Residential New Construction Study

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TURNING DATA INTO INFORMATION

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Executive Summary

ES.1 Introduction

The work presented in this executive summary is part of a two-year study conducted by Regional Economic Research, Inc. (RER) under Pacific Gas & Electric (PG&E) management. The main report, *Residential New Construction Study* (RER 2001), is a separate document. The report investigates energy efficiency in newly constructed low-rise residential homes[1] across 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 and impending energy code changes on these programs. Significant changes in the California energy market, implementation of the 1998 Residential Standards, and the impending implementation of emergency revisions to the Standards under AB 970[2] make this report especially significant.

The remainder of this Executive Summary is organized to include a review of the project's objectives, a discussion of the approach taken, key findings from each of the various sections of the report, and a brief discussion on the next steps in the project.

ES.2 Study Objectives

The study makes extensive use of on-site surveys of residential homes performed for the Statewide Residential Market Share Tracking Study (RMST)[3] and interviews with builders and Title 24 consultants to assess the state of energy efficiency in the residential new construction market. Objectives of the study can be summarized as follows:

- Examine the status of Title 24 compliance for a representative sample of California residences as constructed (or as-built) using the MICROPAS Title 24 computer compliance tool.

1 This includes detached single family homes and multifamily building that are three floors or less.

2 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.

3 *California Residential Efficiency Market Share Tracking – First-Year Interim Report.* RER, Inc. October 2000. Prepared for Southern California Edison.

- Analyze the technical potential of key energy efficiency measures[4] and determine what measures could be most effectively applied to make homes meet the requirements of most RNC programs (such as ENERGY STAR® Labeled New Homes, PG&E Comfort Home, etc.).
- Assess the impacts of recent changes in Title 24 Standards, including the changes in construction practices and compliance behavior attributable to 1998 standards.
- Collect information on builder and Title 24 consultant perceptions on the impact of the AB 970 standards, which were passed in January 2001, on construction practices and compliance behavior and possible impacts on new construction energy efficiency programs.
- Determine if the anticipated changes in building practices, in response to AB 970, will be enough to comply with these new standards.

The results from this study will be used to track common building practices in the residential new construction sector, assist residential new construction program managers to develop and maintain effective energy efficiency initiatives, and assess the energy savings potential for new energy using technologies.

ES.3 Overview of Approach

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

The objective of this phase of the project is to describe common building practices and analyze Title 24 compliance for residential low-rise buildings. To accomplish this task, a software tool was developed that allows for the translation of data from 800 on-site surveys[5] into a MICROPAS input file. These input files were then processed using MICROPAS and the results were made available in a number formats. These results, together with the detailed on-site data, were then analyzed to ascertain common building practices and complete the Title 24 compliance analysis.

There are six major elements to the approach, which are briefly described below.

- ***Review the On-Site Survey Database.*** The initial task was to review the database containing the information from the 800 on-site surveys. These data were then used to establish current building practices. The database contains information regarding general building information such as household characteristics and site information, equipment information (lighting, appliances,

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[4] The measures selected are the four new measures required by Prescriptive Package D of the AB 970 Emergency Standards. These include radiant barriers, high performance fenestration, and HERS-certified duct sealing and refrigerant charge and airflow (RCA) testing.

[5] Collected as a part of the Residential Market Share Tracking project

and water heating equipment), HVAC information, building orientation and construction information, and multifamily-specific data including sketches.

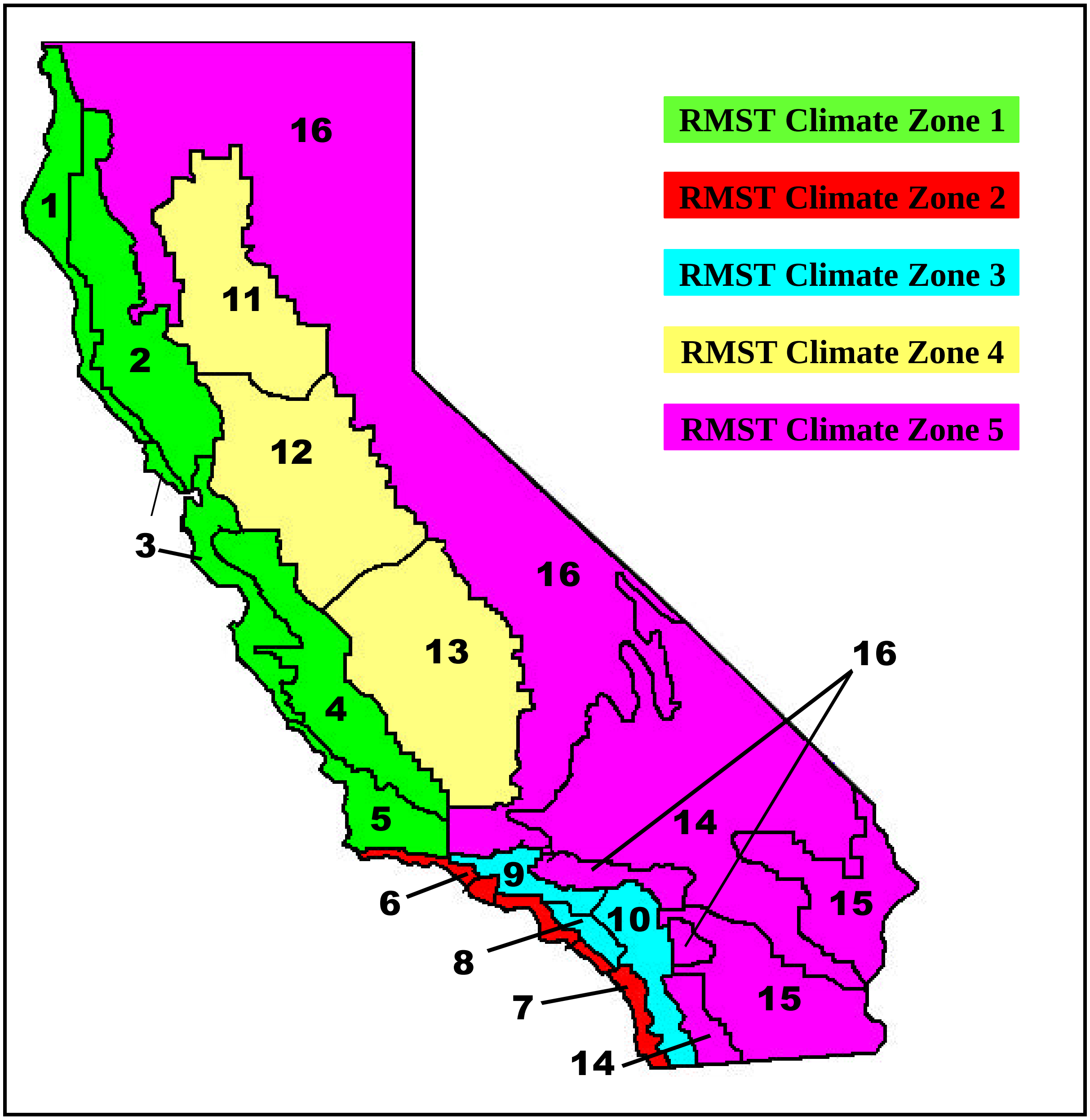
The sample of the 800 on-site surveys was stratified by residence type, RMST climate zone, utility, and six-month period. (The 16 CEC climate zones were grouped into five RMST climate zones for the Residential Market Share Tracking Study. Figure ES-1 provides an illustration on how the CEC climate zones were grouped.) RER developed expansion weights to expand the on-site data to represent the total number of homes built within the three electric IOU territories between July 1, 1998 and June 30, 1999. The expansion weights are based on the number of households in each utility service area and RMST climate zone shown in Table ES-1.[6]

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

Res. Type and RMST Climate Zone	PG&E		SCE		SCG		SDG&E	
	Sample Frame	Completed Targets	Sample Frame	Completed Targets	Sample Frame	Completed Targets	Sample Frame	Completed Targets
SF.CZ1	18,693	118	0	-	-	-	0	-
SF.CZ2	4	-	4,487	34	148	2	5,370	78
SF.CZ3	0	-	22,061	160	2,094	14	1,103	16
SF.CZ4	26,354	164	2,089	16	-	-	0	-
SF.CZ5	579	4	4,313	32	1,415	10	15	-
SF Total	45,630	286	32,950	242	3,657	26	6,488	94
MF.CZ1	9,694	62	0	-	-	-	0	-
MF.CZ2	0	-	1,377	10	119	2	845	12
MF.CZ3	0	-	3,736	28	1,452	12	66	2
MF.CZ4	2,668	18	60	-	-	-	0	-
MF.CZ5	10	-	345	4	198	2	0	-
MF Total	12,372	80	5,518	42	1,769	16	911	14
All Total	**58,002**	**366**	**38,468**	**284**	**5,426**	**42**	**7,399**	**108**

6 New construction frames from the various utilities include both single family and multifamily homes.

Figure ES-1: CEC Climate Zones



- ***Create the RNC Interface.*** The RNC Interface is a software tool that uses data collected from the 800 on-site surveys to create MICROPAS input files and generate MICROPAS compliance runs from the RMST survey data of newly constructed residences. These runs are used to examine the compliance status for each residential building[7] and to explore the energy conservation potential of some key energy saving technologies. The RNC Interface is designed to support batch processing of the compliance analysis and is capable of outputting the compliance

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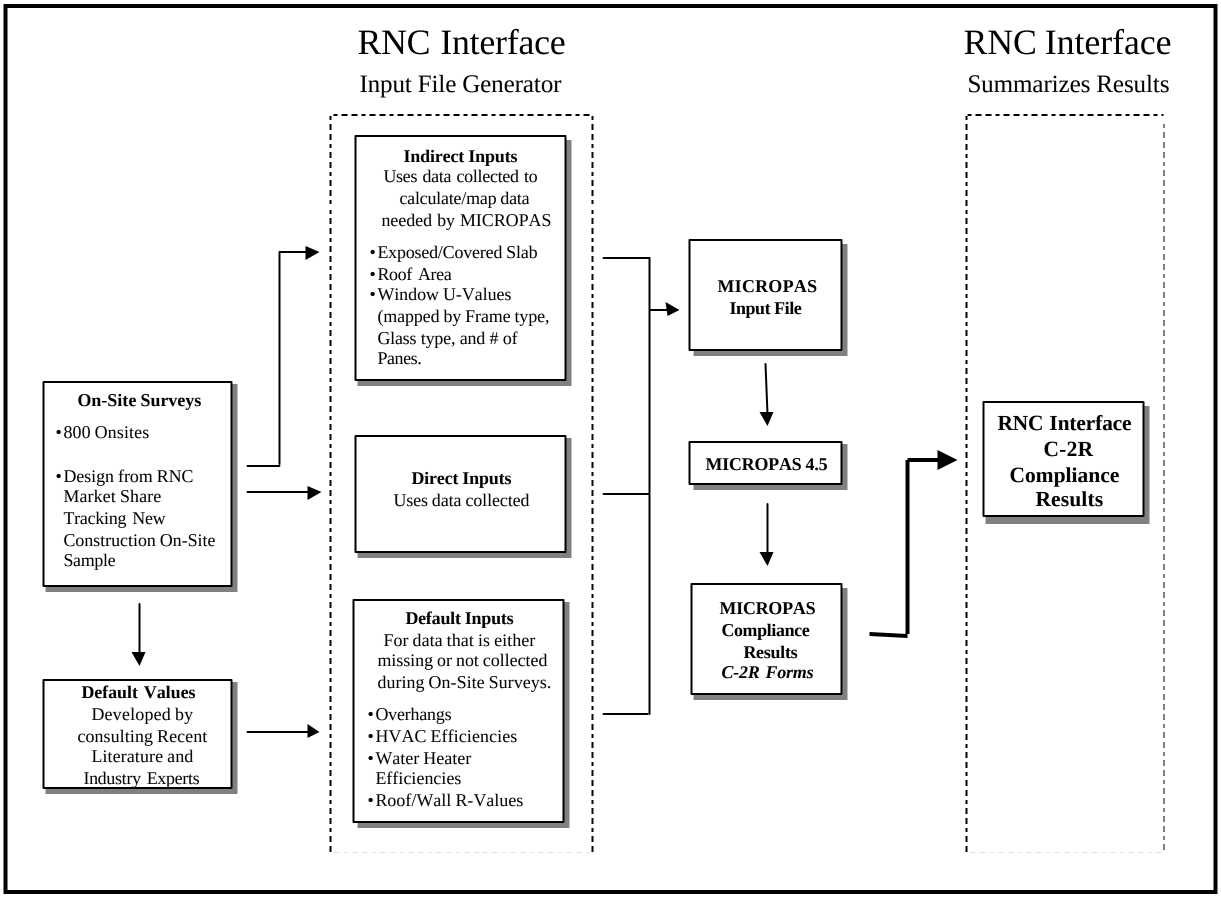
7 Since the houses surveyed for the first year of this report were built between July 1998 and June 1999, nearly all of these homes would have had to comply with the 1995 low-rise residential building standards.

energy use results and producing summary tables of energy use by end use and site. MICROPAS was chosen as the compliance tool because it is the tool of choice of energy consultants for performing low-rise residential compliance analysis.[8]

Figure ES-2: Overview of the RNC Interface Framework



- ***Test the RNC Interface.*** Considerable effort was made to ensure that the RNC Interface produces accurate MICROPAS simulation results given the limitations of the available data and the design of the RNC Interface. To accomplish this task, a testing procedure was developed to evaluate the default parameters and underlying algorithms and structure of the RNC Interface. In particular, C-2R compliance forms for a sub-sample of RMST surveyed sites were gathered from building departments. For each sub-sampled site, data from the C-2R compliance documentation were used to populate an RMST survey form. These forms were then processed through the RNC Interface. The results were then compared to the compliance data on the original C-2R forms. Based on the analysis of the differences in the compliance results, additional changes were made to the RNC

8 Interviews with MICROPAS developers indicate that more than 75% of energy professionals use their product. Further, two recent studies by RER indicate that more than 90% of energy compliance documentation was completed using MICROPAS.

Interface. This procedure was repeated until an acceptable margin of error was reached. A final error band was then developed for use in analyzing the remaining RMST surveyed sites.

- ***Complete the MICROPAS Compliance Analysis of the 800 Residences.*** Of the 800 sites, 735 were ultimately processed through the RNC Interface and the % Compliance Margin[9] was calculated for each site. The error band[10] established during the testing of the RNC Interface was then applied to the results. The sites were then grouped into four compliance categories: non-compliant, indeterminate, compliant, and overly compliant.
- ***Identify Baseline Characteristics.*** Data from the on-site surveys were used to characterize common building practices in the residential sector. In particular, summaries of square footage, glazing areas, insulation levels, window types and efficiencies, and equipment efficiencies by residence type and climate zone were tabulated. These values were used to characterize the baseline practices in the residential new construction sector.[11]
- ***Analyze the Compliance Results.*** Insofar as the performance method was used for Title 24 compliance, it is problematic to isolate particular reasons why a home did or did not comply. This step characterized homes that comply and those that do not in order to discern potential reasons why homes might not comply with Title 24 requirements. In particular, summary tables of shell characteristics and equipment efficiencies were developed for homes that comply, do not comply, and overly comply. These results are presented and analyzed by residence type and climate zone and by percent glazing and window efficiency combinations. Based on this analysis, potential reasons for non-compliance are summarized and discussed.

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[9] The % Compliance Margin represents the compliance margin expressed as a percentage of the standard energy budget. Specifically,

$$\%\ Compliance\ Margin = \frac{(Standard\ Energy\ Budget - Proposed\ Energy\ Budget)}{(Standard\ Energy\ Budget)}$$

[10] The error band developed for this round of on-site surveys is -4% to +6%. This means that if the % Compliance Margin calculated by the RNC interfaces is between -4% and +6%, the compliance of the home is indeterminate. Likewise, if the % Compliance Margin is less than -4%, then the home is not compliant with the 1995 building standards. A home with a % Compliance Margin greater than +6% is compliant.

[11] Note that the baseline characterization focused on water heating and HVAC equipment and building shell features. No attempt is made to characterize lighting and appliance features. These latter two categories are covered in the RMST First-Year Interim Report.

Overview of Approach to Analyze Technical Potential

The objective of this phase of the project was to estimate the technical potential of installing various measures that are required under AB 970 Prescriptive Package D.[12] The general approach taken for the technical potential assessment is summarized below.

- Baseline MICROPAS 6.0 (AB 970 version) runs were performed for the residences as constructed (as-built).
- Measure runs were performed by implementing one of the measures for only those homes that did not already have that measure, and then running MICROPAS 6.0.
- Energy savings[13] (MICROPAS default output) for the measure were determined by subtracting measure run results from the baseline as-built run results.
- Energy savings were "filtered" as required to provide savings estimates that accurately reflect the as-built construction of the home (e.g., no cooling savings if no cooling equipment installed) and applicability of measures under Prescriptive Package D of the AB 970 Standards (i.e., some measures are not required in all CEC climate zones).
- Filtered annual source energy savings were converted to fuel/end-use savings.

Overview of Approach to Assess Impacts of Recent Changes in Title 24 Standards on Title 24 Consultants and Builders

The objective of this phase of the project was to assess the impacts of the 1998 standards and to gather market actors' perceptions of AB 970 and how it will affect building practices and RNC programs. The approach to accomplish this objective involved in-depth interviews and telephone surveys of Title 24 consultants and builders.

In particular, RER conducted 13 in-depth interviews with Title 24 consultants. Following these interviews, a telephone survey for the Title 24 consultants was designed using the knowledge gained from the in-depth interviews and 55 telephone surveys were conducted. In addition, RER conducted 17 in-depth interviews with builders. The general approach taken is summarized below.

- ***Title 24 compliance.*** Barriers to compliance were identified and which energy credits are commonly used or underutilized when meeting Title 24 requirements

[12] For more information on Prescriptive Package D of the AB 970 Standards, please see "Contractor's Report 2001 Update Assembly Bill 970." CEC Volume 1 – Summary. November 2000.

[13] Source energy savings is the basis used for compliance analysis and attempts to account for production and distribution losses inherent in delivering a particular fuel to a home. Engineering units used to specify source energy are "skBtuh" where the "s" denotes source energy. This primarily impacts electricity, where a factor of 3 in addition to the usual conversion factor of 3.413 kBtuh/kW is used to account for generation, transmission, and distribution losses.

was determined. Changes in practices and compliance behavior attributable to changes in Title 24 were investigated and the attitudes between builders and Title 24 consultants relative to key compliance issues were compared. In addition, the role of building departments in the design and compliance of new buildings was analyzed.

- ***Impact of AB 970.*** AB 970 was passed in January 2001 and covers emergency changes to the low-rise residential Title 24 building standards. The in-depth and telephone surveys were designed to gather information on the expected changes to building practices and Title 24 compliance practices due to the implementation of AB 970. Further, information on builder and Title 24 consultant perceptions on the impact of these standards on the available mix of new construction energy efficiency programs was collected for RNC program managers.
- ***Comparisons of builders who build homes that comply and builders who build homes that do not comply with Title 24.*** A comparison of common practices and compliance behavior and attitudes between builders and Title 24 consultants across climate zones was made. Where possible, an attempt was made to identify major reasons for non-compliance. Any correlation between compliance and non-compliance across building department jurisdictions was researched to ascertain any implicit influence of building departments on the compliance of new homes.
- ***Other issues.*** Attitudes towards ENERGY STAR and other RNC programs were also assessed. In addition, the incentives offered for participation and reasons why Title 24 consultants recommend or do not recommend participation in the program(s) were examined. To the extent possible, barriers to participation in ENERGY STAR and utility-sponsored programs were also examined.

Overview of Approach to Analyze the Compliance of Likely Building Practices Under AB 970

Insofar as AB 970 does not become effective until January 2002 (for tract homes) the main sources of information on how builders and Title 24 consultants plan to meet the new standards are self-reported data from telephone surveys with Title 24 consultants. The analysis focuses on taking the self-reported information on likely changes in building practices and simulating these plans using the RNC Interface. The simulations analyze whether builders can meet the new standards using their planned approaches.

ES.4 Summary of Findings

The following is a preview of the study results. These include major findings from the baseline characteristics of newly constructed homes and the compliance analysis.

Baseline Characterization

The following is a summary of current building practices in the low-rise residential sector. In particular, findings on efficiency levels and key differences in construction practice between detached single family homes and multifamily buildings, as well as differences among regions, are summarized.

- ***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 80.4% AFUE, versus the 78% AFUE Standard value. The average efficiency of central air conditioners installed in detached single family homes is 10.5 SEER, versus the 10 SEER Standard value.
- ***Single family detached homes are more likely than multifamily buildings to have higher-than-standard efficiency air conditioners.*** Approximately 20% of detached single family homes have air conditioners with SEER values greater than 11 SEER, compared to none of the multifamily buildings.
- ***A significant number of homes do not have cooling equipment.*** Just over half of single family homes in RMST Climate Zones 1 and 2 do not have a cooling system (51% and 52%, respectively), which is approximately 20% at the state level. Likewise, a significant number of multifamily buildings do not have cooling systems (38% statewide).
- ***The average duct leakage percentage for single family homes is significantly lower than for multifamily buildings.***[14] For detached single family homes, the statewide average duct leakage percentage for those duct systems tested was 13.5%, compared to 28.0% for multifamily buildings. The average duct leakage percentages for detached single family homes do not vary significantly across RMST climate zones.
- ***Efficiency levels of water heating systems are generally above the Minimum Efficiency Standards for both single family homes and multifamily buildings.*** The average EF of water heating systems installed is 16.1% higher than required by the Minimum Efficiency Standards for detached single family homes and 13.3% higher for multifamily buildings.
- ***Dual-paned vinyl windows are typically installed in new homes.*** The predominant window type in for detached single family homes and multifamily buildings is a vinyl-framed, dual-paned, clear glass window.

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[14] A significance test at the 90% confidence level reveals that the estimates of the average percent duct leakage for single family and multifamily homes are significantly different at the state level.

- ***Use of metal-framed windows is more extensive in multifamily buildings than in single family detached homes.***[15] While vinyl-framed, dual-paned, clear glass windows are predominantly used in both detached single family homes and multifamily buildings, metal windows are used more often in multifamily buildings (15.2% compared to 2.0% in detached single family homes).
- ***Use of metal-framed windows varies significantly by climate zone.***[16] For multifamily buildings, the percent of metal-framed windows ranges from a low of 3.3% in RMST Climate Zone 4 to highs of 32.5% and 39.9% in RMST Climate Zones 3 and 5, respectively. For single family homes, the percent of metal-framed windows ranges from 0.9% to 4.5%.
- ***Ceiling and wall insulation levels are usually below prescriptive values.***[17] For those residences where ceiling and wall insulation R-values were obtained, the observed insulation levels were typically lower than prescriptive values, but always greater than or equal to the minimum R-values specified by the Standards.

Analysis of Compliance

Analysis of the MICROPAS results on a *non-compliant/compliant* criterion was not appropriate due to uncertainty with the MICROPAS results. Therefore, it was necessary to develop an error band.[18] Application of the error band resulted in the following four compliance groups, which 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., <-4%).
- ***Indeterminate.*** This category includes sites that have a % Compliance Margin within the error band (-4% to 6%). 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., > 6% and < 26%).
- ***Overly Compliant.*** This category includes sites that, based on the analysis, are overly compliant with Title 24 code. In particular, these sites have a %

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[15] A significance test at the 90% confidence level reveals that, at the state level, there is a significantly higher percentage of metal-framed windows installed in multifamily buildings than in single family homes.

[16] A significance test at the 90% confidence level reveals that there is a significantly higher percentage of metal-framed windows installed in multifamily buildings in RMST Climate Zones 3 and 5 than in multifamily buildings in the remaining RMST Climate Zones.

[17] The prescriptive values, the minimum values allowed by Prescriptive Package D in the 1995 standards, for both ceiling and wall insulation vary by CEC climate zone.

[18] The error band was developed using a criteria of ±10% at a 90% confidence interval.

Compliance Margin greater than 26%. This category was defined to assess the share of homes that would meet the existing ENERGY STAR New Home Construction requirements, given the error band.

The following is a summary of the results from the compliance analysis.

- ***Approximately 13.5% of sites are identified as non-compliant.*** The results from the RNC Interface compliance analysis indicate that 13.5% of all homes built in the study period were non-compliant. As shown in Table ES-2, the vast majority, however, fell within the compliant group (52.1%), while 5.2% fell in the overly compliant group. Figure ES-3 and Figure ES-4 provide a summary of the distribution of sites by % Compliance Margin and compliance group for single family homes and multifamily buildings, respectively.

Table ES-2: MICROPAS Results Summary – Distribution by Compliance Group and Building Type

Compliance Group	All Low-Rise Residence Types	Detached Single Family Homes	Multifamily Buildings
Non-Compliant	13.5%	15.6%	4.8%
Indeterminate	29.3%	32.8%	15.0%
Compliant	52.1%	51.0%	56.5%
Overly Compliant	5.2%	0.5%	23.8%

Figure ES-3: MICROPAS Results Summary – Detached Single Family Homes

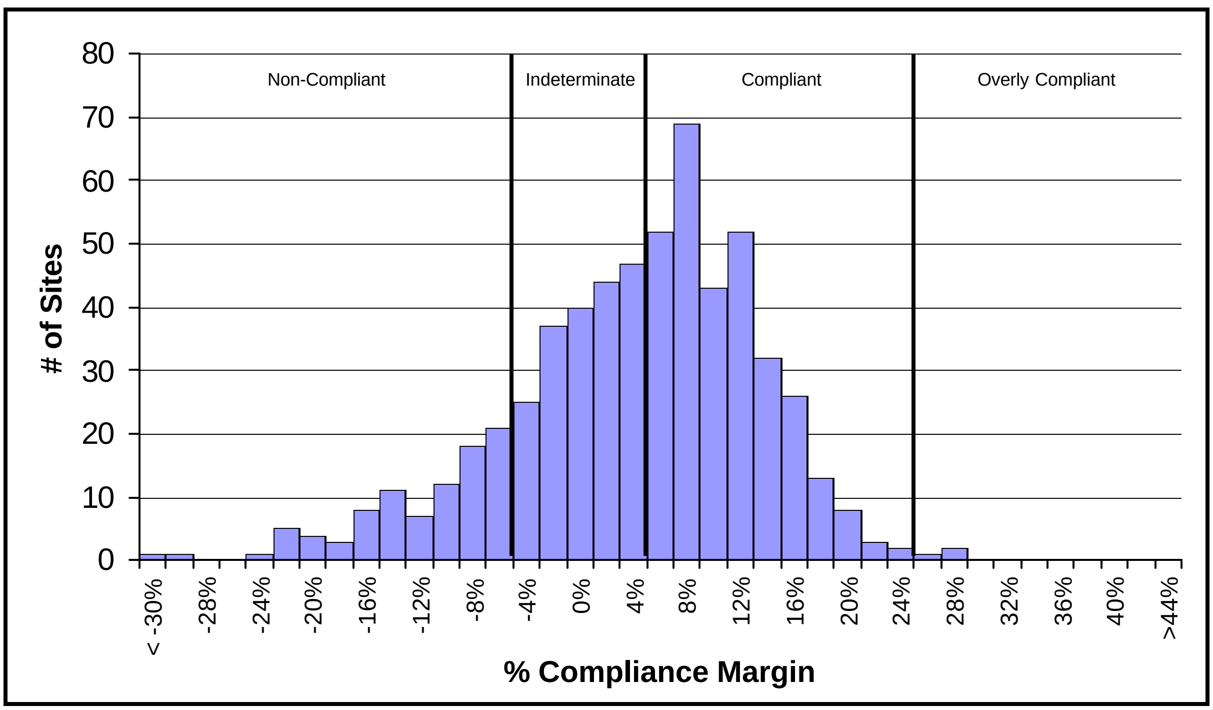
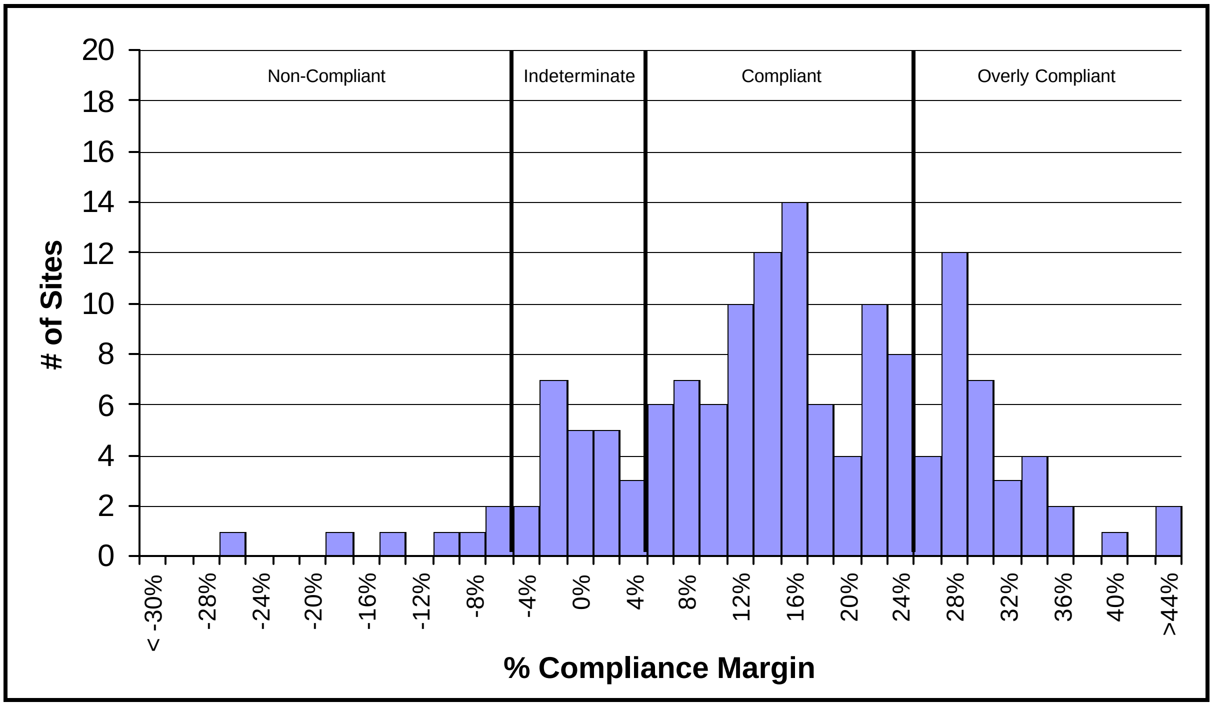


Figure ES-4: MICROPAS Results Summary – Multifamily Buildings



- ***Nearly 90% of Homes have Positive Water Heater Margins.*** Approximately 89.1% of newly constructed homes have water heaters with energy factors above the minimum standard values. This translates into positive water heating (DHW) margins for these homes. In other words, a home that has a high efficiency water heater will have an estimated energy use that is less than the maximum budget allowed—making the home more compliant. Builders and Title 24 consultants validated this result during the in-depth interviews. This is most likely due to the relative low cost associated with increasing water heater efficiency in an effort to meet compliance.

- ***The percent glazing area has a substantial impact on compliance.*** Homes with large glazing percentages, especially glazing percentages exceeding the maximum prescriptive value of 20%, tend to be non-compliant, while homes with small glazing percentages tend to be compliant or overly compliant.

- ***Ceiling and wall insulation play a relatively minor role in compliance.*** The results of the analysis indicate that the impact of increases in wall and ceiling insulation levels on compliance is minimal. As such, when using performance-based methods to determine compliance, builders and Title 24 consultants do not typically use high efficiency insulation. This result is reflected in the fact that ceiling insulation installed in new homes is generally below prescriptive. In addition, wall insulation installed is typically R-13, which is at the prescriptive level in some climate zones but below in others.

- ***The transition period in window manufacturing practices that took place during the compliance analysis might be the cause of some***

homes being well above compliance. The homes covered in the study were built in the second half of 1998 and the first half 1999. As such, they were built in a time of transition in the building industry. In particular, a significant number of homes of this era were designed and compliance documentation was completed with metal-framed windows. However, by the time these homes were built and windows purchased, vinyl-framed windows were becoming the norm and readily available. This was also when higher efficiency water heaters were becoming available for the same cost as standard efficiency units. This factor might be the cause of some homes being well above compliance standards once constructed.

- ***RMST Climate Zone 3 (South Inland) has the highest percentage of compliant homes.*** RMST Climate Zone 3 (South Inland) has the highest percent of compliant homes (84%) and the highest average % Compliance Margin of 12.5%, as shown in Table ES-3. Further, 8% of the sites in RMST Climate Zone 3 fall in the Overly Compliant group, compared to only 2% of RMST Climate Zones 4 and 5. This is due primarily to the impact of glazing percentages and is discussed below.
- ***RMST Climate Zone 5 (Desert and Mountains) has the highest percentage of non-compliant homes.*** RMST Climate Zone 5 is the most non-compliant of the RMST climate zones with an average % Compliance Margin of 0.4%, as shown in Table ES-3. Further, 32% of sites in RMST Climate Zone 5 fall in the non-compliant group, compared to only 6% of RMST Climate Zone 2 and 5% of RMST Climate Zone 3.

Table ES-3: Average Compliance Margins by RMST Climate Zone

	Overall	RMST CZ1	RMST CZ2	RMST CZ3	RMST CZ4	RMST CZ5
Avg. % Comp Margin	7.2%	9.0%	9.5%	12.5%	1.0%	0.4%
Avg. Water Heating Margin	0.75	0.66	0.38	0.68	1.02	0.87
Avg. Space Heating Margin	0.73	0.20	0.15	1.57	0.78	0.08
Avg. Space Cooling Margin	0.42	1.64	1.17	1.23	-1.49	-0.96
Avg. Compliance Margin	1.90	2.51	1.70	3.48	0.31	-0.02

Compliance Variations among Climate Zones

In an attempt to explain the differences in average % Compliance Margins across RMST climate zones, three steps were taken. First, key characteristics such as equipment efficiencies and fenestration information were gathered to compare the average efficiencies for various measures across RMST climate zones. Next, the end-use standard budgets as a percentage of the total standard budgets across RMST climate zones were analyzed. Finally, homes in both the best RMST climate zone and in the two worst RMST climate zones were "relocated" to investigate how each home would comply if it were in a different RMST climate zone.

This analysis of why homes in RMST Climate Zone 3 exhibit higher compliance margins than homes built in RMST Climate Zones 4 and 5 reveals the following. It appears that the fenestration percentage in new homes is relatively constant across the state—regardless of where a house is built, builders/consumers are not willing to decrease the area of windows and glass doors installed, especially in single family homes. However, prescriptive glazing percentages do change. The prescriptive glazing percentage is the lowest in RMST Climate Zones 4 and 5, which makes it more difficult to reach compliance. The analysis of baseline characteristics show that builders in RMST Climate Zones 4 and 5 try to compensate for installing higher glazing percentages than prescriptive by installing more efficient HVAC equipment. Further, since the total HVAC budget is the greatest in RMST Climate Zones 4 and 5, installing high efficiency HVAC equipment provides more "bang for the buck" in these RMST climate zones. These results indicate that insofar as homes in the RMST Climate Zone 4 and 5 do not enjoy the benefit of the lower prescriptive glazing percentage applicable to RMST Climate Zone 3, they tend to install higher efficient HVAC equipment in order to "just comply." These practices lead to a smaller average % Compliance Margin in RMST Climate Zone 4 and 5 relative to RMST Climate Zone 3.

Technical Potential

Once the baseline characterization and compliance analysis were finalized, the technical potential for a handful of energy efficiency measures was estimated. The estimate of technical potential was accomplished by comparing energy use in the as-built case to the high efficiency scenario. Table ES-4 lists the measures analyzed in the technical potential study.

Table ES-4: Description of Measures used in the Technical Potential Analysis

Measure	Description
Low Solar Gain Fenestration	Low solar heat gain fenestration products are typified by a dual-paned, vinyl-framed window with low solar/low emissivity (spectrally selective) glass.
Radiant Barriers	A radiant barrier is a reflective foil or metal-coated surface that is usually placed on or against the underside of the roof.
Tight Ducts	Duct sealing involves actively testing and sealing a duct system with a “duct blaster” or equivalent apparatus.
TXV	The performance of air conditioning systems is strongly dependent on proper refrigerant charge and air flow across the coil. TXVs mitigate the problems of improper refrigerant charge and airflow by making the system operate at its rated efficiency.
All of the above	In addition to analyzing each individually, all measures were analyzed collectively.

Table ES-5 summarizes the results of the technical potential analysis. Total technical potential for each measure was separated into electricity savings (MWh) and gas savings (therms) by residence type. Expansion weights were used to expand the savings found from the 743 homes in the sample to the total number of homes built between July 1, 1998 and June 30, 1999.[19] Table ES-6 shows the potential savings per home, and per 1,000 square foot, of each measure for detached single family homes, while Table ES-7 summarizes the results for multifamily buildings.[20]

[19] During this period, there were 85,554 detached single family homes and 23,506 multifamily units built.

[20] For additional results of the technical potential analysis, please see Section 5 of *the Residential New Construction Study* (RER 2001).

Table ES-5: Summary of Technical Potential of AB 970 Measures for Low-Rise Residences in IOU Service Areas

Measure/Scenario Description	All Low-Rise Residence Types		Detached Single Family Homes		Multifamily Buildings	
	MWh	Therms	MWh	Therms	MWh	Therms
All Measures Implemented	191,907	3,299,956	143,121	2,166,610	48,785	1,133,346
Radiant Barriers	30,889	287,019	22,742	203,573	8,148	83,446
Duct Sealing	32,031	2,441,621	26,948	1,841,889	5,084	599,732
Low Solar Gain Fenestration	119,148	370,078	86,805	-51,324	32,342	421,402
Thermostatic Expansion Valves	30,572	0	23,568	0	7,004	0
Sum of Individual Measures	212,640	3,098,718	160,063	1,994,138	52,578	1,104,580

Table ES-6: Technical Potential Savings of AB 970 Measures – Detached Single Family Homes

Measure/Scenario Description	Cooling Savings[21] (kWh)		Gas Heating Savings[22] (therms)		Electric Heating Savings[23] (kWh)	
	Per Home	Per 1,000 ft^2	Per Home	Per 1,000 ft^2	Per Home	Per 1,000 ft^2
All Measures Implemented	1,749	770	33.5	15.0	435	179
Radiant Barriers	341	150	2.5	1.1	39	16
Duct Sealing	390	172	21.9	9.8	231	95
Low Solar Gain Fenestration	1,062	467	10.5	4.7	194	80
Thermostatic Expansion Valves	344	151	0.0	0.0	0	0
Sum of Individual Measures	2,137	940	34.8	15.6	463	190

[21] The basis for Per Home and Per 1000 ft^2 savings is limited to those homes with cooling equipment.

[22] The basis for Per Home and Per 1000 ft^2 savings estimates is limited to those homes with gas (natural gas and propane) Heating equipment.

[23] The basis Per Home and Per 1000 ft^2 savings estimates is limited to only those homes with electric heating equipment.

Table ES-7: Technical Potential Savings of AB 970 Measures – Multifamily Buildings

Measure/Scenario Description	Cooling Savings[24] (kWh)		Gas Heating Savings[25] (therms)		Electric Heating Savings[26] (kWh)	
	Per Building	Per 1,000 ft^2	Per Building	Per 1,000 ft^2	Per Building	Per 1,000 ft^2
All Measures Implemented	2,541	142	83.3	7.9	969	36
Radiant Barriers	506	28	5.0	0.5	110	4
Duct Sealing	405	28	38.8	3.6	113	4
Low Solar Gain Fenestration	1,694	95	46.2	4.4	835	31
Thermostatic Expansion Valves	480	27	0.0	0.0	0	0
Sum of Individual Measures	3,086	178	90.0	8.4	1,059	40

Table ES-8 and Table ES-9 show the technical potential savings by measure, as well as the technical potential savings as a percentage of the sum of the technical potential savings from the individual measures. Please note that the potential savings from the individual measures are not additive—the sum of the potential savings from the individual measures does not equal the potential savings from all the measures being implemented collectively. This is because there are interactive effects between the individual measures. The results from the tables are summarized below.

- ***The electric technical potential savings from implementing all four measures is <u>less</u> than the sum of the electric technical potential savings from the individual measures.*** This is because low solar gain fenestration and radiant barriers let in less solar heat during the summer, thereby reducing the cooling load required. In turn, there is less potential for savings from duct sealing and installing TXV valves.
- ***The gas technical potential savings from implementing all four measures is <u>greater</u> than the sum of the gas technical potential savings from the individual measures.*** By installing low solar gain fenestration and a radiant barrier in a home, less heat is allowed into the home during winter so more energy is required to heat the home. Therefore, there is more potential for heating savings from duct sealing.

24 The basis for Per Home and Per 1000 ft^2 savings is limited to those homes with cooling equipment.

25 The basis for Per Home and Per 1000 ft^2 savings estimates is limited to those homes with gas (natural gas and propane) heating equipment.

26 The basis Per Home and Per 1000 ft^2 savings estimates is limited to only those homes with electric heating equipment.

- ***A majority of the total electric technical potential savings comes from low solar gain fenestration.*** The electric savings from low solar gain fenestration comprise approximately 54% of the sum of the electric potential savings from the individual measures for detached single family homes (62% for multifamily buildings), whereas the other three measures account for anywhere from 14% to 17% for single family homes and 10% to 16% for multifamily buildings.
- ***For detached single family homes, nearly all of the total gas technical potential savings comes from duct sealing.*** The gas savings from duct sealing comprise just over 92% of the sum of the gas potential savings from the individual measures for detached single family homes. The other three measures account for anywhere from -3% to 10% of the sum.
- ***For multifamily buildings, duct sealing and low solar gain fenestration account for nearly all of the total gas technical potential savings.*** The gas savings from duct sealing comprise just over 54% of the sum of the gas potential savings from the individual measures for detached single family homes and installing low solar gain fenestration accounts for approximately 38%.[27]

Table ES-8: Summary of Technical Potential of AB 970 – Detached Single Family Homes

Measure/Scenario Description	Electric Savings		Gas Savings	
	MWh	% of Sum	Therms	% of Sum
All Measures Implemented	143,121		2,166,610	
Radiant Barriers	22,742	14.2%	203,573	10.2%
Duct Sealing	26,948	16.8%	1,841,889	92.4%
Low Solar Gain Fenestration	86,805	54.2%	-51,324	-2.6%
Thermostatic Expansion Valves	23,568	14.7%	0	0.0%
Sum of Individual Measures	160,063	---	1,994,138	---

[27] There are two main reasons for the significant difference between the gas technical potential savings for low solar heat gain fenestration for detached single family homes (-2.6%) and that for multifamily buildings (38.2%). The first is that the average detached single family home has a 17% glazing area, whereas the average multifamily building has a 9% glazing area. Since more fenestration lets in more solar heat, on average, detached single family homes let in more heat, thereby reducing the heating savings. The second reason is the types of windows currently installed in detached single family homes compared to those installed in multifamily buildings. Section 3.4 shows that the just over 15% of the windows installed in multifamily buildings are metal windows, compared to less than 2% in detached single family homes. The measure calls for dual-paned, vinyl-framed, spectral low-E windows that not only limit the amount of heat that comes in, but also limit the amount of heat that is allowed out, thereby increasing heating savings.

Table ES-9: Summary of Technical Potential of AB 970 Measures – Multifamily Buildings

Measure/Scenario Description	Electric Savings		Gas Savings	
	MWh	**% of Sum**	**Therms**	**% of Sum**
All Measures Implemented	**48,785**		**1,133,346**	
Radiant Barriers	8,148	15.5%	83,446	7.6%
Duct Sealing	5,084	9.7%	599,732	54.3%
Low Solar Gain Fenestration	32,342	61.5%	421,402	38.2%
Thermostatic Expansion Valves	7,004	13.3%	0	0.0%
Sum of Individual Measures	52,578		1,104,580	

Survey of Builders and Title 24 Consultants

To assess the impacts of recent changes in Title 24 standards, RER conducted 13 in-depth and 55 telephone surveys of Title 24 consultants and 17 in-depth interviews with builders of either single family homes or low-rise multifamily buildings. Key findings are summarized below.

Title 24 Consultants

Findings Related to AB 970

- ***HERS certification is not seen as a cost-effective way to meet the AB 970 requirements by the Title 24 consultants.*** Several Title 24 consultants are opposed to using duct credits that require HERS certification because of added financial cost and the time required to schedule a rater to come to the building site.
- ***Title 24 consultants do not believe builders are likely to use measures requiring HERS certification to meet the AB 970 requirements.*** A majority of the Title 24 consultants believes that builders are willing to implement a variety of additional features to negate the need for verification by a HERS rater. They believe that builders will likely use a combination of all four options (high efficiency water heaters, high efficiency central air conditioners, high efficiency furnaces, and increased insulation). They further explained that higher efficiency water heaters are the most popular choice and increasing insulation levels is the least popular.
- ***Taking credit for the use of TXV valves is tied to the use of duct sealing credits.*** TXV valves are inexpensive and, although certification is required to receive the credit, if builders were to use the certified sealed ducts credit they would likely install and take the credit for TXV valves.
- ***Title 24 consultants believe that the most effective way for the utilities to assist builders in meeting the AB 970 requirements is to offer more training and education.*** Many of the Title 24 consultants offered suggestions on how utilities

can assist builders. Thirty-one consultants suggested offering more training. Other suggestions commonly mentioned include providing more information on the utility-sponsored programs, offering rebates, and improving the HERS certification process.

- ***One consultant interviewed believes that AB 970 may encourage builders to participate in a program because, once the new standards are met, the additional measures needed to meet program requirements are not that significant.***

  > *"AB 970 shouldn't affect their residential programs much, in fact new standards may actually encourage builders to participate in programs since the % above standards they will have to achieve will be less. Thirty percent MEC (the current ENERGY STAR requirement) is roughly equivalent to 25% better than Title 24. With AB 970 changes, 30% MEC will probably be about 10-15% better than Title 24. Builders may be more willing to go the extra mile because it doesn't take much effort to do so."*

Title 24 and Other Major Findings

- ***The feature seen as the biggest barrier to compliance is large glazing areas.*** In the in-depth interviews with Title 24 consultants, nearly all of the consultants stated emphatically that large glazing areas are the biggest barriers to meeting compliance for the 1998 standards for single family homes.
- ***Credits are not generally needed to help homes comply with the Title 24 requirements.*** One overarching message gained from the consultants is that they do not need to use the credits in order to meet the requirements of the 1998 standards, builders do not want to use them, and the certification process is cumbersome. This result was found during both the telephone interviews and the in-depth interviews. Many of the consultants explained that implementation of the 1998 standards did not make it more difficult for them to meet compliance, and instead, in some cases, made it easier.

Builders

Findings Related to AB 970

- ***Builders are not generally familiar with the AB 970 requirements.*** Ten builders reported that they are unfamiliar with the new AB 970 standards. Four said that they are somewhat familiar, and three said that they are very familiar with the new standards.
- ***Builders were generally unable to answer the question regarding the impact of the AB 970 standards on the RNC programs.*** Due to a lack of knowledge about AB 970, most builders were not comfortable answering questions relating to the impact of the AB 970 requirements on existing RNC programs.
- ***High performance windows will most likely be used to meet the more stringent requirements.*** The vast majority of builders mentioned that they will most likely use higher performance windows to comply with the new standards.

General Findings

- ***Builders are not generally familiar with the Title 24 standards.*** Seven builders admitted that they are not at all familiar with the 1998 Title 24 low-rise residential standards, seven said they are somewhat familiar with them although unaware of the specifics, and only three are very familiar with the standards.
- ***Compliance issues are usually handled by a Title 24 consultant.*** Lack of in-depth knowledge of the standards reflects the fact that builders do not give much thought to the standards and, instead, pass the responsibility on to a Title 24 consultant. In general, the builders view compliance as something that needs to be done, but not something that requires much, or any, effort on their part.
- ***Water heaters are typically seen as the feature that can be modified most easily to get marginal homes to comply.*** This was mentioned by both single family and multifamily builders.
- ***Credits offered under Title 24 are not generally used.*** Three builders cited that the current housing market is so strong that it is not necessary to offer energy efficiency as a selling point, and that using the various credits takes time and slows down production. Two builders mentioned that it is not cost-effective to use the credits since "the gains are miniscule." Four builders said they are unfamiliar with the credits.

Findings Specific to Single Family Attached and Multifamily Builders

- ***Multifamily builders are less willing to invest in energy efficient equipment.*** The primary differences discovered between single family attached and multifamily builders are that multifamily builders are not as concerned with occupant comfort because they are building rental units. They are also more concerned with initial cost.
- ***Single family attached and multifamily builders are not generally aware of the Title 24 standards.*** Similar to findings from single family detached builders, single family attached builders and multifamily builders are relatively unaware of 1998 Title 24 and AB 970 standards.
- ***Miscellaneous Findings.*** In general, single family attached builders and multifamily builders do not make use of the credits offered under Title 24, are unaware of the AFUE levels of the furnaces they install, use higher efficiency water heaters to make marginal homes to comply, and are likely to use higher efficiency windows to avoid the necessity of using a HERS rater.

Compliance Analysis of Likely Building Practices Under AB 970

As predicted, results show that implementing either low solar heat gain fenestration or duct sealing alone will not be enough for many homes to comply with the new AB 970 Standards. However, implementing one of these measures along with other high efficiency measures causes nearly all detached single family homes to comply. Other key findings are summarized below.

- ***Of the measures required by Prescriptive Package D, builders are most likely use low solar heat gain fenestration.*** Title 24 consultants felt that builders are most likely to install low solar heat gain fenestration. On a scale of 1 to 5, with 5 meaning Very Likely, the average ranking for low solar heat gain fenestration was 3.9, compared to 3.2 and less for the other three measures.
- ***Of the other high efficiency measures, builders are most likely to install high efficiency water heaters and air conditioners.*** The average ranking of these two measures was higher than that for increased insulation levels and high efficiency furnaces.
- ***Installing low solar heat gain fenestration brings homes closer to complying with AB 970 than using duct sealing.*** When globally implementing low solar heat gain fenestration, nearly 56% of homes were compliant and only 15% were non-compliant. However, nearly 39% of homes were non-compliant when duct sealing was globally implemented and only 27% of homes were compliant.
- ***If builders were to implement all four measures required by AB 970 Prescriptive Package D, at least 92.3% of detached single family homes would comply.*** Furthermore, only 1.2% of the homes would be in the non-compliant group.

Table ES-10 presents the compliance results of implementing each of the four measures required by Prescriptive Package D individually as well as together. As shown, nearly all homes comply (92.3%) when all four measures are implemented together. Further, only 1.2% of detached single family homes fall in the non-compliant group, while an additional 6.6% are in the indeterminate group.

Table ES-10: Compliance Results Using Measures Required by Prescriptive Package D – Detached Single Family Homes

	Non-Compliant	Indeterminate	Compliant	Overly Compliant
Baseline	59.9%	22.9%	17.2%	0.0%
Radiant Barriers	51.4%	25.3%	23.3%	0.0%
Duct Sealing	38.6%	34.1%	27.3%	0.0%
Low Solar Heat Gain Fenestration (0.40)	15.2%	29.0%	55.3%	0.5%
Thermostatic Expansion Valves (TXV)	53.0%	25.8%	21.2%	0.0%
All Four Measures	1.2%	6.6%	87.7%	4.6%

Issues Related to RNC Program Offerings

The following discusses some issues and recommendations that relate to residential new construction energy efficiency program design. These issues and recommendations are the result of the compliance analysis, the builder and Title 24 consultant interviews, and discussions with industry experts.

- ***Climate Zone Differences Should Be Recognized.*** Compliance results show that it is much harder to achieve 20% above standard for some climate zones than others. RNC programs should recognize this fact and should provide more incentives in some regions than others. Additionally, the focus or requirements of the program should be tailored to individual climate zones. Insofar as climate zones overlap utility service territories, this might also support an argument for a statewide program versus a utility-based program.
- ***Target Multifamily Buildings.*** Multifamily buildings are not currently targeted for RNC programs, yet it is apparent that there is substantial room for improvement in the multifamily buildings. From this and previous studies, percent glazing used in multifamily buildings is typically much less than the prescriptive values, which yields energy budget excess that can (and is) traded off to utilize other features of lower performance. Emphasis for these buildings is usually first cost. However, multifamily buildings are also inherently more energy efficient than detached single family homes due to lower surface-area-to-volume ratios.[28]
- ***Provide Training to Builders.*** Training and education of builders was believed to be one of the more effective ways to help builders understand and meet the AB 970 requirements.
- ***New Opportunities from AB 970 Environment.*** AB 970 may encourage builders to participate in a program because, once the new standards are met, the additional measures needed to meet program requirements are not that significant.
- ***Multiple HVAC Systems.*** A relatively small number of homes have more than one HVAC system (10% statewide but 20+% in RMST Climate Zones 3 and 5). Multiple systems are typically installed in larger homes and the main reason is comfort. Although using more than one HVAC unit can increase the first cost of a home, downsizing of units, zonal operation, using one to heat/cool and another to circulate can probably lead to significant energy savings if the systems are designed properly. However, operation of both systems during peak demand periods would have an overwhelmingly negative impact. This finding may warrant further consideration, especially if the average home size increases.

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[28] There is currently a pilot program being run by SDG&E that targets multifamily buildings as well as single family homes. PG&E is also considering targeting these building types. In addition, the CEC and associated parties have considered a different set of standards for multifamily buildings, especially regarding percent glazing prescriptive values, for quite some time.

ES.5 Next Steps

The remaining step in the project involves analyzing the data collected for the second year. RER and Volt VIEWtech are presently conducting the second year on-site survey for the RMST study. Surveyors are using the revised survey instrument that was designed after reviewing the data collected from the first year on-site surveys. This second year study will follow the same sample design as the first year study and will cover single and multifamily homes constructed between July 1, 1999 and June 30, 2000. The data from this survey will be used to conduct a second phase of building characterization and compliance using the RNC Interface. The on-site survey is scheduled for completion in May 2001.

1

Introduction

1.1 Overview

The work presented in this report is part of a two-year study conducted by Regional Economic Research, Inc. (RER) under Pacific Gas & Electric (PG&E) management. The report investigates energy efficiency in newly constructed low-rise residential 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 and impending energy code changes on these programs. Significant changes in the California energy market, implementation of the 1998 Residential Standards, and the impending implementation of emergency revisions to the Standards under AB 970[1] make this report especially significant.

Sections 2 through 4 focus on the development of baseline practices and an analysis of Title 24 compliance in newly constructed low-rise residential buildings in California. Section 5 presents the estimated technical potential of five of the measures included in AB 970. Sections 6 and 7 summarize the findings of interviews with Title 24 Consultants and residential builders. Section 8 presents a summary of the key findings of the project, comments on issues that are relevant to residential new construction program planners, comments relating to Title 24 compliance issues, and possible impacts of the emergency residential standards—AB 970.

This section provides a review of the objectives of this project, a discussion of the approach taken along with key findings from each of the various sections of this report, and a brief discussion on the next steps in the project.

[1] 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.

1.2 Objectives

The study makes extensive use of on-site surveys of residential homes performed for the Statewide Residential Market Share Tracking Study (RMST)[2] and interviews with builders and Title 24 consultants to assess the state of energy efficiency in the residential new construction market. Objectives of the study can be summarized as follows:

- Examine the status of Title 24 compliance for a representative sample of California residences as constructed (or as-built), using the MICROPAS Title 24 computer compliance tool.
- Analyze the technical potential of key energy efficiency measures[3] and determine what measures could most be effectively applied to make homes meet the requirements of most RNC programs (such as ENERGY STAR® Labeled New Homes, PG&E Comfort Home, etc.).
- Assess the impacts of recent changes in Title 24 Standards, including changes in construction practices and compliance behavior attributable to 1998 standards.
- Collect information on builder and Title 24 consultant perceptions on the impact of the AB 970 standards passed in January 2001 on construction practices and compliance behavior and possible impacts on new construction energy efficiency programs.
- Determine if the anticipated changes in building practices, in response to AB 970, will be enough to comply with these new standards.

The results from this study will be used to track common building practices in the residential new construction sector, to assist residential new construction program managers to develop and maintain effective energy efficiency initiatives, and to assess the energy savings potential for new energy using technologies.

1.3 Overview of Approach

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

The objective of this phase of the project is to describe common building practices and analyze Title 24 compliance for residential low-rise buildings. To accomplish this task, a

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2 *California Residential Efficiency Market Share Tracking – First-Year Interim Report.* RER, Inc. October 2000. Prepared for Southern California Edison.

3 The measures selected are the four new measures required by Prescriptive Package D of the AB 970 Emergency Standards. These include radiant barriers, high performance fenestration, and HERS-certified duct sealing, and refrigerant charge and airflow (RCA) testing.

software tool was developed that allows the data from 800 on-site surveys[4] to be translated into a MICROPAS input file. These input files are then processed by MICROPAS and the results are made available in a number of formats. These results, together with the detailed on-site data, were then analyzed to ascertain common building practices and complete the Title 24 compliance analysis. The major elements included in the approach are to review the on-site survey database, create the RNC interface, test the RNC interface, complete the MICROPAS compliance analysis of the 800 residences, identify baseline characteristics, and analyze the compliance results.

Overview of Approach to Analyze Technical Potential

The objective of this phase of the project is to estimate the technical potential of installing various measures required under AB 970 Prescriptive Package D. The general approach taken for the technical potential assessment is as follows:

- Perform baseline MICROPAS 6.0 (AB 970 version) runs for the residences as constructed (as-built),
- Perform measure runs by implementing the measure only for those homes that did not already have the measure, and then running them in MICROPAS 6.0,
- Calculate source energy savings[5] (MICROPAS default output) for the measure by subtracting measure run results from the baseline as-built run results,
- "Filter," as required, to provide savings estimates that accurately reflect the as-built construction of the home (e.g., no cooling savings if no cooling equipment installed) and applicability of measures under Prescriptive Package D of AB 970 (i.e., some measures are not required in all CEC climate zones), and
- Convert filtered annual source energy savings to fuel/end-use savings.

Overview of Approach to Assess Impacts of Recent Changes in Title 24 Standards on Title 24 Consultants and Builders

The objective of this phase of the project was to assess the impacts of the 1998 standards and to gather market actors' perceptions of AB 970 and how it will affect building practices and RNC programs. The approach to accomplish this objective involved in-depth interviews and telephone surveys of Title 24 consultants and builders.

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4 Residential Market Share Tracking project being conducted by Regional Economic Research, Inc. for Southern California Edison, 2000-2001.

5 Source energy savings is the basis used for compliance analysis and attempts to account for production and distribution losses inherent in delivering a particular fuel to a home. Engineering units used to specify source energy are "skBtuh" where the "s" denotes source energy. This primarily impacts electricity, where a factor of 3 in addition to the usual conversion factor of 3.413 kBtuh/kW is used to account for generation, transmission, and distribution losses.

In particular, RER conducted 13 in-depth interviews with Title 24 consultants. Following these interviews, a telephone survey for the Title 24 consultants was designed using the knowledge gained from the in-depth interviews and 25 telephone surveys were conducted. In addition, RER conducted 12 in-depth interviews with builders. The initial work plan called for follow-up telephone surveys of over 100 builders. However, due to the recent passing of AB 970, the project team changed the focus of this element of the project to concentrate on gathering information on the impact of AB 970. Insofar as the in-depth interviews revealed a general lack of knowledge about AB 970 on the builders' part, the team decided to omit the builder survey and to complete five additional builder in-depth interviews. These five additional interviews concentrated on gathering information from multifamily builders. The scope of the Title 24 consultants telephone surveys was also revised to include 30 additional Title 24 consultant telephone surveys.

Overview of Approach to Analyze the Compliance of Likely Building Practices Under AB 970

Insofar as AB 970 does not become effective until January 2002, the main sources of information on how builders and Title 24 consultants plan to meet the new standards are self-reported data from telephone surveys with Title 24 consultants. The analysis discussed in this section focuses on taking the self-reported information on likely changes in building practices and simulating these plans using the RNC Interface. The simulations will analyze whether builders can meet the new standards using their planned approaches.

1.4 Next Steps

The remaining step in the project involves analyzing the data collected for the second year. RER and Volt VIEWtech are presently conducting the second year on-site survey for the RMST study. Surveyors are using the revised survey instrument designed after reviewing the data collected from the first year on-site surveys. This second year study will follow the same sample design as the first year study and covers single and multifamily homes constructed between July 1, 1999 and June 30, 2000. The data from this survey will be used to conduct a second phase of building characterization and compliance using the RNC Interface. The on-site survey is scheduled for completion in May 2001.

1.5 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 Residential New Construction Interface (RNC Interface) to MICROPAS.

- Section 3 discusses and summarizes the current building practices in low-rise residential buildings.
- Section 4 discusses the analysis of Title 24 compliance in low-rise residential buildings.
- Section 5 presents the estimated technical potential of five of the measures included in AB 970.
- Section 6 summarizes the findings of both the in-depth and telephone interviews with Title 24 Consultants.
- Section 7 discusses the in-depth interviews with the builders.
- Section 8 presents the compliance analysis of likely building practices under AB 970.
- Section 9 presents a summary of the key findings of the project and comments on issues that are relevant to residential new construction program planners, Title 24 compliance issues, and possible impacts of the emergency residential standards.
- The following appendices are included:
  - Appendix A: Sample C-2R form
  - Appendix B: Summary of the effort to collect C-2R forms
  - Appendix C: On-Site Survey Forms (first year and second year)
  - Appendix D: Duct Blaster Test Survey Forms (first year and second year)
  - Appendix E: Technical Potential – Radiant Barrier Tables
  - Appendix F: Technical Potential – Low-E Windows Tables
  - Appendix G: Technical Potential – TXV Valves Tables
  - Appendix H: Technical Potential – Tight Duct Tables
  - Appendix I: Technical Potential – All Measures Tables
  - Appendix J: Title 24 Consultant Telephone Survey
  - Appendix K: Title 24 Consultant In-Depth Survey
  - Appendix L: Builder Telephone Survey
  - Appendix M: Builder In-Depth Survey

2

The RNC Interface

2.1 Introduction

This section briefly describes the development and testing of the RNC Interface that was created to generate MICROPAS Title 24 standard compliance analyses (compliance runs) based on survey data collected for the California Residential Market Share Tracking (RMST) Study.[1] The primary purpose of the RNC Interface is to generate MICROPAS compliance runs from the RMST survey data of newly constructed residences. These runs are used to examine the compliance status for each residential building and to explore the energy conservation potential of some key energy saving technologies. MICROPAS was chosen as the compliance tool because it is the tool of choice among energy consultants for performing low-rise residential compliance analysis.[2] 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 or 5.1,
- Extract the MICROPAS compliance results, and
- Provide a platform for the technical potential analysis.

The following sections provide an overview of the RNC Interface, details 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 to this year's on-site survey instrument to improve the MICROPAS simulations.

2.2 Overview of the RNC Interface

Figure 2-1 presents an overview of the RNC Interface. As shown, the RNC Interface uses the data collected from 800 on-site surveys to create a MICROPAS input file. This is accomplished by first

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[1] *California Residential Efficiency Market Share Tracking. First-Year Interim Report.* Prepared for Southern California Edison by Regional Economic Research, Inc. October 2000.

[2] Interviews with MICROPAS developers indicate that more than 75% of energy professionals use their product. Further, two recent studies by RER indicate that more than 90% of energy compliance documentation was completed using MICROPAS.

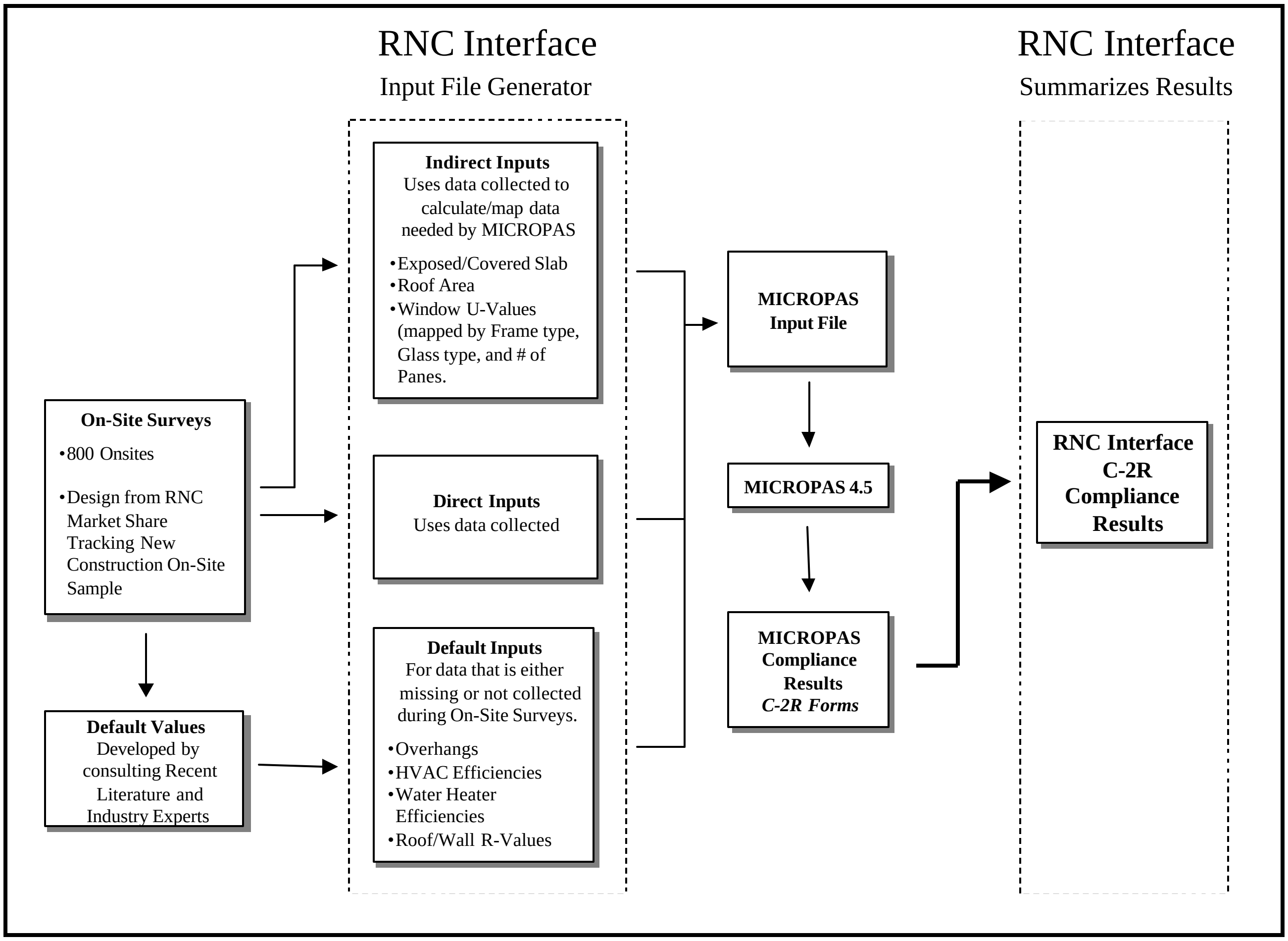
manipulating the data,[3] then "writing" it to a file in the required MICROPAS input format. The RNC Interface then passes the input file through MICROPAS 4.5. Results from the MICROPAS compliance runs utilized for this project are as follows:

- ***C-2R Forms.*** The interface produces results in the same format as the C-2R forms used for compliance documentation. The C-2R form contains the following information:
  - **General Information:** floor area, building type, and number of stories.
  - **Opaque Surfaces:** wall area and the insulation R-value.
  - **Perimeter Losses:** slab edge length, F2 factor, and the insulation R-value.
  - **Fenestration Surfaces:** window area, # of panes, frame type, glass type, U- value, and overhang dimensions.
  - **Thermal Mass:** slab area, slab thickness, and R-value.
  - **HVAC Systems:** duct efficiency, heating equipment efficiency, and cooling equipment efficiency.
  - **Water Heating Systems:** tank size and energy factor.

  A copy of a C-2R form is contained in Appendix A.
- ***Summary of Compliance Energy Simulations.*** In addition, the RNC Interface is capable of outputting the compliance energy use results and producing summary tables of energy use by end use and by site.

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

Figure 2-1: Overview of the RNC Interface Framework



MICROPAS Version 4.5 and 5.1

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. The current standards are the 1998 Standards, which were implemented in July 1999 and superceded the 1995 Standards.

