

**Residential New Construction**  
**Baseline Study of Building Characteristics**  
**Homes Built After 2001 Codes**

**Project Manager**

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# Executive Summary

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## 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.<sup>1</sup> 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,<sup>2</sup> 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.<sup>3</sup>

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<sup>1</sup> 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.

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

<sup>3</sup> 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

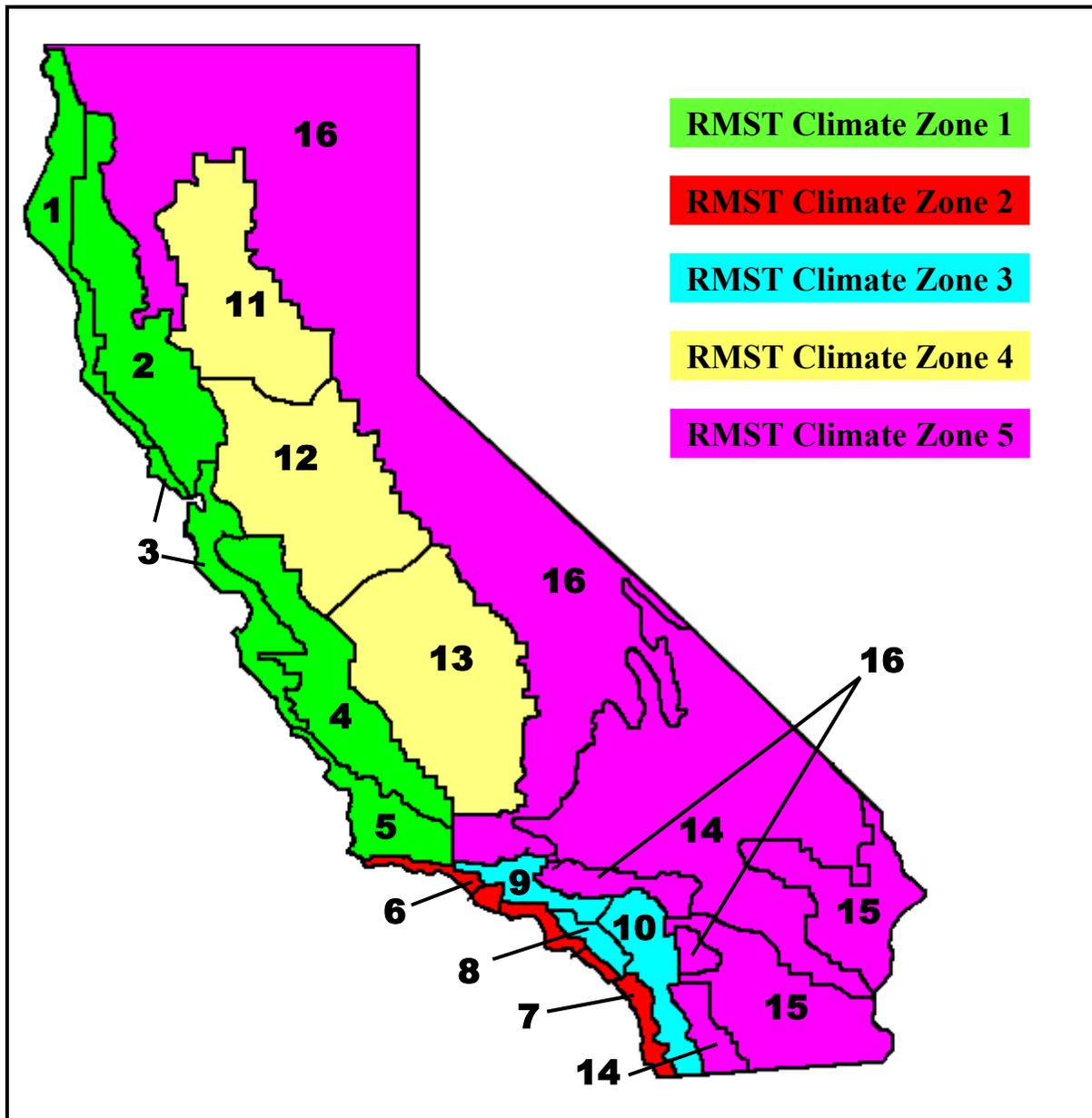


Table ES-1 presents a distribution of the completed on-site surveys of newly constructed single family detached homes by RMST climate zone and number of stories. As shown, 604 homes were surveyed. Since the objective of this study was to develop a baseline, 19 homes were not included in the analysis 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
<b>Single Family Detached Homes</b>						
1 story	189	7	8	29	126	19
2 story	364	29	72	91	150	22
3 story	22	6	8	7	1	0
<b>Used in Analysis</b>	<b>575</b>	<b>42</b>	<b>88</b>	<b>127</b>	<b>277</b>	<b>41</b>
ENERGY STAR Homes	19	14	5			
Single Family Other (Mobile/Manufactured Home)	6	1	2		2	1
Other Omitted Sites	4	2	1	1		
<b>Total</b>	<b>604</b>	<b>59</b>	<b>96</b>	<b>128</b>	<b>279</b>	<b>42</b>

### ***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<sup>4</sup> 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

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<sup>4</sup> 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,<sup>5</sup> 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

