70.9%	75.0%	67.5%
R-15	11.4%	17.3%	6.7%
R-21+	3.5%	7.8%	0.0%
Inland	(n=55)	(n=20)	(n=35)
R-11	1.3%	0.0%	2.3%
R-13	73.2%	58.3%	84.1%
R-15	25.0%	41.7%	12.7%
R-21+	0.5%	0.0%	0.9%

1 Percentages are weighted.

The prescriptive ceiling insulation is R-30 (Climate Zones 2-10) and R-38 (Climate Zones 1 and 11-16). Table 5-14 shows that while most builders specify at least R-30, almost 15% statewide reported below-prescriptive levels. This practice is more evident by builders in the Coastal region.

Table 5-14: Ceiling Insulation R-values, Coastal versus Inland Regions

R-value	Percent of Builders Installing[1]		
	All	Participants	Nonparticipants
Statewide	(n=73)	(n=28)	(n=45)
R-19	14.8%	14.1%	15.3%
R-30	72.8%	77.3%	69.3%
R-38	12.4%	8.5%	15.4%
Coastal	(n=31)	(n=15)	(n=16)
R-19	29.1%	23.0%	34.0%
R-30	65.0%	71.6%	59.7%
R-38	5.9%	5.4%	6.3%
Inland	(n=57)	(n=20)	(n=37)
R-19	10.4%	11.2%	9.7%
R-30	75.2%	79.2%	72.2%
R-38	14.5%	9.6%	18.1%

1 Percentages are weighted.

Characteristics of Specified versus Installed Equipment

While most information obtained through the builder survey reflects the characteristics of equipment *specified* in 2002, little can be verified about the measures actually installed. This is best accomplished through on-site inspection (results of on-site surveys are forthcoming). To gain some insight into potential differences between specified and installed measures, survey respondents were asked a series of questions about changes made to building plans after submitting Title 24 documentation. The survey also included questions designed to reveal how closely the efficiency rating of installed equipment matches the specifications in the building plans.

Changes to Building Shell Characteristics

As shown in Table 5-15, about half of the builders reported that they never make changes to the building shell after issuance of the building permit. Most builders who indicated they makes changes "sometimes," "fairly often," or "always" mentioned changing the size or location of a window, or adding a window or door. Reasons for changes were aesthetics or to meet a homebuyer's request. Two builders clarified that the changes are only made to "fine-tune" new model homes to observe how the building functions and to improve its marketability. The production homes then follow the models exactly. Changes after a building permit is issued that are unrelated to windows included framing (wall location),

siding, and adjustments to accommodate plumbing, electrical wiring, etc. Such changes will generally not affect Title 24 compliance.

Table 5-15: Frequency of Changes to Building Shell Characteristics

How often are design changes made to the building shell after the building permit has been granted?	**Percent of Builders**[1] (n=77)
Never	51.1%
Sometimes	42.6%
Fairly Often	5.4%
Always	0.9%

1 Percentage is weighted.

Changes to Equipment Efficiencies

Survey respondents also reported that most air conditioners, furnaces, and windows have efficiency ratings that match the building plan specifications. As reported in Table 5-16, about 12.1% of central air conditioners and 8.3% of furnaces have efficiency ratings that exceed the plans. Reasons cited include 1) equipment specified on plans is not available, 2) subcontractor specified upgrade to provide value, 3) to provide value to customers, 4) homebuyer request, and 5) to meet energy efficiency program requirement. Builders reported 10.1% of the windows have characteristics that exceed the building plan specifications. Reasons for window upgrades were to providing additional value, change to low-E glass, and meet program requirements. One small builder explained:

> *"It's an in-house decision in order to increase the value and marketability of a home. Our design team will meet to suggest any changes."*

Table 5-16: Efficiency Levels of Specified versus Installed Measures

Average percent of installed units with efficiency rating that …	**Average Percent of Installed Equipment** (n=73)		
	Central Air Conditioners	**Furnaces**	**Windows**
...*matches* specification	87.7%	91.7%	89.9%
...*exceeds* specification	12.1%	8.3%	10.1%
...is *less than* specification	0.1%	0.0%	0.0%

1 Average percentages are weighted means. Weighted standard errors are in parentheses.

Submitting Changes to the Building Department

The final question with respect to design versus as-built home characteristics uncovered how changes made after receiving a building permit are handled with respect to Title 24 compliance. While most builders stated that there were no differences between what is specified on the plans and the measures actually installed, several explained that when necessary, the consultant will re-calculate and re-submit Title 24 compliance documentation to the building department.

5.4 Impact of the 2001 Standards

The 2001 Standards include major revisions from the 1998 Standards. Radiant barriers, low-E windows, HERS-certified duct sealing, and TXV valves for air conditioners are now part of the Prescriptive Package D. These measures affect the energy budgets in performance method calculations, making compliance more difficult. Additionally, an alternative to Package D exists, which does not require HERS-certified duct sealing or TXV valves for air conditioners, but instead requires higher performance windows and high-efficiency HVAC equipment (these requirements vary by climate zone).

To assess the overall impact of the 2001 Standards on builders of single family new homes, all respondents were asked a series of questions relating to changes they adopted in response to the more stringent requirements. These questions solicited builder opinions on 1) the level of effort required to achieve compliance compared to the 1998 Standards 2) radiant barriers, 3) HERS certification requirements for duct sealing and TXVs, and 4) the likelihood of opting for higher performance windows and higher efficiency HVAC equipment to avoid measures that require HERS certification.

Overall Adjustment to the 2001 Standards

As shown in Table 5-17, builders characterize the level of effort to comply with the 2001 Standards compared to the 1998 Standards as "somewhat difficult," or a 2.22 on a scale of 1 to 5. Regionally, builders operating in the South Inland region found the adjustment slightly more difficult and builders operating in the North Coast region found the adjustment fairly easy.[11] Some representative comments provided by builders who felt the adjustment to the 2001 Standards was "difficult" or "very difficult" are provided below.

> *"Insulation costs have gone up over 100% in the last five years."*
>
> *"The biggest challenge is in trying to balance construction regulations with energy regulations."*

[11] Results in these regions were statistically significantly different.

> *"Cost. Each of the T24 requirements mandates an expense. The cost puts homes out of reach for some people. We have to ask what is the cost-to-benefit ratio."*

Table 5-18 presents the results by builder size. The average rating by small builders who completed less than 25 homes in 2002 was lowest (1.73). This result is significantly different than the average rating of larger builders who found the adjustment to the new Standards slightly more difficult. This likely reflects the differences in practices between custom and production homebuilders.

Table 5-17: Adjustment to the 2001 Standards, by Region

"How would you characterize the level of effort required to achieve compliance under the 2001 Standards compared to meeting the 1998 Standards?"	**Average Rating**[1,2]
Statewide	2.22 *(0.14)* (n=72)
North Coastal [3]	1.73 *(0.25)* (n=18)
South Coastal	2.14 *(0.43)* (n=15)
South Inland[3,4]	2.90 *(0.25)* (n=27)
Central Valley	2.16 *(0.18)* (n=29)
Desert	2.08 *(0.42)* (n=7)

1 Average ratings are weighted means. Weighted standard errors are in parentheses.
2 Ratings on a scale of 1 to 5 with a 1 meaning "easy" and a 5 meaning "very difficult."
3 Result is significantly different than the statewide average.
4 Result is significantly different between the South Inland and the North Coastal, Central Valley, and Desert regions.

Table 5-18: Adjustment to the 2001 Standards, by Company Size

"How would you characterize the level of effort required to achieve compliance under the 2001 Standards compared to meeting the 1998 Standards?"	Average Rating[1,2]
Less than 25 homes	1.73 *(0.36)* (n=8)
25 to 100 homes[3]	2.56 *(0.31)* (n=23)
101 to 500 homes[3]	2.48 *(0.21)* (n=29)
Greater than 500 homes	1.99 *(0.35)* (n=12)

1 Average ratings are weighted means. Weighted standard errors are in parentheses.
2 Ratings on a scale of 1 to 5 with a 1 meaning "easy" and a 5 meaning "very difficult."
3 Result is significantly different than the average rating by builders of less than 25 homes.

Radiant Barriers

Builder opinions regarding radiant barriers vary and seem to indicate that the market for the material is still developing.[12] While a few builders strongly endorse radiant barriers, many indicated that they are not familiar with the material and do not have enough information to use it in the homes they build. A few builders explained that contractors in their regions lack the installation experience and one even questioned the availability of the material. A few builders raised technical issues or uncertainties regarding of radiant barriers. Representative opinions about radiant barriers are provided below:

> *"It took my framers a while to get used to using it. Now, it is just about standard for us. The difference is felt when you stand under the sun, then under the barrier – you can really feel the difference." (Small builder)*
>
> *"Radiant barriers were initially difficult to install. Now, as the contractors get more familiar with them, it is among the easiest, especially the foil-lined [material]." (Small builder)*
>
> *"It's not cost efficient yet. It's more expensive and is not a marketing tool at all. People will buy the home with or without it." (Large builder)*

[12] The interviews with Title 24 consultants also revealed this sentiment.

"I think it's an excellent product but currently not cost-effective." (Large builder)

"I don't like it. It potentially increases humidity inside the walls and encourages mold growth." (Large builder)

HERS Certification Requirements

The 2001 Standards require HERS on-site field verification in order to earn credit for several measures including duct sealing, ACCA manual D duct design, refrigerant charge and air flow test, building envelope sealing, TXVs, duct surface area reduction, and improved duct location. Builders have the option of certifying every home, or a sample (minimum of one out every seven) of homes considered the same model. All diagnostics and certification must be conducted by a certified HERS rater.

The results of this builder survey, coupled with the results of the Title 24 consultant survey, indicate that the industry has not whole-heartedly embraced either the measures requiring HERS certification or the HERS certification process itself. First, 68% of builders indicated that they have either used, or their Title 24 consultant has discussed using, a HERS rater to certify sealed ducts. Interviews with Title 24 consultants revealed that they are reluctant to recommend measures requiring HERS certification. The additional burden of scheduling an additional on-site inspection is considered a hassle.

Overall, builders who did use or have discussed using a HERS rater are "somewhat" satisfied with the HERS certification process, or a 2.9 on a scale of 1 to 5. Builders who stated they were "not at all satisfied" were all large builders who explained the HERS certification process is "too complicated" and feel the on-site verification is "a hassle." Two builders had difficulty identifying a certified rater who was qualified to complete the certification process:[13]

"[There is] a lot of un-clarity [about] the requirements…I did not find one person who was fully familiar with the process."

"The challenge [is] finding a HERS rater who is educated on the process of the ENERGY STAR process as it related to the CHEERS requirement. Some raters are not fully educated on ENERGY STAR processes."

[13] Interestingly, our research found that, despite over 250 raters listed on the CHEERS website, there are very few who have actually conducted inspections. Most HERS certification is conducted by a small number of consultants.

As shown in Table 5-19, builders are "fairly likely" to specify higher efficiency windows and HVAC equipment to avoid HERS certification requirements.[14,15] This result is consistent with the increase in high performance windows as reported in Section 4 and through the Title 24 survey results.

Table 5-19: Practices with Respect to HERS Certification Requirements

Likelihood of installing other measures to avoid HERS certification requirement.	Average Rating [1]
Higher efficiency windows	3.67 *(0.20)* (n=39)
Higher efficiency HVAC equipment	3.56 *(0.21)* (n=38)

1 Ratings on a scale of 1 to 5 with a 1 meaning "not at all likely" and a 5 meaning "very likely."

The final question relating to HERS requirements asked builders to state their opinions regarding the options requiring HERS certification of duct sealing and TXVs. Out of the 37 builders who used or have discussed using a HERS rater with their Title 24 consultant, eight offered positive and supportive opinions, such as:

> *"It's a good idea. Duct sealing and TXV valves are added features that add to the quality of the home."*
>
> *"It is a good thing, anyone can make a mistake so it is good for us in order to maintain an efficient system."*
>
> *"I do not mind another set of eyes during production, which is safer, and it helps us to [improve] quality."*

Nine builders of all sizes provided negative opinions citing high costs, hassle, and uncertainty about the need for inspection of TXVs, in particular. Most, however, did support duct sealing and testing requirements.

> *"The TXV inspection is kind of a joke. They would be better off training installers that it's there. On a 12 SEER air conditioner, you have to have it inspected then you have to check it. As far as the duct testing goes, there's value in it, it's getting better now than it was 5 years ago."*

14 This sentiment was also found through the surveys and interviews with Title 24 consultants conducted for this study.

15 In addition, the interviews with Title 24 consultants found that some builders seal ducts but do not specify for them on the building plans solely to avoid the certification process.

> *"TXV testing doesn't seem like an effective process…I do support duct sealing."*

One large builder stated:

> *"I think it is a good thing although I do have issues with the process. Right now they test every fifth home and I believe they should test every home."*

5.5 General Specification Practices for California ENERGY STAR New Homes

Thirty of the 77 respondents indicated that their company built homes in 2002 that qualified for the California ENERGY STAR New Homes Program. These builders estimate that, on average, 42% of the homes that qualified for the program have been certified. This is primarily due to the homes simply not being built yet. The California ENERGY STAR New Homes Program allows two years for homes to be built after they are approved for the program.

While obtaining detailed data on specific measures and measure combinations specified to meet ENERGY STAR requirements was cost-prohibitive with this particular builder survey, program participants were asked to describe the primary differences between homes that qualify for the California ENERGY STAR Program and homes that just meet the 2001 Standards.[16] Table 5-20 summarizes the builder responses with respect to specific measures. As shown, the most prominent measures specified for ENERGY STAR homes are high performance windows. Five of the builders who mentioned windows also mentioned upgrading the insulation (three of which were very large builders). Five of the builders who install high performance windows also mentioned duct sealing/testing.

[16] Note that this information was collected during independent interviews with high-volume ENERGY STAR builders – results can be found in the Title 24 results chapter.

Table 5-20: Specification Practices of ENERGY STAR New Homes

Specific Measures	Number of Builders Mentioned
High performance windows	11
Windows and insulation *Windows and duct sealing/testing*	5 5
Duct sealing/testing	9
High efficiency HVAC	8
Blower door test	5
Upgrade insulation (general)	4
TXV	2
Upgrade ceiling insulation	1
Upgrade wall insulation	1
Upgrade duct insulation (to R-6)	1
Radiant barrier	1
ACCA manual D duct design	1

5.6 Comparison of Interview Results and On-Site Surveys

The following is a comparison of the results of the telephone surveys with non-participant builders and the on-site surveys of single family detached homes.[17]

- ***Space Heating.*** According to self reports by builders, the statewide average AFUE for space heating furnaces was 81.2, which was just slightly lower that the result of the on-site survey (81.4). The greatest difference in furnace efficiencies between builder self reports and on-site surveys was in the north coast (RMST CZ1). In the north coast, the average efficiency rating of builders' self reports was 81.6 AFUE, but the on-site average was 85.3 AFUE.[18]
- ***Space Cooling.*** The self reported efficiencies of the air conditioners installed by builders were very close to the average efficiencies found during the on-sites conducted. The results differed by no more than 0.3 SEER for each RNC climate zone.
- ***Window Types.*** The results of the on-site and telephone surveys demonstrate that, statewide, the predominant window characteristics are dual-paned, vinyl

[17] Note that the on-site survey results include only non-participant homes.

[18] While it appears that the average efficiency, as reported by builders, in the desert (85.7) was much higher than the average found during the on-site surveys (80.8), these results can not be directly compared because the on-site results include homes built in the high deserts and mountains.

framed, low-E glass windows. Although the results of the builders' survey reported a slightly larger percentage of windows with metal frames and a slightly smaller percentage of windows with low-E glass, these differences are not significant.

- ***Radiant Barrier Installation.*** The number of builders statewide who reported installing radiant barriers (5.4%) is not significantly different from the number of homes surveyed (4.0%). The greatest difference in the number of observed and reported radiant barriers occurred in RMST Climate Zone 5, where the builders reported installing radiant barriers in 86% of homes, and the on-site survey found 21% saturation.

5.7 Key Findings

The following summarizes key results of the interviews with builders with respect to standard specification practices for new detached single family homes in California.

- ***Higher efficiency measures are specified more often in Inland and Desert regions.*** Builders of homes in the Inland and Desert regions reported, on average, higher efficiency HVAC equipment, a greater percentage of homes with radiant barriers, and more frequent duct testing. Moreover, low-E glass and vinyl-framed windows are more prevalent in South Inland, Desert, and Central Valley regions of the state.
- ***Tract builders typically specify the same package of measures for each model of a development.*** "High volume" builders of ENERGY STAR homes report that their general compliance strategy is to choose equipment efficiency and window type based on the combination of measures that makes the least complying model meet code.
- ***Adjustment to the 2001 Standards was most difficult for builders in the South Inland region.*** Overall, builders rated the adjustment to the 2001 Standards to be "somewhat difficult." Despite the considerable changes from the 1998 Standards, these results indicate that the building industry has adjusted to the 2001 Standards.[19] The adjustment to the Standards was rated most difficult by builders of homes in the South Inland region, where the requirements are more stringent than along the coast.
- ***High performance windows are becoming standard in single family new homes.*** The specification of high performance windows—vinyl-framed, dual-paned, low-E windows—is standard practice for most builders in California. Builders specify low-E glass and vinyl frames for most homes in the Central Valley and Desert regions, but slightly less frequently in the coastal regions.

[19] The results of the interviews with Title 24 consultants revealed the same pattern; the most difficult period of adjustment immediately follows the inception of new standards. Over time, builders adjust their practices and accept the new requirements.

These results are considerably different from the findings of previous RNC studies, which reported clear glass to be standard.[20]

- ***Average efficiency ratings for space heating and cooling equipment have increased.*** The average SEER and AFUE ratings for space heating and cooling equipment reported by builders are slightly higher than the on-site survey results of the previous RNC studies. The self-reported ratings provided by builders will be verified through the on-site surveys for this current study (results forthcoming).
- ***Market barriers to adoption of radiant barriers exist.*** While the survey results indicate that some builders are installing radiant barriers as a standard practice, many indicated they are not familiar with the material and do not have enough information to justify integrating it into their building plans. Such lack of information and performance uncertainties indicate that training and outreach are still needed for radiant barriers to be more widely accepted technology.
- ***Duct insulation upgrade potential is limited by duct cavity.*** Some builders reported upgrading duct insulation to R-6. R-8 duct insulation is virtually nonexistent because the limited duct space prohibits additional insulation.

[20] Regional Economic Research, Inc.. *Residential New Construction Study*. Prepared for Pacific Gas and Electric Company. September 2001.
Regional Economic Research, Inc.. *Residential New Construction Study – Year 2*. Prepared for Pacific Gas and Electric Company. September 2002.

6

Title 24 Consultant Survey Results

6.1 Overview

As part of the 2003 Statewide Residential New Construction (RNC) Study, Itron conducted telephone surveys with 41 Title 24 consultants throughout California to gain an understanding of building and compliance practices of single family new home builders related to the current Title 24 2001 energy efficiency Standards (the Standards).[1,2] This analysis corresponds in part to the survey of Title 24 consultants conducted for the previous RNC study.[3] One objective of the previous study was to gain insight into the *anticipated* impact of the 2001 Standards with respect to the specification of high efficiency measures to comply with the (then) upcoming Standards. In contrast, the survey administered for this study obtained information on the *actual* incidence of specific measures after the implementation of the 2001 Standards, as well as consultants' insights into the effort required to achieve compliance with the 2001 Standards versus the 1998 Standards. Consultants were also questioned about their knowledge and awareness of the California ENERGY STAR New Homes program and differences in the design and construction of ENERGY STAR homes relative to non-ENERGY STAR homes. The information collected during this phase of the project is interesting and relevant to the baseline study for several reasons.

- Title 24 consultants have intimate knowledge of the Standards and which high efficiency measures are needed in order for each building to comply. Their insight into which measures builders are willing to install is invaluable.
- The ability to compare Title 24 consultants' responses to what builders are installing with the measures actually found during the on-site inspections validates that they have a strong grasp on construction practices.[4]

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1 California Energy Commission. *2001 Energy Efficiency Standards for Residential and Nonresidential Buildings*. August 2001.

2 The 2001 Standards were developed pursuant to California State Assembly Bill 970 (AB 970), enacted on September 6, 2000.

3 Regional Economic Research. *Residential New Construction Study*. Prepared for Pacific Gas & Electric. September 10, 2001.

4 As will be shown in this section, Title 24 Consultants' self reports are not significantly different to the on-site results except for insulation values.

6.2 Background

Title 24 consultants make recommendations to builders about strategies to meet the Standards. However, they do not make final decisions as to which measures are specified and installed. The previous study relied on the judgment of Title 24 consultants to determine anticipated changes to construction practices resulting from the 2001 revisions to the Standards. Builders had very little knowledge of the specific changes to the Standards and, thus, were not surveyed as part of that effort.

In an effort to maintain continuity between this and the previous study, Itron initially contacted the 55 participants of the previous study. Once that list was exhausted, Itron augmented the sample with 50 consultants specializing in residential project analysis obtained from the California Association of Building Energy Consultants (CABEC) roster of Certified Energy Analysts.[5] In all, 26 participants[6] of the previous study were interviewed for this study.