Because of the long lead time usually involved with production-type housing—one to two years from plan approval to actual construction—it was known that most of the residences surveyed in the first year of the RMST study (residences occupied July 1998 through June 1999) would likely have been built under the 1995 Standards. Furthermore, it was expected that most of the sites surveyed for the second year of the RMST study would have been built under the 1998 Standards. In addition, being able to utilize the new features incorporated into MICROPAS5 for the technical potential portion of the RNC study was highly desirable. This situation required that the RNC Interface be able to run both versions of MICROPAS.

The major differences between MICROPAS versions 4.5 and 5.1 include the revision of window performance parameters, the use of water heater insulation blankets, the addition of new compliance credits, and a revision to the use of thermal mass, as summarized below.[4]

- ***Window Shading Performance*** is now based on the Solar Heat Gain Coefficient (SHGC) instead of the Shading Coefficient (SC). The National Fenestration Rating Council (NFRC) ratings from the window manufacturer are the preferred rating source.
- ***Water Heater Insulation Blanket*** installation is no longer a credit, but an R-12 blanket is mandatory if the Energy Factor (EF) is below 0.58.
- ***New Compliance Credits*** for housewrap, radiant barriers, diagnostic duct testing, reduced infiltration, duct design per ACCA Manual D,[5] and combinations of these credits are included in the latest Standards.
- ***Thermal Mass.*** Slab exposed/covered areas are defaulted to 20/80%, respectively, except for exceptionally high mass (>30% exposed area) residences.

Developing MICROPAS Inputs from the RMST On-Site Survey Data

The RMST 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. In particular, some of the information needed to create the input file was simply not collected or had to be manipulated in order to be utilized in the MICROPAS run. As such, the transformation of RMST survey data to MICROPAS inputs can be characterized in the following four categories.

- ***Direct Inputs.*** These values, types, etc., are mapped directly from the RMST 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.
- ***Indirect Inputs.*** These values, types, etc., from the RMST survey database are used to indirectly populate specific fields in the MICROPAS input file, whether by a mathematical calculation or by a query used to map the information obtained to one of MICROPAS' keywords. One example of an indirect input is roof area. Since roof area is not directly collected during the on-site survey, it is calculated from the data that are collected, which includes Total Conditioned Floor Area, Number of Floors, and the Estimated % of Total Floor Area with Vaulted Ceiling. Another is window performance characteristics.
- ***Default Inputs.*** These values, types, etc., are required MICROPAS inputs, including MICROPAS run parameters, for which no equivalent direct or indirect survey data value

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4 A detailed discussion of the differences can be found in the MICROPAS5 User Manual. *MICROPAS5 User Manual*. Enercomp, Inc. June 10, 1999 memo to MICROPAS Users

5 Air Conditioning Contractors of America (ACCA). 1995. *Residential Duct Systems: Manual D. 2nd Ed.* Washington, DC.

exists. Examples of default inputs include the dimensions and positioning of overhangs over windows and doors and slab thickness and thermal performance characteristics.

- ***Direct/Indirect Defaults.*** These are defaults for direct or indirect values that are required MICROPAS inputs, but for which no value was entered on the survey form (missing data). Examples of direct/indirect 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 *indirect inputs*, *default inputs*, and *direct/indirect 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

It was recognized early on that the need 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, was critical to performing the runs efficiently. This task was accomplished using MICROPAS's "command line" run option. This feature allows outside control of MICROPAS execution and outputs results and errors into a comma-delimited text file. The RNC Interface utilizes the MICROPAS command line run option to control the execution of each MICROPAS run, then imports the run results into an Access database table automatically as each run is completed. The command line version of MICROPAS, along with the other controls implemented within the RNC Interface, make it relatively easy to perform batch runs and review the run results for any version of MICROPAS.

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, or 6),
- Select whether to run a Cardinal,[6]
- Select the weather data set to use – FullYear or ReducedYear,[7] and
- Specify the source input database (this feature was used for the testing phase to read in building department C-2R data).

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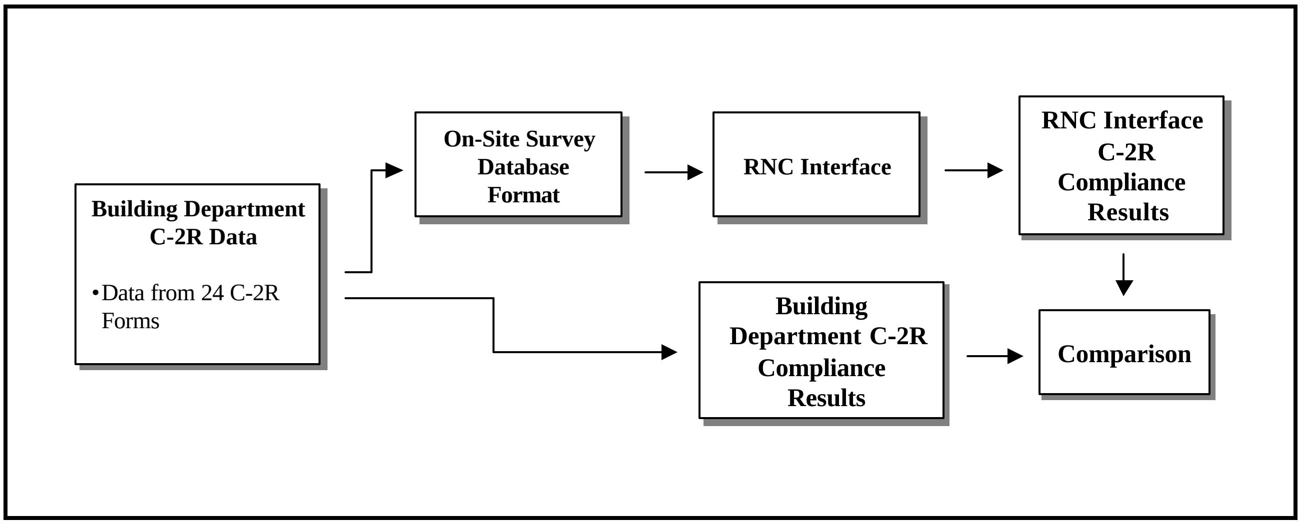
6 A Cardinal run is actually four runs—a run is done for the home facing each of the four cardinal directions (North/East/South/West) and compliance is determined by the run with the smallest margin.

7 "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.*

2.3 Testing the RNC Interface

A considerable effort was made to ensure that the RNC Interface produces accurate MICROPAS simulation results given the limitations of the available data and the design of the RNC Interface. To accomplish this task, a testing procedure to evaluate the default parameters and underlying algorithms and structure of the RNC Interface was developed. An overview of the RNC Interface testing procedure is depicted in Figure 2-2. As shown, Title 24 compliance forms (C-2R forms) for a subsample of RMST surveyed sites were gathered from building departments. For each subsampled site, data from the C-2R compliance documentation were used to populate an RMST survey form. These forms were then processed through the RNC Interface. The results were then compared to the compliance data on the original C-2R forms. Based on the analysis of the differences in the compliance results, additional changes were made to the RNC Interface. This procedure was repeated until an acceptable margin of error was reached. Once reached, a final error band was developed for use in analyzing the remaining RMST surveyed sites.

Figure 2-2: Overview of RNC Interface Testing Procedure



The testing procedure has three major elements:

- Collecting building department compliance documentation,
- Transforming the building department compliance documentation (C-2R forms) into the RMST format, and
- Comparing the RNC Interface compliance results to the building department C-2R compliance results.

Each element is discussed below.

Collecting Building Department Compliance Documentation

The original sampling plan for collecting C-2R forms was a stratified random sample of RMST surveyed sites. The sample was stratified by residence type (i.e., single family, single family detached, multifamily) and climate zone. Primary and secondary lists of sites were randomly selected from the RMST surveyed sites for each stratum. However, after contacting a majority of the sites from both the primary and secondary lists,[8] it was discovered that nearly half of the original sample of building departments did not keep C-2R forms. Further, some of those that did were unable to retrieve the forms due to limited manpower. Therefore, a simplified approach was taken. In particular, RER identified building departments with the largest number of surveyed sites and building departments that had already been contacted as part of the RMST study effort. From this list, an attempt was made to recruit participants from those building departments that have already been providing compliance documentation as part of the RMST study. Also recruited were those building departments on the list in San Diego County. The latter group was added out of convenience so that RER staff could visit the building department in person and facilitate the collection of the compliance documentation. To increase the sample size, RER also tried to recruit those building departments with relatively large numbers of surveyed sites that had not been contacted as part of the RMST study effort. These were the most difficult and time consuming to contact and were used as a last resort.

RER contacted over 50 building departments, but only six were willing and able to contribute C-2R forms. The locations of participating building departments are shown in Figure 2-3. Forms for 40 on-site survey sites were collected, but only 36 of those matched 37 sites (one of the C-2R forms matched two on-site survey sites). A summary of the completed sample of building departments providing C-2R forms is presented in Table 2-1. The distribution is quite different from that given in the original plan, because it was very difficult to convince building departments to contribute to this effort due to their limited time and available manpower. However, all building types and RMST climate zones are represented.

8 The primary and secondary building departments to contact are detailed in the work plan. For further information, please see Appendix B.

Figure 2-3: Location of Building Departments Contributing C-2R forms

Table 2-1: Final Building Department Sample

RER CZ	CEC CZ	Bldg Dept	SF 1-Story	SF 2-Story	SF Attached	MF	Total C-2R Forms
1	3, 12	Alameda	2	5	1		**8**
2	7, 10	San Diego		5		2	**7**
	7	Chula Vista	2	13			**15**
3	9	Simi Valley		2		1	**3**
4	11	Rocklin	1	2		1	**4**
5	15	La Quinta	3				**3**
		Totals	**8**	**27**	**1**	**4**	**40**

Table 2-2 presents a summary listing of key information contained in the C-2R compliance documentation and from the RMST surveys for the test sample. Although C-2R documentation for 40 sites was collected, further review of the documentation revealed that three of the sites were in fact not matched for the RMST surveyed sites. These three sites were dropped from the analysis. Notable findings from these data include the following:

- Total conditioned floor area on the building department C-2R forms (*C2Rft2*) is typically within 10% of the square footage information gathered during the RMST survey (*ONSft2*).
- Thirty-one (31) of the matched C-2R forms were run using MICROPAS v4.5 (*MP Version*). There are also three C-2R forms run using MICROPAS v5.1 and two using Comply 24.
- Almost 90% of the matched C-2R forms were run with the "Cardinal" (*CardRun?*)[9] run option. Custom single family homes using a single front orientation angle comprised the remainder.
- As indicated in the column labeled *C2Rweather* in Table 2-2, 31 of the matched C-2R forms were run with the *ReducedYear*[10] weather run option. The remaining six used the *FullYear* weather run option.
- As indicated in the column labeled *DBTest?* in Table 2-2, duct blaster tests were performed as part of the on-site surveys for four sites.

A key parameter used in the testing of the RNC Interface is the *% Compliance Margin*. The % Compliance Margin is the compliance margin (standard energy budget—proposed energy budget) expressed as a percent of the standard energy budget.[11] A summary of the % Compliance Margin by residence type for the building department C-2R forms is presented in Table 2-3.

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9 If "Cardinal" is specified for the front orientation angle in MICROPAS, four runs are performed, one for each of the four cardinal directions—North, East, South, West—and compliance is determined from the run with the smallest margin (Standard Budget minus Proposed Budget).

10 The MICROPAS *ReducedYear* run-option is a CEC-approved method that allows users to drastically reduce the calculation time associated with a *FullYear* (8760 hourly) run.

11 For further discussion on the "Margin % of Standard," please see Section 2.3 Testing the RNC Interface.

Table 2-2: Key Site and C-2R Compliance Run Characteristics

SiteID	CEC CZ	Bldg Type	# of Units	# Floors	C-2R sq. ft.	On-Site sq. ft.	MP Version	Cardinal Run?	C2R Weather	Duct Blaster Test?
346	3	SF	1	2	1,413	1,400	4.50	Y	ReducedYear	No
405	12	SF	1	1	2,586	2,587	4.50	Y	ReducedYear	No
478	3	SF	1	2	1,819	1,870	4.51	Y	ReducedYear	No
743	11	SF	1	2	4,744	4,778	4.50	**N**	**FullYear**	No
1297	9	**MF**	16	2	9,732	9,200	4.51	Y	ReducedYear	No
2131	7	SF	1	2	1,804	1,800	4.50	Y	ReducedYear	No
2134	7	SF	1	2	2,042	2,200	4.50	Y	ReducedYear	No
2152	7	SF	1	2	2,272	2,145	4.50	Y	ReducedYear	No
2159	7	SF	1	2	1,923	1,923	**5.00**	Y	ReducedYear	No
2161	10	SF	1	2	2,652	2,451	4.50	Y	ReducedYear	Yes
2195	7	SF	1	2	2,181	2,200	4.50	Y	ReducedYear	No
2300	7	SF	1	2	1,798	1,800	**5.00**	Y	ReducedYear	No
2334	7	SF	1	2	1,793	1,793	4.51	Y	ReducedYear	No
2403	7	**MF**	6	2	6,852	10,560	4.50	Y	ReducedYear	No
3452	11	SF	1	2	2,261	2,538	4.50	Y	ReducedYear	No
4563	15	SF	1	1	2,610	2,688	4.51	**N**	ReducedYear	Yes
4571	15	SF	1	1	2,349	2,500	4.51	**N**	ReducedYear	No
4591	7	**MF**	6	2	6,672	7,200	4.50	Y	ReducedYear	Yes
4668	7	SF	1	2	2,025	1,800	4.50	Y	ReducedYear	No
4700	7	SF	1	2	1,698	1,700	4.50	Y	ReducedYear	No
4731	7	SF	1	1	1,856	1,859	4.50	Y	ReducedYear	Yes
4748	7	SF	1	2	1,627	1,600	4.50	Y	ReducedYear	No
4753	7	SF	1	2	2,314	2,300	**5.00**	Y	ReducedYear	No
4764	7	SF	1	2	2,221	2,000	4.50	Y	ReducedYear	No
5014	3	SF	1	2	2,331	2,350	4.50	Y	ReducedYear	No
5300	3	SF	1	1	1,575	1,650	4.50	Y	ReducedYear	No
5350	3	SF	1	2	2,822	3,100	4.50	Y	ReducedYear	No
5841	11	**MF**	8	2	7,793	8,000	4.50	Y	ReducedYear	No
6080	11	SF	1	1	1,674	1,260	4.50	Y	**FullYear**	No
6575	9	SF	1	2	1,183	1,205	4.50	Y	**FullYear**	No
7068	15	SF	1	1	2,025	2,094	**Comply24**	Y	**FullYear**	No
7154	7	SF	1	2	2,017	2,100	4.50	Y	ReducedYear	No
7185	7	SF	1	2	2,952	3,000	4.50	Y	ReducedYear	No
7197	7	SF	1	2	1,860	1,860	4.50	Y	ReducedYear	No
7508	3	SF-A	1	2	2,490	2,000	4.50	Y	ReducedYear	No
7905	3	SF	1	2	2,584	3,300	4.51	Y	**FullYear**	No
14556	15	SF	1	1	2,025	2,000	**Comply24**	Y	**FullYear**	No

Table 2-3: Summary of % Compliance Margin from Building Department C-2R Forms

Building Type	# of Sites	Average % Margin	Minimum % Margin	Maximum % Margin
SF Two Story	24	2.5%	0.0%	11.8%
SF One Story	8	2.2%	0.2%	5.9%
SF Attached	1	4.3%	4.3%	4.3%
MF	4	6.1%	3.5%	8.4%
Total	**37**	**2.9%**	**0.0%**	**11.8%**

As stated above, usable compliance documents for 37 sites were collected. Of these 37 sites, 13 sites were omitted from the analysis of the RNC Interface. In particular, six sites were dropped because the C-2R forms for those sites were run using either MICROPAS v5.1 or Comply 24. The other seven sites were omitted for site-specific reasons.

Transforming Building Department C-2R Information into the On-Site Survey Data Format

The first step in the RNC Interface testing procedure was to transform the data from the building department C-2R forms into the RMST on-site survey data format. This involved first entering the C-2R data into an Access database. These data were then translated into the RMST survey data format by a variety of methods that are characterized as *direct*, *mapped*, and *constructed input*, as explained below.

- ***Direct Input.*** Direct translation values were those building department C-2R values that could be inserted into the RMST on-site survey data format either directly or with a simple mapping of MICROPAS keywords to RMST values. Examples of these values include total conditioned square footage, heating and cooling efficiencies, and water heating efficiency.
- ***Mapped Input.*** This approach involved mapping a set of values from the building department C-2R forms to a corresponding set of RMST survey data values. A good example of this method is the mapping of window performance parameters. For the RNC Interface, window thermal performance parameters (U-values and shading coefficients) are generated from multiple fenestration characteristics collected on the survey form, such as fenestration type (window/door/skylight), glass type, frame type, and number of panes. However, the building department C-2R forms contain only the U-value, shading coefficient, and frame type. As such, the C-2R data were then mapped to the corresponding RMST window type. For example, a window on the building department C-2R form with a U-value=0.60, SC=0.88, and a frame type of *VinylDiv* was mapped in the RMST survey data format to a vinyl-framed, two-paned, clear glass window with dividers.
- ***Constructed Input.*** This approach involved constructing an RMST value using one or more values from the building department C-2R form. A good example of a constructed

input is wall area. The wall area printed on the C-2R form is the net wall area (i.e., gross wall area minus the window and door areas), but gross wall area is collected on the RMST survey form. As such, the C-2R wall, window, and door areas for each orientation had to be summed in order to obtain a value for the gross wall area that could be used in the RMST data format.

These data translation methods were typically implemented via Access queries to convert data from the Building Department C-2R database into an RMST-formatted database that could be used by the RNC Interface.

Comparing the RNC Interface Run to the Building Department C-2R Compliance Results and Refining the RNC Interface

The RNC Interface was refined based on the comparison of the results from the RNC Interface and the original C-2R compliance results. The goal of comparing the results generated by the RNC Interface to the results taken off the building department C-2R was to test the defaults and algorithms used in the RNC Interface.

The % Compliance Margin was used to compare the two sets of results. This value represents the compliance margin expressed as a percentage of the standard energy budget. Specifically,

$$\%\ Compliance\ Margin = \frac{(Standard\ Energy\ Budget - Proposed\ Energy\ Budget)}{(Standard\ Energy\ Budget)}$$

This definition is consistent with the method that most residential new construction programs use to define program compliance. For instance, a home must be 30% better than Title 24 (i.e., % Compliance Margin=30%) to qualify as an ENERGY STAR home.

A multi-step approach was used to refine the RNC Interface based on the comparison of the results.

- ***Step 1: Identify Problem Sites.*** The first step in comparing the two sets of results was to identify sites where the % Compliance Margin generated by the RNC Interface was negative, meaning noncompliance. Also identified were those sites where the % Compliance Margin generated by the RNC Interface was at least ±10% different from the % Compliance Margin taken from the building department C-2R form.
- ***Step 2: Identify Potential Problem Inputs for the Problem Sites.*** For each of these sites, the input parameters generated by the RNC Interface and the original building department C-2R data were examined. Parameters with significant discrepancies were identified and labeled as potential problem input parameters.
- ***Step 3: Conduct a Sensitivity Analysis for each of the Problem Input Parameters.*** In this step, a sensitivity analysis of the % Compliance Margin for each of the problem input parameters and problem sites was conducted. This was done to determine which of the problem input parameters had the largest effect on the

% Compliance Margin. It was determined that some of the problem input parameters identified in the previous step did not have much of an impact on the % Compliance Margin, while others clearly did. For those that did, a further review and refinement was carried out in the next step.

- ***Step 4: Refine the RNC Interface Input Parameters and Algorithms.*** The parameters that had a significant impact were then reviewed and refined based on information from the building department compliance data and industry experts.

Results of the Evaluation of the RNC Interface

The results of the initial RNC Interface compliance runs are presented in Figure 2-4. Based on the multi-step approach presented above, the following refinements were made to the initial RNC Interface.

MICROPAS Run Options. MICROPAS run options are high-level parameters affecting the overall compliance analysis. The run options affected by the interface testing procedure are discussed below.

- ***ReducedYear versus FullYear.*** The interface was originally set up to use the *FullYear* weather data MICROPAS run option. However, as most of the building department C-2R forms were run with the *ReducedYear* option (83% of sites), the interface default was to set to *ReducedYear*.[12]
- ***Cardinal Run versus Actual Front Orientation Angle.*** The interface was originally set up to use the actual front orientation angle associated with each site. However, most of the building department C-2R forms showed that the *Cardinal* run option was used instead of a specific front orientation angle, so the interface default was set to the *Cardinal* option.[13] For a *Cardinal* run, MICROPAS performs four runs in all the cardinal directions—North, East, South, West—and compliance is determined from the run with the smallest compliance margin.

Construction Features not Captured by the RMST Survey Form. Due to the focus, cost, and time constraints of the RMST survey, the data gathered lack detailed information for certain features used to generate a MICROPAS compliance run. As such, default values and algorithms were developed for these features. In some cases, these assumptions were refined during the RNC Interface evaluation process. Examples of these changes are discussed below.

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[12] The FullYear run option uses a full year (365 days) of weather data, whereas the ReducedYear run option uses only 42 days of weather data. The ReducedYear run performs only one-eighth of the calculations of the FullYear run and as such, reduces the required calculation time. Note that a small difference in results may occur between ReducedYear and FullYear calculations; however, both methods are acceptable for compliance.

[13] The only exception to this was custom-built, single family homes that, as might be expected, used the actual orientation angle option instead of the *Cardinal* run option. However, since most of the homes are production/tract type homes and the surveyed residences are supposed to be sample representatives, not just individual sites, the *Cardinal* run option was used for all sites.

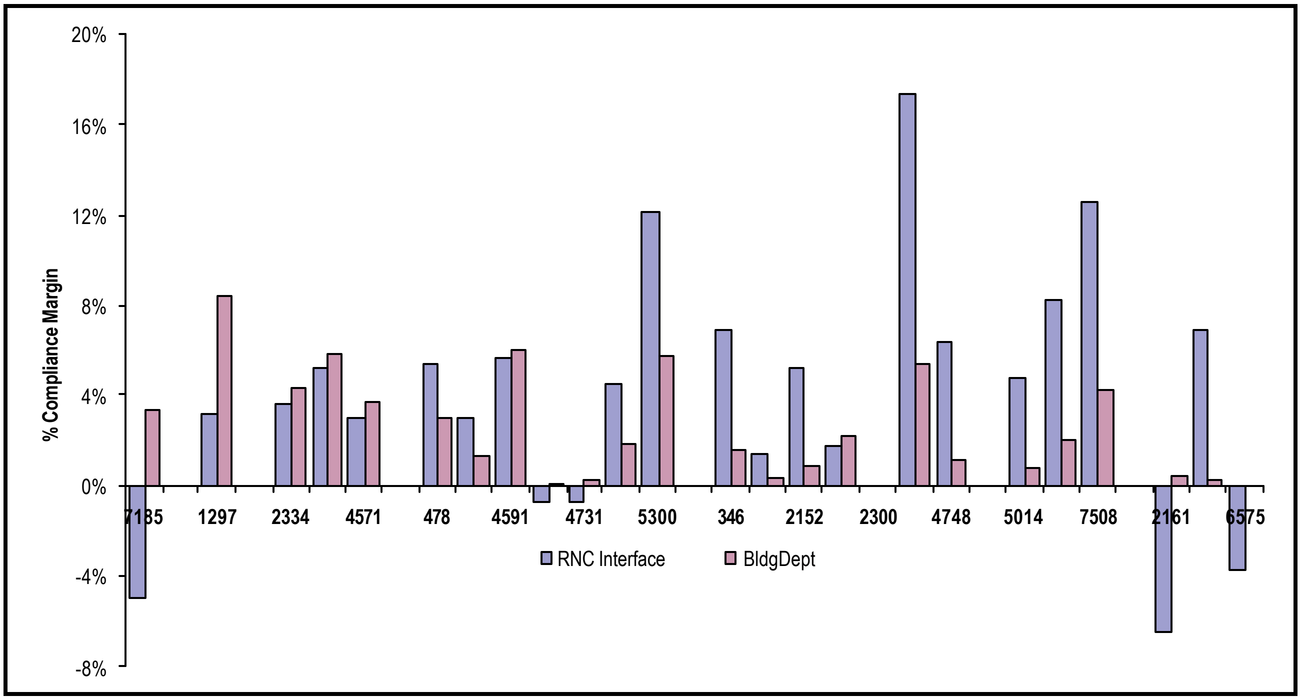
- ***Roof Area for Two-Story Residences.*** The algorithm originally used by the RNC Interface to calculate roof areas was consistently yielding values that were significantly lower than the roof areas indicated on the building department C-2R forms. In particular, the roof area from the building department C-2R data are on average 34% larger than the roof area calculated from our algorithm for two-story homes. Therefore, the RNC Interface multiplies the calculated roof area by 1.34.
- ***Window/Door Overhangs.*** The original RNC Interface baseline assumption was to impose an overhang with some assumed dimensions for window height and overhang height/width on windows in all directions. A close examination of the building department C-2R forms confirmed that most of the building department C-2R forms took a similar approach. However, these sites have overhangs on only a few windows. There was also significant variation in the dimensions used for window height and overhang height/width. To account for these variations, an average value from the C2-R data was developed for use in the RNC Interface.

Thermal Performance Characteristics. Two thermal performance characteristics were refined during the RNC Interface evaluation.

- ***Slab Edge F2 Value.*** Early on in the examination of the C-2R forms, it was determined that the slab edge heat loss factor, or the F2 value, was a key parameter affecting compliance. The algorithm originally used assumed an F2 value of 0.76. However, it was determined that relatively small changes in the value had a significant impact on compliance. Again, information from the building department C-2R data was used to redefine the F2 value as 0.70.[14]
- ***Window U-Values and Glass Shading Coefficients (SC).*** The initial attempt to map the windows reported on the building department C-2R forms to the default set of "standard practice" window U-values and SCs made it difficult to validate the effectiveness of the interface. First, the building department window U-values and SCs from the C-2R forms had to be mapped to the window types listed on the on-site surveys. These window types were then mapped to RER's default window U-values and SCs. RER's window U-value defaults were then changed as a result of comparing the runs using the C-2R data to results on the building department C-2R forms.

[14] The F2 value/factor defines the slab edge heat loss per linear foot of slab edge. The redefined F2 value of 0.70 will result in less heat loss than an F2 value of 0.76.

Figure 2-4: Summary of Initial RNC Interface Compliance Runs



Once the refinements described above were completed, the RNC Interface was finalized for the present round of analyses. Table 2-4 compares the results of the compliance runs using the initial and final RNC Interface. Two factors were compared.

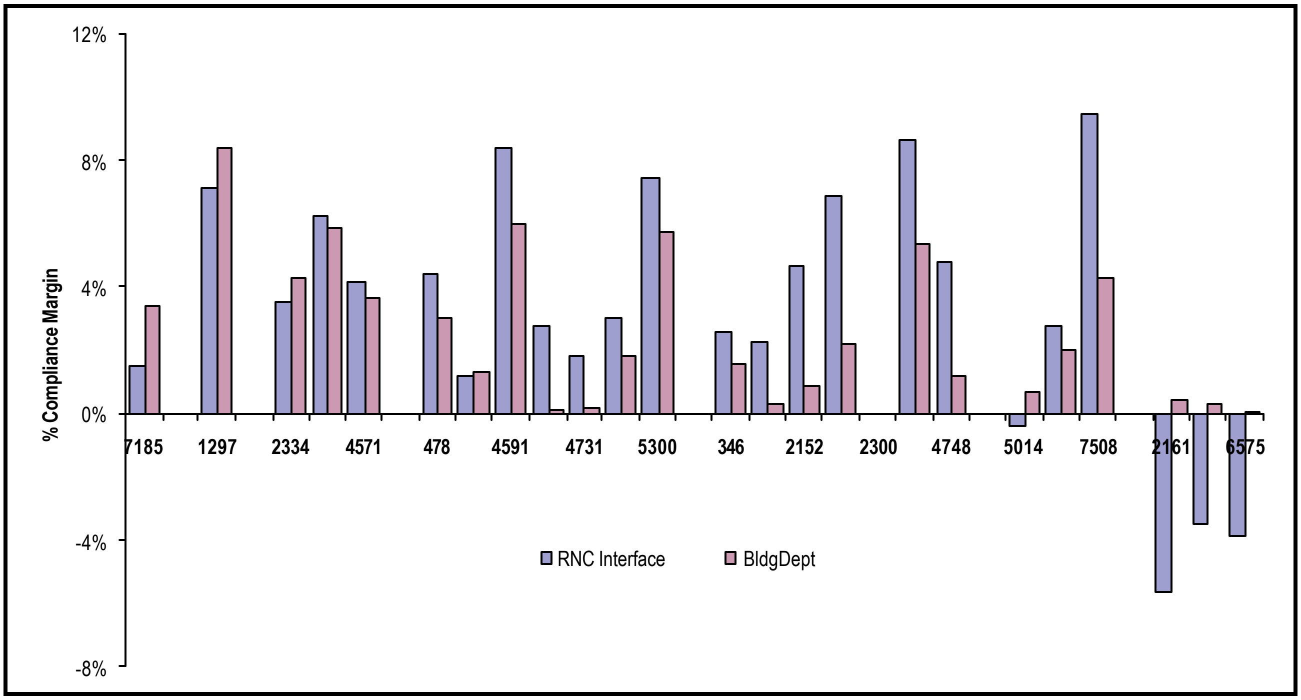
- ***Number of Non-Compliant Sites.*** This is the total number of non-compliant sites.
- ***Difference in % Compliance Margin.*** The difference in the % Compliance Margin is defined as the difference in the % Compliance Margin generated by the RNC Interface and the % Compliance Margin generated by using data from the matching original building department C-2R compliance data.

The refinements to the RNC Interface decreased the number of non-compliant sites and, even more importantly, decreased the average difference in the % Compliance Margin. In particular, the number of non-compliant sites dropped by one and the average difference in % Compliance Margin more than halved from 1.6% to 0.7%. The results of the compliance runs using the final RNC Interface are presented in Figure 2-5.

Table 2-4: Comparison of the Initial and Final RNC Interface Compliance Runs

	Initial RNC Interface	Final RNC Interface
Number of Non-Compliant Sites	5	4
Avg. difference in % Compliance Margin	1.6%	0.7%
Max difference in % Compliance Margin	12.0%	5.2%
Min difference in % Compliance Margin	-8.4%	-6.0%

Figure 2-5: Summary of the Final RNC Interface Compliance Runs



2.4 RNC Interface Error Band

The purpose of establishing the error band for the RNC Interface is that 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:

- 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 -4% to +6% 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% - 4% = 8%, 12% + 6% = 18%).

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$_{RER}$) 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

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

where

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

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

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

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

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

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

Error Band Analysis and Results

A summary of key parameters in the error band analysis is presented in Table 2-5. In particular, the difference estimator is 0.73%, which implies that, on average, the % Compliance Margins generated from the RNC Interface are 0.73% higher than the % Compliance Margin generated from the building department C-2R forms. The standard deviation of the difference estimator is calculated as 0.031. To compute the 90% confidence interval, the standard deviation is multiplied by 1.645, which is 0.0517 or 5.17%. Lastly, since the RNC Interface compliance runs are, on average, 0.73% higher than the building department C-2R compliance runs, 5.17% is both added and subtracted from -0.73% to define the error band. As mentioned above, the resulting error band is -4% to +6%.

Table 2-5: Summary of the RNC Interface Error Band Analysis

Statistic	Value
Difference Estimator	0.73%
Standard Deviation	0.0314
90% Confidence Interval	± 5.17%
Lower Error Band (0.73% - 5.17%)	-4.44%
Upper Error Band (0.73% + 5.17%)	5.90%

2.5 Modifications of the RMST On-Site Survey Designed to Improve the MICROPAS Simulations

A number of modifications were made to the second year RMST on-site survey form and recruitment process. These changes were made to improve data availability and quality for the MICROPAS analysis. Additional changes were made to capture data requested by CEC personnel and other statewide RNC program managers.

- ***Lighting Systems.*** Although not an issue for compliance analysis, detailed information on kitchen lighting and diffuser types, bathroom lighting (especially in bathrooms with toilets), and ceiling fan lighting systems will be gathered.
- ***Miscellaneous Appliances.*** A count of ceiling fans that do not have lights has been added.
- ***HVAC Systems.*** Detailed information on HVAC system location and an estimate of the distance between the HVAC system and water heating system has been added. In addition, for better consistency with MICROPAS5, the HVAC system equipment types have been expanded to make it easier to specify a combination space/water heating system.
- ***Water Heating Equipment.*** Many significant changes were made to this page of the survey form. Up to two different water heaters can now be specified on a single page and a "quantity" field was added. It is now easier and more direct to specify a combination space/water heating type unit. Control types and features reflecting the various credits/debits available in MICROPAS were added. Finally, additional fields needed to record performance and efficiency information for large water heaters and water heaters used in hydronic systems have been added.
- ***Duct Systems.*** Information on the location of supply and return ducts will now be gathered. Duct and duct-sealing types were expanded. A field for recording the duct sealing tape UL label information and brand name was also added. Although, these data were gathered last year, there was no dedicated field to capture the data.
- ***Building Construction and Orientation.*** Most changes were made in this area to enhance the MICROPAS runs. To address door shading, a field was added to specify shading conditions for doors located in recessed entryways or under patio covers. To address the roof area issue discussed in the previous section, the roof area (ceiling-below-roof) will now be recorded directly during the on-site visit. In addition, roof insulation type will also be added to be able to make better use of ceiling insulation levels specified in inches. However, the most significant change to the building construction area of the survey form was made to address the issue of slab floor areas and raised floors above garages for two-story homes. Ground floor area will now be directly estimated including, for slab floors, an estimate of the percent of the slab floor that is exposed (i.e., not carpeted). The second story floor area above an unconditioned garage will also be collected.
- ***Windows, Glass Doors, and Skylights.*** Changes were also made to this section of the survey form. In particular, interior and exterior shading details were separated and

expanded to better reflect MICROPAS options. In addition, glass type options were revised to reflect the use of the ETEKT+ AE1600 Low-E Coating Detectors,[15] which can be used to detect after-market window films as well as low-E coatings. The final revision involved deleting fields that were to be used to collect information from the AAMA Permanent Label that is supposed to be affixed to every AAMA-rated window. Unfortunately, these labels are usually removed before the homeowner's final walk-through and these fields were never used during the first year's survey.

One of the most significant changes is that the surveyors will be using the ETEKT+ Low-E meters to determine if low-E or after-market films have been applied to the windows. Surveyors also now measure the home's three largest windows and then use those measurements as the basis for estimating the areas of other windows (surveyors do not currently measure all the windows due to time and budget constraints).

- ***Recruitment and Survey Process Changes.*** An estimate of total conditioned floor area is now being obtained from the customer at the time of recruitment. This estimate will be used as yet another quality control check for the on-site surveys.

[15] ETETKT+ Low-E Coating Detectors were obtained from Electronic Design to Market, Inc. (www.edtm.com). These meters detect the presence of metal surface coatings on the outer or inner sides of single-paned or dual-paned glass windows.

3

Current Building Practices for Low-Rise Residential Buildings

3.1 Introduction

This section discusses current building practices for low-rise residential buildings. In particular, data from the 800 on-site surveys 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 current building practices by climate zone and residence type.

3.2 Overview of On-Site Survey Sample Design

This section presents an overview of the sample design for the Residential Market Share Tracking (RMST) on-site survey.[1] The overview includes a discussion on the sample frame, sample sampling plan, sample selection, and sample weights.

RMST On-Site Sample Frame

The RMST new construction sample frame was developed using customer frame data provided to RER by California's investor-owned utilities (IOUs). For purposes of developing the new construction sample frame, RER defines newly constructed homes as those first occupied between July 1, 1998 and June 30, 1999. Further, it was essential that the frame data include information on residence type and CEC climate zone.

- ***Residence Type.*** Each utility has a residence type indicator in their billing frame. These definitions vary widely and, at best, could be aggregated only into single family and multifamily designators. Common area accounts were omitted from the sample frame.
- ***CEC Climate Zone.*** As shown in Figure 3-1, there are 16 CEC climate zones in California. For this study, these zones were collapsed into five regions. The criterion for the aggregation of the climate zones was that the Title 24

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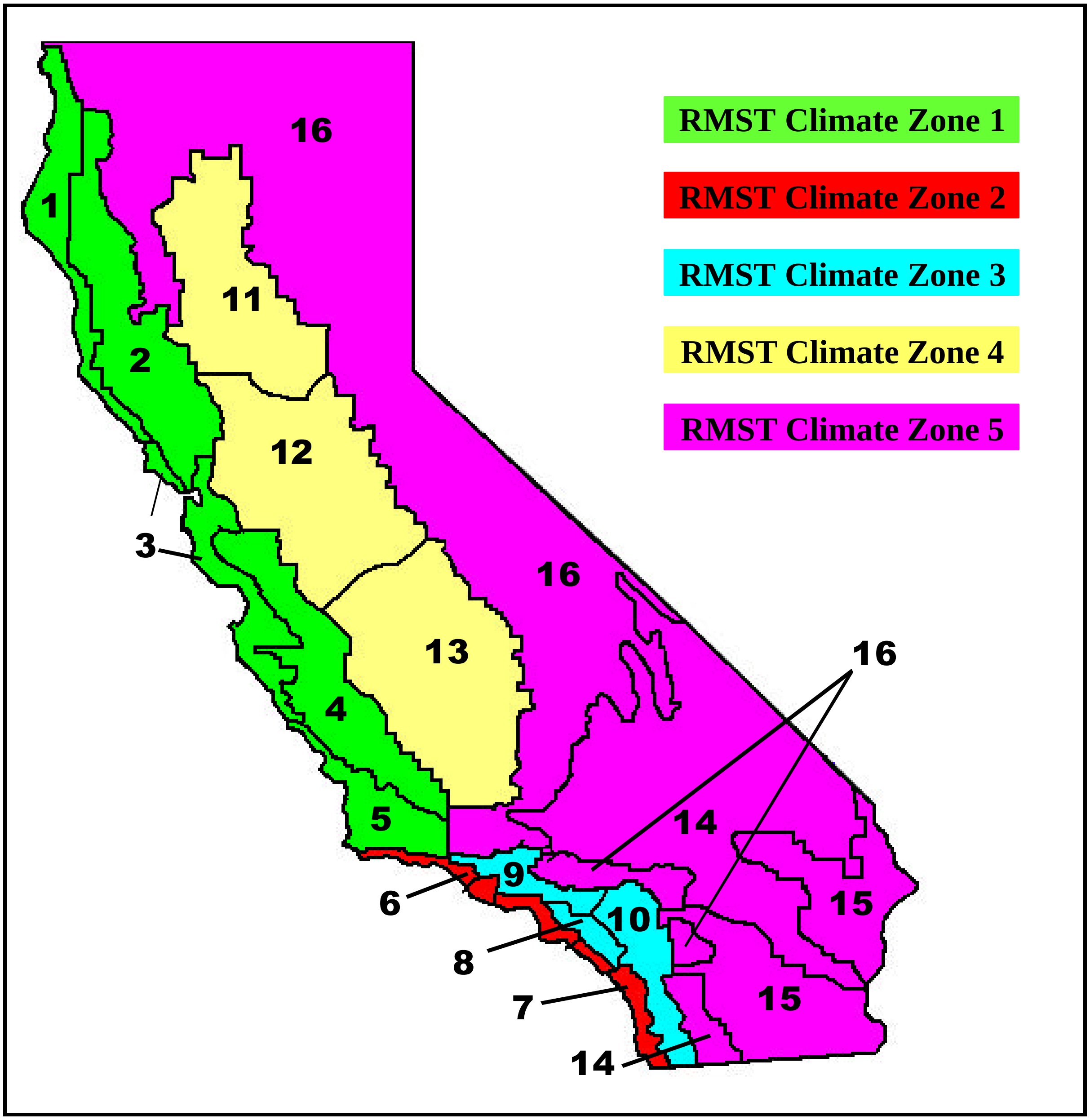
1 See Section 2 of the Residential Market Share Tracking Study (RER 2000) for details of the sample design.

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) encompasses CEC Climate Zones 1, 2, 3, 4, and 5
- RMST Climate Zone 2 (CZ2) encompasses CEC Climate Zones 6 and 7
- RMST Climate Zone 3 (CZ3) encompasses CEC Climate Zones 8, 9, and 10
- RMST Climate Zone 4 (CZ4) encompasses CEC Climate Zones 11, 12, and 13
- RMST Climate Zone 5 (CZ5) encompasses CEC Climate Zones 14, 15, and 16.

Figure 3-1: CEC Climate Zones



Source: California Energy Commission.

In addition to the residence type and climate zone indicators, the frame data contained an identifier that allows the gathering of usage data, such as premise identifier, meter number, or account number.

Sampling Plan and Sample Selection

Next, RER developed the sampling plan for the on-site survey. The sample was stratified by residence type, CEC climate zone, and utility.[2] RER allocated the sample targets proportionally with some over sampling for the SDG&E service territory, for a total completed sample size of 800. With the sampling plan complete, RER randomly selected the primary and secondary members of the sample-by-sample stratum.

Table 3-1 presents a summary of the combined frame used for developing the new construction survey sampling plan and the completed sample.

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

	PG&E		SCE		SDG&E	
Res. Type and Climate Zone	**Sample Frame**	**Completed Targets**	**Sample Frame**	**Completed Targets**	**Sample Frame**	**Completed Targets**
SF.CZ1	18,693	118	0	-	0	-
SF.CZ2	4	-	4,487	34	5,370	78
SF.CZ3	0	-	22,061	160	1,103	16
SF.CZ4	26,354	164	2,089	16	0	-
SF.CZ5	579	4	4,313	32	15	-
SF Total	45,630	286	32,950	242	6,488	94
MF.CZ1	9,694	62	0	-	0	-
MF.CZ2	0	-	1,377	10	845	12
MF.CZ3	0	-	3,736	28	66	2
MF.CZ4	2,668	18	60	-	0	-
MF.CZ5	10	-	345	4	0	-
MF Total	12,372	80	5,518	42	911	14
All Total	**58,002**	**366**	**38,468**	**284**	**7,399**	**108**

SF = Single Family
MF = Multifamily

2 The RMST sample design also stratified the sample by six-month periods.

RMST On-Site Survey Expansion Weights

RER developed expansion weights to expand the on-site data to represent to the total number of homes that were built within the three electric IOU territories between July 1, 1998 and June 30, 1999. The expansion weights are based on the number of households in each utility service area and CEC climate zone shown in Table 3-2.[3] In particular, the expansion weights for HVAC equipment are based on utility and climate zone, while the expansion weights for water heaters and windows are based solely on utility.

Table 3-2: New Homes Built Between July 1, 1998 and June 30, 1999

CEC Climate Zone	PG&E	SCE	SDG&E	All
CZ:1	28,387	-	-	28,387
CZ:2	4	5,864	6,215	12,350
CZ:3	-	25,797	1,169	30,512
CZ:4	29,022	2,149	-	31,171
CZ:5	589	4,658	15	6,875
Total	**58,002**	**38,468**	**7,399**	**109,295**

Specifically, expansion weights were calculated as follows:

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

where

$N_{U,CZ,HT,SA}$ = the total number of houses built between July 1, 1998 and June 30, 1999, by utility, climate zone, housing type, and semi-annual classification, and

$n_{U,CZ,HT,SA}$ = the number of completed samples points for houses built between July 1, 1998 and July 30, 1999, by utility, climate zone, housing type, and semi-annual classification.

[3] New construction frames from the various utilities include both single family and multifamily homes.

3.3 Reference Basis 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, Glazing Performance Groups, 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 a later section, 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[4] for construction features affecting energy efficiency are presented in Table 3-3 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 1998 Standards and maximum allowable Shading Coefficient (SCs) for the 1995 Standards. Both 1998 and 1995 Standard values are presented, because it was expected (and confirmed) that some homes in the first year's RMST sample would have been built under the 1995 Standards.

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

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

CEC CZ	Ceiling R-Value	Wall R-Value	Glazing Percent	Glazing U-Value	SHGC[5] (orientation)	SC[5] (orientation)
1	38	21	16	0.65		0.66 (all)
2	30	13	16	0.65		0.66 (all)
3	30	13	20	0.75		0.66 (all)
4	30	13	20	0.75		0.66 (all)
5	30	13	16	0.75		0.66 (all)
6	30	13	20	0.75		0.66 (all)
7	30	13	20	0.75		0.66 (all)
8	30	13	20	0.75	0.40 (W/E)	0.40 (W/E)/0.66 (S/N)
9	30	13	20	0.75	0.40 (W/E)	0.40 (W/E)/0.66 (S/N)
10	30	13	20	0.75	0.40 (W/E)	0.40 (W/E)/0.66 (S/N)
11	38	19	16	0.65	0.40 (W/E)	0.40 (W/E)/0.66 (S/N)
12	38	19	16	0.65	0.40 (W/E)	0.40 (W/E)/0.66 (S/N)
13	38	19	16	0.65	0.40 (W/E)	0.40 (W/E)/0.66 (S/N)
14	38	21	16	0.65	0.40 (W/E)	0.40 (W/E)/0.66 (S/N)
15	38	21	16	0.65	0.40 (S/W/E)	0.40 (S/W/E)/0.66 (N)
16	38	21	16	0.60		0.66 (all)

Windows. Two values are used to rate window performance: U-value and Solar Heat Gain Coefficient (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. The Solar Heat Gain Coefficient (SHGC) measures how well a product transmits sunlight. The 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 solar heat gain coefficient, the less heat transmitted.

Since U-values and SHGCs were not observed during the on-site visits, the analysis of window efficiencies focuses on the types of windows installed. After reviewing every possible combination of window type, RER found that only five types of windows had

[5] Prescriptive shading requirements are defined as Solar Heat Gain Coefficients (SHGC) values for the 1998 Standards and Shading Coefficients (SC) for the 1995 Standards.

saturations greater than 1%. These five window types, listed below, are the focus of the analysis presented here.

- Clear glass, double pane, wood/vinyl frame, and air filled.
- Clear glass, double pane, metal frame, and air filled.
- Clear glass, double pane, wood/vinyl frame, and gas filled.
- Low-E glass, double pane, wood/vinyl frame, and air filled.
- Reflective/tinted glass, double pane, wood/vinyl frame, and air filled.

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%.[6,7] 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 (CAC) is the Seasonal Energy Efficiency Ratio (SEER). The higher the SEER rating, the more efficient the cooling equipment. SEER ratings range from 9.9 to over 15. Standard efficiency for CACs is 10 SEER.[8,9] 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.[10] 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, RER computed the percent-above-standard for each water heater observed from the on-site surveys. The formula used for these calculations is:

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

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

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

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

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

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

where

Eff_i = Actual efficiency rating of unit i, and
$StdEff_i$ = $0.62 - (0.0019 \times (TankVolume_i))$.[11]

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 would be 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 and compared in Table 3-4.

- ***CEC Climate Zones.*** These are the 16 standard climate zones, as defined by the CEC, that 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, utility service areas, and number of permits issued.
- ***Performance Groups.*** These are based on the Prescriptive Package D requirements for glazing percent and window shading, as shown in Table 3-4. These are the same breakouts used in a recent CEC report on multifamily buildings.[12] Performance groups are defined as follows:

[11] 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.

[12] Regional Economic Research, Inc. July 2000. *Low-Rise Multifamily Building New Construction Characteristics Study*. Prepared for the California Energy Commission. P400-00-012.

- **16% Glazing, No Shading (*16%-NS*).** CEC Climate Zones 1, 2, 5, and 16 are in this group, which has prescriptive values of 16% glazing area and no shading requirements.
- **16% Glazing, With Shading (*16%-WS*).** CEC Climate Zones 11, 12, 13, 14, and 15 are in this group, which have prescriptive values of 16% glazing area and shading requirements.
- **20% Glazing, No Shading (*20%-NS*).** CEC Climate Zones 3, 4, 6, and 7 are in this group, which has prescriptive values of 20% glazing area and no shading requirements.
- **20% Glazing, With Shading (*20%-WS*).** CEC Climate Zones 8, 9, and 10 are in this group, which have prescriptive values of 16% glazing area and shading requirements.

- ***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, SCG, 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.

Table 3-4: Comparison of Regions Used as Basis – Analyzing Results

RMST Climate Zones	CEC Climate Zones	CEC Climate Zone Reference City	Prescriptive Glazing Performance Groups	Utility Service Areas
1	CZ1	Arcata	16%-NoShading	PG&E
	CZ2	Santa Rosa	16%-NoShading	PG&E
	CZ3	Oakland	20%-NoShading	PG&E
	CZ4	Sunnyvale	20%-NoShading	PG&E/SCG
	CZ5	Santa Maria	16%-NoShading	PG&E/SCG
2	CZ6	Los Angeles	20%-NoShading	SCE/SCG
	CZ7	San Diego	20%-NoShading	SDG&E
3	CZ8	El Toro	20%-WithShading	SCE/SCG/SDG&E
	CZ9	Pasadena	20%-WithShading	SCE/SCG
	CZ10	Riverside	20%-WithShading	SCE/SCG/SDG&E
4	CZ11	Red Bluff	16%-WithShading	PG&E
	CZ12	Sacramento	16%-WithShading	PG&E
	CZ13	Fresno	16%-WithShading	PG&E/SCG
5	CZ14	China Lake	16%-WithShading	SCE/SCG/SDG&E
	CZ15	El Centro	16%-WithShading	SCE/SCG/SDG&E
	CZ16	Mount Shasta	16%-NoShading	PG&E/SCE/SCG

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, RMST climate zone, and residence type 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,

- Shell features, and
- Ducts.

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 and Table 3-6 present a summary of the square footage, number of stories, and equipment saturations by RMST climate zone for single family detached and multifamily residences, respectively. Single family detached residences vary in size from an average of 1,952 square feet in RMST Climate Zone 4 to 2,436 square feet in RMST Climate Zone 3. Not surprisingly, almost all of the water heaters and central furnaces are natural gas or propane. Further, the saturation of central air conditioners increases sharply in the hot dry RMST Climate Zones 3, 4, and 5. Multifamily buildings range in size from 10,792 square feet in RMST Climate Zone 5 to 16,979 square feet in RMST Climate Zone 1. As with single family residences, natural gas and propane are the predominate fuels for water heaters and central furnaces. Again, the saturation of central air conditioning systems increases substantially in RMST Climate Zones 3, 4, and 5.

Table 3-5: Square Footage, Number of Stories, and Equipment Saturations – Detached Single Family Homes

Analysis Parameter Description	Statewide	RMST CZ1	RMST CZ2	RMST CZ3	RMST CZ4	RMST CZ5
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
Heating Equipment Saturation						
Central Furnace	98.0%	96.6%	100.0%	99.4%	96.8%	100.0%
Central Heat Pump	1.0%	-	-	0.6%	2.6%	-
Electric Resistance	-	-	-	-	-	-
Hydronic	0.8%	3.4%	-	-	-	-
Wall Furnace	0.2%	-	-	-	0.6%	-
Wall Heat Pump	-	-	-	-	-	-
Water Loop Heat Pump	-	-	-	-	-	-
Cooling Equipment Saturation						
Central Air Conditioner	79.2%	48.6%	48.5%	98.4%	92.4%	91.0%
Central Heat Pump	1.0%	-	-	0.6%	2.6%	-
Evaporative Cooler	-	-	-	-	-	-
Hydronic	0.2%	0.8%	-	-	-	-
No Air Conditioner	19.6%	50.6%	51.5%	1.0%	5.1%	9.0%
Wall Heat Pump	-	-	-	-	-	-
Water Loop Heat Pump	-	-	-	-	-	-
Water Heater Saturation						
Electric	0.3%	-	1.5%	0.6%	-	-
Gas	94.0%	96.6%	97.0%	98.2%	87.2%	93.4%
Propane	5.5%	2.6%	1.5%	1.1%	12.8%	6.6%
Solar	0.2%	0.7%	-	-	-	-

Table 3-6: Square Footage, Number of Stories and Equipment Saturations – Multifamily Buildings

Analysis Parameter Description	Statewide	RMST CZ1	RMST CZ2	RMST CZ3	RMST CZ4	RMST CZ5
Average Square Footage	15,463	16,979	14,911	15,060	13,852	10,792
Average Number of Stories	2.3	2.4	2.6	2.2	1.9	1.8
Heating Equipment Saturation						
Central Furnace	47.1%	33.9%	70.5%	53.5%	51.9%	29.2%
Central Heat Pump	7.2%	-	13.4%	18.2%	4.1%	-
Electric Resistance	9.4%	23.6%	-	-	-	-
Hydronic	19.9%	18.5%	11.3%	16.4%	26.2%	70.8%
Wall Furnace	3.4%	8.6%	-	-	-	-
Wall Heat Pump	11.2%	15.4%	4.7%	11.8%	8.1%	-
Water Loop Heat Pump	1.7%	-	-	-	9.8%	-
Cooling Equipment Saturation						
Central Air Conditioner	28.6%	5.2%	37.6%	47.5%	47.0%	29.2%
Central Heat Pump	7.2%	-	13.4%	18.2%	4.1%	-
Evaporative Cooler	0.9%	-	-	-	4.9%	-
Hydronic	12.8%	1.9%	11.3%	14.5%	26.2%	70.8%
No Air Conditioner	37.5%	77.5%	32.9%	8.0%	-	-
Wall Heat Pump	11.2%	15.4%	4.7%	11.8%	8.1%	-
Water Loop Heat Pump	1.7%	-	-	-	9.8%	-
Water Heater Saturation						
Electric	-	-	-	-	-	-
Gas	96.9%	100.0%	100.0%	100.0%	82.7%	100.0%
Propane	3.1%	-	-	-	17.3%	-
Solar	-	-	-	-	-	-

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%.[13] Average percent glazing values are presented in Table 3-7 and Table 3-8 by RMST climate zones. The following observations can be made from these tables.

- Detached single family homes are on average 5% less than the prescriptive values, and multifamily buildings are 49% less. The average glazing percentage for single family homes is less than the prescriptive value in RMST Climate Zones 1, 2, and 3.
- RMST Climate Zone 2 has the highest average percent glazing for detached single family homes (19%) and RMST Climate Zone 1 has the highest average percent glazing for multifamily buildings (11%).
- RMST Climate Zones 4 and 5 have the largest number of detached single family homes with percent glazing values less than the prescriptive value.

Table 3-7: Percent Glazing – Detached Single Family Homes

Analysis Parameter Description	Statewide	RMST CZ1	RMST CZ2	RMST CZ3	RMST CZ4	RMST CZ5
Higher Performance	64%	62%	65%	96%	44%	39%
Equal to Prescriptive	1%	-	1%	-	2%	5%
Lower Performance	35%	38%	34%	4%	54%	57%
Average % of Prescriptive	-5%	-2%	-7%	-19%	4%	4%
Average % Glazing	17%	18%	19%	16%	17%	17%

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

Table 3-8: Percent Glazing – Multifamily Buildings

Analysis Parameter Description	Statewide	RMST CZ1	RMST CZ2	RMST CZ3	RMST CZ4	RMST CZ5
Higher Performance	91%	87%	94%	97%	88%	100%
Equal to Prescriptive	1%	2%	-	-	-	-
Lower Performance	8%	11%	6%	3%	12%	-
Average % of Prescriptive	-49%	-39%	-63%	-56%	-49%	-47%
Average % Glazing	9%	11%	7%	9%	8%	8%

Figure 3-2 and Figure 3-3 offer a more in-depth look at percent glazing values. Percent glazing values for all sites are presented versus CEC climate zone and RMST climate zones. These results suggest the following:

- Most detached single family homes in CEC climate zones with a prescriptive glazing percentage of 20% have glazing percentages below prescriptive.
- Nearly all multifamily buildings have glazing percentages well below prescriptive.
- A handful of single family attached homes in CEC Climate Zones 2, 3, and 4 have glazing percentages well above prescriptive values.

Figure 3-2: Percent Glazing Values by CEC Climate Zone and RMST Climate Zone – Detached Single Family Homes

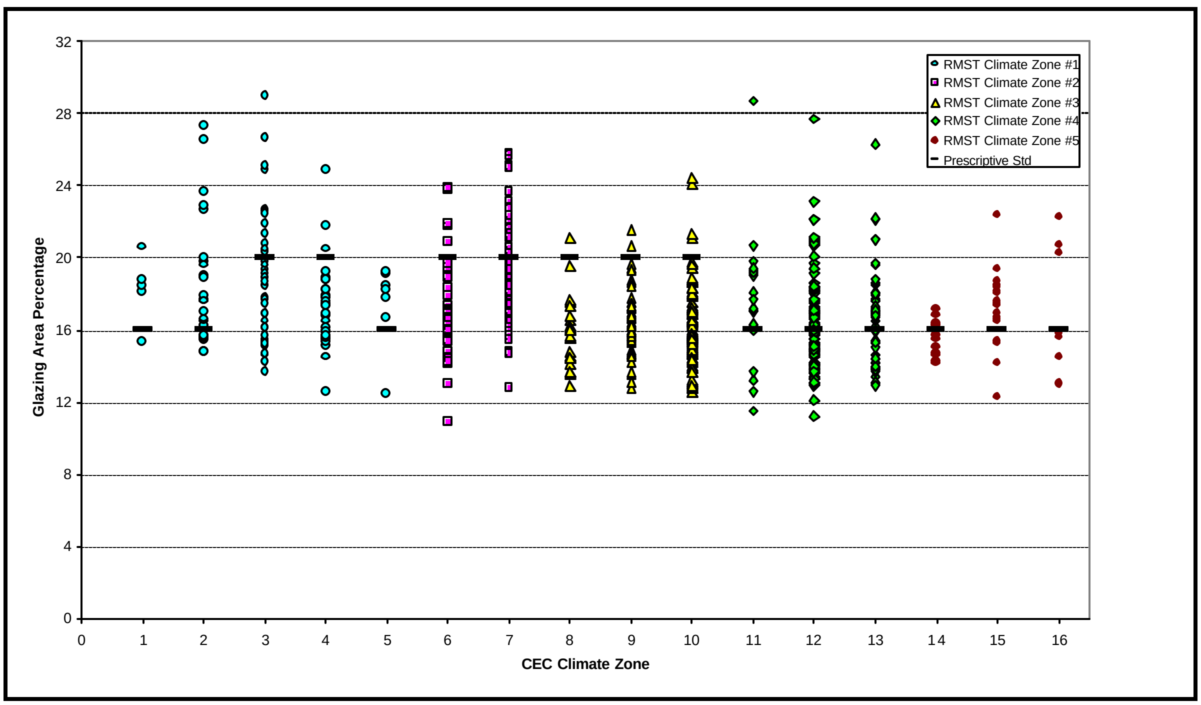
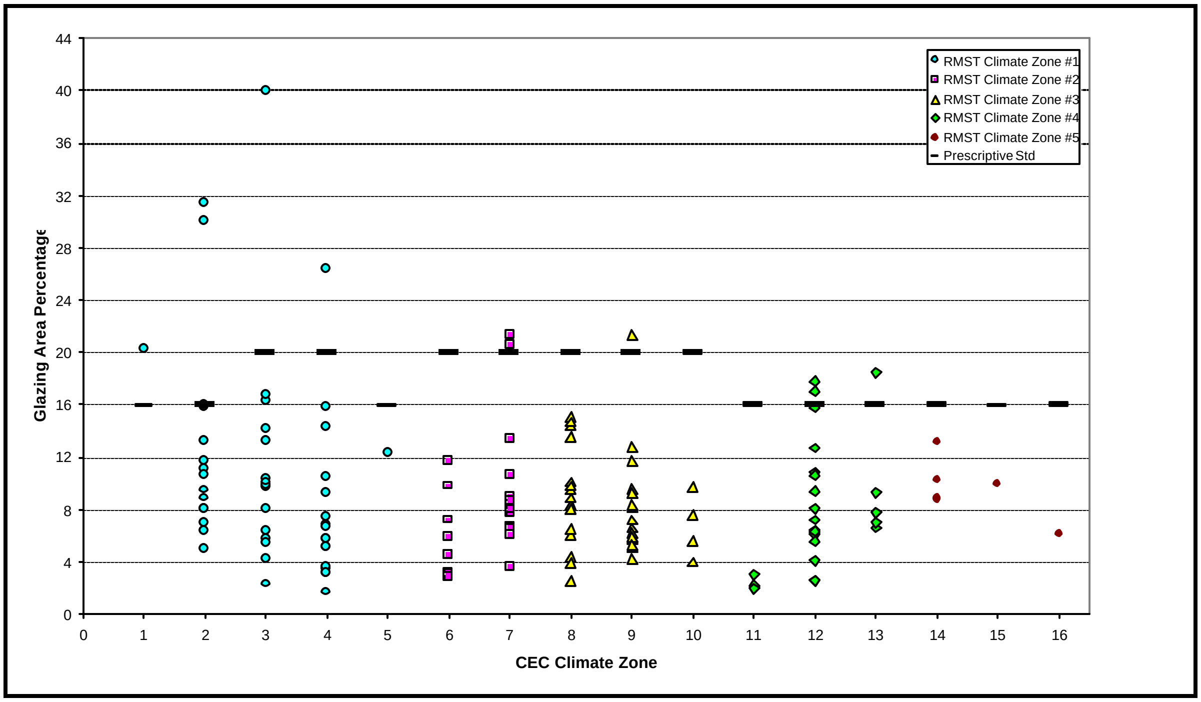


Figure 3-3: Percent Glazing Values by CEC Climate Zone and RMST Climate Zone – Multifamily Buildings



Window Types

Typical construction for window types—frame type, glass type, and number of panes—is presented in Table 3-9 for detached single family homes and Table 3-10 for multifamily buildings. These following results are shown.

- The predominant window type for all building types is vinyl-framed, dual-paned, clear glass (87.8% for detached single family homes and 78.2% multifamily buildings).
- The predominant window in all detached single family residence types is vinyl-framed, dual-paned, clear glass. However, RMST Climate Zone 5 has significant amount (4.5%) of windows with below-prescriptive values (i.e., metal-framed windows).
- Multifamily buildings show a different trend. Although most are vinyl-framed, dual-paned, clear glass windows, there is a definite trend toward increased use of metal windows in RMST Climate Zone 3 (32.5%) and RMST Climate Zone 5 (39.9%).
- This reflects a general trend for multifamily buildings that was previously observed in the CEC Multifamily Building Characteristics study,[14] which showed

[14] Regional Economic Research, Inc. July 2000. *Low-Rise Multifamily Building New Construction Characteristics Study*. Prepared for the California Energy Commission. P400-00-012.

that lower-than-prescriptive percent glazing is traded off against lower-performance windows.

Table 3-9: Distribution of Window Types – Detached Single Family Homes

Window Types (# of panes, frame type, glass type)	**Statewide**	**RMST CZ1**	**RMST CZ2**	**RMST CZ3**	**RMST CZ4**	**RMST CZ5**
2-paned Vinyl, Clear Glass	87.8%	86.0%	91.3%	91.4%	86.2%	81.7%
2-paned Metal, Clear Glass	1.8%	0.9%	1.2%	1.8%	1.9%	4.5%
2-paned Vinyl, Low-E	5.3%	8.2%	3.1%	1.2%	7.6%	4.8%
2-paned Vinyl, Tinted/Reflective	4.4%	3.3%	4.4%	5.0%	3.7%	9.0%
1-paned Vinyl, Clear Glass	0.2%	-	-	0.6%	-	-
1-paned Metal, Clear Glass	0.2%	-	-	-	0.6%	-
Other Window Types	0.4%	1.6%	0.0%	-	-	-

Table 3-10: Distribution of Window Types – Multifamily Buildings

Window Types (# of panes, frame type, glass type)	**Statewide**	**RMST CZ1**	**RMST CZ2**	**RMST CZ3**	**RMST CZ4**	**RMST CZ5**
2-paned Vinyl, Clear Glass	78.2%	79.2%	85.8%	67.0%	91.8%	43.5%
2-paned Metal, Clear Glass	10.4%	6.2%	6.2%	20.9%	3.3%	39.9%
2-paned Vinyl, Low-E	4.5%	11.2%	-	-	-	-
2-paned Vinyl, Tinted/Reflective	0.7%	1.7%	-	-	-	-
1-paned Vinyl, Clear Glass	1.5%	-	-	0.6%	4.9%	16.7%
1-paned Metal, Clear Glass	4.7%	1.7%	8.0%	11.6%	-	-

Fenestration Average U-Values

The following tables use average U-values as obtained from the MICROPAS compliance runs. These results give a more comprehensive look at fenestration (as opposed to just windows). Results are presented in Table 3-12 for detached single family homes and Table 3-13 for multifamily buildings. Table 3-11 provides a reference against which to evaluate the average U-values computed in these tables. These following results are shown.

- The average U-value for detached single family homes is 0.59, which is fairly consistent across RMST climate zones.

- For detached single family homes, the percent of metal-framed windows ranges from 0.9% in RMST Climate Zone 1 to 4.5% in RMST Climate Zone 5.
- Multifamily buildings show a different trend. There is more variation in average U-values across climate zones. RMST Climate Zone 1 has the lowest average U-value at 0.598, while the sites in RMST Climate Zone 5 have an average U-value of 0.725. This is also reflected in the percentage of metal-framed windows used in RMST Climate Zone 5 (39.9%), compared to only 8.0% in RMST Climate Zone 1.

Table 3-11: Default Window Thermal Performance Values

RMST Survey Fields and Descriptions				Default Values	
Frame Type	Number of Panes	Glazing Type	Grids/ Muntins	U-Value	SC/SHGC
Vinyl	2	Clear	Yes	0.60	0.88/0.65
Vinyl	2	Tinted/Refl	Yes	0.60	0.74/0.53
Vinyl	2	Low-E	Yes	0.37	0.58/0.41
Metal	2	Clear	Yes	0.75	0.88/0.70
Metal	2	Tinted/Refl	Yes	0.75	0.74/0.59

Table 3-12: Average Window U-Values – Detached Single Family Homes

Analysis Parameter Description	Statewide	RMST CZ1	RMST CZ2	RMST CZ3	RMST CZ4	RMST CZ5
Higher Performance	96%	98%	98%	98%	94%	87%
Equal to Prescriptive	2%	1%	1%	2%	2%	2%
Lower Performance	2%	1%	2%	1%	4%	11%
Average % difference from Prescriptive	-16%	-20%	-21%	-21%	-10%	-8%
Average U-Value	0.586	0.576	0.592	0.594	0.584	0.591
% of Sites w/Metal Frames	2.0%	0.9%	1.2%	1.8%	2.5%	4.5%

Table 3-13: Average Window U-Values – Multifamily Buildings

Analysis Parameter Description	Statewide	RMST CZ1	RMST CZ2	RMST CZ3	RMST CZ4	RMST CZ5
Higher Performance	84%	90%	87%	70%	92%	43%
Equal to Prescriptive	7%	4%	5%	18%	-	-
Lower Performance	9%	5%	8%	12%	8%	57%
Average % difference from Prescriptive	-10%	-17%	-12%	-5%	-4%	16%
Average U-Value	0.644	0.598	0.661	0.711	0.624	0.725
% of Sites w/Metal Frames	15.2%	8.0%	14.2%	32.5%	3.3%	39.9%

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.

Equipment Type and Location

A distribution of the space heating system equipment types and locations are presented in Table 3-14 for detached single family homes and Table 3-15 for multifamily buildings. Results are as follows.

- Detached single family space heating systems are predominantly furnaces (98.0%), with a small number of heat pumps located primarily in RMST Climate Zones 3 and 4 (0.6% and 2.6% respectively) and hydronic systems in RMST Climate Zone 1 (3.4%). Most of the space heating system units (76% statewide) are located in the attic.
- Heating equipment types in multifamily buildings are much more diverse. Although furnaces are still the predominant system (50.5% statewide), there are many more heat pumps (20.2%) and hydronic systems (19.9%) and even some electric resistance heating (9.4%) being used, but only in RMST Climate Zone 1. Heat pumps are probably more popular in multifamily residences because they eliminate the need to pipe gas to all units.
- RMST Climate Zone 3 has the most significant percentage of heat pumps (30%) for multifamily homes.
- RMST Climate Zone 5 has the most significant percentage of hydronic systems (71%) for multifamily homes.

- A significant number of space/water heating combination units were found in multifamily residences. There may even be more than were positively identified due to site access and survey form issues. As previously mentioned, multifamily HVAC units are the most difficult to access and obtain good make/model information. In addition, the survey form was not set up to easily capture these systems. These issues are being addressed in the second year of the RMST survey via survey form modifications and more diligent efforts to collect these data by following up with property managers and/or HVAC maintenance contractors.