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<sup>5</sup> 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.**<sup>6</sup> 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,<sup>7</sup> characterized by the error band discussed in

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<sup>6</sup> 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.

<sup>7</sup> 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*).<sup>8</sup> As shown below, this high efficiency group, includes homes with a % Compliance Margin greater than 19%.<sup>9</sup> 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.

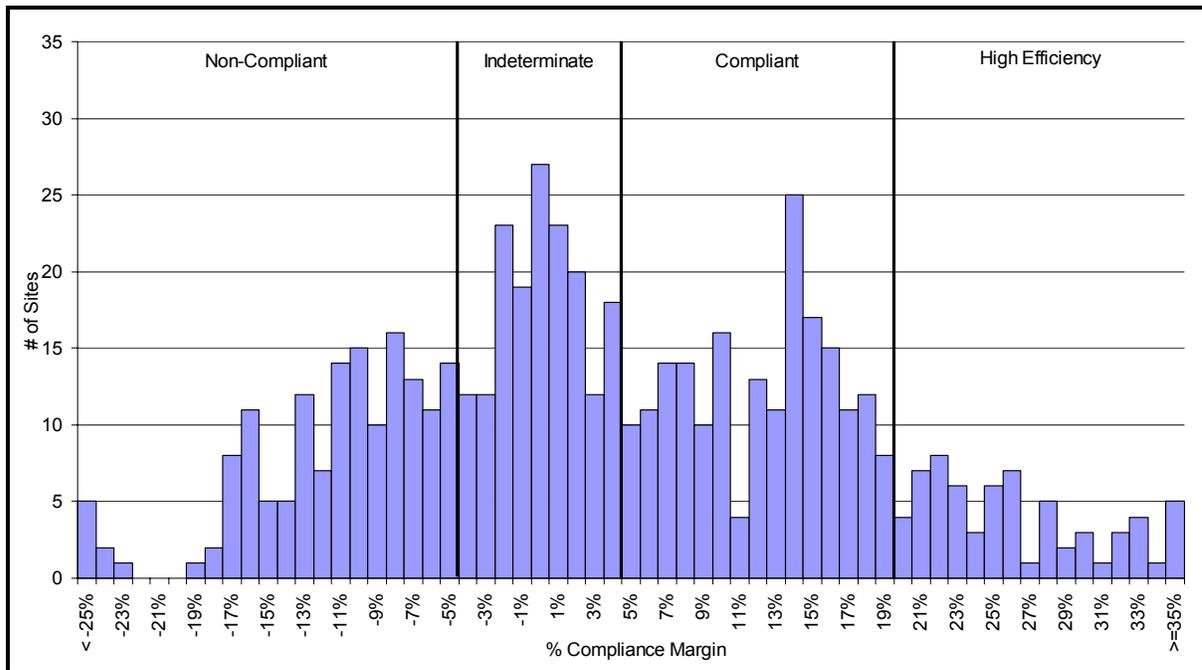
- **Approximately 27% of sites are identified as non-compliant.** The results from the RNC Interface compliance analysis indicate that 27% of all homes built in the study period were non-compliant. Thirty-four percent of homes fell within the compliant group, while 13% fell in the high efficiency group.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

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<sup>8</sup> 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.

<sup>9</sup> 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<sup>10</sup>. Below are several reasons for the disparity in compliance between coastal and inland homes.

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<sup>10</sup> 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 coastal 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.<sup>11</sup>

- **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.<sup>12</sup>
- **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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<sup>11</sup> Note that the on-site survey results include only nonparticipant homes.

<sup>12</sup> 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.