In addition to the telephone surveys, in-depth interviews were conducted with three "high-volume" firms who provide ENERGY STAR turnkey services and/or Title 24 compliance analysis. The interview guide used in the in-depth interviews contained a subset of key questions from the telephone survey, enabling interviewers to focus primarily on specification and design practices. Since the focus and structure of the in-depth interviews was quite different from that of the telephone surveys, the results from these interviews are reported separately throughout this report.

The remainder of this section includes the following subsections:

- General Title 24 Consultant Information,
- Compliance and Building Practices Relative to the 2001 Title 24 Standards,
- The California ENERGY STAR New Homes Program, and
- General Comments from Survey Respondents.

6.3 General Title 24 Consultant Information

Most of the consultants surveyed work for relatively small firms that employ an average of five consultants who conduct Title 24 analysis. Of the 41 respondents, 11 are certified HERS raters.

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5 See http://www.cabec.org/directory.html.

6 While 28 participants from the previous study were interviewed, the results for 26 participants were used. The two participants whose data was not included in the results were thrown out because the percentage of the plans that they analyzed under the Standards for residential new construction was less than 20%.

Residential plans account for approximately 88% of the total plans analyzed by the consultants during 2002, while commercial building plans account for the remaining 12%. Of the residential plans, 90% constituted detached single family homes and 10% were multifamily buildings. The consultants surveyed conducted compliance analysis on an estimated 16,053 building plans representing an estimated 55,801 detached single family homes during 2002, which represents approximately 45% of the new homes in California. According to Construction Industry Research Board (CIRB) data, approximately 108,468 single family housing starts were reported in California in 2001.

Table 6-1 presents the geographic distribution of buildings analyzed (in 2002) by the respondents and the number of respondents who practice in each region. As shown, the Central Valley, North Coastal, and South Inland regions account for most of the buildings represented by the consultants surveyed.

Table 6-1: Geographic Distribution of Sample

Region (CEC Climate Zones)	**Number of Consultants**	**Number of Homes**	**% of Total**	**Housing Starts***	**% of Total**
North Coastal (1-5)	23	13,246	24%	20,041	18%
South Coastal (6-7)	12	5,103	9%	11,180	10%
South Inland (8-10)	15	10,398	19%	24,027	22%
Central Valley (11-13)	27	22,625	41%	43,666	40%
Desert (14)	5	1,778	3%	2,446	2%
High Desert (15)	5	2,120	4%	4,667	4%
Mountain (16)	15	530	1%	2,442	2%
Total	**41**	**55,800**	**51%**	**108,468**	

* Housing starts in 2001. Construction Industry Research Board.

6.4 Construction and Compliance Practices – New Single Family Homes

To support the baseline analysis for the RNC study, the Title 24 consultant surveys were developed specifically to obtain information about the characteristics of homes planned during 2002 and the strategies that builders and designers use to comply with the 2001 Standards. This section summarizes the compliance methods, consultants' assessments of builder attitudes toward the 2001 Standards, the incidence of high efficiency measures in new construction, and the changes in design and construction practices attributed specifically to the 2001 Standards.

Use of Performance and Prescriptive Compliance Methods

Title 24 offers builders and designers some flexibility in meeting energy efficiency requirements. The performance approach specifies the maximum allowable water heating and space conditioning energy use, enabling builders and designers (and Title 24 consultants) to specify the measures and features that best suit their design practices and construction budgets. When using the performance approach, Title 24 consultants conduct compliance analysis with one of several approved computer programs, such as MICROPAS,[7] EnergyPro,[8] or CalRes.[9]

Table 6-2 shows that consultants used the performance method for 99% of their projects in 2002. Over three-fourths were evaluated with MICROPAS and less than one-fourth with EnergyPro.

The remaining projects were developed using a prescriptive approach. The prescriptive approach allows for specific combinations of energy-related measures and design requirements that are necessary to achieve compliance. The 2001 Standards offer three prescriptive packages (C, D, and an alternative to D). Packages A and B of the 1998 Standards are no longer allowed.[10]

Table 6-2: Compliance Approaches for Residential New Construction Projects

About what percentage of your low-rise residential new construction projects were analyzed using the following compliance methods?	Average
Performance Method	99.6%
Prescriptive Package C	0.1%
Prescriptive Package D	0.1%
Prescriptive Package D-Alternative	0.3%
About what percentage of your low-rise residential new construction projects were analyzed using the each of the following programs?	**Average**
Calres	0.1%
EnergyPro	22.3%
MICROPAS	76.3%
Other	1.3%

Values are weighted percentages, with weighted standard errors in parentheses.

7 Enercomp, Inc. See http://www.micropas.com/.

8 EnergySoft LLC. See http://www.energysoft.com/.

9 California Energy Commission. See http://www.energy.ca.gov/title24/calres_software/.

10 California Energy Commission. *2001 Energy Efficiency Standards for Residential and Nonresidential Buildings.* August 2001. Section 151.

Attitudes toward the 2001 Standards

Overall, the consultants characterized builder attitudes toward the 2001 Standards as one of *acceptance*. Although builders and developers generally do not welcome restrictions on construction practices, about two-thirds of the respondents stated that builders have grown accustomed to working with the Standards over the 25 years since their inception.

While about 20% of the respondents noted that the Standards are clearly more stringent than the 1998 requirements, just over 18% indicated that the 2001 revisions are not as difficult as they had anticipated. Attitudes toward the 2001 Standards compared to the 1998 Standards generally address one or more of the following three issues: cost, third party verification requirements, and maximum glazing area percentages.

- ***Cost.*** Almost 10% of the consultants indicated that revisions to the Standards increase the cost of homes "a little bit." While cost is not a critical issue during a strong housing market, it may present a significant obstacle when the market weakens.
- ***Third Party Verification.*** Nearly half (48%) of the consultants explained that measures requiring verification are specified only if absolutely necessary to achieve compliance. The cost and level of effort associated with scheduling and the potential delays in the construction schedule are commonly cited as reasons to avoid measures that require third party verification. Thus, many consultants never recommend or specify HERS-certified sealed ducts or TXVs.

  Duct system verification is a point of contention among builders. One consultant in particular explained that the market is not developed fully enough to accommodate such a requirement. Another cited difficulty in locating a contractor to conduct the testing, while two consultants explained that the building departments are not enforcing this standard. As one consultant explained, "If they want to have tight ducts, they should make it mandatory and enforce it."

  To avoid the duct sealing and testing requirement, almost two-thirds of the consultants explained that many builders specify high performance windows, high efficiency HVAC equipment, or radiant barriers (in the Central Valley). (As explained below, the exception to this strategy is specification of HERS measures for ENERGY STAR qualified homes.)
- ***Maximum Glazing Area Percentages.*** Consistent with the results of the previous study, the surveys revealed that compliance strategies are a function of the maximum glazing area percentages mandated through the Standards. In general, California homebuyers demand a large number of windows. Incorporating large glazing areas presents builders and Title 24 consultants with challenges in complying with the Standards—particularly in the Central Valley and other weather-intense climate zones.

  Despite the challenges associated with glazing percentages, 68% of the consultants explained that high performance windows (double-paned, low-E, vinyl-framed)

> are standard for many builders. One claimed that there "were such terrific advances in the energy efficiency of windows and other measures that it hasn't been too difficult to comply in any climate zone."

In addition to conducting compliance analysis and preparing documentation, Title 24 consultants provide builder education. Two consultants mentioned that educating builders about new requirements and how their practices must change is one of the most significant challenges Title 24 consultants face with each revision of the Standards.

Changes in Practices Due to the 2001 Residential Standards

To ascertain how the 2001 Standards affected builders, respondents were asked to characterize the level of effort required to achieve compliance under the 2001 Standards versus the 1998 Standards. They were then asked to comment on any changes in the design and specification practices that they felt were due specifically to the implementation of the 2001 Standards.

Table 6-3 presents the consultants' perceptions of the level of effort required to achieve compliance of the 2001 Standards versus the 1998 Standards. On average, respondents rated the adjustment "very difficult" in the Desert and High Desert regions (4.5 on a scale of 1 to 5) and least difficult in the coastal climate zones (1.6 to 1.9). This is not surprising since the focus of the 2001 changes were to decrease peak energy usage primarily by decreasing energy used for space cooling.

Table 6-3: Adjustment to the 2001 Standards

How would you characterize the level of effort required to achieve compliance under the 2001 Standards compared to meeting the 1998 Standards?	Average Rating *(Std. Error)* # of Respondents
North Coastal (CZ 1-5)	1.9 *(0.21)* n = 18
South Coastal (CZ 6-7)	1.6 *(0.53)* n = 6
South Inland (CZ 8-10)	3.4 *(0.32)* n = 9
Central Valley (CZ 11-13)	2.7 *(0.19)* n = 20
Desert (CZ 14)	4.6 *(1.22)* n = 2
High Desert (CZ 15)	4.6 *(0.50)* n = 2
Mountains (CZ 16)	2.4 *(0.19)* n = 10

Ratings provided on a scale of 1 to 5 with a 1 meaning "easy" and a 5 meaning "very difficult."
Values are weighted means, with weighted standard errors in parentheses.

Additional insight provided by the respondents includes the following.

- Compliance is still fairly effortless in the South Coastal region. One consultant explained that low-E glass and high efficiency central air conditioners are used to comply if necessary.
- Three consultants indicated that homes in the Central Valley are the most difficult to make comply. One added that "a lot of high efficiency measures are needed to just meet the Standards." However, one consultant added that even though "Climate Zone 12 is the toughest in the state, it was tough before the 2001 Standards."

To gain further insight into the adjustments to building and construction practices after the implementation of the 2001 Standards, consultants were asked to comment on changes they attribute to the new Standards. Two-thirds of the consultants interviewed indicated that their clients have changed their standard design and specification expressly because of the 2001 Standards, and that about 70% of the homes they analyzed in 2002 reflect such changes. Responses are summarized below.

- ***Duct System.*** While duct sealing is not commonly specified in new construction, two consultants attributed increased awareness of duct construction and "pushing contractors to provide better quality duct work" to the 2001 revisions.
- ***High Performance Windows.*** Six consultants attributed the increased use of low-E glass to the 2001 Standards and that "builders have accepted vinyl-framed, low-E windows as standard." One consultant claimed the Standards have not had much of an impact on glazing "because the market is going there anyway." As revealed through other questions in the survey, the adoption of high performance windows is at least partly a response by builders, designers, and consultants to avoid HERS inspection requirements.
- ***Radiant Barriers.*** One consultant stated that radiant barriers were not used in Climate Zone 15 prior to the 2001 Standards, but they are now routinely specified in that region.
- ***Thermostatic Expansion Valves.*** One consultant explained that "builders are more prepared to use a unit with a TXV; they were not aware of it before the 2001 Standards."

Incidence of High Efficiency Measures in Low-Rise Residential New Construction

To determine the incidence of various high efficiency measures specified for new single family homes, Title 24 consultants were asked how frequently builders/designers specify each measure. They were then asked to estimate the percentage of homes covered by their compliance analyses in 2002 that included each measure by geographic region.

To assess the incidence of high efficiency measures in new single family homes, survey respondents were asked to estimate the percentage of homes planned in 2002 that include each measure. Table 6-4 presents the percentage of non-ENERGY STAR ("standard") homes throughout California that include various high efficiency measures as reported by the Title 24 consultants interviewed.

Table 6-4: Incidence of High Efficiency Measures in "Standard" Homes As Estimated by Respondents

	Overall	North Coastal	South Coastal	South Inland	Central Valley	Desert	High Desert	Mtn.
CEC Climate Zone		1-5	6-7	8-10	11-13	14	15	16
# of Respondents	40	23	12	15	27	5	5	15
Homes represented	55,801	13,246	5,103	10,398	22,625	1,778	2,120	530
HERS cert. sealed ducts	16%	1%	1%	9%	20%	72%	93%	5%
TXV / Ref charge air flow test	25%	1%	0%	23%	34%	99%	100%	7%
ACCA Manual D duct design	3%	3%	0%	9%	1%	0%	19%	0%
Duct location	8%	19%	2%	11%	1%	0%	0%	35%
Duct surface area	3%	4%	1%	9%	1%	0%	0%	0%
R-8 duct insulation	2%	2%	1%	7%	0%	0%	0%	2%
Bldg. envelope sealing (Blower Door)	0%	0%	0%	0%	0%	0%	0%	1%
High-perf. windows	66%	52%	33%	49%	84%	100%	100%	70%
Radiant barriers	10%	21%	7%	5%	3%	10%	44%	51%
Higher eff. water heater	91%	85%	75%	91%	97%	100%	90%	89%
Higher eff. CAC	43%	11%	10%	31%	65%	100%	90%	57%
Higher eff. furnace	13%	29%	10%	12%	5%	0%	0%	90%
Increased roof/wall insulation	66%	51%	54%	89%	64%	95%	75%	74%

Values are weighted means

Observations with respect to these results are provided below.

- ***Thermostatic Expansion Valves.*** Statewide, TXVs are specified in about 25% of "standard" homes. The incidence of TXVs parallels that of central air conditioners, both of which are more prevalent in areas with high cooling load. Interviews also confirmed earlier assumptions that while TXVs would be an upgrade for 10 SEER units, they are a standard feature in most 12 SEER and all 14+ SEER air conditioners. Additionally, the higher frequency of TXV installation relative to duct testing might imply that many homes are installing TXVs but not taking credit for the installation to avoid potential problems associated with verification requirements.
- ***Duct-Related Measures,*** including HERS-certified sealed ducts, ACCA Manual D duct design, duct location, duct surface area, and R-8 duct insulation are not commonly utilized measures in "standard" residential new construction.

According to respondents, R-8 duct insulation is not a practical upgrade because it does not fit into standard sized trusses. R-6 is a much more common upgrade from R-4.2.

- ***Building Envelope Sealing*** is not used in "standard" residential new construction. Additionally, consultants indicated that builders are reluctant to conduct blower tests for fear that the home would fail an inspection, requiring additional work on the air distribution system.
- ***High Performance Windows*** were specified in about 66% of "standard" homes statewide. Both builders and Title 24 consultants explained that double-paned vinyl-framed windows with low-E glass are standard features of most new single family homes in California. However, aluminum-framed windows are specified in some coastal homes and even in some homes in extreme hot climates, such as Palm Springs. One consultant added that unless vinyl-framed windows are installed the day of delivery to the construction site, they can warp if left in the hot sun. To avoid this risk, some builders might prefer aluminum-framed windows.
- ***Radiant Barriers*** are specified in about 10% of the "standard" homes statewide and are most common in extreme desert climates. Survey results indicate that the market for radiant barriers is still immature. Some Title 24 consultants explained that many builders are not informed about the costs and one mentioned the material is not available in certain areas. A few consultants mentioned that because the material is one-sided there is a considerable amount of wasted product, particularly in custom homes. Interestingly, the high volume turnkey service providers and consultants indicated that they do not specify radiant barriers at all statewide—*in either standard homes or ENERGY STAR homes*. One explained that radiant barriers are specified only when it is needed to meet Title 24.
- ***Higher Efficiency Water Heaters*** (0.60+ EF) are commonly specified in over 90% of "standard" homes statewide. One turnkey company explained that they specify 0.60 to 0.62 EF units (40 to 75 gallon) and that 75-gallon units are more common in Southern California where homes tend to be larger. Builders of large homes, however, are beginning to specify tankless, on-demand equipment.
- ***High Efficiency Central Air Conditioners.*** Overall, high efficiency air conditioners (12+ SEER) are specified in 43% of standard new homes statewide, and are more prevalent in cooling zones (11 through 16) and less prevalent in the coastal regions.
- ***High Efficiency Furnaces.*** As indicated by both Title 24 consultants and turnkey service providers, high efficiency furnaces are seldom specified in new construction, except in the Mountain region. Some respondents attributed this to the high cost of 90+ AFUE units. This sentiment was repeated by one of the high volume turnkey service providers interviewed for this study.
- ***Increased Roof and Wall Insulation*** were specified in about two-thirds of "standard" homes. According to respondents, increasing insulation levels is a

fairly cost-effective approach to meet Title 24. It is interesting to note that this result is inconsistent with past on-site surveys, which report that most homes possess lower levels of insulation than the prescriptive requirement. The on-site surveys currently being conducted in homes built under the 2001 Standards will likely provide greater insight into whether building practices regarding insulation have changed in response to the 2001 Standards.

Specification of Measures that Would Not Meet Prescriptive Requirements

Because the performance method of compliance affords builders and designers flexibility in meeting the Title 24 Standards, some (understandably) specify measures that would not meet the prescriptive requirements. Ninety percent of the consultants indicated that builders exceed the maximum prescriptive glazing percentage and about two-thirds indicated that builders specify less than prescriptive wall insulation.

Table 6-5: Using Measures that do not meet Prescriptive Requirements

Measure	% of Respondents
Roof insulation	25%
Wall insulation	64%
Percent glazing	90%

Specification Practices Not Reflected in Compliance Analysis

Interestingly, approximately 75% of the consultants indicated that builders were specifying measures for which they were not taking credit in the Title 24 compliance analysis. The most common measure not included in the compliance analysis was tight ducts. One consultant explained:

> *"We make some of the architects put notation on the plans for tight ducts but not take the credit due to possibility of inspection failure."*

Another repeated this sentiment:

> *"Some builders have standard policy to do duct testing on all their homes, but they do not want the hassle of third-party verification."*

One consultant revealed insurance issues with respect to duct sealing:

> *"[Builders] do not take credit for tight ducts since [it] requires that duct testers have professional liability insurance. It is hard to find testers with this insurance."*

Two consultants also believed that builders were specifying or installing high performance windows and not taking Title 24 credit. In fact, one of the high-volume consultants explained that they model the plans using default window values (worst-case scenario), which provides them with the flexibility to install any variety of windows for any homes in the plan.

Regional Differences in Specification Practices

Most respondents indicated there are differences in design and construction practices between the northern and southern areas of the state and between the coastal and inland regions (94% and 95%, respectively). Few offered insight into the reasons for the differences between the northern and southern regions relating to energy efficiency. However, one consultant stated that homes in Northern California have increased insulation.

According to the respondents, high performance glazing is far more commonly specified in the inland regions than on the coast, followed by high efficiency central air conditioners. Two consultants also mentioned radiant barriers and increased insulation, two measures rarely observed in the coastal areas. These sentiments reinforce the Title 24 consultants' estimates with respect to the incidence of high efficiency measures by climate region presented above in Table 6-4.

Because of the temperate climate in the coastal regions, the Standards are less stringent. Instead of upgrading cooling equipment, builders on the coast specify a TXV valve to increase cooling efficiency. One consultant explained:

> *"[A]nything works in coastal zones because there is no (space conditioning) load in coastal zones. The water heater makes the biggest difference."*

6.5 Comparing Survey Responses to the 2001 Survey

As explained above, in an effort to maintain continuity between this and the previous study, Itron surveyed participants of the previous study. Of the 41 Title 24 consultants surveyed for the 2003 study, 26 were participants of the 2001 study. Table 6-6 provides the average likelihood of installing high efficiency measures reported by Title 24 consultants during the 2001 and the 2003 interviews. As shown, there are noticeable differences between what consultants anticipated prior to the implementation of the 2001 Standards (pre-AB 970) and what was actually specified in 2002 (post AB 970) for five high efficiency measures: windows, radiant barriers, water heaters, furnaces, and roof and wall insulation. The differences associated with each of these measures are discussed in further detail:

- ***High Efficiency Windows.*** As shown in Table 6-6, responses to the current survey indicate that consultants believe high-performance windows to be specified

more often than they had anticipated previously; average ratings increased from a 3.9 to a 4.8 on a scale of 1 to 5. As explained below, consultants indicated that, overall, high-performance windows are becoming prevalent in residential new construction and that many builders use them as a standard practice.

- ***Radiant Barriers.*** Before the implementation of the 2001 Standards, consultants believed radiant barriers would be "somewhat likely" to be specified, or about a 3 on a scale of 1 to 5. Over a year after the implementation of the Standards, consultants indicated that radiant barriers are "not at all likely" to be specified. The most common explanation for this divergence is that the credit for radiant barriers is lower than what they anticipated, particularly in the mild climate zones.

  Additionally, one consultant explained that not using radiant barriers is "a marketing choice by a lot of builders" who would rather install high efficiency space conditioning equipment because it is more cost effective and more easily understood by consumers. Another consultant stated that some builders specify radiant barriers but then actually forget to install them. One consultant claimed to always recommend radiant barriers but that his clients do not want to use them.

  Despite the fact that radiant barriers are specified much less frequently than anticipated, the few respondents who have used them provided very positive feedback. One consultant stated that "if builders saw a radiant barrier demo[onstrate]d, they'd want it." Another claimed that radiant barriers "provide the biggest bang for the buck."

- ***High Efficiency Water Heaters.*** Consultants' ratings of the likelihood of use of high efficiency water heaters decreased from 3.8 to 2.1 after the implementation of the 2001 Standards. In the case of water heaters, the decrease does not denote fewer high efficiency water heaters in new homes. Rather, what consultants and builders consider to be "high efficiency" seems to have changed. Since the last study, 0.60 and 0.62 EF units have become standard; high efficiency water heaters are 0.63 EF or greater.

- ***High Efficiency Furnaces.*** On average, high efficiency furnaces are believed to be specified less often than consultants anticipated in the previous study. As noted below, high efficiency furnaces were specified in less than one-fifth of new homes in 2002 and are rarely used to upgrade a home to the ENERGY STAR qualification.