Table 3-14: Space Heating Equipment Type and Location – Detached Single Family Homes

Analysis Parameter Description	Statewide	RMST CZ1	RMST CZ2	RMST CZ3	RMST CZ4	RMST CZ5
Equipment Type						
Central Furnace	98.0%	96.6%	100.0%	99.4%	96.8%	100.0%
Central Heat Pump	1.0%	-	-	0.6%	2.6%	-
Electric Resistance	-	-	-	-	-	-
Hydronic	0.8%	3.4%	-	-	-	-
Wall Furnace	0.2%	-	-	-	0.6%	-
Wall Heat Pump	-	-	-	-	-	-
Water Loop Heat Pump	-	-	-	-	-	-
Equipment Location						
Attic	76.0%	73.2%	84.2%	90.3%	63.3%	72.2%
Garage	14.5%	20.9%	8.1%	5.9%	20.2%	12.0%
None	1.8%	0.8%	3.3%	1.2%	1.9%	4.9%
Other	7.7%	5.0%	4.4%	2.5%	14.6%	11.0%

Table 3-15: Space Heating Equipment Type and Location – Multifamily Buildings

Analysis Parameter Description	Statewide	RMST CZ1	RMST CZ2	RMST CZ3	RMST CZ4	RMST CZ5
Equipment Type						
Central Furnace	47.1%	33.9%	70.5%	53.5%	51.9%	29.2%
Central Heat Pump	7.2%	-	13.4%	18.2%	4.1%	-
Electric Resistance	9.4%	23.6%	-	-	-	-
Hydronic	19.9%	18.5%	11.3%	16.4%	26.2%	70.8%
Wall Furnace	3.4%	8.6%	-	-	-	-
Wall Heat Pump	11.2%	15.4%	4.7%	11.8%	8.1%	-
Water Loop Heat Pump	1.7%	-	-	-	9.8%	-
Equipment Location						
Attic	33.8%	25.2%	41.7%	39.8%	37.7%	38.6%
Garage	7.1%	14.0%	-	3.0%	4.1%	-
None	34.2%	38.9%	15.6%	30.2%	43.1%	40.3%
Other	24.8%	21.9%	42.7%	27.0%	15.2%	21.2%

Equipment Efficiency

Table 3-16 and Table 3-17 present a summary of gas space heating system efficiencies for detached single family homes and multifamily residences, respectively. 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 for multifamily buildings is 80.0% AFUE, while the statewide average for detached single family homes is slightly higher at roughly 80.4% AFUE.
- Penetration of high efficiency space heating units (> 90% AFUE) is very low—2.2% for detached single family homes. For detached single family homes, there are some units in every RMST climate zone except Climate Zone 2. For multifamily buildings, though, there are no high efficiency space heating units.
- Space heating system efficiencies were collected for a much larger percentage of detached single family homes than for multifamily buildings—77% versus 51.4%, respectively. This was due primarily to the inaccessibility of HVAC units in multifamily (typically rental) units. In these situations, the units are usually locked up and accessible only to the property manager and not to the occupant (and hence not to the surveyor).

Table 3-16: Gas Space Heating System Efficiency – Detached Single Family Homes

Analysis Parameter Description	Statewide Average	RMST CZ1	RMST CZ2	RMST CZ3	RMST CZ4	RMST CZ5
Average Efficiency (AFUE)*	80.39	80.28	80.05	80.22	80.81	80.35
>= 78% and <= 80% AFUE*	91.8%	96.4%	94.0%	93.3%	87.1%	87.8%
> 80% and <= 90% AFUE*	6.0%	2.4%	6.0%	5.2%	8.3%	10.3%
> 90% AFUE*	2.2%	1.3%	-	1.5%	4.7%	1.9%
% of sites with observed data	77.1%	74.5%	77.7%	81.8%	70.9%	91.6%
% of sites with default values	22.9%	25.5%	22.3%	18.2%	29.1%	8.4%
Default AFUE	80.00	80.00	80.00	80.00	80.00	80.00
Average AFUE including defaults	80.30	80.21	80.04	80.18	80.57	80.32

* Of observed data.

Table 3-17: Gas Space Heating System Efficiency – Multifamily Buildings

Analysis Parameter Description	Statewide Average	RMST CZ1	RMST CZ2	RMST CZ3	RMST CZ4	RMST CZ5
Average Efficiency (AFUE)*	79.99	80.00	80.00	79.87	80.13	81.00
>= 78% and <= 80% AFUE*	92.9%	100.0%	100.0%	100.0%	67.5%	-
> 80% and <= 90% AFUE*	7.1%	-	-	-	32.5%	100.0%
> 90% AFUE*	-	-	-	-	-	-
% of sites with observed data	49.4%	49.0%	38.5%	60.1%	46.5%	42.9%
% of sites with default values	50.6%	51.0%	61.5%	39.9%	53.5%	57.1%
Default AFUE	80.00	80.00	80.00	80.00	80.00	80.00
Average AFUE including defaults	80.00	80.00	80.00	79.92	80.06	80.43

* 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 for detached single family homes and multifamily buildings.

Equipment Type and Location

A distribution of the space cooling system equipment types and locations are presented in Table 3-18 for detached single family homes and Table 3-19 for multifamily buildings. Key findings are highlighted below.

- For detached single family homes, the predominant space cooling system is a conventional central air conditioner (79.2%). However, 19.6% of the homes do not have air conditioning and a small number of sites have a heat pump (1.0%) or a hydronic system (0.2%).
- For detached single family homes, heat pumps have the highest penetration in RMST Climate Zone 4 (2.6% versus 0.6% in RMST Climate Zone 3).
- Space cooling equipment is typically installed in the attic of detached single family homes (78.5%).
- For multifamily buildings, a much more diverse range of equipment types is used. Although central air conditioners are still the predominant system for those units that have air conditioning, a significant percentage of multifamily sites statewide do not have air conditioning (37.5%).
- Unlike detached single family homes, multifamily buildings have a significant number of water loop heat pumps and hydronic systems (11.2% and 7.2%, respectively).

Table 3-18: Space Cooling Equipment Types – Detached Single Family Homes

Analysis Parameter Description	Statewide	RMST CZ1	RMST CZ2	RMST CZ3	RMST CZ4	RMST CZ5
Equipment Type						
Central Air Conditioner	79.2%	48.6%	48.5%	98.4%	92.4%	91.0%
Central Heat Pump	1.0%	-	-	0.6%	2.6%	-
Evaporative Cooler	-	-	-	-	-	-
Hydronic	0.2%	0.8%	-	-	-	-
No Air Conditioner	19.6%	50.6%	51.5%	1.0%	5.1%	9.0%
Wall Heat Pump	-	-	-	-	-	-
Water Loop Heat Pump	-	-	-	-	-	-
Equipment Location						
Attic	78.5%	80.5%	86.7%	91.4%	64.8%	76.1%
Garage	13.0%	12.7%	9.0%	6.1%	20.2%	13.6%
Other	8.5%	6.9%	4.3%	2.6%	14.9%	10.3%

Table 3-19: Space Cooling Equipment Types – Multifamily Buildings

Analysis Parameter Description	Statewide	RMST CZ1	RMST CZ2	RMST CZ3	RMST CZ4	RMST CZ5
Equipment Type						
Central Air Conditioner	28.6%	5.2%	37.6%	47.5%	47.0%	29.2%
Central Heat Pump	7.2%	-	13.4%	18.2%	4.1%	-
Evaporative Cooler	0.9%	-	-	-	4.9%	-
Hydronic	12.8%	1.9%	11.3%	14.5%	26.2%	70.8%
No Air Conditioner	37.5%	77.5%	32.9%	8.0%	-	-
Wall Heat Pump	1.7%	-	-	-	9.8%	-
Water Loop Heat Pump	11.2%	15.4%	4.7%	11.8%	8.1%	-
Equipment Location						
Attic	56.8%	65.0%	36.5%	57.2%	66.2%	64.6%
Garage	4.7%	14.0%	-	3.2%	7.2%	-
Other	38.5%	21.0%	63.5%	39.6%	26.6%	35.4%

Equipment Efficiency

Results for cooling system efficiencies are presented in Table 3-20 for detached single family homes and Table 3-21 for multifamily buildings. Results are highlighted below.

- For detached single family homes, statewide and RMST climate zone average efficiencies are significantly higher than the minimum efficiency (10 SEER).
- Higher-than-standard efficiency is the result of significant penetration of high efficiency equipment (>11 SEER) for detached single family homes (20.2% statewide), especially in RMST Climate Zones 4 and 5 (41.6% and 37.4%, respectively).
- A significant number of single family homes in RMST Climate Zones 1 and 2 do not have a cooling system (50.6% and 51.5%, respectively), which is 19.6% at the state level.
- For multifamily buildings, average efficiencies are much less than detached single family homes and much closer to the minimum standard (10.07 versus 10.53).
- A significant number of multifamily buildings do not have cooling systems (36.1% statewide). RMST Climate Zone 1 is the most extreme with 77.5% of sites not having a cooling system. RMST Climate Zone 2 is more consistent with detached single family homes (32.9%).
- Space cooling system efficiencies were collected for a much larger percent of detached single family homes than for multifamily buildings (73.8% and 41.0%, respectively). This was due primarily to the inaccessibility of HVAC units in multifamily (typically rental) units. In these situations, the units are usually locked up and accessible only to the property manager, and not to the occupant (and hence not to the surveyor).

Table 3-20: Central Air Conditioner Efficiency – Detached Single Family Homes

Analysis Parameter Description	Statewide	RMST CZ1	RMST CZ2	RMST CZ3	RMST CZ4	RMST CZ5
Average Efficiency (SEER) *	10.53	10.39	10.19	10.17	10.95	10.87
<= 10 SEER*	35.1%	28.1%	55.3%	34.5%	34.3%	37.0%
> 10 and <= 11 SEER*	44.6%	63.0%	39.0%	62.6%	24.1%	25.6%
> 11 and <= 12 SEER*	16.8%	8.9%	5.8%	1.1%	38.5%	18.1%
> 12 and <= 13 SEER*	3.2%	-	-	1.8%	3.1%	16.6%
> 13 and <= 14 SEER*	0.2%	-	-	-	-	2.7%
> 14 SEER*	-	-	-	-	-	-
% of sites w/cooling systems and observed efficiency	73.8%	43.6%	47.2%	96.7%	81.2%	88.6%
% of sites w/cooling systems and default efficiency	6.6%	5.9%	1.2%	2.3%	13.7%	2.4%
% of sites w/o cooling systems (CEC “NoCooling” default used)	19.6%	50.6%	51.5%	1.0%	5.1%	9.0%
Default SEER	10.00	10.00	10.00	10.00	10.00	10.00
Average SEER for all sites (including defaults)	10.48	10.34	10.18	10.16	10.81	10.84

* Of observed data.

Table 3-21: Space Cooling System Efficiency – Multifamily Buildings

Analysis Parameter Description	Statewide	RMST CZ1	RMST CZ2	RMST CZ3	RMST CZ4	RMST CZ5
Average Efficiency (SEER)*	10.07	10.00	10.04	10.05	10.15	10.01
<= 10 SEER*	74.3%	100.0%	87.4%	65.6%	63.6%	90.6%
> 10 and <= 11 SEER*	25.7%	-	12.6%	34.4%	36.4%	9.4%
> 11 and <= 12 SEER*	-	-	-	-	-	-
> 12 and <= 13 SEER*	-	-	-	-	-	-
> 13 and <= 14 SEER*	-	-	-	-	-	-
> 14 SEER*	-	-	-	-	-	-
% of sites w/cooling systems and observed efficiency	41.0%	7.1%	60.1%	58.6%	67.0%	100.0%
% of sites w/cooling systems and default efficiency	21.5%	15.4%	7.0%	33.5%	33.0%	-
% of sites w/o cooling systems (CEC “NoCooling” default used)	37.5%	77.5%	32.9%	8.0%	-	-
Default SEER	10.00	10.00	10.00	10.00	10.00	-
Average SEER for all sites (including defaults)	10.04	10.00	10.03	10.03	10.10	10.01

* 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 3-22 for detached single family homes and Table 3-23 for multifamily buildings. Results are highlighted below.

- Approximately 14% of detached single family homes have multiple (two or more) HVAC units. Multiple HVAC systems are even more prevalent in RMST Climate Zones 3 and 5 (23% and 26%, respectively). In RMST Climate Zone 2, two sites (1.7%) had three HVAC systems.
- Digital thermostats are the most common thermostat type (73.6% statewide). However, a significant number of electromechanical thermostats are still used (25.6% statewide), especially in RMST Climate Zones 5, 3, and 2 (51.3%, 40.0%, and 38.3%, respectively).
- A very small number of Home Automation Systems (HAS) were found and only in RMST Climate Zone 1 (1.7%).

- For multifamily buildings, only 4.5% of the residences have multiple (two or more) HVAC units. All of these residences are in RMST Climate Zones 1 (11.2%).
- Digital thermostats are also the most common thermostat type for multifamily buildings (59.9% statewide). However, electromechanical thermostats are close behind (37.7% statewide) and, in fact, in RMST Climate Zones 1 and 3 the percentages are largest and almost equal, smaller in Climate Zone 5, and smallest in Climate Zone 2. It is also interesting to note that RMST Climate Zones 2 and 4 are heavily weighted towards digital thermostats.
- The number of Home Automation Systems (HAS) found in multifamily buildings is close to that for detached single family buildings, and again these are exclusively in RMST Climate Zone 1 (2.6% versus 1.7%).

Table 3-22: Multiple HVAC Systems and Thermostat Types – Detached Single Family Homes

Analysis Parameter Description	Statewide	RMST CZ1	RMST CZ2	RMST CZ3	RMST CZ4	RMST CZ5
Number of HVAC Systems						
1	85.9%	90.6%	88.0%	76.9%	92.7%	74.2%
2	13.9%	9.4%	10.3%	23.1%	7.3%	25.8%
3	0.2%	-	1.7%	-	-	-
Thermostat Types						
Digital	73.6%	82.9%	60.7%	59.5%	90.0%	46.3%
Electromechanical	25.6%	15.3%	38.3%	40.0%	10.0%	51.3%
Hybrid	0.1%	-	-	0.5%	-	-
Home Automation System	0.4%	1.7%	-	-	-	-
None	0.3%	-	1.1%	-	-	2.4%
Other	-	-	-	-	-	-

Table 3-23: Multiple HVAC Systems and Thermostat Types – Multifamily Buildings

Analysis Parameter Description	Statewide	RMST CZ1	RMST CZ2	RMST CZ3	RMST CZ4	RMST CZ5
Number of HVAC Systems						
1	95.5%	88.8%	100.0%	100.0%	100.0%	100.0%
2	4.5%	11.2%	-	-	-	-
3	-	-	-	-	-	-
Thermostat Types						
Digital	59.9%	42.6%	77.2%	51.4%	95.1%	70.8%
Electromechanical	37.7%	52.9%	18.1%	48.6%	4.9%	29.2%
Hybrid	-	-	-	-	-	-
Home Automation System	1.0%	2.6%	-	-	-	-
None	0.8%	1.9%	-	-	-	-
Other	0.7%	-	4.7%	-	-	-

Water Heating

A summary of water heating equipment characteristics for units installed in newly constructed homes are discussed in this section. These characteristics include average system efficiencies, system type, 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 3-24 and Table 3-26 for detached single family homes and Table 3-25 and Table 3-29 for multifamily buildings. Key findings are highlighted below.

- For detached single family homes, the conventional storage-type water heater is the most predominant system type (99.4%). Natural gas fueled units are most common (93.3%), followed by propane (5.5%).
- Of detached single family homes statewide, 8.0% utilize recirculation pumps in their water heating systems. Recirculation pumps are used primarily in RMST Climate Zones 1 and 2 (15.6% and 13.1%, respectively).
- For multifamily buildings, the conventional gas fueled storage-type water heater is also the predominant system type (70.4%). However, a significant percentage of sites have central distribution systems (24.4%).

- Of multifamily buildings statewide, 6.8% utilize recirculation pumps in their water heating systems. This is only slightly higher than reported for detached single family homes. That percentage is highest in RMST Climate Zones 1, 2, and 4 (13.2%, 8.0%, and 7.4%, respectively).
- Statewide, 99.5% of the detached single family homes have water heaters that are gas fueled. Small percentages of electric water heaters were found in RMST Climate Zones 2 and 3 (1.5% and 0.6%).
- Less than half of one percent of detached single family homes utilize solar water heaters.
- Statewide, 100.0% of the water heaters in multifamily buildings are gas fueled.
- Statewide, only 1.5% of detached single family homes had two water heaters. The percent of sites with two water heaters in RMST Climate Zone 2 is almost double that of other RMST climate zones (3.1% versus 1.2-1.8%).

Table 3-24: Water Heating Fuel Type and Presence of Recirculation Pumps – Detached Single Family Homes

Analysis Parameter Description	Statewide	RMST CZ1	RMST CZ2	RMST CZ3	RMST CZ4	RMST CZ5
Style/Fuel Type						
Boiler	0.4%	1.7%	-	-	-	-
Central System	-	-	-	-	-	-
Storage/Standard – ElecResist	0.3%	-	1.5%	0.6%	-	-
Storage/Standard – NatGas	93.3%	93.7%	97.0%	98.2%	87.2%	93.4%
Storage/Standard – Propane	5.5%	2.6%	1.5%	1.1%	12.8%	6.6%
Solar	0.2%	0.7%	-	-	-	-
Storage/Standard – NatGas (Default)	0.3%	1.2%	-	-	-	-
Systems w/Recirculating Pumps	8.0%	15.6%	13.1%	6.8%	1.9%	7.6%

Table 3-25: Water Heating Fuel Type and Presence of Recirculaiton Pump – Multifamily Buildings

Analysis Parameter Description	Statewide	RMST CZ1	RMST CZ2	RMST CZ3	RMST CZ4	RMST CZ5
Style/Fuel Type						
Boiler	1.4%	3.5%	-	-	-	-
Central System	24.4%	23.6%	30.5%	26.0%	20.4%	16.7%
Storage/Standard – ElecResist	-	-	-	-	-	-
Storage/Standard – NatGas	70.4%	72.9%	69.5%	71.3%	62.2%	83.3%
Storage/Standard – Propane	3.1%	-	-	-	17.3%	-
Solar	-	-	-	-	-	-
Storage/Standard – NatGas (Default)	0.7%	-	-	2.7%	-	-
Systems w/Recirculating Pumps	6.8%	8.0%	13.2%	2.0%	7.4%	-

Table 3-26: Water Heaters – Detached Single Family Homes

Analysis Parameter Description	Statewide	RMST CZ1	RMST CZ2	RMST CZ3	RMST CZ4	RMST CZ5
Natural Gas	94.0%	96.6%	97.0%	98.2%	87.2%	93.4%
Propane	5.5%	2.6%	1.5%	1.1%	12.8%	6.6%
Electric	0.3%	-	1.5%	0.6%	-	-
Solar	0.2%	0.7%	-	-	-	-
sites w/1 Water Heater	98.5%	98.2%	96.9%	98.8%	98.8%	100.0%
sites w/2 Water Heaters	1.5%	1.8%	3.1%	1.2%	1.2%	-

Table 3-27: Water Heaters – Multifamily Buildings

Analysis Parameter Description	Statewide	RMST CZ1	RMST CZ2	RMST CZ3	RMST CZ4	RMST CZ5
Natural Gas	96.9%	100.0%	100.0%	100.0%	82.7%	100.0%
Propane	3.1%	-	-	-	17.3%	-
Electric	-	-	-	-	-	-
Solar	-	-	-	-	-	-

Equipment Efficiency

A summary of water heating system efficiencies is presented in Table 3-26 for detached single family homes and Table 3-29 for multifamily buildings. 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 values for sites with actual data is 13.3% for multifamily buildings and 16.1% for detached single family buildings

This supports findings from other studies that available (i.e., standard practice) water heating systems are already significantly more efficient than the Appliance Standard minimums. This might be due to high efficiency units being useful for meeting compliance requirements. In particular, the water heating budget and margins are often the most significant parts of the compliance margin, especially in those climate zones with mild weather.

Table 3-28: Gas Water Heater Efficiency – Detached Single Family Homes

Analysis Parameter Description	Statewide	RMST CZ1	RMST CZ2	RMST CZ3	RMST CZ4	RMST CZ5
Average % above standard*	16.1%	15.7%	16.5%	16.7%	15.3%	16.6%
% sites w/actual data	67.4%	77.7%	62.4%	66.3%	59.4%	80.0%
% sites w/default values	27.5%	18.5%	23.6%	28.0%	36.8%	20.1%
% sites w/CEC default values	5.1%	3.8%	14.0%	5.7%	3.8%	0.0%
Average % above std inc. defaults	14.8%	14.6%	13.8%	15.2%	14.7%	16.4%

* Of observed data.

Table 3-29: Gas Water Heater Efficiency – Multifamily Buildings

Analysis Parameter Description	Statewide	RMST CZ1	RMST CZ2	RMST CZ3	RMST CZ4	RMST CZ5
Average % above standard*	13.3%	14.2%	14.5%	12.9%	10.8%	13.2%
% sites w/actual data	58.5%	64.3%	59.9%	50.3%	54.4%	70.8%
% sites w/default values	11.6%	5.1%	3.3%	16.5%	25.2%	12.5%
% sites w/CEC default values	29.9%	30.6%	36.8%	33.2%	20.4%	16.7%
Average % above std inc. defaults	9.6%	9.9%	9.2%	9.0%	10.0%	11.2%

* Of observed data.

Water Heater Efficiency and Water Heater Blanket

Significant credit can be obtained in the performance compliance method under the 1995 Standards by adding an external insulating blanket to an already high efficiency water heater. Note that this credit was removed from the 1998 Standards. Results for this aspect of water heating are shown in Table 3-30 for detached single family homes and Table 3-31 for multifamily buildings. Key findings are summarized below.

- For detached single family homes, 67.5% of water heaters have EFs better than the standard minimum and do not have blankets. However, a substantial number (27.3%) are high efficiency and have blankets.
- All RMST climate zones have some high efficiency units with blankets, but these are most significant in RMST Climate Zone 4 where 43.7% of water heaters are high efficiency and also have blankets.
- For multifamily buildings, using high efficiency water heaters without blankets is the predominant practice (57.6%), but is less common than in detached single family homes.
- Nearly 11% of multifamily buildings statewide have high efficiency water heaters with blankets.

Table 3-30: Water Heater Efficiency and Blanket Status – Detached Single Family Homes

Analysis Parameter Description	Statewide	RMST CZ1	RMST CZ2	RMST CZ3	RMST CZ4	RMST CZ5
EF = Std EF, No blanket	0.7%	2.1%	2.1%	-	-	-
EF > Std EF, No blanket	67.5%	76.1%	75.6%	70.5%	52.5%	81.3%
EF < Std EF, Blanket present	-	-	-	-	-	-
EF = Std EF, Blanket present	4.4%	1.7%	12.1%	5.7%	3.8%	-
EF > Std EF, Blanket present	27.3%	20.0%	10.2%	23.8%	43.7%	18.7%

Table 3-31: Water Heater Efficiency and Blanket Status – Multifamily Buildings

Analysis Parameter Description	Statewide	RMST CZ1	RMST CZ2	RMST CZ3	RMST CZ4	RMST CZ5
EF = Std EF, No blanket	28.5%	30.6%	35.2%	28.7%	20.4%	16.7%
EF > Std EF, No blanket	57.6%	61.7%	55.8%	50.3%	58.1%	70.8%
EF < Std EF, Blanket present	1.8%	-	-	-	9.9%	-
EF = Std EF, Blanket present	1.4%	-	1.7%	4.5%	-	-
EF > Std EF, Blanket present	10.7%	7.7%	7.3%	16.5%	11.5%	12.5%

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 3-32 for detached single family homes and Table 3-33 for multifamily buildings. 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.

- Actual ceiling insulation values were gathered for only 38% of detached single family homes statewide. However, this value was as high as 64% in RMST Climate Zone 1 and as low as 15% in RMST Climate Zone 3. Default values used for the MICROPAS runs were developed for each CEC climate zone from the actual values.

- For detached single family homes, 47% statewide have ceiling insulation levels that are lower than the prescriptive values. RMST Climate Zones 1 and 5, which have the most extreme weather conditions, have the highest percentage of sites with ceiling insulation installed at or above prescriptive values (90% and 63%, respectively).
- Approximately 5% of the detached single family homes statewide have ceiling insulation levels that exceed the prescriptive values. As might be expected, these are located primarily in RMST Climate Zones 1, 3, and 5.
- Actual ceiling insulation values were gathered for only 18% of multifamily buildings statewide.

Table 3-32: Ceiling Insulation – Detached Single Family Homes

Analysis Parameter Description	Statewide	RMST CZ1	RMST CZ2	RMST CZ3	RMST CZ4	RMST CZ5
Average R-Value*	29.1	29.9	19.6	21.4	31.2	35.3
Average % difference from Prescriptive*	-13.2%	-1.3%	-34.7%	-28.6%	-18.0%	-7.2%
Higher Performance*	5%	8%	-	11%	1%	9%
Equal to Prescriptive*	48%	82%	6%	7%	31%	54%
Lower Performance*	47%	10%	94%	82%	67%	36%
% of sites w/actual data	38%	64%	23%	15%	48%	26%
% of sites w/default values	62%	36%	77%	85%	52%	74%
Average % difference from Prescriptive	-24.5%	-1.0%	-36.7%	-36.7%	-21.1%	0.0%
Average % difference from Prescriptive inc defaults	-20.2%	-1.2%	-36.2%	-35.5%	-19.6%	-1.8%

* Of observed data.

Table 3-33: Ceiling Insulation – Multifamily Buildings

Analysis Parameter Description	Statewide	RMST CZ1	RMST CZ2	RMST CZ3	RMST CZ4	RMST CZ5
Average R-Value*	28.1	30.0	16.6	19.0	33.0	-
Average % difference from Prescriptive*	-13.1%	0.0%	-44.5%	-36.7%	-13.2%	-
Higher Performance*	-	-	-	-	-	-
Equal to Prescriptive*	58%	100%	-	-	33%	-
Lower Performance*	42%	-	100%	100%	67%	-
% of sites w/actual data	18%	22%	14%	9%	29%	-
% of sites w/default values	82%	78%	86%	91%	71%	100%
Average % difference from Prescriptive	-19.2%	-0.5%	-36.7%	-36.7%	-21.1%	0.0%
Average % difference from Prescriptive inc defaults	-18.1%	-0.4%	-37.8%	-36.7%	-18.7%	0.0%

* Of observed data.

Wall Insulation

Wall insulation practices are summarized in Table 3-34 for detached single family homes and Table 3-35 for multifamily buildings. Both tables show that very little actual data on wall insulation were gathered for either detached single family homes or multifamily homes (only 23% and 10%, respectively). A high reliance on default values was the result, and defaults were set at prescriptive values. However, the Residential Standards require a minimum of R-13 wall insulation and there is limited space for insulation in a 2×4 stud frame. Therefore, assuming R-13 wall insulation for all sites might be better than using prescriptive values as the defaults.

Table 3-34: Wall Insulation – Detached Single Family Homes

Analysis Parameter Description	Statewide	RMST CZ1	RMST CZ2	RMST CZ3	RMST CZ4	RMST CZ5
Average R-Value*	14.4	13.4	15.7	19.0	14.7	17.0
Average % difference from Prescriptive*	-9.4%	0.2%	20.5%	46.2%	-22.7%	-19.1%
Higher Performance*	12%	10%	58%	100%	7%	-
Equal to Prescriptive*	38%	74%	-	-	12%	-
Lower Performance*	50%	16%	41%	-	81%	100%
% of sites w/actual data	23%	44%	3%	3%	36%	14%
% of sites w/default values	77%	56%	97%	97%	64%	86%
Average % difference from Prescriptive	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Average % difference from Prescriptive inc defaults	-2.2%	0.1%	0.5%	1.5%	-8.1%	-2.6%

* Of observed data.

Table 3-35: Wall Insulation – Multifamily Buildings

Analysis Parameter Description	Statewide	RMST CZ1	RMST CZ2	RMST CZ3	RMST CZ4	RMST CZ5
Average R-Value*	17.0	15.7	-	-	18.6	-
Average % difference from Prescriptive*	11.1%	21.1%	-	-	-2.1%	-
Higher Performance*	36%	24%	-	-	53%	-
Equal to Prescriptive*	49%	76%	-	-	13%	-
Lower Performance*	14%	-	-	-	33%	-
% of sites w/actual data	10%	15%	-	-	25%	-
% of sites w/default values	90%	85%	100%	100%	75%	100%
Average % difference from Prescriptive	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Average % difference from Prescriptive inc defaults	1.1%	3.1%	0.0%	0.0%	-0.5%	0.0%

* 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 for detached single family homes is included in Table 3-36. Key findings are summarized below.

- Radiant barriers are installed in only 2.3% of detached single family homes statewide. As expected, RMST Climate Zones 4 and 5 have the highest penetration of radiant barriers (6.2% and 2.4%, respectively).
- Metal framing is used in 1.0% of the detached single family homes statewide. Homes with metal framing are concentrated primarily in RMST Climate Zone 4 (2.5%), but there are also a few sites in RMST Climate Zone 1 (0.9%).

Table 3-36: Radiant Barrier and Framing Practices – Detached Single Family Homes

Analysis Parameter Description	Statewide	RMST CZ1	RMST CZ2	RMST CZ3	RMST CZ4	RMST CZ5
Radiant barriers installed						
No	97.7%	99.1%	100.0%	100.0%	93.8%	97.6%
Yes	2.3%	0.9%	-	-	6.2%	2.4%
Framing						
Metal	1.0%	0.9%	-	-	2.5%	-
Wood	99.0%	99.1%	100.0%	100.0%	97.5%	100.0%

HVAC Duct System

Duct leakage and duct construction practices, material types, sealant types, and location are summarized and discussed below.

Duct Leakage Rate

Duct blaster tests[15] to determine duct leakage rates were conducted for a sub-sample of 100 of the 800 RMST surveyed sites. Of these sites, 84 were valid MICROPAS sites. Test results are contained in Table 3-37 for detached single family homes and Table 3-38 for multifamily buildings. Results are presented in four numeric categories of leakage. A fifth

[15] Duct leakage rates are obtained from duct blaster tests by isolating the duct system, sealing all other outlets such as registers and plenums, pressurizing the duct system, and in this configuration, recording air flow through the duct system, which is the measured leakage rate. Duct blaster tests were conducted at 25 KPa, as described in Appendix C of the RMST report.

category notes those duct systems that could not be pressurized in order to perform the duct blaster test. Key findings are summarized below.

- Overall, 23.1% detached single family homes and 19.2% multifamily buildings had tight duct systems (leakage was low enough that they would qualify for RNC programs).
- A considerable number of duct systems in detached single family homes had leakage rates greater than 300 cfm (18.4%), including two sites that could not be pressurized.
- For detached single family homes, duct systems tested in RMST Climate Zone 5 were on average the leakiest at 331 cfm[16], while those in RMST Climate Zone 4 were the tightest (182 cfm).
- There were no duct systems in multifamily buildings with leakage rates greater than 500 cfm. This is probably a result of smaller duct runs and smaller HVAC systems. However, 68.4% of the homes in RMST Climate Zone 2 could not be pressurized.

Table 3-37: Summary of Duct Blaster Tests – Detached Single Family Homes

Analysis Parameter Description	Statewide	RMST CZ1	RMST CZ2	RMST CZ3	RMST CZ4	RMST CZ5
Number of Sites	72	16	10	19	20	7
Average Leakage Rate (valid tests)	218	216	241	221	182	331
Leakage Categories (All Sites):						
<=110 cfm (RNC programs)	23.1%	30.1%	13.3%	5.8%	35.8%	15.1%
> 110 & <=300 cfm	55.9%	44.0%	56.9%	76.8%	53.9%	43.5%
> 300 & <=500 cfm	13.4%	20.3%	24.5%	11.6%	5.1%	14.5%
> 500 cfm	5.0%	5.6%	5.4%	-	5.1%	14.5%
Could not pressurize	2.6%	-	-	5.8%	-	12.5%

[16] The average leakage rate in RMST Climate Zone 5 is not significantly greater than the average leakage rates in the remaining RMST Climate Zones.

Table 3-38: Summary of Duct Blaster Tests – Multifamily Residences

Analysis Parameter Description	Statewide	RMST CZ1	RMST CZ2	RMST CZ3	RMST CZ4	RMST CZ5
Number of Sites	24	6	5	8	3	2
Average Leakage Rate (valid tests)	185	120	269	217	137	278
Leakage Categories (All Sites):						
<=110 cfm (RNC programs)	19.2%	50.0%	12.9%	9.6%	-	-
> 110 & <=300 cfm	50.9%	50.0%	-	78.4%	100.0%	44.1%
> 300 & <=500 cfm	11.9%	-	18.8%	12.0%	-	55.9%
> 500 cfm	-	-	-	-	-	-
Could not pressurize	18.0%	-	68.4%	-	-	-

In addition, duct blaster test results for those customers who indicated their home was built under an RNC program were examined. Only four detached single family homes fit this category and of these three had duct leakage rates less than 85 cfm, which is consistent with RNC program requirements. However, the duct system for one of these homes could not be pressurized.

Percent Duct Leakage

An estimate of percent duct leakage requires that the total supply fan system flow rate be known. Percent duct leakage is the ratio of the measured duct leakage rate over the total supply fan system flow rate. However, since this information was difficult to collect on-site, supply fan flows were estimated by utilizing cooling and heating capacity data, Title 24 Residential Standards sizing rules, and the following logic:

- For HVAC systems where cooling capacities were available from the on-site survey, a value of 400 CFM per ton was used to estimate total supply CFM.
- For HVAC systems where heating capacities were available from the on-site survey, a value of 21.7 CFM per kBtuh was used to estimate total supply CFM.
- For HVAC systems where <u>neither</u> cooling nor heating capacities were available from the on-site survey, the following process was followed:
  - Default ft^2/ton and ft^2/kBtuh values were calculated for each building type (single-family detached homes and multifamily buildings) by computing and averaging these values for those residences that had capacities.
  - If the residence had a cooling system, the default ft^2/ton value and floor area of the residence were used to compute a default cooling capacity, and a value of 400 CFM per ton was used to estimate total supply CFM.

- If the residence did not have a cooling system, the default ft^2/kBtuh value and floor area of the residence were used to compute a default heating capacity, and a value of 21.7 CFM per kBtuh was used to estimate total supply CFM.

The results of this process are displayed in Table 3-39, which presents the average percent duct leakage by RMST climate zone. These results suggest no evidence of significant differences across RMST climate zones.[17] The results also reveal that single family homes have a significantly lower percent duct leakage than multifamily residences.[18] This is a major deviation from the common perception that duct leakage for multifamily residences would be less than that in single-family homes due to smaller duct run lengths. Instead, these results suggest that although duct runs are shorter, duct construction/sealing for multifamily buildings is possibly of lower quality. This might also suggest that building cavities and other such unfinished air flow paths are used more often in multifamily buildings than in single-family detached homes.

Table 3-39: Average Percent Duct Leakage by Utility

	Statewide	RMST CZ1	RMST CZ2	RMST CZ3	RMST CZ4	RMST CZ5
Single Family Homes	**13.5%**	**13.9%**	**16.6%**	**11.7%**	**11.4%**	**19.3%**
	(0.0122)	*(0.0260)*	*(0.0392)*	*(0.0149)*	*(0.0164)*	*(0.0814)*
	n = 70	*n = 16*	*n = 10*	*n = 18*	*n = 20*	*n = 6*
Multifamily Buildings	**28.0%**	**14.0%**	**36.1%**	**34.5%**	**20.2%**	**40.0%**
	(0.0355)	*(0.0256)*	*(0.1017)*	*(0.0577)*	*(0.0185)*	*(0.1996)*
	n = 23	*n = 6*	*n = 4*	*n = 8*	*n = 3*	*n = 2*

Standard errors in parentheses.

Duct Construction Type and Location

Duct construction practices as characterized by duct construction type and duct location are summarized in Table 3-40 for detached single family homes and Table 3-41 for multifamily buildings. Key findings are summarized below.

- As expected, the majority (97.5%) of detached single family homes used ducted systems.

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[17] The only exception to this is that a significance test at the 90% confidence level reveals that the average percent duct leakage for multifamily homes in RMST Climate Zone 1 is significantly different from the average percent duct leakage for multifamily homes in RMST Climate Zones 2, 3, and 4.

[18] A significance test at the 90% confidence level reveals that the estimates of the average percent duct leakage for single family and multifamily homes are significantly at the state level.

- Significantly more non-ducted systems are utilized by multifamily buildings, primarily in RMST Climate Zone 1. This is primarily due to the absence of cooling systems for a high percentage of sites (see *Space Cooling Systems*).
- Flex duct installed in the attic is the dominant construction practice for both detached single family homes and multifamily buildings (96.4% and 58.2%, respectively), although a higher percentage of metal duct work is utilized in multifamily buildings (12.7% versus 9.8% for detached single family homes).
- Unfinished wall cavities are not permitted under the standards. However, unfinished wall cavities were used as part of the duct system in a small percent of both detached single family homes (2.6% in RMST CZ2 and 1.8% in RMST CZ3) and multifamily buildings (7.3% in RMST Climate Zone 3, 4.8% in RMST Climate Zone 4, and 23.3% in RMST Climate Zone 5).

Table 3-40: Duct Construction Types and Locations – Detached Single Family Homes

Analysis Parameter Description	Statewide	RMST CZ1	RMST CZ2	RMST CZ3	RMST CZ4	RMST CZ5
System Type:						
Ducted	97.5%	99.1%	98.3%	96.1%	98.7%	91.3%
Non-Ducted	2.5%	0.9%	1.7%	3.9%	1.3%	8.7%
Construction Types:						
Flex	96.4%	94.8%	96.0%	97.7%	95.6%	100.0%
Metal	9.8%	16.6%	5.4%	8.2%	7.7%	9.3%
Panned	1.1%	-	5.7%	1.8%	-	-
Unfinished Wall Cavity	0.8%	-	2.6%	1.8%	-	-
Duct Location:						
Attic	95.0%	96.5%	93.3%	97.2%	92.4%	95.5%
Wall	17.9%	7.7%	17.8%	16.9%	24.8%	25.1%
Crawlspace	4.2%	10.4%	1.5%	-	4.5%	2.6%
Conditioned Space	0.4%	1.2%	1.2%	-	-	-
Basement	-	-	-	-	-	-
Other Location	0.4%	-	1.7%	0.6%	-	-

Table 3-41: Duct Construction Types and Locations – Multifamily Residences

Analysis Parameter Description	Statewide	RMST CZ1	RMST CZ2	RMST CZ3	RMST CZ4	RMST CZ5
System Type:						
Ducted	65.6%	40.2%	85.8%	77.6%	85.3%	90.6%
Non-Ducted	34.4%	59.8%	14.2%	22.4%	14.7%	9.4%
Construction Types:						
Flex	58.2%	51.4%	57.5%	54.2%	63.7%	100.0%
Metal	12.7%	39.1%	8.0%	-	7.4%	-
Panned	-	-	-	-	-	-
Unfinished Wall Cavity	4.3%	-	-	7.3%	4.8%	23.3%
Duct Location:						
Attic	58.6%	60.6%	58.7%	49.0%	65.6%	76.7%
Wall	37.7%	32.8%	27.3%	38.1%	50.5%	37.1%
Crawlspace	1.0%	-	-	3.4%	-	-
Conditioned Space	2.6%	8.7%	2.7%	-	-	-
Basement	-	-	-	-	-	-
Other Location	1.2%	4.8%	-	-	-	-

Duct Sealant Methods and Tape Types

Duct sealant and tape certification types are summarized in Table 3-42 for detached single family homes and Table 3-43 for multifamily buildings. Note that two or more sealing methods may have been used on each residence. Consequently, percentages in the table by RMST climate zone will add to more than 100%. Note also that, regarding the tape certifications listed in this table, these listings were compiled from the brand names recorded from the sealant tapes observed by the RMST surveyors. Key findings are summarized below.

- Butyl tape is the most utilized sealant method for both building types: 73.4% for detached single family homes and 43.8% for multifamily buildings.
- Most detached single family homes and multifamily buildings use multiple sealing methods, typically butyl tapes, metal tapes, and sometimes mastic.
- For detached single family homes, the highest percentage of mastic sealing occurs in RMST Climate Zone 1 (23.2%), and this is significantly higher than in other climate zones. This could be an indication of the influence of PG&E RNC

programs and the actions of other market actors like Beutler and Consol that emphasize and encourage tight ducts.

- Regarding duct tape UL 181 certification, which is required by the Standards, most tapes for which a rating could be identified were UL 181 rated. However, there was still a significant percentage of tapes being used that are not UL 181 certified—overall 9.4% for detached single family homes and 2.0% for multifamily buildings.
- The use of non-UL 181 certified tapes is the highest for detached single family homes in RMST Climate Zones 5 and 3 (37.5% and 17.1%, respectively).

Table 3-42: Duct Sealant Methods and Tape Types – Detached Single Family Homes

Analysis Parameter Description	Statewide	RMST CZ1	RMST CZ2	RMST CZ3	RMST CZ4	RMST CZ5
Duct Sealant Methods:[19]						
Butyl Tape	73.4%	66.4%	76.2%	79.2%	68.4%	92.3%
Metal Tape	54.8%	35.3%	71.0%	67.5%	45.9%	86.6%
Mastic	10.9%	23.2%	1.8%	5.1%	9.9%	10.8%
Clamp	6.8%	12.0%	7.8%	4.7%	5.8%	-
Other Sealant Method	1.5%	2.4%	-	1.3%	1.9%	-
Duct Tape Types:						
UL 181 – DK UL 723 – DK	71.8%	93.0%	62.9%	42.5%	92.6%	40.8%
UL 181 – No UL 723 – No	3.6%	-	7.1%	6.3%	0.6%	11.8%
UL 181 – No UL 723 – Yes	5.8%	0.9%	2.3%	10.8%	1.3%	25.7%
UL 181 – Yes UL 723 – No	16.3%	0.9%	23.8%	36.1%	1.7%	40.2%
UL 181 – Yes UL 723 – Yes	7.1%	1.7%	3.1%	16.1%	3.2%	12.3%

[19] Although identification of aerosol sealing was part of the RMST survey, no homes using this sealing method were found.

Table 3-43: Duct Sealant Methods and Tape Types – Multifamily Buildings

Analysis Parameter Description	Statewide	RMST CZ1	RMST CZ2	RMST CZ3	RMST CZ4	RMST CZ5
Duct Sealant Types:						
Butyl Tape	43.8%	47.8%	52.2%	41.7%	35.9%	42.5%
Metal Tape	31.8%	39.0%	25.2%	33.0%	20.8%	71.3%
Mastic	7.2%	6.4%	5.3%	-	20.0%	-
Clamp	1.7%	-	1.9%	-	5.7%	-
Other Sealant Method	0.7%	-	3.9%	-	-	-
Duct Tape Types:						
UL 181 – DK UL 723 – DK	76.0%	88.3%	62.8%	67.1%	70.7%	81.3%
UL 181 – No UL 723 – No	-	-	-	-	-	-
UL 181 – No UL 723 – Yes	2.0%	-	4.0%	5.8%	-	-
UL 181 – Yes UL 723 – No	7.2%	1.9%	22.7%	10.2%	4.0%	-
UL 181 – Yes UL 723 – Yes	2.3%	-	3.3%	7.2%	-	-

Lighting and Consumer Appliances

Typical installation practices for lighting and refrigerators, clothes washers, and dishwashers are outside the scope of this study and are not presented. However, this information is available from the RMST study.[20]

[20] Regional Economic Research, Inc. July 2000. *Low-Rise Multifamily Building New Construction Characteristics Study*. Prepared for the California Energy Commission. P400-00-012.

3.5 Summary of Current Construction Practices

Current building practices in the low-rise residential sector are summarized below. In particular, findings on efficiency levels and key differences in construction practice between detached single family homes and multifamily buildings and regions are summarized.

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 detached single family homes is 80.4, 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 10.5.
- The average EF of water heating systems installed is 16.1% higher than required by the Minimum Efficiency Standards for detached single family homes and 13.3% higher for multifamily buildings.
- The predominant window in all detached single family residence types is vinyl-framed, dual-paned, clear glass.

Regional Construction Practices

A number of differences in building practices among RMST climate zones were detected during the analysis. Table 3-44 and Table 3-45 summarize some of the key characteristics, by RMST climate zones, for detached single family homes and multifamily buildings respectively.

- 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. Ceiling insulation is usually the Standards minimum of R-19 for multifamily buildings. However, this varies for detached single family homes.
- For single family homes, the percent of metal-framed windows ranges from a low of 0.9% in RMST Climate Zone 1 to highs of 4.5% and 2.5% in RMST Climate Zones 5 and 3, respectively.
- A significant number of single family homes in RMST Climate Zones 1 and 2 do not have a cooling system (50.6% and 51.5%, respectively) compared to 20% at the state level. Likewise, a significant number of multifamily buildings do not have cooling systems (37.5% statewide). RMST Climate Zone 1 is the most extreme with 77.5% of sites not having a cooling system. Moreover, unlike detached single family homes, some multifamily buildings in RMST Climate Zone 3 do not have cooling systems (8.0%).

- For detached single family homes, duct systems tested in RMST Climate Zone 5 were on average the leakiest at 331 cfm, while those in RMST Climate Zone 4 were the tightest (182 cfm).

Table 3-44: Summary of Key Characteristics by RMST Climate Zone – Detached Single Family Homes

	Overall	RMST CZ1	RMST CZ2	RMST CZ3	RMST CZ4	RMST CZ5
Building Shell						
Average Square Footage	2232	2324	2353	2436	1952	2179
Average Number of Stories	1.6	1.7	1.9	1.7	1.3	1.2
Windows						
Higher Performance	64%	62%	65%	96%	44%	39%
Equal to Prescriptive	1%	-	1%	-	2%	5%
Lower Performance	35%	38%	34%	4%	54%	57%
Average % of Prescriptive	-5%	-2%	-7%	-19%	4%	4%
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
Above Standard	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
Above Standard	92%	96%	94%	93%	87%	88%
Gas Water Heaters						
Avg, % Above Std Energy Factor	16%	16%	16%	17%	15%	17%

Table 3-45: Summary of Key Characteristics by RMST Climate Zone – Multifamily Buildings

	Overall	RMST CZ1	RMST CZ2	RMST CZ3	RMST CZ4	RMST CZ5
Building Shell						
Average Square Footage	15463	16979	14911	15060	13852	10792
Average Number of Stories	2.3	2.4	2.6	2.2	1.9	1.8
Windows						
Higher Performance	91%	87%	94%	97%	88%	100%
Equal to Prescriptive	1%	2%	-	-	-	-
Lower Performance	8%	11%	6%	3%	12%	-
Average % of Prescriptive	-49%	-39%	-63%	-56%	-49%	-47%
Average % Glazing	9%	11%	7%	9%	8%	8%
Prescriptive % Glazing		16% & 20%	20%	20%	16%	16%
Average U-value	0.644	0.598	0.661	0.711	0.624	0.725
Air Conditioners						
Average SEER of Observed Data	10.07	10.00	10.04	10.05	10.15	10.01
Above Standard	26%	0%	13%	34%	36%	9%
% of sites w/No Air Conditioner	38%	77%	33%	8%	-	-
Gas Furnaces						
Average AFUE of Observed Data	79.99	80.00	80.00	79.87	80.13	81.00
Above Standard	93%	100%	100%	100%	68%	-
Gas Water Heaters						
Avg. % Above Std Energy Factor	13%	14%	14%	13%	11%	13%

Building Type

A number of differences in building practices were also found between detached single family homes and multifamily buildings.

- Glazing percentages in multifamily buildings are much smaller than for detached single family homes.
- While vinyl-framed, dual-paned, clear glass windows are predominantly used in both detached single family homes and multifamily buildings, metal windows are

used more often in multifamily buildings (15.2% compared to 2.0% in detached single family homes).

- Of detached single family homes, 20.2 % have a higher-than-standard efficiency air conditioner (>11 SEER) compared to none of the multifamily buildings.
- Space cooling system efficiencies were collected for a much larger percentage of detached single family homes than for multifamily buildings (73.8% and 41.0%, respectively). This was due primarily to the inaccessibility of HVAC units in multifamily (typically rental) units.

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%). However, looking only at average glazing percentages can be deceptive; percent glazing for *individual* sites can be as high as 29% and as low as 11%.

Window Types

The predominant window type for all building types is vinyl-framed, dual-paned, clear glass. However, a large number of multifamily building windows, particularly in RMST Climate Zones 5 and 3, are still metal framed (39.9% and 32.5%, respectively).

Space Heating Systems

Space heating systems are predominantly central gas furnaces with efficiencies slightly above 80% AFUE. Heat pumps in detached single family homes are located exclusively in RMST Climate Zones 3 and 4, while hydronic systems are located exclusively in RMST Climate Zone 1. Penetration of high efficiency (≥90%) space heating units is very low for detached single family homes (2.2%) and multifamily buildings (0%). For detached single family homes, high efficiency units are concentrated in RMST Climate Zone 4 (4.7%).

Heating equipment types in multifamily buildings are much more diverse than in detached single family homes. Although central furnaces are still the predominant system (47.1% statewide), there are many more heat pumps (20.1%) and even some electric resistance heating (9.4%), but only in RMST Climate Zone 1. Heat pumps are probably more popular in multifamily residences because they eliminate the need to pipe gas to all units. Several hydronic systems were also found in multifamily residences (19.9%).

Space Cooling Systems

Space cooling systems are predominantly central air conditioners. A significant number of new homes do not have air conditioners—19.6% of detached single family homes and 37.5% of multifamily buildings, primarily in RMST Climate Zones 1 and 2. Penetration of high efficiency (>11 SEER) space cooling units is approximately 20.2% statewide for detached single family homes. These units are concentrated in RMST Climate Zones 4 and 5 (41.6% and 37.4%, respectively).

Water Heating Systems

Standard practice water heaters are already significantly more efficient than Appliance Standard minimums (average 16.1% higher). This percentage is fairly consistent across RMST climate zones. This is because high efficiency water heaters are cost-effective, are readily available, and offer better performance (hence fewer customer complaints). In addition, statewide, 1.5% of detached single family homes have two water heaters. These are concentrated in RMST Climate Zone 2.

Building Shell Characteristics

Most detached single family homes (47% 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. A similar result was found regarding wall insulation. However, it is important to note that wall insulation values were collected for less than one-fourth of the sites.

Miscellaneous Practices

Number of HVAC Systems. Of detached single family homes, 14.1% have multiple (two or more) HVAC units. These are concentrated in RMST Climate Zones 3 and 5 (23.1% and 25.8%, respectively).

Thermostat Type. Digital thermostats are the most common thermostat type with 73.6% for single family homes and 59.9 for multifamily buildings. However, a significant number of electromechanical thermostats are still used—25.6% and 37.7% statewide for single family and multifamily, respectively.

4

Analysis of Title 24 Compliance for Low-Rise Residential Buildings

4.1 Introduction

This section discusses an assessment of the Title 24 compliance for low-rise residential buildings. The analysis is based on the MICROPAS simulation results using the on-site survey data. In particular, 735 sites were processed through the RNC Interface and the % Compliance Margin was calculated for each site. The primary objective of the analysis is to establish key characteristics of buildings that are compliant (compliant) and those that are not compliant with Title 24 standards (non-compliant). This was accomplished by examining the MICROPAS results. Specifically, the Compliance Margin Groups as defined in Section 4.3 were segmented and analyzed by RMST climate zones, building type (single family vs. multifamily), construction features, equipment types and efficiencies, and other building characteristics.

The remainder of this section presents a summary of the compliance data and 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, building type, end-use energy budgets, building shell features, fenestration, HVAC equipment, and water heating equipment, as well as participation in residential new construction (RNC) programs and housing price.

4.2 Summary of Compliance Data

Compliance analysis was attempted for all 800 sites contained in the Residential Market Share Tracking (RMST) Study on-site database. The status and disposition of the compliance runs for the 800 on-site surveys are presented in Table 4-1. As depicted in Table 4-1, 46 of the surveyed sites were excluded from the MICROPAS compliance runs because they are not subject to the Title 24 Low-Rise Residential Standards, leaving 754 usable sites. Table 4-1 also shows that 19 of the 754 valid MICROPAS sites presently have a MICROPAS run-time error and therefore do not yet have compliance results. These errors will be corrected before the final report and these sites included in the final analysis.

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

Site Disposition	# of Sites
Non-Usable Sites:	**46**
Mobile Homes	3
Manufactured Homes	13
Residences > 3 Stories Tall	30
Usable Sites:	**754**
Running	735
Run-Time Errors	19
Total	**800**

A distribution of the usable sites by residence type and RMST climate zone[1] is presented in Table 4-2. The RMST climate zone with the largest number of sites (218) is RMST Climate Zone 3. RMST Climate Zone 3 roughly corresponds to the interior regions of Los Angeles and San Diego counties, while the smallest number of sites is in the desert and mountain regions of the state (RMST Climate Zone 5). Most one-story single family homes are in RMST Climate Zone 4 (47%), whereas a large number of two-story single family homes are in RMST Climate Zone 3 (37%).

[1] A mapping of the CEC climate zones to the five RMST climate zones used in this analysis is provided in Section 3.2.

Table 4-2: Distribution of Usable Sites

	Overall	RMST CZ1	RMST CZ2	RMST CZ3	RMST CZ4	RMST CZ5
Overall	735	164	118	218	185	50
SF (single family detached)	588	115	93	177	160	43
1 story	251	38	10	52	118	33
2 story	334	76	82	124	42	10
3 story	3	1	1	1	0	0
SF-A (single family attached)	52	14	14	16	7	1
1 story	8	3	0	2	3	0
2 story	41	11	11	14	4	1
3 story	3	0	3	0	0	0
MF (multifamily)	95	35	11	25	18	6
1 story	5	0	1	0	3	1
2 story	47	13	1	17	11	5
3 story	43	22	9	8	4	0

4.3 Definition of Compliance Groups

Analysis of the MICROPAS results on a *non-compliant/compliant* criterion was not appropriate due to uncertainty with the MICROPAS results, characterized by the error band discussed in Section 2.4. As a result, a minimum of three "compliance groups" would have been needed to characterize the compliance runs. However, because of the interest in RNC programs, an additional group was formed. As shown below, this group, the overly compliant group, includes those sites that have a % Compliance Margin greater than 26%.[2] 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., <-4%).

2 ENERGY STAR® requires that a home use approximately 20% less energy than the maximum allowed. The error band, discussed in Section 2.4, was then put around the 20%, which results in the 26% shown as the cut-off for this group.

- ***Indeterminate.*** This category includes sites that have a % Compliance Margin within the error band (-4% to 6%). 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., > 6% and < 26%).
- ***Overly Compliant.*** This category includes sites that, based on the analysis, are overly compliant with Title 24 code. In particular, these sites have a % Compliance Margin greater than 26%. This category was defined to assess the share of homes that would meet the existing ENERGY STAR® New Home Construction requirements, given the error band.

The distribution of sites within each compliance grouping is illustrated in Figure 4-1. 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 sites by compliance groups and RMST climate zones and examining the average % Compliance Margin by RMST climate zone.

Distribution of Sites by Compliance Groups and RMST Climate Zones

A distribution of sites 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 57% of the sites (383 + 38) are identified as compliant (i.e., they are in the compliant or overly compliant compliance groups). Note that only 5.2% of the sites fall into the overly compliant group.
- Approximately 13.5% of the sites (99) are identified as non-compliant (i.e., they are in the non-compliant group).
- Just over 29% of the sites (215) are in the indeterminate group, which means they are within the error band and compliance status can not be determined.
- RMST Climate Zone 3 has the largest percentage of MICROPAS-run sites (29.7%) and RMST Climate Zone 5 has the smallest percentage of MICROPAS-run sites (6.8%).

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

Compliance Group	Totals	Percent	RMST CZ1	RMST CZ2	RMST CZ3	RMST CZ4	RMST CZ5
Non-Compliant	99	13.5%	15	7	11	50	16
Indeterminate	215	29.3%	50	34	25	86	20
Compliant	383	52.1%	86	73	165	46	13
Overly Compliant	38	5.2%	13	4	17	3	1
# Sites in the Sample	735	100.0%	164	118	218	185	50
Overall Percentage	100.0%		22.3%	16.1%	29.7%	25.2%	6.8%

Figure 4-1: MICROPAS Results Summary – All Sites

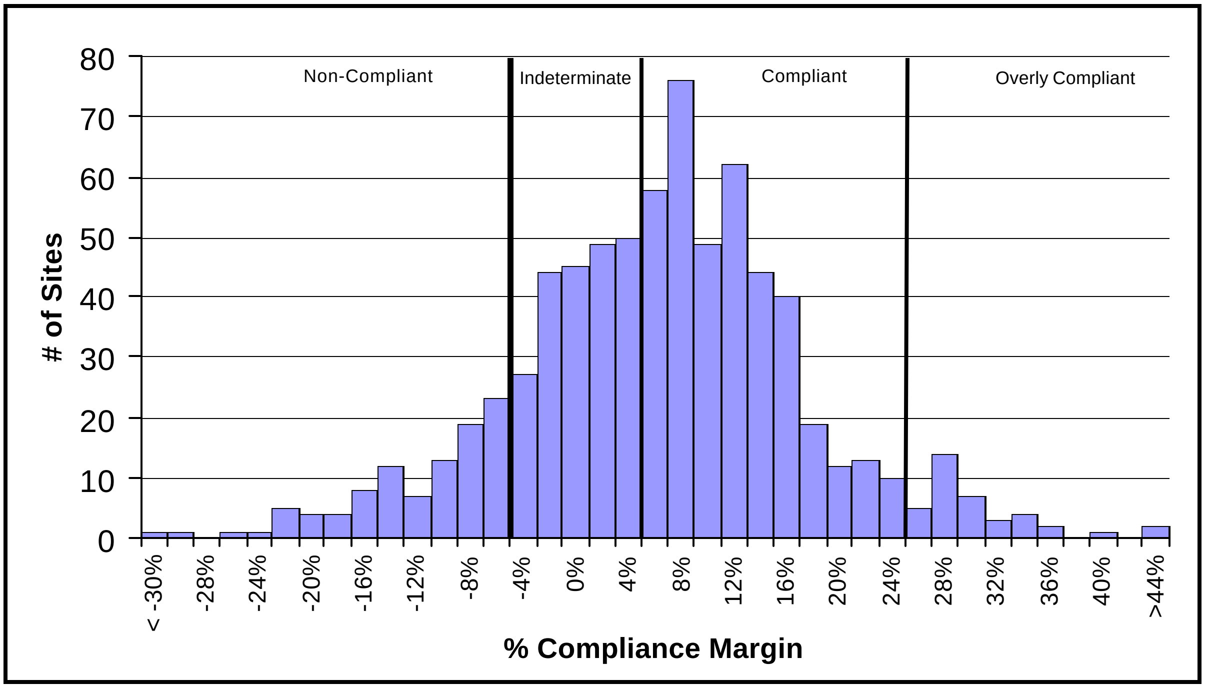


Figure 4-2: MICROPAS Results for RMST Climate Zone 1, All Sites

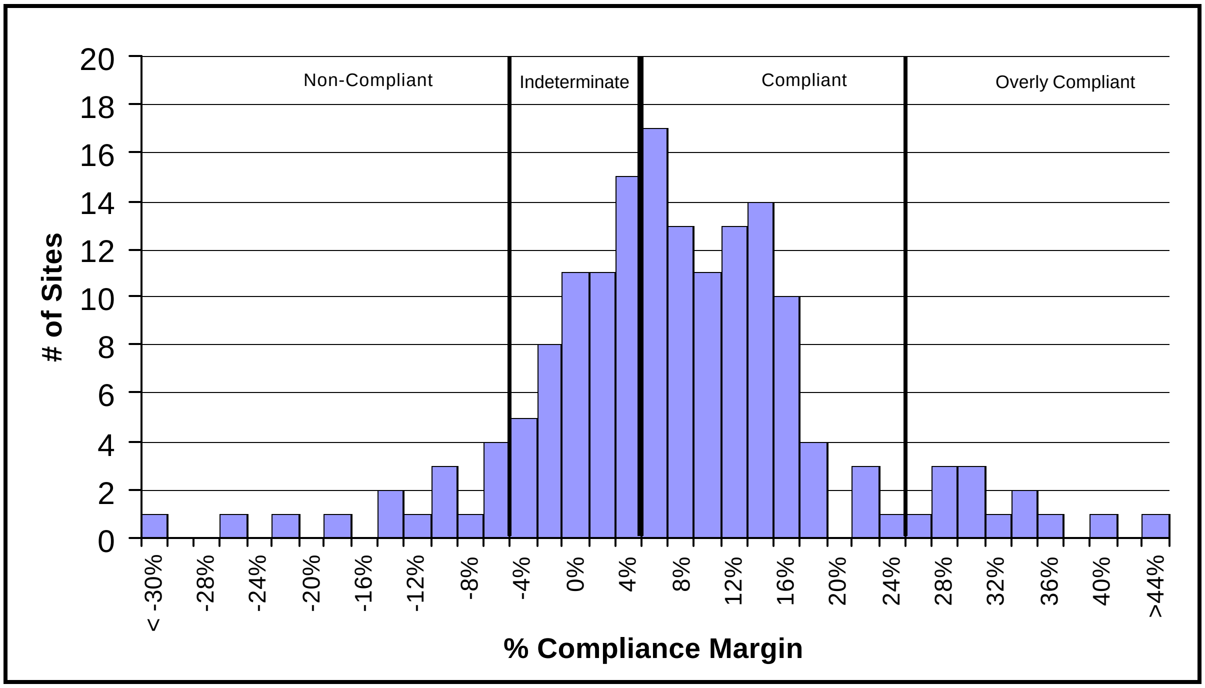


Figure 4-3: MICROPAS Results for RMST Climate Zone 2, All Sites

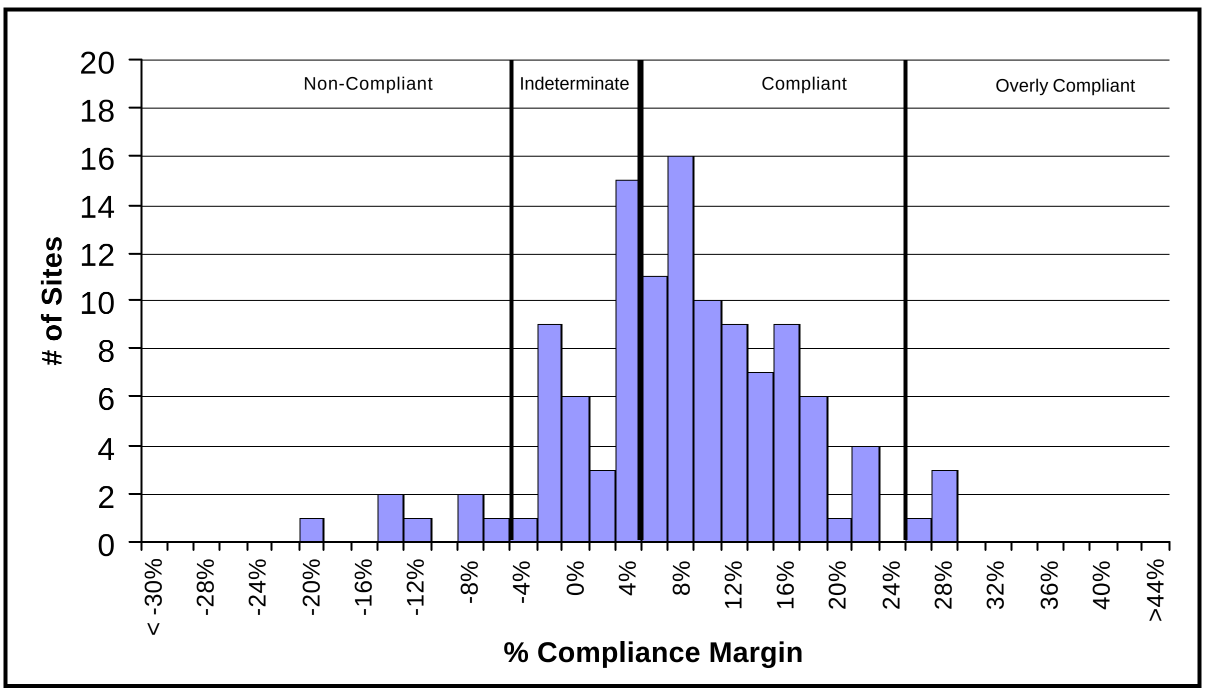


Figure 4-4: MICROPAS Results for RMST Climate Zone 3, All Sites

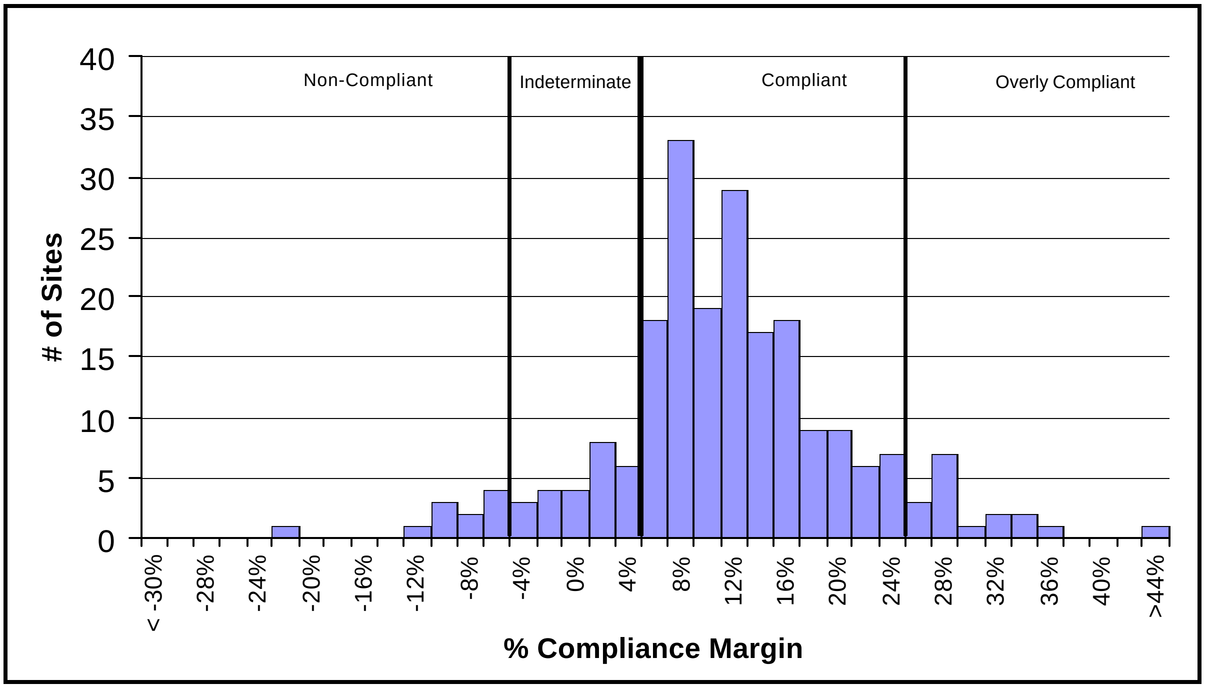


Figure 4-5: MICROPAS Results for RMST Climate Zone 4, All Sites

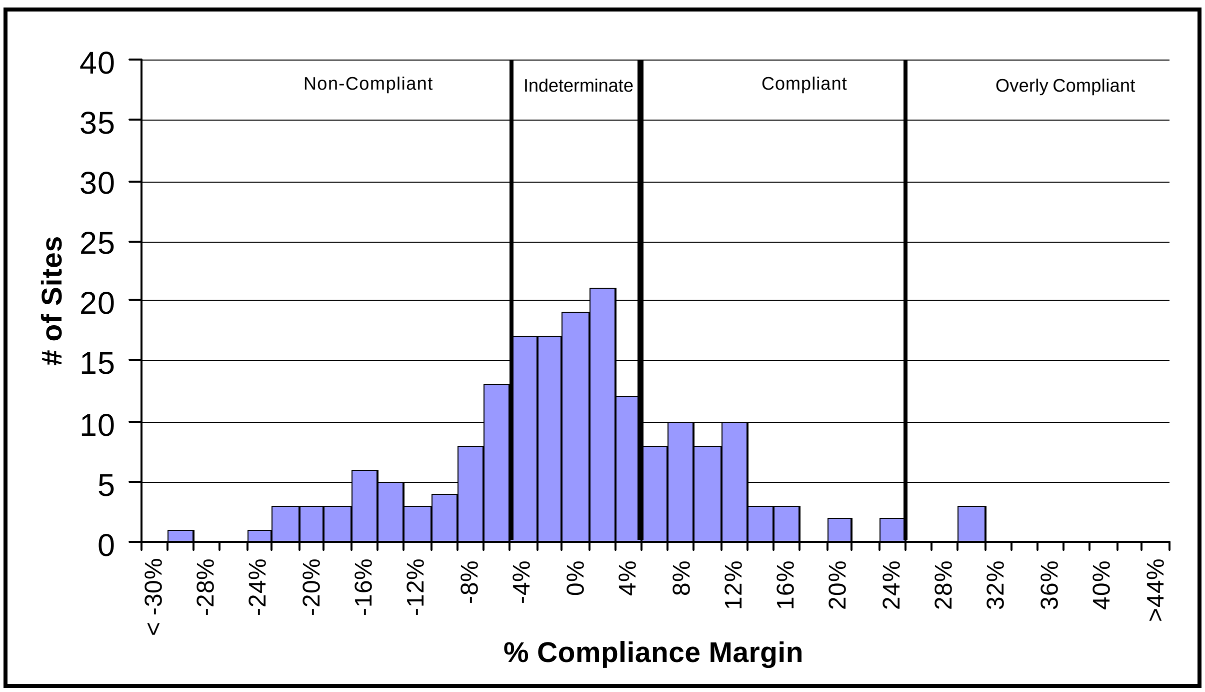
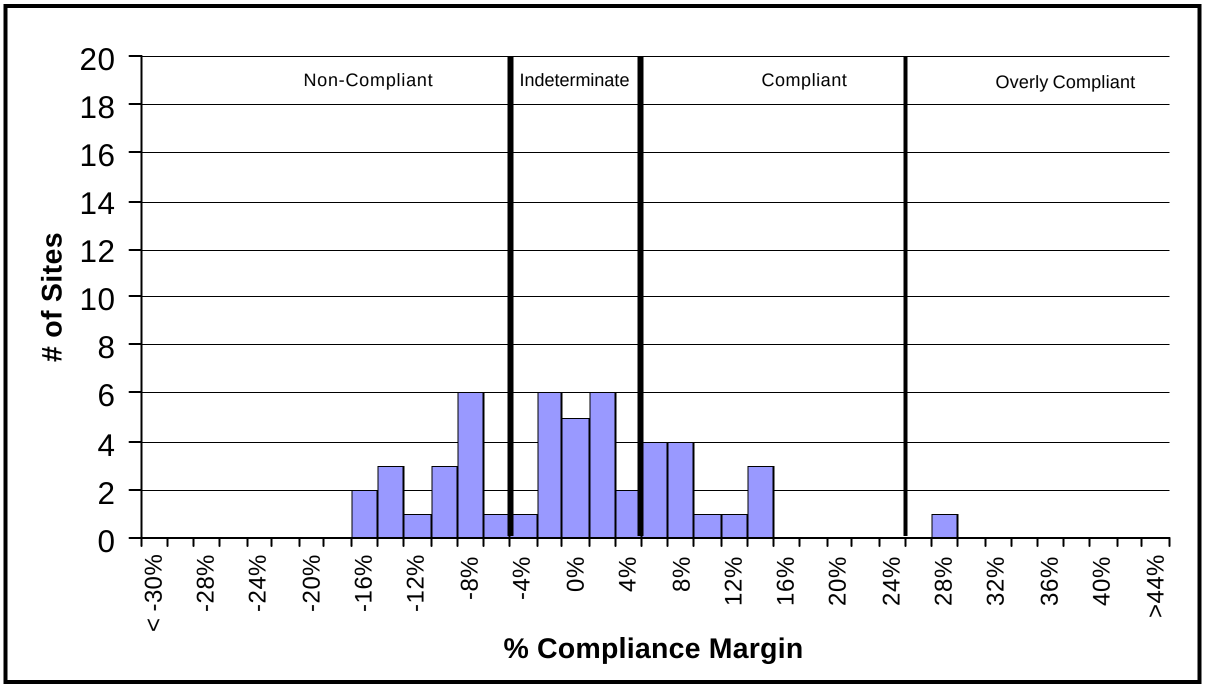


Figure 4-6: MICROPAS Results for RMST Climate Zone 5, All Sites



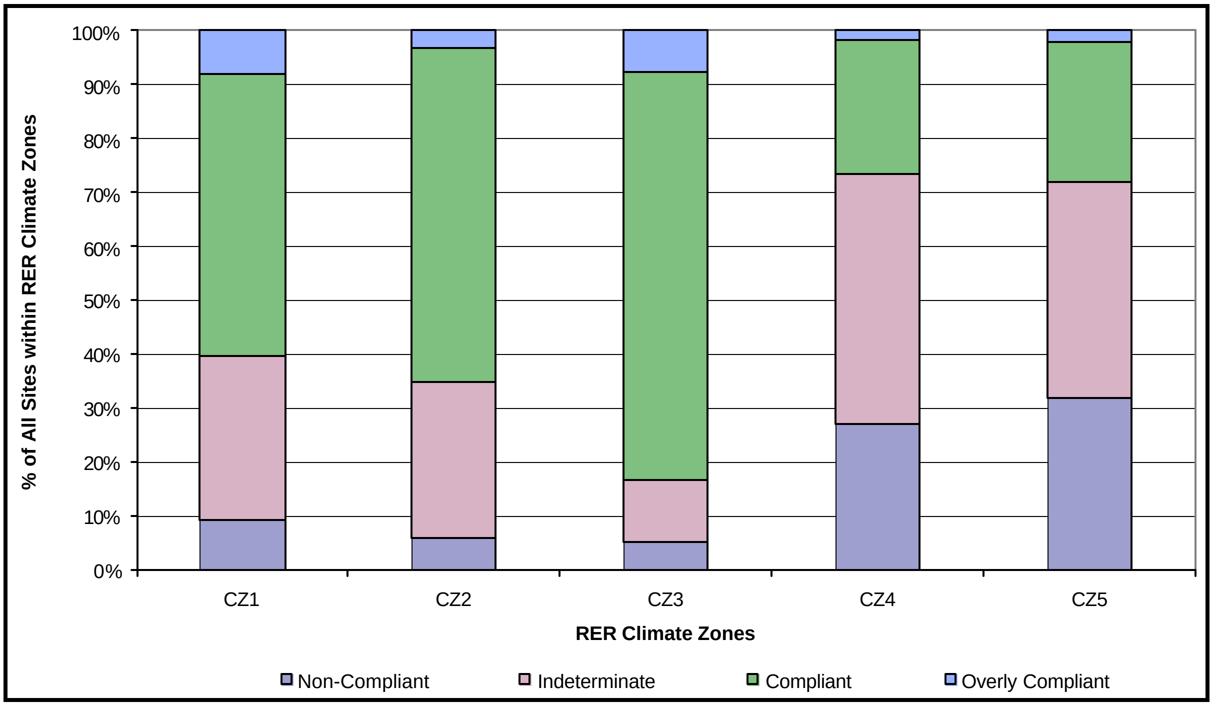
The percentage of sites in each compliance group is presented in Table 4-4 and Figure 4-7 for each RMST climate zone. Analysis on this basis was performed in order to make a qualitative assessment of the general compliance status of each RMST climate zone. Key findings are summarized below.

- Sites in RMST Climate Zones 4 and 5 appear to be the least compliant: most sites are either non-compliant or indeterminate (73% and 72%, respectively).
- Sites in RMST Climate Zone 3 appear to be the most compliant. Eight percent (8%) are overly compliant and 86% are either overly compliant or compliant. In addition, only 5% are non-compliant versus 27% and 32% for RMST Climate Zones 4 and 5, respectively.

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

Compliance Group	# Sites in Sample	RMST CZ1	RMST CZ2	RMST CZ3	RMST CZ4	RMST CZ5
Non-Compliant	99	9%	6%	5%	27%	32%
Indeterminate	215	30%	29%	11%	46%	40%
Compliant	383	52%	62%	76%	25%	26%
Overly Compliant	38	8%	3%	8%	2%	2%
# Sites in Sample	735	164	118	218	185	50
Overall Percentage		22.3%	16.1%	29.7%	25.2%	6.8%

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



Average % Compliance Margin *by RMST Climate Zone*

The relationship between average % Compliance Margin and RMST climate zones is summarized in Table 4-5.

- RMST Climate Zone 3 has the highest overall average % Compliance Margin (12.5%).
- RMST Climate Zone 5 has the smallest overall average % Compliance Margin (0.4%), although RMST Climate Zone 4 is close behind (1.0%).

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

RMST CZ	CEC CZ	# of Sites	Overall Average
CZ1	1, 2, 3, 4, 5	164	9.0%
CZ2	6, 7	118	9.5%
CZ3	8, 9, 10	218	12.5%
CZ4	11, 12, 13	185	1.0%
CZ5	14, 15, 16	50	0.4%

4.5 Compliance Analysis by Building Type

This section studies the relationship between compliance groups and building types by examining the distribution of sites by compliance groups and building types and examining other building characteristics such as number of floors and conditioned floor area by compliance group.

Distribution of Sites by Compliance Groups and Building Types

Results showing the relationship between compliance groups and building types are presented in Table 4-6 and illustrated in Figure 4-8 for detached single family homes and Figure 4-9 for multifamily buildings.

- Most multifamily buildings and single family homes are in the compliant group.
- There are many more multifamily buildings in the overly compliant group than detached single family homes.

Table 4-6: Distribution of Sites by Compliance Group and Building Type

Compliance Group	# Sites in Sample	Detached Single Family Homes	Multifamily Buildings
Non-Compliant	99	92	7
Indeterminate	215	193	22
Compliant	383	300	83
Overly Compliant	38	3	35
# Sites in Sample	735	588	147
Overall Percentage		80%	20%

Figure 4-8: MICROPAS Results Summary – Detached Single Family Homes

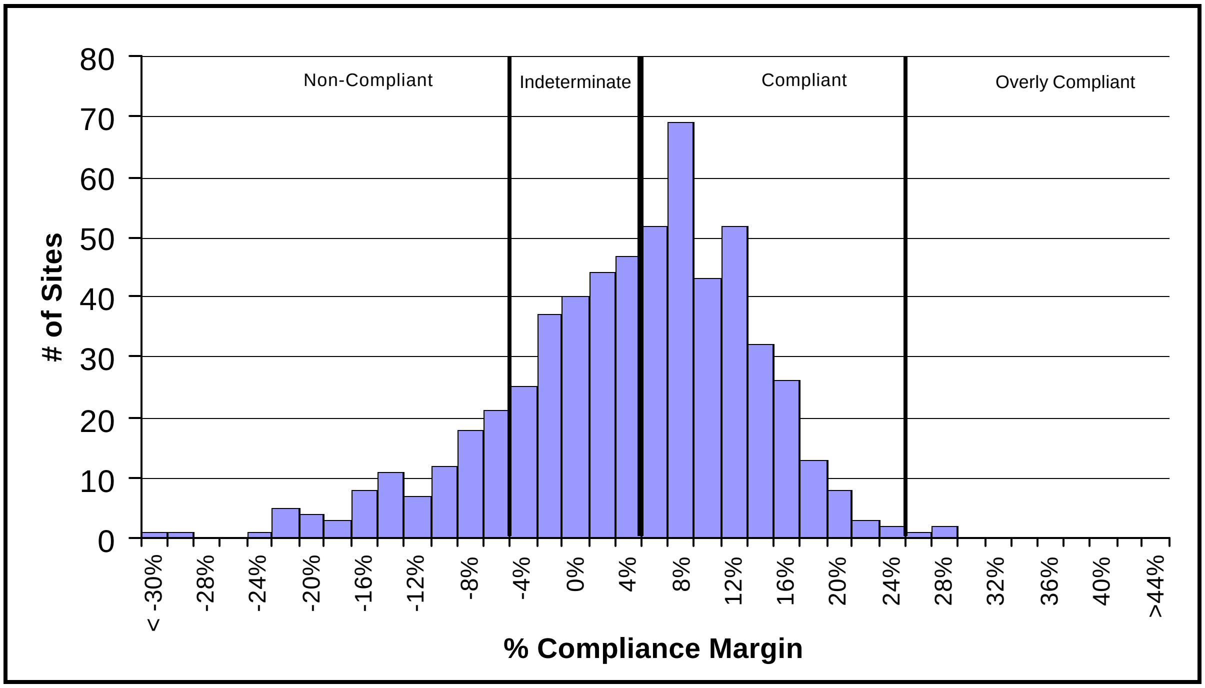
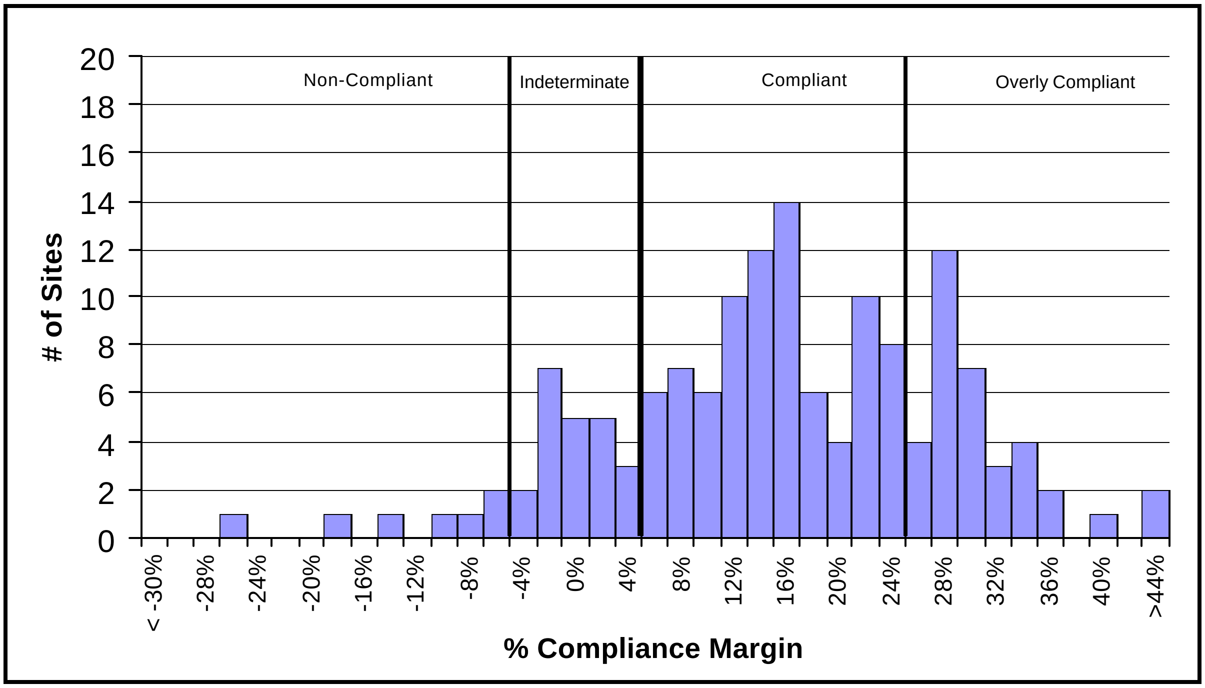


Figure 4-9: MICROPAS Results Summary – Multifamily Buildings



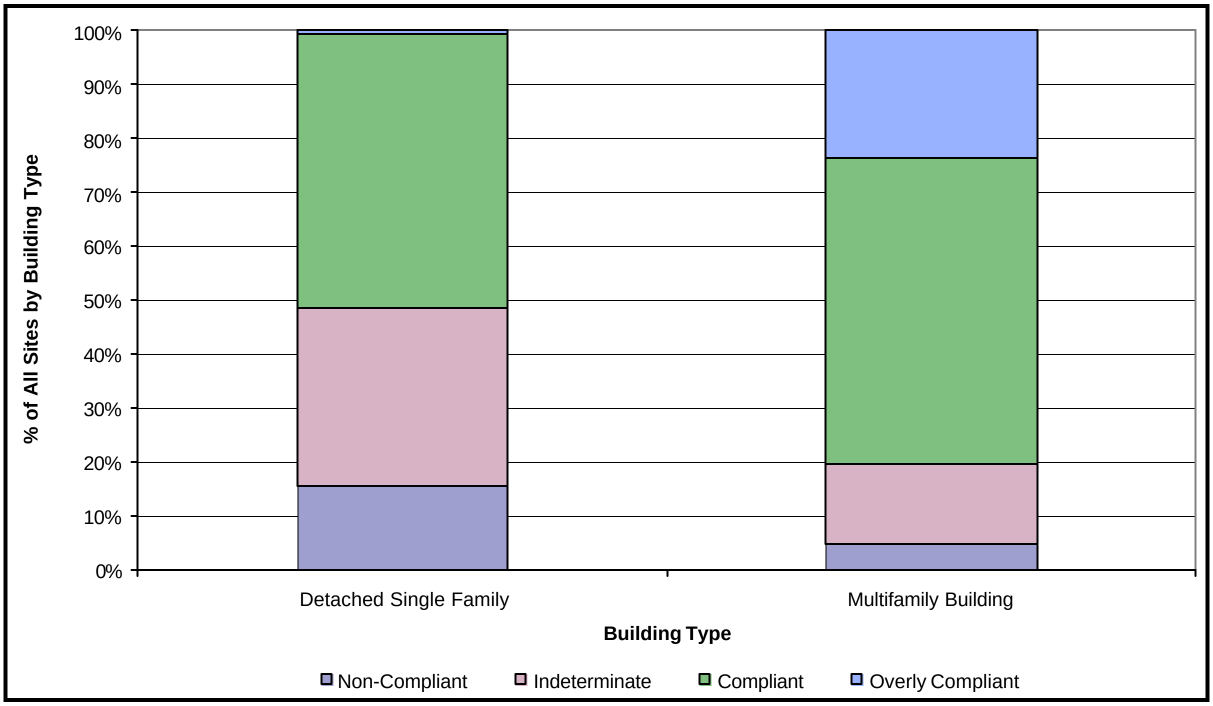
For each building type, the percentage of sites in each compliance group is presented in Table 4-7 and Figure 4-10. Analysis on this basis was performed in order to make a qualitative assessment of any differences in general compliance tendencies by building type. Key findings are summarized below.

- The majority of sites for both building types are compliant and representative percentages are relatively close: 50% for detached single family homes and 56% for multifamily buildings.
- Multifamily buildings are slightly more compliant than detached single family homes based on percentages of overly compliant and compliant sites: 73% (4% overly compliant, 69% compliant) for detached single family homes versus 79% (23% overly compliant, 56% compliant) for multifamily buildings.

Table 4-7: Summary of Compliance Groups by Building Type

Compliance Group	# Sites in Sample	Detached Single Family Homes	Multifamily Buildings[3]
For Each Building Type, % of Sites in Each Compliance Group			
Non-Compliant	99	16%	5%
Indeterminate	215	33%	15%
Compliant	383	51%	57%
Overly Compliant	38	1%	24%
# Sites in Sample	735	588	147

Figure 4-10: Distribution of Compliance Groups by Building Type



3 Includes both attached single family homes and multifamily buildings.

Distribution of Sites by Compliance Group, Building Type, and Number of Floors

The relationship between building types and compliance groups is summarized in Table 4-8. Key findings are summarized below.

- Examining the compliant and overly compliant site percentages, single family detached homes tend to be slightly less compliant than either single family attached homes or multifamily residences (51% versus 89% and 75%, respectively).
- For detached single family homes, one-story homes tend to be less compliant than multi-story homes. Non-compliant percentages by number of floors decrease from 24% for one-story homes to 10% for two-story homes, and compliant/overly compliant percentages by number of floors increase from 33% for one-story homes to 64% for two-story homes.
- For multifamily buildings (attached single family and multifamily), this same pattern is less evident and the results are much more dispersed.
- Most custom built, single family detached homes are compliant (42%). However, a significant percentage of these homes are non-compliant (22%) or indeterminate (36%).

Table 4-8: Distribution of Compliance Groups by Building Type and Number of Floors

Analysis Parameter Description	Overall (735 Sites)	Non-Compliant (99 Sites)	Indeter-minate (215 Sites)	Compliant (383 Sites)	Overly Compliant (38 Sites)
SF (single family detached)	588	16%	34%	50%	1%
1 story	251	24%	43%	33%	0%
2 story	334	10%	26%	63%	1%
3 story	3	-	-	100%	-
SF-A (single family attached)	52	6%	5%	62%	27%
1 story	8	-	-	78%	22%
2 story	41	8%	6%	58%	28%
3 story	3	-	-	63%	37%
MF (multifamily)	95	6%	20%	54%	21%
1 story	5	47%	18%	35%	-
2 story	47	2%	20%	55%	23%
3 story	43	5%	20%	54%	21%
Tract Single Family detached homes		15%	33%	51%	0%
Custom Single Family detached homes		22%	36%	42%	1%

Distribution of Sites by Compliance Group and Conditioned Floor Area

The relationship for conditioned floor area by building type and compliance group is summarized in Table 4-9. Key findings are summarized below.

- The average floor area of detached single family homes is 2,232 square feet.
- The average floor area of attached single family homes is 8,412 square feet, while the average for multifamily homes is significantly greater (18,958 square feet).

Table 4-9: Summary of Comparison Groups by Average Conditioned Floor Area

Analysis Parameter Description	Overall (735 Sites)	Non-Compliant (99 Sites)	Indeter-minate (215 Sites)	Compliant (383 Sites)	Overly Compliant (38 Sites)
SF (single family detached)	2,232	2,149	2,134	2,319	2,829
1 story	1,904	1,875	1,933	1,874	2,974
2 story	2,484	2,699	2,405	2,480	2,759
3 story	4,188	-	-	4,188	-
SF-A (single family attached)	8,412	6,800	4,513	7,911	10,599
1 story	2,628	-	-	2,523	2,991
2 story	8,586	6,800	4,513	8,402	10,398
3 story	28,970	-	-	27,325	31,752
MF (multifamily)	18,958	10,867	13,260	16,267	33,324
1 story	3,960	3,374	5,445	3,988	-
2 story	9,389	7,590	7,872	8,689	12,562
3 story	29,191	17,875	18,898	24,199	54,467

4.6 Compliance Analysis across HVAC and Water Heating Energy Budgets

Since compliance is determined by comparing the proposed energy used 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 4-10 shows how the standard energy budget changes across RMST climate zones. As shown, RMST Climate Zone 2 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 budget for RMST Climate Zones 4 and 5 is approximately double that of RMST Climate Zone 2.

Table 4-10: 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	13.18	12.04	12.19	13.34	12.09
% of Total Standard Budget	44.7%	64.5%	42.4%	36.0%	27.9%
Space Heating Intensity					
Average Standard Budget	11.16	2.92	6.42	13.10	11.62
% of Total Standard Budget	37.9%	15.6%	22.3%	35.4%	26.8%
Space Cooling Intensity					
Average Standard Budget	5.15	3.72	10.16	10.60	19.57
% of Total Standard Budget	17.5%	19.9%	35.3%	28.6%	45.2%
Total					
Average Standard Budget	29.49	18.68	28.77	37.04	43.28

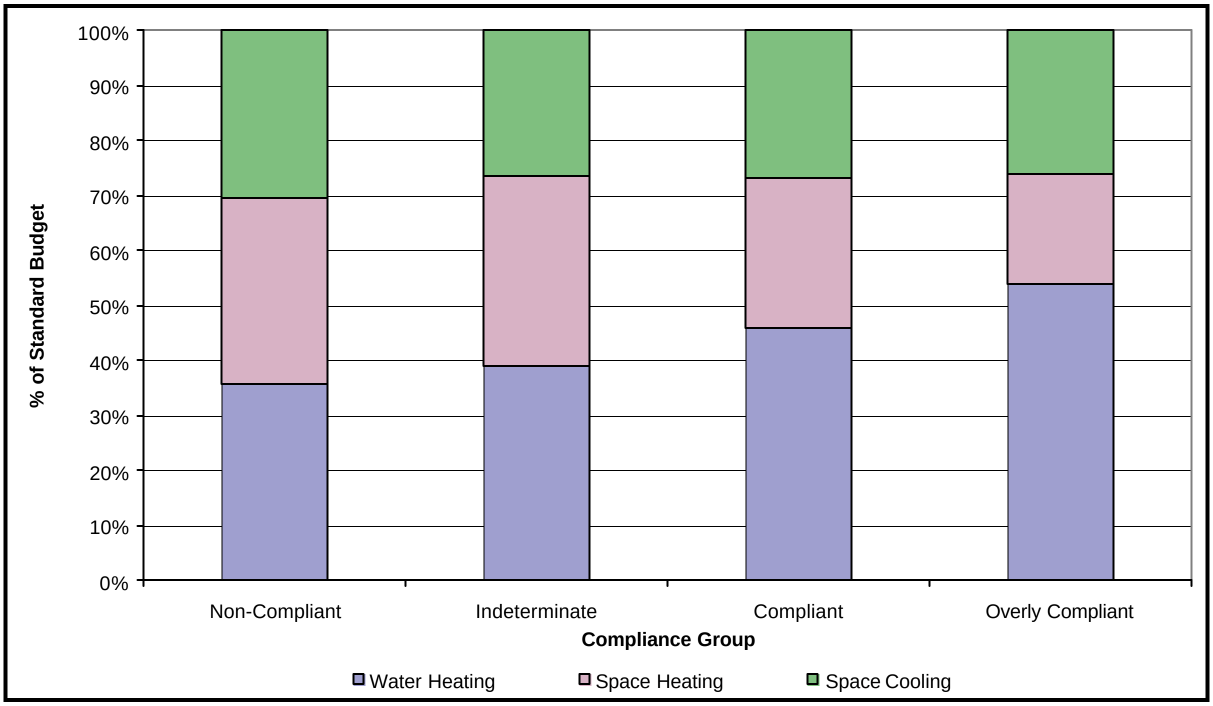
For each compliance group, the average proportion of each end use (space heating, space cooling, and water heating), as developed from MICROPAS Standard budget results, is shown in Table 4-11 and Figure 4-11. Key findings are summarized below.

- Overall, water heating comprises approximately 43% of the total standard budget.
- Water heating has a slightly larger percentage of the energy budget for compliant and overly compliant sites (46% and 54%) than for indeterminate and non-compliant sites (36%).
- The space heating percentage varies across compliance groups much more than space cooling: 20% to 34% versus 26% to 30%, respectively.

Table 4-11: Average Proportions of Standard Budget from Compliance Analysis

Analysis Parameter Description	Overall (735 Sites)	Non-Compliant (99 Sites)	Indeterminate (215 Sites)	Compliant (383 Sites)	Overly Compliant (38 Sites)
Water Heating	43%	36%	39%	46%	54%
Space Heating	30%	34%	34%	27%	20%
Space Cooling	27%	30%	26%	27%	26%

Figure 4-11: Average HVAC and Water Heating Percentages of Standard Budget by Comparison Group



<u>Standard vs. Proposed Energy Budgets by HVAC and Water Heating</u>

Table 4-12 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 Zone 5 has the largest. Also shown is that RMST Climate Zone 3 has the largest total margin. One other interesting point is that RMST Climate Zones 4 and 5 have negative space cooling margins.

Table 4-12: Average Annual End Use Energy Intentsities (kBtuh/ft^2 per year) by RMST Climate Zone

Analysis Parameter Description	RMST CZ1	RMST CZ2	RMST CZ3	RMST CZ4	RMST CZ5
Water Heating Intensity					
Average Standard Budget	13.18	12.04	12.19	13.34	12.09
Average Proposed Budget	12.52	11.67	11.51	12.31	11.22
Average Margin	0.66	0.38	0.68	1.02	0.87
Space Heating Intensity					
Average Standard Budget	11.16	2.92	6.42	13.10	11.62
Average Proposed Budget	10.96	2.77	4.85	12.32	11.54
Average Margin	0.20	0.15	1.57	0.78	0.08
Space Cooling Intensity					
Average Standard Budget	5.15	3.72	10.16	10.60	19.57
Average Proposed Budget	3.50	2.55	8.93	12.09	20.54
Average Margin	1.64	1.17	1.23	-1.49	-0.96
Total					
Average Standard Budget	29.49	18.68	28.77	37.04	43.28
Average Proposed Budget	26.98	16.98	25.29	36.73	43.30
Average Margin	2.51	1.70	3.48	0.31	-0.02

For each compliance group, the average end-use (space heating, space cooling and water heating) energy intensities, as developed from MICROPAS budget results, are presented Table 4-13 and illustrated in Figure 4-12 by compliance group. Key findings are summarized below.

- The average standard heating budget decreases from the non-compliant group to the overly compliant group (12.00 to 5.44). Likewise, the average standard cooling budget also decreases from the non-compliant group to the overly compliant group (11.48 to 7.14).

- Non-compliant sites are typically non-compliant because of their large negative cooling margins, while overly compliant sites are typically overly compliant because of their large positive cooling margins.

Table 4-13: Average Annual End-Use Energy Intentsities (kBtuh/ft^2 per year) by Compliance Group

Analysis Parameter Description	Overall (735 Sites)	Non-Compliant (99 Sites)	Indeter-minate (215 Sites)	Compliant (383 Sites)	Overly Compliant (38 Sites)
Water Heating Intensity					
Average Standard Budget	12.76	12.52	12.68	12.73	14.06
Average Proposed Budget	12.00	11.98	11.99	11.92	12.95
Average Margin	0.75	0.54	0.69	0.81	1.10
Space Heating Intensity					
Average Standard Budget	9.52	12.00	11.79	7.95	5.44
Average Proposed Budget	8.79	12.92	11.43	6.75	2.94
Average Margin	0.73	-0.92	0.36	1.20	2.50
Space Cooling Intensity					
Average Standard Budget	8.83	11.48	9.25	8.04	7.14
Average Proposed Budget	8.40	15.09	9.85	6.39	2.21
Average Margin	0.42	-3.61	-0.60	1.65	4.93
Total					
Average Standard Budget	31.10	35.99	33.72	28.72	26.64
Average Proposed Budget	29.20	39.98	33.27	25.06	18.11
Average Margin	1.90	-3.99	0.45	3.66	8.53

Figure 4-12: Average Annual End-Use Energy Intentsities (kBtuh/ft^2 per year)

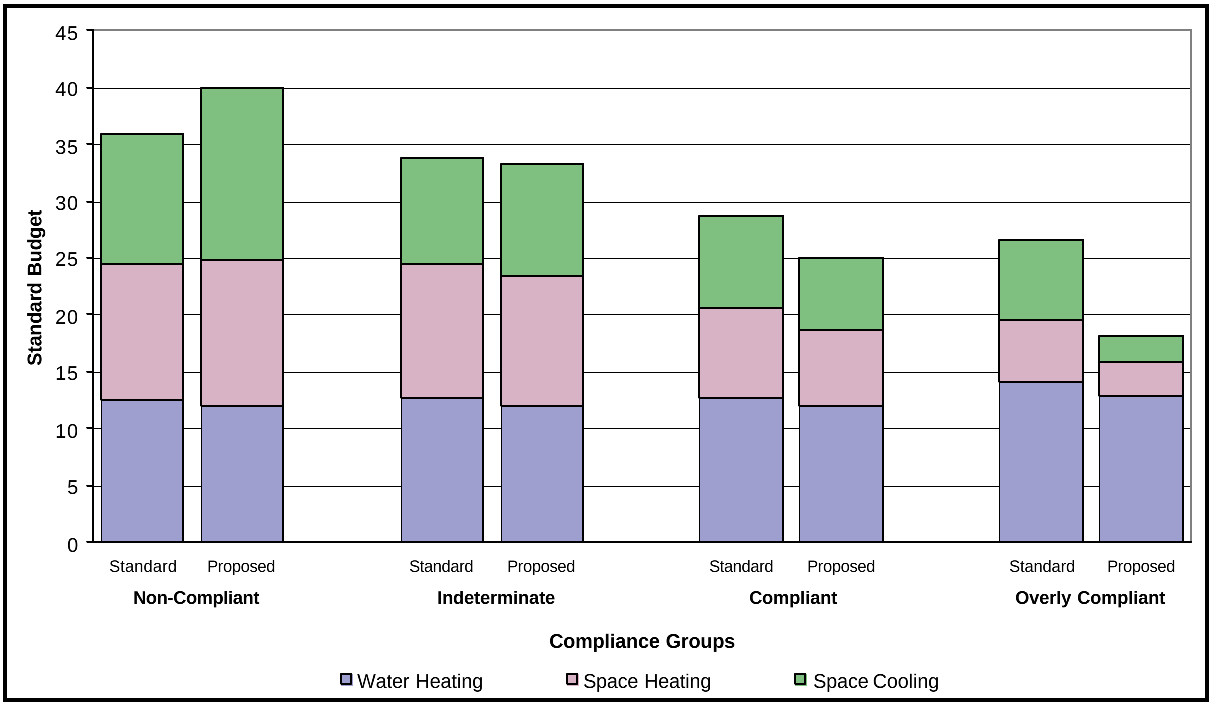


Figure 4-12 clearly shows that the average total standard energy budget decreases as one moves from the non-compliant group to the overly compliant group (approximately 35 kBtuh/ft^2 in the non-compliant and indeterminate groups, just under 30 kBtuh/ft^2 in the compliant group, and just over 25 kBtuh/ft^2 in the overly compliant group). As shown, water heating budgets remain relatively constant throughout the compliance groups. Also shown is that, on average, sites in every group have a small positive water heating margin (average margins range from 0.54 to 1.10). With the exception of sites with electric water heaters, water heating budgets do not seem to impact compliance much. Instead, HVAC budgets drive whether a site is non-compliant or overly compliant.

As shown in Section 4.4, sites in RMST Climate Zones 2 and 3 tend to be more compliant than sites in other RMST climate zones. One reason is that homes in these zones have glazing percentages that are lower than the glazing percentages prescribed by Title 24.[4] While the average on-site glazing percentages seem to remain fairly constant across RMST climate zones, the prescriptive glazing percentage allowed is higher in RMST Climate Zones 2 and 3 than the other RMST climate zones.[5] Therefore, since homes in RMST Climate Zones 2 and 3 do not take advantage of the opportunity to install more windows, these homes tend to be more compliant.

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4 As shown in later in this section, percent glazing is the single largest factor in determining the heating and cooling energy budgets (proposed budget).

5 Table 3-4 in Section 3.3 lists the prescriptive glazing percentages by RMST climate zone.

As shown in Table 4-10, sites in RMST Climate Zones 2 and 3 have a relatively lower average standard budget than sites in RMST Climate Zones 4 and 5. Therefore, because sites in RMST Climate Zones 2 and 3 are more compliant than those in other RMST climate zones, and because RMST Climate Zone 2 has the lowest average standard budget (followed by RMST Climate Zones 1 and 3), the average total standard energy budget decreases as one moves from the non-compliant group to the overly compliant group.

Water Heating and HVAC Compliance Margins

The relationship between water heating (DHW) and HVAC compliance margins and compliance groups is summarized in Table 4-14. Results are shown below.

- Compliant and overly compliant sites generally have positive HVAC and DHW margins. In fact, 95% of the overly compliant sites and 90% of the sites in the compliant group have a positive HVAC margin and a non-negative DHW margin
- Approximately 97% of non-compliant sites have negative HVAC margins, while only 16% have negative DHW margins.

Table 4-14: Water Heating Margin and HVAC Margin by Compliance Group

Analysis Parameter Description	Overall (735 Sites)	Non-Compliant (99 Sites)	Indeter-minate (215 Sites)	Compliant (383 Sites)	Overly Compliant (38 Sites)
DHW Margin > 0 HVAC Margin > 0	53%	-	28%	80%	75%
DHW Margin = 0 HVAC Margin > 0	8%	-	6%	10%	20%
DHW Margin < 0 HVAC Margin > 0	8%	3%	10%	9%	5%
DHW Margin > 0 HVAC Margin < 0	27%	76%	53%	1%	-
DHW Margin = 0 HVAC Margin < 0	1%	8%	1%	-	-
DHW Margin < 0 HVAC Margin < 0	2%	13%	2%	-	-
HVAC Margin > 0 HVAC Margin < 0	70% 30%	3% 97%	44% 56%	99% 1%	100% -

4.7 Building Shell Analysis

This section looks at 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 4-15 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 % below prescriptive values, and the percentages of sites with observed insulation levels—each by compliance group. The following observations can be made.

- Ceiling insulation R-values were gathered for approximately 34% of sites statewide.
- New homes have insulation that is, on average, 20% less efficient than prescriptive.
- For sites with observed data, examination of the *Average % of Presc. R-Value* shows a clear pattern of nearing prescriptive values across the compliance groups from non-compliant to overly compliant (-24%, -13%, -8%, 1%).

Table 4-15: Summary of Ceiling Insulation Levels by Compliance Group

Analysis Parameter Description	**Overall** (735 Sites)	**Non-Compliant** (99 Sites)	**Indeter-minate** (215 Sites)	**Compliant** (383 Sites)	**Overly Compliant** (38 Sites)
Higher Performance (>Presc)	2%	2%	2%	1%	2%
Equal to Prescriptive	34%	27%	39%	33%	47%
Lower Performance (<Presc)	64%	71%	60%	66%	51%
Average % of Presc. R-Value	-20%	-20%	-16%	-22%	-17%
% of sites w/observed data	34%	52%	39%	27%	20%
Average % of Presc. R-Value	-13%	-24%	-13%	-8%	1%
% of sites w/default R-values	66%	48%	61%	73%	80%
Average % of Presc. R-Value	-23%	-16%	-17%	-27%	-22%

Table 4-16 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 % below prescriptive value, and the percentage of sites with observed insulation levels—each by compliance group. The following observations can be made.

- Wall insulation R-values were gathered for very few sites (21% overall).

- There is a general pattern of wall insulation levels nearing and then exceeding the prescriptive values across compliance groups from non-compliant to overly compliant. Non-compliant site percentages for higher/equal/lower-than-prescriptive wall insulation values are 1%/67%/32%, while overly compliant site percentages are 8%/92%/0%,
- For sites with observed data, the *Average % of Presc. R-value* increases across compliance groups (-26% for non-compliant to 37% for overly compliant).

Table 4-16: Summary of Wall Insulation Levels by Compliance Group

Analysis Parameter Description	**Overall** (735 Sites)	**Non-Compliant** (99 Sites)	**Indeter-minate** (215 Sites)	**Compliant** (383 Sites)	**Overly Compliant** (38 Sites)
Higher Performance (>Presc)	3%	1%	2%	4%	8%
Equal to Prescriptive	87%	67%	85%	94%	92%
Lower Performance (<Presc)	10%	32%	13%	2%	-
Average % of Presc. R-Value	-1%	-9%	-3%	1%	6%
% of sites w/observed data	21%	36%	25%	14%	16%
Average % of Presc. R-Value	-7%	-26%	-13%	7%	37%
% of sites w/default R-values (set to prescriptive value)	79%	64%	75%	86%	84%

Roof, Wall, and Floor Construction

Table 4-17 shows the distribution of sites by Compliance Group and roof construction type. The following observations can be made regarding roof construction.

- Approximately 88% of homes 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.
- Nearly 42% of homes in the overly compliant group have a framed-without-attic roof type.

Table 4-17: Summary of Roof Construction Type by Compliance Group

Analysis Parameter Description	Overall (735 Sites)	Non-Compliant (99 Sites)	Indeter-minate (215 Sites)	Compliant (383 Sites)	Overly Compliant (38 Sites)
Framed w/Attic (FAT)	88.1%	89.9%	93.3%	87.8%	58.2%
Framed w/o Attic (FNO)	11.7%	10.1%	6.7%	11.9%	41.8%
Metal Decking (MET)	0.1%	-	-	0.3%	-

Table 4-18 shows the distribution of sites by compliance group and wall construction type. The following observations can be made.

- The percentage of metal-framed sites for non-compliant and overly compliant groups is almost the same (7.2% and 10.4% respectively). This is very interesting insofar as it should be inherently more difficult to achieve compliance for metal-framed homes. However, some of these homes are overly compliant.

Table 4-18: Summary of Wall Construction Type by Compliance Group

Analysis Parameter Description	Overall (735 Sites)	Non-Compliant (99 Sites)	Indeter-minate (215 Sites)	Compliant (383 Sites)	Overly Compliant (38 Sites)
% Wood Framing	97.3%	92.8%	99.5%	98.1%	89.6%
% Metal Framing	2.7%	7.2%	0.5%	1.9%	10.4%

Table 4-19 shows the distribution of sites by Compliance Group and floor type. In addition, since 95% of homes are slab-on-grade, sites with this floor type are further broken out by building type. Regarding floor construction, the following observations can be made.

- Approximately 95% of the sites in the compliant group have slab-on-grade floors.
- A larger percentage (10%) of sites in the non-compliant group have raised floors (i.e., crawlspace) than those in the compliant and overly compliant groups (1.5% and 0.0%, respectively).

Table 4-19: Summary of Typical Floor Construction Type by Compliance Group

Analysis Parameter Description	**Overall** (735 Sites)	**Non-Compliant** (99 Sites)	**Indeter-minate** (215 Sites)	**Compliant** (383 Sites)	**Overly Compliant** (38 Sites)
% Slab-On-Grade	95.1%	90.3%	92.8%	98.0%	93.1%
Single family detached	14.7%	6.3%	10.3%	15.0%	57.9%
Multifamily	78.0%	90.2%	88.5%	76.2%	8.4%
Single family attached	7.2%	3.5%	1.2%	8.8%	33.8%
% Crawlspace	4.2%	9.7%	6.8%	1.5%	-
% Other	0.7%	-	0.4%	0.4%	6.9%

4.8 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 the tendency of a site to be compliant or non-compliant.

- The percentage of sites with higher-than-prescriptive percent glazing values decreases drastically across compliance groups (non-compliant to overly compliant drops from 63% to 47%, then 12% to 0%). Conversely, the percentage of sites with lower-than-prescriptive percent glazing values increases drastically across compliance groups (non-compliant to overly compliant goes from 36% to 100%).
- The sites in the non-compliant group have the largest average percent glazing (9%). The average percent glazing then decreases across compliance groups and is only 7% for sites in the overly compliant group.

Table 4-20: Percent Glazing by Compliance Group

Analysis Parameter Description	Overall (735 Sites)	Non-Compliant (99 Sites)	Indeter-minate (215 Sites)	Compliant (383 Sites)	Overly Compliant (38 Sites)
% of Sites in Compliance Group					
Higher than Prescriptive	28.9%	62.5%	46.7%	12.3%	-
Equal to Prescriptive	1.0%	1.1%	1.8%	0.6%	-
Less than Prescriptive	70.1%	36.4%	51.5%	87.1%	100.0%
Average % of Prescriptive	-14%	11%	-1%	-24%	-64%
Average % Glazing	15%	19%	17%	15%	7%

Window Types

Typical construction for window types—frame type, glass type, and number of panes—versus compliance group are presented in Table 4-21 on an average fenestration U-value basis and in Table 4-22 on a window type basis. Key findings are summarized below.

The trend for fenestration/windows across compliance groups is that non-compliant sites have lower performance fenestration/windows than overly compliant sites.

- The percentage of sites with lower performance fenestration decreases drastically across the first three compliance groups (non-compliant to compliant goes from 10% to 2%). However, 6% of the overly compliant sites have windows that are lower performance than prescriptive.
- The average U-value remains fairly constant across compliance groups—ranging only from 0.594 to 0.609.

Regarding the use of metal-framed windows, these are more prevalent in non-compliant sites than overly compliant sites.

- Less than 5% of the homes statewide have predominantly metal-framed windows.
- While a higher percentage of non-compliant sites (8.1%) have predominantly metal-framed windows than indeterminate and compliant sites (2.9% and 4.5%, respectively), the overly compliant group has the largest percentage of homes with predominantly metal-framed windows (10.0%).

Regarding the use of low-E windows, these are more prevalent in compliant/overly compliant sites than non-compliant sites.

- The representative percentage of low-E windows for each compliance group is highest for compliant and overly compliant sites at 5.8% and 12.5%, respectively.

Table 4-21: Summary of Average Fenestration U-Values by Compliance Group

Analysis Parameter Description	**Overall** (735 Sites)	**Non-Compliant** (99 Sites)	**Indeter-minate** (215 Sites)	**Compliant** (383 Sites)	**Overly Compliant** (38 Sites)
Higher Performance (<Presc)	93.3%	87.0%	93.2%	95.5%	89.4%
Equal to Prescriptive	2.7%	3.5%	1.8%	2.8%	4.8%
Lower Performance (>Presc)	4.0%	9.5%	5.0%	1.7%	5.8%
Average % of Prescriptive	-15%	-9%	-12%	-19%	-18%
Average U-value	0.599	0.609	0.602	0.594	0.604
Sites with metal framed windows					
% of compliance group sites	4.8%	8.1%	2.9%	4.5%	10.0%
Sites with Low-E glass					
% of compliance group sites	5.1%	3.2%	3.4%	5.8%	12.5%

Table 4-22: Summary of Window Types by Compliance Group

Analysis Parameter Description	**Overall** (735 Sites)	**Non-Compliant** (99 Sites)	**Indeter-minate** (215 Sites)	**Compliant** (383 Sites)	**Overly Compliant** (38 Sites)
2-paned Vinyl, Clear Glass	85.7%	87.6%	85.8%	86.4%	74.2%
2-paned Metal, Clear Glass	3.6%	6.9%	1.9%	3.3%	7.8%
2-paned Vinyl, Low-E	5.1%	3.2%	3.4%	5.8%	12.5%
2-paned Vinyl, Tinted/Reflective	3.6%	1.1%	6.2%	2.9%	2.7%
1-paned Vinyl, Clear Glass	0.5%	-	0.8%	0.4%	0.6%
1-paned Metal, Clear Glass	1.2%	1.1%	1.0%	1.2%	2.2%
Other Window Types	0.3%	-	1.0%	-	-

4.9 Space Heating and Space Cooling Equipment Analysis

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

Space Heating Systems

A summary of space heating system characteristics, including average system efficiencies and the saturation of high efficiency gas furnaces, is presented in Table 4-23 by compliance groups. Regarding space heating efficiencies, the following observations can be made.

- Overall, as well as by compliance group, average AFUEs reflect a very low penetration of high efficiency systems. Averages range from 80.0% to 80.4% AFUE.
- The average AFUE and percentage of sites with high efficiency heating systems are highest for the indeterminate sites. This may be an indication that high efficiency space heating systems are one method used in achieving compliance for sites that tend to be non-compliant, possibly due to high glazing percentage.

Table 4-23: Space Heating System Efficiencies by Compliance Group[6]

Analysis Parameter Description	**Overall** (653 Sites)	**Non-Compliant** (89 Sites)	**Indeter-minate** (199 Sites)	**Compliant** (343 Sites)	**Overly Compliant** (22 Sites)
Average Efficiency (AFUE)	80.27	80.24	80.37	80.23	80.00
% of sites >= 90% AFUE	1.9%	1.2%	2.7%	1.7%	-
% of sites w/observed data	74%	75%	72%	75%	67%
Average AFUE	80.36	80.32	80.52	80.30	80.00
% of sites w/default (set at 80% AFUE)	26%	25%	28%	25%	33%

Table 4-24 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.

- The dominant heating system type for all compliance groups is a central furnace (87.1% overall).
- While nearly 90% of sites in the non-compliant, indeterminate, and compliant groups have central furnaces, only 51% of homes in the overly compliant group

6 Only sites with natural gas or propane furnaces are included in this table.

do. Instead, 15.6% of the sites have a hydronic heating system and 28.4% have a window/wall heat pump.

- The overly compliant group has the largest percentage of homes with non-ducted HVAC systems (32.3% compared to 5.6%, 5.6%, and 9.0% for the non-compliant, indeterminate, and compliant groups, respectively).

Table 4-24: Space Heating Equipment Types and Locations by Compliance Group

Analysis Parameter Description	Overall (735 Sites)	Non-Compliant (99 Sites)	Indeter-minate (215 Sites)	Compliant (383 Sites)	Overly Compliant (38 Sites)
System Types					
Central Furnace	87.1%	87.1%	91.9%	88.1%	51.1%
Central Heat Pump	2.3%	5.4%	0.5%	2.3%	5.0%
Hydronic	4.9%	3.7%	2.6%	5.4%	15.6%
Electric Resistance	2.0%	2.6%	4.3%	0.8%	-
Wall Furnace	0.9%	1.1%	-	1.5%	-
Window/Wall Heat Pump	2.4%	-	0.7%	1.3%	28.4%
Water Loop Heat Pump	0.4%	-	-	0.7%	-
HVAC Location					
Attic	66.9%	60.8%	70.3%	69.9%	36.1%
Garage	12.9%	16.5%	12.2%	12.4%	12.2%
None (non-ducted)	8.8%	5.6%	5.6%	9.0%	32.3%
Other	11.4%	17.0%	11.8%	8.7%	19.4%

Space Cooling Systems

Table 4-25 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 for the overly compliant sites is the lowest of all compliance groups (10.15 versus 10.23, 10.60, and 10.38 for other compliance groups).
- The indeterminate group has the largest percentage of high efficiency air conditioners (18%). The non-compliant and the compliant groups have the next highest (7% and 10%, respectively), while the overly compliant group has the lowest percentage (3%). This pattern could indicate that high efficiency cooling

equipment is being used as a tool to achieve compliance for sites that would otherwise be non-compliant.

Table 4-25: Space Cooling System Efficiencies by Compliance Groups

Analysis Parameter Description	**Overall** (735 Sites)	**Non-Compliant** (99 Sites)	**Indeter-minate** (215 Sites)	**Compliant** (383 Sites)	**Overly Compliant** (38 Sites)
Average Efficiency (SEER)	10.41	10.23	10.60	10.38	10.15
% of sites w/AC >= 12 SEER	12%	7%	18%	10%	3%
% of sites w/observed data	67%	66%	65%	70%	47%
Average SEER	10.47	10.27	10.69	10.41	10.27
% of sites w/default 10 SEER	33%	34%	35%	30%	53%

Table 4-26 shows the distribution of cooling system types and duct locations by compliance group. The following observations can be made regarding space cooling system types and duct locations.

- The leading system type for sites with cooling is central air conditioning (CAC) at 68.4% overall.
- The overly compliant group has the highest percentage of window/wall heat pumps (28.4%). Since these are non-ducted systems and the base system is a ducted system, this is not surprising.

Table 4-26: Space Cooling Equipment Types and Locations by Compliance Groups

Analysis Parameter Description	Overall (735 Sites)	Non-Compliant (99 Sites)	Indeter-minate (215 Sites)	Compliant (383 Sites)	Overly Compliant (38 Sites)
System Types					
Central Air Conditioner	68.4%	70.9%	72.4%	67.7%	45.1%
Central Heat Pump	2.3%	5.4%	0.5%	2.3%	5.0%
Evaporative Cooler	0.2%	-	-	0.4%	-
No Air Conditioner	23.5%	21.5%	24.8%	24.0%	16.3%
Hydronic	2.9%	2.1%	1.5%	3.6%	5.3%
Water Loop Heat Pump	0.4%	-	-	0.7%	-
Window/Wall Air Conditioner	-	-	-	-	-
Window/Wall Heat Pump	2.4%	-	0.7%	1.3%	28.4%
HVAC Location					
Attic	54%	50%	55%	56%	32%
Garage	9%	11%	9%	8%	5%
None (non-ducted)	29%	24%	26%	30%	46%
Other	9%	14%	9%	6%	17%

4.10 Water Heating Equipment Analysis

A summary of water heating system characteristics including average system efficiencies, fuel type, and blanket versus efficiency level by compliance zone[7] is presented in Table 4-27 and Table 4-28.

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

- Water heaters installed in new homes are, on average, 14% above the minimum energy factor.
- The non-compliant and indeterminate groups have proportionately more high performance water heaters (92% and 93%) than the other compliance groups (88%

[7] 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 Standards.

and 70%). (Note that the CEC default was given to sites with energy factors equal-to-prescriptive. The CEC default is exactly at the prescriptive level.)

Table 4-27: Water Heating System Efficiencies by Compliance Group

Analysis Parameter Description	Overall (735 Sites)	Non-Compliant (99 Sites)	Indeter-minate (215 Sites)	Compliant (383 Sites)	Overly Compliant (38 Sites)
Higher Performance	89.1%	92.1%	92.5%	88.4%	70.0%
Equal to Prescriptive	10.5%	7.9%	7.0%	11.1%	30.0%
Lower Performance	0.4%	-	0.4%	0.5%	-
Average Efficiency (% above Min. Energy Factor)	13.7%	13.1%	14.1%	14.0%	10.8%
% of sites w/actual data	65%	65%	71%	65%	43%
Average % above Standard	15.6%	14.6%	15.2%	16.1%	15.3%
% of sites w/RER default Efs[8]	24%	27%	22%	24%	27%
Average % above Standard	14.7%	13.3%	14.9%	15.0%	15.7%
% of sites w/CEC Standard water heater (=Min. Std EF)[9]	10%	8%	7%	11%	30%

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

- All sites with electric water heaters are non-compliant and those sites with gas water heaters are non-compliant due to their HVAC margin, not their water heater margin.
- The non-compliant group has the largest percentage of water heaters with higher performance water heaters and external insulation blankets (27%). This could indicate that wrapping an insulation blanket around an already high efficiency water heater was one feature used as an attempt to achieve compliance for what would otherwise have been a non-compliant site.
- The predominant blanket efficiency configuration for all compliance groups is no blanket and efficiency greater than the standard minimum

8 RER default efficiency values are higher than standard efficiency and were intended to represent typical construction practice. These values were developed from actual data that were available, and vary by tank size.

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

Table 4-28: Water Heater Fuel Type and Blanket/Efficiency Level by Compliance Group

Analysis Parameter Description	**Overall** (735 Sites)	**Non-Compliant** (99 Sites)	**Indeter-minate** (215 Sites)	**Compliant** (383 Sites)	**Overly Compliant** (38 Sites)
Gas/Propane Water Heater	99.6%	98.2%	100.0%	99.7%	100.0%
Electric Water Heater	0.3%	1.8%	-	-	-
EF > Std. w/Blanket	23.8%	27.2%	22.1%	23.5%	26.6%
EF > Std. w/out Blanket	65.4%	64.9%	70.5%	64.9%	43.5%
EF = Std. w/Blanket	3.8%	5.4%	4.9%	3.0%	0.6%
EF = Std. w/out Blanket	6.7%	2.5%	2.1%	8.1%	29.4%

4.11 Analysis of Extraneous Non-MICROPAS Features

This section examines extraneous features not reflected in the MICROPAS runs that may have a bearing on how the residence is built. This includes issues such as participation of the residence in an existing RNC program and the cost of the home (low-cost homes might be less compliant than expensive homes).

Participation in Utility-Sponsored Programs

Each customer was asked, as part of the RMST survey, if the home was built as part of an RNC program. RNC programs represented in these responses included the following:

- ENERGY STAR (one home),
- PG&E Comfort Home (31 homes),
- SCE/SDG&E (Consol) ComfortWise (three homes), and
- SCG Program (four homes).

Results for these homes are reported by compliance group in Table 4-29 and show the following.

- Overall, only 6% of the residences self-reported participation in RNC programs.
- The percentage of these homes is highest for the non-compliant (9%) group and decreases across compliance groups to 0% for the overly compliant group. This is exactly the opposite of the pattern that might be expected for such homes. However, participation in an RNC program and the use of such features as duct sealing were not accounted for in the MICROPAS runs.

Table 4-29: Participation in Utility Sponsered Programs by Compliance Group

Analysis Parameter Description	Overall (735 Sites)	Non-Compliant (99 Sites)	Indeterminate (215 Sites)	Compliant (383 Sites)	Overly Compliant (38 Sites)
Nonparticipant	94%	91%	92%	95%	100%
RNC Program Participant	6%	9%	8%	5%	-
# of sites	43	9	17	18	0

Housing Purchase Price

Compliance groups versus housing purchase price are presented in Table 4-30. It was suspected that lower cost homes would tend to be less compliant than higher cost homes. Key findings are summarized below.

- There are no homes under $100,000 that are overly compliant, but there are also very few of these sites (16).
- The overly compliant group has the largest percentage of high cost homes (over $400,000) at 65%.
- The average price of the homes increases across compliance groups from an average of $264,959 for non-compliant sites to $410,304 for overly compliant sites.

Table 4-30: Housing Purchase Prices Versus Compliance Group

Analysis Parameter Description	Overall (678 Sites)	Non-Compliant (88 Sites)	Indeterminate (190 Sites)	Compliant (362 Sites)	Overly Compliant (38 Sites)
Average Home Price Ranges					
Under $100,000	3%	2%	6%	1%	-
$100,000 - $200,000	30%	50%	29%	27%	12%
$200,000 - $300,000	23%	18%	25%	25%	15%
$300,000 - $400,000	12%	5%	17%	12%	8%
Over $400,000	32%	24%	22%	35%	65%
Average Home Price	$313,895	$264,959	$294,762	$325,938	$410,304

4.12 Differences in Compliance Performance across RMST Climate Zones

As mentioned above, RMST Climate Zones 4 and 5 are the least compliant of the RMST climate zones, while RMST Climate Zone 3 is the most compliant. These differences in average compliance performance could be attributable to the following:

- Differences in the efficiency of the equipment installed across RMST climate zones,
- Differences in the prescriptive standards required across RMST climate zones, especially the prescriptive glazing percentages, and
- Differences in the mixtures of end-use budget compared to the total compliance budget for each home.

In an attempt to explain the differences in average % Compliance Margins across RMST climate zones, three steps were taken. First, key characteristics, such as equipment efficiencies and fenestration information, were gathered to compare the average efficiencies for various measures across RMST climate zones. Next, the end-use standard budgets as a percentage of the total standard budgets across RMST climate zones were analyzed. Finally, homes in both the best RMST climate zone and in the two worst RMST climate zones were "relocated" to investigate how each home would comply if it were actually in a different RMST climate zone.

Key Characteristics by RMST Climate Zone

To test whether homes in RMST Climate Zones 4 and 5 are being built with less efficient measures than homes in the other three RMST climate zones, key housing characteristics were compared. However, as shown in Table 4-31, and discussed below, this is clearly not the case. Instead, the homes in these RMST climate zones have the highest average HVAC efficiencies in the state.

Table 4-31 provides a summary of key characteristics by RMST climate zone including average glazing percentages, average SEER value, average AFUE values, and average percent above standard for gas water heaters. Each of these measures is discussed below.

Table 4-31: Summary of Key Characteristics by RMST Climate Zone

	Overall	RMST CZ1	RMST CZ2	RMST CZ3	RMST CZ4	RMST CZ5
Building Shell						
Average Number of Stories	1.7	1.9	2.1	1.8	1.4	1.3
Windows						
Average % Glazing	15%	16%	16%	15%	15%	16%
Prescriptive % Glazing		16% & 20%	20%	20%	16%	16%
Average U-value	0.599	0.583	0.611	0.618	0.589	0.604
Air Conditioners						
Average SEER of Observed Data	10.47	10.36	10.14	10.15	**10.86**	**10.77**
% of sites w/No Air Conditioner	23%	59%	47%	2%	4%	8%
Gas Furnaces						
Average AFUE of Observed Data	80.36	80.25	80.05	80.19	**80.77**	80.36
Gas Water Heaters						
Avg, % Above Std Energy Factor	16%	15%	16%	16%	15%	16%

Number of Stories

The average number of stories presented in Table 4-31 includes both detached single family homes and multifamily buildings. RMST Climate Zones 4 and 5 have the lowest average number of stories (1.3 and 1.4, respectively) and therefore the largest percent of homes with only one story. RMST Climate Zone 2 has the highest average number of stories (2.1), while RMST Climate Zones 1 and 3 are close behind (1.9 and 1.8, respectively). As mentioned earlier in this section, one-story homes are inherently less compliant.

Fenestration

As shown, average percent glazing remains relatively constant across RMST climate zones. It is important to note that while the average percent glazing values by RMST climate zone are approximately 15%, the prescriptive glazing percentages vary by RMST climate zone. The prescriptive glazing percentage in RMST Climate Zones 4 and 5 is 16%, compared to 20% in RMST Climate Zone 3.[10] The higher the prescriptive glazing percentage, the more fenestration can be added to the home. However, since average percent glazing values are

[10] The prescriptive glazing value is used in the calculation of the standard budget.

not significantly different across RMST climate zones,[11] this causes homes in RMST Climate Zones 2 and 3 to easily comply while homes in RMST Climate Zones 4 and 5 have more difficulty complying with the building standards.

Cooling

RMST Climate Zones 4 and 5 have the highest average SEER values (10.86 and 10.77 respectively). The average SEER values of air conditioners installed in RMST Climate Zones 2 and 3, however, are closer to the 10 SEER standard. This is not surprising since these climate zones have fairly mild weather.

Heating

The results are similar for space heating. RMST Climate Zone 4 has the highest average AFUE value at 80.8% AFUE, while the average AFUE for gas furnaces in RMST Climate Zone 2 is less than 80.1%.

Water Heating

As shown in Table 4-31, the average percent above standard efficiency for gas water heaters across in RMST climate zones is not significantly different.[12] The reason for this result is a combination of 1) the water heater budget is a large portion of the total budget in each of the RMST climate zones (this topic is discussed in further detail below) and 2) installing higher efficiency water heaters is seen as one of the most cost-effective ways to reach compliance.

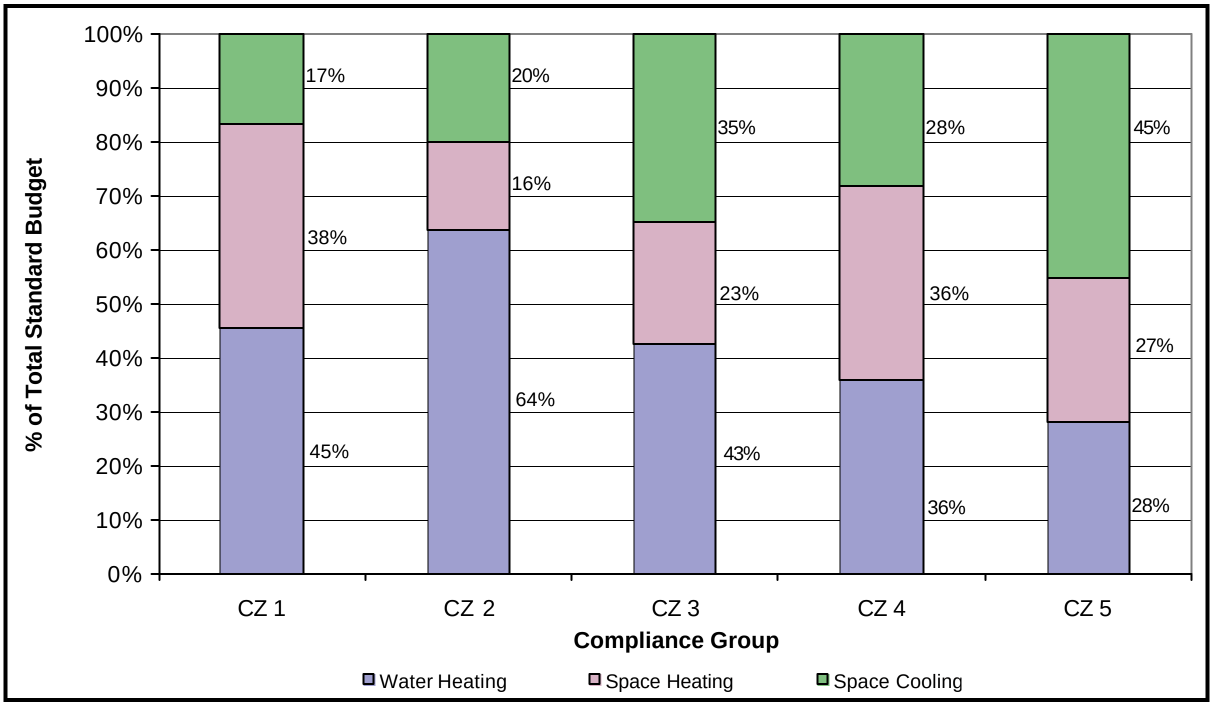
End-Use Budgets

In order to understand the differences in % Compliance Margins among RMST climate zones, it is important to first understand the differences in how the standard budgets are broken out by end use. As shown in Figure 4-13, RMST Climate Zone 5 has the largest space cooling budget, while RMST Climate Zones 1 and 4 have the largest space heating budget, as will be explained below. This information, along with the results of the compliance analysis by end use, helps to provide an explanation of why RMST Climate Zones 4 and 5 have the lowest average % Compliance Margin and why RMST Climate Zones 3 has the highest average % Compliance Margin.

[11] Significant at the 90% level.

[12] Significant at the 90% level.

Figure 4-13: Average End-Use Standard Budget as % of Total Standard Budget



"Relocation" Compliance Results

Since it is clearly not the case that measures installed in RMST Climate Zones 4 and 5 are less efficient than in other RMST climate zones, the question was raised on whether homes built in RMST Climate Zones 4 and 5 would be more compliant if they were built in a different RMST climate zone. To test this, the homes in RMST Climate Zones 4 and 5 were "put into" CEC Climate Zone 9 (RMST Climate Zone 3) and passed through the RNC Interface again.[13] Similarly, the homes in RMST Climate Zone 3 were passed through the RNC Interface using CEC Climate Zone 15 (RMST Climate Zone 5).

Table 4-32 provides the results of both the original compliance analysis, using the correct CEC climate zone for each home, and the "relocation" runs. The first row of the table provides the number of homes in each RMST climate zone. The next row presents the average % Compliance Margin by RMST climate zone. Results of the test runs are discussed below.

[13] RMST Climate Zone 3 was chosen because it is the most compliant RMST climate zone.

Table 4-32: Average % Compliance Margins for RMST Climate Zones 3, 4, and 5 – Actual vs. "Relocated"

	RMST CZ3		RMST CZ4		RMST CZ5	
End Use	**Actual**	**CEC CZ15**	**Actual**	**CEC CZ9**	**Actual**	**CEC CZ9**
# of Sites	29836		30789		7030	
Total	12.5% (0.0062)	-2.1% (0.0072)	1.0% (0.0077)	11.8% (0.0069)	0.4% (0.0128)	12.6% (0.0105)
Space Heating	27.5% (0.0103)	23.3% (0.0123)	7.1% (0.0111)	26.4% (0.0128)	12.8% (0.025)	26.1% (0.0177)
Space Cooling	15.4% (0.0169)	-6.6% (0.0105)	-13.4% (0.0225)	11.6% (0.0196)	-0.5% (0.0348)	13.2% (0.0335)
Water Heating	5.5% (0.0067)	5.6% (0.0067)	7.4% (0.0055)	7.4% (0.0055)	7.2% (0.0058)	7.2% (0.0058)

Stand errors are shown in parenthesis.

- ***Relocation of RMST Climate Zone 3 to RMST Climate Zone 5.*** As shown in Table 4-32, the average % Compliance Margin for homes in RMST Climate Zone 3 is 12.5%. However, if these same homes were built in RMST Climate Zone 5, the average % Compliance Margin would be -2.1%, meaning that the majority would either not comply or would fall in the indeterminate group. In fact, this new % Compliance Margin is significantly lower than the original % Compliance Margins for the homes truly built in RMST Climate Zones 4 and 5.[14] This result is not surprising given that the prescriptive glazing percentage in RMST Climate Zone 5 is only 16% (lower than the RMST Climate Zone 3 prescriptive glazing percentage of 20%). This makes it more difficult for homes to comply. Further, unlike homes in RMST Climate Zones 4 and 5, which use more efficient HVAC to offset the impact of the prescriptive glazing requirement, homes in RMST Climate Zone 3 have near standard HVAC equipment.
- ***Relocation of RMST Climate Zone 4 to RMST Climate Zone 3.*** As shown in Table 4-32, when the homes in RMST Climate Zones 4 are "relocated" to CEC Climate Zone 9 (RMST Climate Zone 3), the average % Compliance Margin jumps significantly—up to 11.8%.[15] However, this is not significantly different than RMST Climate Zone 3 homes at 12.5%. One reason that homes in RMST Climate Zone 4 are not more compliant than those in RMST Climate Zone 3 is that these homes do not receive much of a credit for more efficient gas furnaces since the standard heating budget, compared to the overall budget, is

[14] Significant at the 90% level.

[15] Significant at the 90% level.

much smaller in RMST Climate Zone 3. Another reason is that there are more one-story homes, which are inherently less efficient.

- ***Relocation of RMST Climate Zone 5 to RMST Climate Zone 3.*** When homes in RMST Climate Zones 5 are "relocated" to CEC Climate Zone 9 (RMST Climate Zone 3), the average % Compliance Margin jumps significantly—up to 12.6%.[16] However, this is not significantly different than the RMST Climate Zone 3 homes at 12.5%.[17] One reason that homes in RMST Climate Zone 5 are not more compliant than those in RMST Climate Zone 3 is that these homes do not receive much of a credit for more efficient central air conditioners since the standard heating budget, compared to the overall budget, is much smaller in RMST Climate Zone 3. Another reason is that there are more one-story homes, which are inherently less efficient.