- ***Roof and Wall Insulation.*** The average likelihood of increased roof and wall insulation also decreased since the implementation of the 2001 Standards.

Table 6-6: Likelihood of Specifying High Efficiency Measures – All Respondents

Using a scale of 1 to 5 with a 1 meaning "not at all likely" and 5 meaning "very likely" how often do builders/designers specify the following measures?	**Post AB 970** *(Std. Error)* # of Respondents	**Pre-AB 970** *(Std. Error)* # of Respondents
HERS Certified sealed ducts	2.7 *(0.16)* n=40	2.7 *(0.17)* n =52
TXV /Refrigerant charge air flow test	2.2 *(0.15)* n=40	2.3 *(0.2)* n=50
High-performance windows	4.8 *(0.11)* n=40	3.9 *(0.13)* n=53
Radiant barriers	1.4 *(0.14)* n=40	3.2 *(0.18)* n=53
Higher efficiency water heater	2.5 *(0.26)* n=40	3.9 *(0.16)* n=48
Higher efficiency central air conditioner	3.3 *(0.14)* n=40	3.7 *(0.17)* n=47
Higher efficiency furnace	2.1 *(0.18)* n=40	3.5 *(0.17)* n=48
Increased wall and/or roof insulation levels	2.1 *(0.2)* n=40	3.4 *(0.16)* n=48
R-8 duct insulation	1.3 *(0.1)* n=40	*(not avail.)*

Values are weighted means, with weighted standard errors in parentheses.
Difference of means test reveals the differences between pre- and post-AB 970 responses are significantly different for all measures except HERS-certified sealed ducts and TXVs.

Table 6-7 also presents average likelihood of installing high efficiency measures reported by Title 24 consultants, but only for respondents who participated in *both* the 2001 and 2003 surveys—pre- and post-AB 970. When comparing the pre- and post-AB 970 results, they are similar to the above results for HERS-certified sealed ducts, high performance windows, radiant barriers, high efficiency water heaters, and high efficiency furnaces. This means that if a measure is statistically different or not in Table 6-6, then it is also statistically different or not in Table 6-7. However, when comparing the results for just the Title 24 consultants who participated in both surveys, the average likelihoods for TXV valves, high efficiency central air conditioners, and roof/wall insulation are not similar to those when comparing all respondents. These respondents reported that the use of TXV valves was significantly less likely, unlike the results of all respondents, which show no significant difference between what they anticipated before AB 970 was implemented and what has been seen since its implementation. Similarly, Table 6-7 shows that there is no significant difference between the pre- and post-AB 970 average likelihoods of specifying high efficiency air conditioners or increased roof/wall insulation.

Table 6-7: Likelihood of Specifying High Efficiency Measures – Participants from the Previous and Current Year Study Only

Using a scale of 1 to 5 with a 1 meaning "not at all likely" and 5 meaning "very likely" how often do builders/designers specify the following measures?	**Post AB 970** *(Std. Error)* # of Respondents	**Pre-AB 970** *(Std. Error)* # of Respondents
HERS Certified sealed ducts	2.3 *(0.21)* n=25	2.6 *(0.30)* n=23
TXV /Refrigerant charge air flow test	1.2 *(0.11)* n=26	2.1 *(0.22)* n=24
High-performance windows	4.7 *(0.13)* n=26	4.3 *(0.18)* n=22
Radiant barriers	1.9 *(0.26)* n=26	3.3 *(0.27)* n=25
Higher efficiency water heater	3.0 *(0.23)* n=26	3.7 *(0.27)* n=22
Higher efficiency central air conditioner	3.3 *(0.11)* n=26	3.7 *(0.29)* n=21
Higher efficiency furnace	2.4 *(0.33)* n=26	3.5 *(0.28)* n=22
Increased wall and/or roof insulation levels	2.3 *(0.14)* n=24	2.8 *(0.29)* n=22

Values are weighted means, with weighted standard errors in parentheses.
The number of respondents that ranked the likelihood of specifying each measure pre- and post-AB 970 varied since not all respondents ranked the likelihood of specifying each measure.

6.6 Specification Practices for California ENERGY STAR New Homes

Program Awareness and Participation

On average, Title 24 consultants indicated they are "somewhat knowledgeable" of the California ENERGY STAR New Homes Program, or a 2.8 on a scale of 1 to 5. Of the 55,801 homes represented by the consultants surveyed for this study, approximately 8,690 (15%) were being designed to meet the ENERGY STAR qualification.

Observations on Specification Practices of ENERGY STAR New Homes

The specification practices relating to California ENERGY STAR homes were obtained through the in-depth surveys conducted with high volume Title 24 consultants and turnkey service providers.[11] Two approaches were taken to obtain the best estimates of the types of measures being installed. First, in order to compare the percentages of measures installed in ENERGY STAR homes to those installed in "standard" homes (Table 6-4), these high volume participants were asked to estimate how frequently each high efficiency measure listed Table 6-8 was specified in the ENERGY STAR homes for which they conducted compliance analysis in 2002. Then, these consultants were asked to explain how they upgrade a "standard" home to an ENERGY STAR home.

Table 6-8 presents the percentage of single family ENERGY STAR homes planned in 2002 that included each high efficiency measure. The following observations were made when comparing these results to the percentages of "standard" homes with the same measures.

- ***Duct system-related measures.*** Duct design, sealing, and testing are used by builders to upgrade homes to the ENERGY STAR level. As shown in Table 6-8, HERS-certified sealed ducts are specified for all ENERGY STAR homes in extreme climate zones and in over three-fourths of the homes in the North Coastal region. Comparing these results to Table 6-4, duct upgrades are most prevalent in the Central Valley, South Inland, and North Coastal climate zones. Note, however, that duct location, duct surface area, and R-8 duct insulation are not used by these consultants for ENERGY STAR qualification.
- ***Building envelope sealing.*** High volume participants reported that about 55% of the ENERGY STAR homes for which they conducted compliance analysis were specified to have building envelope sealing. In comparison, none of the consultants interviewed reported specifying building envelope sealing in their "standard" homes.

[11] These consultants reportedly planned approximately 7,800 California ENERGY STAR new homes in 2002. Please note that the data in Table 6-8 represent 7,141 homes because estimates of specific measures installed were not available for approximately 650 of the homes.

- ***TXVs and higher efficiency central air conditioners.*** TXVs and higher efficiency central air conditioners are also common upgrades to meet ENERGY STAR requirements for homes in cooling climate regions, particularly in the South Inland and Central Valley regions.
- ***High performance windows.*** Although high performance windows are becoming standard in a majority of new "standard" homes, low-E glass is even more commonly specified by builders when developing plans for ENERGY STAR homes. One consultant explained that in regions requiring 16% glazing, having low-E windows and sealed ducts will raise the house to the ENERGY STAR level if the prescriptive glazing requirement is met.

Table 6-8: Incidence of High Efficiency Measures in ENERGY STAR Homes

	Overall	North Coastal	South Coastal	South Inland	Central Valley	Desert	High Desert	Mtn.
CEC Climate Zone		1-5	6-7	8-10	11-13	14	15	16
# of Respondents	3	2	1	2	3	1	1	1
CA ENERGY STAR Homes represented[12]	7,141	974	240	912	4,295	240	240	240
HERS cert. sealed ducts	88%	83%	10%	50%	100%	100%	100%	100%
TXV / Ref charge air flow test	79%	17%	0%	75%	100%	100%	100%	0%
ACCA Manual D duct design	37%	33%	0%	0%	40%	100%	100%	50%
Duct location	0%	0%	0%	0%	0%	0%	0%	0%
Duct surface area	0%	0%	0%	0%	0%	0%	0%	0%
R-8 duct insulation	0%	0%	0%	0%	0%	0%	0%	0%
Bldg. envelope sealing (Blower Door)	55%	33%	0%	0%	71%	75%	100%	50%
High-perf. windows	95%	67%	75%	100%	100%	100%	100%	100%
Radiant barriers	7%	0%	0%	0%	5%	25%	75%	0%
Higher eff. water heater	97%	87%	100%	100%	99%	100%	100%	100%
Higher eff. CAC	67%	0%	0%	100%	78%	100%	100%	0%
Higher eff. furnace	8%	0%	0%	0%	7%	0%	0%	100%
Increased roof/wall insulation	76%	100%	100%	100%	61%	100%	100%	100%

Values are weighted means

- ***Increased Roof and Wall Insulation.*** While increasing the roof and wall insulation in "standard" homes is reportedly used in over three-fourths of the homes in most regions, it is used to upgrade coastal homes to the ENERGY STAR level.
- ***Water Heaters.*** Survey results do not reveal significant differences between ENERGY STAR and non-ENERGY STAR homes with respect to water heaters.

When high volume participants were asked to explain the additional features needed to bring a "standard" home just meeting Title 24 needs up to ENERGY STAR qualifications, there

[12] Please note that the number of ENERGY STAR homes by region for each consultant is estimated using the following calculation: total number of homes that the consultant analyzed in 2002 (including ENERGY STAR and "standard" homes) times the percentage ENERGY STAR homes, times the percentage of homes built in each region.

responses were similar to the results above. Duct sealing was mentioned by all three respondents as one of the first upgrades to push homes to the ENERGY STAR level. Not only was it reported to be used by all three consultants, but one mentioned that it is the first measure used and another pointed out that duct sealing alone would make homes in some CEC climate zones meet ENERGY STAR requirements. Two consultants reported using high efficiency windows as an upgrade while another consultant said that these were specified for all of their "standard" homes.

TXVs and 12 SEER air conditioners were reported to be the next upgrades used depending on the climate zone. While two of the three high volume participants reported specifying building envelope sealing (blower door testing), one mentioned that a home with this measure was considered "ENERGY STAR *plus"* since it is not needed to meet ENERGY STAR qualifications, but rather to surpass them. Duct design and high efficiency furnaces were both reported to be used by one high volume participant and only as a last resort, primarily in extreme climate zones.

6.7 General Comments from Survey Respondents

About one-third of the consultants interviewed for this study took advantage of the opportunity to provide additional comments regarding the Title 24 Standards with respect to residential new construction.

- Three consultants provided comments regarding duct sealing HERS verification requirements. One stated,

  > *"[There is] not a lot of interest in HERS. [There is] not a lot of infrastructure or awareness about HERS, so [I] do not want to recommend something to clients that they are unfamiliar with."*

  It is important to note here that a small percentage of organizations account for most HERS inspections. This perspective seems to be representative of those who are not involved with HERS.

  Additionally, one consultant offered a suggestion for streamlining the verification process:

  > *"Ducts that can be visually inspected by a building inspector, and ducts in conditioned space, should be able to be examined by a building official rather than a third-party HERS inspector."*

- Eight consultants voiced opinions about enforcement of the Standards. While most expressed concern over the apparent lack of enforcement, a few noted improvement in the levels of enforcement over the years. Examples of comments are provided below.

> *"There must be more implementation at the field inspection level to make sure that Title 24 requirements are being met."*
>
> *"For Title 24 to work, city inspectors must enforce HERS inspections… Lack of enforcement makes it hard for me as a CHEERS rater."*
>
> *"I am thankful for the efforts I am beginning to see in building departments in enforcing Title 24. There is improved education and greater knowledge among building inspectors."*

- Finally, three consultants offered opinions regarding the availability of information with respect to the Standards. These respondents feel that the architectural community should be better informed about the Standards.

6.8 Comparison of Interview Results and On-Site Surveys

The following briefly compares the results of the Title 24 consultant interviews and the on-site surveys for single family homes.

- ***Insulation Levels.*** Although the Title 24 consultants reported that increased roof and wall insulation levels occurred in 66% of the "standard" homes, the on-site analysis of single family homes revealed that only 5% of homes had higher performance (greater than prescriptive) ceiling installation levels and only 6% had higher performance wall insulation. This was the greatest discrepancy between the reported and observed results.
- ***Window Types.*** The percentage of homes actually installing high performance windows (dual-paned, vinyl-framed, low-E glass) was higher (79%) than the percentage reported by the Title 24 consultants (66%).
- ***Heating and Cooling Equipment.*** Title 24 consultants reported that 13% of nonparticipant homes had heating equipment with efficiencies greater than 90% AFUE. This closely matches the percentage of the homes that had higher efficiency units (11%). Title 24 consultants also reported that more homes (43%) had higher efficiency air conditioning units (greater than 12 SEER) than actually did (6%). However, it is interesting to note that 36% of homes surveyed have air conditioners that are greater than 11 SEER. Note that there is room for interpretation since each Title 24 consultant was asked about high efficiency and not a specific SEER rating. Therefore, if some of the Title 24 consultants surveyed consider anything over 11 SEER high efficiency, their self-report is close to the saturations found on-site.
- ***Radiant Barriers.*** The number of sites statewide with radiant barriers installed was 4%, which is less than the consultant reports of 10%. There were fewer sites with radiant barriers than were reported for every climate zone, with the greatest discrepancy in the desert and mountain regions (RMST CZ 5).

6.9 Key Findings

Title 24 consultants have a strong familiarity and understanding of the energy-related characteristics of new homes as well as builder specification strategies to comply with the Title 24 Standards. The surveys and in-depth interviews provide valuable insight into how the 2001 revision to the Standards impacted compliance practices, as well as the differences between homes that just meet Title 24 and those that qualify for the ENERGY STAR New Homes program. The following are key findings.

- ***Impact of the 2001 Standards.*** The 2001 Standards have had the greatest impact on building practices in the Desert and High Desert regions (CEC Climate Zones 14 and 15), followed by the South Inland and Central Valley regions (CEC Climate Zones 8 though 13). This result confirms expectations of earlier studies and is not surprising since the 2001 revisions focused on reducing cooling peak demand.
- ***Measures requiring third party verification are specified only as last resort for Title 24 compliance.*** According to Title 24 consultants, the additional cost, potential disruption to the construction schedule, and potential insurance risk associated with measures requiring third party verification create a significant disincentive for specification of such measures. HERS-related measures are most commonly found in the Desert and High Desert where the Title 24 Standards are most stringent. Additionally, some builders claim to use duct and building envelope sealing practices but do not include them in the Title 24 compliance analysis specifically to avoid verification requirements.
- ***Specification practices of ENERGY STAR homes.*** Interviews with high volume consultants who provide turnkey services and conduct analysis for both ENERGY STAR and non-ENERGY STAR homes revealed that duct system sealing is a common upgrade for ENERGY STAR qualification. High efficiency central air conditioning, thermostatic expansion valves (TXVs), and high performance windows are also used in the cooling climate regions.

7

Summary of Results

7.1 Introduction

This section provides an overview of key findings discussed in the various sections of this report. It includes highlights from the baseline characterization, analysis of compliance, and interviews with Title 24 Consultants and builders. This section also contains a brief discussion on residential standards issues.

7.2 Baseline Characterization

The following is a summary of current building practices in single family homes.

- ***The predominant window type is vinyl-framed, dual-paned, Low-E glass (79%).***
- ***The average AFUE of space heating systems installed in homes is approximately 81***, slightly higher than required by the Minimum Efficiency Standards.
- ***The average SEER of the space cooling systems is 10.9,*** which is also higher than required by the Minimum Efficiency Standards.
- ***The average EF of water heating systems installed is 17% higher than required by the Minimum Efficiency Standards.***
- ***The average square footage of homes built in 2003 increased by over 10%*** when compared to homes built in 2002.
- ***Almost half of homes (46% statewide) are constructed using ceiling insulation levels that are lower than prescriptive values. Similarly, 52% of homes are built with wall insulation below prescriptive values.***

7.3 Analysis of Compliance

Analysis of the MICROPAS results on a *non-compliant*/*compliant* criterion was not appropriate due to some on-site measurement error,[1] characterized by the error band discussed in Section 2.4. As a result, a third "compliance group" would have been added to characterize the compliance runs (*indeterminate*). However, because of the interest in RNC programs, an additional group was formed (*high efficiency*). As shown below, this group includes those homes with a % compliance margin greater than 19%.[2] As such, four compliance groups were used as the basis for analysis of the MICROPAS results.

- ***Non-Compliant.*** This category includes homes that, based on the analysis, are not compliant with Title 24 code. In particular, these homes have a % compliance margin less than the lower end of the error band (i.e., <-5%).
- ***Indeterminate.*** This category includes homes that have a % compliance margin within the error band (-5% to 4%). As such, it is indeterminate as to whether these homes comply with the Title 24 codes.
- ***Compliant.*** This category includes homes that, based on the analysis, are compliant with Title 24 code. In particular, these homes have a % compliance margin greater than the upper end of the error band (i.e., > 4% and < 19%).
- ***High Efficiency.*** This category includes homes that, based on the analysis, are overly compliant with Title 24 code. In particular, these homes have a % compliance margin greater than 19%. This category was created to account for the share of homes that would meet the existing California ENERGY STAR New Home construction requirements, given the error band.[3]

Below is a summary of the results from the compliance analysis.

- ***Approximately 27% of sites are in the non-compliant group.*** Of the 155 non-compliant sites, 75% (117 homes) were from RMST Climate Zone 4.
- ***Approximately 13% of sites are in the high efficiency group.*** Of the 72 high efficiency sites, 39% (28 homes) were from RMST Climate Zone 2.

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1 On-site measurement error is described as items estimated during, or after, the on-site survey for those items that can not always be verified or exact. Examples include: using mapped U-values and SHGC values for fenestration since these can not be recorded during the on-site survey due to removal of window stickers after the occupant moves in and using default wall R-values due to the inability to always obtain wall insulation values as the surveyor is not allowed to drill a hole in the wall.

2 ENERGY STAR® requires that a home use 15% less energy than the maximum allowed. The error band, discussed in Section 2.4, was then put around the 15%, which results in the 19% shown as the cut-off for this group.

3 Please note that homes in this group were not ENERGY STAR New Homes participants as all participants were removed from the baseline. This group simply includes homes that, as-built, would have qualified to be ENERGY STAR New Homes.

- ***Nearly 47% of the homes are identified as compliant*** (i.e., they are in the compliant or high efficiency compliance groups).
- ***RMST Climate Zone 5 (Desert and Mountain) is the most non-compliant of the RMST climate zones*** based on the average % compliance margin of -6%. In fact, 55% of sites in RMST Climate Zone 5 fall in the non-compliant group, compared to only 1% of RMST Climate Zone 2 and 3% of RMST Climate Zone 1.[4]
- ***RMST Climate Zones 1 and 2 (North and South Coast) are the most compliant of the RMST climate zones*** based on the average % compliance margin of 19% and 16%, respectively. In fact, 48% of sites in RMST Climate Zone 1 fall in the high efficiency group, as opposed to only 1% of RMST Climate Zone 4 and 3% of RMST Climate Zone 5.[5]

Figure 7-1: MICROPAS Results Summary

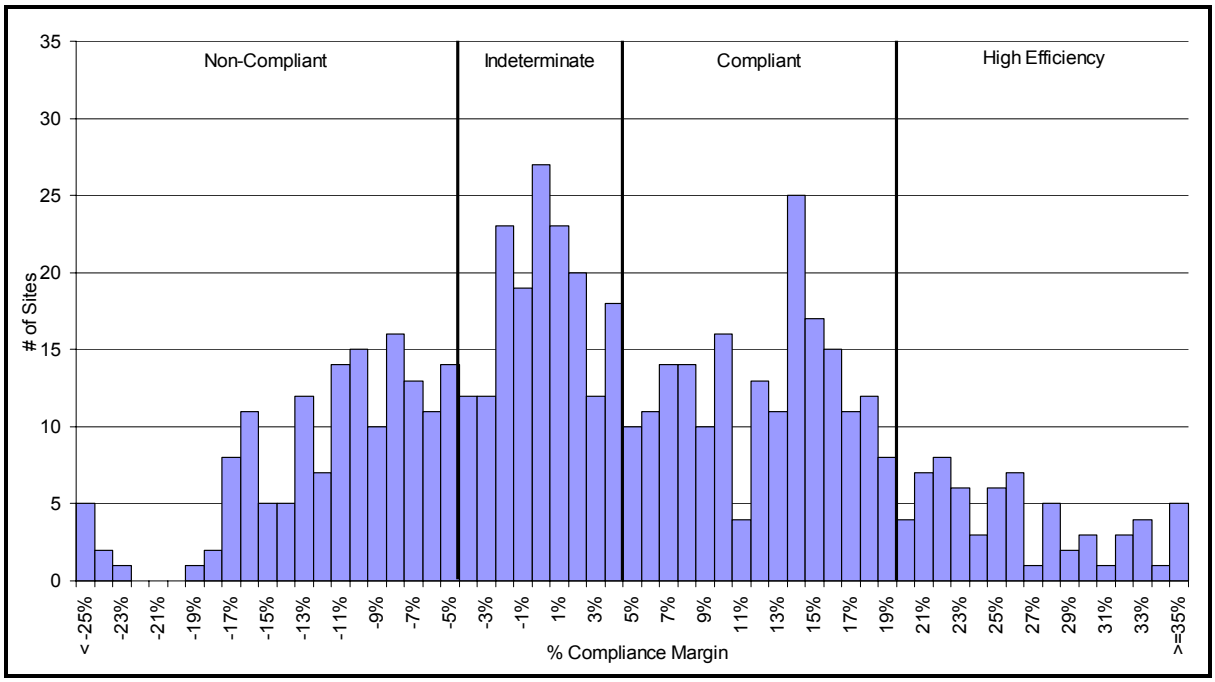

Table 7-1: Average Compliance Margins by RMST Climate Zone

	Overall	RMST CZ1	RMST CZ2	RMST CZ3	RMST CZ4	RMST CZ5
Average % Compliance Margin	3.8%	19.2%	16.0%	9.4%	-2.9%	-5.7%

4 See Section 3.5 for a summary of key characteristics by RMST climate zone.

5 See Section 3.5 for a summary of key characteristics by RMST climate zone.

7.4 Builder Surveys

The following summarizes key results of the builder interviews with respect to standard specification practices for new detached single family homes in California.