Conclusion

The analysis of why homes in RMST Climate Zone 3 exhibit higher compliance margins than homes built in RMST Climate Zones 4 and 5 reveals the following. It appears that the fenestration percentage in new homes is relatively constant across the state—regardless of where a house is built, builders/consumers are not willing to decrease the area of windows and glass doors installed, especially in single family homes. However, prescriptive glazing percentages do change. The prescriptive glazing percentage is the lowest in RMST Climate Zones 4 and 5, which makes it more difficult to reach compliance. The analysis of baseline characteristics show that builders in RMST Climate Zones 4 and 5 try to compensate for installing higher glazing percentages than prescriptive by installing more efficient HVAC equipment. Further, since the total HVAC budget is the greatest in RMST Climate Zones 4 and 5, installing high efficiency HVAC equipment provides more "bang for the buck" in these RMST climate zones. These results indicate that insofar as homes in the RMST Climate Zone 4 and 5 do not enjoy the benefit of the lower prescriptive glazing percentage applicable to RMST Climate Zone 3, they tend to install higher efficient HVAC equipment in order to "just comply." These practices lead to a smaller average % Compliance Margin in RMST Climate Zone 4 and 5 relative to RMST Climate Zone 3.

4.13 Summary of Compliance Results

The following summarizes the key findings of this chapter. Results are organized into the following groups:

- Statewide/general,
- Regional (by RMST climate zone),

16 Significant at the 90% level.

17 Significant at the 90% level.

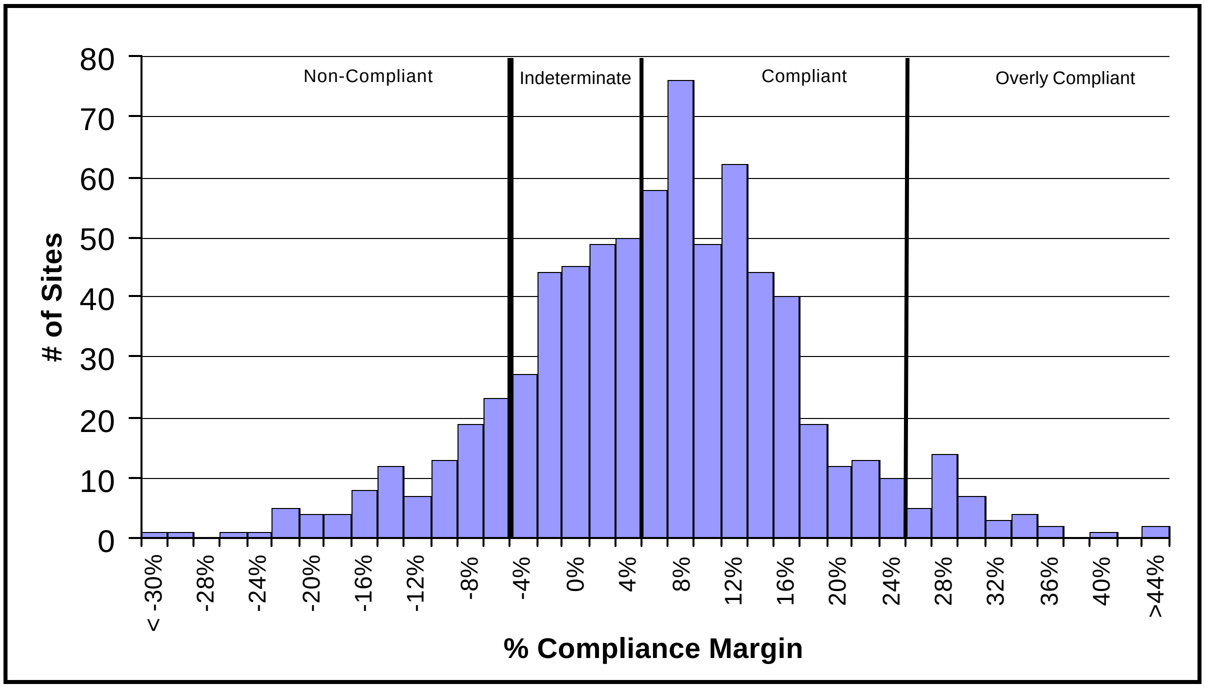
- Building type (single family vs. multifamily), and
- Compliance groups.

General Compliance Results

A brief summary of the statewide compliance results follows.

- **Approximately 13.5% of sites are in the non-compliant group.** Results from the RNC Interface show that most sites fall within the compliant group (52%) or within the error band (the indeterminate group).[18]
- **Approximately 5.2% of sites are in the overly compliant group.**

Figure 4-14: MICROPAS Results Summary – All Sites



Regional

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

- ***RMST Climate Zone 1*** (North Coast) tends to be compliant, as evidenced by an average % Compliance Margin of 9.0%. Of the sites in RMST Climate Zone 1, 52% fall in the compliant group, however 39% are in either the indeterminate or non-compliant groups.

[18] See Section 2.4 for an explanation on the development of the error band.

- ***RMST Climate Zone 2*** (South Coast) tends to be even more compliant than RMST Climate Zone 1 with an average % Compliance Margin of 9.5%. Approximately 6% of sites in RMST Climate Zone 2 fall in the non-compliant group.
- ***RMST Climate Zone 3*** (South Inland) is the most compliant of the RMST climate zones with an average % Compliance Margin of 12.5%. In fact, 8% of sites in RMST Climate Zone 3 fall in the overly compliant group, compared to only 2% in RMST Climate Zones 4 and 5.
- ***RMST Climate Zone 4*** (Central Valley) tends to be less compliant, which is evidenced by an average % Compliance Margin of 1.0%. Of the sites in RMST Climate Zone 4, 27% fall in the non-compliant group and 46% are indeterminate.
- ***RMST Climate Zone 5*** (Desert/Mountain) is the most non-compliant of the RMST climate zones with an average % Compliance Margin of 0.4%. In fact, 32% of sites in RMST Climate Zone 5 fall in the non-compliant group and 40% are indeterminate.

Table 4-33: Average Compliance Margins by RMST Climate Zone

	Overall	RMST CZ1	RMST CZ2	RMST CZ3	RMST CZ4	RMST CZ5
Avg. % Comp Margin	7.2%	9.0%	9.5%	12.5%	1.0%	0.4%
Avg. Water Heating Margin	0.75	0.66	0.38	0.68	1.02	0.87
Avg. Space Heating Margin	0.73	0.20	0.15	1.57	0.78	0.08
Avg. Space Cooling Margin	0.42	1.64	1.17	1.23	-1.49	-0.96
Avg. Compliance Margin	1.90	2.51	1.70	3.48	0.31	-0.02

Building Type

The following difference was found between detached single family homes and multifamily buildings.

- Multifamily buildings are slightly more compliant than detached single family homes based on percentages of overly compliant and compliant sites: 51% (1% overly compliant, 50% compliant) for detached single family homes versus 79% (23% overly compliant, 56% compliant) for multifamily buildings.

Compliance Groups

The following is a summary of the compliance results by compliance groups.[19]

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

Non-Compliant

- **Large Glazing Percentages.** The average percent glazing for non-compliant sites is 19%, larger than for other compliance categories.
- **One-Story Homes are More Typical.** A higher percentage of one-story homes fall in the non-compliant group than two-story homes. This applies to both single family and multifamily homes.
- **Negative HVAC Margins.** Approximately 97% of homes in this group have negative HVAC margins.
- **RMST Climate Zone 5** (desert and mountain areas) is the most non-compliant of the RMST climate zones based on the average % Compliance Margin of 0.4%. In fact, 32% of sites in RMST Climate Zone 5 fall in the non-compliant group, compared to only 6% of RMST Climate Zone 2 and 5% of RMST Climate Zone 3.[20]
- **RMST Climate Zone 4** (the Central Valley) also tends to be less compliant based on the average % Compliance Margin of 1.0%. Of sites in RMST Climate Zone 4, 27% fall in the non-compliant group.[21]

Compliant and Overly Compliant

- **Smaller Glazing Percentages.** The average percent glazing for overly compliant sites is 7%, smaller than for other compliance categories.
- **Two-Story Homes are More Typical.** A higher percentage of two-story homes fall in the overly compliant group than one-story homes. This applies to both single family and multifamily homes.
- **Positive HVAC Margins.** Approximately 99% of sites in the compliant group have a positive HVAC margin. Furthermore, every site in the overly compliant group also has a positive HVAC margin.
- **RMST Climate Zone 3** (South Inland) is the most compliant of the RMST climate zones based on the average % Compliance Margin of 12.5%. In fact, 8% of sites in RMST Climate Zone 3 fall in the overly compliant group, as opposed to only 2% of RMST Climate Zones 4 and 5.[22]

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

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

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

5

Technical Potential Assessment

5.1 Overview

This section discusses the technical potential assessment element of the study. The objective was to examine the energy savings potential from the installation of energy efficiency measures that might be included in future energy efficiency initiatives or as part of Title 24 codes. In particular, the technical potential for four measures was estimated:

- Low solar gain fenestration,
- Radiant barriers,
- Duct sealing (tight ducts), and
- Thermostatic expansion valves (TXVs).

In addition, a fifth scenario was estimated in which all four measures were installed. The four individual measures are the measures that were added to Prescriptive Package D under the 2001 AB 970 Standards. A summary of these new requirements is presented in Table 5-1. This table also shows the applicability of each measure by CEC climate zones. As noted in the AB 970 documentation, these measures are primarily space cooling measures.

For purposes of this study, technical potential is defined as *the amount of energy saved in the first year from installing a measure in all homes and/or multifamily units that do not presently have the measure,* as determined from the on-site surveys. Further, technical potential savings are first-year estimates of annual energy savings for homes built between July 1, 1998 and June 30, 1999. That is, the technical potential estimates do not take into account multi-period savings or the lifetime of the measure.

Table 5-1: Summary of Major Changes to Prescriptive Package D Under AB 970

RMST Sample Region	CEC Climate Zone	Basic Prescriptive Package D (HERS rating required for Ducts & TXV)					Alternative Package Features (Non-HERS rating approach)			
		Window SHGC	Rad. Barrier	Window U-Factor	Tight Ducts	TXV	Window SHGC	Window U-Factor	SEER	Heating Efficiency
1	1	-		0.65	Yes			0.55		90 AFUE/ 7.6 HSPF
	2	0.40	Yes	0.65	Yes	Yes	0.35	0.40		
	3			0.75	Yes			0.55		
	4	0.40	Yes	0.75	Yes		0.35	0.40		
	5			0.75	Yes			0.55		
2	6			0.75	Yes			0.55		
	7	0.40		0.75	Yes		0.35	0.40		
3	8	0.40	Yes	0.75	Yes	Yes	0.35	0.40		
	9	0.40	Yes	0.75	Yes	Yes	0.35	0.40	11	
	10	0.40	Yes	0.65	Yes	Yes	0.35	0.40	11	
4	11	0.40	Yes	0.65	Yes	Yes	0.35	0.40	11	
	12	0.40	Yes	0.65	Yes	Yes	0.35	0.40	11	
	13	0.40	Yes	0.65	Yes	Yes	0.35	0.40	12	
5	14	0.40	Yes	0.65	Yes	Yes	0.30	0.40	12	
	15	0.40	Yes	0.65	Yes	Yes	0.30	0.40	13	
	16			0.60	Yes			0.55		90 AFUE/ 7.6 HSPF

The remainder of this section discusses the following issues relating to the technical potential assessment:

- The measures and measure combinations examined and why they were selected,
- Major issues and caveats affecting the analysis and technical potential estimates,
- The general approach taken in evaluating technical potential,
- A general description of the table format in which results are presented,
- The specifics of the technical potential assessment for each measure and measure combination, and
- Summary and discussion of technical potential results for all measure and measure combinations.

These issues are addressed in the following sections.

- General Approach used to Estimate Technical Potential
- Technical Potential Assessment Issues
- Low Solar Gain Fenestration Technical Potential
- Radiant Barriers Technical Potential

- Duct Sealing Technical Potential
- Thermostatic Expansion Valves Technical Potential
- All-Measures Scenario Technical Potential
- Summary and Conclusions

Note that the results presented in this report are only a summary of the detailed results generated for this study. A complete compilation of the results tables generated for this analysis is contained in Appendix E through Appendix I.

5.2 General Approach used to Estimate Technical Potential

The general approach used to estimate technical potential is a multi-step process. These steps are summarized below.

- ***Simulate As-Built Energy Use.*** Baseline MICROPAS 6.0 (AB 970 version) runs were performed for the residences as constructed (as-built). As-built refers to the actual construction/configuration of the home (insulation levels, heating/cooling equipment type and efficiencies, etc.) as found by the on-site survey.
- ***Simulate Energy Use with Measure Installed.*** Measure runs were performed by implementing the measure only for those homes that did not already have the measure, and then running in MICROPAS 6.0.
- ***Estimate Source Energy Savings.*** Source energy savings[1] (MICROPAS default output) for the measure were determined by subtracting measure run results from the baseline as-built run results.
- ***Estimate Savings Controlling for As-Built Characteristics.*** Savings were "filtered" as required to provide savings estimates that accurately reflect the as-built construction of the home (e.g., no cooling savings if no cooling equipment was installed) and applicability of measures under Prescriptive Package D of the Standards (i.e., some measures are not required in all CEC climate zones).
- ***Convert Estimated Source Energy Savings to Savings by Fuel Type.*** Filtered annual source energy savings were converted to fuel/end-use savings.

A detailed description of the approach used to assess technical potential for each measure is provided in the respective measure sections.

[1] Source energy savings is the basis used for compliance analysis and attempts to account for production and distribution losses inherent in delivering a particular fuel to a home. Engineering units used to specify source energy are "skBtuh" where the "s" denotes source energy. This primarily impacts electricity, where a factor of 3 in addition to the usual conversion factor of 3.413 kBtuh/kW is used to account for generation, transmission, and distribution losses.

5.3 Technical Potential Assessment Issues

This section describes background information needed to evaluate and interpret the technical potential results developed in the analysis.

General Issues

- ***MICROPAS Version 6.*** The technical potential analysis was performed with MICROPAS 6.0 because it allows direct simulation and evaluation of savings for all the measures including TXV valves and duct sealing for multifamily residences.
- ***Vintage of Simulation Sample.*** The baseline for this assessment is on-site survey data for residences built in investor-owned utility (IOU) service areas between June 1, 1998 and June 30, 1999. These are not statewide savings estimates.
- ***Simulation Sample Size***. There were 109,060 units—85,554 single family detached homes and 23,506 multifamily units—built in IOU service territories during this period. Five hundred ninety-six (596) single family detached homes and 188 multifamily units were surveyed. Of these, 593 single family detached homes and 148 multifamily units were used for this analysis.
- ***Technical Potential Developed for Single and Multifamily Residences.*** Technical potential estimates for single family detached homes and multifamily buildings are presented separately. As discussed earlier in this report, "multifamily buildings" include both single family attached and true multifamily residences.
- ***Filtering of "NoCooling" Savings from MICROPAS Results.*** The Standards require that, for compliance purposes, even those residences without cooling equipment must be simulated as if they had cooling equipment. This situation is simulated in MICROPAS by specifying the cooling system type as "NoCooling." MICROPAS then yields cooling savings for all homes/units, even those that as-built *do not have cooling systems*. As such, cooling savings for "NoCooling" sites had to be appropriately filtered from the raw MICROPAS results to obtain savings estimates that were truly representative of cooling systems as-built.
- ***Fixed Orientation.*** For each site, the orientation for the baseline as-built run that produced the smallest compliance margin was used as the reference orientation for all the technical potential runs. The homes are run in MICROPAS using the "Cardinal" run option, which essentially performs four runs for the residence, one in each of the cardinal directions—North, East, South, West. Overall compliance is then determined from the orientation run with the smallest compliance margin. However, adding a measure can often *change* the orientation that determines overall compliance. As such, calculating savings by comparing the results for the run with the smallest compliance margin *regardless of orientation* would yield inconsistent savings estimates.

Source Energy

Compliance with the Standards is performed on a "source energy" basis, which accounts for production and distribution losses inherent in delivering a particular fuel to a home. Engineering units used to specify source energy are "skBtuh," where "s" is used to denote source energy. This modeling approach primarily impacts electricity, where a factor of 3 is used to account for generation, transmission, and distribution losses. Source energy conversion factors are presented in Table 5-2.

Table 5-2: Source Energy Conversion Rates

Energy Source	skBtu per Unit Consumption
Electricity	10.239 skBtu/kWh
Natural Gas	100 skBtu/therm
LPG (Propane)	91.080 skBtu/gallon
Fuel Oil	138.400 skBtu/gallon

MICROPAS Baseline Energy Use Estimates

Technical potential estimates are derived directly from the MICROPAS compliance analysis results. No attempt was made to use actual billing data for the surveyed sites to adjust the MICROPAS estimates. One way to sanity check the MICROPAS results is to look at annual end-use energy estimates, or UECs,[2] derived in the MICROPAS as-built simulations. These are provided for detached single family homes in Table 5-3 and for multifamily buildings in Table 5-4. These results reflect both the underlying operation schedules defined by the Standards and weather impacts. Insofar as heating and cooling usage is influenced by weather, the heating/cooling degree days (HDD/CDD) used in the MICROPAS simulations are also presented in the tables.

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2 Unit Energy Consumption (UEC) is defined as the average annual energy consumption for each appliance (unit).

Table 5-3: Average MICROPAS UECs for Detached Single Family Homes

RMST CZ	CEC CZ	Space Cooling kWh	Space therms	Heating kWh	Water Heating therms	Cooling Degree-Days CDD65	Heating Degree-Days HDD65
1	1	2	418	-	219	0	4085
	2	2,310	494	-	233	551	2889
	3	406	267	-	236	100	2541
	4	1,651	315	-	246	398	2413
	5	234	280	-	220	99	2277
2	6	400	127	2,703	253	459	1474
	7	983	64	-	232	629	1344
3	8	1,726	124	-	231	998	1316
	9	3,088	159	-	249	1215	1260
	10	3,982	162	1,418	231	1437	1636
4	11	3,832	314	3,873	220	1385	2656
	12	2,647	368	-	226	1038	2648
	13	4,890	227	2,499	215	1996	2227
5	14	5,499	375	-	223	1596	3113
	15	12,371	49	-	228	3906	845
	16	991	1,031	-	224	218	5579

Table 5-4: Average MICROPAS UECs for Multifamily Buildings

RMST CZ	CEC CZ	Space Cooling kWh	Space therms	Heating kWh	Water Heating therms	Cooling Degree-Days CDD65	Heating Degree-Days HDD65
1	1	0	519	-	1,308	0	4085
	2	3,881	611	32,607	1,822	551	2889
	3	539	469	12,473	1,708	100	2541
	4	2,965	638	6,173	5,094	398	2413
	5	180	84	-	333	99	2277
2	6	393	253	1,601	2,117	459	1474
	7	1,518	127	648	2,033	629	1344
3	8	3,114	191	3,099	1,805	998	1316
	9	5,310	176	1,747	3,326	1215	1260
	10	9,332	258	-	2,590	1437	1636
4	11	4,648	453	4,365	1,689	1385	2656
	12	7,360	859	11,862	4,108	1038	2648
	13	6,655	196	3,775	676	1996	2227
5	14	15,499	1,124	-	1,590	1596	3113
	15	21,062	49	-	752	3906	845
	16	1,141	3,011	-	2,004	218	5579

5.4 Low Solar Gain Fenestration Technical Potential

The technical potential assessment for low solar gain fenestration is presented in this section. Included is a description of low solar gain fenestration and how it achieves energy savings, a discussion on the applicability of the measure to construction types and CEC climate zones, a presentation of measure-specific issues affecting the assessment and results, an outline of how the technical potential assessment for this measure was performed, and a presentation of energy saving potentials for low solar gain fenestration in single family detached homes and multifamily buildings.

Low Solar Gain Fenestration Description

Low solar gain fenestration is primarily a cooling measure and can also reduce heating, but may slightly *increase* heating in heating-predominant climate zones. Low solar heat gain fenestration products are typified by a dual-paned, vinyl-framed window with low solar/low emissivity (spectrally selective) glass. These products reduce cooling energy use via a low U-factor and low Solar Heat Gain Coefficient (SHGC). The low solar heat gain glass filters out solar heating components (low solar gain) and reduces radiative losses from the interior to the outdoors (low emissivity or low-E), while the vinyl frame and dual panes of glass provide insulation from the outdoor environment (low U-factor). The U-factor and SHGC values used to represent low solar gain fenestration products for this analysis were 0.37 and 0.35 respectively.[3] In keeping with the approach taken for the compliance analysis, note that these values represent the values for a "typical" low solar gain fenestration product rather than the CEC minimum prescriptive values presented in Table 1-1.

Low Solar Gain Fenestration Applicability

This measure is applicable to all residences not built with low solar gain fenestration products. Existing saturations for low-E windows from the on-site survey are presented in Table 5-5 for detached single family homes and Table 5-6 for multifamily buildings. Saturations for low solar gain fenestration products are not available from the survey data. The issue here is that there are two types of low-E glazing—high solar gain (SHGC=0.60) and low solar gain (SHGC=0.35)—but that it is impossible to distinguish between the two types in the field. As such, windows reported as being low-E are not necessarily low solar gain fenestration products. That said, survey results are summarized below.

Saturation of Low-E Windows in Detached Single Family Homes

- In the IOU service areas, 5.3% already have low-E windows.
- Low-E windows were found in all RMST climate zones.
- The highest percentages of low-E glass are 8.2% in RMST Climate Zone 1 (CEC Climate Zones 1-5) and 7.6% in RMST Climate Zone 4 (CEC Climate Zones 11-13).

Table 5-5: Saturation of Low-E Windows in Detached Single Family Homes

Window Types (# of panes, frame type, glass type)	**Statewide**	**RMST CZ1**	**RMST CZ2**	**RMST CZ3**	**RMST CZ4**	**RMST CZ5**
2-paned Vinyl, Clear Glass	87.8%	86.0%	91.3%	91.4%	86.2%	81.7%
2-paned Vinyl, Low-E	**5.3%**	**8.2%**	**3.1%**	**1.2%**	**7.6%**	**4.8%**
2-paned Vinyl, Tinted/Reflective	4.4%	3.3%	4.4%	5.0%	3.7%	9.0%
2-paned Metal, Clear Glass	1.8%	0.9%	1.2%	1.8%	1.9%	4.5%
Other Window Types	0.8%	1.6%	0.0%	0.6%	0.6%	-

[3] These values were developed through consultation with Ken Nittler of Enercomp/Westlab.

Saturation of Low-E Windows in Multifamily Buildings

- In the IOU service areas, 4.5% of multifamily units already have low-E windows.
- Low-E windows were found only on multifamily buildings in RMST Climate Zone 1 (CEC Climate Zones 1-5) and the percentage is higher than that for single family detached homes—11.2% versus 8.2%, respectively.

Table 5-6: Saturation of Low-E Windows in Multifamily Buildings

Window Types (# of panes, frame type, glass type)	Statewide	RMST CZ1	RMST CZ2	RMST CZ3	RMST CZ4	RMST CZ5
2-paned Vinyl, Clear Glass	78.2%	79.2%	85.8%	67.0%	91.8%	43.5%
2-paned Metal, Clear Glass	10.4%	6.2%	6.2%	20.9%	3.3%	39.9%
1-paned Metal, Clear Glass	4.7%	1.7%	8.0%	11.6%	-	-
2-paned Vinyl, Low-E	**4.5%**	**11.2%**	**-**	**-**	**-**	**-**
Other Window Types	2.2%	1.7%	-	0.6%	4.9%	16.7%

Regarding the applicability of this measure to CEC climate zones for Prescriptive Package D, as shown in Table 5-1, low solar gain fenestration is only required in CEC Climate Zones 2, 4, and 7 through 15, as indicated by the SHGC value of 0.4. An additional change from the 1998 Standards is that this requirement now applies to all orientations and not just select orientations.

Low Solar Gain Fenestration Special Issues

As mentioned previously, it was impossible to distinguish between high solar gain and low solar gain low-E treatments for the on-site survey. As such, the U-factor and SHGC values used for the analysis of as-built residences were a composite value, roughly based on the type of low-E treatment available in the market at the time the homes were built (June 1998 through June 1999), as determined in consultation with Enercomp/WestLab. The values used for low-E windows in the baseline as-built analysis were U-factor=0.37 and SHGC=0.41. Other issues impacting the technical potential estimates for this measure are discussed below.

- Percent glazing has a significant impact on the amount of savings that can be realized—the larger the percent glazing, the larger the savings.
- Technical potential assessment was initially defined as low-E fenestration SHGC=0.40. This SHGC value is a CEC default value intended to be used for assessing compliance rather than being a representative value for the spectrally selective products actually available on the market. Therefore, in keeping with the baseline as-built analysis utilization of U-factors and SHGC values that reflect the

"typical" product on the market, an SHGC of 0.35 instead of SHGC 0.40 was used to assess technical potential.

- Heating may increase for those residences with vinyl-framed, dual-paned, non-low-E fenestration.
- There are distinct differences between the windows used in detached single family homes versus those used in multifamily residences. Metal-framed, single-paned windows are more predominant in multifamily residences in some CEC climate zones.

Approach to Estimating Low Solar Gain Fenestration Technical Potential

As explained previously, two technical potential scenarios were performed: SHGC=0.40, representing the compliance-based value, and SHGC=0.35, which better represents typical products on the market. Under these scenarios, even those residences with low-E fenestration as-built will show some savings, because the SHGC values used for the baseline run are slightly higher than the SHGC values used for technical potential runs (0.41 versus 0.40/0.35). However, these savings should be minimal and therefore were not filtered from the results.

Technical potential was assessed by essentially changing out as-built windows and doors to vinyl-framed, dual-paned, low solar gain (SHGC= 0.40 and 0.35) products. However, skylights and "art glass" were not changed out for this analysis.

Technical potential for low solar gain windows ($TECHPOTWIN_h$) for residential building h can be expressed as:

$$TECHPOTWIN_h = (ABHTUSE_h - WINHTUSE_h)HT_h + (ABCLUSE_h - WINCLUSE_h)CL_h$$

where:

ABHTUSE	= Heating usage *as-built* characteristics
WINHTUSE	= Heating usage with *as-built* characteristics and low solar gain windows
HT	= Binary variable equal to one if central heating, otherwise zero
ABCLUSE	= Cooling usage *as-built* characteristics
TXVCLUSE	= Cooling usage with *as-built* characteristics and low solar gain windows
CL	= Binary variable equal to one if there is central cooling, otherwise zero

Note that for homes where low solar gain windows are already installed, as-built and as-built with low solar gain windows could be equal (*ABHTUSE=WINHTUSE* and *ABCLUSE=WINCLUSE*). Thus, the technical potential in these homes is zero.

Technical potential is then defined for all homes of type s as:

$$TECHPOTWIN_{s} = \sum_{h} TECHPOTWIN_{s,h}$$

Results for Low Solar Gain Fenestration in Detached Single Family Homes

End-use electric and gas savings results are presented in Table SF-LSGF-EF. These results represent savings for all homes including those that already had low-E fenestration installed and only include cooling savings for those homes in which cooling equipment was actually installed. Homes that already had low-E windows were not filtered out of the analysis for the following reasons.

- Filtering technical potential results is done at the home level and would require the homes to be classified as “low-E fenestration” homes. However, because most homes have a mix of fenestration types, this would have been difficult to do.
- The U-factor and SHGC values used for the low solar gain fenestration technical potential analysis were very close to those used for the baseline analysis and as such, savings for those homes that already have low-E windows should be minimal or negligible.

Results for detached single family homes are discussed below.

Savings for Applicable Climate Zones

- Total cooling savings is 83,659 MWh, which is 1,436 kWh per home.
- Total gas heating savings is 4,353 therms, which is 0.1 therms per home. Although overall savings is positive, heating usage is increased in six of the 11 CEC climate zones.
- Total electric heating savings is 94.1 MWh, which is 143 kWh per home. However, only two CEC climate zones are represented here and heating usage is increased in one.

Savings for IOU Service Areas (All Climate Zones)

- Total cooling savings is 86,762 MWh, which is 1,304 kWh per residential unit.
  - The largest savings occurs in CEC Climate Zone 10 at 21,558 MWh.
- Total increased gas use (there are no savings) is -51,324 therms, which is -0.6 therms per residential unit.
- Total electric heating savings is 43.9 MWh, which is 53 kWh per residential unit.

Results for Low Solar Gain Fenestration in Multifamily Buildings

End-use electric and gas savings results are presented in Table MF-LSGF-EF. As discussed for single family detached homes, these results represent savings for all homes including those that already had low-E fenestration installed, and only include cooling savings for those homes in which cooling equipment was actually installed.

Savings for Applicable Climate Zones

- Total cooling savings is 28,323 MWh, which is 2,333 kWh per residential unit.
- Total gas heating savings is 280,299 therms, which is 25.5 therms per residential unit.
- Total electric heating savings is 2,5734 MWh, which is 466 kWh per residential unit.

Savings for IOU Service Areas (All Climate Zones)

- Total cooling savings is 29,508 MWh, which is 2,023 kWh per residential unit.
  - The largest savings occurs in CEC Climate Zone 12 at 7,895 GWh, although CEC Climate Zones 9 and 4 are also significant at 6,711 GWh and 4,549 GWh, respectively.
- Total gas heating savings is 421,402 therms, which is 25.4 therms per residential unit.
- Total electric heating savings is 2,834 MWh, which is 409 kWh per residential unit.

Table SF-LSGF-EF: End-Use/Fuel Energy Savings for Low Solar Heat Gain Fenestration in Detached Single Family Homes

RMST CZ	CEC CZ	Meas Req'd. For AB970 PackageD	Cooling Savings[4] (kWh)			Gas Heating Savings[5] (therms)			Electric Heating Savings[6] (kWh)		
			All AirCond Homes	Per Home	Per 1,000 Sq Ft	All GasHtd Homes	Per Home	Per 1,000 ft^2	All ElecHtd Homes	Per Home	Per 1,000 ft^2
1	1		-	-	-	4,371	4.4	2.32	-	-	-
	2	Yes	1,804,164	1,126	469.6	27,483	6.5	3.05	-	-	-
	3		745,159	278	114.8	-71,228	-9.8	-4.23	-	-	-
	4	Yes	4,379,833	961	378.3	-6,416	-1.1	-0.44	-	-	-
	5		125,063	249	80.9	-5,797	-4.9	-2.18	-	-	-
2	6		531,763	223	77.5	-47,111	-11.1	-4.49	-50,255	-301	-53.7
	7	Yes	1,338,448	648	255.3	18,345	3.9	1.70	-	-	-
3	8	Yes	2,953,400	866	348.8	-16,038	-4.7	-1.89	-	-	-
	9	Yes	10,179,017	1,490	529.3	-6,021	-0.9	-0.31	-	-	-
	10	Yes	21,558,123	1,625	725.0	-8,770	-0.7	-0.29	-15,139	-103	-46.8
4	11	Yes	3,419,752	1,351	678.1	3,496	1.2	0.58	-	-	-
	12	Yes	14,540,747	1,162	554.8	42,049	3.1	1.52	-	-	-
	13	Yes	12,631,234	1,473	836.2	-24,044	-3.0	-1.68	109,292	214	138.0
5	14	Yes	3,823,468	1,889	915.7	244	0.1	0.05	-	-	-
	15	Yes	8,369,508	2,839	1,312.4	-7,631	-2.6	-1.20	-	-	-
	16		361,881	563	229.6	45,744	50.6	22.88	-	-	-
TotalSavingsAB970PkgD_CZs			**84,997,694**	**1,409**		**22,698**	**0.3**		**94,153**	**1**	
TotalSavingsIOUServiceArea			**86,761,560**	**1,304**	**572.8**	**-51,324**	**-0.6**	**-0.28**	**43,898**	**53**	**21.4**

4 The basis for per home and per 1000 ft^2 savings is limited to those homes with cooling equipment.
5 The basis for per home and per 1000 ft^2 savings estimates is limited to those homes with gas (natural gas and propane) heating equipment.
6 The basis for per home and per 1000 ft^2 savings estimates is limited to only those homes with electric heating equipment.

Table MF-LSGF-EF: End-Use/Fuel Energy Savings for Low Solar Heat Gain Fenestration in Multifamily Buildings

RMST CZ	CEC CZ	Meas Req'd. For AB970 PackageD	Cooling Savings[7] (kWh)			Gas Heating Savings[8] (therms)			Electric Heating Savings[9] (kWh)		
			All AirCond ResUnit	Per ResUnit	Per 1,000 Sq Ft	All GasHtd ResUnit	Per ResUnit	Per 1,000 ft^2	All ElecHtd ResUnit	Per Res Unit	Per 1,000 ft^2
1	1		-	-	-	14,305	87.8	14.63	-	-	-
	2	Yes	-	-	-	25,072	20.6	4.65	1,083,870	784	39.5
	3		-	-	-	54,837	24.3	3.02	228,095	279	15.3
	4	Yes	4,549,092	2,179	61.6	60,416	31.1	1.60	702,959	488	13.1
	5		-	-	-	-36	-0.2	-0.10	-	-	-
2	6		340,074	265	15.7	-19,173	-11.8	-0.82	21,487	96	3.3
	7	Yes	714,380	794	49.4	10,737	10.4	0.66	10,987	30	5.1
3	8	Yes	4,063,303	1,736	132.7	36,036	15.8	1.63	-23,099	-49	-2.0
	9	Yes	6,711,934	2,436	136.7	34,207	23.7	2.84	445,142	340	12.0
	10	Yes	863,455	2,453	140.6	746	1.8	0.12	-	-	-
4	11	Yes	365,758	727	68.7	391	2.3	0.30	40,634	121	10.1
	12	Yes	7,894,947	2,998	161.7	93,498	42.0	4.37	295,040	725	10.7
	13	Yes	1,700,813	1,640	468.2	5,108	5.9	2.16	28,440	167	22.5
5	14	Yes	1,826,363	5,294	465.7	25,390	73.6	6.47	-	-	-
	15	Yes	347,099	3,990	797.9	-566	-6.5	-1.30	-	-	-
	16		131,292	499	41.8	80,433	305.8	25.59	-	-	-
TotalSavingsAB970PkgD_CZs			**29,037,144**	**2,227**		**291,035**	**24.2**		**2,583,971**	**215**	
TotalSavingsIOUServiceArea			**29,508,509**	**2,023**	**113.0**	**421,402**	**25.4**	**2.40**	**2,833,553**	**409**	**15.2**

7 The basis for per home and per 1000 ft^2 savings is limited to those homes with cooling equipment.
8 The basis for per home and per 1000 ft^2 savings estimates is limited to those homes with gas (natural gas and propane) heating equipment.
9 The basis for per home and per 1000 ft^2 savings estimates is limited to only those homes with electric heating equipment.

5.5 Radiant Barriers Technical Potential

The technical potential assessment for radiant barriers is presented in this section. This includes a description of radiant barriers and how they achieve energy savings, a discussion on the applicability of the measure to construction types and CEC climate zones, a presentation of measure-specific issues affecting the assessment and results, an outline of how the technical potential assessment for this measure was performed, and a presentation of energy saving potentials for radiant barriers in single family detached homes and multifamily buildings.

Radiant Barrier Description

Radiant barriers are primarily a cooling measure but can also help reduce heating. A radiant barrier is a reflective foil or metal-coated surface that is usually placed on or against the underside of the roof. In the summer, radiant barriers reduce radiant solar heat gain into the attic. Reduced attic temperatures result in a reduced cooling load for ducts located in attics. In the winter, the radiant barrier's low emissivity (low-E) reduces radiative losses from the roof, thereby reducing heating loads.

Radiant Barrier Applicability

This measure is applicable to all residences not built with radiant barriers. Existing saturations of radiant barriers from the on-site survey are presented in Table 5-5 for detached single family homes. These results show that only 2.3% of detached single family homes in IOU service areas had radiant barriers, and that cooling-predominant RMST Climate Zone 4 had the largest saturation at 6.2%.

Table 5-7: Radiant Barrier Practices for Detached Single Family Homes

Analysis Parameter Description	Statewide	RMST CZ1	RMST CZ2	RMST CZ3	RMST CZ4	RMST CZ5
Radiant barriers installed						
No	97.7%	99.1%	100.0%	100.0%	93.8%	97.6%
Yes	2.3%	0.9%	-	-	6.2%	2.4%

Existing saturations of radiant barriers for multifamily buildings could not be determined from the on-site survey for all multifamily buildings and therefore could not be reported here. For the RMST survey, individual multifamily units were surveyed, not entire buildings. As such, these units were very often not on the top-most floor (i.e., below the attic) and even when they were, the attic space was usually not accessible. However, in multifamily buildings where the attic was accessible, radiant barriers were not found.

Regarding the applicability of this measure to CEC climate zones for Prescriptive Package D, as shown in Table 5-1, radiant barriers are only applicable to CEC Climate Zones 2, 4, and 7 through 15, and are not required in Climate Zones 1, 3, 5, 6, and 16.

Radiant Barrier Special Issues

The only issue to consider is that this measure will have a much larger impact on residences with ducts located in the attic, then it will on those that do not have ducts in the attic, or are non-ducted.

Approach to Estimating Radiant Barrier Technical Potential

Savings were assessed only for those residences that did not already have radiant barriers. For multifamily buildings, this meant all buildings. Radiant barriers were then applied to these residences. The resulting savings were filtered by excluding cooling savings from the MICROPAS estimates for homes that, as-built, did not have a cooling system installed.

Technical potential for radiant barriers ($TECHPOTRB_h$) for residential building h can be expressed as:

$$TECHPOTRB_h = (ABHTUSE_h - RBHTUSE_h)HT_h + (ABCLUSE_h - RBCLUSE_h)CL_h$$

where:

ABHTUSE	=	Heating usage *as-built* characteristics
RBHTUSE	=	Heating usage with *as-built* characteristics and a radiant barrier
HT	=	Binary variable equal to one if central heating, otherwise zero
ABCLUSE	=	Cooling usage *as-built* characteristics
RBCLUSE	=	Cooling usage with *as-built* characteristics and a radiant barrier
CL	=	Binary variable equal to one if there is central cooling, otherwise zero

Note that for homes where a radiant barrier is already installed, as-built and as-built with radiant barrier are equal ($ABHTUSE = RBHTUSE$ and $ABCLUSE – RBCLUSE$). Thus, the technical potential in these homes is zero.

Technical potential is then defined for all homes of type s as:

$$TECHPOTRB_s = \sum_h TECHPOTRB_{s,h}$$

Results for Radiant Barriers in Detached Single Family Homes

End-use electric and gas savings results are presented in Table SF-RB-EF. These results represent savings for those homes that did not already have radiant barriers and only include cooling savings for those homes in which cooling equipment was actually installed. Results are summarized below.

Savings for Applicable Climate Zones

- Total cooling savings is 22,179 MWh, which is 381 kWh per home.
- Total gas heating savings is 161,233 therms, which is 2.5 therms per home.
- Total electric heating savings is 27.3 MWh, which is 42 kWh per home.

Savings for IOU Service Areas (All Climate Zones)

- Total cooling savings is 22,710 MWh, which is 341 kWh per home.
- Total gas heating savings is 203,573 therms, which is 2.5 therms per home.
- Total electric heating savings is 31.9 MWh, which is 39 kWh per home.

Results for Radiant Barriers in Multifamily Buildings

End-use electric and gas savings results are presented in Table MF-RB-EF. These results represent savings for all multifamily units since it was assumed that none had radiant barriers, and only include cooling savings for those units in which cooling equipment was actually installed. Results are summarized below.

Savings for Applicable Climate Zones

- Total cooling savings is 7,066 MWh, which is 582 kWh per residential unit.
- Total gas heating savings is 56,727 therms, which is 5.2 therms per residential unit.
- Total electric heating savings is 653.3 MWh, which is 118 kWh per residential unit.

Savings for IOU Service Areas (All Climate Zones)

- Total cooling savings is 7,382 MWh, which is 506 kWh per residential unit.
- Total gas heating savings is 83,446 therms, which is 5.0 therms per residential unit.
- Total electric heating savings is 765.6 MWh, which is 110 kWh per residential unit.

Table SF-RB-EF: End-Use/Fuel Energy Savings for Radiant Barriers in Detached Single Family Homes

RMST CZ	CEC CZ	Meas Req'd. For AB970 PackageD	Cooling Savings[10] (kWh)			Gas Heating Savings[11] (therms)			Electric Heating Savings[12] (kWh)		
			All AirCond Homes	Per Home	Per 1,000 Sq Ft	All GasHtd Homes	Per Home	Per 1,000 ft^2	All ElecHtd Homes	Per Home	Per 1,000 ft^2
1	1		-	-	-	3,982	4.0	2.11	-	-	-
	2	Yes	378,491	236	98.5	20,018	4.8	2.22	-	-	-
	3		113,743	42	17.5	15,441	2.1	0.92	-	-	-
	4	Yes	668,387	147	57.7	15,221	2.6	1.03	-	-	-
	5		28,347	56	18.3	3,642	3.1	1.37	-	-	-
2	6		127,076	53	18.5	5,141	1.2	0.49	4,569	27	4.9
	7		191,584	93	36.5	7,406	1.6	0.69	-	-	-
3	8	Yes	541,285	159	63.9	5,571	1.6	0.66	-	-	-
	9	Yes	2,109,376	309	109.7	13,367	2.0	0.70	-	-	-
	10	Yes	4,897,434	369	164.7	25,976	1.9	0.87	2,523	17	7.8
4	11	Yes	932,258	368	184.9	9,351	3.1	1.55	-	-	-
	12	Yes	3,423,223	273	130.6	38,925	2.9	1.41	-	-	-
	13	Yes	4,095,601	478	271.1	21,901	2.7	1.53	24,830	49	31.3
5	14	Yes	1,208,221	597	289.3	8,691	3.7	1.74	-	-	-
	15	Yes	3,924,924	1,331	615.4	2,212	0.8	0.35	-	-	-
	16		69,736	108	44.2	6,728	7.4	3.37	-	-	-
TotalSavingsAB970PkgD_CZs			**22,179,201**	**381**		**161,233**	**2.5**		**27,353**	**42**	
TotalSavingsIOUServiceArea			**22,709,688**	**341**	**149.9**	**203,573**	**2.5**	**1.10**	**31,922**	**39**	**15.6**

10 The basis for per home and per 1000 ft^2 savings is limited to those homes with cooling equipment.
11 The basis for per home and per 1000 ft^2 savings estimates is limited to those homes with gas (natural gas and propane) heating equipment.
12 The basis for per home and per 1000 ft^2 savings estimates is limited to only those homes with electric heating equipment.

Table MF-RB-EF: End-Use/Fuel Energy Savings for Radiant Barriers in Multifamily Buildings

RMST CZ	CEC CZ	Meas Req'd. For AB970 PackageD	Cooling Savings[13] (kWh)			Gas Heating Savings[14] (therms)			Electric Heating Savings[15] (kWh)		
			All AirCond ResUnit	Per ResUnit	Per 1,000 Sq Ft	All GasHtd ResUnit	Per ResUnit	Per 1,000 ft^2	All ElecHtd ResUnit	Per Res Unit	Per 1,000 ft^2
1	1		-	-	-	784	4.8	0.80	-	-	-
	2	Yes	-	-	-	5,695	4.7	1.06	308,681	223	11.3
	3		-	-	-	9,877	4.4	0.54	92,541	113	6.2
	4	Yes	897,875	430	12.1	14,156	7.3	0.38	177,382	123	3.3
	5		-	-	-	324	1.4	0.90	-	-	-
2	6		90,863	71	4.2	5,483	3.4	0.23	9,299	42	1.4
	7		173,764	193	12.0	2,756	2.7	0.17	10,524	29	4.9
3	8	Yes	816,803	349	26.7	6,221	2.7	0.28	19,331	41	1.6
	9	Yes	1,545,892	561	31.5	4,387	3.0	0.36	29,912	23	0.8
	10	Yes	360,312	1,024	58.7	1,912	4.6	0.30	-	-	-
4	11	Yes	194,928	388	36.6	1,174	7.0	0.90	28,837	86	7.2
	12	Yes	1,844,525	701	37.8	16,813	7.5	0.79	80,465	198	2.9
	13	Yes	681,686	657	187.6	3,023	3.5	1.28	8,656	51	6.8
5	14	Yes	558,958	1,620	142.5	3,260	9.4	0.83	-	-	-
	15	Yes	164,840	1,895	378.9	87	1.0	0.20	-	-	-
	16		51,787	197	16.5	7,495	28.5	2.38	-	-	-
TotalSavingsAB970PkgD_CZs			**7,065,819**	**582**		**56,727**	**5.2**		**653,264**	**118**	
TotalSavingsIOUServiceArea			**7,382,234**	**506**	**28.3**	**83,446**	**5.0**	**0.48**	**765,628**	**110**	**4.1**

13 The basis for per home and per 1000 ft^2 savings is limited to those homes with cooling equipment.
14 The basis for per home and per 1000 ft^2 savings estimates is limited to those homes with gas (natural gas and propane) heating equipment.
15 The basis for per home and per 1000 ft^2 savings estimates is limited to only those homes with electric heating equipment.

5.6 Duct Sealing Technical Potential

The technical potential assessment for duct sealing (or tight ducts) is presented in this section. This includes a description of duct sealing and how it achieves energy savings, a discussion on the applicability of the measure to construction types and CEC climate zones, a presentation of measure-specific issues affecting the assessment and results, an outline of how the technical potential assessment for this measure was performed, and a presentation of energy saving potentials for duct sealing in single family detached homes and multifamily buildings.

Duct Sealing Description

Duct sealing is both a cooling and a space heating measure. Duct sealing involves actively testing and sealing a duct system with a duct blaster or equivalent apparatus. After isolating the duct system by sealing off supply and return registers and plenums, the duct system is pressurized (25 Pa for this study) and a leakage rate measured in cubic-feet-per-minute (CFM). If the leakage rate is greater than a target value, which varies based on the configuration of the space cooling/heating equipment at the time of testing, then leaks are located and sealed until the leakage rate is at or below the target value. The heating/cooling system configurations and their corresponding target values, which are expressed as a percentage of total supply fan air flow, are as follows.

1. If the space heating/cooling system is <u>installed</u> and heating/cooling <u>capacities are known</u>, then the leakage target is 6% of the supply fan capacity, calculated as 400 CFM per ton of air conditioning or 21.7 CFM per kBtuh of furnace capacity.
2. If the space heating/cooling system is <u>installed</u> but heating/cooling <u>capacities are not known</u>, the leakage target varies by CEC climate zone as follows:
   - For CEC Climate Zone 8 through 15: 6% of 0.70 CFM per ft^2 of conditioned floor area (CFA).
   - For CEC Climate Zone 1 through 7 and 16: 6% of 0.50 CFM per ft^2 of CFA.
3. If the space heating/cooling system is <u>not installed</u> at the time duct sealing is performed, then the leakage target is as follows:
   - For CEC Climate Zone 8 through 15: 4% of 0.70 CFM per ft^2 of CFA.
   - For CEC Climate Zone 1 through 7 and 16: 4% of 0.50 CFM per ft^2 of CFA.

In addition to leakage rate, there are requirements regarding materials and methods that must be used in constructing the duct system. As this is the only measure that significantly affects both heating and cooling energy use, it offers the largest savings potential of any measure examined here.

Duct Sealing Applicability

This measure is applicable to all residences that utilize *ducted* heating and/or cooling systems. The existing saturations of residences with ducted systems are presented in Table 5-8 for detached single family homes and Table 5-9 for multifamily buildings and are discussed below.

Saturation of Ducted Systems in Detached Single Family Homes

As might be expected, detached single family homes are primarily ducted systems with ducts located in the attic.

- In the IOU service areas, 97.5% of homes are ducted systems and 95% of those have duct work located in the attic.
- RMST Climate Zone 5 (CEC Climate Zones 14-16) has the lowest percentage of ducted systems at 91.3%.

Table 5-8: Duct Types and Duct Locations in Detached Single Family Homes

Analysis Parameter Description	IOU ServAreas	RMST CZ1	RMST CZ2	RMST CZ3	RMST CZ4	RMST CZ5
Ducted Systems	97.5%	99.1%	98.3%	96.1%	98.7%	91.3%
Ducts in Attic	95.0%	96.5%	93.3%	97.2%	92.4%	95.5%
Ducts not in Attic	22.9%	19.3%	22.2%	17.5%	29.3%	27.7%
Non-Ducted Systems	2.5%	0.9%	1.7%	3.9%	1.3%	8.7%

Saturation of Ducted Systems in Multifamily Buildings

Multifamily buildings utilize a much larger variety of heating and cooling systems. As a result, although ducted systems are still the predominant system type, the saturation of ducted systems is much lower than for detached single family homes.

- In the IOU service areas, 65.6% of multifamily building units are ducted systems, and only 58.6% of those have duct work located in the attic.
- RMST Climate Zone 1 (CEC Climate Zones 1-5) has the lowest percentage of ducted systems at 40.2%. This is about half that for other RMST climate zones.

Table 5-9: Duct Types and Duct Locations in Multifamily Buildings

Analysis Parameter Description	IOU ServAreas	RMST CZ1	RMST CZ2	RMST CZ3	RMST CZ4	RMST CZ5
Ducted Systems	65.6%	40.2%	85.8%	77.6%	85.3%	90.6%
Ducts in Attic	58.6%	60.6%	58.7%	49.0%	65.6%	76.7%
Ducts not in Attic	42.5%	46.3%	30.0%	41.5%	50.5%	37.1%
Non-Ducted Systems	34.4%	59.8%	14.2%	22.4%	14.7%	9.4%

Regarding the applicability of this measure to CEC climate zones for Prescriptive Package D, as shown in Table 5-1, duct sealing (Tight Ducts) is the only measure applicable to all CEC climate zones.

Duct Sealing Special Issues

Issues having an impact on the technical potential results are listed below.

- ***Duct Sealing in MICROPAS*** is only a Yes/No option (credit or no credit).
- ***Duct Blaster Test Data*** for 100 homes were available from the on-site survey data. However, this information was not used in performing the baseline as-built runs.
- ***Duct Blaster Test Data Were Used to Adjust the Raw Duct Sealing Technical Potentials.*** An average percent leakage rate was developed for detached single family homes and multifamily buildings. This average value was used to adjust the results. Percent leakage rates were calculated for each site using the measured leakage flow rates and total fan flow as determined from the survey data as follows:
  - If cooling capacity was available, then a factor of 400 was applied to the cooling capacity in tons to obtain total fan flow.
  - If cooling capacity was missing or no cooling system was installed, but heating capacity was known, then a factor of 21.7 was applied to the heating capacity to obtain total fan flow.
  - If neither cooling or heating capacity was known, average ft^2/ton and ft^2/kBtuh values were developed from the survey data and applied using the home's or residential unit's floor area. If the residence had a cooling system installed, then the cooling capacity was calculated from floor area times the default ft^2/ton value and the CFM/ton factor of 400. If the residence had only heating (no cooling equipment) installed, then the heating capacity was determined from floor area multiplied by the default ft^2/kBtuh and the CFM/kBtuh factor of 21.7 factor.
- ***Survey Data/Format Issue.*** The survey form allowed surveyors to indicate all locations for supply and return ducts, but not a percentage of duct system in each

location. Most sites noted ducts in multiple locations. This issue was dealt with by setting up a logical hierarchy for selecting the duct type used in MICROPAS based on the order from worst to best duct location. For example, if any part of the duct system was located in the attic, then Attic was assumed the duct location. If no part of the duct system was in the attic, then the surveyor would look for Crawlspace and follow same procedure as above. The MICROPAS hierarchy from worst to best duct location is Attic, Crawlspace, Basement, and Conditioned Space.

- Until AB 970, duct sealing for multifamily residences was not an option.

Approach to Estimating Duct Sealing Technical Potential

Duct sealing was simulated in MICROPAS by setting the "TestedLeakage" keyword to "Yes."

Since leakage rates could not be dialed in, savings were assumed to be linear and results were adjusted by applying a factor based on average actual % leakage rate, determined as explained in the section above. The average % leakage rate for duct systems was 13% for detached single family homes and 24% for multifamily buildings. Since "No" was assumed to be 22% leakage and "Yes" 6% leakage, the assumed relationship was linear and results were adjusted by a factor of (13-6)/(22-6)=0.4375.

Technical potential for duct sealing ($TECHPOTDUCT_h$) for residential building *h* can be expressed as:

$$\begin{aligned} TECHPOTDUCT_h = & \left(ABHTUSE_h - DUCTHTUSE_h\right)HT_h \\ & + \left(ABCLUSE_h - DUCTCLUSE_h\right)CL_h \end{aligned}$$

where:

ABHTUSE	= Heating usage *as-built* characteristics
WINHTUSE	= Heating usage with *as-built* characteristics and sealed ducts
HT	= Binary variable equal to one if central heating, otherwise zero
ABCLUSE	= Cooling usage *as-built* characteristics
DUCTCLUSE	= Cooling usage with *as-built* characteristics and sealed ducts
CL	= Binary variable equal to one if there is central cooling, otherwise zero

Technical potential is then defined for all homes of type *s* as:

$$TECHPOTDUCT_s = \sum_h TECHPOTDUCT_{s,h}$$

Results for Duct Sealing in Detached Single Family Homes

End-use electric and gas savings results are presented in Table SF-DS-EF. These results represent adjusted (duct blaster test factor applied) and unadjusted savings (values direct from the table) for all homes with ducted heating/cooling systems and only include cooling savings for those homes in which cooling equipment was actually installed. Because duct sealing is applicable to all CEC climate zones, only one set of results is needed. Savings for all single family detached homes in IOU service areas are as follows.

- Total adjusted (unadjusted) cooling savings is 11,689 (26,718) MWh, which is 170.6 (390) kWh per home.
- Total adjusted (unadjusted) gas heating savings is 805,826 (1,841,889) therms, which is 9.6 (21.9) therms per home.
- Total adjusted (unadjusted) electric heating savings is 100,441 (229.6) MWh, which is 101.1 (231) kWh per home.

Results for Duct Sealing in Multifamily Buildings

End-use electric and gas savings results are presented in Table MF-DS-EF. These results represent savings for all multifamily units with ducted heating/cooling systems and only include cooling savings for those units in which cooling equipment was actually installed. Because this measure is applicable to all CEC climate zones, only one set of results is needed. In addition, since the average leakage rate from the duct blaster tests was higher than 22%, no adjustment was made to the derived savings estimates. Savings for multifamily building units in IOU service areas are as follows.

- Total cooling savings is 4,846 MWh, which is 405 kWh per residential unit.
- Total gas heating savings is 599,732 therms, which is 38.8 therms per residential unit.
- Total electric heating savings is 237.1 MWh, which is 113 kWh per residential unit.

Table SF-DS-EF: End-Use/Fuel Energy Savings for Duct Sealing in Detached Single Family Homes

RMST CZ	CEC CZ	Meas Req'd. For AB970 PackageD	Cooling Savings[16] (kWh)			Gas Heating Savings[17] (therms)			Electric Heating Savings[18] (kWh)		
			All AirCond Homes	Per Home	Per 1,000 Sq Ft	All GasHtd Homes	Per Home	Per 1,000 ft²	All ElecHtd Homes	Per Home	Per 1,000 ft²
1	1	Yes	-	-	-	32,367	32.8	17.19	-	-	-
	2	Yes	378,588	236	98.5	188,451	44.7	20.93	-	-	-
	3	Yes	78,903	28	11.3	156,419	21.6	9.51	-	-	-
	4	Yes	524,313	115	45.3	158,643	26.6	10.78	-	-	-
	5	Yes	10,353	21	6.7	29,609	25.1	11.12	-	-	-
2	6	Yes	66,467	28	9.7	41,982	9.9	4.01	35,635	213	38.1
	7	Yes	131,614	64	25.1	21,617	4.6	2.01	-	-	-
3	8	Yes	420,436	123	49.6	33,224	9.7	3.92	-	-	-
	9	Yes	1,986,786	291	103.3	92,182	13.5	4.79	-	-	-
	10	Yes	5,708,353	430	192.0	182,241	13.6	6.11	17,662	120	54.6
4	11	Yes	1,343,337	468	235.4	91,079	28.4	14.41	59,951	353	163.3
	12	Yes	3,576,014	278	133.1	430,484	31.8	15.33	-	-	-
	13	Yes	5,143,784	539	302.4	184,503	20.4	11.37	116,331	228	146.9
5	14	Yes	1,517,289	750	363.4	89,477	38.4	17.95	-	-	-
	15	Yes	5,786,692	1,868	848.4	13,491	4.4	1.98	-	-	-
	16	Yes	45,034	70	28.6	96,120	106.3	48.09	-	-	-
TotalSavingsAB970PkgD_CZs			**26,385,591**	**439**		**1,463,776**	**22.5**		**193,945**	**234**	
TotalSavingsIOUServiceArea			**26,717,961**	**390**	**171.7**	**1,841,889**	**21.9**	**9.80**	**229,580**	**231**	**94.9**

16 The basis for per home and per 1000 ft² savings is limited to those homes with cooling equipment.
17 The basis for per home and per 1000 ft² savings estimates is limited to those homes with gas (natural gas and propane) heating equipment.
18 The basis for per home and per 1000 ft² savings estimates is limited to only those homes with electric heating equipment.

Table MF-DS-EF: End-Use/Fuel Energy Savings for Duct Sealing in Multifamily Buildings

RMST CZ	CEC CZ	Meas Req'd. For AB970 PackageD	Cooling Savings[19] (kWh)			Gas Heating Savings[20] (therms)			Electric Heating Savings[21] (kWh)		
			All AirCond ResUnit	Per ResUnit	Per 1,000 Sq Ft	All GasHtd ResUnit	Per ResUnit	Per 1,000 ft^2	All ElecHtd ResUnit	Per Res Unit	Per 1,000 ft^2
1	1	Yes	-	-	-	0	0.0	0.00	-	-	-
	2	Yes	-	-	-	51,684	57.9	14.01	-	-	-
	3	Yes	-	-	-	59,311	35.0	4.31	-	-	-
	4	Yes	73,671	114	3.6	90,867	46.7	2.41	-	-	-
	5	Yes	-	-	-	-	-	-	-	-	-
2	6	Yes	42,733	33	2.0	27,168	16.7	1.16	17,103	76	2.6
	7	Yes	87,311	117	6.1	10,170	9.9	0.62	11,904	55	6.2
3	8	Yes	504,066	215	16.5	26,666	11.7	1.21	121,218	255	10.3
	9	Yes	570,783	278	34.9	19,875	13.7	1.65	28,802	47	6.7
	10	Yes	393,846	1,119	64.2	9,207	22.2	1.46	-	-	-
4	11	Yes	0	0	0.0	0	0.0	0.00	-	-	-
	12	Yes	1,366,150	519	28.0	161,844	72.7	7.57	0	0	0.0
	13	Yes	774,182	747	213.1	15,416	17.8	6.52	58,116	342	45.9
5	14	Yes	738,853	2,142	188.4	39,204	113.6	10.00	-	-	-
	15	Yes	274,451	3,155	630.9	348	4.0	0.80	-	-	-
	16	Yes	20,335	77	6.5	87,973	334.5	27.99	-	-	-
TotalSavingsAB970PkgD_CZs			**4,696,000**	**486**		**415,110**	**38.9**		**208,136**	**125**	
TotalSavingsIOUServiceArea			**4,846,379**	**405**	**28.4**	**599,732**	**38.8**	**3.55**	**237,143**	**113**	**4.5**

19 The basis for per home and per 1000 ft^2 savings is limited to those homes with cooling equipment.
20 The basis for per home and per 1000 ft^2 savings estimates is limited to those homes with gas (natural gas and propane) heating equipment.
21 The basis for per home and per 1000 ft^2 savings estimates is limited to only those homes with electric heating equipment.

5.7 Thermostatic Expansion Valves (TXVs) Technical Potential

The technical potential assessment for thermostatic expansion valves (TXVs) is discussed in this section. This section also describes what a TXV is and how it achieves energy savings, discusses measure applicability to construction types and CEC climate zones, presents measure-specific issues affecting the assessment and results, outlines how the technical potential assessment for this measure was performed, and presents energy saving potentials for TXVs in single family detached homes and multifamily buildings.

TXV Description

The performance of air conditioning systems is strongly dependent on proper refrigerant charge and air flow across the coil, both of which are sensitive to poor installation practices for split-type cooling systems. TXVs mitigate the problems of improper refrigerant charge and airflow by making the system operate at its rated efficiency. Under the Standards, compliance credits for TXVs require field verification by a certified HERS rater. Access is required so that the HERS rater can visually observe the presence of the TXV.

TXV Applicability

This measure is only applicable to split-type cooling systems—that is, systems with condensers located away from the evaporator/heat exchanger/blower unit. These are the typical central air type heating/cooling systems installed in most detached single family homes.

Existing saturations of this measure were not checked for the on-site survey. However, saturations of split-type cooling systems can be obtained from the survey data and are presented in Table 5-10 for detached single family homes and in Table 5-11 for multifamily buildings. Results are summarized below.

Saturation of Split-System Type Cooling Systems in Detached Single Family Homes

- In the IOU service areas, 89.4% of homes have central type air distribution systems, which are typically split systems.
- Most homes in RMST Climate Zone 1 (CEC Climate Zones 1-5) and RMST Climate Zone 2 (CEC Climate Zones 6-7) do not have any type of cooling system. This could impact the overall technical potential for TXVs, except that there is only one CEC climate (Climate Zone 2) where TXVs are required as part of Prescriptive Package D.

Saturation of Split-System Type Cooling Systems in Multifamily Buildings

- Of the units in multifamily buildings, 48.6% have central type air distribution systems, which are typically split systems.

- The vast majority (77.5%) of units in multifamily buildings in RMST Climate Zone 1 (CEC Climate Zones 1-5) do not have any type of cooling system.

Table 5-10: Space Cooling System Types in Detached Single Family Homes

Space Cooling Equipment Type	IOU ServArea	RMST CZ1	RMST CZ2	RMST CZ3	RMST CZ4	RMST CZ5
Central Air Conditioner	79.4%	49.4%	48.5%	98.4%	92.4%	91.0%
Central Heat Pump	1.0%	-	-	0.6%	2.6%	-
No Air Conditioner	19.6%	50.6%	51.5%	1.0%	5.1%	9.0%

Table 5-11: Space Cooling System Types in Multifamily Buildings

Space Cooling Equipment Type	IOU ServArea	RMST CZ1	RMST CZ2	RMST CZ3	RMST CZ4	RMST CZ5
Central Air Conditioner	41.4%	7.1%	48.9%	62. 0%	73.2%	100.0%
Central Heat Pump	7.2%	-	13.4%	18.2%	4.1%	-
Water Loop Heat Pump	11.2%	15.4%	4.7%	11.8%	8.1%	-
No Air Conditioner	37.5%	77.5%	32.9%	8.0%	-	-
Non-Split Cooling Systems	2.6%	-	-	-	14.7%	-

Regarding the applicability of this measure to CEC climate zones, as shown in Table 5-1, TXVs are only required in CEC Climate Zones 2 and 8 through 15.

TXV Special Issues

Although TXVs are primarily applicable to split-type cooling systems, the Standards allow a credit to be taken for TXVs on package units. However, TXVs are only built into the Standard Budget for split-type cooling systems in CEC climate zones applicable to this measure.

Approach to Estimating TXV Technical Potential

To simulate this in MICROPAS, "TXV" is added to end of the cooling system type keyword. That is, "ACSplit" becomes "ACSplitTXV." TXV was added to all split and package systems for the technical potential analysis.

Technical potential for TXV valves ($TECHPOTTXV_h$) for residential building h can be expressed as:

$$TECHPOTTXV_h = (ABHTUSE_h - TXVHTUSE_h)HT_h + (ABCLUSE_h - TXVCLUSE_h)CL_h$$

where:

ABHTUSE	=	Heating usage *as-built* characteristics
TXVHTUSE	=	Heating usage with *as-built* characteristics and a TXV valve
HT	=	Binary variable equal to one if central heating, otherwise zero
ABCLUSE	=	Cooling usage *as-built* characteristics
TXVCLUSE	=	Cooling usage with *as-built* characteristics and a TXV valve
CL	=	Binary variable equal to one if there is central cooling, otherwise zero

Note that for homes where a TXV valve is already installed, as-built and as-built with TXV valve are equal (*ABHTUSE* = *TXVHTUSE* and *ABCLUSE* = *TXVCLUSE*). Thus, the technical potential in these homes is zero.

Technical potential is then defined for all homes of type *s* as:

$$TECHPOTTXV_s = \sum_h TECHPOTTXV_{s,h}$$

Results for TXVs in Detached Single Family Homes

End-use electric and gas savings results are presented in Table SF-TXV-EF. These results represent savings for all homes that had cooling systems, and only include cooling savings for those homes in which cooling equipment was actually installed. Results are highlighted below.

- For applicable CEC climate zones, the total cooling savings is 22,315 MWh, which is 402 kWh per home.
- For IOU service areas, the total cooling savings is 23,568 MWh, which is 344 kWh per home.

Results for TXVs in Multifamily Buildings

End-use electric and gas savings results are presented in Table MF-TXV-EF. These results represent savings for all units in multifamily buildings with cooling systems and only include cooling savings for those units in which cooling equipment was actually installed. Results are highlighted below.

- For applicable CEC climate zones, the total cooling savings is 6,048 MWh, which is 602 kWh per residential unit.
- For IOU service areas, the total cooling savings is 7,004 MWh, which is 480 kWh per residential unit.

Table SF-TXV-EF: End-Use/Fuel Energy Savings for Thermostatic Expansion Valve in Detached Single Family Homes

RMST CZ	CEC CZ	Meas Req'd. For AB970 PackageD	Cooling Savings[22] (kWh)			Gas Heating Savings[23] (therms)			Electric Heating Savings[24] (kWh)		
			All AirCond Homes	Per Home	Per 1,000 Sq Ft	All GasHtd Homes	Per Home	Per 1,000 ft^2	All ElecHtd Homes	Per Home	Per 1,000 ft^2
1	1		-	-	-	0	0.0	0.00	-	-	-
	2	Yes	399,549	249	104.0	0	0.0	0.00	-	-	-
	3		110,744	39	15.9	0	0.0	0.00	-	-	-
	4		763,065	167	65.9	0	0.0	0.00	-	-	-
	5		15,577	31	10.1	0	0.0	0.00	-	-	-
2	6		88,430	37	12.9	0	0.0	0.00	0	0	0.0
	7		209,972	102	40.0	0	0.0	0.00	-	-	-
3	8	Yes	582,673	171	68.8	0	0.0	0.00	-	-	-
	9	Yes	2,088,241	306	108.6	0	0.0	0.00	-	-	-
	10	Yes	5,246,038	395	176.4	0	0.0	0.00	0	0	0.0
4	11	Yes	1,102,937	384	193.3	0	0.0	0.00	0	0	0.0
	12	Yes	3,393,784	264	126.3	0	0.0	0.00	-	-	-
	13	Yes	4,623,043	485	271.8	0	0.0	0.00	0	0	0.0
5	14	Yes	1,082,776	535	259.3	0	0.0	0.00	-	-	-
	15	Yes	3,796,812	1,226	556.7	0	0.0	0.00	-	-	-
	16		64,343	100	40.8	0	0.0	0.00	-	-	-
TotalSavingsAB970PkgD_CZs			**22,315,854**	**402**		**0**	**0.0**		**0**	**0**	
TotalSavingsIOUServiceArea			**23,567,983**	**344**	**151.4**	**0**	**0.0**	**0.00**	**0**	**0**	**0.0**

22 The basis for per home and per 1000 ft^2 savings is limited to those homes with cooling equipment.
23 The basis for per home and per 1000 ft^2 savings estimates is limited to those homes with gas (natural gas and propane) heating equipment.
24 The basis for per home and per 1000 ft^2 savings estimates is limited to only those homes with electric heating equipment.

Table MF-TXV-EF: End-Use/Fuel Energy Savings for Thermostatic Expansion Valve in Mulitfamily Building

RMST CZ	CEC CZ	Meas Req'd. For AB970 PackageD	Cooling Savings[25] (kWh)			Gas Heating Savings[26] (therms)			Electric Heating Savings[27] (kWh)		
			All AirCond ResUnit	Per ResUnit	Per 1,000 Sq Ft	All GasHtd ResUnit	Per ResUnit	Per 1,000 ft²	All ElecHtd ResUnit	Per Res Unit	Per 1,000 ft²
1	1		-	-	-	0	0.0	0.00	-	-	-
	2	Yes	-	-	-	0	0.0	0.00	0	0	0.0
	3		-	-	-	0	0.0	0.00	0	0	0.0
	4		719,273	344	9.7	0	0.0	0.00	0	0	0.0
	5		-	-	-	0	0.0	0.00	-	-	-
2	6		66,817	52	3.1	0	0.0	0.00	0	0	0.0
	7		140,480	156	9.7	0	0.0	0.00	0	0	0.0
3	8	Yes	780,085	333	25.5	0	0.0	0.00	0	0	0.0
	9	Yes	1,447,315	525	29.5	0	0.0	0.00	0	0	0.0
	10	Yes	364,569	1,036	59.4	0	0.0	0.00	-	-	-
4	11	Yes	229,191	456	43.0	0	0.0	0.00	0	0	0.0
	12	Yes	1,902,207	722	38.9	0	0.0	0.00	0	0	0.0
	13	Yes	613,045	591	168.7	0	0.0	0.00	0	0	0.0
5	14	Yes	530,172	1,537	135.2	0	0.0	0.00	-	-	-
	15	Yes	181,409	2,085	417.0	0	0.0	0.00	-	-	-
	16		29,574	112	9.4	0	0.0	0.00	-	-	-
TotalSavingsAB970PkgD_CZs			**6,047,994**	**602**		**0**	**0.0**		**0**	**0**	
TotalSavingsIOUServiceArea			**7,004,137**	**480**	**26.8**	**0**	**0.0**	**0.00**	**0**	**0**	**0.0**

25 The basis for per home and per 1000 ft² savings is limited to those homes with cooling equipment.
26 The basis for per home and per 1000 ft² savings estimates is limited to those homes with gas (natural gas and propane) heating equipment.
27 The basis for per home and per 1000 ft² savings estimates is limited to only those homes with electric heating equipment.

5.8 All-Measures Scenario Technical Potential

The technical potential assessment for the all-measure scenario is discussed in this section. This section also describes how the individual measures were implemented under the scenario, presents special issues affecting the assessment and results, outlines how the technical potential assessment for this measure was performed, and presents energy saving potentials for the all-measures scenario in single family detached homes and multifamily buildings.

Scenario Description

Duct sealing, TXVs, radiant barriers, and low solar gain fenestration were imposed on all homes. AB 970 applicability is irrelevant for this scenario. Results are presented based on all homes in IOU service areas.

Special Issues

Special issues are described below.

- Are there any residence types where none of the measures is applicable? Yes, these types are non-ducted heating-only/non-cooled residences in heating-predominant climate zones that already have low-E fenestration. However, these sites should be very rare indeed and savings should be zero or minimal. Hence, such sites were not filtered out of the analysis results.
- NoCooling issue—do not count cooling savings if there is no air conditioning equipment installed in the residence.
- Duct sealing savings are not adjusted for duct blaster test results.
- Measures are implemented in all climate zones if they are not already installed and not just limited to measure-specific applicable CEC climate zones.

Approach to Estimating All-Measures Technical Potential

The approach for estimated savings for the all-measures scenario is the same as for each individual measure as outlined previously.

Results for All-Measures Scenario in Detached Single Family Homes

End-use electric and gas savings results are presented in Table SF-AM-EF. These results represent savings for all detached single family homes and only include cooling savings for those homes in which cooling equipment was actually installed. Savings for all single family detached homes in IOU service areas are as follows.

- Total cooling savings is 142,799 MWh, which is 2084 kWh per home.
- Total gas heating savings is 2,166,610 therms, which is 25.6 therms per home.

- Total electric heating savings is 322.4 MWh, which is 324 kWh per home.

Results for the All-Measures Scenario in Multifamily Buildings. End-use electric and gas savings results are presented in Table MF-AM-EF. These results represent savings for all multifamily units with ducted heating/cooling systems and only include cooling savings for those units in which cooling equipment was actually installed. Savings for all multifamily building units in IOU service areas are as follows.

- Total cooling savings is 44,222 MWh, which is 3,032 kWh per unit.
- Total gas heating savings is 1,133,346 therms, which is 68.4 therms per unit.
- Total electric heating savings is 4,564 MWh, which is 658 kWh per unit.

Table SF-AM-EF: End-Use/Fuel Energy Savings for All Measures in Detached Single Family Homes

RMST CZ	CEC CZ	Meas Req'd. For AB970 PackageD	Cooling Savings[28] (kWh)			Gas Heating Savings[29] (therms)			Electric Heating Savings[30] (kWh)		
			All AirCond Homes	Per Home	Per 1,000 Sq Ft	All GasHtd Homes	Per Home	Per 1,000 ft²	All ElecHtd Homes	Per Home	Per 1,000 ft²
1	1	Yes	-	-	-	47,908	48.6	25.45	-	-	-
	2	Yes	2,682,635	1,675	698.3	219,102	52.0	24.34	-	-	-
	3	Yes	857,153	300	122.8	178,978	24.2	10.34	-	-	-
	4	Yes	5,601,634	1,229	483.9	179,509	30.1	12.19	-	-	-
	5	Yes	151,995	303	98.3	32,575	27.7	12.23	-	-	-
2	6	Yes	640,888	269	93.4	28,608	6.8	2.73	-7,310	-44	-7.8
	7	Yes	1,641,267	795	313.0	38,623	8.2	3.59	-	-	-
3	8	Yes	4,126,454	1,210	487.3	18,914	5.5	2.23	-	-	-
	9	Yes	14,698,958	2,152	764.4	108,464	15.9	5.64	-	-	-
	10	Yes	32,001,727	2,412	1,076.2	193,126	14.5	6.47	27,440	187	84.8
4	11	Yes	6,873,499	2,394	1,204.6	124,766	38.9	19.75	35,181	207	95.8
	12	Yes	23,010,658	1,790	856.2	552,182	40.3	19.54	-	-	-
	13	Yes	25,154,953	2,637	1,478.7	181,256	20.1	11.17	267,140	523	337.3
5	14	Yes	6,605,369	3,264	1,581.9	113,961	48.8	22.86	-	-	-
	15	Yes	18,290,402	5,906	2,681.7	21	0.0	0.00	-	-	-
	16	Yes	461,240	717	292.7	148,616	164.4	74.35	-	-	-
TotalSavingsAB970PkgD_CZs			**142,798,834**	**2,084**		**2,166,610**	**25.6**		**322,451**	**324**	
TotalSavingsIOUServiceArea			**142,798,834**	**2,084**	**917.5**	**2,166,610**	**25.6**	**11.46**	**322,451**	**324**	**133.3**

28 The basis for per home and per 1000 ft² savings is limited to those homes with cooling equipment.
29 The basis for per home and per 1000 ft² savings estimates is limited to those homes with gas (natural gas and propane) heating equipment.
30 The basis for per home and per 1000 ft² savings estimates is limited to only those homes with electric heating equipment.

Table MF-AM-EF: End-Use/Fuel Energy Savings for All Measures in Multifamily Buildings

RMST CZ	CEC CZ	Meas Req'd. For AB970 PackageD	Cooling Savings[31] (kWh)			Gas Heating Savings[32] (therms)			Electric Heating Savings[33] (kWh)		
			All AirCond ResUnit	Per ResUnit	Per 1,000 Sq Ft	All GasHtd ResUnit	Per ResUnit	Per 1,000 ft^2	All ElecHtd ResUnit	Per Res Unit	Per 1,000 ft^2
1	1	Yes	-	-	-	15,089	92.6	15.43	-	-	-
	2	Yes	-	-	-	78,593	64.4	14.58	1,328,225	960	48.4
	3	Yes	-	-	-	126,230	55.8	6.95	867,832	1,062	58.2
	4	Yes	6,224,957	2,981	84.2	171,136	88.0	4.54	1,092,310	758	20.4
	5	Yes	-	-	-	504	2.1	1.40	-	-	-
2	6	Yes	438,741	342	20.3	31,296	19.2	1.34	47,889	214	7.4
	7	Yes	1,046,396	1,163	72.4	24,919	24.2	1.53	37,704	102	17.4
3	8	Yes	5,592,575	2,390	182.7	56,601	24.9	2.56	113,227	238	9.6
	9	Yes	9,340,059	3,390	190.3	62,838	43.5	5.22	557,871	426	15.1
	10	Yes	1,633,311	4,640	266.0	11,377	27.5	1.80	-	-	-
4	11	Yes	739,307	1,470	138.8	1,696	10.1	1.30	73,403	218	18.2
	12	Yes	11,711,951	4,448	239.8	290,449	130.4	13.58	348,684	857	12.7
	13	Yes	3,293,193	3,176	906.5	22,289	25.7	9.43	96,449	567	76.3
5	14	Yes	3,184,740	9,231	812.1	73,071	211.8	18.63	-	-	-
	15	Yes	806,358	9,268	1,853.7	44	0.5	0.10	-	-	-
	16	Yes	210,267	799	66.9	167,216	635.8	53.19	-	-	-
TotalSavingsAB970PkgD_CZs			**44,221,856**	**3,032**		**1,133,346**	**68.4**		**4,563,595**	**658**	
TotalSavingsIOUServiceArea			**44,221,856**	**3,032**	**169.4**	**1,133,346**	**68.4**	**6.46**	**4,563,595**	**658**	**24.5**

31 The basis for per home and per 1000 ft^2 savings is limited to those homes with cooling equipment.
32 The basis for per home and per 1000 ft^2 savings estimates is limited to those homes with gas (natural gas and propane) heating equipment.
33 The basis for per home and per 1000 ft^2 savings estimates is limited to only those homes with electric heating equipment.

5.9 Summary and Conclusions

Table 5-12 summarizes the results of the technical potential analysis. Total technical potential for each measure was separated into electricity savings (MWh) and gas savings (therms) by residence type. Expansion weights were used to expand the savings found from the 743 homes in the sample to the total number of homes built between July 1, 1998 and June 30, 1999.[34] In addition, Table 5-12 shows the potential savings per home, and per 1,000 square foot, of each measure for detached single family homes, while Table 5-13 summarizes the results for multifamily buildings.

Table 5-12: Summary of Technical Potential of AB 970 Measures for Low-Rise Residences in IOU Service Areas

Measure/Scenario Description	All Low-Rise Residence Types		Detached Single Family Homes		Multifamily Buildings	
	MWh	Therms	MWh	Therms	MWh	Therms
All Measures Implemented	**191,907**	**3,299,956**	**143,121**	**2,166,610**	**48,785**	**1,133,346**
Radiant Barriers	30,889	287,019	22,742	203,573	8,148	83,446
Duct Sealing	32,031	2,441,621	26,948	1,841,889	5,084	599,732
Low Solar Gain Fenestration	119,148	370,078	86,805	-51,324	32,342	421,402
Thermostatic Expansion Valves	30,572	0	23,568	0	7,004	0
Sum of Individual Measures	212,640	3,098,718	160,063	1,994,138	52,578	1,104,580

34 During this period, 85,554 detached single family homes and 23,506 multifamily units were built.

Table 5-13: Technical Potential Savings of AB 970 Measures - Detached Single Family Homes

Measure/Scenario Description	Cooling Savings[35] (kWh)		Gas Heating Savings[36] (therms)		Electric Heating Savings[37] (kWh)	
	Per Home	Per 1,000 Sq Ft	Per Home	Per 1,000 Sq Ft	Per Home	Per 1,000 Sq Ft
All Measures Implemented	**1,749**	**770**	**33.5**	**15.0**	**435**	**179**
Radiant Barriers	341	150	2.5	1.1	39	16
Duct Sealing	390	172	21.9	9.8	231	95
Low Solar Gain Fenestration	1,062	467	10.5	4.7	194	80
Thermostatic Expansion Valves	344	151	0.0	0.0	0	0
Sum of Individual Measures	2,137	940	34.8	15.6	463	190

Table 5-14: Technical Potential Savings of AB 970 Measures Multifamily Buildings

Measure/Scenario Description	Cooling Savings[38] (kWh)		Gas Heating Savings[39] (therms)		Electric Heating Savings[40] (kWh)	
	Per Home	Per 1,000 Sq Ft	Per Home	Per 1,000 Sq Ft	Per Home	Per 1,000 Sq Ft
All Measures Implemented	**2,541**	**142**	**83.3**	**7.9**	**969**	**36**
Radiant Barriers	506	28	5.0	0.5	110	4
Duct Sealing	405	28	38.8	3.6	113	4
Low Solar Gain Fenestration	1,694	95	46.2	4.4	835	31
Thermostatic Expansion Valves	480	27	0.0	0.0	0	0
Sum of Individual Measures	3,086	178	90.0	8.4	1,059	40

35 The basis for per home and per 1000 ft^2 savings is limited to those homes with cooling equipment.

36 The basis for per home and per 1000 ft^2 savings estimates is limited to those homes with gas (natural gas and propane) heating equipment.

37 The basis for per home and per 1000 ft^2 savings estimates is limited to only those homes with electric heating equipment.

38 The basis for per home and per 1000 ft^2 savings is limited to those homes with cooling equipment.

39 The basis for per home and per 1000 ft^2 savings estimates is limited to those homes with gas (natural gas and propane) heating equipment.

40 The basis for per home and per 1000 ft^2 savings estimates is limited to only those homes with electric heating equipment.

Table 5-15 and Table 5-16 list the technical potential savings by measure as a percentage of the sum of the total technical potential savings for each individual measure. Results are summarized below.

- **The electric technical potential savings from implementing all four measures is <u>less</u> than the sum of the electric technical potential savings from the individual measures.** The explanation for this is that the low solar gain fenestration and the radiant barriers let in less solar heat, thereby reducing the cooling load required. In turn, there is less potential for savings from duct sealing and installing TXV valves.
- **The gas technical potential savings from implementing all four measures is <u>greater</u> than the sum of the gas technical potential savings from the individual measures.** The explanation for this is that low solar gain fenestration and radiant barriers let in less solar heat, thereby increasing the heating load required. In turn, there is more potential for savings from duct sealing.
- **A majority of the total electric technical potential savings comes from low solar gain fenestration.** The electric savings from low solar gain fenestration make up approximately 54% of the sum of the electric potential savings from the individual measures for detached single family homes (62% for multifamily buildings). The other three measures account for anywhere from 14% to 17% for single family homes and 10% to 16% for multifamily buildings.
- **For detached single family homes, nearly all of the total gas technical potential savings comes from duct sealing.** The gas savings from duct sealing makes up just over 92% of the sum of the gas potential savings from the individual measures for detached single family homes. The other three measures account for anywhere from -3% to 10%.
- **For multifamily buildings, duct sealing and low solar gain fenestration account for nearly all of the total gas technical potential savings.** The gas savings from duct sealing accounts for just over 54% of the sum of the gas potential savings from the individual measures for detached single family homes. Installing low solar gain fenestration accounts for approximately 38%.[41]

[41] There are two main reasons for the drastic difference between the gas technical potential savings for low solar heat gain fenestration for detached single family homes (-2.6%) and that for multifamily buildings (38.2%). The first is that the average detached single family home has 17% glazing area, whereas the average multifamily building has 9% glazing. Since more fenestration lets in more solar heat, on average, detached single family homes let in more heat, thereby reducing the heating savings. The second reason is the types of windows currently installed in detached single family homes compared to those installed in multifamily buildings. Section 3.4 shows that the just over 15% of the windows installed in multifamily buildings are metal windows – compared to less than 2% in detached single family homes. The measure calls for dual-paned, vinyl-framed, spectral low-E windows, which not only limit the amount of light that comes in but also limit the amount of heat allowed out, thereby increasing heating savings.

Table 5-15: Summary of Technical Potential of AB 970 Measures for Detached Single Family Homes

Measure/Scenario Description	Electric Savings		Gas Savings	
	MWh	% of Sum	Therms	% of Sum
All Measures Implemented	**143,121**		**2,166,610**	
Radiant Barriers	22,742	14.2%	203,573	10.2%
Duct Sealing	26,948	16.8%	1,841,889	92.4%
Low Solar Gain Fenestration	86,805	54.2%	-51,324	-2.6%
Thermostatic Expansion Valves	23,568	14.7%	0	0.0%
Sum of Individual Measures	160,063	---	1,994,138	---

Table 5-16: Summary of Technical Potential of AB 970 Measures for Multifamily Buildings

Measure/Scenario Description	Electric Savings		Gas Savings	
	MWh	% of Sum	Therms	% of Sum
All Measures Implemented	**48,785**		**1,133,346**	
Radiant Barriers	8,148	15.5%	83,446	7.6%
Duct Sealing	5,084	9.7%	599,732	54.3%
Low Solar Gain Fenestration	32,342	61.5%	421,402	38.2%
Thermostatic Expansion Valves	7,004	13.3%	0	0.0%
Sum of Individual Measures	52,578		1,104,580	

6

Title 24 Consultants

6.1 Overview

Thirteen in-depth interviews and 55 telephone surveys were conducted with Title 24 consultants in order to gain an understanding of building and compliance practices as they relate to Title 24 standards. The consultants were also questioned about their opinions on the new AB 970 standards, residential new construction (RNC) programs, and California Building Industry Association (CBIA) training. The consultants were asked similar questions during the two phases of questioning, although the in-depth interview asked questions in a more open-ended fashion. This provided insight into the reasoning behind their feelings, opinions, and decisions. Because the consultants were not asked the questions in the same manner, their responses are reported separately. In addition, only the responses from the telephone surveys are presented in the tables and figures.

This report is divided into the following sections.

- General Title 24 Consultant Information
- Title 24 1998 Low-Rise Residential Standards
  - Barriers to compliance
  - Use of performance and prescriptive compliance methods
  - Use of energy credits
- Assembly Bill 970
  - Awareness
  - Use of features in Prescriptive Package D
  - Use of features not included in Prescriptive Package D
  - Barriers to compliance
  - Utility assistance
  - Opinions on what else should have been included
  - Effect on RNC programs
  - General comments
- Residential New Construction Programs
- Awareness
- Barriers to Participation.

6.2 Preview of Key Findings

Many issues brought up during the in-depth interviews were supported by the telephone survey results. Other areas were explored more fully in the in-depth interviews, resulting in a better understanding of Title 24 compliance options and preferences. The following are key findings from the Title 24 consultant interviews. These results are discussed more completely later in this section.

Findings Related to AB 970

HERS certification is seen as not being cost-effective by the Title 24 consultants. Several Title 24 consultants are opposed to using duct credits that require HERS certification because of added financial cost and the time required to schedule a rater to come to the building site.

Title 24 consultants do not believe builders are likely to use measures requiring HERS certification to meet the AB 970 requirements. Most Title 24 consultants believe that builders are willing to implement a variety of additional features to negate the need for verification by a HERS rater. They believe that builders will likely use a combination of all four options (high efficiency water heaters, high efficiency central air conditioners, high efficiency furnaces, and increased insulation), with higher efficiency water heaters the most popular choice and increasing insulation levels the least popular.

Use of TXV valves are tied to duct sealing. TXV valves are inexpensive and, although certification is required to receive the credit, this process would already be occurring if builders were using the certified sealed ducts credit. Therefore, the likelihood of using the credit for TXV valves should closely match that of certified sealed ducts.

Title 24 consultants believe that the most effective way for the electric/gas utilities to assist builders in meeting the AB 970 requirements is to offer more training and education. Many Title 24 consultants offered suggestions on how utilities can assist builders. Thirty-one consultants suggested offering more training. Other suggestions commonly mentioned include providing more information on utility-sponsored programs, offering rebates, and providing more HERS raters.

One consultant interviewed in depth believes that AB 970 may encourage builders to participate in a program because, once the new standards are met, the additional measures needed to meet program requirements are not that significant.

> *"AB 970 shouldn't affect their residential programs much, in fact new standards may actually encourage builders to participate in programs since the % above standards they will have to achieve will be less. Thirty percent MEC (the current*

ENERGY STAR® requirement) is roughly equivalent to 25% better than Title 24. With AB 970 changes, 30% MEC will probably be about 10-15% better than Title 24. Builders may be more willing to go the extra mile because it doesn't take much effort to do so."

Title 24 and Other Major Findings

The feature seen as the biggest barrier to compliance is large glazing areas. This corresponds with information collected from the in-depth interviews where, when asked about particular design features or characteristics of single family homes that make it difficult to meet the standards, all the consultants stated emphatically that large glazing areas is the biggest barrier to meeting compliance for the 1998 Standards

Credits are not generally needed to help homes comply with the Title 24 requirements. One overarching message gained from the consultants is that they do not need to use the credits in order to meet the requirements of the 1998 Standards, builders do not want to use them, and the certification process is cumbersome. This finding was found during both the telephone interviews and the in-depth interviews. Many consultants explained that implementation of the 1998 Standards did not make it more difficult for them to meet compliance, and instead, in some cases, it made it easier.

6.3 General Title 24 Consultant Information

The Title 24 consultants were asked to provide general information about themselves as well as the work they performed during 2000.

Consultant Background

When asked what type of company they work for, 62% responded that they are independent contractors, 26% said they are an employee of a company specializing in Title 24 compliance, and 2% said they were an employee of an HVAC services company. On average, the individuals have been Title 24 consultants for 15 years and work for companies employing four full-time Title 24 consultants. Table 6-1 lists the services, other than compliance analysis, that the Title 24 consultants offer. Services mentioned but not included in the list of options were solar heating consultant, HERS rater, research and energy researcher, and small utility energy specialist.

Table 6-1: Additional Services Offered by Title 24 Consultants – In-Depth Interviews

Additional Services Offered by Consultants	Count
Home Inspection	5
HVAC Services	9
Architectural	5
Support Utility Program Participation Documentation	13
Duct Blaster/Blower Door Testing	4
None	8
Other	14

Number and Type of Plans Analyzed by Title 24 Consultants

Residential plans accounted for approximately 69% of the total plans analyzed by the consultants during 2000, while the remaining 31% were for commercial buildings. Of the residential plans, approximately 85% were detached single family homes and 15% were multifamily buildings. Of the detached single family plans analyzed, approximately 70% were custom homes. Although this percentage appears to be very high, it was learned from the in-depth surveys that Title 24 consultants consider custom-style tract homes to be custom homes even though they are built as tract developments. This is supported by the fact that the total number of homes far exceeds the number of plans analyzed for a significant portion of the consultants. In addition, the consultants performed compliance analysis for an average of 120 builders/subcontractors on 531 building plans (representing 1,748 residential buildings) during 2000.

Table 6-2: Compliance Analysis of New Buildings in 2000

What percentage of the plans you analyzed in the past year were for:	**Average** *Std Error* *Sample Size*
Commercial	**31%** *(2.94)* *n=48*
Residential	**69%** *(2.94)* *n=55*
Multifamily	**15%** *(2.48)* *n=44*
Single Family	**85%** *(2.48)* *n=55*
Tract	**30%** *(4.96)* *n=37*
Custom	**70%** *(4.96)* *n=37*

Values are weighted means. Weighted standard errors are shown in parentheses.

6.4 Title 24 1998 Low-Rise Residential Standards

Barriers to Compliance of the 1998 Standards

The consultants were next asked questions that attempted to capture the obstacles they face in trying to complete Title 24 compliance analysis.

Title 24 Consultants' Influence during the Planning Process

The consultants were asked to rate how influential they are during the planning process for new homes using a scale from 1 to 5, with 1 meaning "Not at all Influential" and 5 meaning "Very Influential." The means of their self-ratings are presented in Table 6-3, along with the standard errors in parentheses. Similar to the results of the in-depth interviews, the Title 24 consultants interviewed during the telephone survey believe they are more influential during the planning process for custom homes than for production homes.[1]

During the in-depth interviews, the consultants explained that custom home builders are not as concerned with cost or time constraints as builders of production homes. They also explained that custom home buyers are more interested in energy efficient equipment and are more likely to feel comfortable making the initial investment for such equipment, typically because they are not first-time buyers (indicating that they have more discretionary income). In addition, because this is not generally their first home, they better understand the benefits of investing in energy efficient equipment (i.e., lower utility bills, occupant comfort, etc.).

Table 6-3: Self Reported Influence in the Planning Process of New Homes

In your opinion, how influential are you in the planning process of :	**Average** *Std Error* *Sample Size*
Tract Homes	**3.15** *(0.18)* *n=53*
Custom Homes	**3.68** *(0.13)* *n=55*

Values are weighted means. Weighted standard errors are shown in parentheses.

Impact of Various Design Features on Achieving Compliance

Several questions were then asked to determine what features present the greatest obstacles to meeting compliance and how builders/consultants overcome these obstacles. Consultants were asked to rate how big an impact various features have in achieving Title 24 compliance on a scale from 1 to 5, with 1 meaning "Not a Significant Barrier" and 5 meaning "Significant Barrier." Table 6-4 depicts consultants' responses for both single family homes and multifamily buildings, while Figure 6-1 illustrates these responses.

The feature seen as the biggest barrier to compliance is large glazing areas. This corresponds with information collected from the in-depth interviews where, when asked about particular design features or characteristics of single family homes that make it difficult to meet the standards, all of the consultants stated emphatically that large glazing area is the biggest barrier to meeting

1 This result is significant at the 95% level of confidence using the difference of mean test. Kanji, G.K. 1993. *100 Statistical Tests*. p29. SAGE Publications.

compliance for the 1998 Standards.[2] In addition, climate zone specific requirements are considered a greater barrier than both number of stories and metal frame construction.[3] Orientation is seen as a more significant barrier than number of stories and metal frame construction.[4] In fact, metal frame construction is less significant than any other feature.[5]

When comparing responses for single family homes and multifamily buildings, it becomes clear that those performing compliance analysis on single family homes view the features as much more of a barrier.[6]

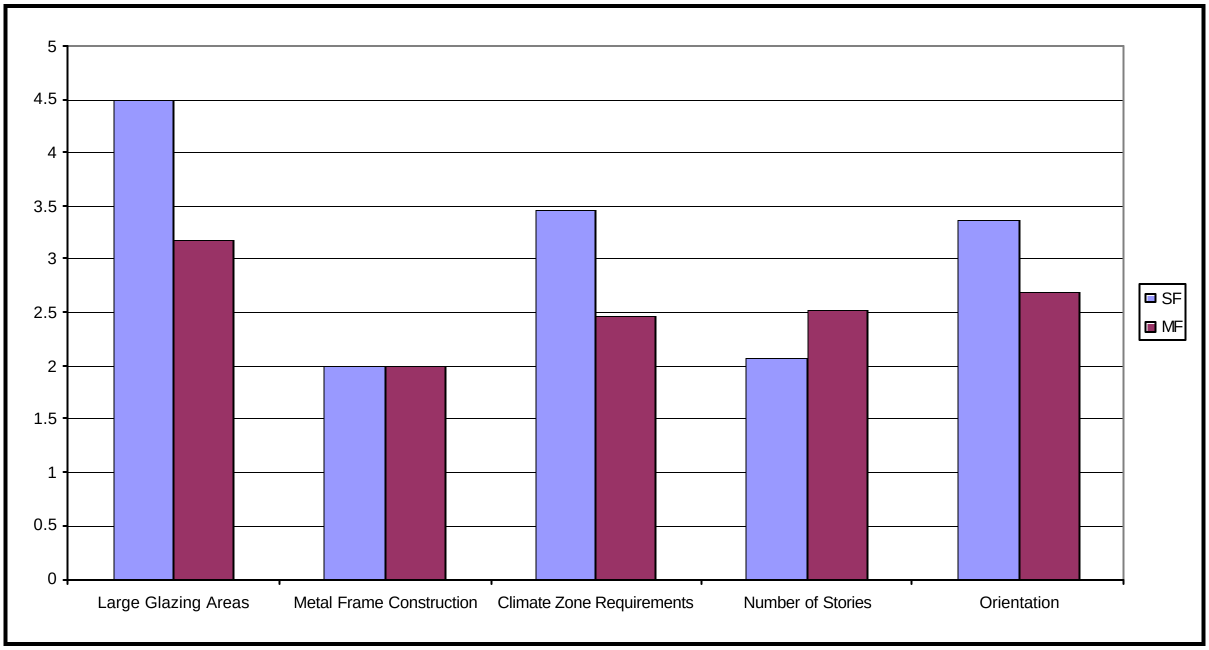
Table 6-4: Average Impact of Design Features on Achieving Compliance by Building Type

How much of an impact do the following design features have in achieving Title 24 compliance? Answer using a scale of 1 to 5, with 1 meaning No Impact and 5 meaning a Large Impact	**Single Family** **Average** *Std Error* *Sample Size*	**Multifamily** **Average** *Std Error* *Sample Size*
Large Glazing Areas	**4.50** *(0.13)* *n=54*	**3.18** *(0.17)* *n=47*
Metal Frame Construction	**2.36** *(0.25)* *n=49*	**2.00** *(0.00)* *n=42*
Climate Zone Specific Requirements	**3.46** *(0.16)* *n=55*	**2.45** *(0.14)* *n=47*
Number of Stories	**2.08** *(0.11)* *n=55*	**2.51** *(0.13)* *n=47*
Orientation	**3.38** *(0.19)* *n=55*	**2.70** *(0.12)* *n=47*

Values are weighted means. Weighted standard errors are shown in parentheses.

2 For single family homes, the difference in mean test showed that windows are a larger barrier than any other listed (all significant at the 95% level of confidence).
3 Significant at the 95% level.
4 Significant at the 95% level.
5 Significant at the 95% level.
6 Large glazing areas is significant at the 90% level, while all others are significant at the 95% level.

Figure 6-1: Average Impact of Design Features on Achieving Compliance by Building Type



<u>Measures Most Likely Used to Overcome Barriers in Order to Achieve Compliance</u>

The consultants were then asked what features they typically use to compensate for these barriers. Once again, they were asked to respond to how often they use each of the following features using a scale of 1 to 5, with 1 meaning "Never" and 5 meaning "Very Often." Table 6-5 presents the means and standard errors for each feature and Figure 6-2 illustrates the means.

Changing the design is not typically viewed as an option for compensating for the barriers presented under Title 24.[7] This result is not surprising because Title 24 consultants generally are not in a position to recommend design changes to the builders. In addition, the consultants reported being more likely to use higher efficiency water heaters over higher efficiency furnaces and increased insulation levels, higher efficiency central air conditioners over high efficiency furnaces, higher efficiency windows over each of the other features, and increased insulation over higher efficiency furnaces.

The results for the multifamily buildings were similar. Once again, the consultants are significantly more likely to use higher efficiency windows than each of the other measures, and higher efficiency water heaters over each of the remaining four measures.[8] They are also more likely to use high efficiency furnaces over higher efficiency central air conditioners and design changes.[9]

7 All other features are significant at the 95% level when compared to change in the design.

8 Significant at the 95% level.

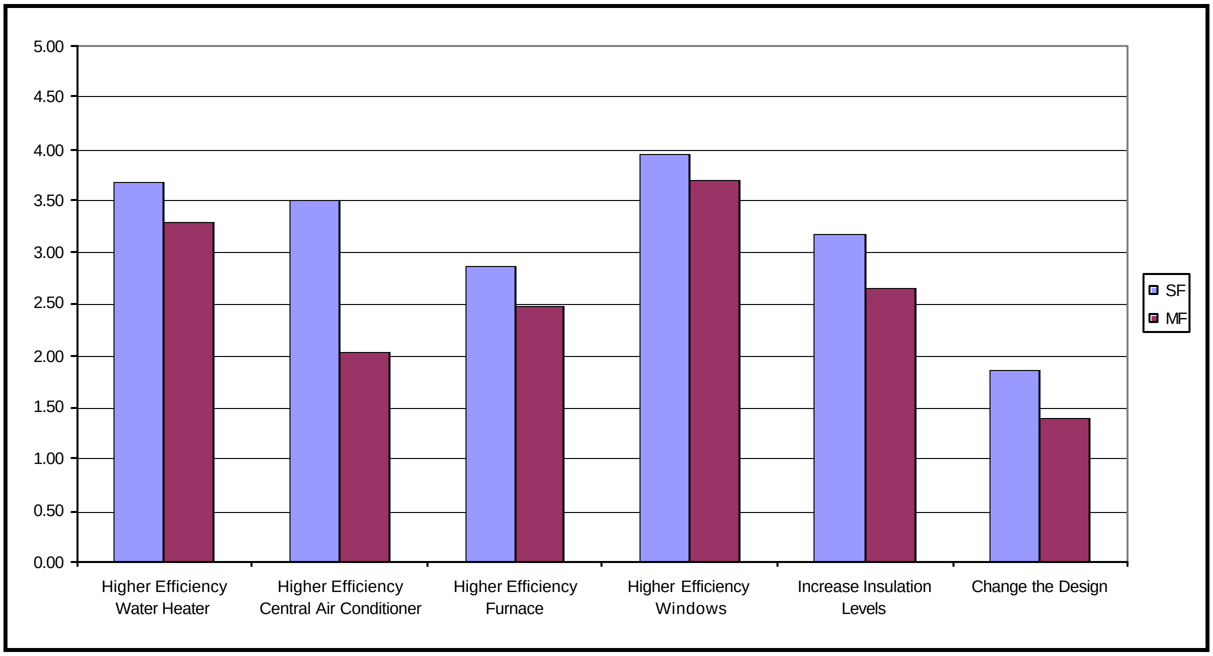
9 Significant at the 95% level.

Table 6-5: Likelihood of Using Particular Features to Overcome Barriers to Compliance by Building Type

How often do use the following measures to overcome these conditions in order to achieve compliance? Answer using a scale of 1 to 5, with 1 meaning Never and 5 meaning Very Often	**Single Family** **Average** *Std Error* *Sample Size*	**Multifamily** **Average** *Std Error* *Sample Size*
Higher Efficiency Water Heater	**3.68** *(0.16)* *n=55*	**3.29** *(0.16)* *n=42*
Higher Efficiency Central Air Conditioner	**3.50** *(0.14)* *n=55*	**2.02** *(0.17)* *n=42*
Higher Efficiency Furnace	**2.88** *(0.18)* *n=55*	**2.47** *(0.12)* *n=43*
Higher Efficiency Windows	**3.96** *(0.10)* *n=55*	**3.70** *(0.13)* *n=42*
Increase Insulation Levels	**3.17** *(0.12)* *n=55*	**2.66** *(0.12)* *n=42*
Change the Design	**1.87** *(0.15)* *n=55*	**1.41** *(0.09)* *n=42*

Values are weighted means. Weighted standard errors are shown in parentheses.

Figure 6-2: Likelihood of Using Particular Features to Overcome Barriers to Compliance by Building Type



Changes in Practices due to the 1998 Residential Standards

In order to determine how implementation of the 1998 Standards affected builders and Title 24 consultants, the consultants were asked if the methods they currently use for single family homes are different from those used before the implementation of the 1998 Standards. Interestingly, 80% said that their methods have not changed. Similarly, of the 42 consultants who perform compliance analysis on multifamily buildings, 88% said that their methods for meeting compliance have not changed with the implementation of the 1998 Standards. These results are similar to what was discovered during the in-depth interviews, which provide additional insight into this result.

During the in-depth interviews, six participants stated that the 1998 Standards were not significantly different from the 1995 Standards and, therefore, changes to their practices were not necessary. Three explained that a much larger adjustment was necessary when moving from the 1992 Standards to the 1995 Standards. Two consultants said that their methods of meeting compliance have not changed; they merely use higher efficiency equipment.

For those who did change their practices in response to the new Standards, no clear strategy has emerged. The following differences were mentioned:

- Two cited increased use of low-E windows,
- Three discussed decreased use of shading credits,
- Two use radiant barriers more frequently,
- One mentioned using water heater controls more often,

- One uses the housewrap credit more often, and
- One has used the duct testing credit more often.

Use of Performance and Prescriptive Compliance Methods

Title 24 consultants have the option of using the performance-based method (i.e., computer compliance programs such as Micropas, EnergyPro, and CalRes) or one of the prescriptive packages included in the 1998 Standards when performing compliance analysis. Consequently, the consultants were asked questions to determine which method they used for compliance analysis for both single family homes and multifamily buildings. Once their use of the performance method was established, they were asked what computer software package they use for compliance analysis.

Prescriptive Packages versus Performance Based

Table 6-6 shows the average use of each method for both single family and multifamily residences. Interestingly, the consultants made very little use of Prescriptive Packages A, B, or C for any of the single family homes or multifamily buildings they performed compliance analysis on during 2000. While Prescriptive Package D was the most commonly used package (3.4%), nearly all compliance analysis completed in 2000 was done using performance-based software (91.1%).

Table 6-6: Average Use of Compliance Methods by Building Type

For the homes analyzed within the last year, what percentage of newly constructed homes used the following compliance methods?	Single Family **Average** *Std Error* *Sample Size*	Multifamily **Average** *Std Error* *Sample Size*
Performance-Based	**91.1%** *(2.89)* *n=55*	**91.8%** *(3.47)* *n=49*
Prescriptive Package A	**0.8%** *(0.40)* *n=55*	**0.1%** *(0.08)* *n=48*
Prescriptive Package B	**1.2%** *(0.58)* *n=54*	**1.9%** *(0.98)* *n=47*
Prescriptive Package C	**1.2%** *(0.57)* *n=54*	**1.1%** *(0.59)* *n=47*
Prescriptive Package D	**3.4%** *(0.98)* *n=55*	**0.9%** *(0.50)* *n=48*

Values are weighted means. Weighted standard errors are shown in parentheses.

Computer Compliance Programs

When asked which computer compliance program they use most often, 47.3% said EnergyPro, 41.8% said MICROPAS, and the remaining 5.5% said CALRES. The in-depth interviews also pointed to EnergyPro and MICROPAS as the most popular programs. While most consultants used both MICROPAS and EnergyPro, MICROPAS was preferred in this group.

Use of Energy Credits Under the 1998 Standards

The various energy credits available under the 1998 Standards have been broken into three groups: duct credits that require HERS certification, duct credits that do not require HERS certification, and all other credits. For each credit, the consultants were asked how often the credit is used for both single family and multifamily residences.

Use of Duct Sealing and/or Building Envelope Credits that Require HERS Certification

Only 10 consultants use the duct efficiency and/or building envelope sealing credits that require HERS certification. These 10 consultants were asked in what percentage of the homes that they used various duct credits. As shown in Table 6-7, few consultants used the credits for duct location, duct surface area, or building envelope sealing and mechanical ventilation (1.2%, 1.9%, and 1.9% respectively), while the building envelope sealing credit was used in approximately 4.4% of the homes. The two duct credits used most often are duct sealing (9.3%) and duct design per ACCA Manual D (9.4%). In fact, these credits are used significantly more often than the other three credits.[10]

Table 6-7: Average Usage of Duct Credits Requiring HERS Certification

Please indicate which credits were used and the corresponding % of residences that utilized the credit.	**Average** *Std Error* *Sample Size*
Duct Sealing	**9.3%** *(3.58)* *n=55*
Duct Design per ACCA Manual D	**9.4%** *(3.00)* *n=55*
Duct Location	**1.2%** *(0.46)* *n=55*
Duct Surface Area	**1.9%** *(0.70)* *n=55*
Building Envelope Sealing	**4.4%** *(1.67)* *n=55*
Building Envelope Sealing and Mechanical Ventilation	**1.9%** *(1.63)* *n=55*

Values are weighted means. Weighted standard errors are shown in parentheses.

The in-depth interview results reinforce the telephone survey results and explain the low percentages for some categories. Eleven of the consultants interviewed in-depth do not use energy credits requiring HERS certification. Of these, nine were opposed to using such credits because of the added financial cost and time required to schedule a rater to come to the building site. In addition, three of the consultants worked solely on custom homes. They explained that credits requiring HERS certification are not cost-effective for custom homes because cost is not a great concern. As such, they are able to use more energy efficient building practices instead of needing third-party verification of other measures.

[10] Significant at the 95% level.

Of the two consultants who did use the credits requiring HERS certification, one uses the credits as part of the ComfortWise and ENERGY STAR programs and the other only uses the duct blasting credit (on approximately 15% of homes). Two consultants expect to start using these credits when AB 970 Standards are implemented, and another two said that they believe the general use of these credits will increase with AB 970.

Use of Duct Sealing and/or Building Envelope Credits Not Requiring HERS Certification

In contrast to the results where HERS certification is required, 37 of the consultants interviewed (67%) use the duct efficiency and/or building envelope sealing credits that do not require HERS certification. The average percentages of homes using the credits in this category are presented in Table 6-8 along with standard errors. As shown, the default duct location is the most highly used duct efficiency credit (35.6%), with duct sealing running a close second (30.5%). The default duct location credit is significantly more likely to be used than the credits for duct insulation greater than 4.2, housewrap, and radiant barriers.[11] Duct sealing is more common than installing a housewrap, which is more likely to be used than duct insulation greater than 4.2 and radiant barriers.[12]

[11] Significant at the 95% level.

[12] Significant at the 95% level.

Table 6-8: Average Usage of Duct Credits Not Requiring HERS Certification

The following is a list of duct efficiency and/or building envelope sealing credits that only require building inspector verification (i.e., do not require HERS certification). Please indicate which credits you have used in the last year and the corresponding percentage of residences that utilized the credit.	**Average** *Std Error* *Sample Size*
Duct Insulation >4.2 R-Value	**6.6%** *(2.05)* *n=54*
Radiant Barriers	**5.5%** *(2.10)* *n=55*
Default Duct Location	**35.5%** *(5.46)* *n=54*
Duct Sealing	**30.5%** *(5.94)* *n=55*
Housewrap	**17.2%** *(4.83)* *n=55*

Values are weighted means. Weighted standard errors are shown in parentheses.

Table 6-9 presents the results for the in-depth interviews. These results reinforce the conclusion that duct credits are much more widely used when HERS certification is not required. Ten of the 13 consultants use at least one of the energy credits not requiring HERS certification. Unlike findings from the telephone interviews, the most commonly used credits reported during the in-depth interviews are those for duct insulation and housewrap. None of the consultants interviewed has used the duct sealing credit.

Several comments were made during the in-depth interviews regarding difficulties in using the duct insulation credit. First, three consultants stated that duct insulation greater than a 4.2 R-value makes the ducts too large. One consultant added that this increased size prevents the duct from fitting inside prefabricated trusses. In addition, one consultant explained that larger R-values are not generally available.

There were also comments made about problems regarding radiant barriers. Four consultants claimed that radiant barriers are not readily available (stores do not carry them). Another consultant feels that there is not enough credit given for radiant barriers. In addition, two consultants only use the features if they are specifically requested, and that this happens infrequently because of lack of knowledge.

Table 6-9: Use of Energy Credits Not Requiring HERS Certification – In-Depth Interviews

Credit	Number of Consultants Using	Range of Homes Used On	Average Percent of Homes Used On
Duct Insulation	8	1% - 40%	8.9%
Radiant Barriers	5	5% - 40%	19.0%
Default Duct Location	3	1% - 5%	1.7%
Duct Sealing	0	N/A	N/A
Housewrap	7	1% - 100%	30.3%

Reasons for Not Using Duct Credits

In addition to capturing how often each credit is used, the consultants were asked why these credits are not used more often. The consultants were asked to rate the importance of each factor in deciding not to use the available duct sealing and/or building envelope sealing credits on a scale from 1 to 5, with 1 meaning "Not at all Influential" and 5 meaning "Very Influential." "Less cost-effective than other measures" is more significant than the "availability of HERS raters"[13] and "impact on builders' completion schedule."[14] Similarly, "not cost-effective in the climate zones you work in" is more significant than the "availability of HERS raters" and "impact on builders' completion schedule."[15]

13 Significant at the 95% level.

14 Significant at the 90% level.

15 Significant at the 95% level.

Table 6-10: Reasons for Not Using Duct Credits

How influential, in your opinion, were each of the following in the decision not to utilize the duct efficiency and/or building envelope sealing credits more? Answer using a scale of 1 to 5, with 1 meaning Not Influential and 5 meaning Very Influential.	**Average** *Std Error* *Sample Size*
Less Cost-Effective than Other Measures	**2.73** *(0.23)* *n=52*
Not Cost-Effective in the Climate Zones you Work in	**2.86** *(0.18)* *n=52*
Impact on Builders' Completion Schedule	**2.18** *(0.22)* *n=51*
Availability of HERS Raters	**2.02** *(0.18)* *n=53*

Values are weighted means. Weighted standard errors are shown in parentheses.

As shown in Table 6-10, the results do not accurately capture the reasons for not using the available credits. The highest average is approximately 2.9, which corresponds to "Somewhat Influential." Therefore, the consultants were asked their opinions on other reasons for not utilizing the duct efficiency and/or building envelope sealing credits more often. These answers are presented in Table 6-11 along with the counts. The predominant message gained from the consultants is that they do not need to use the credits to meet the requirements of the new Standards, builders do not want to use them, and the certification process is cumbersome. This finding was also found during the in-depth interviews. The 13 consultants explained that implementing the 1998 Standards did not make it more difficult for them to meet compliance and even, in some cases, made it easier.

Table 6-11: Reasons Given for Not Using Duct Efficiency and/or Building Envelope Sealing Credits – In-Depth Interviews

Reasons for not Using Duct Efficiency and/or Building Envelope Sealing Credits	Number Consultants
Did not need to use to meet compliance	10
Builders do not want to use	8
Cumbersome certification process	7
Other options are easier to implement	5
Do not want to use HERS raters	4
Impractical/not cost-effective	4
Lack of knowledge about credits	3
Needs marketing effort	3
Only worthwhile for tract homes	2
Leaves room for mistakes	1
Used the features in Package D	1

Use of Other Credits

The Title 24 consultants were then asked about their use of other credits available under the 1998 Standards. The means and standard errors for single family homes and multifamily buildings can be seen in Table 6-12. As shown, each credit is generally used less frequently for multifamily buildings than for single family homes (the hydronic system credit is the one exception). In addition, the average percentage of homes that use the credits is less than 25% in all cases. For single family homes, the most popular credit is water heating controls at approximately 22%. Coming in second are zonal control, interior shading, and hydronic systems credits, which range from 7-11%. The least popular choice was the evaporative system cooling credit at 1.1%.

For multifamily buildings, the most popular credit is water heating controls at 20%, followed by hydronic systems at 14.8%. The remaining credits were used 4% or less. The water heating controls credit and the hydronic system credit are used significantly more often than the other credits in multifamily buildings.[16]

[16] Significant at the 95% level.

Table 6-12: Average Use of "Other" Credits by Building Type

For compliance analyses performed within the last year, please indicate which credits were used in the past year and the corresponding percentage of residences that used the credit.	**Single Family** **Average** *Std Error* *Sample Size*	**Multifamily** **Average** *Std Error* *Sample Size*
Zonal Control Credit	**7.2%** *(2.27)* *n=32*	**0.8%** *(0.41)* *n=30*
Evaporative Cooling System Credit	**1.1%** *(0.41)* *n=10*	**0.8%** *(0.4)* *n=10*
Hydronic System Credit	**11.2%** *(2.39)* *n=40*	**14.8%** *(2.03)* *n=39*
Interior Shading Credit	**9.1%** *(3.07)* *n=30*	**3.3%** *(2.21)* *n=26*
Water Heating Controls Credit	**21.9%** *(3.86)* *n=30*	**20.3%** *(5.68)* *n=29*

Values are weighted means. Weighted standard errors are shown in parentheses.

During the in-depth interviews, Title 24 consultants were asked to estimate how often they use other credits in performing compliance analysis. As shown in Table 6-12, the water heating controls and the zonal control credits are used by most consultants. However, of the consultants that use each credit, the interior shading credit is used most often. While eight consultants use the zonal control credit, two other consultants felt that this credit is too restrictive and it is too difficult to meet the requirements. The in-depth interviews also explained the unpopularity of the cooling credit. Of the three consultants that have used the evaporative cooling credit, two have only used it for a few custom homes (less than 0.1%). Two consultants think that the evaporative cooling credit is not used more often because of the system's tendency, in climates with hot summers, to make the air "damp and sticky."

Table 6-13: Use of Other Energy Credits – In-Depth Interviews

Credit	Number of Consultants Using	Range of Homes Used On	Average Percent of Homes Used On
Zonal control	8	1% - 75%	16.5%
Evaporative cooling system	3	0.1% - 5%	1.7%
Hydronic or combined hydronic heating system	4	2% - 10%	5.3%
Interior shading	5	1% - 98%	38.8%
Water heating controls	12	1% - 80%	19.9%

Change in the Use of Other Credits Due to the Implementation of the 1998 Standards

In addition to capturing how often each credit is used, the consultants were also asked if the use of any of these credits has changed since the implementation of the 1998 Standards, and by what percent they have changed. In response, 82% said that their use of the various credits has not changed, while the remaining 18% said that it has changed. Those whose use has changed were asked what percentage of homes used the various credits before the implementation of the 1998 Standards. The means and standard errors since implementation of the 1998 Standards are shown for single family homes and multifamily buildings in Table 6-14. For both single family homes and multifamily residences, the water heating controls credit was used significantly more often than any other credit.[17]

[17] Single family is significant at the 95% level; multifamily is significant at the 90% level. Also, the interior shading credit was used more frequently than the hydronic system credit (90%) and the zonal control and the evaporative cooling system credits (95%).

Table 6-14: Average Use of Credits Prior to Implementation of the 1998 Standards

For each credit listed, what percentage of residences used the credit prior to the implementation of the 1998 Standards?	**Single Family Average** *Std Error* *Sample Size*	**Multifamily Average** *Std Error* *Sample Size*
Zonal Control Credit	**1.9%** *(1.21)* *n=10*	**1.5%** *(0.71)* *n=10*
Evaporative Cooling System Credit	**1.5%** *(0.73)* *n=10*	**1.5%** *(0.71)* *n=10*
Hydronic System Credit	**3.5%** *(2.03)* *n=10*	**3.7%** *(0.99)* *n=10*
Interior Shading Credit	**8.6%** *(2.25)* *n=10*	**5.7%** *(2.03)* *n=10*
Water Heating Controls Credit	**14.5%** *(3.81)* *n=10*	**15.9%** *(4.80)* *n=10*

Values are weighted means. Weighted standard errors are shown in parentheses.

Of particular interest is the percent increase in the self-reported use of these features by the consultants since the implementation of the 1998 Standards, which is shown in Table 6-15 and Table 6-16.

Table 6-15: Change in the Use of Credits Due to the Implementation of the 1998 Standards – Single Family Detached Homes

Credit	Prior to 1998 Standards	After 1998 Standards	Increase in Use
Zonal Control Credit	1.9%	7.2%	283.0%
Evaporative Cooling System Credit	1.5%	1.1%	-28.8%
Hydronic System Credit	3.5%	11.2%	219.7%
Interior Shading Credit	8.6%	9.1%	6.5%
Water Heating Controls Credit	14.5%	21.9%	51.4%

Values are weighted means. Weighted standard errors are shown in parentheses.

Table 6-16: Change in the Use of Credits Due to the Implementation of the 1998 Standards – Multifamily Buildings

Credit	Prior to 1998 Standards	After 1998 Standards	Increase in Use
Zonal Control Credit	1.5%	0.8%	-45.9%
Evaporative Cooling System Credit	1.5%	0.8%	-48.9%
Hydronic System Credit	3.7%	14.8%	298.3%
Interior Shading Credit	5.7%	3.3%	-42.1%
Water Heating Controls Credit	15.9%	20.3%	28.1%

Values are weighted means. Weighted standard errors are shown in parentheses.

6.5 Assembly Bill 970[18]

Fifty-five consultants were contacted to participate in the telephone portion of the survey, in addition to the 13 that participated in the in-depth surveys. The questions focused on various areas of AB 970, including the consultants' awareness of the new standards, how likely they believe builders are to use the methods included as part of Prescriptive Package D and, alternatively, measures not included as part of Prescriptive Package D. The consultants were also asked their thoughts on what requirements would present the largest difficulty for builders, how the utilities can assist industry

[18] 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.

professionals in meeting the new standards, what should have been included in the new standards, and how the new requirements will affect the residential new construction programs.

Awareness of Assembly Bill 970

Each Title 24 consultant was asked to rate how knowledgeable he/she is about AB 970 in order to ascertain the level of awareness of the emergency Standards. Responses were given on a scale of 1 to 5, with one representing "Not at all Knowledgeable" and 5 representing "Very Knowledgeable." The average result is 3.4, which corresponds to "Fairly Knowledgeable." Specifically, nine consultants feel they are not at all knowledgeable, 19 feel they are somewhat knowledgeable, and 27 feel they are very knowledgeable.

The 13 consultants interviewed in depth were asked about their knowledge of AB 970 as well as whether they favored or opposed the emergency Standards. Only eight of the 13 consultants felt that they were knowledgeable enough to discuss AB 970 in detail. Those who felt knowledgeable about AB 970 were split in their opinions on the bill. Eight consultants are in favor of the tougher standards, saying that the number of changes is not significant and there is a great need to reduce energy consumption. Those not in favor of the more stringent requirements feel that it is too soon after the implementation of the 1998 Standards to make more changes. They provided the following comments.

- Not enough time has passed to determine effects of the stricter requirements of the 1998 Standards,
- It is difficult for builders to change practices so quickly, that the residential new construction building industry should not be made the scapegoat of the deregulation fiasco, and
- The government should focus on reducing energy consumption in the commercial/industrial sector, not the residential sector.

Use of Features in Prescriptive Package D

If the consultant indicated that he/she was not knowledgeable about AB 970, the interviewer read a short summary describing the major changes to the low-rise residential standards. Each consultant was then asked how likely he/she is to use each of the four methods that will be required under AB 970 when performing compliance analysis under Prescriptive Package D. Responses were given on a scale of 1 to 5, with one representing "Not at all Likely" and 5 representing "Very Likely." Table 6-17 presents the means and standard errors of the consultants' responses to these questions.

As shown, consultants feel that they are more likely to use better windows (average 3.92) than the other measures. This result is significantly greater than the likelihood of using TXV valves, radiant barriers, and HERS-certified sealed ducts. In addition, the average likelihood of using radiant barriers is significantly greater than using HERS-certified sealed ducts and TXV valves.[19]

It is interesting to note that only 20 consultants reported that builders would be likely (rating of 3, 4, or 5) to use both the HERS-certified sealed ducts and high performance windows. If the observations from the consultants who said they are likely to use all four measures (rating of 4 or 5) are removed from the sample, the number decreases to 10.

Table 6-17: Likelihood of Use

How likely are you to use the following when performing compliance analysis under these new standards? Answer using a scale of 1 to 5 with 1 meaning Not at all Likely and 5 meaning Very Likely.	**Average** *Std Error* *Sample Size*
HERS Certified Sealed Ducts	**2.68** *(0.17)* *n=52*
TXV Valves	**2.27** *(0.20)* *n=50*
Better Windows (SHGC and U-Values)	**3.92** *(0.13)* *n=53*
Radiant Barriers	**3.18** *(0.18)* *n=53*
All Four Measures	**2.84** *(0.18)* *n=53*

Values are weighted means. Weighted standard errors are shown in parentheses.

As can be seen in Table 6-18, the consultants believe that builders are significantly more likely to use higher efficiency windows than any other measure (significant at the 95% level). In addition, the consultants believe that builders are more likely to use TXV valves over HERS-certified sealed ducts (significant at the 95% level).

19 Significant at the 95% level.

Table 6-18: Likelihood of Use – Given that Not All Four Measures are Used

Likely use of Individual Measures Listed in the Updated Prescriptive Package D, Given that all Four will not be Used Together.	**Average** *Std Error* *Sample Size*
HERS Certified Sealed Ducts	**2.07** *(0.16)* *n=46*
TXV Valves	**2.70** *(0.20)* *n=43*
Higher Efficiency Windows	**4.11** *(0.15)* *n=46*
Radiant Barriers	**3.02** *(0.21)* *n=46*

Values are weighted means. Weighted standard errors are shown in parentheses.

Use of Features not Included in Prescriptive Package D

When the more stringent requirements are enacted, it will become necessary for builders to implement several different energy efficient methods simultaneously if they choose not to use both higher performance windows together with HERS-certified sealed ducts. Therefore, the consultants who indicated that builders would not use all of the previously mentioned measures were asked how likely they believe builders are to use each of the following to meet the Title 24 requirements: higher efficiency central air conditioning systems, furnaces, windows, and increased insulation levels. Once again, the consultants were asked to rate the likelihood of using each on a scale from 1 to 5, with 1 meaning "Not at all Likely" and 5 meaning "Very Likely." The means and standard errors are presented in Table 6-19.[20]

When considered alongside the previous question, it is clear that the Title 24 consultants believe that builders are willing to implement a variety of additional features to negate the need for verification by a HERS rater. As shown in Table 6-19, the consultants believe that builders will likely use a combination of all four options, with higher efficiency water heaters the most popular choice at 3.85 and increasing insulation levels the least popular at 3.35.

[20] Note: the windows section of this question was intended to determine the probability of using even higher efficiency windows than required under Prescriptive Package D of AB 970. However, there was some confusion among the consultants regarding this, so the results for this portion of the question were not analyzed.

In particular, the consultants believe that builders will be more likely to use higher efficiency water heaters over higher efficiency insulation,[21] and higher efficiency air conditioners over higher efficiency insulation.[22] When the means of the other measures were compared against each other, the results were not significant.

Table 6-19: Anticipated Use of Alternative Features – Given that Not All Four of the Features Included in Prescriptive Package D are Likely to be Used

Likely use of Individual Measures not Listed in the Updated Prescriptive Package D, Given that all Four will not be Used Together.	**Average** *Std Error* *Sample Size*
Higher Efficiency Water Heater	**3.85** *(0.16)* *n=48*
Higher Efficiency Central Air Conditioner	**3.74** *(0.17)* *n=47*
Higher Efficiency Furnace	**3.48** *(0.17)* *n=48*
Increase Insulation Levels	**3.35** *(0.16)* *n=48*

Values are weighted means. Weighted standard errors are shown in parentheses.

The in-depth surveys found (and the telephone interviews support this) that builders are most likely to use higher efficiency windows to meet the more stringent requirements of AB 970. As mentioned previously, however, windows alone will not be enough to make a home comply under the new standards. Therefore, it is interesting to see the consultants' opinions of what other features builders will use in combination with more efficient windows to meet the new requirements. In order to investigate this, the other measures were examined to determine which combinations will most likely be used given the use of higher efficiency windows. The means and standard errors can be seen in Table 6-20. The consultants believe that builders are more likely to use higher efficiency water heaters over increased insulation.[23] Other results were not significant when using the difference of mean test.

[21] Significant at the 95% level.

[22] Significant at the 90% level.

[23] Significant at the 95% level.

Table 6-20: Likelihood of Use – Given that they will use High Performance Windows

Likely use of Individual Measures not Listed in the Updated Prescriptive Package D, Given that High-Performance Windows will be used.	**Average** *Std Error* *Sample Size*
Higher Efficiency Water Heater	**3.86** *(0.18)* *n=42*
Higher Efficiency AC	**3.76** *(0.19)* *n=41*
Higher Efficiency Furnace	**3.50** *(0.19)* *n=42*
Increase Insulation Levels	**3.36** *(0.18)* *n=42*

Values are weighted means. Weighted standard errors are shown in parentheses.

Furthermore, under AB 970 it will be necessary to use both high efficiency windows and HERS-certified sealed ducts, or one of these measures in combination with several other measures not included as part of Prescriptive Package D, in order to meet the new standards. Interestingly, 20 consultants (36%) believe that builders will use both high efficiency windows and HERS-certified sealed ducts to meet compliance (ratings for each between 3 and 5).

On the other hand, none believed that builders would use HERS-certified sealed ducts without higher efficiency windows, and 18 (33%) believe that higher efficiency windows will be used without HERS-certified sealed ducts. As explained previously, if high efficiency windows are used without HERS certified sealed ducts, other measures must also be used for the home to comply. Therefore, the following analysis restricts the observations to those who rated the likelihood of using HERS-certified sealed ducts as a 1 or 2, high efficiency windows a 3, 4, or 5, and did not report it being likely that all four measures would be used together (not rated a 5). Table 6-21 shows the means and standard errors.

The consultants believe that builders are most likely to use higher efficiency water heaters and furnaces, less likely to use higher efficiency central air conditioning, and least likely to increase insulation levels. None of these results is significant, however.

Table 6-21: Likelihood of Use – Given that they will use High Performance Windows and Not Duct Sealing

Likely use of Individual Measures not Listed in the Updated Prescriptive Package D, Given that High-Performance Windows will be used, but Duct Sealing will not.	**Average** *Std Error* *Sample Size*
Higher Efficiency Water Heater	**3.96** *(0.20)* *n=26*
Higher Efficiency Central Air Conditioner	**3.80** *(0.26)* *n=25*
Higher Efficiency Furnace	**3.96** *(0.20)* *n=26*
Increase Insulation Levels	**3.35** *(0.25)* *n=26*

Values are weighted means. Weighted standard errors are shown in parentheses.

Barriers to Meeting the More Stringent Requirements of AB 970

It is predicted that AB 970 will have a large impact on builders' practices. In an attempt to capture the relative impact of various changes, the Title 24 consultants were asked how difficult they think it will be for the builders to adapt to individual changes incorporated in AB 970. Responses were given on a scale of 1 to 5, with one representing "Not Difficult" and 5 representing "Very Difficult."

The consultants believe that sealed ducts and the increase in required documentation and inspection requirements will present the greatest difficulty for the builders (average 3.82 and 3.32). In fact, these two features are significant when compared to each of the other measures, and duct sealing is significant over the increase in required documentation.[24] In addition, higher efficiency heating is seen as being more difficult to adapt to than higher efficiency cooling and mandatory duct construction.[25] Understandably, the consultants do not believe that installing TXV valves and having them certified will present as much difficulty as the HERS-certified sealed ducts. TXV valves are inexpensive and, although certification is required to receive the credit, this process would already be occurring if builders were using the certified sealed ducts credit. Therefore, the likelihood of using the credit for TXV valves should closely match that of certified sealed ducts.

[24] Both results are significant at the 95% level

[25] Significant at the 90% level.

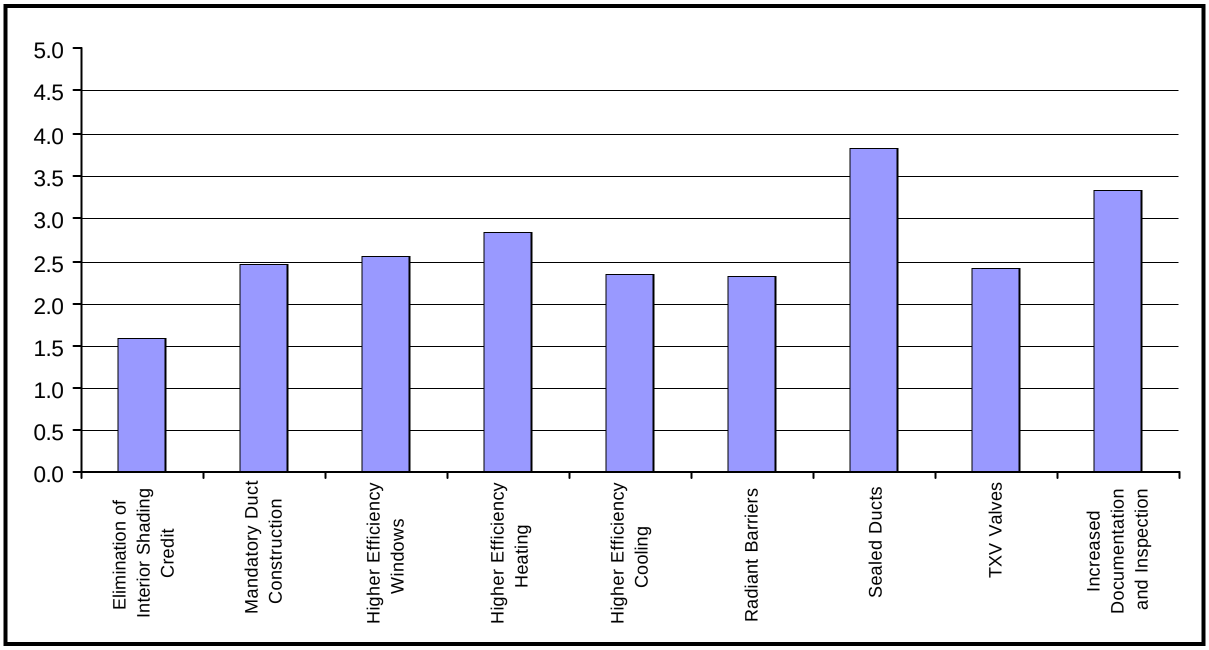
Similar to the in-depth survey results, the consultants do not believe that builders will have a difficult time adapting to the elimination of the interior shading credit. In fact, results for this question show that the assumed level of difficulty for this measure is significantly lower than for all other measures. Table 6-22 presents the means and standard errors of the consultants' responses to these questions, while Figure 6-3 illustrates these mean responses.

Table 6-22: Perceived Difficulty for Builders to Adopting Changes

In your opinion, how difficult will it be for the builders to adapt to the following? Answer using a scale of 1 to 5 with 1 representing Not Difficult and 5 being Very Difficult.	**Average** *Std Error* *Sample Size*
Elimination of Interior Shading Credit	**1.59** *(0.16)* *n=54*
Mandatory Duct Construction	**2.45** *(0.17)* *n=54*
Higher Efficiency Windows	**2.56** *(0.14)* *n=55*
Higher Efficiency Heating	**2.82** *(0.12)* *n=55*
Higher Efficiency Cooling	**2.35** *(0.14)* *n=55*
Radiant Barriers	**2.32** *(0.16)* *n=54*
Sealed Ducts	**3.82** *(0.17)* *n=55*
TXV Valves	**2.41** *(0.18)* *n=53*
Increased Documentation and Inspection Requirements	**3.32** *(0.20)* *n=55*

Values are weighted means. Weighted standard errors are shown in parentheses.

Figure 6-3: Perceived Difficulty for Builders to Adopting Changes



Recommendations for Effective Utility Assistance

Recommendations as to how the electric/gas utilities can most effectively assist the builders, Title 24 consultants, and other compliance industry professionals in meeting the AB 970 Standards are in keeping with recommendations offered during the in-depth interviews. Table 6-23 is an inclusive summary of responses given by the consultants and shows that providing more information is the dominant response.

Table 6-23: Recommendations for Assisting with AB 970 – In-Depth Interviews

Recommendation	Number of Consultants
Provide more information on the utility sponsored programs	5
Provide more training and education	31
Offer rebates	9
Provide more hers raters	4

Note: One consultants interviewed as part of the telephone surveys and four interviewed as part of the in-depth surveys mentioned the necessity of increased enforcement by building inspectors during this line of questioning. They all stated that without increased enforcement, the new standards will not have the desired effects because builders will not meet the requirements unless they feel they will be punished if they do not.

Additional Requirements

The Title 24 consultants also offered several suggestions for energy efficiency features for residential new construction that they would have liked to see included in the new standards. Table 6-24 shows these suggestions and the frequency with which they were suggested.

Table 6-24: Suggestions for Additions to AB 970 – In-Depth Interviews

Suggestion	Number of Consultants
Offer credits for high efficiency air conditioning systems	3
Offer credits or high efficiency lighting	3
Offer credits for solar	4
Offer credits for overhangs	2
Tighten natural gas requirements	2
Tighten window requirements	1
Make low-E windows mandatory in coastal regions	2
Require more insulation	1
Offer credit for point of use power generation	1
Offer credits for thermal mass	1

Effect of AB 970 Requirements on RNC Programs

In keeping with the in-depth survey results, only four consultants offered any insight into how AB 970 might affect RNC programs. One consultant believes the new standards will increase the use of the programs, another two stated that AB 970 makes creating and maintaining new programs difficult, and one believes that implementation of the new Standards will not have much affect on RNC programs. When asked about the effect of AB 970 on new home programs, consultants who had been interviewed in depth and who were qualified to answer merely stated that the programs would need to be updated or dropped completely.

One consultant interviewed in depth believes that AB 970 may encourage builders to participate in a program because, once the new standards are met, the additional measures needed to meet program requirements are not that significant.

> *"AB 970 shouldn't affect their residential programs much, in fact new standards may actually encourage builders to participate in programs since the % above*

standards they will have to achieve will be less. Thirty percent MEC (the current ENERGY STAR requirement) is roughly equivalent to 25% better than Title 24. With AB 970 changes, 30% MEC will probably be about 10-15% better than Title 24. Builders may be more willing to go the extra mile because it doesn't take much effort to do so."

General Comments

The consultants were next given the opportunity to add final comments regarding the new standards. The comments are presented in Table 6-25 along with their counts.

Table 6-25: General Comments on AB 970 – In-Depth Interviews

Comment	Number of Consultants
Increase the flow of information	4
Increase promotion of the RNC programs	4
Offer more credits	1
Promote solar design	1
It will be difficult to get builders to comply	1
It will result in better buildings being built	1
Enforcement needs to increase	1
Duct testing should be mandatory	1
Low-E windows should be mandatory	2
The maximum shading SHGC is really hard to comply with on east and west side orientations	1
The new requirements are a good thing	2
Makes it more difficult to use the prescriptive packages	1

6.6 Residential New Construction Programs

Awareness and Participation

The Title 24 consultants were asked to rate their familiarity with various RNC programs, including ENERGY STAR and the programs sponsored by California utilities, on a scale from 1 to 5, with 1 meaning "Not at all Familiar" and 5 meaning "Very Familiar." The means and standard errors are shown in Table 6-26. As shown, the consultants are most familiar with the Comfort Home ENERGY STAR programs, although they do not rate themselves as being very familiar with any.