- ***Adjustment to the 2001 Standards was most difficult for builders in the South Inland region.*** Overall, builders rated the adjustment to the 2001 Standards to be "somewhat difficult." Despite the considerable changes from the 1998 Standards, these results indicate that the building industry has adjusted to the 2001 Standards.[6] The adjustment to the Standards was rated most difficult by builders of homes in the South Inland region where the requirements are more stringent than along the coast.
- ***High performance windows are becoming standard in single family new homes.*** The specification of high performance windows—vinyl-framed, dual-paned, low-E windows—is standard practice for most builders in California. Builders specify low-E glass and vinyl frames for most homes in the Central Valley and Desert regions, but slightly less frequently in the coastal regions. These results are considerably different from the findings of previous RNC studies, which reported clear glass to be standard.[7]
- ***Tract builders typically specify the same package of measures for each model of a development.*** High volume builders of ENERGY STAR homes report that their general compliance strategy is to choose the efficiency of the equipment and type of windows based on the combination of measures that makes the least complying model meet code.
- ***Market barriers to adoption of radiant barriers exist.*** While the survey results indicate that some builders are installing radiant barriers as a standard practice, many indicated they are not familiar with the material and do not have enough information to justify integrating it into their building plans. Such lack of information and performance uncertainties indicate that training and outreach are still needed for radiant barriers to be more widely accepted technology.
- ***Duct insulation upgrade potential is limited by duct cavity.*** Some builders reported upgrading duct insulation to R-6. R-8 duct insulation is virtually nonexistent because the limited duct space prohibits additional insulation.
- ***Builders are knowledgeable regarding the equipment installed in new homes.*** Interviews with builders show that they are knowledgeable about the efficiencies of measures being installed in new homes.

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6 The results of the interviews with Title 24 consultants revealed the same pattern – the most difficult period of adjustment immediately follows the inception of new standards. Over time, builders adjust their practices and accept the new requirements.

7 Regional Economic Research. *Residential New Construction Study*. Prepared for the Pacific Gas and Electric Company. September 2001.
Regional Economic Research. *Residential New Construction Study – Year 2*. Prepared for the Pacific Gas and Electric Company. September 2002.

7.5 Title 24 Consultant Surveys

Title 24 consultants have a strong familiarity and understanding of the energy-related characteristics of new homes as well as builder specification strategies to comply with Title 24 Standards. The surveys and in-depth interviews provide valuable insight into how the 2001 revision to the Standards impacted compliance practices, as well as the differences between homes that just meet Title 24 and those that qualify for the ENERGY STAR New Homes program. The following are key findings.

- ***Impact of the 2001 Standards.*** The 2001 Standards have had the greatest impact on building practices in the Desert and High Desert regions (CEC Climate Zones 14 and 15), followed by the South Inland and Central Valley regions (CEC Climate Zones 8 though 13). This result confirms expectations of earlier studies and is not surprising since the 2001 revisions focused on reducing cooling peak demand.
- ***Measures requiring third party verification are specified only as last resort for Title 24 compliance.*** According to Title 24 consultants, the additional cost, potential disruption to the construction schedule, and potential insurance risk associated with measures requiring third party verification create a significant disincentive for specification of such measures. HERS-related measures are most commonly found in the Desert and High Desert where the Title 24 Standards are most stringent. Additionally, some builders claim to use duct and building envelope sealing practices, but do not include them in the Title 24 compliance analysis specifically to avoid verification requirements.
- ***Specification practices of ENERGY STAR homes.*** Interviews with high volume consultants who provide turnkey services and conduct analysis for both ENERGY STAR and non-ENERGY STAR homes revealed that duct system sealing is a common upgrade for ENERGY STAR qualification. High efficiency central air conditioning, thermostatic expansion valves (TXVs) and high performance windows are also used in the cooling climate regions.
- ***Title 24 Consultants have a good grasp on construction practices.*** Interviews with Title 24 consultants show that they are very knowledgeable about the efficiencies of measures being installed in new homes. When comparing their self-reported results to the results of the on-site surveys, the only measure group where answers were significantly different was insulation.

7.6 Residential Standards Issues

The following are some suggestions and observations designed to highlight issues that might be important to Title 24 consultants and agencies that design/revise the Standards.

- ***A new baseline for single family attached and multifamily buildings is needed.*** The most recent baseline study of multifamily buildings was conducted several years ago and analyzed buildings built in 2000 under the 1998 Standards. A baseline must be developed to accurately determine savings from the California ENERGY STAR New Homes program for these building types. A new baseline study would also provide data on whether multifamily builders are switching to low-E windows and other trends seen in single family detached homes.
- ***A billing analysis of MICROPAS and EnergyPro results is needed.*** In order to better develop kWh and therms savings estimates, it would be useful to conduct a billing analysis of both the 2001 and 2005 compliance software. This will be especially important under the 2005 Standards since the time dependent valuation (TDV) version will predict peak demand and time-of-use (TOU) usage.

Appendix A

Sample C-2R Form – 2001 Standards

```
COMPUTER METHOD SUMMARY                                    Page 1          C-2R
================================================================================
Project Title..... PG&E RNC 2003                      Date..06/30/04 14:46:04
Project Address..... 5555 Main Street         *******  ---------------------
                     Stockton                 *v6.54*  | ________________ |
Documentation Author... Itron, Inc.           *******  | Building Permit # |
                     Regional Economic Research       | ________________ |
                     11236 El Camino Real             | Plan Check / Date |
                     San Diego, CA  92130             | ________________ |
                     858-481-0081                     | Field Check/ Date |
Climate Zone..... 12                                  ---------------------
Compliance Method..... MICROPAS6 v6.54 for 2001 Standards by Enercomp, Inc.
================================================================================
|     MICROPAS6 v6.54  File-O0312414  Wth-CTZ12S92  Program-FORM C-2R         |
|         User#-MP2206  User-Regional Economic Researc  Run-Site.12414        |
--------------------------------------------------------------------------------

       ================================================================
       =                  MICROPAS6 ENERGY USE SUMMARY                =
       =                  ----------------------------                =
       =  Energy Use                Standard    Proposed   Compliance  =
       =  (kBtu/sf-yr)               Design      Design      Margin     =
       =  ----------------------  ----------  ----------  ----------  =
       =  Space Heating.........     20.05       18.37        1.68     =
       =  Space Cooling.........      5.82        8.98       -3.16     =
       =  Water Heating.........     13.94       12.15        1.79     =
       =                           --------    --------    --------   =
       =              North Total    39.81       39.50        0.31     =
       =                                                              =
       =  Space Heating.........     20.05       19.97        0.08     =
       =  Space Cooling.........      5.82        8.62       -2.80     =
       =  Water Heating.........     13.94       12.15        1.79     =
       =                           --------    --------    --------   =
       =               East Total    39.81       40.74       -0.93     =
       =                                                              =
       =  Space Heating.........     20.05       20.49       -0.44     =
       =  Space Cooling.........      5.82        6.45       -0.63     =
       =  Water Heating.........     13.94       12.15        1.79     =
       =                           --------    --------    --------   =
       =              South Total    39.81       39.09        0.72     =
       =                                                              =
       =  Space Heating.........     20.05       18.96        1.09     =
       =  Space Cooling.........      5.82        7.63       -1.81     =
       =  Water Heating.........     13.94       12.15        1.79     =
       =                           --------    --------    --------   =
       =               West Total    39.81       38.74        1.07     =
       =                                                              =
       =  *** Building does not comply with Computer Performance ***  =
       ================================================================
_
```

COMPUTER METHOD SUMMARY Page 2 C-2R

Project Title..... PG&E RNC 2003 Date..06/30/04 14:46:04

MICROPAS6 v6.54 File-O0312414 Wth-CTZ12S92 Program-FORM C-2R
User#-MP2206 User-Regional Economic Researc Run-Site.12414

GENERAL INFORMATION

Conditioned Floor Area.....	1800 sf
Building Type.....	Single Family Detached
Construction Type	New
Building Front Orientation.	Cardinal - N,E,S,W
Number of Dwelling Units...	1
Number of Building Stories.	1
Weather Data Type.....	ReducedYear
Floor Construction Type....	Slab On Grade
Number of Building Zones...	1
Conditioned Volume.....	18900 cf
Slab-On-Grade Area.....	1800 sf
Glazing Percentage.....	15.1 % of floor area
Average Glazing U-factor...	0.37 Btu/hr-sf-F
Average Glazing SHGC.....	0.41
Average Ceiling Height.....	10.5 ft

BUILDING ZONE INFORMATION

Zone Type	Floor Area (sf)	Volume (cf)	# of Dwell Units	Cond-itioned	Thermostat Type	Vent Height (ft)	Vent Area (sf)	Air Leakage Credit
HOUSE								
Residence	1800	18900	1.00	Yes	Setback	2.0	Standard	No

OPAQUE SURFACES

Surface	Area (sf)	U-factor	Insul R-val	Act Azm	Tilt	Solar Gains	Form 3 Reference	Location/ Comments
HOUSE								
1 Wall	145	0.088	13	0	90	Yes	W.13.2X4.16	Default RVal
2 Wall	283	0.088	13	0	90	No	W.13.2X4.16	Default RVal
3 Wall	509	0.088	13	90	90	Yes	W.13.2X4.16	Default RVal
4 Wall	490	0.088	13	180	90	Yes	W.13.2X4.16	Default RVal
5 Wall	485	0.088	13	270	90	Yes	W.13.2X4.16	Default RVal
6 Door	24	0.500	0	0	90	Yes	None	Metal Door
7 Door	24	0.500	0	90	90	Yes	None	Metal Door
8 Roof	1800	0.031	30	n/a	0	Yes	R.30.2X4.24	Default RVal

COMPUTER METHOD SUMMARY Page 3 C-2R

Project Title..... PG&E RNC 2003 Date..06/30/04 14:46:04

MICROPAS6 v6.54 File-O0312414 Wth-CTZ12S92 Program-FORM C-2R
User#-MP2206 User-Regional Economic Researc Run-Site.12414

PERIMETER LOSSES

Surface	Length (ft)	F2 Factor	Insul R-val	Solar Gains	Location/Comments
HOUSE					
9 SlabEdge	170	0.700	R-0	No	Slab

FENESTRATION SURFACES

Orientation	Area (sf)	U-factor	SHGC	Act Azm	Tilt	Exterior Shade Type	Location/Comments
HOUSE							
1 Wind Back (S)	20.0	0.370	0.410	180	90	Standard	WB1/VW.2.LowE.Wind
2 Wind Back (S)	50.0	0.370	0.410	180	90	Standard	WB2/VW.2.LowE.Wind
3 Door Back (S)	13.0	0.370	0.410	180	90	Standard	DB3/VW.2.LowE.Door
4 Wind Right (W)	15.0	0.370	0.410	270	90	Standard	WR4/VW.2.LowE.Wind
5 Wind Back (S)	39.0	0.370	0.410	180	90	Standard	WB5/VW.2.LowE.Wind
6 Wind Left (E)	20.0	0.370	0.410	90	90	Standard	WL6/VW.2.LowE.Wind
7 Wind Right (W)	20.0	0.370	0.410	270	90	Standard	WR6/VW.2.LowE.Wind
8 Wind Left (E)	6.0	0.370	0.410	90	90	Standard	WL7/VW.2.LowE.Wind
9 Wind Right (W)	2.0	0.370	0.410	270	90	Standard	WR8/VW.2.LowE.Wind
10 Wind Front (N)	3.0	0.370	0.410	0	90	Standard	WF9/VW.2.LowE.Wind
11 Wind Right (W)	48.0	0.370	0.410	270	90	Standard	WR10/VW.2.LowE.Wind
12 Wind Front (N)	35.0	0.370	0.410	0	90	Standard	WF11/VW.2.LowE.Wind

OVERHANGS AND SIDE FINS

		Window		Overhang			Left Fin			Right Fin		
Surface	Area (sf)	Wdth	Hgth	Dpth	Hght	Left Ext	Rght Ext	Ext	Dpth	Hght	Ext	Dpth	Hght
HOUSE													
10 Window	3.0	n/a	5.916	2.5	12	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
11 Window	48.0	n/a	5.916	2.5	12	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
12 Window	35.0	n/a	5.916	2.5	1	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

SLAB SURFACES

Slab Type	Area (sf)
HOUSE	
Standard Slab	1800

COMPUTER METHOD SUMMARY Page 4 C-2R

Project Title..... PG&E RNC 2003 Date..06/30/04 14:46:04

MICROPAS6 v6.54 File-O0312414 Wth-CTZ12S92 Program-FORM C-2R
User#-MP2206 User-Regional Economic Researc Run-Site.12414

HVAC SYSTEMS

System Type	Minimum Efficiency	Refrigerant Charge and Airflow	Duct Location	Duct R-value	Tested Duct Leakage	ACCA Manual D	Duct Eff
HOUSE							
Furnace	0.820 AFUE	n/a	Attic	R-4.2	No	No	0.743
ACSplit	12.00 SEER	No	Attic	R-4.2	No	No	0.674

WATER HEATING SYSTEMS

Tank Type	Heater Type	Distribution Type	Number in System	Energy Factor	Tank Size (gal)	External Insulation R-value
1 Storage	Gas	Standard	1	0.6	50	R- n/a

SPECIAL FEATURES AND MODELING ASSUMPTIONS

*** Items in this section should be documented on the plans, ***
*** installed to manufacturer and CEC specifications, and ***
*** verified during plan check and field inspection. ***

This is a multiple orientation building with no orientation restrictions.
This printout is for the front facing North.

Appendix B

2003 On-Site Survey Instrument

Site ID #

2003 Residential New Construction
Detached Single Family Home
On-Site Survey Form

Itron-RER, Inc. and Kema-Xenergy, Inc.

Version: 2/28/2003

Contact Information:

Contact Name:			
Phone Number:	**( )**		
Street Address:			
City:		Zip Code:	
Mailing			
City:		Zip Code:	
County:		CEC Climate Zone #:	

* Only needed if different from Street Address

Photo Information

Survey Tracking Information:

	Date:	**Performed by, Initials**
Field Survey Performed:	__ / __ / __	__ __ __
Quality Control Check:	__ / __ / __	__ __ __
Data Entry Complete:	__ / __ / __	__ __ __
Survey and Data Received by RER:	__ / __ / __	__ __ __

Table of Contents

Energy Utility Meters & Accounts

Is customer responsible for the utility bills? ☐ Yes ☐ No

Item #	Service Type*	Utility	Meter Number (Enter –7 if can't read it)	Account Number
1	**E G O**	**SDG&E SCE SCG PG&E SMUD OT** _____		
2	**E G O**	**SDG&E SCE SCG PG&E SMUD OT** _____		
3	**E G O**	**SDG&E SCE SCG PG&E SMUD OT** _____		

*Description for Other (**O**) Service Type: _____

Comments

General Site Information

Type of residence: (CHECK ONLY ONE)

- ☐ Detached, tract-built single family house
- ☐ Detached, custom-built single family house
- ☐ Other detached single family home _____

Does the occupant own or rent this residence? ☐ Own ☐ Rent

If owned, is the occupant a first-time homebuyer? ☐ Yes ☐ No

How many stories tall is the residence (including basement)? ___ ☐ Split foyer ☐ Split level

What is the total conditioned floor area of the residence other than garage, basement, and porch? _____

How many bedrooms/bathrooms does the residence have? _____ / _____

Are any of the following areas used as conditioned living space? (ENTER FLOOR AREA FOR ALL THAT APPLY)

_____ Garage (ft^2) _____ Porch ($ft^{2)}$
_____ Basement (ft^2) _____ Other (ft^2)

HOMEOWNERS ONLY: Any Title 24 documents present in homeowner's information packet? If so, indicate below what forms were found and ask the homeowner if you can take the documents to make a copy. If they will not allow documents to be copied, record the minimum information indicated in the training manual.

- ☐ C-2R Computer Method Summary
- ☐ CF-1R Certificate of Compliance
- ☐ CF-6R Installation Certificate
- ☐ CF-4R Certificate of Field Verification & Diagnostic Testing or other CHEERS/HERS certification
- ☐ Evidence of new construction energy-efficiency program participation (e.g. Energy Star, etc.)

What was the purchase price of the home?

Actual price $_____

OR ☐ Declined to state

OR

☐**1**	Under $100,000	☐**6**	$500,000 - $600,000
☐**2**	$100,000 - $200,000	☐**7**	$600,000 - $700,000
☐**3**	$200,000 - $300,000	☐**8**	$700,000 - $800,000
☐**4**	$300,000 - $400,000	☐**9**	$800,000 - $900,000
☐**5**	$400,000 - $500,000	☐**10**	over $900,000

Builder/Development Information

Builder's Name:	
Development/Complex Name:	
Month/Year the home was occupied by current resident:	
Month/Year the home was built:	

FOR HOMEOWNERS ONLY: Was the residence built under any of the following utility or federal residential energy-efficiency new construction programs? (NOTE: Check customers document package for this information.)

- ☐ Don't know
- ☐ **California Energy Star New Homes**
- ☐ **Energy Star Home** (look for a bronze plaque mounted somewhere on the home)
- ☐ **Comfort Home** Program (Pacific Gas & Electric)
- ☐ **ComfortWise** Program (Southern California Edison or San Diego Gas & Electric)
- ☐ **Energy Advantage** Home (Southern California Gas)
- ☐ **SMUD Advantage** Home (Sacramento Municipal Utility District)
- ☐ Other new construction program (Build America, Habitat for Humanity, etc.) _____

Were any energy-saving options offered by the builder?

- ☐ No high-efficiency options offered
- ☐ High-efficiency cooling or heating equipment
- ☐ Advanced heating/cooling control/thermostat
- ☐ Improved performance windows (e.g. LowE, spectral LowE, or LowE^2)
- ☐ Pre-wired Home Automation System
- ☐ Solar water heating
- ☐ Solar electric/photovoltaic panels
- ☐ Energy Star appliances
- ☐ Other _____
- ☐ Don't know

How would you rate the overall performance of your heating and cooling system?

- ☐ Excellent (<u>all</u> rooms/floors very well conditioned, system is very quiet)
- ☐ Good (<u>most</u> rooms/floors are adequately conditioned, system is quiet enough)
- ☐ Poor (<u>most</u> rooms/floors are not adequately conditioned and/or noisy system)
- ☐ Major problems, describe: _____

Household Characteristics

Please have the resident answer the following questions:

Number of people who live in this home at least 9 months of the year in the following age groups:

under 2 years	_____
2-5	_____
6-21	_____
40-64	_____
65 and over	_____

Does your home utilize any devices that significantly impact energy use or energy conservation, for example well pumps, photovoltaic systems, backup generator systems, electric automobiles, etc.? Ask the occupant about these items and record relevant notes on the <u>comments page at the end of the survey form</u>.

Indoor & Outdoor Lighting

Item #	1	2	3	4	5	6	7	8
Location: **X**=OutsideLtg **G**=Garage **LN**=Laundry Rm **L**=LivingRm **D**=DiningRm **F**=FamilyRm **U**=UtilityRm ***BathRm***: **BS**= ShwrTub&Toilet **BB**= ShwrTub, no toilet **BT**= Toilet, no ShwrTub **BO**= No ShwrTub or toilet **MB** = MstrBdRm **OB** = OthrBedRm **H** = Halls/Entry **N** = BrkfstNook **OT** = Other _____ ***Kitchen***: **KG** = General/Area **KD** = Decorative/Other								
***Kitchen Diffuser Color / Mat'l:** **G**=Glass **CP**=ClearPlastic **WP**=WhitePlastic **OT**=Other								
Control Type: **S** = Switch (on/off) **M** = Motion sensor **D** = Dimmer **P** = Photocell **T** = Timer **H** = Home Automation System **OT** = Other (describe) _____								
Fixture Type: **C** = Ceiling, surface-mounted **L** = Floor/table lamp **D** = Downlights (cans) **T** = Torchiere **W** = Wall –mounted **H** = Other hard-wired **R** = Recessed **P** = Other plug-in **S** = Suspended **F** = Ceiling fan**								
****Ceiling Fan: Is it the only light source in the room?**	**Y N**	**Y N**	**Y N**	**Y N**	**Y N**	**Y N**	**Y N**	**Y N**
Total Number of Fixtures								
Number of Lamps per Fixture								
Watts per Lamp (enter 2 or 3-way as 50/100/150)								
Lamp Type & Lamp-Specific Details								
I = Incandescent Standard, medium base	I	I	I	I	I	I	I	I
IS = Incandescent Standard, small base	IS	IS	IS	IS	IS	IS	IS	IS
IP = Incandescent PAR	IP	IP	IP	IP	IP	IP	IP	IP
IR = Incandescent Reflector	IR	IR	IR	IR	IR	IR	IR	IR
For Incand. lamps: CFs Applicable (medium base)?	Y N	Y N	Y N	Y N	Y N	Y N	Y N	Y N
F = Fluorescent Tube	F	F	F	F	F	F	F	F
UT = Fluorescent U-tube	UT	UT	UT	UT	UT	UT	UT	UT
OF = Other Fluorescent (describe in comment block)	OF	OF	OF	OF	OF	OF	OF	OF
For Fluor. Tubes: Length in ft. (e.g., 2 4 6 8)								
Diameter (e.g. T8 T10 T12)								
CFG = CF w/Globe-Shaped diffuser	CFG	CFG	CFG	CFG	CFG	CFG	CFG	CFG
CFC = CF, w/Capsule-Shaped diffuser	CFC	CFC	CFC	CFC	CFC	CFC	CFC	CFC
CFR = CF w/reflector	CFR	CFR	CFR	CFR	CFR	CFR	CFR	CFR
CF = Compact Fluorescent, Other	CF	CF	CF	CF	CF	CF	CF	CF
CIR = Circline	CIR	CIR	CIR	CIR	CIR	CIR	CIR	CIR
For CF and CIR,lamps, indicate base type: S = Screw-based P = Pin-based	S P	S P	S P	S P	S P	S P	S P	S P
I=Integrated M=Modular D=Dedicated	I M D	I M D	I M D	I M D	I M D	I M D	I M D	I M D
HA= Halogen "A"	HA	HA	HA	HA	HA	HA	HA	HA
HT = Halogen Tubular	HT	HT	HT	HT	HT	HT	HT	HT
HL = Halogen low voltage	HL	HL	HL	HL	HL	HL	HL	HL
HP = Halogen reflector/PAR **HI**= Halogen IR	HP HI	HP HI	HP HI	HP HI	HP HI	HP HI	HP HI	HP HI
MV = Mercury Vapor **MH** = Metal Halide	MV MH	MV MH	MV MH	MV MH	MV MH	MV MH	MV MH	MV MH
SodiumVapor : HPS = HighPressure **LPS**=LowPress.	HPS LPS	HPS LPS	HPS LPS	HPS LPS	HPS LPS	HPS LPS	HPS LPS	HPS LPS

Indoor & Outdoor Lighting

Item #	9	10	11	12	13	14	15	16
Location: **X**=OutsideLtg **G**=Garage **LN**=Laundry Rm **L**=LivingRm **D**=DiningRm **F**=FamilyRm **U**=UtilityRm ***BathRm***: **BS**= ShwrTub&Toilet **BB**= ShwrTub, no toilet **BT**= Toilet, no ShwrTub **BO**= No ShwrTub or toilet **MB** = MstrBdRm **OB** = OthrBedRm **H** = Halls/Entry **N** = BrkfstNook Other _____ ***Kitchen****: **KG** = General/Area **KD** = Decorative/Other								
***Kitchen Diffuser Color / Mat'l:** **G**=Glass **CP**=ClearPlastic **WP**=WhitePlastic **OT**=Other								
Control Type: **S** = Switch (on/off) **M** = Motion sensor **D** = Dimmer **P** = Photocell **T** = Timer **H** = Home Automation System **OT** = Other (describe) _____								
Fixture Type: **C** = Ceiling, surface-mounted **L** = Floor/table lamp **D** = Downlights (cans) **T** = Torchiere **W** = Wall –mounted **H** = Other hard-wired **R** = Recessed **P** = Other plug-in **S** = Suspended **F** = Ceiling fan**								
****Ceiling Fan: Is it the only light source in the room?**	**Y N**	**Y N**	**Y N**	**Y N**	**Y N**	**Y N**	**Y N**	**Y N**
Total Number of Fixtures								
Number of Lamps per Fixture								
Watts per Lamp (enter 2 or 3-way as 50/100/150)								
Lamp Type & Lamp-Specific Details								
I = Incandescent Standard, medium base	I	I	I	I	I	I	I	I
IS = Incandescent Standard, small base	IS	IS	IS	IS	IS	IS	IS	IS
IP = Incandescent PAR	IP	IP	IP	IP	IP	IP	IP	IP
IR = Incandescent Reflector	IR	IR	IR	IR	IR	IR	IR	IR
For Incand. lamps: CFs Applicable (medium base)?	Y N	Y N	Y N	Y N	Y N	Y N	Y N	Y N
F = Fluorescent Tube	F	F	F	F	F	F	F	F
UT = Fluorescent U-tube	UT	UT	UT	UT	UT	UT	UT	UT
OF = Other Fluorescent (describe in comment block)	OF	OF	OF	OF	OF	OF	OF	OF
For Fluor. Tubes: Length in ft. (e.g., 2 4 6 8)								
Diameter (e.g. T8 T10 T12)								
CFG = CF w/Globe-Shaped diffuser	CFG	CFG	CFG	CFG	CFG	CFG	CFG	CFG
CFC = CF, w/Capsule-Shaped diffuser	CFC	CFC	CFC	CFC	CFC	CFC	CFC	CFC
CFR = CF w/reflector	CFR	CFR	CFR	CFR	CFR	CFR	CFR	CFR
CF = Compact Fluorescent, Other	CF	CF	CF	CF	CF	CF	CF	CF
CIR = Circline	CIR	CIR	CIR	CIR	CIR	CIR	CIR	CIR
For CF and CIR,lamps, indicate base type: S = Screw-based P = Pin-based	S P	S P	S P	S P	S P	S P	S P	S P
I=Integrated M=Modular D=Dedicated	I M D	I M D	I M D	I M D	I M D	I M D	I M D	I M D
HA= Halogen "A"	HA	HA	HA	HA	HA	HA	HA	HA
HT = Halogen Tubular	HT	HT	HT	HT	HT	HT	HT	HT
HL = Halogen low voltage	HL	HL	HL	HL	HL	HL	HL	HL
HP = Halogen reflector/PAR **HI**= Halogen IR	HP HI	HP HI	HP HI	HP HI	HP HI	HP HI	HP HI	HP HI
MV = Mercury Vapor **MH** = Metal Halide	MV MH	MV MH	MV MH	MV MH	MV MH	MV MH	MV MH	MV MH
SodiumVapor : HPS = HighPressure **LPS**=LowPress.	HPS LPS	HPS LPS	HPS LPS	HPS LPS	HPS LPS	HPS LPS	HPS LPS	HPS LPS

Indoor & Outdoor Lighting

Item #	__	__	__	__	__	__	__	__
Location: **X**=OutsideLtg **G**=Garage **LN**=Laundry Rm **L**=LivingRm **D**=DiningRm **F**=FamilyRm **U**=UtilityRm ***BathRm***: **BS**= ShwrTub&Toilet **BB**= ShwrTub, no toilet **BT**= Toilet, no ShwrTub **BO**= No ShwrTub or toilet **MB** = MstrBdRm **OB** = OthrBedRm **H** = Halls/Entry **N** = BrkfstNook **OT** = Other _____ ***Kitchen****: **KG** = General/Area **KD** = Decorative/Other								
***Kitchen Diffuser Color / Mat'l:** **G**=Glass **CP**=ClearPlastic **WP**=WhitePlastic **OT**=Other								
Control Type: **S** = Switch (on/off) **M** = Motion sensor **D** = Dimmer **P** = Photocell **T** = Timer **H** = Home Automation System **OT** = Other (describe) _____								
Fixture Type: **C** = Ceiling, surface-mounted **L** = Floor/table lamp **D** = Downlights (cans) **T** = Torchiere **W** = Wall –mounted **H** = Other hard-wired **R** = Recessed **P** = Other plug-in **S** = Suspended **F** = Ceiling fan**								
****Ceiling Fan: Is it the only light source in the room?**	Y N	Y N	Y N	Y N	Y N	Y N	Y N	Y N
Total Number of Fixtures								
Number of Lamps per Fixture								
Watts per Lamp (enter 2 or 3-way as 50/100/150)								
Lamp Type & Lamp-Specific Details								
I = Incandescent Standard, medium base	I	I	I	I	I	I	I	I
IS = Incandescent Standard, small base	IS	IS	IS	IS	IS	IS	IS	IS
IP = Incandescent PAR	IP	IP	IP	IP	IP	IP	IP	IP
IR = Incandescent Reflector	IR	IR	IR	IR	IR	IR	IR	IR
For Incand. lamps: CFs Applicable (medium base)?	Y N	Y N	Y N	Y N	Y N	Y N	Y N	Y N
F = Fluorescent Tube	F	F	F	F	F	F	F	F
UT = Fluorescent U-tube	UT	UT	UT	UT	UT	UT	UT	UT
OF = Other Fluorescent (describe in comment block)	OF	OF	OF	OF	OF	OF	OF	OF
For Fluor. Tubes: Length in ft. (e.g., 2 4 6 8)								
Diameter (e.g. T8 T10 T12)								
CFG = CF w/Globe-Shaped diffuser	CFG	CFG	CFG	CFG	CFG	CFG	CFG	CFG
CFC = CF, w/Capsule-Shaped diffuser	CFC	CFC	CFC	CFC	CFC	CFC	CFC	CFC
CFR = CF w/reflector	CFR	CFR	CFR	CFR	CFR	CFR	CFR	CFR
CF = Compact Fluorescent, Other	CF	CF	CF	CF	CF	CF	CF	CF
CIR = Circline	CIR	CIR	CIR	CIR	CIR	CIR	CIR	CIR
For CF and CIR,lamps, indicate base type: S = Screw-based P = Pin-based	S P	S P	S P	S P	S P	S P	S P	S P
I=Integrated M=Modular D=Dedicated	I M D	I M D	I M D	I M D	I M D	I M D	I M D	I M D
HA= Halogen "A"	HA	HA	HA	HA	HA	HA	HA	HA
HT = Halogen tubular	HT	HT	HT	HT	HT	HT	HT	HT
HL = Halogen low voltage	HL	HL	HL	HL	HL	HL	HL	HL
HP = Halogen reflector/PAR **HI**= Halogen IR	HP HI	HP HI	HP HI	HP HI	HP HI	HP HI	HP HI	HP HI
MV = Mercury Vapor **MH** = Metal Halide	MV MH	MV MH	MV MH	MV MH	MV MH	MV MH	MV MH	MV MH
SodiumVapor : HPS = HighPressure **LPS**=LowPress.	HPS LPS	HPS LPS	HPS LPS	HPS LPS	HPS LPS	HPS LPS	HPS LPS	HPS LPS

Appliances & Other Equipment

Refrigerators & Freezers *- Manufacturer/Model Data*

Item #1 -- Manufacturer & Brand\Product Line	
-- Model Number	
Item #2 -- Manufacturer & Brand\Product Line	
-- Model Number	
Item #3 -- Manufacturer & Brand\Product Line	
-- Model Number	

Refrigerators & Freezers *- Type/Configuration Data*

Item #	**1**	**2**	**3**
Equipment type: **R** = Refrigerator/Freezer **F** = Freezer **OT=** Other	**R F OT**	**R F OT**	**R F OT**
Defrost type: **F** = Frost-free **M** = Manual	**F M**	**F M**	**F M**
Configuration: ***Ref/Frz:*** **T**=Top-mount freezer **B**=Bottom-mount freezer **S**=Side-by-side **D**=1-door ***Freezer:*** **C** = Chest **U** = Upright **OT** = Other _____	**T B S D** **C U OT**	**T B S D** **C U OT**	**T B S D** **C U OT**
Space/Location: **C** = Conditioned **U** = Unconditioned	**C U**	**C U**	**C U**
Total volume/size, ft^3			
Age in years (enter 1 if less than 1 year old)			
EnergyStar (E☆) labeled/certified?	☐	☐	☐
Through-the-door water and/or ice? **Y**= Yes **N** = No	**Y N**	**Y N**	**Y N**
Automatice ice maker? **Y**= Yes **N** = No	**Y N**	**Y N**	**Y N**
EF (Energy Factor, ft^3/kWh/day)			

	E☆?	**Axis Type**	**Manufacturer**	**Brand\Product Line**	**Model Number**	**Age**
Dishwasher	☐					
Clothes Washer	☐	**V**ert **H**oriz				
	Fuel Type		**Manufacturer**	**Brand\Product Line**	**Model Number**	**Age**
Clothes Dryer	E G P O					

Miscellaneous Equipment

Appliance	**Quantity**	**Fuel Type**
Oven		E G P O
Range		E G P O
Pool Heater		E G P O
Spa Heater		E G P O
Pool Pump		
Color Televisions		
Personal Computers		
Ceiling Fans (non-lamped)		Location from page 7 (circle all): **L D F BT BN MB OB H K N OT**
Other _____		
Other _____		

Water Heating Equipment

	Item # ___	___
Manufacturer		
Model Number (include dash numbers)		
Energy Factor (EF)		
Location: **G**=Garage **A**=Attic **S**=Cond. Space **O**=Outside closet **M**= Mech. Room/Closet **OT**=Other _____	**G A S O M OT**	**G A S O M OT**
Quantity		
Equipment type: **S** = Standard (Storage) Water Heater **I =** Instantaneous (Tankless) **HP** = Heat Pump Water Heater **B** = Boiler **C** = Central plant, shared service **OT** = Other _____	**S I HP B C OT**	**S I HP B C OT**
Fuel Type: **E** = Electricity **G** = Natural Gas **P** = Propane (LPG) **S** = Solar w/back-up **F** = Fuel Oil **N**=Not Heated	**E G P S F N**	**E G P S F N**
-- Solar Backup Type (if relevant): **E** = Electricity **G** = Natural Gas **P** = Propane (LPG) **OT**=Other _____	**E G P OT**	**E G P OT**
Service type: **D** = DHW only **S** = Space heating only **C** = Combined (provides both DHW and space heating)	**D S C**	**D S C**
Tank Capacity/Volume (Gallons)		
Rated Input Capacity		
-- Units for Rated Input Capacity: **B** = kBtuh **W** = kW	**B W**	**B W**
Recovery Efficiency/AFUE(fraction)		
Standby Loss (fraction)		
Does the hot water tank have an external insulation jacket? **Y**=Yes **N**=No	**Y N**	**Y N**
Are hot water heater pipes insulated? **Y**=Yes **N**=No	**Y N**	**Y N**
-- Is pipe insulation R-4 or greater? **Y**=Yes **N**=No	**Y N**	**Y N**
Is water heater less than 8' away from all DHW fixtures? **Y**=Yes **N**=No	**Y N**	**Y N**
Does the system utilize hot water reclaim/recovery? **Y**=Yes **N**=No	**Y N**	**Y N**
Hot water recirculation system present? **Y**=Yes **N**=No	**Y N**	**Y N**
-- Recirculation pump power (hp) *Enter **0** for no pump*	_____ hp	_____ hp
-- Recirc Pump Control type (circle all that apply): **C** = Continous **TP** = Temperature **TM** = Timer **D** = Demand **OT** = Other _____	**C TP TM D OT**	**C TP TM D OT**
Heat trap present? Y=yes, N=no	**Y N**	**Y N**
Low-flow fixtures (showerheads, faucets, etc.)? **Y**=yes, **N**=no	**Y N**	**Y N**
Hot water temperature (°F) If unknown: **H**=High **M**=Medium **L**=Low	**H M L**	**H M L**

Heating, Cooling, Fans, and Ducts

Heating and Cooling Systems

System ID	# ___	#___
Number of units:		
System Information	*(Ref:Upstairs unit)*	*(Ref:Downstairs unit)*
System Type: **C** = Central Unit** **EV** = Evaporative Cooler **RT** = Room Unit, Thru-the-wall **RW** = Room Unit, Window **FR** = Free-standing Room Unit **FL** = Floor Furnace Unit **WF** = Wall Furnace w/fan **WG** = Wall Furnace, gravity **HF** = Hydronic (Fan Coil)** **HR** = Hydronic (Radiant) **BB** = Baseboard/Radiant Heater **S** = Shared central system **P** = Portable Unit **OT** = Other* _____	C EV RT RW FR FL WF WG HF HR BB S P OT	C EV RT RW FR FL WF WG HF HR BB S P OT
% of Residence Served by this System		
Location: **G**=Garage **A**=Attic **S**=Cond. Space **R**=Roof **M**= Mech. Room/Closet **OT**=Other _____	**G A S R** **M OT**	**G A S R** **M OT**
Heating Equipment		
Manufacturer		
Model Number (include dash numbers)		
Equipment Type: **F** = Furnace **HP** = Heat Pump **RH** = Radiant Heater **ER** = Elec. Resistance **HW** = WaterHtgSyst (pg10) **BB** = Baseboard Heater **N** = None **OT** = Other* **Fuel Type:** **E** = Electricity **G** = Natural Gas **P** = Propane (LPG) **F** = Fuel Oil **W** = Wood **OT** = Other* _____	**F** / **HP** / **RH** / **ER** / **HW** / **BB** / **N** / **OT** **E** / **G** / **P** / **F** / **W** / **OT**	**F** / **HP** / **RH** / **ER** / **HW** / **BB** / **N** / **OT** **E** / **G** / **P** / **F** / **W** / **OT**
Input Capacity (circle appropriate units, kBtuh or kW)	_____ kBtuh kW	_____ kBtuh kW
Efficiency | Efficiency Units (A=AFUE H=HSPF E=EER C=COP)	| **A H E C**	| **A H E C**
***HP only**: -- Supplemental Heating Capacity (kW)*		
-- Soft start? (Y/N)	**Y N**	**Y N**
Cooling Equipment		
Manufacturer		
Model Number (include dash numbers)		
Type: **AC** = A/C (Std DX) **ID** = Indirect/Direct Evap **HP** = Heat Pump **N** = None **EV** = Direct Evap **OT** = Other _____	**AC ID** **HP N** **EV OT**	**AC ID** **HP N** **EV OT**
***AC or HP only:** Split-system (S) or Package (P) unit?*	**S P**	**S P**
-- TXValve present? (Yes/No/Don'tKnow/NotApplicable)	**Y N DK NA**	**Y N DK NA**
-- TXV access panel present? (Y/N/DK/NA)	**Y N DK NA**	**Y N DK NA**
Output Capacity (kBtuh)		
Efficiency | Efficiency Units (S=SEER E=EER P=% Sat. Eff)	| **S E P**	| **S E P**
Non-AirCooled Condenser Type: E=Evap **G**=Ground **W**=Water	**E G W**	**E G W**

* Describe Other (**OT**) types in the space provided or comment block.

Heating and Cooling Systems (cont.)

System ID	# ___	#___
Fans/Ventilation (Ducted systems only)		
Indoor Fan, hp		
Supply Air Rate (CFM)		
Fan Type: **C**=Constant **T**=2-speed **V**=Variable	**C T V**	**C T V**
Special Features: **SV**= SmartVent™/Economizer **WH***=Whole-house fan **OT***=Other _____	**SV WH OT**	**SV WH OT**
Thermostat/Controls		
Manufacturer		
Model Number		
Zoned/Zonal Control System?	**Y N**	**Y N**
Thermostat Type (only if applicable): **EM** = Electromechanical **D** = Digital **H** = Hybrid **HAS** = HomeAutomationSystem **OT** = Other _____	**EM D H HAS OT**	**EM D H HAS OT**

* Describe Other (**OT**) types in the space provided or comment block.

Duct Systems

☐ N/A

Does this residence have an accessible attic or ceiling crawl space? ☐ Yes ☐ No

Does this residence have an accessible floor crawl space? ☐ Yes ☐ No

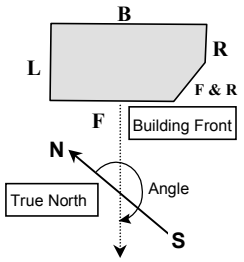
	Supply	**Return**
Predominant Location of Registers: **F**=Floor **C** =Ceiling **I**=Interior Walls **P**=Perimeter/Exterior **OT**=Other*	**F C I P OT**	**F C I P OT**
Location of Ducts (circle all that apply): **A**=Attic **CR** = Crawlspace **CS**=Conditioned Space **W**=Wall Cavity **B**=Basement **OT**=Other*	**A CR CS W B OT**	**A CR CS W B OT**
Duct Types (circle all that apply): **PF**=Plastic Flexduct **MF**=Metal Flexduct **M**=Sheet Metal **P**=Panned Joist **D**=Ductboard **U**=Unfinished wall cavity **OT**=Other*	**PF MF M P D U OT**	**PF MF M P D U OT**
Duct Sealant Types (circle all that apply): **M**=Mastic **BT**=Butyl Tape **MT**=Metal Tape **CT**=Cloth tape **D**=Duct tape **C**=Mech. clamps **OT**=Other*	**M BT MT CT D C OT**	**M BT MT CT D C OT**
--- **Aerosol sealing used** (check for certificate)**?**	**Y N**	**Y N**
--- For tapes, list **UL Label/Brand Name** if visible (e.g. UL181B-FX, UL723)		
Duct Insulation R-Value (–7 if insulation not labeled, 0 if uninsulated)	**-7 0 4.2 6 8**	**-7 0 4.2 6 8**
Duct Condition		
Plenum Condition		

* Describe Other types in comments block.