Table 6-26: Average Familiarity of RNC Programs

How knowledgeable are you of the following new construction energy efficiency programs? Answer using a scale of 1 to 5 with 1 representing Not At All Knowledgeable and 5 being Very Knowledgeable.	**Average** *Std Error* *Sample Size*
Comfort Home	**3.40** *(0.18)* *n=54*
ComfortWise	**1.70** *(0.14)* *n=53*
Energy Advantage	**1.60** *(0.12)* *n=53*
ENERGY STAR	**3.02** *(0.19)* *n=53*

Values are weighted means. Weighted standard errors are shown in parentheses.

Not surprisingly, when taken in the context of the previous question, the consultants' self-reported participation in the various programs is extremely low. Table 6-27 presents the means and standard errors.

Table 6-27: Percent of Homes Participating in RNC Programs

What percentage of the homes for which you provided a compliance analysis within the last year participated in these programs?	**Average** *Std Error* *Sample Size*
Comfort Home	**5.9%** *(1.33)* *n=50*
ComfortWise	**2.6%** *(0.85)* *n=50*
Energy Advantage	**3.3%** *(1.27)* *n=50*
ENERGY STAR	**3.5%** *(0.95)* *n=50*

Values are weighted means. Weighted standard errors are shown in parentheses.

The results from the in-depth interviews exhibited more familiarity with the various programs. Seven consultants reported being at least somewhat knowledgeable about at least one of the utility-sponsored new construction programs. Five of these consultants feel equally knowledgeable about each program, while the remaining two felt that they know more about the programs in their area. While most of the consultants are knowledgeable about the programs, only five have performed compliance analysis for homes that qualify for one of the programs. Of the five, two have participated in the ComfortWise program, two with the Comfort Home program, three with Energy Advantage, and two have participated in the ENERGY STAR program.[26]

Barriers to Participating in RNC Programs

Since participation in RNC programs has not been great, the consultants were asked for their opinions on barriers to participation and for recommendations on increasing participation. The consultants were first presented with a list of possible barriers to program participation. They were then asked to rate each on a scale from 1 to 5, with 1 meaning “Not Significant” and 5 meaning “Very Significant.” The means and standard errors are presented in Table 6-28. As shown, each item was rated as being a fairly significant barrier. The largest barrier was found to be insufficient incentives (4.03). The smallest barrier was the volume of required documentation (2.64).[27]

[26] Of the five, one consultant reported performing compliance analysis for at least a few homes in each of the four programs, while another reported participating in two programs.

[27] Significant at the 95% level.

Table 6-28: Average Significance of Barriers to Participation in Programs

How significant of a barrier are each of the following to builders participating in the RNC New Construction Programs? Answer using a scale of 1 to 5, with one meaning Not Significant and 5 meaning Very Significant.	**Average** *Std Error* *Sample Size*
Complex Documentation	**3.19** *(0.25)* *n=23*
Volume of Required Documentation	**2.64** *(0.28)* *n=21*
Required Verification Process	**3.48** *(0.26)* *n=22*
Insufficient Incentives	**4.03** *(0.19)* *n=22*
Not Cost-Effective	**3.31** *(0.31)* *n=21*

Values are weighted means. Weighted standard errors are shown in parentheses.

To gain more insight into the reasons for nonparticipation, the consultants were also asked their opinions on other barriers to participation. Of the 12 consultants who offered suggestions, six said lack of education/information and training was a barrier, three said cost, one said the short-term nature of the programs, and one stated that the utilities need to "be ahead of the architects and builders to let them know what they would like." In addition, one consultant specified that a marketing effort should be directed at builders because participation in the programs is "in their hands."

Similarly, when the consultants were asked for suggestions on how to improve participation in the programs, six consultants suggested increased information and communication, one suggested that the utilities provide long-term project agreements and reduced paperwork involved in the inspections, and three suggested that the utilities offer more rebates.

In the in-depth interviews, the consultants also felt that the largest barrier to participating in the RNC programs is lack of knowledge. Moreover, they cited the cost involved in participating and the amount of paperwork required. Specifically, one consultant who is knowledgeable about several programs mentioned that he has tried to find more information about the ENERGY STAR program, but has been unable to locate much.

7

Builders

7.1 Overview

Initially, 12 builders were contacted to participate in the in-depth portion of this study. They were asked questions concerning their perceptions of Title 24 requirements and the use of credits offered under the Standards, interactions with building departments, perceptions of the new AB 970 requirements, and perceptions of the residential new construction (RNC) programs. After completing the in-depth surveys, it became clear that builders of single family attached and multifamily buildings were significantly underrepresented in the sample. Therefore, a concentrated effort was made to complete five additional in-depth surveys focusing on such builders.[1] Due to their potentially unique equipment installation practices (multifamily builders are assumed to build rental units),[2] questions regarding installation practices were extended and refined to focus on the individual units and common areas of the complexes in question. In addition, a section focusing on the attendance and value of CBIA training sessions was added to the survey instrument. Care was taken to ensure that the remainder of the survey remained as close to the original as possible so as not to compromise the results.

The remainder of this section is organized as follows. Single family and multifamily builders' responses are presented together unless otherwise noted in the text.

- Summary of Important Findings
- General Builder Information
- Title 24 1998 Low-Rise Residential Standards
- Interaction with Building Departments
- AB 970 Revision of Standards
- Residential New Construction Programs
- High Potential Areas of Energy Savings.

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1 The breakdown of these five builders consisted of two who build both single family attached and multifamily homes, two who build single family attached homes, and one who builds multifamily homes.

2 We have assumed that single family detached and single family attached homes are owner-occupied, whereas multifamily homes are rental units. These assumptions were made on the basis that builders are unaware of the occupancy of the units, but build with these assumptions in mind.

7.2 Preview of Key Findings

Several important findings were discovered during the in-depth builder surveys. These findings are presented briefly here and discussed more fully later in this section.

Findings Related to AB 970

Builders are not generally familiar with the AB 970 requirements. Ten builders reported that they are unfamiliar with the new AB 970 Standards. Four said that they are somewhat familiar and three said that they are very familiar with the new Standards.

Builders were generally unable to answer the question regarding the impact of the AB 970 Standards on the RNC programs. Due to a lack of knowledge about AB 970, most builders were not comfortable answering questions relating to the impact of the AB 970 requirements on existing RNC programs.

High performance windows will most likely be used to meet the more stringent requirements. The vast majority of builders mentioned that they will most likely use higher performance windows to comply with the new Standards.

General Findings

Builders are not generally familiar with the Title 24 Standards. Seven builders admit that they are not at all familiar with the 1998 Title 24 Low-Rise Residential Standards, seven say they are somewhat familiar with them although unaware of the specifics, and only three are very familiar with the Standards.

Compliance issues are usually handled by a Title 24 consultant. Lack of in-depth knowledge of the Standards reflects the fact that builders do not give much thought to the Standards and, instead, pass the responsibility on to a Title 24 consultant. In general, the builders view compliance as something that needs to be done, but not something that requires much, or any, effort on their part.

Water heaters are typically seen as the feature that can be modified most easily to get marginal homes to comply. This was mentioned by both single family and multifamily builders.

Credits offered under Title 24 are not generally used. Three builders cited that the current housing market is so strong that it is not necessary to offer energy efficiency as a selling point, and that using the various credits takes time and slows down production. Two builders mentioned that it is not cost-effective to use the credits since “the gains are miniscule.” Four builders said they are unfamiliar with the credits.

Findings Specific to Single Family Attached and Multifamily Builders

Multifamily builders are less willing to invest in energy efficient equipment. The primary differences discovered between single family attached and multifamily builders are that multifamily builders are not as concerned with occupant comfort because they are building rental units. They are more concerned with initial cost because it will not be picked up by the resident of the unit.

Single family attached and multifamily builders are not generally aware of the Title 24 Standards. Similar to findings from single family detached builders, single family attached builders and multifamily builders are relatively unaware of 1998 Title 24 and AB 970 Standards.

Miscellaneous Findings. Single family attached and multifamily builders do not make use of the credits offered under Title 24, are unaware of the AFUE levels of the furnaces they install, use higher efficiency water heaters to make marginal homes to comply, and are likely to use higher efficiency windows to avoid the necessity of using a HERS rater.

7.3 General Builder Information

The builders were first asked several questions regarding their background in order to discern whether they were appropriate candidates to participate in the survey.

Respondents' Title and Duties

It was discovered through this screening process that the respondents have been with their companies from two to 20 years, have varying titles including Owner, General Superintendent, Purchasing Agent, Operations Manager, Project Manager, Vice President, Designer, Vice President of Operations, and President, and have responsibilities that depend on their particular position, but include the following:

- Bidding,
- Contract negotiations, and
- Equipment procurement.

When the builders were asked whether their duties include making final decisions about design features and the selection and procurement of equipment, the vast majority explained that final decisions are generally made by a team, but they are a part of such a team. In addition to the respondents, the teams typically include architects, engineers, designers, and a high-level executive.

Builder Information

The builders contacted built between 50 and 1,610 single family homes in 2000, with an average of 431. Of those who built single family homes, 10 predominantly built tract homes and one predominantly built custom homes. Seven were concentrated in Southern California, four in Northern California, three in Central California, and two worked throughout the state.

7.4 Title 24 Low-Rise Residential Standards

The builders were next asked several questions regarding their opinions and practices regarding the Title 24 requirements to see how implementation of the 1998 Standards affected their building practices.

Awareness

When the builders were asked how familiar they are with the 1998 Title 24 Low-Rise Residential Standards, seven admitted that they are not at all familiar with them, seven said they are somewhat familiar with them although unaware of the specifics, and only three claimed to be very familiar with the Standards. One possible interpretation of these responses is that the appropriate individuals were not interviewed, however, this is not the case. Instead, this lack of in-depth knowledge of the Standards reflects the fact that builders do not give much thought to the Standards because they pass the responsibility of compliance issues on to a Title 24 consultant. In general, the builders view compliance as something that needs to be done, but not something that requires much or any effort on their part.

General Compliance Procedures

Compliance Process

All but two builders use Title 24 consultants for compliance analysis. Of the two who do not, one relies on a team composed of architects and area managers and one relies on an engineer. As explained above, the compliance process is usually taken care of after the plans have been drawn. Typically, the Title 24 consultant makes the necessary calculations and establishes what, if anything, needs to changed in order for the home(s) to meet the requirements. One builder who is very familiar with Title 24 requirements explained that her Title 24 consultant knows what the purchasing agent wants and what will be installed as far as equipment is concerned, and uses these specifications in the compliance calculations. She explained that the consultant does have some leeway to require higher efficiency equipment on marginal homes, but overall does not have much discretion regarding equipment specifications. Interestingly, water heaters are typically seen as the feature that can be modified most easily to make marginal homes to comply. This was mentioned by both single family and multifamily builders.

Striving to Exceed the Standards?

In order to gain an idea of the builders' opinions and attitudes towards energy efficiency, they were asked about their general building philosophy regarding Title 24 requirements. When single family builders were asked whether they strive to meet the requirements or exceed them, all five explained that they always try to exceed the Standards as a selling feature.[3] One single family builder specified that it depends on the type of the home because, typically, higher end homes will surpass the Standards while lower end homes just meet them. When probed as to what features they typically use to exceed the Standards, the builders said that higher efficiency windows are the most common means of surpassing the requirements. Heat pumps, better insulation, and zoning were also mentioned.

Multifamily builders, on the other hand, do not generally try to exceed Title 24 requirements. This is because, for multifamily homes, there is no marketing advantage accruing to rental units from exceeding the Standards. One multifamily builder explained, however, that although her company only tries to meet the Title 24 Standards, they usually exceed them because the Standards are not difficult to pass.

Interaction with Title 24 Consultants

Builders were next asked whether more interaction with their consultants has been necessary since the implementation of the 1998 Standards. In keeping with previous information gathered from these builders, they stated that interactions with their consultants have not increased—the plans are simply passed on for the consultant to work with and make the necessary calculations for the home(s) to pass. One builder, however, stated that he has always had a great deal of interaction with his consultant.[4]

Barriers to Compliance with the 1998 Standards

None of the builders reported any difficulties in meeting the 1998 Standards aside from the increased costs involved. One multifamily builder explained that increased cost is particularly problematic for multifamily homes because "project budgets are smaller and such residences are entry-level products where low cost is particularly important."

Similarly, when asked how implementation of the 1998 Standards has affected their building practices, the builders explained that their building practices have changed very little due to the new Standards. Higher efficiency equipment, especially windows, is sometimes necessary now but no significant changes have been required. One single family home builder, however, did say that she is sometimes forced to use 12 SEER air conditioning systems and duct testing on marginal homes. When asked what the most difficult barriers

[3] Due to changes in the survey instrument, the other builders were not asked this question directly.

[4] This question was not asked of the five multifamily builders.

were to overcome with respect to the 1998 Standards, four single family builders and one multifamily builder mentioned glazing areas, while one cited large homes and high ceilings.

Installation Practices/Use of Measures (Credits) for Single Family Homes

The next series of questions focused on builders' installation practices and their use of the credits offered under the 1998 Title 24 Standards for the installation of energy efficient equipment. Due to significant changes made to the survey instrument to capture an in-depth knowledge of single family attached and multifamily builders' installation practices, these results are split into two sections. This section discusses the findings as related to single family homes, and the following section discusses the results for single family attached and multifamily homes.

Furnaces

Surprisingly, only one out of five builders[5] was knowledgeable about the AFUE level of furnaces that are typically installed in new homes. This builder typically installs 80% AFUE furnaces.

Air Conditioners

All five builders who were asked what SEER level of air conditioning system is typically installed responded that they typically install 10 SEERs unless a 12 SEER air conditioning system was necessary to meet Title 24 requirements on marginal homes. One builder qualified his answer by explaining that it depends on the size of the home.

Water Heaters

Interestingly, only one builder knew the efficiency level of water heaters typically installed. Two did not know and two allow the Title 24 consultant to determine the necessary efficiency in order to comply with the Title 24 requirements. Conversely, the builders are aware of whether their company installs water heater blankets. Of the five builders that were asked, two builders automatically install them while three do not.

Windows

All of the builders install some variety of energy efficient windows by default, although the exact specifications vary. Specifically, five builders typically install dual-paned vinyl-framed windows, four install dual-paned metal-framed windows, and three install low-E windows.

[5] Due to changes in the survey instrument, the following installation questions were asked only of five builders where noted.

Ducts

Four builders have the ducts in the homes they build sealed/tested at least some of the time. Two builders always have them tested, one has his homes tested randomly, and one tests only marginal homes. The remaining four builders do not seal or test the ducts in their homes.

Insulation

The level of insulation typically installed varies by builder. However, it was found that walls are insulated with lower R-values than ceilings.

Other Features

The following table shows that higher than standard duct insulation is typically used, while radiant barriers and housewrap are not.

Table 7-1: Use of Features

Feature	Typically Used	Typically Not Used
Radiant Barriers	1	4
Duct Insulation >4.2	5	0
Housewrap	0	5

Use of Credits Offered under Title 24

The in-depth interviews made it clear that the builders do not use Title 24 credits as standard practice. Five builders stated that they only use the credits if they are told by the Title 24 consultant that it is necessary, which rarely happens. Three builders cited that the current housing market is so strong that it is not necessary to offer energy efficiency as a selling point, and that using the various credits takes time and slows down production and are therefore not cost-effective. Two builders mentioned that it is not cost-effective to use the credits since "the gains are miniscule," while another four builders said they are unfamiliar with the credits. One builder said that the various features associated with the credits are offered to clients as options, but that they are not generally desired.

When asked which of the credits are the most cost-effective, one builder responded that the radiant barrier and zonal systems credits were the most worthwhile, while another builder cited the HVAC and windows credits. The other builders did not offer any insight.[6]

[6] This question was only asked of the builders who indicated using the credits.

Installation Practices/Use of Measures (Credits) for Single Family Attached and Multifamily Homes

Use of Central Systems

The single family attached and multifamily builders were next asked a series of questions regarding their use of central systems as opposed to individual units. They were first asked about central heating and cooling systems. The three builders who build multifamily homes (apartments) used individual heating and cooling systems in each unit built during 2000. Of the three builders who built single family attached homes during 2000, two installed individual heating and cooling systems in each unit, while one used central systems.

Regarding water heaters, one multifamily (apartment) builder used central water heaters, while the other two used individual water heaters in each unit. The single family attached builders all used individual water heaters in each unit.

HVAC Systems

Similar to findings for single family builders, no single family attached or multifamily builders were aware of the AFUE levels of furnaces that are typically installed. When questioned about the SEER level of central air conditioning systems typically installed, one builder said that he always installs 10 SEER and four said they install either 10 or 12 SEER depending on the size of the residential unit.

Water Heaters

When the single family attached and multifamily builders were asked how they determine the efficiency level of water heaters that are typically installed, three said they install the minimum needed to meet Title 24 requirements, one added that the ComfortWise requirements also come into play, one said that it depends on the proximity of the plumbing fixtures, and one did not answer. None of the single family attached and multifamily builders installs water heater blankets.

Windows

Regarding windows installed during 2000, four builders stated that they install dual-paned windows with aluminum frames and one said he uses aluminum frames with low-E glass. All five said that they occasionally use vinyl frames if needed to meet compliance, but do not generally use them. One builder did say that the type of windows installed depends on the climate zone, and one said that it depends on the noise level of the street where the building is located. However, there was no difference between single family attached or multifamily homes.

Ducts

Three builders have the ducts on all of their homes sealed and tested, with one specifying that it is required by his insurance company and one explaining that it is required by the ComfortWise Program. The remaining two builders said that their companies install tight duct systems but do not have them tested.

Insulation

Interestingly, all five builders said that they use an insulation level of R-13 in the walls and R-19 in the ceiling. There was no difference in insulation levels between single family attached and multifamily homes.

Other Measures

None of the builders uses radiant barriers. One builder, however, said that he was looking into using them. Similarly, only one builder uses duct insulation with an R-value greater than 4.2. Two of the four builders use housewrap on the single family attached and multifamily homes they build.

Appliances

All five builders install refrigerators and dishwashers in the homes they build. Two builders install the most efficient equipment they can obtain from their suppliers, one installs the minimum acceptable level, and two said that efficiency is not even a consideration in the procurement of the appliances that are installed.

Lighting

The three builders who build single family attached homes install compact fluorescent lamps (CFLs) in the kitchens and bathrooms, while the two who build multifamily homes do not.

Common Areas of Multifamily Homes

The single family attached and multifamily builders were next questioned about the equipment installed in the common areas of complexes. Two builders explained that there were no common areas and hence were not asked these questions. The three builders who answered said that they do not hardwire for compact fluorescent lamps (CFLs) in hallways, garages, or laundry rooms, and none knew if the washing machines installed in the laundry facilities were energy efficient, but did not think so.

Use of Credits

None of the single family attached and multifamily builders was aware of or used any of the credits available under Title 24. All of the multifamily builders stated that there was no need for using the credits because meeting the Title 24 requirements is not difficult.

Reasons for Over/Under Compliance

The builders were next asked a series of questions that attempted to indirectly ascertain the reasons why some "as built" homes do not comply with the Title 24 requirements.

Building Shell

Builders were first asked how often design changes are made to the building shell after the building permit has been granted. Eleven of the single family builders said that such changes occur very rarely. Two builders, however, said that such changes are made often. Interestingly, all five of the single family attached and multifamily builders said that design changes happen frequently. Five builders say they contact the Title 24 consultant so these changes can be incorporated into the compliance documentation, while one builder says that his company does not bother to update the plans.

The builders who stated that design changes are made said that these are random changes (i.e., cabinet location, hard floor vs. carpeting, wall positioning, or the addition or deletion of an entire home from the development) that rarely have an impact on Title 24 compliance.

Equipment

When asked about how equipment is specified on the plans, 10 builders say that features are only generically specified while three say the plans indicate exactly what will be installed to the level of make and model number. Those who only generically specify equipment on the plans said that they do so because they take competitive bids from manufacturers, have national agreements with manufacturers that vary, and/or base the decision on cost and availability. In addition, two builders said that they generally install higher efficiency equipment than specified on the plans in order to ensure compliance, and one builder explained that it depends on city codes as well as area demands,[7] the requirements of national arrangements with various equipment manufacturers, and whether he believes there is a marketing advantage to be gained.

Of the five single family attached and multifamily builders, three said that the equipment installed exactly matches what is indicated on the plans, while the other two said that it either exactly matches or exceeds what is specified on the plans. These answers held for both

[7] He uses higher efficiency equipment in desert areas.

single family attached and multifamily homes, as well as for air conditioners, furnaces, and windows.

Reasons for Over Compliance

When the builders were asked for their insights as to why some houses exceed the Standards by 20% or more, their responses fell into two categories: miscalculations by the Title 24 consultant and perceived marketing advantages on the part of the builder.

Several builders answered this question based on their own experiences. For example, one builder explained that although his company typically installs higher than required efficiency equipment to ensure homeowner satisfaction and comfort, he rarely takes credit for it with respect to compliance. He explained that the extra cost involved with installing higher efficiency equipment is made up for by the reduced costs in the customer service department; installing higher efficiency equipment results in far fewer comfort problems and, therefore, far fewer complaints by homeowners. Similarly, one builder explained that it is sometimes difficult to purchase exactly what is specified on the plans, so they install higher efficiency equipment. He also stated that this provides a marketing advantage.

In addition, one builder suggested that builders are fairly uninformed regarding Title 24 requirements and, therefore, completely rely on their Title 24 consultants. The Title 24 consultant, in an effort to protect himself or herself, recommends installing higher efficiency equipment than necessary to ensure compliance—"it provides a margin of cushion."

The single family attached and multifamily builders offered additional suggestions as to why some homes may exceed compliance. These include supervisors taking an active role in monitoring the contractors, miscalculations on the plans, participation in the utility programs, and obtaining a marketing advantage arising from the fact that energy is expensive.

Reasons for Non-Compliance

When builders were asked why some homes do not meet the compliance requirements, several mentioned negligence on the part of the contractors. Additional suggestions offered by the builders were that the inspectors do not check the homes closely enough and that the engineering was not done properly upfront.

One builder suggested that unless the design changes dramatically, the only reason for non-compliance would be that the equipment specified on the plans is not what is eventually installed. Another builder believes that non-compliance is intentional because builders are trying to cut costs and do not believe that compliance is enforced. Additionally, one builder believes it is most likely a problem with the plans.

The single family attached and multifamily builders added lazy builders, damaged duct systems, and non-efficient equipment to the list of reasons why some homes do not comply.

7.5 Interaction with Building Departments

This section focuses on the relationship of the builders with the various building departments and the building departments' role with regard to compliance issues.

All of the builders reported that building departments play a very limited role, if any, in the design phase relating to compliance issues. Additionally, the builders do not believe building departments should play a role in promoting energy efficiency. Five builders believe that building departments are so busy that they will never be able to play a role in promoting energy efficiency.

Although the builders do not believe that building departments play a role in promoting energy efficiency, all but one believe building departments are generally fairly knowledgeable and diligent about compliance issues, with four specifying that it depends upon the department in question. The one dissenting builder believes building departments are not at all knowledgeable and, in fact, are negligent when it comes to compliance issues.

Only one multifamily builder reported having any interaction with building departments. He reported that building departments are extremely uninformed about compliance issues, but are fairly diligent about inspection as long as everything is laid out clearly for them.

7.6 AB 970 Revision of Standards

The next series of questions centered around the AB 970 Standards. The builders were first asked about their awareness of the new Standards and then how they believe these new Standards will affect their building practices.

Awareness

When asked how familiar they are with the emergency revisions, ten builders say they do not know anything about the new AB 970 Standards, two say that they have heard a lot about them but do not know the specifics, and one says that he is very familiar with the new Standards. All five single family attached and multifamily builders reported being somewhat familiar with AB 970 Standards.

If the builder in question admitted to not being familiar with the Standards, the interviewer read a short script summarizing the background of and major revisions to the Standards. The builder was then asked hypothetical questions regarding possible changes in building practices due to the upcoming implementation of the new Standards.

Due to the general lack of knowledge about AB 970, most questions in this section of the survey could not be answered in an informed way and the builders were, for the most part, unwilling to put forth an uneducated opinion.

Opinions about New Requirements/Measures for Single Family Detached Builders

Required Use of a HERS Rater

One builder replied that he was not opposed to using the options requiring HERS certification provided that doing so would not hold up the sale of the home or increase his carrying cost. Similarly, two builders said that, although they are not opposed to testing per se, they believe that the process must be made more economical. They both recommended spot or random testing.

Anticipated Use of Alternative Features

When asked which measures they were most likely to use to meet the performance criteria, three builders said the least-cost option. They elaborated by saying this would most likely be an increase in insulation together with higher efficiency windows. One builder went a step further by saying his next choice would be to install higher efficiency water heaters. Another builder said he would use high performance windows and duct testing.

Opinions about New Requirements/Measures for Single Family Attached and Multifamily Builders

Radiant Barriers

When the single family attached and multifamily builders were asked their opinions on the requirement of installing radiant barriers, one said that he was "not too worried," one thinks they are a "neat product," and three had concerns about the price. One also worried about availability.

Required Use of a HERS Rater

The builders were next asked about the requirement of having HERS-certified sealed ducts and TXV valves. One builder was already using HERS raters and would not be affected, one does not have a problem with using a third party rater, but the other three are opposed to the option. These three builders said they are likely to install higher efficiency windows to avoid the requirement of HERS certification.

When asked how the HERS rating process can be made easier, one builder suggested that there be only one test for the entire project, one said that the process needs to be accelerated, one said it is okay the way it is, and one did not have any suggestions.

Use of Alternative Features

The single family attached and multifamily builders were next asked which measures, in addition to sealed ducts and high efficiency windows, they are likely to use when the new requirements go into effect. One said that he is likely to increase the insulation level or use higher efficiency central air conditioners, one said that it will be an economic decision but would not elaborate, and three said that they are already meeting the new requirements.

Other Issues

The builders were next asked what they perceive to be the largest barrier to meeting the new Standards. The builders responded that the HERS rating process and lack of information will be the primary barriers to meeting the new requirements.

As expected, when the builders were asked if they anticipate accelerating their projects through the permitting process in order to beat the implementation deadline, three said yes and two said it was not applicable because they were already meeting the requirements.

7.7 Residential New Construction Programs

The focus of the survey shifted to awareness of and participation in RNC programs.

Awareness and Participation

The builders were first asked how familiar they are with the RNC programs. Six of the single family detached builders said that they are not at all familiar with the RNC programs. One said he is somewhat familiar with ComfortWise, two are familiar with the Comfort Home Program, and two are somewhat familiar with ENERGY STAR. One builder had limited participation in the ComfortWise program several years ago, but has not kept current with requirements due to company downsizing. Two builders participated in the Comfort Home Program in the past.

Of the single family attached and multifamily builders, one participates in the ComfortWise Program and one is looking into participation in the ENERGY STAR program. The remaining three do not consider themselves to be knowledgeable about the programs.

Barriers to Participating

One reason builders gave for not participating in the programs is lack of time. They also stated that the programs are not a "marketing plus"—they do not help sell homes. In addition, two builders explained that they used to participate in the Comfort Home Program but there is no longer any benefit. In fact, these builders said that participation cost them a lot of money because incentives were cancelled and not enough effort was put into the program's promotion. In addition, the builders are generally opposed to rebates because they are forced to pay the money upfront and in many cases the programs are later cancelled, leaving the builders unable to recoup their investment. The reasons given for nonparticipation were the same for both single family and multifamily builders.

When asked their opinions on how to increase participation in the RNC programs, the builders say that the best ways to increase program participation is to increase monetary incentives and for the utilities to play a larger role during the design phase of homes.

7.8 Training

The single family attached and multifamily builders were asked if they attend CBIA training sessions. None reported attending.

7.9 High Potential Areas of Energy Savings

The final question asked builders their opinions of potential areas of energy savings. The builders' suggestions were limited. Of the suggestions offered, high performance windows were the most popular. Increased insulation levels and tighter ducts were also proposed. These suggestions were the same for single family attached, single family detached, and multifamily builders.

8

Compliance Analysis of Likely Building Practices Under AB 970

8.1 Introduction

Insofar as AB 970 does not become effective until January 2002,[1] the main sources of information on how builders and Title 24 consultants plan to meet the new standards are self-reported data from telephone surveys with Title 24 consultants. The analysis discussed in this section focuses on taking the self-reported information on likely changes in building practices and simulating these plans using the RNC Interface. The simulations will analyze whether builders can meet the new standards using their planned approaches.

This section summarizes the compliance methods used to meet the new Title 24 Standards, reviews the findings from the telephone surveys of energy consultants, and examines the impacts on compliance from the various measures builders are likely to use. Please note that only detached single family homes were used in this analysis.

8.2 Title 24 Consultants and Builder Interviews

As AB 970 has yet to be implemented, there is much conjecture as to which measures will be used in the performance-based method to meet compliance requirements. Preliminary discussions with Title 24 consultants and others involved in analyzing the impacts of AB 970 suggest that the performance method will continue as the preferred method of compliance. However, builders will need to go beyond their usual methods (e.g., high performance windows, high efficiency equipment) and adopt some of these new measures to make homes comply. The Title 24 and builder surveys were designed to collect this information and address which combination of measures are most likely to be used to meet the new compliance requirements. This section discusses the data collected from the telephone surveys of Title 24 consultants and builders.

[1] June 2001 is the official effective date. However, approved master plans are exempt until December 31, 2001.

Title 24 consultants were asked questions to determine what measures builders will likely use to meet compliance once AB 970 Standards are in effect. First, consultants were asked how likely they believe builders are to use each measure required by Prescriptive Package D. The consultants were then asked how likely they were to use four other measures to meet compliance. This is important since the more stringent requirements call for builders to implement several energy efficient measures at once if they choose not to use both low solar heat gain fenestration and HERS-certified sealed ducts.

Use of Features Included in Prescriptive Package D

Each consultant was asked how likely he/she believes builders will be to use the four methods required under AB 970. Responses were given on a scale of 1 to 5, with one representing "Not at all Likely" and 5 representing "Very Likely." As shown in Table 8-1, consultants feel that builders are more likely to use low solar heat gain fenestration (average 3.9) than other measures. In fact, Title 24 consultants feel that builders are significantly more likely to install low solar heat gain fenestration than TXV valves, radiant barriers, or HERS-certified sealed ducts. Additionally, 20 consultants reported that builders would be likely (rating of 3, 4, or 5) to use both HERS-certified sealed ducts and high performance windows.

Table 8-1: Likelihood of Use for Compliance under AB 970 – Features in Prescriptive Package D

	Average *Std Error* *Sample Size*
HERS Certified Sealed Ducts	**2.68** *(0.17)* *n =52*
TXV Valves	**2.27** *(0.20)* *n =50*
Better Windows (SHGC and U-Values)	**3.92** *(0.13)* *n =53*
Radiant Barriers	**3.18** *(0.18)* *n =53*
All Four Measures	**2.84** *(0.18)* *n =53*

Values are weighted means.

Use of Features not Included in Prescriptive Package D

As mentioned earlier, builders will likely use low solar heat gain fenestration to meet the more stringent requirements of AB 970. However, it is likely that higher efficiency windows alone will be insufficient to make a home comply under the new standards. Therefore, the team examined the consultants' opinions of what other features builders will use in combination with low solar heat gain fenestration. As shown in Table 8-2, the consultants believe that builders are most likely to use higher efficiency water heaters and/or air conditioners in combination with low solar heat gain fenestration.

Table 8-2: Likelihood of Use for Compliance under AB 970 – Given the use Low Solar Heat Gain Fenestration

	Average *Std Error* *Sample Size*
Higher Efficiency Water Heater	**3.86** *(0.18)* *n =42*
Higher Efficiency AC	**3.76** *(0.19)* *n =41*
Higher Efficiency Furnace	**3.50** *(0.19)* *n =42*
Increase Insulation Levels	**3.36** *(0.18)* *n =42*

Values are weighted means.

To meet the more stringent requirements of AB 970, builders will need to use both duct sealing and low solar heat gain fenestration, or one of these in combination with several other measures, to comply. Thus, the consultants' opinions regarding other features that will be used along with duct sealing were examined. Similar to the results above, Table 8-3 shows that the consultants believe builders are most likely to use higher efficiency water heaters and/or air conditioners along with duct sealing.

Table 8-3: Likelihood of Use for Compliance under AB 970 – Given the use HERS-Certified Sealed Ducts

	Average *Std Error* *Sample Size*
Higher Efficiency Water Heater	**3.69** *(0.35)* *n = 16*
Higher Efficiency AC	**3.69** *(0.28)* *n = 16*
Higher Efficiency Furnace	**2.75** *(0.30)* *n = 16*
Increase Insulation Levels	**3.38** *(0.27)* *n = 16*

Values are weighted means.

Summary of Findings from Title 24 Consultant and Builder Surveys

Data from the telephone surveys suggest that builders will likely use low solar heat gain fenestration to comply with the new standards. However, since installing low solar heat gain fenestration alone will be insufficient to comply with the new Standards, Title 24 consultants added that builders will likely install higher efficiency water heaters and air conditioners. Also, Title 24 consultants feel that builders are less likely to use duct sealing and TXVs—measures that require HERS certification.

8.3 Compliance Analysis

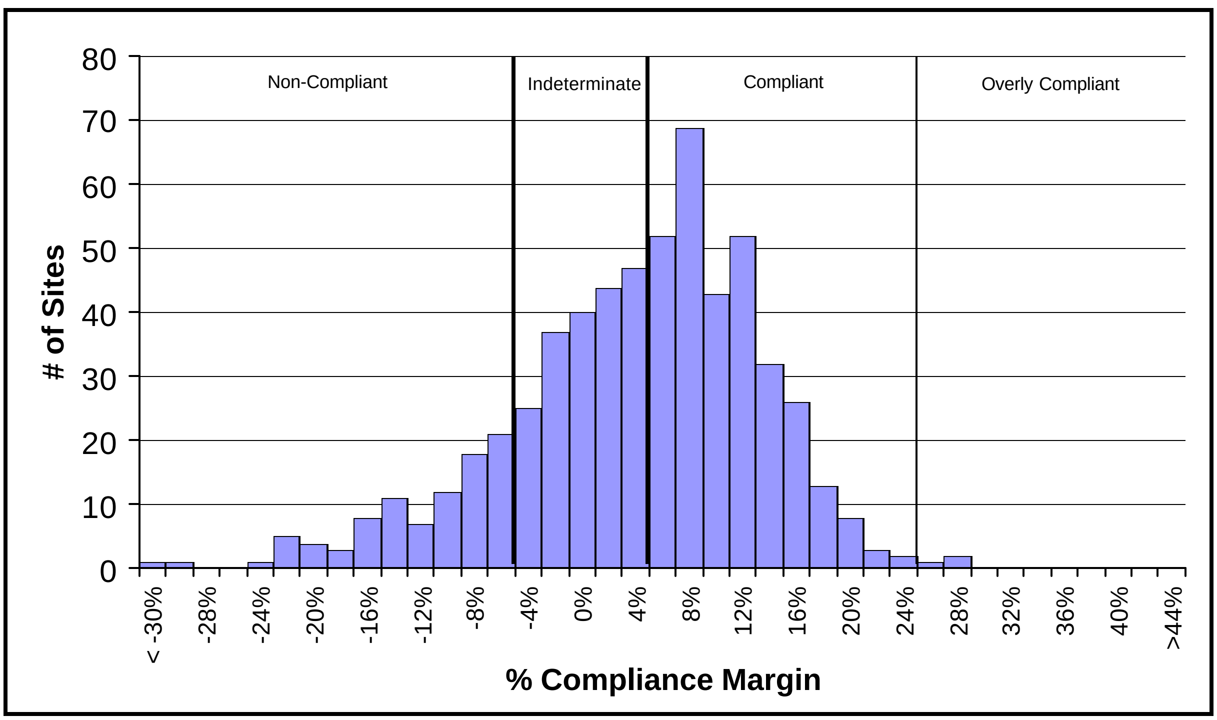
The survey findings provided a good qualitative assessment about what measures and combinations of measures the respondents think would work in meeting the more stringent Standards. The next logical step was to test their opinions and quantitatively evaluate which approaches would most likely comply. In particular, the following approach was used to test which, if any, of the planned approaches would result in a large percentage of homes meeting the Standards. First, on-site survey data for 800 newly constructed homes were used to test if the homes, as-built, would comply with AB 970. Next, taking advantage of the RNC Interface's flexibility, radiant barriers were globally implemented—meaning a radiant barrier was added to each home. After artificially adding this measure, the homes were again analyzed to determine if implementing this one measure would make the homes comply. This procedure was repeated for each remaining measure included in Prescriptive Package D: sealed ducts, low solar heat gain fenestration, and TXV valves. Next, using information collected during the Title 24 consultant interviews, a list of the most likely combinations of measures was developed. Each combination was globally implemented and the compliance results of each analyzed.

Development of the RNC Interface and the compliance results of each run are discussed below. . Please note that only detached single family homes were used in this analysis.

Compliance Results – 1995 Standards

To accomplish the Baseline Study objectives, detailed compliance analyses were performed using MICROPAS and data from 800 on-site surveys of newly constructed homes. The initial compliance analysis performed on these homes used the 1995 low-rise residential standards, since these homes were built between July 1, 1998 and June 30, 1999—before the 1998 standards went into effect. As shown in Figure 8-1, RNC Interface compliance analysis results indicate that 15.6% of detached single family homes built in the study period were non-compliant. Most homes, however, fell within the compliant group (51.0%) and 0.5% fell in the overly compliant group.

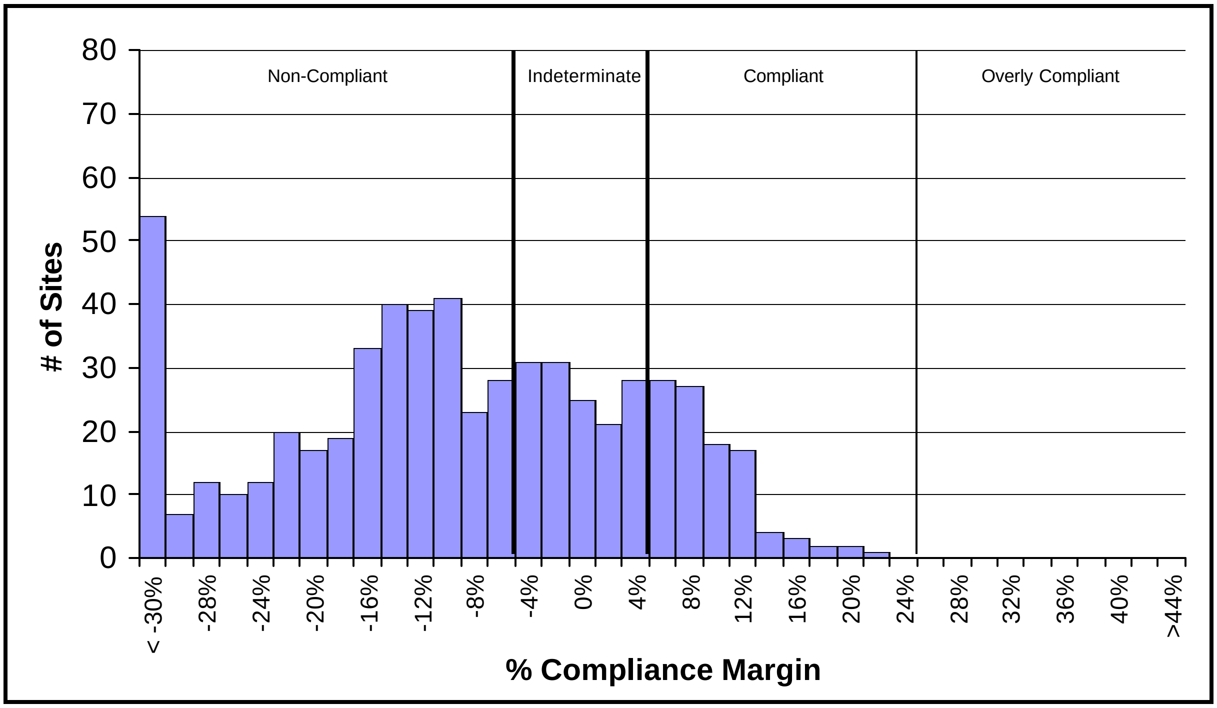
Figure 8-1: Compliance Results – 1995 Standards – As-Built



Compliance Results – AB 970 Baseline

To implement the measures required by Prescriptive Package D, the latest version of MICROPAS incorporating the new standards was used. Using the RNC Interface, compliance analysis was performed again for the as-built detached single family homes to provide a baseline. Table 8-4 and Figure 8-2 show that only 17% of homes built between July 1, 1998 and June 30, 1999 would comply with AB 970 as-built, while nearly 60% would not comply. Another 23% fell in the indeterminate group.

Figure 8-2: Compliance Results – AB 970 Standards – As-Built



Compliance Results – AB 970 – Implementing All Four Measures

Figure 8-3 illustrates the compliance results of implementing all four measures required by Prescriptive Package D in each home. As shown, nearly all homes comply (92.3%). Further, only 1.2% of homes fall in the non-compliant group, while an additional 6.6% are in the indeterminate group. Table 8-4 presents a breakout of the compliance results by measure.

Compliance Results – All Measures – Technical Potential

Technical potential savings were estimated for each of the four measures required by Prescriptive Package D for existing projects. Savings were also estimated for all four measures implemented together. Table 8-5 shows that on average a detached single family home with a cooling system would save approximately 1,750 kWh per year, while a home with a central gas furnace on average will save 33.5 therms per year. Table 8-6 shows the total estimated technical potential savings for California. As shown, the potential savings from implementing low solar heat gain fenestration accounts for most of the potential electric[2] savings of the individual measures (54.2%). Conversely, the potential savings of duct sealing accounts for nearly all of the potential gas[3] savings (92.4%).

Figure 8-3: Compliance Results – AB 970 Standards – With All Four Technical Potential Measures

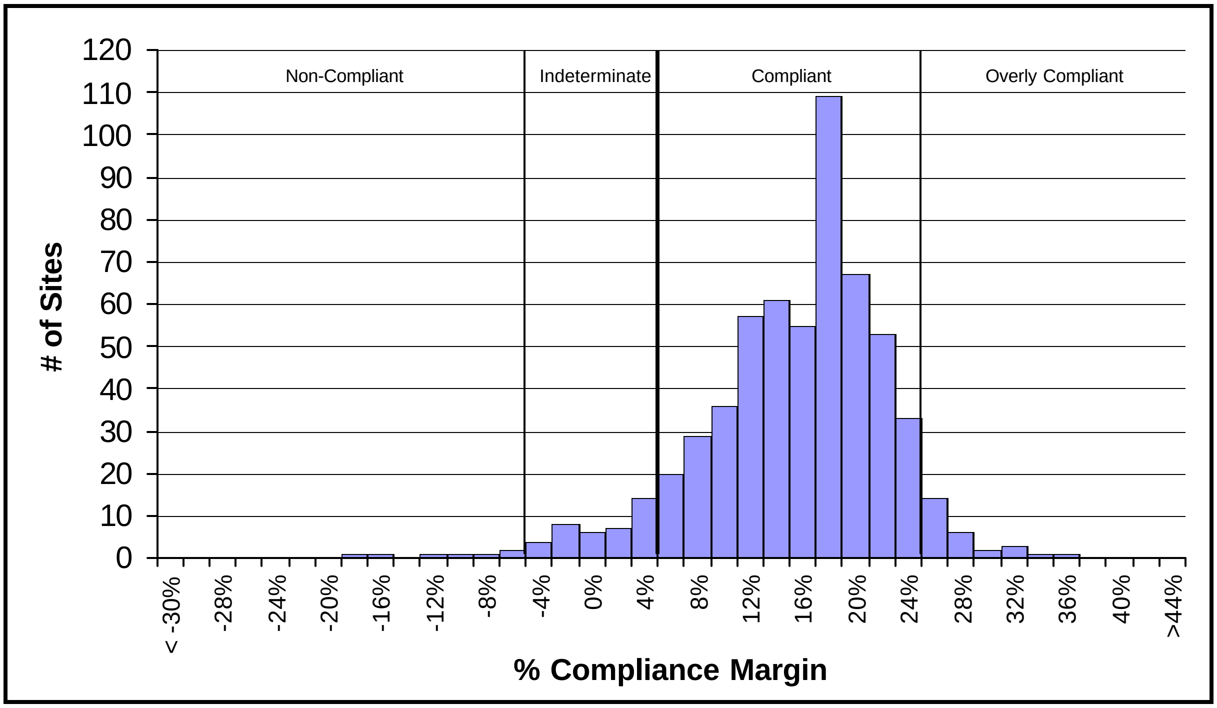


Table 8-4: Compliance Results – Using Measures Required by Prescriptive Package D

	Non-Compliant	Indeterminate	Compliant	Overly Compliant
Baseline	59.9%	22.9%	17.2%	0.0%
Radiant Barriers	51.4%	25.3%	23.3%	0.0%
Duct Sealing	38.6%	34.1%	27.3%	0.0%
Low Solar Heat Gain Fenestration (0.40)	15.2%	29.0%	55.3%	0.5%
Thermostatic Expansion Valves (TXV)	53.0%	25.8%	21.2%	0.0%
All Four Measures	1.2%	6.6%	87.7%	4.6%

[2] Electric savings are primarily cooling savings. Electric heating accounts for a small percentage of electric savings.

[3] Gas savings are exclusively heating savings.

Table 8-5: Technical Potential Savings of AB 970 Measures – per Home

Measure/Scenario Description	Cooling Savings[4] (kWh)		Gas Heating Savings[5] (therms)		Electric Heating Savings[6] (kWh)	
	Per Home	Per 1,000 ft2	Per Home	Per 1,000 ft2	Per Home	Per 1,000 ft2
Radiant Barriers	341	150	2.5	1.1	39	16
Duct Sealing	390	172	21.9	9.8	231	95
Low Solar Heat Gain Fenestration	1,062	467	10.5	4.7	194	80
Thermostatic Expansion Valves	344	151	0.0	0.0	0	0
All Measures Implemented[7]	**1,749**	**770**	**33.5**	**15.0**	**435**	**179**

Table 8-6: Technical Potential Savings of AB 970 Measures – Total for Detached Single Family Homes

Measure/Scenario Description	Electric Savings		Gas Savings	
	MWh	% of Sum	Therms	% of Sum
All Measures Implemented	**143,121**		**2,166,610**	
Radiant Barriers	22,742	14.2%	203,573	10.2%
Duct Sealing	26,948	16.8%	1,841,889	92.4%
Low Solar Heat Gain Fenestration	86,805	54.2%	-51,324	-2.6%
Thermostatic Expansion Valves	23,568	14.7%	0	0.0%
Sum of Individual Measures	**160,063**		**1,994,138**	

Compliance Results – AB 970 – Implementing Low Solar Heat Gain Fenestration

As mentioned above, Title 24 consultants believe that builders are most likely to use low solar heat gain fenestration. When told that installing this alone was not enough for a home to comply, they added that builders were also likely to use high efficiency water heaters and air conditioners. Table 8-7 presents a breakout of compliance results by measure combination. Figure 8-4 illustrates the compliance results with all homes receiving low solar gain fenestration. These results suggest that many homes will not pass with low solar heat gain fenestration (SHGC=0.40) alone. In particular, approximately 44% of detached single family homes are either in the non-compliant or indeterminate groups and only 0.5% are in the overly compliant group. However, when both high efficiency air conditioning and water

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4 The basis for per home and per 1000 ft^2 savings estimates is limited to those homes with cooling equipment.

5 The basis for per home and per 1000 ft^2 savings estimates is limited to those homes with gas (natural gas and propane) heating equipment.

6 The basis for per home and per 1000 ft^2 savings estimates is limited to only those homes with electric heating equipment.

7 Please note that the sum of the potential savings for the individual measures does not total the potential savings when all four measures are implemented simultaneously because the measures are not additive.

heating systems are added along with high performance fenestration (SHGC=0.35), over 77% of homes comply and only 7% of homes do not. Figure 8-5 shows the compliance distribution for homes with low solar heat gain fenestration (SHGC=0.35) and high efficiency air conditioning and water heating systems artificially implemented.

Table 8-7: Compliance Results – Using Measures Not Included by Prescriptive Package D with Low Solar Heat Gain Fenestration

	Non-Compliant	Indeterminate	Compliant	Overly Compliant
Baseline	59.9%	22.9%	17.2%	0.0%
Low Solar Heat Gain Fenestration (0.40)	15.2%	29.0%	55.3%	0.5%
Low Solar Heat Gain Fenestration (0.35) and High Efficiency Water Heaters	10.6%	18.9%	69.1%	1.3%
Low So lar Heat Gain Fenestration (0.35) and High Efficiency Water Heaters and High Efficiency Air Conditioners	7.4%	15.3%	75.7%	1.5%

Figure 8-4: Compliance Results – AB 970 Standards – Low Solar Heat Gain Fenestration (SHGC = 0.40)

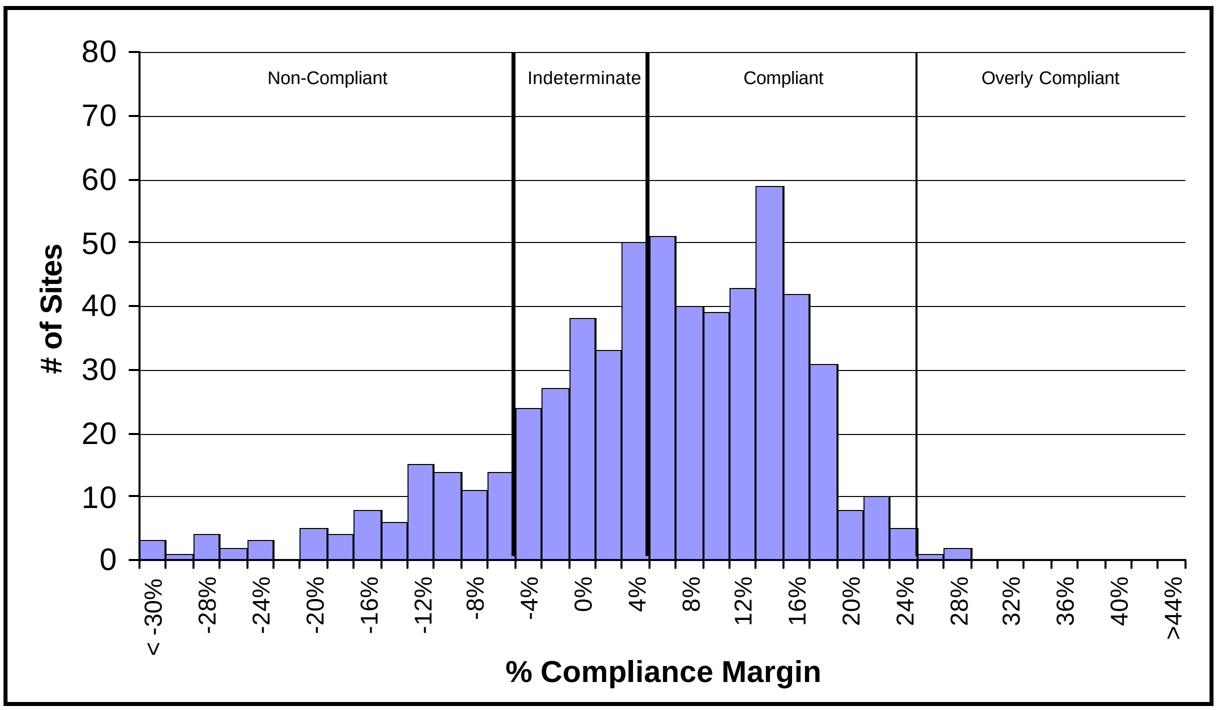
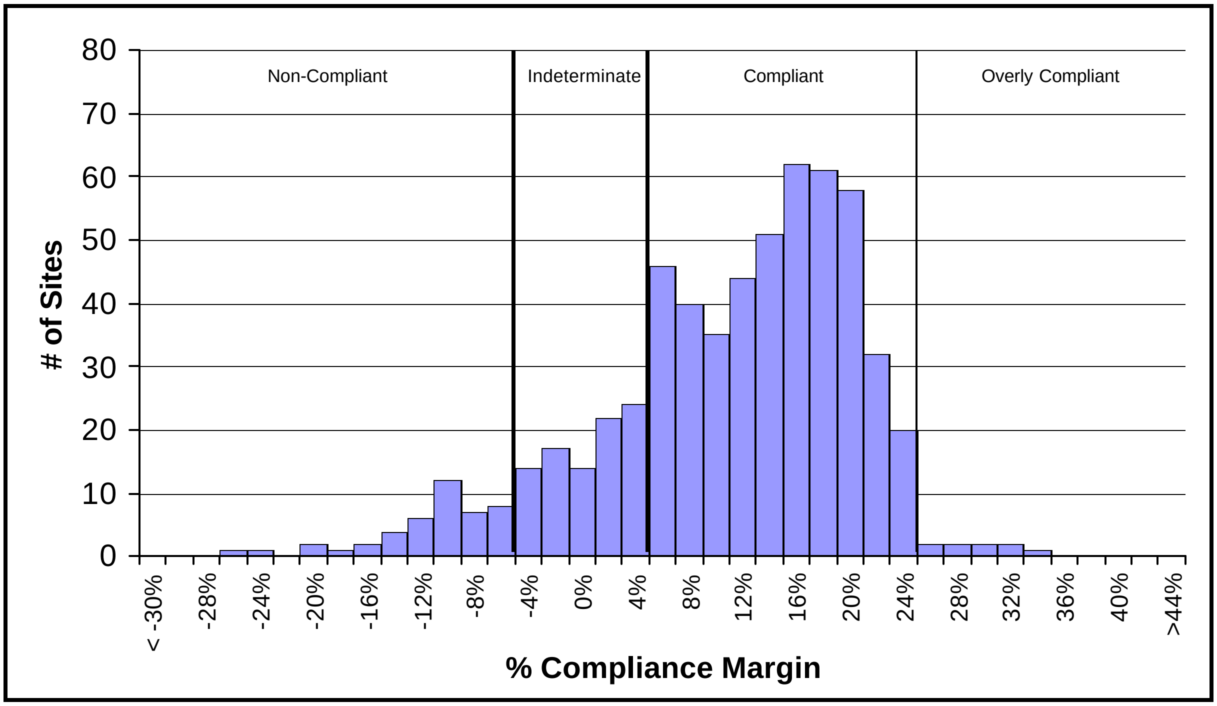


Figure 8-5: Compliance Results – AB 970 Standards – Low Solar Heat Gain Fenestration (SHGC = 0.35) and High Efficiency Air Conditioning and High Efficiency Water Heating



Compliance Results – AB 970 – Implementing HERS-certified Duct Sealing

As in low solar heat gain fenestration, if only ducts were sealed a typical home would not meet the Standards. However, if ducts are sealed and other measures added, the home would be closer to reaching compliance. As mentioned above, Title 24 consultants believe builders will likely use high efficiency water heaters and air conditioners along with sealing duct systems. Many consultants added that if builders went through the "hassle" of having the duct sealing certified by a HERS rater, they would also install a TXV valve since this device is inexpensive. Table 8-8 presents a breakout of compliance results by measure combination. Figure 8-6 illustrates the compliance results with all homes receiving HERS-certified duct sealing. These results suggest that many homes will not pass with duct sealing alone. As shown, approximately 73% of detached single family homes are either non-compliant or indeterminate and no homes are overly compliant. However, when TXVs and high efficiency air conditioning and water heating systems are added, approximately 58% of homes comply and just under 13% of homes do not. Figure 8-7 shows the compliance distribution for homes with duct sealing, TXV, and high efficiency air conditioning and water heating systems artificially implemented.

Table 8-8: Compliance Results – Using Measures Not Included by Prescriptive Package D with Duct Sealing and Thermostatic Expansion Valves

	Non-Compliant	Indeterminate	Compliant	Overly Compliant
Baseline	59.9%	22.9%	17.2%	0.0%
Duct Sealing	38.6%	34.1%	27.3%	0.0%
Thermostatic Expansion Valves (TXV)	53.0%	25.8%	21.2%	0.0%
Duct Sealing, TXV, and High Efficiency Water Heaters	19.7%	37.4%	42.7%	0.2%
Duct Sealing, TXV, and High Efficiency Water Heaters and High Efficiency Air Conditioners	12.5%	29.7%	57.3%	0.5%

Figure 8-6: Compliance Results – AB 970 Standards – HERS-Certified Duct Sealing

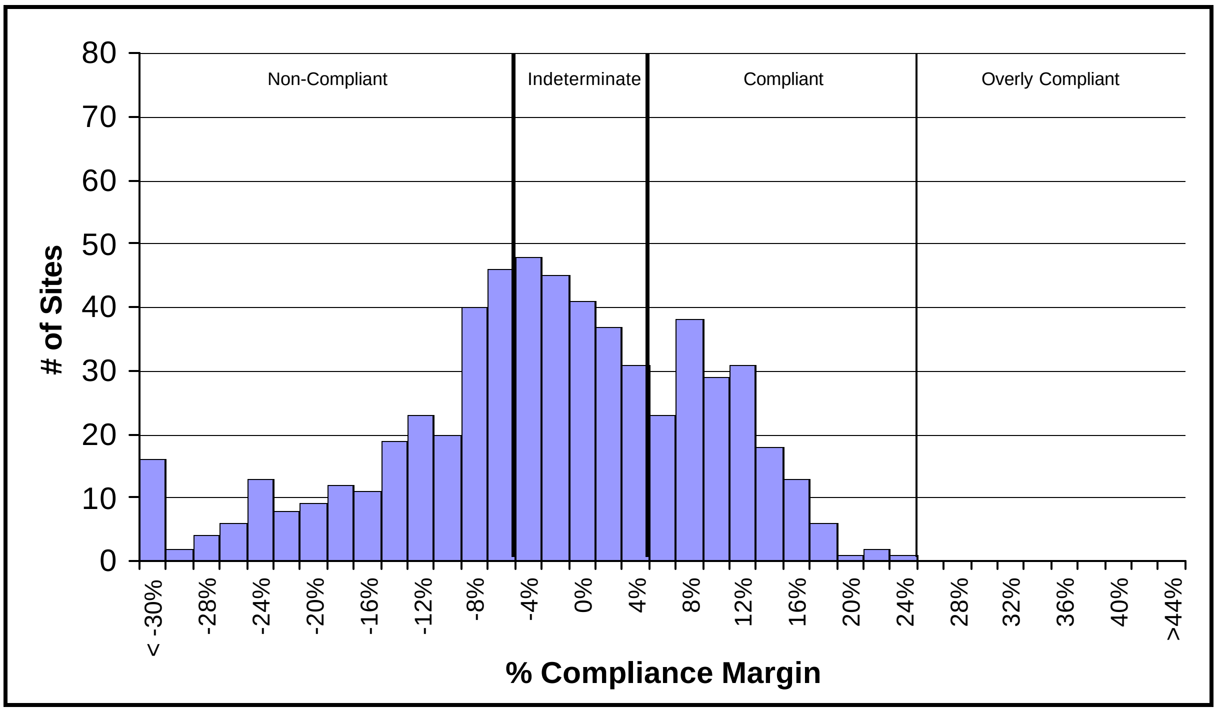
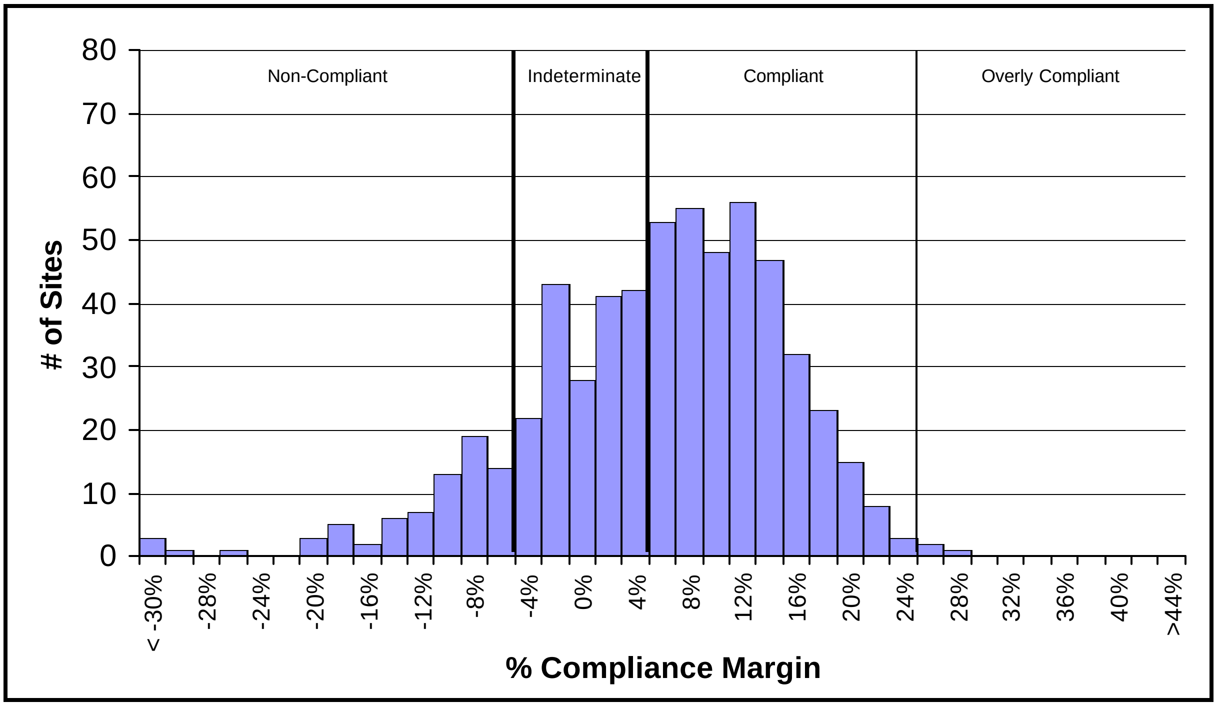


Figure 8-7: Compliance Results – AB 970 Standards – HERS-Certified Duct Sealing and TXV Valves and High Efficiency Air Conditioning and High Efficiency Water Heating



Summary of Compliance Analysis Findings

The compliance analysis results show that nearly 39% of homes will not comply if duct sealing is the only measure implemented. However, if builders also installed high efficiency air conditioners and water heaters, only 15.0 % would be non-compliant. Likewise, only implementing low solar heat gain fenestration would cause approximately 15% to be non-compliant. If builders also installed high efficiency air conditioners and water heaters, only 7.4% would be non-compliant. Also interesting is if builders were to implement all four measures required by Prescriptive Package D, as shown in Figure 8-3, most homes more than comply. In fact, 4.6% would fall in the overly compliant group.

8.4 Summary of Key Findings

As predicted, implementing either low solar heat gain fenestration or duct sealing alone will not be enough for many homes to comply with the new Standards. However, implementing one of these measures along with other high efficiency measures causes nearly all detached single family homes to comply. Other key findings are summarized below.

- **Of the measures required by Prescriptive Package D, builders are most likely use low solar heat gain fenestration.** Title 24 consultants felt that builders are most likely to install low solar heat gain fenestration. On a scale of 1 to 5, with 5 meaning Very Likely, the average ranking for low solar heat gain fenestration was 3.9, compared to 3.2 and less for the other three measures.

- **Of the other high efficiency measures, builders are most likely to install high efficiency water heaters and air conditioners.** The average ranking of these two measures was higher than that for increased insulation levels and high efficiency furnaces.
- **Installing low solar heat gain fenestration brings homes closer to complying with AB 970 than using duct sealing.** When globally implementing low solar heat gain fenestration, nearly 56% of homes were compliant and only 15% were non-compliant. However, nearly 39% of homes were non-compliant when duct sealing was globally implemented and only 27% of homes were compliant.
- **If builders were to implement all four measures required by AB 970 Prescriptive Package D, at least 92.3% of detached single family homes would comply.** Furthermore, only 1.2% of the homes would be in the non-compliant group.

9

Summary and Recommendations

9.1 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, technical potential, Title 24 consultant surveys, and builder surveys. This section also contains a brief discussion on the next steps in the project.

9.2 Baseline Characterization

The following is a summary of current building practices in the low-rise residential sector. In particular, findings on efficiency levels and key differences in construction practice between detached single family homes and multifamily buildings, as well as differences among regions are summarized.

- ***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 80.4% AFUE, versus the 78% AFUE Standard value. The average efficiency of central air conditioners installed in detached single family homes is 10.5 SEER, versus the 10 SEER Standard value.
- ***Single family detached homes are more likely than multifamily buildings to have higher-than-standard efficiency air conditioners.*** Approximately 65% of detached single family homes have a higher-than-standard efficiency air conditioner (> 10 SEER), compared to 26% of multifamily buildings.
- ***A significant number of homes do not have cooling equipment.*** Just over half of single family homes in RMST Climate Zones 1 and 2 do not have a cooling system (51% and 52%, respectively), which is approximately 20% at the state level. Likewise, a significant number of multifamily buildings do not have cooling systems (38% statewide).

- ***The average duct leakage percentage for single family homes is significantly lower than for multifamily buildings.***[1] For detached single family homes, the average duct leakage percentage for those duct systems tested statewide was 13.5%, compared to 28.0% for multifamily buildings. The average duct leakage percentages for detached single family homes do not vary significantly across RMST climate zones.

- ***Efficiency levels of water heating systems are generally above the Minimum Efficiency Standards for both single family homes and multifamily buildings.*** The average EF of water heating systems installed is 16.1% higher than required by the Minimum Efficiency Standards for detached single family homes and 13.3% higher for multifamily buildings.

- ***Dual-paned vinyl-framed windows are typically installed in both detached single family homes and multifamily buildings.*** The predominant window type in for detached single family homes and multifamily buildings is a vinyl-framed, dual-paned, clear glass window.

- ***Use of metal-framed windows is more extensive in multifamily buildings than in single family detached homes.***[2] While vinyl-framed, dual-paned, clear glass windows are predominantly used in both detached single family homes and multifamily buildings, metal windows are used more often in multifamily buildings (15.2% compared to 2.0% in detached single family homes).

- ***Use of metal-framed windows varies significantly by climate zone.***[3] For multifamily buildings, the percent of metal-framed windows ranges from a low of 3.3% in RMST Climate Zone 4 to highs of 32.5% and 39.9% in RMST Climate Zones 3 and 5, respectively. For single family homes, the percent of metal-framed windows ranges from 0.9% to 4.5%.

- ***Ceiling and wall insulation levels are usually below prescriptive values***[4]***.*** For those residences where ceiling and wall insulation R-values were obtained, the observed insulation levels were typically lower than prescriptive values, but always greater than or equal to the minimum R-values specified by the Standards.

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1 A significance test at the 90% confidence level reveals that the estimates of the average percent duct leakage for single family and multifamily homes are significantly at the state level.

2 A significance test at the 90% confidence level reveals that there is a significantly higher percentage of metal framed window installed in multifamily buildings than in single family homes - at the state level.

3 A significance test at the 90% confidence level reveals that there is a significantly higher percentage of metal framed window installed in multifamily buildings in RMST Climate Zones 3 and 5 than in multifamily buildings in the remaining RMST Climate Zones.

4 The prescriptive values, the minimum values allowed by Prescriptive Package D in the 1995 standards, for both ceiling and wall insulation vary by CEC climate zone.

9.3 Analysis of Compliance

Analysis of the MICROPAS results on a *non-compliant/compliant* criterion was not appropriate due to uncertainty with the MICROPAS results. Therefore, it was necessary to develop an error band.[5] Application of the error band resulted in the following four compliance groups, which 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., <-4%).
- ***Indeterminate.*** This category includes sites that have a % Compliance Margin within the error band (-4% to 6%). 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., > 6% and < 26%).
- ***Overly Compliant.*** This category includes sites that, based on the analysis, are overly compliant with Title 24 code. In particular, these sites have a % Compliance Margin greater than 26%. This category was defined to assess the share of homes that would meet the existing ENERGY STAR® New Home Construction requirements, given the error band.

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

- ***Approximately 13.5% of Sites are Identified as Non-Compliant.*** The results from the RNC Interface compliance analysis indicate that 13.5% of all homes built in the study period were non-compliant. The vast majority, however, fell within the compliant group (52.1%), while 5.2% fell in the overly compliant group. Figure 9-1 and Figure 9-2 provide a summary of the distribution of sites by % Compliance Margin and compliance group for single family homes and multifamily buildings respectively.[6]

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5 The error band was developed using a criteria of ±10% at a 90% confidence interval.