Comments:

Building Orientation and Construction

Front Wall Orientation



Front orientation angle: (0-360°) _____

External Walls and Doors

Wall orientation (reference: facing the Front wall)	**Front**	**Left**	**Back**	**Right**
Wall Shading: N= None L=Light M=Medium H=Heavy				
Gross Wall Area, ft^2 (*inc. windows, doors, etc.)*				
Demising Wall Area (wall between cond. and uncond. Space),				
Wall Surface Type: S=Stucco W=Wood siding V=Vinyl siding M=Metal siding B=Brick/Block OT=Other*				
Exterior Wall Construction Type: WF24 = 2X4 Wood Framed; WF26 = 2X6 Wood Framed; MF24 = 2X4 Metal Framed; MF26 = 2X6 Metal Framed; WFOM = Wood Foam Panel; BLO = Concrete Block; BRI = Brick; OT = Other*				
Wall Insulation R-Value (from insulation certificate if available)				
Number of Wooden Doors				
Number of Insulated Metal Doors				
Number of Uninsulated Metal Doors				
Door Shading: Patio Cover or Recessed Entry? **Y**es or **N**o	**Y N**	**Y N**	**Y N**	**Y N**

Roof/Ceilings

Ceiling (under Roof) Footprint Area, ft^2	_____ ft^2	
Roof/Ceiling Type	FAT=Framed w/Attic-Crawl Space MET=Metal Decking ADB= Conditioned space above FNO=Framed w/o Attic-Crawl Space CON=Concrete Decking	
-- External Roof Surface	T=Tile (Clay, Concrete, etc.) C=Composition B=Built-up S= Shingle/Shake OT=Other*	
-- External Roof Color	W=White L=Light M=Medium D=Dark	
Radiant barrier type:	**N**=None **NA**=NoAccess **D**=Attached to decking **R**=Attached to rafters	
Non-Vaulted Ceiling Height, ft		ft
Overall Average Ceiling Height, ft		ft
=> Vaulted Ceilings, Estimated % of Total Floor Area with Vaulted Ceilings?		%
Ceiling Insulation R-value	Indicate R-value OR	
	Insulation type: **B** = Batt/Blanket **L** = Loose-fill **OT** = Other _____	
	Indicate inches of insulation in roof cavity	

* Note "Other" construction types in comments block.

Building Orientation and Construction (cont.)

Floor(s)

Number of floors		_____
Total Conditioned Floor Area, ft^2		_____ ft^2
Ground Floor Area, ft^2 (=same as above for 1-story home)		_____ ft^2
-- Ground Floor Construction Type	**S** = Slab **C** = Crawl/Raised **U** = Unheated Basement **O** = Open (Garage) **ADB** = Cond. Space below	
-- Ground Floor Insulation R-Value		R-_____
-- For Slab Floors: Exposed Slab (e.g. tiled, wood flooring) Area, ft2		_____ ft^2
2nd Floor, Floor area over an unconditioned garage, ft^2		_____ ft^2
-- Raised Floor Insulation R-Value		R-_____

Windows, Glass Doors, and Skylights

Item # (use multiple sheets if necessary)		1	2	3	4	5	6
Unit Type	**W**=Window **D**=Door **S**=Skylight **G**=Glass-in-door						
Exterior Shading Device Type	**S** = BugScreens **W** = WovenShadeScreens Louvered: **A** = LowSunAngle(LSA) **L** = Not LSA **R** = Roll-down (blinds/awnings/slats) **N** = None						
Exterior Shading Features	**O** = Architectural Overhang **A** = Awning **N** = None **C** = PatioCover/RecessedEntry **OT** = Other						
Overhang height	Distance from top of window to overhang in feet						
Overhang depth	Depth of the overhang in feet						
Style	**S**=Slider **F**=Fixed **A**=Art glass **D**=Double-hung **B**=Bay/Bow **C**=Casement **W**=Awning **OT**=Other						
Layers of glazing	**1**=Single-pane **2**=Dual-pane **3**=Triple-pane						
Muntins/grids?	**I**=Internal/between panes **E**=External **B**=Both						
Frame type	**M**=Metal **W**=Wood **V**=Vinyl **OT**=Other*						
Glass Type	**C**=Clear **T**=Tinted **R**=Reflective **LowE**: **LN**=Near **LF**=Far						
-- Was this an after-market film/treatment?		**Y N**	**Y N**	**Y N**	**Y N**	**Y N**	**Y N**
Height/Diameter	inches						
Width	inches						
-- Estimated?	Check if estimated & explain in Comments block	☐	☐	☐	☐	☐	☐
Number of *Units* installed:	=> **Front** wall (or **Roof** if skylight)						
	=> **Left** wall						
	=> **Back** wall						
	=> **Right** wall						
Gas-filled (i.e. argon or krypton, not air)?		☐	☐	☐	☐	☐	☐

* Describe Other frame type in comments block

Building Orientation and Construction (cont.)

Windows, Glass Doors, and Skylights (cont.)

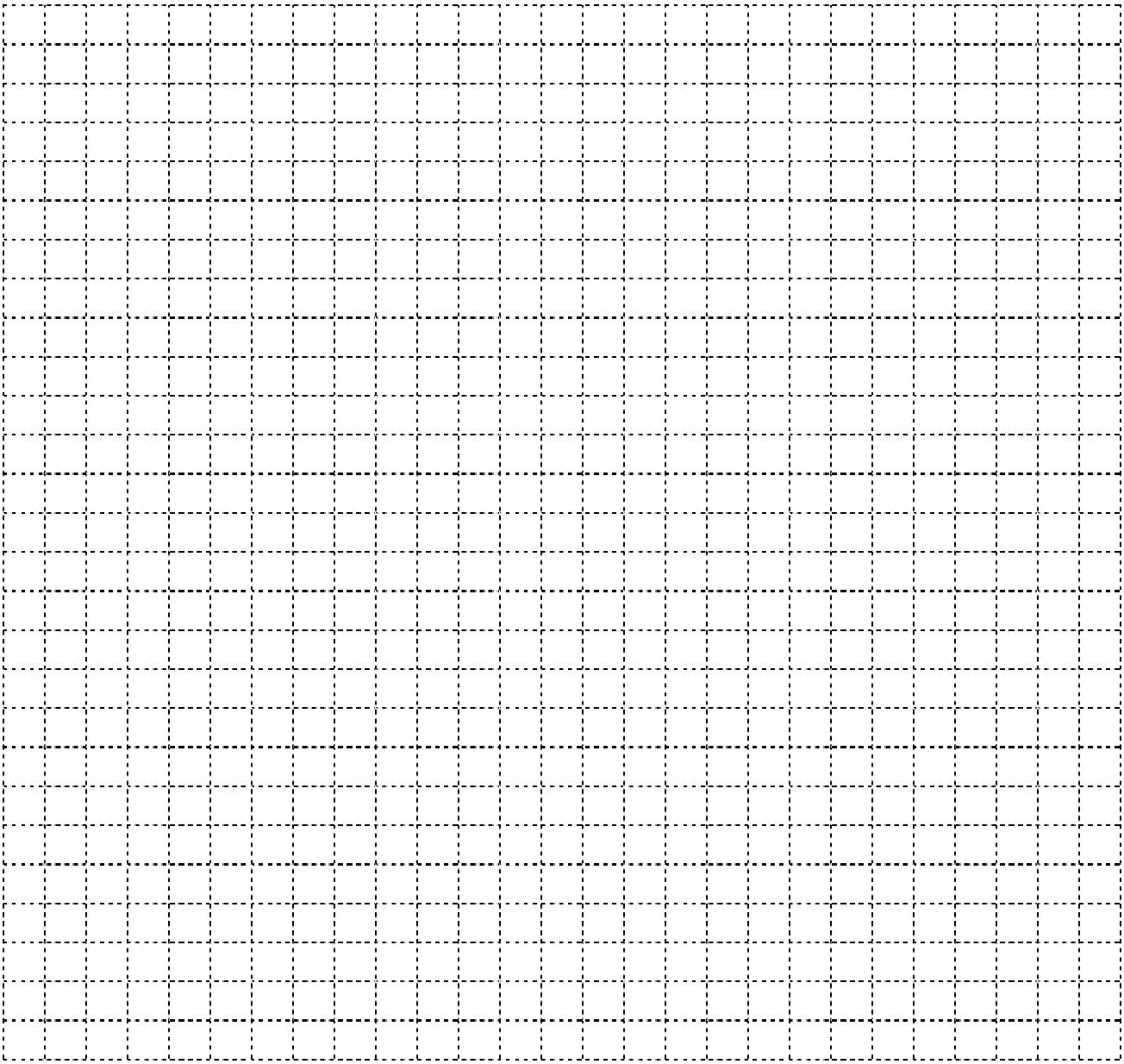
Item # (use multiple sheets if necessary)		__	__	__	__	__	__
Unit Type	**W**=Window **D**=Door **S**=Skylight **G**=Glass-in-door						
Exterior Shading Device Type	**S** = BugScreens **W** = WovenShadeScreens Louvered: **A** = LowSunAngle(LSA) **L** = Not LSA **R** = Roll-down (blinds/awnings/slats) **N** = None						
Exterior Shading Features	**O** = Architectural Overhang **A** = Awning **C** = PatioCover/RecessedEntry **OT** = Other						
Overhang height	Distance from top of window to overhang in feet						
Overhang depth	Depth of the overhang in feet						
Style	**S**=Slider **F**=Fixed **A**=Art glass **D**=Double-hung **B**=Bay/Bow **C**=Casement **W**=Awning **OT**=Other						
Layers of glazing	**1**=Single-pane **2**=Dual-pane **3**=Triple-pane						
Muntins/grids?	**I**=Internal/between panes **E**=External **B**=Both						
Frame type	**M**=Metal **W**=Wood **V**=Vinyl **OT**=Other*						
Glass Type	**C**=Clear **T**=Tinted **R**=Reflective **LowE**: **LN**=Near **LF**=Far						
-- Was this an after-market film/treatment?		**Y N**	**Y N**	**Y N**	**Y N**	**Y N**	**Y N**
Height/Diameter	inches						
Width	inches						
-- Estimated?	Check if estimated & explain in Comments block	☐	☐	☐	☐	☐	☐
Number of units installed:	=> **Front** wall (or **Roof** if skylight)						
	=> **Left** wall						
	=> **Back** wall						
	=> **Right** wall						
Gas-filled (i.e. argon or krypton, not air)?		☐	☐	☐	☐	☐	☐

* Describe Other frame type in comments block

Comments:

Site Sketch

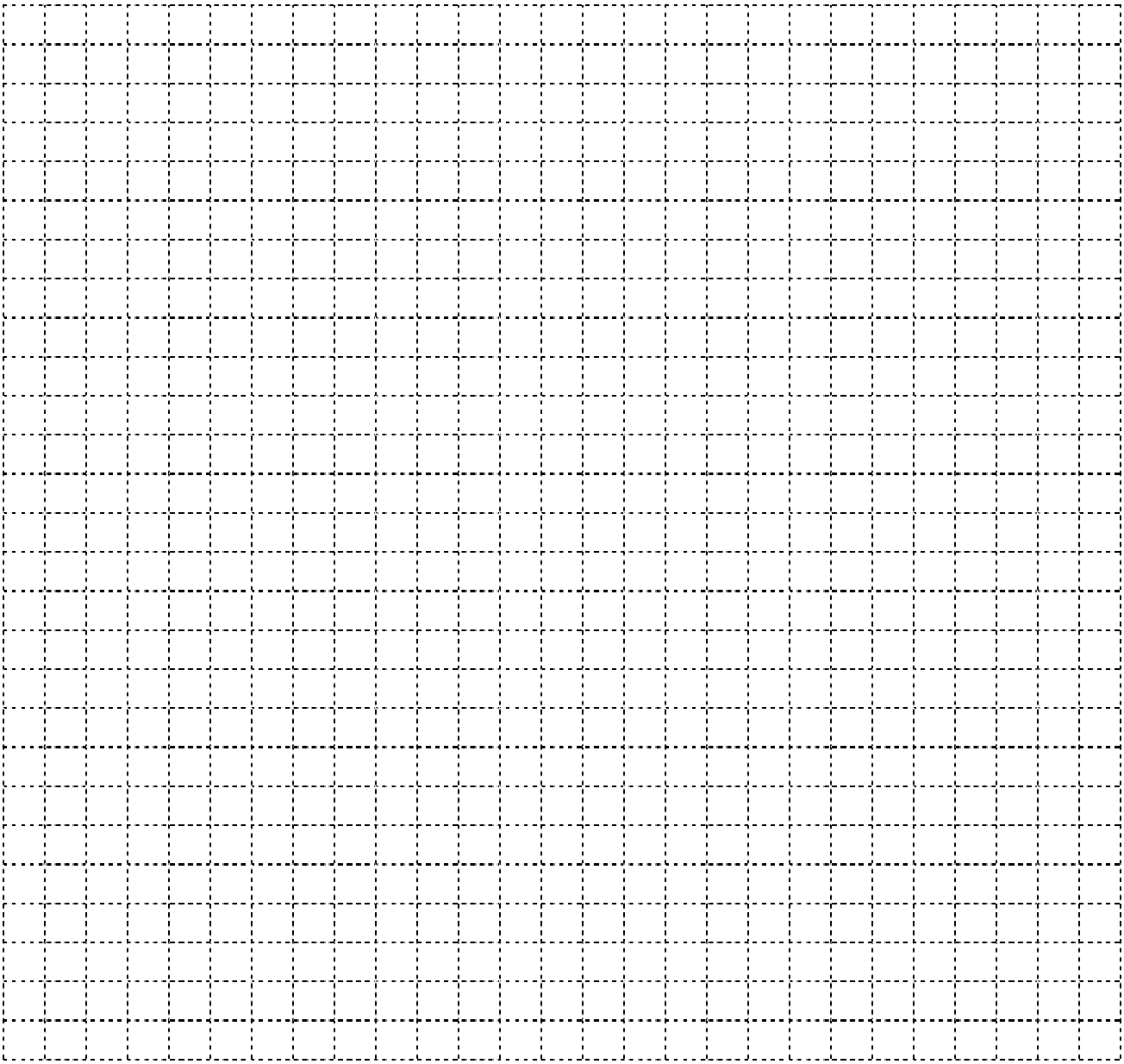
Sketch an outline (i.e. external walls) of the site. Include dimensions and note location of the garage. Draw an arrow to indicate North and show the Front Orientation angle. Note other external walls as Left, Right, and Back (see page 8). Indicate areas with vaulted ceilings. Indicate glazing locations. Show any trees or structures that provide significant shading. Use multiple sheets if needed and number accordingly.



Comments

Site Sketch, Additional Sheet

Sketch an outline (i.e. external walls) of the site. Include dimensions and note location of the garage. Draw an arrow to indicate North and show the Front Orientation angle. Note other external walls as Left, Right, and Back (see page 8). Indicate areas with vaulted ceilings. Indicate glazing locations. Show any trees or structures that provide significant shading. Use multiple sheets if needed and number accordingly.



Comments

Comments and Observations

Page #	Item	Comments

Worksheet for Using the Low-E Coating Detecctor

Instructions:.

1) Find a window that is relatively clean. The ETEKT+ works by detecting the presence and location of an electrically conductive coating in or on a window. All Low-E coatings are conductive, but unfortunately so is pollution, so the window tested should be relatively clean.

2) Take a meter reading from <u>inside the house</u> on at least one window (most typical construction) on each side of the house and record results in Table 1-1 below.

3) Take a meter reading from <u>outside the house</u> on the same windows tested in step 2) and record results in Table 1-1 below.

4) In addition, check any west-facing or southwest-facing windows that appear to be a different color than other windows in the house (these may have had after-market window films applied to them). Also test additional windows if the Low-E surface is found to be installed incorrectly.

Table 1-1 ETEKT+ Meter Worksheet for Determing Window Treatment

Window Item # (from page 14/15)		____	____	____	____	____
Side of Home	**F** = Front **B** = Back **L** = Left **R** = Right	**F B** **L R**	**F B** **L R**	**F B** **L R**	**F B** **L R**	**F B** **L R**
ETEKT reading from inside the house	**G** = Green / Clear **Y** =Yellow / On NEAR surface **R** =Red / On FAR surface **A** =All / On Contacting surface	**G** **Y** **R** **A**	**G** **Y** **R** **A**	**G** **Y** **R** **A**	**G** **Y** **R** **A**	**G** **Y** **R** **A**
ETEKT reading from outside the house	**G** = Green / Clear **Y** =Yellow / On NEAR surface **R** =Red / On FAR surface **A** =All / On Contacting surface	**G** **Y** **R** **A**	**G** **Y** **R** **A**	**G** **Y** **R** **A**	**G** **Y** **R** **A**	**G** **Y** **R** **A**
Glass Type	**C** = Clear **T** =Tinted **R** =Reflective **LN** =LowE NEAR surface **LF** =LowE FAR surface	**C** **T** **R** **LN** **LF**	**C** **T** **R** **LN** **LF**	**C** **T** **R** **LN** **LF**	**C** **T** **R** **LN** **LF**	**C** **T** **R** **LN** **LF**
-- Was this an after-market film/treatment?		**Y N**	**Y N**	**Y N**	**Y N**	**Y N**

Decoding the ETEKT+ Indicators, Examples:.

Inside Reading	Outside Reading	Glass Type	Aftermarket Film?
CLEAR	CLEAR	C	N
ALL	CLEAR	R or T	Y (on inside surface)
NEAR	FAR	LN (incorrect LowE)	N
FAR	NEAR	LF (correct LowE)	N
ALL	FAR	LN	Y (on inside surface)
ALL	NEAR	LF	Y (on a lowE window)
FAR	FAR	Glass and/or gap too thick for LowE meter	N

Appendix C

Telephone Interview Guide for Title 24 Consultants

Telephone Interview Guide for Title 24 Consultants

FIRM NAME:_____ CONTACT: _____

PHONE #: _____ TITLE: _____

ADDRESS: _____

CITY/ZIP: _____

Introduction

PREFACE: "Hello, my name is _____ and I'm with Itron, Inc. We're conducting a study on how energy consultants like yourself are implementing the Title 24 2001 Low-Rise Residential Standards. The results of this study will be used to establish baseline compliance methods and building practices. We are contacting you because you participated in a similar survey we conducted two years ago, regarding the emergency revision of the Standards under Assembly Bill AB 970. The survey should not take more than 15 minutes. Would you be interested in participating in this follow-up study?

If **Yes***: continue*
If **No***: thank and terminate*

Is now a good time to talk?

If **Yes***: continue*
If **No***: arrange interview time*
Preferred Date/Time: _____/ _____

Before we begin, let me emphasize again that all the questions I am going to ask relate to compliance work done for Low-Rise Residential projects. Let me also assure you that your input will remain confidential.

Background

I would first like to ask you a few background questions about you and your company.

1. During the last interview you stated that approximately #____ Title 24 consultants work in your company. Is this still true?

   ☐ Yes ☐ No ____ # Title 24 consultants

   If not, please explain:

   _____

2. During the last survey you mentioned that approximately ___% of the plans you analyzed were for residential homes and that of these, ___% were detached single family homes and ___% were multifamily buildings. Are these still accurate percentages for the plans that you have analyzed under the 2001 Standards?

   ☐ Yes ☐ No _____% Res _____% SF _____% MF

   If not, please explain:

   _____

3. How many residential building plans have you performed compliance analysis for under the 2001 Standards? How many residential buildings did these plans cover?

   _____ Total # of residential building plans
   _____ Total # of residential buildings represented

4. Approximately what percentage of the homes that you have analyzed under the 2001 Standards were in the following regions / CEC climate zones?

   _____ North Coastal (CEC CZs 1-5)
   _____ South Coastal (CEC CZs 6-7)
   _____ South Inland (CEC CZs 8-10)
   _____ Central Valley (CEC CZs 11-13)
   _____ Desert (CEC CZ 14)
   _____ High Desert (CEC CZ 15)
   _____ Mountains (CEC CZ 16)

5. What percentage of your low-rise residential projects were done using each of the following compliance methods? *(Read list)*

   _____ % Performance Method (*skip to 6. if answer is 100%*)
   _____ % Package D Prescriptive method
   _____ % Alternate to Package D Prescriptive method
   _____ % Package C Prescriptive method

6. What computer compliance programs do you use, and about what percentage of your low-rise residential projects were done using each of those programs? *(Read list)*

   _____ % CALRES
   _____ % EnergyPro
   _____ % MICROPAS
   _____ % Other _____

Changes Seen as a Result of the Implementation of the 2001 Standards

Now I would like to ask you about the changes you have seen in compliance and building practices since the implementation of the 2001 Standards. When answering these questions, please give your answers in the context of region and/or single family/multifamily building type whenever possible.

7. How would you characterize the level of effort required to achieve compliance under the 2001 Standards, versus that required to meet the 1998 Standards? Please answer using a scale of 1 to 5 with a 1 meaning "easy" (not difficult at all) and a 5 meaning "very difficult." Please answer on the basis of the following regions and building types in which you practice (*read from the list based on responses to Q2 {bldg types} and Q4 {climate zones-regions}*):

		Single Family	Multifamily
North Coastal	(CEC CZs 1-5)	_____	_____
South Coastal	(CEC CZs 6-7)	_____	_____
South Inland	(CEC CZs 8-10)	_____	_____
Central Valley	(CEC CZs 11-13)	_____	_____
Desert	(CEC CZ 14)	_____	_____
High Desert	(CEC CZ 15)	_____	_____
Mountains	(CEC CZ 16)	_____	_____

Please Explain:

_____

_____

_____

_____

_____

8. During the last survey, you were asked how likely you thought builders were to use a variety of measures when performing compliance analysis under the 2001 standards. Based on the plans that you have analyzed under the 2001 Standards, how would you now answer for each of the following four measures, using a scale of 1 to 5 with 1 meaning Not at all Likely and 5 meaning Very Likely. Please indicate any differences you have seen by climate zone/region or by residence type. *(Read list and enter values in Now column.)*

(Prev.)	Now	
(____)	____	HERS Certified sealed ducts
(____)	____	TXV(ThermostaticExpansionValve)/Refrigerant Charge Air Flow test
(____)	____	High-performance (LowE or spectrcal LowE) windows
(____)	____	Radiant barriers
(____)	____	Higher efficiency water heater
(____)	____	Higher efficiency central air conditioner
(____)	____	Higher efficiency furnace
(____)	____	Increased wall and/or roof insulation levels
	____	R-8 (versus mandatory R-4) duct insulation

If significant differences from previous responses, probe for differences by region and residence type.

_____

_____

_____

_____

9. In approximately what percentage of the single family homes that you have analyzed under the 2001 Standards implemented the measures listed above?

Single Family	**North Coastal (1-5)**	**South Coastal (6-7)**	**South Inland (8-10)**	**Central Valley (11-13)**	**Desert (14)**	**High Desert (15)**	**Moun-tains (16)**
a. HERS Certified sealed ducts							
b. TXV / Refrigerant Charge Air Flow test							
c. Duct Design per ACCA Manual D							
d. Duct location (basement conditioned space, etc.)							
e. Duct surface area (low % of ducts in attic)							
f. R-8 duct insulation							
g. Building envelope sealing (Blower Door)							
h. High-performance windows							
i. Radiant barriers							
j. Higher efficiency water heater							
k. Higher efficiency central air conditioner							
l. Higher efficiency furnace							
m. Increased roof/wall insulation levels							

_____

_____

_____

_____

_____

10. In approximately what percentage of the multifamily homes that you have analyzed under the 2001 Standards implemented the measures listed above?

Multifamily	**North Coastal (1-5)**	**South Coastal (6-7)**	**South Inland (8-10)**	**Central Valley (11-13)**	**Desert (14)**	**High Desert (15)**	**Mountains (16)**
a. HERS Certified sealed ducts							
b. TXV / Refrigerant Charge Air Flow test							
c. Duct Design per ACCA Manual D							
d. Duct location (basement conditioned space, etc.)							
e. Duct surface area (low % of ducts in attic)							
f. R-8 duct insulation							
g. Building envelope sealing (Blower Door)							
h. High-performance windows							
i. Radiant barriers							
j. Higher efficiency water heater							
k. Higher efficiency central air conditioner							
l. Higher efficiency furnace							
m. Increased roof/wall insulation levels							

_____

_____

_____

_____

_____

11. Are there any other changes that builders have made to standard compliance or construction practices in response to the 2001 Standards?

    ☐ Yes ☐ No

    (If yes) Please describe these changes and indicate the percentage of homes in which builders are installing these measures? *(or the percentage of homes which reflect these changes in practices)*

    _____

    _____

    _____

    _____

12. Are builders installing any measures or features that do not meet the prescriptive (i.e. Package D) requirements of the 2001 Standards? *(Read from list.)*

    ___% Roof insulation lower than prescriptive value
    ___% Wall insulation lower than prescriptive value
    ___% Percent glazing lower than the prescriptive value
    ___% Windows that are lower-performance than prescriptive
    ___% Other measures/features _____

    (If yes) Please indicate the percentage of homes in which this is occurring, and explain any regional variations .

    _____

    _____

13. Are builders installing any Prescriptive package or other measures - like TXVs, high-performance windows, or radiant barriers - but not taking the compliance credit they could? *If so, please explain why.*

    _____

    _____

Energy Efficiency Programs

There are a number of programs in the state that promote energy efficiency in residential new construction projects. I would like to ask you a few questions about your experiences with these programs.

14. How knowledgeable are you of the California Energy Star New Homes Program? Answer using a scale of 1 to 5 with 1 representing Not At All Knowledgeable and 5 being Very Knowledgeable.

    _____

15. What percentage of the single family detached homes for which you provided a compliance analysis under the 2001 Standards, participated in the California Energy Star New Homes Program? What percentage of multifamily?

    ___% Single family detached

    ___% Multifamily

16. What additional features/measures <u>beyond</u> what they would have had to use to just comply with the 2001 Standards, are builders using to meet the California Energy Star Homes requirements? *Probe for building type and climate zone differences and obtain percentages where possible. Also probe whether they simply add a few energy efficient measures to reach EnergyStar or if they use an entirely different package of measures due to the CHEERS requirement. (ex. Do they use duct sealing and other measures that need to be verified more often in EnergyStar homes since the CHEERS rater has to perform a site visit anyway?)*

    _____

    _____

    _____

    _____

    _____

17. How significant of a barrier is each of the following to builders participating in the California Energy Star New Homes Program? Answer using a scale of 1 to 5, with one meaning Not At All Significant and 5 meaning Very Significant. *(Read list.)*

    ___ Complex documentation
    ___ Volume of required documentation
    ___ Required verification process
    ___ Insufficient incentives to participants
    ___ Not cost effective

    17A. In your opinion, are there any other barriers to builders participating in the California Energy Star New Homes Program? *(Probe for differences between building type, climate zone.)*

    _____

    _____

18. Do you have any suggestions for improving participation in the California Energy Star New Homes Program?

    _____

    _____

19. Do you have any final thoughts or comments regarding the Title 24 2001 Residential Standards as they affect residential new construction?

    _____

    _____

    _____

    _____

20. How knowledgeable are you of the proposed 2005 Standards? Answer using a scale of 1 to 5 with 1 representing Not At All Knowledgeable and 5 being Very Knowledgeable.

    _____

Appendix D

In-Depth Interview Guide: Title 24 Consultants

In-Depth Interview Guide: Title 24 Consultants

RERID #:
Interview Date:
Company Name:
Contact Name:
Contact Title:
Phone #:
Street Address:
City/State/Zip:
Elec Utility:

Introduction

PREFACE: "Hello, my name is _____ and I'm with Regional Economic Research (RER). I am contacting you because you participated in a study we conducted two years ago regarding the emergency revision of the Standards under Assembly Bill AB 970. We're now conducting a follow-up study on building practices relative to the Title 24 2001 Low-Rise Residential Standards. The results of this study will help establish baseline compliance methods and building practices. The survey should not take more than 15 minutes. Would you be interested in participating in this follow-up study?

*If **Yes**: continue*
*If **No**: thank and terminate*

Is now a good time to talk?

*If **Yes**: continue*
*If **No**: Preferred Date/Time: _____*

Before we begin, let me emphasize again that all the questions I am going to ask relate to compliance work done for low-rise residential new construction projects. Let me also assure you that your input will remain confidential.

Background

I would first like to ask you a few background questions about you and your company.

1. How many Title 24 consultants work in your company?

   ____ Title 24 consultants

2. Approximately what percentage of the plans you analyzed under the 2001 standards were for residential new construction, *excluding additions*? About what percent of those were for single family detached and what percent were multi-family buildings?

   _____% Res _____% SF _____% MF

   If differences from previous study, probe for explanation:

   _____

   _____

3. How many single-family detached residential building plans have you performed compliance analysis for under the 2001 Standards? How many residential buildings did these plans represent?

   _____ Building plans _____ Buildings

4. Approximately what percentage of the homes that you have analyzed under the 2001 Standards were in the following regions / CEC climate zones? *(Read list)*

   _____ North Coastal (CEC CZs 1-5)
   _____ South Coastal (CEC CZs 6-7)
   _____ South Inland (CEC CZs 8-10)
   _____ Central Valley (CEC CZs 11-13)
   _____ Desert (CEC CZ 14)
   _____ High Desert (CEC CZ 15)
   _____ Mountains (CEC CZ 16)

5. What percentage of your low-rise residential new construction projects analyzed used the following compliance methods? *(Read list)*

   _____ % Performance Method (*skip to 6. if answer is 100%*)
   _____ % Package D Prescriptive method
   _____ % Alternate to Package D Prescriptive method
   _____ % Package C Prescriptive method

6. About what percentage of your low-rise residential new construction projects were analyzed using each of the following programs? *(Read list)*

   _____ % CALRES
   _____ % EnergyPro
   _____ % MICROPAS
   _____ % Other _____

Implementation of the 2001 Standards

Now I am going to ask you about any changes you have observed regarding building design and specification practices since the implementation of the 2001 Standards. Please answer these questions in the context of geographic region (the climate zones/regions you indicated earlier).

7. What is the general attitude of builders with respect to meeting the 2001 Title 24 standards? *Do they think the codes are too restrictive/not restrictive enough? Are certain elements of the code too difficult to meet? Do the standards make sense from their perspective? Probe for attitudes for specific components of the code – measures, packages, etc. and difference in code across climate zones.*

   _____
   _____
   _____
   _____
   _____

8. On a scale of 1 to 5 with a 1 meaning "easy" and a 5 meaning "very difficult," how would you characterize the level of effort required to achieve compliance under the 2001 Standards, compared to meeting the 1998 Standards? *Probe for explanation of the transition and any differences across climate zones.*

North Coastal	(CEC CZs 1-5)	_____
South Coastal	(CEC CZs 6-7)	_____
South Inland	(CEC CZs 8-10)	_____
Central Valley	(CEC CZs 11-13)	_____
Desert	(CEC CZ 14)	_____
High Desert	(CEC CZ 15)	_____
Mountains	(CEC CZ 16)	_____

   _____
   _____
   _____
   _____

9. a. Are there any other changes that builders/designers have made regarding the design and specification of energy-related equipment and shell measures of single family detached homes that were specifically in response to the 2001 Standards?

   ☐ Yes ☐ No

   If yes:
   b. Please describe these changes and indicate the percentage of homes in which builders are installing these measures? *Or the percentage of homes which reflect these changes in practices* _____ %

   _____
   _____
   _____
   _____

10. Using a scale of 1 to 5 with 1 meaning "not at all likely" and 5 meaning "very likely," how often do builders/designers specify the following measures? *Read list. Probe for explanation of differences across climate zones/geographic regions and for significant differences from previous responses.*

(Prev.)	Now	
()	____	HERS Certified sealed ducts
()	____	TXV (Thermostatic Expansion Valve)/Refrigerant Charge Air Flow test
()	____	High-performance (LowE or spectral LowE) windows
()	____	Radiant barriers
()	____	Higher efficiency water heater
()	____	Higher efficiency central air conditioner
()	____	Higher efficiency furnace
()	____	Increased wall and/or roof insulation levels
	____	R-8 (versus mandatory R-4) duct insulation

   _____
   _____
   _____

11. Now I will read you a list of measures. For each measure tell me the approximate percentage of the single-family homes you have analyzed under the 2001 Standards that include each measure for each geographic region covered by your business.

	North Coastal (1-5)	**South Coastal (6-7)**	**South Inland (8-10)**	**Central Valley (11-13)**	**Desert (14)**	**High Desert (15)**	**Mtns (16)**
a. HERS Certified sealed ducts							
b. TXV / Refrigerant Charge Air Flow test							
c. Duct Design per ACCA Manual D							
d. Duct location (basement cond. space, etc.)							
e. Duct surface area (low % of ducts in attic)							
f. R-8 duct insulation							
g. Bldg. envelope sealing (Blower Door)							
h. High-performance windows							
i. Radiant barriers							
j. Higher efficiency water heater							
k. Higher efficiency CAC							
l. Higher efficiency furnace							
m. Increased roof/wall insulation levels							

_____

_____

_____

_____

12. Now I will read you the same list of measures again. Please provide your approximation of incremental costs for each measure, and if there are differences in incremental costs across geographic regions.

☐ Do not know/Do not have information on measure costs.

Measure	Est. Incremental Cost ($/unit)	Comments
a. HERS Certified sealed ducts		
b. TXV / Refrigerant Charge Air Flow test		
c. Duct Design per ACCA Manual D		
d. Duct location (basement conditioned space, etc.)		
e. Duct surface area (low % of ducts in attic)		
f. R-8 duct insulation (vs. R-4)		
g. Building envelope sealing (Blower Door)		
h. High-performance windows		
i. Radiant barriers		
j. Higher efficiency water heater (vs. std. efficiency)		
k. Higher efficiency central air conditioner (vs. std. efficiency)		
l. Higher efficiency furnace (vs. std. efficiency)		
m. Increased roof/wall insulation levels		

_____
_____
_____
_____
_____
_____

13. a. Have you observed any major differences in construction practices, such as equipment specification, overall design, and the measures specified to meet Title 24, between homes in the coastal regions and homes in the inland valleys? *Probe for specific measures, combinations of measures, reasons for these differences, and when differences arose.*

    ☐ Yes ☐ No ☐ Not applicable/Do not know

    b. Between homes in Northern California and homes in Southern California?

    ☐ Yes ☐ No ☐ Not applicable/Do not know

    _____
    _____
    _____
    _____

14. We are aware that the performance method allows for trade-offs among measures such that the energy efficiency of some measures is less than the prescriptive requirements. Are builders specifying (or are you recommending) any of the following measures or features that do <u>not</u> meet the <u>prescriptive</u> (i.e. Package D) requirements of the 2001 Standards? *Read from list. If respondent indicates yes, ask for the percentage of homes in which this is occurring, and probe for any regional variations.*

a. Roof insulation	☐ Yes ____%	☐ No	☐ Do not know
b. Wall insulation	☐ Yes ____%	☐ No	☐ Do not know
c. Percent glazing	☐ Yes ____%	☐ No	☐ Do not know
d. Windows	☐ Yes ____%	☐ No	☐ Do not know
e. Other measures/features _____	☐ Yes ____%	☐ No	☐ Do not know

    _____
    _____
    _____
    _____

15. Are builders installing any Prescriptive package or other measures - like TXVs, high-performance windows, or radiant barriers - but not taking the compliance credit they could? *If so, probe for explanation.*

    ☐ Yes ☐ No ☐ Do not know

    _____
    _____
    _____

16. a. Are you certified to conduct CHEERS/HERS rating inspections?

☐ Yes ☐ No

If yes:

b. How many inspections have you conducted? _____
c. What is the average inspection cost per home? $_____
d. Does this include TXV inspection? ☐ Yes ☐ No
e. Does this include duct testing? ☐ Yes ☐ No

Energy Efficiency Programs

There are a number of programs in the state that promote energy efficiency in residential new construction projects.

17. On a scale of 1 to 5 with 1 meaning "not at all knowledgeable" and 5 meaning "very knowledgeable," how knowledgeable are you of the California ENERGY STAR New Homes Program? _____ *If 1, skip to Q21*

18. What percentage of the single-family detached homes for which you provided a compliance analysis under the 2001 Standards, participated in the California ENERGY STAR New Homes Program? _____% *If 0% skip to Q21* ☐ Do not know

19. What additional features/measures <u>beyond</u> what they would have had to use to just comply with the 2001 Standards, are builders/designers specifying to meet the California ENERGY STAR Homes requirements? *Probe for building type and climate zone differences and obtain percentages where possible. Also probe whether they simply added a few energy efficient measures to reach ENERGY STAR or if they use an entirely different package of measures due to the CHEERS requirement. Do they use duct sealing and other measures that need to be verified more often in ENERGY STAR homes since the CHEERS rater has to perform a site visit anyway?*

_____
_____
_____
_____

20. Has complying homes for the ENERGY STAR New Homes program influenced you to change the way you comply non-participating new homes? In particular, do you …. *Probe for other standard practices attributable to ENERGY STAR program.*

☐ Yes ☐ No Recommend different measures or groups of measures that you would not have before? *If yes, probe for the measures.*

_____
___
_____
___

☐ Yes ☐ No Recommend more high efficiency measures than you did before?
If yes, probe for the measures.

_____
_____
___
_____
___

☐ Yes ☐ No Ask the builder/homeowner if they wish to exceed the minimum efficiency required by Title 24?

☐ Yes ☐ No Ask the builder/homeowner if they wish to meet or exceed ENERGY STAR standards?

☐ Yes ☐ No Other

_____
_____
___
_____
___
_____
___

21. a. Are you aware of any residential developments that meet the ENERGY STAR criteria, but do not go through with the certification?

☐ Yes ☐ No ☐ Do Not Know

If no, skip to Q23

b. About how many such developments have not been certified as ENERGY STAR homes, even though they meet the energy efficiency criteria of the program? About how many homes do these developments represent?

_____ Developments _____ Homes ☐ Do Not Know

22. From your perspective, what do you feel are the major barriers faced by builders seeking to certify homes under the ENERGY STAR New Homes program? *Do not read list, check all that apply. Probe for other barriers not listed and explanation.*

    ☐ Program timeline
    ☐ Verification requirements
    ☐ Product availability
    ☐ Inspection costs
    ☐ There are no barriers to program compliance/certification
    ☐ Do not know
    ☐ Other *Please specify:* _____

    _____
    _____
    _____

23. Using a scale of 1 to 5 with 1 representing "not at all knowledgeable and 5 meaning "very knowledgeable," how knowledgeable are you of the proposed 2005 Standards?

    _____

24. Do you have any final thoughts or comments regarding the Title 24 2001 Residential Standards as they affect residential new construction?

    _____
    _____
    _____
    _____

That is the end of the survey. Thank you for your time, the information you have provided is very valuable to our study.

Appendix E

Builder Interview Guide

Interview Guide: Builders
Participants and Nonparticipants

Contact ID#
RERID #:
Interview Date:
Company Name:
Contact Name:
Contact Title:
Phone #:
Street Address:
City/State/Zip:

Hello, my name is _____ and I'm with Itron. We are conducting a study on behalf of the California utilities (*PG&E, SCE, SDG&E, and SoCalGas)* to assess how the Title 24 2001 Residential Building Standards have impacted design practices and compliance strategies of residential new construction in California.

Are you the person most familiar with the characteristics of the equipment installed in your company's residential projects? *We're specifically interested in characteristics of HVAC system, windows, insulation, and other features that would affect energy usage and that would be related to the Title 24 standards.*

01 Yes – *Continue*
00 No – Who is more appropriate to speak with?
New Contact Name/Title:_____
Phone: _____

We are contacting builders of residential new construction in California to learn about the design and equipment characteristics of their homes. Your participation in this study involves answering some questions over the phone and will take about 20-30 minutes. I would like to emphasize that your input will remain completely confidential. Is now a good time to talk*?*

01 Yes – Continue
00 No – Arrange time for interview: Date/Time: _____/ _____

General Information

First I'd like to ask you a few background questions.

1. How long have you been with the company?
   ___ years/months
   99 refused

2. What is your title? *Do not read, check response.*
   01 CEO, President, Partner, CFO, COO, Chairman of the Board, Executive Director, Owner
   02 Division President, Regional Director, Regional Manager
   03 Vice President, Senior Vice President, Executive Vice President
   04 Purchasing - Director, Vice President, Manager
   05 Construction - Director, Vice President, Manager
   06 Sales & Marketing – Director, Vice President, Manager
   07 Development – Director, Vice President, Manager
   08 Operations – Director, Vice President, Manager
   09 General Manager, Project Manager
   09 Other: _____
   99 Refused

3. Do your duties include making final decisions about **design features** of new homes that affect compliance with Title 24 *(e.g. building shell, HVAC ducting, water heating system design)*?
   01 Yes – *Continue*
   00 No – Who makes such decisions?
      New Contact Name/Title: _____
      Phone: _____

4. Do your duties include making final decisions about the **selection and procurement of equipment** installed in new homes?
   01 Yes – Continue
   00 No – Who makes such decisions?
      New Contact Name/Title: _____
      Phone: _____

5. Who else is on the design/specification ("product development") team? *Do not read list, check all that apply.*
   - 01 Architect
   - 02 Title 24 or energy consultant
   - 03 Mechanical/HVAC contractor
   - 04 Engineer – in house
   - 05 Engineer – consultant
   - 06 Sales & Marketing staff
   - 07 Other: _____
   - 99 Do not know
   - 98 Refused

Types of Homes

Now I would like to ask you a few questions about the homes your company built last year.

6. What percentage of the homes your company built last year were single-family? Multi-family?
   - a. ____ % Single-family 999 Do not know/refused
   - b. ____ % Multi-family 999 Do not know/refused

   % must add to 100

   If Q6a<20% then terminate: This study is specifically in regard to single-family homes. Because the majority of your company's projects are multi-family, we do not need your input. Thank you anyway for your time.

7. About how many single-family new homes did your company build in 2002?
   - ____ Homes
   - 999 Do not know/refused

This study we are conducting is specifically in regard to newly constructed single-family detached homes. Please answer the remaining questions only with respect to single-family homes.

8. What percentage of the single-family homes your company built last year were production homes?
   - ____ % Production 999 Do not know/refused
   - ____ % Custom/Semi-custom 999 Do not know/refused

   % must add to 100

9. About what percent of the homes you built last year were in each of the following regions? *Read list.*

   a. North Coastal: _____%
   b. South Coastal: _____%
   c. South Inland: _____%
   d. Central Valley: _____%
   e. Desert: _____%
   f. Mountain: _____%

! *Note: The regions provided here should be used for Q32 and in probes to uncover differences in practices across geographic regions.*

10a. Did your company build homes last year that qualified for the California ENERGY STAR New Homes Program?

   00 No – *Nonparticipant Survey Module (Q1-Q38 and Q68-Q92)*
   01 Yes – *Participant Survey Module (Q1-Q38 and Q39 – Q67)*
   999 Do not know/refused – Confirm respondent is most appropriate contact.

If 10a = Yes

10b. What percentage of the homes your company planned in 2002 were committed into the ENERGY STAR program?

   _____%
   999 Do not know/refused

If 10a = Yes

10c. What percentage of these committed homes have been built and certified as ENERGY STAR?

   _____%
   999 Do not know/refused

Current Practices with Respect to Title 24 2001 Low-rise Residential Standards

Now I would like to ask you some questions regarding your experience with the current 2001 Title 24 Residential Standards.

11. On a scale of 1 to 5 with a 1 meaning not at all familiar and a 5 meaning very familiar, how familiar are you with the 2001 Title 24 requirements?
    5 4 3 2 1

    If Q12=1, need to identify more appropriate contact for this section of the survey. See responses to Q3 and 4.

General Description of Compliance Procedures

12. Did an individual with an in-house position or an outside consultant conduct the compliance analysis for the homes that your company built last year?
    01 In house position
    02 Outside consultant
    99 Do not know

    If outside consultant:
    a. Who is the outside consultant?

    _____

    99 Do not know/refused

13. What is your company's typical strategy to make sure your homes comply the Title 24 standards? *Probe: Do they typically use the same measures or combination of measures? Does it vary by geographic region? Do they always specify some measures and avoid others? Why?*
    99 Do not know

    _____
    _____
    _____
    _____

    Does this vary by …
    a. Project?
       00 No
       01 Yes – Describe: _____
    b. Project location?
       00 No
       01 Yes – Describe: _____

Current Design/Specification Practices

Now I would like to ask you a few questions about the selection of specific equipment and shell measures specified for the homes your company built last year.

HVAC Equipment

14. What AFUE level of furnace do you typically install?
    ___ AFUE
    999 Do not know – *skip to Q15*

a. Does it vary by climate zone?
    00 No
    01 Yes – *Probe for differences between climate zones.*
    _____
    _____
    999 Do not know

15. What percentage of the homes do you install furnaces with AFUEs:
    a. 78 to 80 _____% 999 Do not know
    b. 81 to 90 _____% 999 Do not know
    c. greater than 90 _____% 999 Do not know

16. What SEER level of central air conditioning systems do you typically install?
    ___ SEER
    999 Do not know *skip to Q17*

a. Does it vary by climate zone?
    00 No
    01 Yes – *Probe for differences between climate zones.*
    _____
    _____
    999 Do not know

17. What percentage of the homes do you install central air conditioners with SEERs:
    a. 10 to 10.9_____% 999 Do not know
    b. 11 to <11.9_____% 999 Do not know
    c. 12 to <12.9_____% 999 Do not know
    d. 13 to <13.9_____% 999 Do not know
    e. 14 or greater _____% 999 Do not know

Duct System

18. Do you currently have the ducts tested in the homes you build?
    00 No – *Skip to Q22*
    01 Yes
    999 Do not know– *Skip to Q22*

19. In what percent of homes?

___ %

999 Do not know

20. When did you begin duct testing?

___ month ___ year

999 Do not know

21. What prompted you to begin duct testing? *Do not read, check all that apply.*

01 Credit for Title 24 compliance
02 Desire to build better quality homes
03 Avoid law suits
04 Marketing advantage
99 Do not now

22. What is the R-value duct insulation you use in the homes you build?

___

999 Do not know

Building Shell Measures

23. What percent of the homes you built last year had windows with the following characteristics…

a. *(Read list.)*

Single pane _____%
Double pane _____%
Triple pane _____%
Percent should sum 100%

b. *(Read list.)*

Clear glass _____%
Low-E glass _____%
Tinted/reflective glass_____%
Percent should sum 100%

c. *(Read list.)*

Metal framed _____%
Vinyl framed _____%
Percent should sum 100%

d. Explain any differences in the characteristics of windows your company uses across geographic regions.

00 No difference
99 Do not know

_____
_____
_____
_____

24. Do you currently install radiant barriers on the homes you build?

00 No
01 Yes
999 Do not know – *skip to Q25*

a. In what percent of homes? *Probe for variations across geographic regions.*

___ %
999 Do not know

25. What is the R-value of the wall insulation do you typically use?

___
999 Do not know

26. What is the R-value of the roof insulation do you typically use?

___
999 Do not know

Reasons for Non-Compliance and Over Compliance

We realize that there is considerable lag time between when plans receive a building permit and when homes are constructed.

27. How often are design changes made to the building shell *(window types, insulation, glazing area)* after the building permit has been granted?
    01 Never – *Skip to Q28*
    02 Sometimes
    03 Fairly often
    04 Always
    999 Do not know– *Skip to Q28*

a. What are the most common changes?

_____

_____

b. What are the major reasons for these changes?

_____

_____

In some cases HVAC equipment, windows, and water heating equipment tend to be generically specified on the plans.

28. What percentage of installed air conditioners match what is specified on the plans? What percent have ratings that exceed and what percent have a rating less than the rating on the plans?
    999 Do not know
    _____ % Match
    _____ % Exceed efficiency rating on plans – Explain: _____
    _____ % Less than efficiency rating on plans– Explain: _____

29. What percentage of homes have furnaces with AFUEs that match what is specified on the plans? What percent have ratings that exceed and what percent have a rating less than the rating on the plans?
    999 Do not know
    _____ % Match
    _____ % Exceed efficiency rating on plans – Explain: _____
    _____ % Less than efficiency rating on plans– Explain: _____

30. What percentage of homes have windows installed that match what is specified on the plans? What percent have windows that exceed and what percent have windows less than the specified efficiency?
    999 Do not know
    _____ % Match
    _____ % Exceed efficiency rating on plans – Explain: _____
    _____ % Less than efficiency rating on plans– Explain: _____

31. How are the differences between what is specified in the plans and what is actually installed handled with respect to Title 24 compliance?

_____

_____

Changes in Practices As a Result of the 2001 Standards

Now I am going to ask you about any changes you have observed regarding building design and specification practices since the implementation of the 2001 Title 24 Standards.

32. On a scale of 1 to 5 with a 1 meaning "easy" and a 5 meaning "very difficult," how would you characterize the level of effort required to achieve compliance under the 2001 Standards, compared to meeting the 1998 Standards? *Obtain answer for each region indicated above in Q9.*

North Coast	5	4	3	2	1	99 not applicable
South Coast	5	4	3	2	1	99 not applicable
South Inland	5	4	3	2	1	99 not applicable
Central Valley	5	4	3	2	1	99 not applicable
Desert	5	4	3	2	1	99 not applicable
Mountain	5	4	3	2	1	99 not applicable

If any response(s) are 4 or 5:

a. What do you feel are the biggest challenges to meeting the requirements of the 2001 Standards?

_____

_____

33. What is your opinion about installing radiant barriers? *Do you feel radiant barriers are cost effective? Have you experienced any problems identifying contractors familiar with their installation? Do the special handling requirements keep you from using radiant barriers?*

_____

_____

34. Have you ever used or has your Title 24 consultant ever discussed using a HERS rater with you?

00 No – *Skip to Q39 or Q68*
01 Yes
999 Do not know – *Skip to Q39 or Q68*

35. On a scale of 1 to 5, rate your satisfaction with the HERS rating process, with a 1 meaning not at all satisfied and a 5 meaning very satisfied.
    5 4 3 2 1 99

    If response is a 1 or 2:
    a. What in particular about the process are you not satisfied with?

    _____
    _____

36. On a scale of 1 to 5, with a 1 meaning not at all likely and a 5 meaning very likely, how likely are you to install higher efficiency windows to avoid the HERS certification requirement?
    5 4 3 2 1 99

37. Using the same scale, how likely are you to install higher efficiency HVAC equipment to avoid the the HERS certification requirement?
    5 4 3 2 1 99

38. What are your opinions regarding the options requiring HERS certification of duct sealing and TXV valves?

    _____
    _____

ENERGY STAR New Homes *(Participant Module – if Q10=Yes)*

The remaining questions of this survey are with respect to your company's participation in the California ENERGY STAR New Homes program and characteristics of the ENERGY STAR homes your company built last year.

39. Are you the person at your company who is the primary contact with respect to the ENERGY STAR New Homes program?
    01 Yes – *Continue*
    00 No – Who is more appropriate to speak with?
    New Contact Name/Title:_____
    Phone: _____
    Introduction with new contact:

    Hello, my name is _____ and I'm with Itron. _____ referred me to you as the person to contact regarding the ENERGY STAR New Homes program. We are conducting a study on behalf of the California utilities (*PG&E, SCE, SDG&E, and SoCalGas)* to examine the differences between ENERGY STAR qualified homes and homes that just meet the minimum energy efficiency standards. Your participation in this study involves answering some questions over the phone and will take about 10

minutes. I would like to emphasize that your input will remain completely confidential. Is now a good time to talk*?*

01 Yes – *Continue*
00 No – *Arrange time for interview*

Comparison to Non-ENERGY STAR Homes

40. What features/measures does your company specify to meet the California ENERGY STAR Homes requirements compared to homes that are designed to just meet Title 24?
Probe for climate zone differences and obtain percentages where possible, whether they simply added a few energy efficient measures to reach ENERGY STAR or if they use an entirely different package of measures due to the CHEERS requirement. Do they use duct sealing and other measures that need to be verified more often in ENERGY STAR homes since the CHEERS rater has to perform a site visit anyway?

_____
_____
_____

41. On average, how does the construction costs of an ENERGY STAR home compare to that of an equivalent non-ENERGY STAR Home?
00 About the same
01 More – About what percentage more? ____%
02 Less – About what percentage less? ____%
99 Do not know

42. As a result of what you have learned through the program, are there any measures you now typically specify for all of your homes that you did not previously? *Do not read. Check all that apply.*
00 No/none
01 High efficiency air conditioners
02 High efficiency furnaces
03 Sealed ducts
04 Roof insulation
05 Radiant barriers
06 High performace glazing
07 Water heaters
08 Duct sealing, blower door tests
09 ACCA duct design
10 TXV – Thermostatic expansion valves
11 Other – Specify: _____
99 Do not know

Program Awareness and Motivations

43. How did you first become aware of the ENERGY STAR Homes program? *Do not read, Check all that apply.*
    01 Other builder
    02 Friend
    03 EPA Website
    04 Utility Website
    05 Pamphlet
    06 Newspaper
    07 Television commercial
    08 Radio
    09 Bill Insert
    10 Sign
    11 Other – Specify: _____
    99 Do not know
    98 Refused

44. What were your motivations for participating in the 2002 California ENERGY STAR New Homes Program? *Do not read, Check all that apply.*
    01 Financial Incentives
    02 Advertising Partnership
    03 A means to achieve 2001 Title-24 compliance
    04 Differentiation in the market place
    05 Third-party inspections and recognized labels
    06 Other – Specify: _____
    99 Do not know

ENERGY STAR as a Marketing Tool

45. How would you characterize the impact of the ENERGY STAR label on the marketability of a home? Would you say that the ENERGY STAR label has …
    00 No impact on the sale of home
    01 A positive impact on the marketability of homes – Explain: _____
    02 A negative impact on the marketability of home– Explain: _____
    99 Don't Know/Not Sure

46. Has participation in the program helped you to get more marketing exposure?
    00 No
    01 Yes
    02 Possibly
    99 Don't Know/Not Sure

47. Which of the following types of marketing support have you received from the program? *Check all that apply.*
    00 None
    01 Ongoing advertising support
    02 Point-of-sale brochures
    03 World Wide Web page with links to ComfortWise and your web site
    04 ComfortWise sales training and support
    05 Model "Grand Opening" assistance by ComfortWise staff
    06 ComfortWise display for your models
    07 Video
    08 Enhanced builder image and reputation as an environmentally friendly builder
    09 Developed a reputation for quality construction and cutting-edge technology
    99 Do not know

Program Satisfaction

I am going to read a list of aspects of the ENERGY STAR Homes Program. Rate your satisfaction of each on a scale of 1 to 5, where 1 is very unsatisfied and 5 is very satisfied.

48. Amount of incentives 5 4 3 2 1 99
If 1 or 2: What do you find unsatisfactory?
_____

49. Advertising partnership 5 4 3 2 1 99
If 1 or 2: What do you find unsatisfactory?
_____

50. 3rd-party inspections 5 4 3 2 1 99
If 1 or 2: What do you find unsatisfactory?
_____

51. Certification process 5 4 3 2 1 99
If 1 or 2: What do you find unsatisfactory?
_____

52. Application documentation 5 4 3 2 1 99
If 1 or 2: What do you find unsatisfactory?
_____

53. Required margin of compliance 5 4 3 2 1 99
If 1 or 2: What do you find unsatisfactory?
_____

54. Incentive processing and payment 5 4 3 2 1 99
If 1 or 2: What do you find unsatisfactory?
_____

55. Communication with utility 5 4 3 2 1 99
If 1 or 2: What do you find unsatisfactory?
_____

56. The program, overall 5 4 3 2 1 99
If 1 or 2: What do you find unsatisfactory?
_____

Barriers to ENERGY STAR Certification

57. Have you experienced any barriers to certifying homes under the ENERGY STAR New Homes program? *Do not read list, check all that apply.*
    99 Don't Know
    00 No
    01 Yes - Explain: _____
        01 Program timeline
        02 Verification requirements
        03 Product availability
        04 Inspection costs
        05 There are no barriers to program compliance/certification
        06 Other - Specify: _____
        99 Do not know

Barriers to Program Participation

Finally, I am going to read you a list of statements. Please score each statement on a 1 to 5 scale, where 1 is "completely disagree" and 5 is "completely agree"?

58. Staying current on the various construction options to meet ENERGY STAR criteria is difficult.	5	4	3	2	1	99
59. It is difficult to find qualified contractors that understand how to install and/or comply with some of the measures required to meet ENERGY STAR.	5	4	3	2	1	99
60. ENERGY STAR Homes require measures that are not cost effective in new home construction	5	4	3	2	1	99
61. Most homeowners do not consider long-term energy costs when buying homes	5	4	3	2	1	99
62. The differentiation in the market place that I have realized as an ENERGY STAR Homes builder has added value to my business.	5	4	3	2	1	99
63. Homebuyer satisfaction is greater among my ENERGY STAR Home buyers than it is among my non- ENERGY STAR home buyers.	5	4	3	2	1	99

64. My ENERGY STAR Homes sell faster than my non- ENERGY STAR Homes.	5	4	3	2	1	99
65. Construction costs of ENERGY STAR Homes are equal to or less than those of my non- ENERGY STAR homes	5	4	3	2	1	99
66. The added cost of building ENERGY STAR homes outweighs all other benefits of program participation.	5	4	3	2	1	99
67. Energy efficient equipment is much harder to find than standard equipment.	5	4	3	2	1	99

That completes the survey. Thank you very much for your time!
Terminate

ENERGY STAR New Homes *(Nonparticipant Module– if Q10=No)*

68. Are you the person at your company who would be the primary contact with respect to utility programs that provide incentives to builders for installing energy efficient equipment and features in new homes?
    - 01 Yes – *Continue*
    - 00 No – Who is more appropriate to speak with?

      New Contact Name/Title:_____

      Phone: _____

      Introduction with new contact:

      Hello, my name is _____ and I'm with Itron. _____ referred me to you as the person to contact regarding the incentive programs offered by utilities for energy efficient housing. We are conducting a study on behalf of the California utilities (*PG&E, SCE, SDG&E, and SoCalGas)* that will help them improve their incentive programs for builders. Your participation in this study involves answering some questions over the phone and will take about 10 minutes. I would like to emphasize that your input will remain completely confidential. Is now a good time to talk*?*

      - 01 Yes – *Continue*
      - 00 No – *Arrange time for interview*

69. Have you heard of the California ENERGY STAR New Homes program?
    00 No - *read paragraph below, then Skip to Q87*
    01 Yes - *Skip to Q70*
    99 Refused - *read paragraph below, then continue*

    The California ENERGY STAR New Homes Program offers rebates to single- and multi-family builders to exceed the Title 24 building energy standards. To qualify for ENERGY STAR, all new homes must exceed Title-24 requirements by at least 15% and the builder must follow the CHEERS inspection and data protocols. In addition to receiving financial incentives, builders meeting the program requirements are able to use the ENERGY STAR logo to promote the homes.

70. How did you first become aware of the ENERGY STAR Homes program? *Do not read list, check all that apply.*
    01 Other builder
    02 Friend
    03 EPA Website
    04 Utility Website
    05 Pamphlet
    06 Newspaper
    07 Television commercial
    08 Radio
    09 Bill Insert
    10 Sign
    11 Other _____
    99 Do not know
    98 Refused

71. What is the main reason why you chose not to participate in the ENERGY STAR program?

_____
_____
_____

I am going to read a list of ENERGY STAR Homes Program aspects to you. If you have had any experience with the program in the following areas, please rate each aspect on a scale of 1 to 5 where 1 is not a barrier to participation and 5 is a large barrier to participation.

Coding: 98 – refused, 99 – do not know, 100 – not applicable

72. Understanding of Program — 1 2 3 4 5 98 99 100
If 4 or 5, ask why it is a barrier: _____

73. Amount of Incentives — 1 2 3 4 5 98 99 100
If 4 or 5, ask why it is a barrier: _____

74. 3rd-party Inspections — 1 2 3 4 5 98 99 100
If 4 or 5, ask why it is a barrier: _____

75. Certification Process — 1 2 3 4 5 98 99 100
If 4 or 5, ask why it is a barrier: _____

76. Program Application Documentation — 1 2 3 4 5 98 99 100
If 4 or 5, ask why it is a barrier: _____

77. Program Required Margin of Compliance — 1 2 3 4 5 98 99 100
If 4 or 5, ask why it is a barrier: _____

78. Communication with utility — 1 2 3 4 5 98 99 100
If 4 or 5, ask why it is a barrier: _____

I am now going to read you a list of statements. If you have had any experience with the program in the following areas, score each statement on a 1 to 5 scale, where 1 means you completely disagree and 5 means you completely agree.

79. Staying current on the various construction options to meet ENERGY STAR criteria is difficult. — 1 2 3 4 5 98 99 100

80. ENERGY STAR Homes require measures that are not cost effective in new home construction — 1 2 3 4 5 98 99 100

81. It is difficult to find qualified contractors that understand how to install and/or comply with some of the measures required to meet ENERGY STAR — 1 2 3 4 5 98 99 100

82. Energy efficient equipment is much harder to find than standard equipment.	1	2	3	4	5	98	99	100
83. Most homeowners don't consider long-term energy costs when buying homes	1	2	3	4	5	98	99	100
84. Construction costs of ENERGY STAR Homes are equal to or less than non ENERGY STAR homes	1	2	3	4	5	98	99	100
If Q84 = 3, 4, 5, 98, 99, 100 skip to Q85								
85. The added cost of building ENERGY STAR homes outweighs all other benefits of program participation.	1	2	3	4	5	98	99	100

86. Lastly, do you have any suggestions or comments about the program?

_____

_____

That completes the survey. Thank you very much for your time!!
Terminate

87. Are you interested in learning more about the ENERGY STAR Homes program?
    00 No – Why not? _____ - *Skip to Q92*
    01 Yes
    02 Maybe
    99 Don't Know
    98 Refused
    Verbatim response:

    _____

    _____

88. What is the preferred method for contacting you and others in your company about these kinds of programs? *Do not read list, check all that apply.*
    01 In person visit by program representative
    02 Phone call by program representative
    03 Email
    04 Print material (postal mail)
    05 Other – *specify:*_____
    99 Do not know

    a. What about for periodic follow-ups (with program updates, etc.)? *Do not read list, check all that apply.*
        01 In person visit by program representative
        02 Phone call by program representative
        03 Email
        04 Print material (postal mail)

05 Other – *specify:*_____
99 Do not know

89. What are the best avenues through which the utilities can distribute information about the California Energy New Homes Program and other rebate programs to a broader audience of residential builders and developers?
    01 In person visit by program representative
    02 Phone call by program representative
    03 Email
    04 Postal mail
    05 Industry conference – *specify:*_____
    06 Magazine, trade publications – *specify:*_____
    07 Other – *specify:*_____
    99 Do not know

90. Who is the primary decision maker in your organization about participation in these types of programs? *Do not read list, check all that apply.*
    01 Company owner, president, CEO, executive director, partner
    02 Vice president or Director of construction/development
    03 Vice president or Director sales/marketing
    04 Project manager
    05 Architect/Engineer
    06 Title 24 consultant or energy consultant
    07 Other - *specify:* _____
    99 Do not know
    98 Refused

91. Would your company benefit from training on how to cost-effectively meet the program requirements?
    00 No
    01 Yes
    99 Do not know

    a. Do you feel that such training would increase the participation of your company or participation of other developers?
        00 No
        01 Yes
        99 Do not know

92. Do you have any suggestions for generating more builder interest in the California ENERGY STAR New Homes program?

_____

_____

That completes the survey. Thank you very much for your time!!
Terminate