6 Please see Section 2.4 for a detailed discussion on the development of the error band and the compliance categories.

Figure 9-1: MICROPAS Results Summary – Detached Single Family Homes

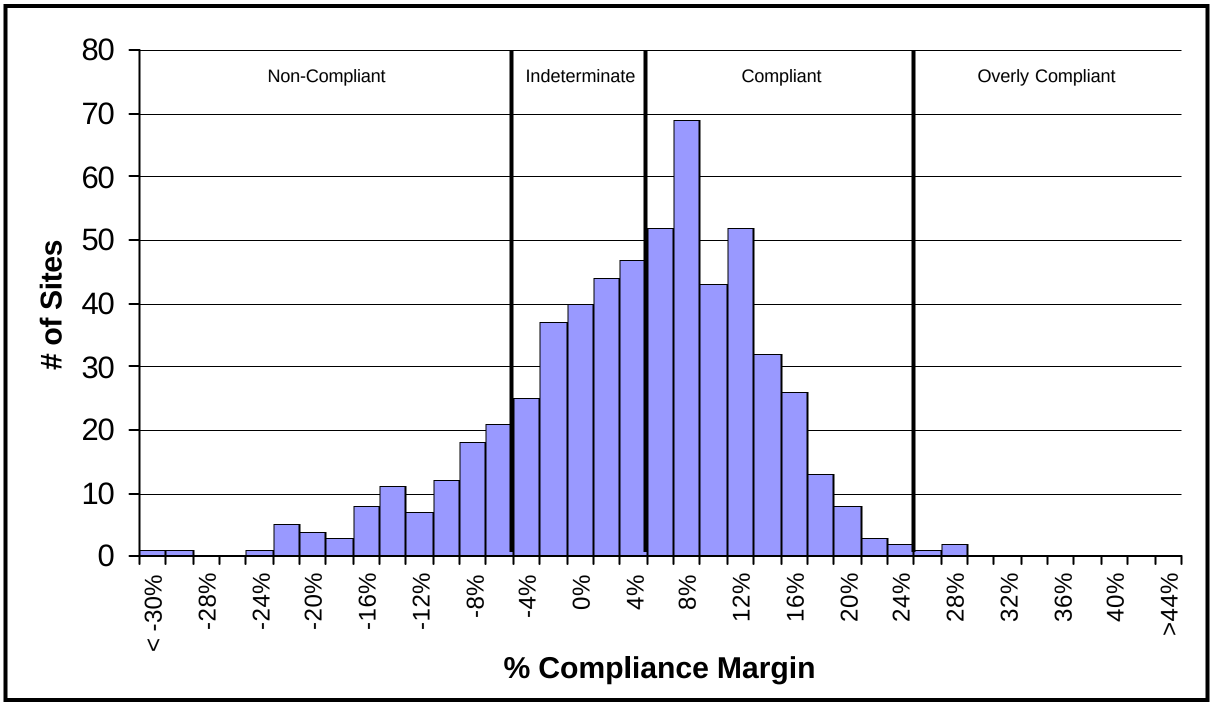
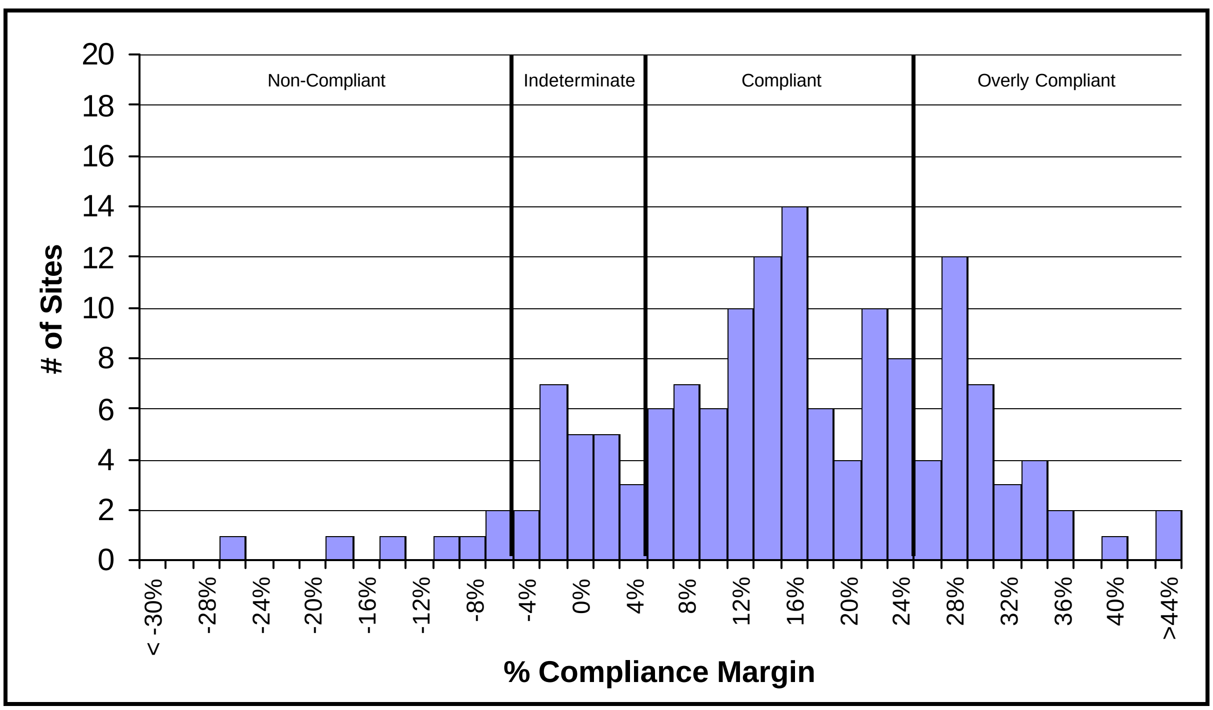


Figure 9-2: MICROPAS Results Summary – Multifamily Buildings



- ***Nearly 90% of Homes have Positive Water Heater Margins.*** Approximately 89.1% of newly constructed homes have water heaters with energy factors above the minimum standard values. This translates into positive water heating (DHW) margins for these homes. In other words, a home that has a high efficiency water heater will have an estimated energy use that is less than the maximum budget allowed—making the home more compliant. Builders and Title 24 consultants validated this result during the in-depth interviews. This is most likely due to the relatively low cost associated with increasing the water heater efficiency in an effort to meet compliance.

- ***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 overly compliant.
- ***The Percent Glazing Area has an Even Greater Impact on Compliance when the Prescriptive Percent Glazing Area is High.*** While the average on-site glazing percentages seem to remain fairly constant across RMST climate zones, the prescriptive glazing percentage allowed is higher in RMST Climate Zones 2 and 3 than other RMST climate zones. Therefore, homes in RMST Climate Zones 2 and 3 that do not take advantage the opportunity to install more windows tend to be overly compliant.
- ***Ceiling and Wall Insulation Play a Relatively Minor Role in Compliance.*** The results of the analysis indicate that the impact of increases in wall and ceiling insulation levels on compliance is minimal. As such, when using performance-based methods to determine compliance, builders and Title 24 consultants do not typically use high efficiency insulation. This result is reflected in the fact that ceiling insulation installed in new homes is generally below prescriptive. In addition, wall insulation installed is typically R-13, which is at the prescriptive level in some climate zones but below in others.
- ***The transition period in window manufacturing practices that took place during the compliance analysis might be the cause of some homes being well above compliance.*** The homes covered in the study were built in the second half of 1998 and the first half 1999. As such, they were built in a time of transition in the building industry. In particular, a significant number of homes of this era were designed and compliance documentation completed using metal-framed windows. However, by the time these homes were built and windows purchased, vinyl-framed windows were becoming the norm and were readily available. This was also when higher efficiency water heaters were becoming available for the same cost as a standard efficiency water heater. This factor might be the cause of some homes being well above compliance standards once constructed.
- ***RMST Climate Zone 3 (South Inland) has the Highest Percentage of Compliant Homes.*** RMST Climate Zone 3 (South Inland) has the highest percentage of compliant homes (84%) and the highest average % Compliance Margin at 12.5%. Further, 8% of sites in RMST Climate Zone 3 fall in the overly compliant group, compared to only 2% for RMST Climate Zones 4 and 5. This is due primarily to the impact of glazing percentages and is discussed below.

- ***RMST Climate Zone 5 (Desert and Mountains) has the Highest Percentage of Non-Compliant Homes.*** RMST Climate Zone 5 is the most non-compliant of the RMST climate zones based on the average % Compliance Margin of 0.4%. Further, 32% of sites in RMST Climate Zone 5 fall in the non-compliant group, compared to only 6% for RMST Climate Zone 2 and 5% for RMST Climate Zone 3.

Compliance Variations Among Climate Zones

In an attempt to explain the differences in average % Compliance Margins across RMST climate zones, three steps were taken. First, key characteristics, such as equipment efficiencies and fenestration information, were gathered to compare the average efficiencies for various measures across RMST climate zones. Next, the end-use standard budgets as a percentage of the total standard budgets across RMST climate zones were analyzed. Finally, homes in both the best RMST climate zone and in the two worst RMST climate zones were "relocated" to investigate how each home would comply if it were actually in a different RMST climate zone.

This analysis of why homes in RMST Climate Zone 3 exhibit higher compliance margins than homes built in RMST Climate Zones 4 and 5 reveals the following. It appears that the fenestration percentage in new homes is relatively constant across the state—regardless of where a house is built, builders/consumers are not willing to decrease the area of windows and glass doors installed, especially in single family homes. However, prescriptive glazing percentages do change. The prescriptive glazing percentage is the lowest in RMST Climate Zones 4 and 5, which makes it more difficult to reach compliance. The analysis of baseline characteristics show that builders in RMST Climate Zones 4 and 5 try to compensate for installing higher glazing percentages than prescriptive by installing more efficient HVAC equipment. Further, since the total HVAC budget is the greatest in RMST Climate Zones 4 and 5, installing high efficiency HVAC equipment provides more "bang for the buck" in these RMST climate zones. These results indicate that insofar as homes in the RMST Climate Zone 4 and 5 do not enjoy the benefit of the lower prescriptive glazing percentage applicable to RMST Climate Zone 3, they tend to install higher efficient HVAC equipment in order to "just comply." These practices lead to a smaller average % Compliance Margin in RMST Climate Zone 4 and 5 relative to RMST Climate Zone 3.

9.4 Technical Potential

Once the baseline characterization and compliance analysis were finalized, the technical potential for a handful of energy efficiency measures was estimated. The estimate of technical potential was accomplished by comparing energy use in the as-built case to the high efficiency scenario. Table 9-1 lists the measures analyzed in the technical potential study.

Table 9-1: Description of Measures used in the Technical Potential Analysis

Measure	Description
Low Solar Gain Fenestration	Low solar heat gain fenestration products are typified by a dual-paned, vinyl-framed window with low solar/low emissivity (spectrally selective) glass.
Radiant Barriers	A radiant barrier is a reflective foil or metal-coated surface that is usually placed on or against the underside of the roof.
Tight Ducts	Duct sealing involves actively testing and sealing a duct system with a "duct blaster" or equivalent apparatus.
TXV	The performance of air conditioning systems is strongly dependent on proper refrigerant charge and air flow across the coil. TXVs mitigate the problems of improper refrigerant charge and airflow by making the system operate at its rated efficiency.
All of the above	In addition to analyzing each individually, all measures were analyzed collectively.

Table 9-2 summarizes the results of the technical potential analysis. Total technical potential for each measure was separated into electricity savings (MWh) and gas savings (therms) by residence type. Expansion weights were used to expand the savings found from the 743 homes in the sample to the total number of homes built between July 1, 1998 and June 30, 1999.[7] Table 9-3 shows the potential savings per home, and per 1,000 square foot, of each measure for detached single family homes, while Table 9-4 summarizes the results for multifamily buildings.

Table 9-2: Summary of Technical Potential of AB 970 Measures for Low-Rise Residences in IOU Service Areas

Measure/Scenario Description	All Low-Rise Residence Types		Detached Single Family Homes		Multifamily Buildings	
	MWh	Therms	MWh	Therms	MWh	Therms
All Measures Implemented	191,907	3,299,956	143,121	2,166,610	48,785	1,133,346
Radiant Barriers	30,889	287,019	22,742	203,573	8,148	83,446
Duct Sealing	32,031	2,441,621	26,948	1,841,889	5,084	599,732
Low Solar Gain Fenestration	119,148	370,078	86,805	-51,324	32,342	421,402
Thermostatic Expansion Valves	30,572	0	23,568	0	7,004	0
Sum of Individual Measures	212,640	3,098,718	160,063	1,994,138	52,578	1,104,580

7 During this period, there were 85,554 detached single family homes and 23,506 multifamily units built.

Table 9-3: Technical Potential Savings of AB 970 Measures – Detached Single Family Homes

Measure/Scenario Description	Cooling Savings[8] (kWh)		Gas Heating Savings[9] (therms)		Electric Heating Savings[10] (kWh)	
	Per Home	Per 1,000 ft^2	Per Home	Per 1,000 ft^2	Per Home	Per 1,000 ft^2
All Measures Implemented	1,749	770	33.5	15.0	435	179
Radiant Barriers	341	150	2.5	1.1	39	16
Duct Sealing	390	172	21.9	9.8	231	95
Low Solar Gain Fenestration	1,062	467	10.5	4.7	194	80
Thermostatic Expansion Valves	344	151	0.0	0.0	0	0
Sum of Individual Measures	2,137	940	34.8	15.6	463	190

8 The basis for Per Home and Per 1000 ft^2 savings is limited to those homes with cooling equipment.

9 The basis for Per Home and Per 1000 ft^2 savings estimates is limited to those homes with gas (natural gas and propane) Heating equipment.

10 The basis Per Home and Per 1000 ft^2 savings estimates is limited to only those homes with electric heating equipment.

Table 9-4: Technical Potential Savings of AB 970 Measures – Multifamily Buildings

Measure/Scenario Description	Cooling Savings[11] (kWh)		Gas Heating Savings[12] (therms)		Electric Heating Savings[13] (kWh)	
	Per Building	Per 1,000 ft^2	Per Building	Per 1,000 ft^2	Per Building	Per 1,000 ft^2
All Measures Implemented	2,541	142	83.3	7.9	969	36
Radiant Barriers	506	28	5.0	0.5	110	4
Duct Sealing	405	28	38.8	3.6	113	4
Low Solar Gain Fenestration	1,694	95	46.2	4.4	835	31
Thermostatic Expansion Valves	480	27	0.0	0.0	0	0
Sum of Individual Measures	3,086	178	90.0	8.4	1,059	40

Table 9-5 and Table 9-6 show the technical potential savings by measure, as well as the technical potential savings as a percentage of the sum of the technical potential savings from the individual measures. Please note that the potential savings from the individual measures are not additive—the sum of the potential savings from the individual measures does not equal the potential savings from all the measures being implemented collectively. This is because there are interactive effects between the individual measures. The results from the tables are summarized below.

- ***The electric technical potential savings from implementing all four measures is <u>less</u> than the sum of the electric technical potential savings from the individual measures.*** This is because low solar gain fenestration and radiant barriers let in less solar heat during the summer, thereby reducing the cooling load required. In turn, there is less potential for savings from duct sealing and installing TXV valves.
- ***The gas technical potential savings from implementing all four measures is <u>greater</u> than the sum of the gas technical potential savings from the individual measures.*** By installing low solar gain fenestration and a radiant barrier in a home, less heat is allowed into the home during winter so more energy is required to heat the home. Therefore, there is more potential for heating savings from duct sealing.

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11 The basis for Per Home and Per 1000 ft^2 savings is limited to those homes with cooling equipment.

12 The basis for Per Home and Per 1000 ft^2 savings estimates is limited to those homes with gas (natural gas and propane) heating equipment.

13 The basis Per Home and Per 1000 ft^2 savings estimates is limited to only those homes with electric heating equipment.

- ***A majority of the total electric technical potential savings comes from low solar gain fenestration.*** The electric savings from low solar gain fenestration comprise approximately 54% of the sum of the electric potential savings from the individual measures for detached single family homes (62% for multifamily buildings), whereas the other three measures account for anywhere from 14% to 17% for single family homes and 10% to 16% for multifamily buildings.
- ***For detached single family homes, nearly all of the total gas technical potential savings comes from duct sealing.*** The gas savings from duct sealing comprise just over 92% of the sum of the gas potential savings from the individual measures for detached single family homes. The other three measures account for anywhere from -3% to 10% of the sum.
- ***For multifamily buildings, duct sealing and low solar gain fenestration account for nearly all of the total gas technical potential savings.*** The gas savings from duct sealing comprise just over 54% of the sum of the gas potential savings from the individual measures for detached single family homes and installing low solar gain fenestration accounts for approximately 38%.[14]

Table 9-5: Summary of Technical Potential of AB 970 Measures for Detached Single-Family Homes

Measure/Scenario Description	Electric Savings		Gas Savings	
	MWh	% of Sum	Therms	% of Sum
All Measures Implemented	143,121		2,166,610	
Radiant Barriers	22,742	14.2%	203,573	10.2%
Duct Sealing	26,948	16.8%	1,841,889	92.4%
Low Solar Gain Fenestration	86,805	54.2%	-51,324	-2.6%
Thermostatic Expansion Valves	23,568	14.7%	0	0.0%
Sum of Individual Measures	160,063	---	1,994,138	---

[14] There are two main reasons for the significant difference between the gas technical potential savings for low solar heat gain fenestration for detached single family homes (-2.6%) and that for multifamily buildings (38.2%). The first is that the average detached single family home has a 17% glazing area, whereas the average multifamily building has a 9% glazing area. Since more fenestration lets in more solar heat, on average, detached single family homes let in more heat, thereby reducing the heating savings. The second reason is the types of windows currently installed in detached single family homes compared to those installed in multifamily buildings. Section 3.4 shows that the just over 15% of the windows installed in multifamily buildings are metal windows, compared to less than 2% in detached single family homes. The measure calls for dual-paned, vinyl-framed, spectral low-E windows that not only limit the amount of heat that comes in, but also limit the amount of heat that is allowed out, thereby increasing heating savings.

Table 9-6: Summary of Technical Potential of AB 970 Measures for Multifamily Buildings

Measure/Scenario Description	Electric Savings		Gas Savings	
	MWh	% of Sum	Therms	% of Sum
All Measures Implemented	**48,785**		**1,133,346**	
Radiant Barriers	8,148	15.5%	83,446	7.6%
Duct Sealing	5,084	9.7%	599,732	54.3%
Low Solar Gain Fenestration	32,342	61.5%	421,402	38.2%
Thermostatic Expansion Valves	7,004	13.3%	0	0.0%
Sum of Individual Measures	52,578		1,104,580	

9.5 Survey of Builders and Title 24 Consultants

In order to assess the impacts of recent changes in Title 24 Standards, RER conducted 13 in-depth surveys and 55 telephone surveys of Title 24 consultants and 17 in-depth interviews with builders of either single family homes or low-rise (three floors or less) multifamily buildings.

Key findings are highlighted below.

Title 24 Consultants

Findings Related to AB 970

- ***HERS certification is not seen as a cost-effective way to meet the AB 970 requirements by the Title 24 consultants.*** Several Title 24 consultants are opposed to using duct credits that require HERS certification because of added financial cost and the time required to schedule a rater to come to the building site.
- ***Title 24 consultants do not believe builders are likely to use measures requiring HERS certification to meet the AB 970 requirements***. Most Title 24 consultants believe that builders are willing to implement a variety of additional features to negate the need for verification by a HERS rater. They believe that builders will likely use a combination of all four options (high efficiency water heaters, high efficiency central air conditioners, high efficiency furnaces, and increased insulation). They further explained that higher efficiency water heaters are the most popular choice and increasing insulation levels are the least popular.
- ***Taking credit for the use of TXV valves is tied to the use of duct sealing credits.*** TXV valves are inexpensive. Although certification is required

to receive the credit, if builders were to use the certified sealed ducts credit they would likely install and take the credit for TXV valves.

- ***Title 24 consultants believe that the most effective way for the utilities to assist builders in meeting the AB 970 requirements is to offer more training and education.*** Many Title 24 consultants offered suggestions on how utilities can assist builders. Thirty-one consultants suggested offering more training. Other suggestions commonly mentioned include providing more information on the utility sponsored programs, offering rebates, and improving the HERS certification process.

- ***One consultant interviewed believes that AB 970 may encourage builders to participate in a program because, once the new Standards are met, the additional measures needed to meet program requirements are not that significant.***

  > *"AB 970 shouldn't affect their residential programs much, in fact new Standards may actually encourage builders to participate in programs since the % above Standards they will have to achieve will be less. Thirty percent MEC (the current ENERGY STAR requirement) is roughly equivalent to 25% better than Title 24. With AB 970 changes, 30% MEC will probably be about 10-15% better than Title 24. Builders may be more willing to go the extra mile because it doesn't take much effort to do so."*

Title 24 and Other Major Findings

- ***The feature seen as the biggest barrier to compliance is large glazing areas***. In the in-depth interviews with Title 24 consultants, nearly all stated emphatically that large glazing area is the biggest barrier to meeting compliance for the 1998 Standards for single family homes.

- ***Credits are not generally needed to help homes comply with the Title 24 requirements.*** One overarching message gained from the consultants is that they do not need to use the credits in order to meet the requirements of the 1998 Standards, builders do not want to use them, and the certification process is cumbersome. This result was found during both the telephone interviews and the in-depth interviews. Many consultants explained that implementation of the 1998 Standards did not make it more difficult for them to meet compliance, and instead, in some cases, it made it easier.

Builders

Findings Related to AB 970

- ***Builders are not generally familiar with the AB 970 requirements.*** Ten builders reported that they are unfamiliar with the new AB 970 Standards. Four said that they are somewhat familiar and three said that they are very familiar with the new Standards.

- ***Builders were generally unable to answer the question regarding the impact of the AB 970 Standards on the RNC programs.*** Due to a lack of knowledge about AB 970, most builders were not comfortable answering questions relating to the impact of the AB 970 requirements on existing RNC programs.
- ***High performance windows will most likely be used to meet the more stringent requirements.*** The vast majority of builders mentioned that they would most likely use higher performance windows to comply with the new Standards.

General Findings

- ***Builders are not generally familiar with the Title 24 Standards.*** Seven builders admitted that they are not at all familiar with the 1998 Title 24 Low-Rise Residential Standards, seven said they are somewhat familiar with them although unaware of the specifics, and only three are very familiar with the Standards.
- ***Compliance issues are usually handled by a Title 24 consultant.*** Lack of in-depth knowledge of the Standards reflects the fact that builders do not give much thought to the Standards and, instead, pass the responsibility on to a Title 24 consultant. In general, the builders view compliance as something that needs to be done but not something that requires much, or any, effort on their part.
- ***Water heaters are typically seen as the feature that can be modified most easily to make marginal homes comply.*** This was mentioned by both single family and multifamily builders.
- ***Credits offered under Title 24 are not generally used.*** Three builders cited that the current housing market is so strong that it is not necessary to offer energy efficiency as a selling point, and that using the various credits takes time and slows down production. Two builders mentioned that it is not cost-effective to use the credits since "the gains are miniscule." Four builders said they are unfamiliar with the credits.

Findings Specific to Single Family Attached and Multifamily Builders

- ***Multifamily builders are less willing to invest in energy efficient equipment.*** The primary differences discovered between single family attached and multifamily builders are that multifamily builders are not as concerned with occupant comfort because they are building rental units and they are more concerned with initial cost.
- ***Single family attached and multifamily builders are not generally aware of the Title 24 Standards.*** Similar to findings from single family detached builders, the single family attached builders and multifamily builders are relatively unaware of 1998 Title 24 and AB 970 Standards.
- ***Miscellaneous Findings.*** In general, single family attached builders and multifamily builders do not make use of the credits offered under Title 24, are unaware of the AFUE levels of the furnaces they install, use higher efficiency

water heaters to make marginal homes comply, and are likely to use higher efficiency windows to avoid the necessity of using a HERS rater.

9.6 Compliance Analysis of Likely Building Practices under AB 970

Insofar as AB 970 does not become effective until January 2002, the main sources of information on how builders and Title 24 consultants plan to meet the new standards are self-reported data from telephone surveys with Title 24 consultants. The analysis summarized in this section focuses on taking the self-reported information on likely changes in building practices and simulating these plans using the RNC Interface. The simulations will analyze whether builders can meet the new standards using their planned approaches.

As predicted, results show that implementing either low solar heat gain fenestration or duct sealing alone will not be enough for many homes to comply with the new Standards. However, implementing one of these measures along with other high efficiency measures causes nearly all detached single family homes to comply. Other key findings are summarized below:

- ***Of the measures required by Prescriptive Package D, builders are most likely use low solar heat gain fenestration.*** Title 24 consultants felt that builders are most likely to install low solar heat gain fenestration. On a scale of 1 to 5, with 5 meaning Very Likely, the average ranking for low solar heat gain fenestration was 3.9, compared to 3.2 and less for the other three measures.
- ***Of the other high efficiency measures, builders are most likely to install high efficiency water heaters and air conditioners.*** The average ranking of these two measures was higher than that for increased insulation levels and high efficiency furnaces.
- ***Installing low solar heat gain fenestration brings homes closer to complying with AB 970 than using duct sealing.*** When globally implementing low solar heat gain fenestration, nearly 56% of homes were compliant and only 15% were non-compliant. However, nearly 39% of homes were non-compliant when duct sealing was globally implemented and only 27% of homes were compliant.
- ***If builders were to implement all four measures required by AB 970 Prescriptive Package D, at least 92.3% of detached single family homes would comply.*** Furthermore, only 1.2% of the homes would be in the non-compliant group.

Table 9-7 presents the compliance results of implementing each of the four measures individually together required by Prescriptive Package D as well as implementing all four measures together. As shown, nearly all homes comply (92.3%) when all four measures are implemented together. Further, only 1.2% of detached single family homes fall in the non-compliant group, while an additional 6.6% are in the indeterminate group.

Table 9-7: Compliance Results – Using Measures Required by Prescriptive Package D

	Non-Compliant	Indeterminate	Compliant	Overly Compliant
Baseline	59.9%	22.9%	17.2%	0.0%
Radiant Barriers	51.4%	25.3%	23.3%	0.0%
Duct Sealing	38.6%	34.1%	27.3%	0.0%
Low Solar Heat Gain Fenestration (0.40)	15.2%	29.0%	55.3%	0.5%
Thermostatic Expansion Valves (TXV)	53.0%	25.8%	21.2%	0.0%
All Four Measures	1.2%	6.6%	87.7%	4.6%

9.7 Issues Related to RNC Program Offerings

The following discusses some issues and recommendations that relate to RNC energy efficiency program design. These issues and recommendations are the result of the compliance analysis, the builder and Title 24 consultant interviews, and discussions with industry experts.

- ***Climate Zone Differences Should Be Recognized.*** Compliance results show that it is much more difficult to achieve 20% above standard for some climate zones than others. RNC programs should recognize this fact and provide more incentives in certain regions. Additionally, the focus or requirements of the program should be tailored to individual climate zones. Insofar as climate zones overlap utility service territories, this might also support an argument for a statewide program versus a utility-based program.
- ***Target Multifamily Buildings.*** Multifamily buildings are not currently targeted for RNC programs, yet it is apparent that there is considerable room for improvement in multifamily buildings. From this and previous studies, percent glazing used in multifamily buildings is typically much less than the prescriptive values, which yields energy budget excess that can (and is) traded off to utilize other features with lower performance. Emphasis for these buildings is usually first cost. However, multifamily buildings are also inherently more energy efficient than detached single family homes due to lower surface-area-to-volume ratios.[15]

[15] There is currently a pilot program being run by SDG&E that targets multifamily as well as single family. PG&E is also considering targeting these building types. In addition, the CEC and associated parties have considered a different set of standards for multifamily buildings, especially regarding percent glazing prescriptive values, for quite some time.

- ***Provide Training to Builders.*** Training and education of builders was believed to be the most effective way to help builders understand and meet AB 970 requirements.
- ***New Opportunities from AB 970 Environment.*** AB 970 may encourage builders to participate in a program because, once the new Standards are met, the additional measures needed to meet program requirements are not that significant.
- ***Multiple HVAC Systems.*** A relatively small number of homes have more than one HVAC system (10% statewide, but 20+% in RMST Climate Zones 3 and 5). Multiple systems are typically installed in larger homes and the main reason is comfort. Although, using more than one HVAC unit can increase the first cost of a home, downsizing of units, zonal operation, using one to heat/cool and other one to circulate can probably lead to significant energy savings if the systems are designed properly. However, operation of both systems during peak demand periods would have an overwhelmingly negative impact. This finding may warrant further consideration, especially if the average home size increases.

9.8 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.

- ***Window Performance Trade-Offs in Multifamily Buildings.*** From this and previous studies, percent glazing used in multifamily buildings is typically much less than the prescriptive values, which yields energy budget excess that can (and is) traded off against lower performance windows (i.e., metal-framed, clear glass windows). The highest concentration of low-performance windows is in those regions subject to Prescriptive 20% glazing value.
- ***Percent Glazing in Detached Single Family Homes.*** Average percent glazing seems to be consistent across RMST climate zones (13%), but this is still being examined.
- ***Separate Standards for Multifamily Buildings.*** Baseline values for water heating usage and internal loads between single family detached and multifamily buildings (single family attached and multifamily) already exist. A completely separate set of Standards for multifamily buildings has been considered and is currently/constantly being evaluated.[16]
- ***Multiple HVAC Systems.*** A few homes have more than one HVAC system (10% statewide, but 20+% in RMST Climate Zones 3 and 5). Multiple systems are typically installed in larger homes and the main reason is comfort. Although, using more than one HVAC unit can increase the first cost of a home, downsizing of units, zonal operation, using one to heat/cool and other one to circulate can

[16] Separate standards for multifamily homes were considered as part of the AB 970 proceedings, but were not pursued.

probably lead to significant energy savings if the systems are designed properly. However, operation of both systems during peak demand periods would have an overwhelmingly negative impact. This finding may warrant further consideration, especially if the average home size increases.

- ***Unavailability of Insulation Certificate.*** Very few surveyors were able to locate an insulation certificate posted around the home or obtain this documentation from the homeowner.

9.9 Next Steps

The remaining step in the project involves analyzing the data collected for the second year. RER and Volt VIEWtech are presently conducting the second year on-site survey for the RMST study. Surveyors are using the revised survey instrument that was designed after reviewing the data collected from the first year on-sites surveys. This second year study will follow the same sample design as the first year study and covers single and multifamily homes constructed between July 1, 1999 and June 30, 2000. The data from this survey will be used to conduct a second phase of building characterization and compliance using the RNC Interface. The on-site survey is scheduled for completion in May 2001.

Appendix A

Sample C-2R Form

```
Project Title.......... PG&E RNC 2000                      Date........ 12/08/00
Project Address........ 753 Whispering Trails    *******  ---------------------
                        _________________________*v4.50*  | _________________ |
Documentation Author... RER, 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........... 07                                ---------------------
Compliance Method...... MICROPAS4 v4.70 for 1995 Standards by Enercomp, Inc.
```

```
|     MICROPAS4 v4.50  File-C2R02131  Wth-CTZ07S92  Program-FORM C-2R         |
|         User#-MP2206  User-Regional Economic Researc  Run-Site.2131          |
```

MICROPAS4 ENERGY USE SUMMARY

Energy Use (kBtu/sf-yr)	Standard Design	Proposed Design	Compliance Margin
Space Heating..........	3.22	3.28	-0.06
Space Cooling..........	4.90	4.44	0.46
Water Heating..........	12.61	10.80	1.81
North Total	20.73	18.52	2.21
Space Heating..........	3.22	3.38	-0.16
Space Cooling..........	4.90	6.39	-1.49
Water Heating..........	12.61	10.80	1.81
East Total	20.73	20.57	0.16
Space Heating..........	3.22	3.66	-0.44
Space Cooling..........	4.90	4.60	0.30
Water Heating..........	12.61	10.80	1.81
South Total	20.73	19.06	1.67
Space Heating..........	3.22	3.51	-0.29
Space Cooling..........	4.90	3.49	1.41
Water Heating..........	12.61	10.80	1.81
West Total	20.73	17.80	2.93

*** Building complies with Computer Performance ***

GENERAL INFORMATION

Conditioned Floor Area..... 1804 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. 2

Project Title.......... PG&E RNC 2000 Date........ 12/08/00

MICROPAS4 v4.50 File-C2R02131 Wth-CTZ07S92 Program-FORM C-2R
User#-MP2206 User-Regional Economic Researc Run-Site.2131

Weather Data Type.......... ReducedYear
Floor Construction Type.... Slab On Grade
Number of Building Zones... 1
Conditioned Volume......... 18220 cf
Footprint Area............. 902 sf
Ground Floor Area.......... 902 sf
Slab-On-Grade Area......... 902 sf
Glazing Percentage......... 25.8 % of floor area
Average Glazing U-value.... 0.7 Btu/hr-sf-F
Average Ceiling Height..... 10.1 ft

BUILDING ZONE INFORMATION

Zone Type	Floor Area (sf)	Volume (cf)	# of Dwell Units	Cond-itioned	Thermostat Type	Vent Height (ft)	Special Vent Area (sf)
HOUSE							
Residence	1804	18220	1.00	Yes	Setback	8.0	n/a

OPAQUE SURFACES

Surface	Area (sf)	U-value	Insul R-val	Act Azm	Tilt	Solar Gains	Form 3 Reference	Location/ Comments
HOUSE								
1 Wall	309	0.088	13	0	90	Yes	W.13.2X4.16	Default RVal
2 Wall	168	0.088	13	0	90	No	W.13.2X4.16	Default RVal
3 Wall	601	0.088	13	90	90	Yes	W.13.2X4.16	Default RVal
4 Wall	428	0.088	13	180	90	Yes	W.13.2X4.16	Default RVal
5 Wall	373	0.088	13	270	90	Yes	W.13.2X4.16	Default RVal
6 Wall	213	0.088	13	270	90	No	W.13.2X4.16	Default RVal
7 Door	40	0.330	0	0	90	Yes	None	Wooden Door
8 Roof	1209	0.031	30	n/a	0	Yes	R.30.2X4.24	Default RVal

PERIMETER LOSSES

Surface	Length (ft)	F2 Factor	Insul R-val	Solar Gains	Location/Comments
HOUSE					
9 SlabEdge	120	0.700	R-0	No	Slab

FENESTRATION SURFACES

Surface	Area (sf)	# of Pan-es	Frame Type	Vent Open Type	U-value	Act Azm	Tlt	SC Glass Only	SC Int Shade	Interior Shading/ Description
HOUSE										
1 Window	48.0	2	VinylDiv	Slider	0.600	0	90	0.88	0.78	VW.2.Clear.Wind

2	Window	12.0	2	VinylDiv	Slider	0.600	0	90	0.88	0.78	VW.2.Clear.Wind
3	Window	24.0	2	VinylDiv	Slider	0.600	0	90	0.88	0.78	VW.2.Clear.Wind
4	Window	30.0	2	Vinyl	Slider	0.600	0	90	0.88	0.78	VW.2.Clear.Wind

Project Title.......... PG&E RNC 2000 Date........ 12/08/00

| MICROPAS4 v4.50 File-C2R02131 Wth-CTZ07S92 Program-FORM C-2R |
| User#-MP2206 User-Regional Economic Researc Run-Site.2131 |

FENESTRATION SURFACES

Surface	Area (sf)	# of Pan-es	Frame Type	Vent Open Type	U-value	Act Azm	Tlt	SC Glass Only	SC Int Shade	Interior Shading/ Description
5 Window	24.0	2	VinylDiv	Slider	0.600	90	90	0.88	0.78	VW.2.Clear.Wind
6 Window	4.0	2	VinylDiv	Slider	0.600	90	90	0.88	0.78	VW.2.Clear.Wind
7 Window	48.0	2	Metal	Slider	0.750	90	90	0.88	0.78	Mtl.2.Clear.Win
8 Window	8.0	2	Metal	Slider	0.750	90	90	0.88	0.78	Mtl.2.Clear.Win
9 Window	36.0	2	Metal	Slider	0.750	90	90	0.88	0.78	Mtl.2.Clear.Win
10 Window	24.0	2	Metal	Slider	0.750	90	90	0.88	0.78	Mtl.2.Clear.Win
11 Window	11.0	2	Metal	Slider	0.750	180	90	0.88	0.78	Mtl.2.Clear.Win
12 Door	40.0	2	Metal	Slider	0.730	180	90	0.88	0.78	Mtl.2.Clear.Doo
13 Window	12.0	2	Metal	Slider	0.750	180	90	0.88	0.78	Mtl.2.Clear.Win
14 Window	36.0	2	Metal	Slider	0.750	180	90	0.88	0.78	Mtl.2.Clear.Win
15 Window	20.0	2	Metal	Slider	0.750	180	90	0.88	0.78	Mtl.2.Clear.Win
16 Window	18.0	2	Metal	Slider	0.750	180	90	0.88	0.78	Mtl.2.Clear.Win
17 Window	24.0	2	Metal	Slider	0.750	180	90	0.88	0.78	Mtl.2.Clear.Win
18 Window	24.0	2	Metal	Slider	0.750	180	90	0.88	0.78	Mtl.2.Clear.Win
19 Window	12.0	2	Metal	Slider	0.750	270	90	0.88	0.78	Mtl.2.Clear.Win
20 Window	10.0	2	Metal	Slider	0.750	270	90	0.88	0.78	Mtl.2.Clear.Win

OVERHANGS AND SIDE FINS

		---Window--		------Overhang-----				---Left Fin---			---Right Fin--		
Surface	Area (sf)	Hght	Wdth	Dpth	Hght	Left Ext	Rght Ext	Ext	Dpth	Hght	Ext	Dpth	Hght
HOUSE													
1 Window	48.0	4.5	n/a	2.0	2.5	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
2 Window	12.0	4.5	n/a	2.0	2.5	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
3 Window	24.0	4.5	n/a	2.0	2.5	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
4 Window	30.0	4.5	n/a	2.0	2.5	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
5 Window	24.0	4.5	n/a	2.0	2.5	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
6 Window	4.0	4.5	n/a	2.0	2.5	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
7 Window	48.0	4.5	n/a	2.0	2.5	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
8 Window	8.0	4.5	n/a	2.0	2.5	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
9 Window	36.0	4.5	n/a	2.0	2.5	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
10 Window	24.0	4.5	n/a	2.0	2.5	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
11 Window	11.0	4.5	n/a	2.0	2.5	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
12 Door	40.0	7.5	n/a	3.0	1.75	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
13 Window	12.0	4.5	n/a	2.0	2.5	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
14 Window	36.0	4.5	n/a	2.0	2.5	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
15 Window	20.0	4.5	n/a	2.0	2.5	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
16 Window	18.0	4.5	n/a	2.0	2.5	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
17 Window	24.0	4.5	n/a	2.0	2.5	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
18 Window	24.0	4.5	n/a	2.0	2.5	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
19 Window	12.0	4.5	n/a	2.0	2.5	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
20 Window	10.0	4.5	n/a	2.0	2.5	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Project Title.......... PG&E RNC 2000 Date........ 12/08/00

MICROPAS4 v4.50 File-C2R02131 Wth-CTZ07S92 Program-FORM C-2R
User#-MP2206 User-Regional Economic Researc Run-Site.2131

THERMAL MASS

Mass Type	Area (sf)	Thick (in)	Heat Cap	Conduct-ivity	Surface R-value	Location/Comments
HOUSE						
1 SlabOnGrade	180	3.5	28.0	0.98	R-0.0	20% Exposed Default
2 SlabOnGrade	722	3.5	28.0	0.98	R-2.0	80% Covered Default

HVAC SYSTEMS

System Type	Minimum Efficiency	Duct Location	Duct R-value	Duct Efficiency
HOUSE				
Furnace	0.800 AFUE	Attic	R-4.2	0.880
ACSplit	10.00 SEER	Attic	R-4.2	0.870

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	0.615	40	R-12

SPECIAL FEATURES/REMARKS

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

Appendix B

Gathering Building Department Compliance Forms

This section discusses the original methodology and final results of the effort to gather copies of C-2R and CF-1R compliance forms for a sample of surveyed sites, in order to use them to test the Interface.

B.1 Objectives

Identifying Building Departments to be Recruited

It does not make sense to contact a building department and only ask for the forms for a single site. As much as possible when contacting a building department, team members asked for forms for as many sites as possible. Other recruitment criteria included the following:

- Identifying building departments with the largest number of surveyed sites AND those that we have already contacted as part of the RMST CF-6R acquisition effort.
- Recruiting first from "friendly" building departments (those already providing CF-6Rs, especially those that provided forms for the overlap sites), and from those with "easy" driving distance from RER offices in San Diego.
- Attempting to recruit those building departments that were not providing CF-6Rs, but had been previously contacted for this effort.
- Identifying those building departments with the largest number of surveyed sites that had NOT been contacted as part of the RMST CF-6R acquisition effort. These were the most difficult and time-consuming to contact and were used as a last resort.

Key Features Used in Site Selection

The first step in selecting the test sites and building departments from which to recruit from is to identify key criteria. The following criteria were selected for examination:

- Building department and the total number of surveyed sites under the jurisdiction of each building department,

- Whether the building department was one previously contacted for the CF-6R effort, and whether they contributed to that effort,
- RER climate zone,
- Residence type,
- Predominant HVAC system type, and
- Existance of multiple HVAC systems.

A listing summarizing these features for every site was assembled. Also, in the process of identifying these features, some unique “special interest” sites were identified as follows:

- Sites with multiple HVAC system types
- Sites with multiple water heaters
- Sites that utilize hydronic heating systems

Criteria for Selecting Building Departments and Sites

Once the list of key features was assembled, the following criteria were used to ensure that selected sites provided enough variations to thoroughly test the process:

- Ensure all climate zones are represented in the sample.
- Obtain a mix of single family, single family attached, and multifamily types.
- Obtain as good a mix of HVAC system types as is possible.
- Attempt to obtain a few “special interest” sites, even if this means obtaining forms for only a single site from a building department that had never been contacted.

Selecting the Building Departments to be Contacted

RER reviewed the summary listing of key parameters and, for each climate zone, selected at least three building departments—a primary, a secondary, and a runner-up(s). Primary and secondary building departments were needed because some building departments only keep records for a limited time, and some may not keep the C-2R forms. Runner-ups were used as a last resort, some of which were building departments that had not contacted in the past. Initial selection of these building departments is given in the tables below.

Table B-1: Building Department Targets

RER CZ	BldgDept	SF-A[1]	SF	MF	BldgDept	SF-A	SF	MF
Primary and Secondary Targets								
1	Napa		5		Morgan Hill	2	3	
2	San Diego[2]	3	26	16	Chula Vista[2]	2	18	
3	Simi Valley		11	2	Murrieta		9	
4	Chico		4		Rocklin	1	8	2
5	Apple Valley		3		Palm Desert		6	
	Totals	**3**	**49**	**18**		**1**	**44**	**2**
Runner-Up Targets								
1	San Francisco		5		Oakland	2	1	2
2	None							
3	Temecula		3	1				
4	Bakersfield	1	20					
5	Hemet		3	2				
	Totals	**1**	**26**	**2**		**2**	**1**	**2**

Contacting Building Departments and Determine CF-1R/C-2R Status

The targeted building departments were contacted to determine if they had CF-1R and C-2R forms for the surveyed sites. Those previously contacted received a fax and a list of the sites for which forms were needed. This was then followed up with a telephone call to see if the building department was willing and able to contribute. Some forms were mailed to RER, while others were obtained by visiting the site to obtain copies.

B.2 Compliance Form Collection Results

RER contacted about 50 building departments, however only six were able to contribute CF-1R and C-2R forms. Forms for 40 on-site survey sites were collected. Of those, only 36 of matched 37 sites (one C-2R form matched two on-site survey sites). A final tabulation of the forms received from building departments is given in Table B-2. The locations of building departments contributing forms are shown in Figure B-1. The distribution is quite different from that given in the original plan. It was very difficult to entice building departments to

1 SF=Single-family, unattached. SF-A=Single-family attached. MF=Multifamily.

2 RER will physically visit these building departments to obtain copies of the CF-1R and C-2R forms.

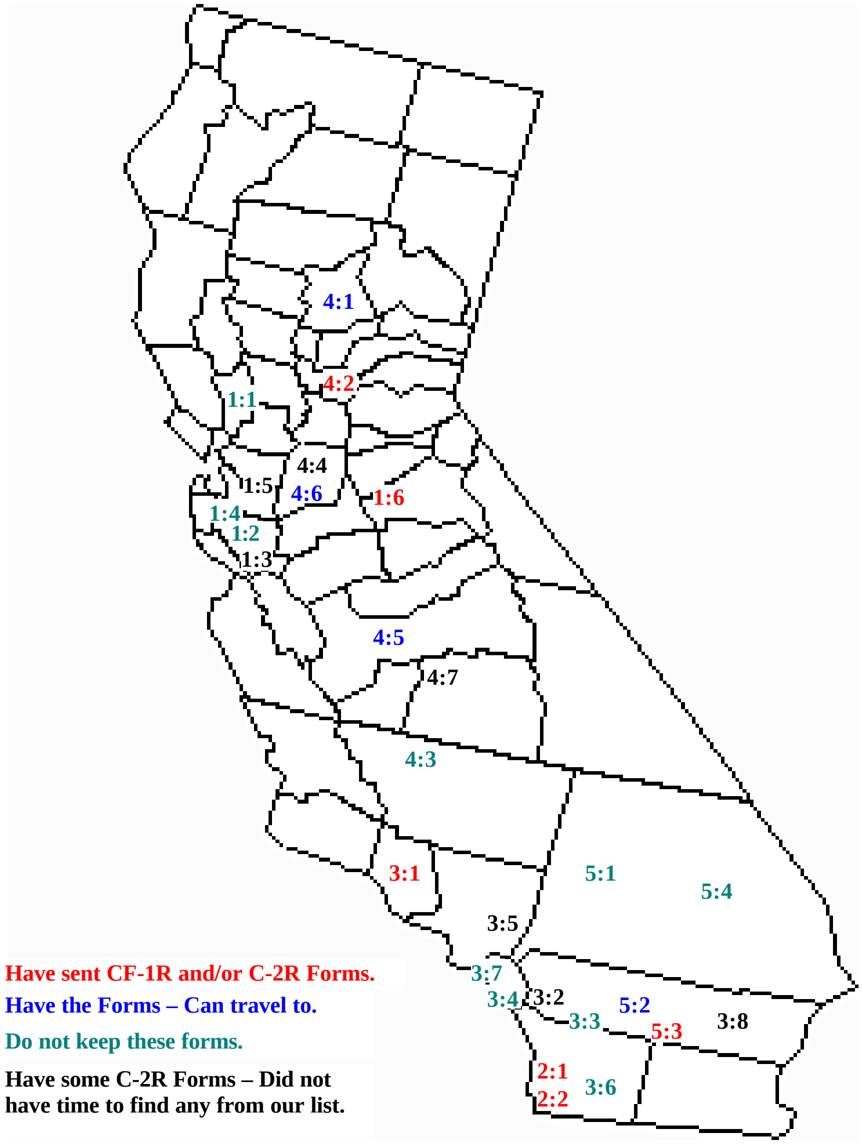
contribute to this effort due to their limited time and available manpower. However, all building types and RER climate zones are represented.

Table B-2: Final Building Department Sample

RER CZ	CEC CZ	BldgDept	SF-1Story	SF-2Story	SF-Attached	MF	Total C-2Rs
1	3, 12	Alameda	2	5	1		**8**
2	7, 10	San Diego		5		2	**7**
2	7	Chula Vista	2	13			**15**
3	9	Simi Valley		2		1	**3**
4	11	Rocklin	1	2		1	**4**
5	15	La Quinta	3				**3**
		Totals	**8**	**27**	**1**	**4**	**40**

Figure B-1: Location of Building Departments Contributing C-2Rs

1:1	Napa
1:2	Morgan Hill
1:3	Gilroy
1:4	San Jose
1:5	Fremont
1:6	Alameda
2:1	San Diego
2:2	Chula Vista
3:1	Simi Valley
3:2	Murrieta
3:3	Temecula
3:4	Orange County
3:5	Corona
3:6	San Diego County
3:7	Irvine
3:8	Riverside County
4:1	Chico
4:2	Rocklin
4:3	Bakersfield
4:4	Stockton
4:5	Fresno
4:6	Tracy
4:7	Visalia
5:1	Apple Valley
5:2	Palm Desert
5:3	La Quinta
5:4	San Bernardino County



Appendix C

On-Site Survey Instrument

This appendix contains the survey forms used for both the first and second year of on-site surveys, as well as an overview of the differences between the two forms.

C.1 Modifications of the RMST On-Site Survey Form for the Second Year

A number of modifications were made to the second year RMST on-site survey form. These changes were made to improve data availability and quality for the MICROPAS[1] analysis, and also to capture data requested by CEC personnel and other statewide RNC program managers. The changes are summarized below.

- Detailed information on kitchen lighting and diffuser types, bathroom lighting, and ceiling fan lighting systems were added.
- Ceiling fans that do not have lights are counted as miscellaneous equipment.
- Information on HVAC system location and an estimate of the distance between the HVAC system and water heating system was added. HVAC system equipment types were also expanded.
- Several changes were made to the water heating equipment page. A more direct way to specify a combination space/water heating type unit was added. Control types and features reflecting the various credits/debits available in MICROPAS were also added. Finally, additional fields needed to record performance and efficiency information for large water heaters and water heaters used in hydronic systems were added.
- Information on the location of supply and return ducts was added. Duct and duct-sealing types were expanded. A field for recording the duct sealing tape UL label information and brand name was also added (although, this data was gathered last year, there was no dedicated field to capture the data).
- Building shell data changes were made to enhance the MICROPAS runs. More detailed information on door shading, roof areas, roof insulation type, ground floor

[1] MICROPAS is a computer software tool used for performing Title 24 compliance analysis on low-rise residential buildings.

area, exposed/covered floor percentages and floor area above an unconditioned garage were added.

- For windows, interior and exterior shading details were separated and expanded to better reflect MICROPAS options. In addition, glass type options were revised to reflect the use of the ETEKT+ AE1600 Low-E Coating Detectors,[2] which were used to detect after-market window films as well as low-E coatings. In addition, surveyors measured the home's three largest windows and then used those measurements as the basis for estimating the areas of other windows (surveyors do not measure every window in the home due to time and budget constraints).

[2] ETETKT+ Low-E Coating Detectors were obtained from Electronic Design to Market, Inc. (www.edtm.com). These meters detect the presence of metal surface coatings on the outer or inner sides of single-paned or dual-paned glass windows.

1999 On-Site Survey Instrument

Site ID #

Residential New Construction
Market Share Tracking Project
On-Site Survey Form

Regional Economic Research, Inc. and Volt VIEWtech

Version: 11/1/1999

Contact Information:

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

Survey Tracking Information:

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

Duct Blaster test site?

Survey and Data Received by RER:	__ / __ / __	__ __ __

Table of Contents

Description **Page**

Energy Utility Meters & Accounts

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

If Yes, is the customer aware of electric industry deregulation and the option to switch providers? ☐ Yes ☐ No

-- If Yes, has the customer changed energy providers? ☐ 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 OT**		
2	**E G O**	**SDG&E SCE SCG PG&E OT**		
3	**E G O**	**SDG&E SCE SCG PG&E OT**		
4	**E G O**	**SDG&E SCE SCG PG&E OT**		
5	**E G O**	**SDG&E SCE SCG PG&E OT**		
6	**E G O**	**SDG&E SCE SCG PG&E OT**		

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

Comments

____

____

____

____

General Site Information

Type of residence: (CHECK ONLY ONE. If **MF** indicated, complete pages 18 and 19)

SF ☐ Detached, tract-built single family house
SF ☐ Detached, custom-built single family house
MF ☐ Attached home, Townhome/Condo
MF ☐ Apartment in small complex (fewer than 5 units)
MF ☐ Apartment in large complex (5+ units)
SF ☐ Manufactured housing
SF ☐ Mobile home/trailer
MF ☐ Other, describe ________________________________

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)

What was the purchase price of the home?

Actual price $____________

OR ☐ Declined to state

OR ☐ Under $100,000
☐ $100,000 - $200,000
☐ $200,000 - $300,000
☐ $300,000 - $400,000
☐ over $400,000

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

- ☐ Don't know
- ☐ Energy Star Home (look for a bronze plaque mounted somewhere on the home)
- ☐ Pacific Gas & Electric (PG&E) Comfort Home
- ☐ Southern California Edison (SCE) ComfortWise Home
- ☐ Southern California Gas (SCG) Energy Advantage Home
- ☐ San Diego Gas & Electric (SDG&E) ComfortWise Home

FOR HOME OWNERS ONLY: 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
- ☐ Pre-wired Home Automation System
- ☐ Other ______________________________________
- ☐ Don't know

Household Characteristics

Please have the respondent 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 __________
22-39 __________
40-64 __________
65 and over __________

Indicate the household's current annual income before taxes?

- ☐ Under $20,000 per year
- ☐ $20,000 - 39,999
- ☐ $40,000 - 59,999
- ☐ $60,000 - 79,999
- ☐ $80,000 - 120,000
- ☐ Over $120,000
- ☐ Refused

<u>If any significant devices that affect energy use or conservation (i.e photovoltaic systems, backup generator systems for Y2K, electric automobiles, etc.) are observed during the survey, ask the occupant about them and record relevant notes on the comments page at the end of the survey form.</u>

Indoor & Outdoor Lighting

Item #	1	2	3	4	5	6	7	8
Location: **X** = Outside Lighting **K** = Kitchen **L**=Living Room **D** = Dining Room **F** = Family Room **H** = Halls/Entry **B** = Bathroom **MB** = Master Bed. **OB** = Other Bedroom **G** = Garage **OT** = Other (describe)								
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								
Total Number of Fixtures								
Number of lamps per fixture								
Watts per Lamp (enter 2 or 3-way as 50/100/150)								
Lamp Type								
I = Incandescent Standard, medium base **IS** = Incandescent Standard, small base **IP** = Incandescent PAR **IR** = Incandescent Reflector	I IS IP IR	I IS IP IR	I IS IP IR	I IS IP IR	I IS IP IR	I IS IP IR	I IS IP IR	I IS IP IR
For Incandescent lamps: CFs Applicable (medium base)?	Y N	Y N	Y N	Y N	Y N	Y N	Y N	Y N
F = Fluorescent Tube **UT** = Fluorescent U-tube **OF** = Other Fluorescent (describe in comment block)	F UT OF	F UT OF	F UT OF	F UT OF	F UT OF	F UT OF	F UT OF	F UT OF
For Fluorescent tubes: Length in ft. (e.g., 2 4 6 8)								
Diameter (T5 T8 T9 T10 T12)								
CFG = CF w/Globe-Shaped diffuser **CFC** = CF, w/Capsule-Shaped diffuser **CFR** = CF w/reflector **CF** = Compact Fluorescent, Other **CIR** = Circline	CFG CFC CFR CF CIR	CFG CFC CFR CF CIR	CFG CFC CFR CF CIR	CFG CFC CFR CF CIR	CFG CFC CFR CF CIR	CFG CFC CFR CF CIR	CFG CFC CFR CF CIR	CFG CFC CFR CF CIR
For CF and CIR,lamps, indicate base type: ***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" **HT** = Halogen Tubular **HL** = Halogen low voltage **HP** = Halogen reflector/PAR	HA HT HL HP	HA HT HL HP	HA HT HL HP	HA HT HL HP	HA HT HL HP	HA HT HL HP	HA HT HL HP	HA HT HL HP
MV = Mercury Vapor **MH** = Metal Halide **HPS** = High Pressure Sodium Vapor **LPS** = Low Pressure Sodium Vapor	MV MH HPS LPS	MV MH HPS LPS	MV MH HPS LPS	MV MH HPS LPS	MV MH HPS LPS	MV MH HPS LPS	MV MH HPS LPS	MV MH HPS LPS
Field Notes: (Counts)								

Indoor & Outdoor Lighting

Item #	9	10	11	12	13	14	15	16
Location: **X** = Outside Lighting **K** = Kitchen **L**=Living Room **D** = Dining Room **F** = Family Room **H** = Halls/Entry **B** = Bathroom **MB** = Master Bed. **OB** = Other Bedroom **G** = Garage **OT** = Other (describe)								
Control Type: **S** = Switch (on/off) **M** = Motion sensor **D** = Dimmer **P** = Photocell **T** = Timer **H** = Home Automation System **OT** = Other (describe) ___________________________								
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Total Number of Fixtures								
Number of lamps per fixture								
Watts per Lamp (enter 2 or 3-way as 50/100/150)								
Lamp Type								
I = Incandescent Standard, medium base **IS** = Incandescent Standard, small base **IP** = Incandescent PAR **IR** = Incandescent Reflector	I IS IP IR	I IS IP IR	I IS IP IR	I IS IP IR	I IS IP IR	I IS IP IR	I IS IP IR	I IS IP IR
For Incandescent lamps: CFs Applicable (medium base)?	Y N	Y N	Y N	Y N	Y N	Y N	Y N	Y N
F = Fluorescent Tube **UT** = Fluorescent U-tube **OF** = Other Fluorescent (describe in comment block)	F UT OF	F UT OF	F UT OF	F UT OF	F UT OF	F UT OF	F UT OF	F UT OF
For Fluorescent tubes: Length in ft. (e.g., 2 4 6 8)								
Diameter (T5 T8 T9 T10 T12)								
CFG = CF w/Globe-Shaped diffuser **CFC** = CF, w/Capsule-Shaped diffuser **CFR** = CF w/reflector **CF** = Compact Fluorescent, Other **CIR** = Circline	CFG CFC CFR CF CIR	CFG CFC CFR CF CIR	CFG CFC CFR CF CIR	CFG CFC CFR CF CIR	CFG CFC CFR CF CIR	CFG CFC CFR CF CIR	CFG CFC CFR CF CIR	CFG CFC CFR CF CIR
For CF and CIR,lamps, indicate base type: ***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" **HT** = Halogen Tubular **HL** = Halogen low voltage **HP** = Halogen reflector/PAR	HA HT HL HP	HA HT HL HP	HA HT HL HP	HA HT HL HP	HA HT HL HP	HA HT HL HP	HA HT HL HP	HA HT HL HP
MV = Mercury Vapor **MH** = Metal Halide **HPS** = High Pressure Sodium Vapor **LPS** = Low Pressure Sodium Vapor	MV MH HPS LPS	MV MH HPS LPS	MV MH HPS LPS	MV MH HPS LPS	MV MH HPS LPS	MV MH HPS LPS	MV MH HPS LPS	MV MH HPS LPS
Field Notes: (Counts)								

Indoor & Outdoor Lighting

Item #	__	__	__	__	__	__	__	__
Location: **X** = Outside Lighting **K** = Kitchen **L**=Living Room **D** = Dining Room **F** = Family Room **H** = Halls/Entry **B** = Bathroom **MB** = Master Bed. **OB** = Other Bedroom **G** = Garage **OT** = Other (describe)								
Control Type: **S** = Switch (on/off) **M** = Motion sensor **D** = Dimmer **P** = Photocell **T** = Timer **H** = Home Automation System **OT** = Other (describe) ___________________________								
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Total Number of Fixtures								
Number of lamps per fixture								
Watts per Lamp (enter 2 or 3-way as 50/100/150)								
Lamp Type								
I = Incandescent Standard, medium base **IS** = Incandescent Standard, small base **IP** = Incandescent PAR **IR** = Incandescent Reflector	I IS IP IR	I IS IP IR	I IS IP IR	I IS IP IR	I IS IP IR	I IS IP IR	I IS IP IR	I IS IP IR
For Incandescent lamps: CFs Applicable (medium base)?	Y N	Y N	Y N	Y N	Y N	Y N	Y N	Y N
F = Fluorescent Tube **UT** = Fluorescent U-tube **OF** = Other Fluorescent (describe in comment block)	F UT OF	F UT OF	F UT OF	F UT OF	F UT OF	F UT OF	F UT OF	F UT OF
For Fluorescent tubes: Length in ft. (e.g., 2 4 6 8)								
Diameter (T5 T8 T9 T10 T12)								
CFG = CF w/Globe-Shaped diffuser **CFC** = CF, w/Capsule-Shaped diffuser **CFR** = CF w/reflector **CF** = Compact Fluorescent, Other **CIR** = Circline	CFG CFC CFR CF CIR	CFG CFC CFR CF CIR	CFG CFC CFR CF CIR	CFG CFC CFR CF CIR	CFG CFC CFR CF CIR	CFG CFC CFR CF CIR	CFG CFC CFR CF CIR	CFG CFC CFR CF CIR
For CF and CIR,lamps, indicate base type: ***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" **HT** = Halogen Tubular **HL** = Halogen low voltage **HP** = Halogen reflector/PAR	HA HT HL HP	HA HT HL HP	HA HT HL HP	HA HT HL HP	HA HT HL HP	HA HT HL HP	HA HT HL HP	HA HT HL HP
MV = Mercury Vapor **MH** = Metal Halide **HPS** = High Pressure Sodium Vapor **LPS** = Low Pressure Sodium Vapor	MV MH HPS LPS	MV MH HPS LPS	MV MH HPS LPS	MV MH HPS LPS	MV MH HPS LPS	MV MH HPS LPS	MV MH HPS LPS	MV MH HPS LPS
Field Notes: (Counts)								

Appliances & Other Equipment

Refrigerators & Freezers - Manufacturer/Model Data

Item #1 -- Manufacturer	
-- Model Number	
Item #2 -- Manufacturer	
-- Model Number	
Item #3 -- Manufacturer	
-- 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 **B**=Bottom mount **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
Volume/size, ft^3			
Age in years (enter 1 if less than 1 year old)			
EF (Energy Factor, ft^3/kWh/day)			

Dishwasher

Manufacturer	Model Number

Clothes Washer

Axis Type	Manufacturer	Model Number	Age
Vert **H**oriz			

Clothes Dryer

Fuel Type	Manufacturer	Model Number	Age
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		
Other ____________________		
Other ____________________		
Other ____________________		

Water Heating Equipment

Manufacturer	Model Number	EF (Energy Factor)

Equipment type: **S** = Standard 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**
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**
Solar Backup Type (if relevant): **E** = Electricity **G** = Natural Gas **P** = Propane (LPG) **OT**=Other ________	**E G P OT**
Heat trap? Y=yes, N=no	**Y N**
Low-flow fixtures (showerheads, faucets, etc.)? **Y**=yes, **N**=no	**Y N**
Input Capacity (Check units, either kBtuh or kW)	❑ kBtuh ❑ kW
Tank Capacity (Gallons)	
Does the hot water tank have an external insulation jacket? **Y**=yes, **N**=no	**Y N**
Are hot water pipes insulated? **Y**=yes, **N**=no	**Y N**
Hot water recirculation system present? **Y**=yes, **N**=no	**Y N**
Recirculation pump power (hp) (Enter zero for no pump.)	________ hp
Hot water temperature (°F) If unknown: **H**=High **M**=Medium **L**=Low	**H M L**
Where is the water heater located? **C**=Conditioned or **U**=Unconditioned space	**C U**
Does the water heater serving this dwelling also serve others? Y=yes, N=no	**Y N**

Heating, Cooling, Fans, and Ducts

Heating and Cooling Systems

System ID	# ___		#___	
System Information				
System Type: **C** = Central Unit **P** = Portable Unit **WW** = Window/Wall Unit **S** = Shared central system **EV** = Evaporative Cooler **OT** = Other* ________ **H** = Hydronic **BB** = Baseboard/Radiant Heater	C WW EV H BB	P S OT	C WW EV H BB	P S OT
% of Residence Served by this System				
Location: **G**=Garage **A**=Attic **S**=Cond. Space **M**= Mech. Room **OT**=Other ________________	**G A S M OT**		**G A S M OT**	
Heating Equipment				
Manufacturer				
Model Number (include dash numbers)				
Number of units:				
Equipment Type: **F** = Furnace **HP** = Heat Pump **RH** = Radiant Heater **ER** = Elec. Resist **HW** = Boiler **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**
Output Capacity (Check units, either 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)				
Number of Units:				
Type: **AC** = A/C (Std DX) **ID** = Indirect/Direct Evap **HP** = Heat Pump **N** = None **EV** = Direct Evap **OT** = Other ____________	**AC HP EV ID N OT**		**AC HP EV ID N OT**	
Output Capacity (kBtuh)				
Efficiency | Efficiency Units (S=SEER E=EER P=% Sat. Eff)	| **S E P**		| **S E P**	
Condenser Type: **A**=Air **E**=Evap **G**=Ground W=Water	**A E G W**		**A E G W**	

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 ™ **WH***=Whole-house fan **OT***=Other	**SV WH OT**	**SV WH OT**
Thermostat/Controls		
Manufacturer		
Model Number		
Thermostat Type (only if applicable): **EM** = Electromechanical **D** = Digital **H** = Hybrid **HAS** = Home Automation System **OT** = Other _______________	**EM** **D** **H** **HAS** **OT**	**EM** **D** **H** **HAS** **OT**

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**
Location of Ducts (indicate all that apply): **A**=Attic **CR** =Crawl Space **CS**=Cond. Space **W**=Wall Cavity **B**=Basement **OT**=Other*	**A CR CS** **W B OT**	**A CR CS** **W B OT**
Duct Types (indicate all that apply): **F**=Flexduct **M**=Metal **P**=Panned Joist **U**=Unfinished wall cavity **OT**=Other*	**F M P** **U OT**	**F M P** **U OT**
Duct Sealant Types (indicate all that apply): **M**=Mastic **BT**=Butyl Tape **MT**=Metal Tape **C**=Mech. clamps **OT**=Other*	**M BT MT** **C OT**	**M BT MT** **C OT**
--- Aerosol sealing used (check for certificate)**?**	**Y N**	**Y N**
Duct Insulation R-Value (–7 if insulation not labeled, 0 if not insulated)		
Duct Condition		
Plenum Condition		

* Describe Other types in comments block.

Additional Comments: ____

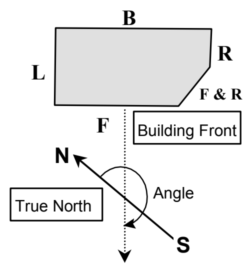
____

____

____

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
Shading: N= None L=Light M=Medium H=Heavy				
Gross Wall Area, ft^2 *(inc. windows, doors, etc.)*				
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)				
Demising Wall Area (Wall between cond. and uncond. space)	ft^2	ft^2	ft^2	ft^2
Number of Wooden Doors				
Number of Insulated Metal Doors				
Number of Uninsulated Metal Doors				

Roof/Ceilings

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?		**Y N**
Non-Vaulted Ceiling Height	Feet	
=> Vaulted Ceilings, Estimated % of Total Floor Area with Vaulted Ceilings?		%
Ceiling Insulation R-value	Indicate R-value OR	
	Indicate inches of insulation in roof cavity	

* Note "Other" construction types in comments block.

Building Orientation and Construction (cont.)

Floor

Number of floors	
Total conditioned floor area, ft^2	
Floor construction type	**S** = Slab **C** = Crawl U = Unheated Basement **O** = Open (Garage)
Insulation R-value	

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						
Shading	**I** = Interior (blinds/drapes) **N** = None **E** = Exterior (overhangs/awnings) **B** = Both						
Style	**S**=Slider **F**=Fixed **A**=Art glass **D**=Double-hung **B**=Bay/Bow **C**=Casement **W**=Awning **OT**=Other						
Layers of glazing	**S**=Single **D**=Double **T**=Triple						
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 **L**=LowE						
-- Was this an after-market film/treatment?		**Y N**	**Y N**	**Y N**	**Y N**	**Y N**	**Y N**
Area per unit	Square feet						
Number of units installed:	=> **Front** wall (or **Roof** if skylight)						
	=> **Left** wall						
	=> **Back** wall						
	=> **Right** wall						
Fill Type	**N**=None **A**=Air **G**=Gas-filled						
Mfr. Or MFR. CODE	Enter **SB** if it looks like it was site-built						
SERIES	Enter window series/style						
SHGC	Solar Heat Gain Coefficient						
U-Value	Overall heat transfer coefficient						

* Describe Other frame type in comments block

Comments: ____

____

____

____

____

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						
Shading	**I** = Interior (blinds/drapes) **N** = None **E** = Exterior (overhangs/awnings) **B** = Both						
Style	**S**=Slider **F**=Fixed **A**=Art glass **D**=Double-hung **B**=Bay/Bow **C**=Casement **W**=Awning **OT**=Other						
Layers of glazing	**S**=Single **D**=Double **T**=Triple						
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 **L**=LowE						
-- Was this an after-market film/treatment?		**Y N**	**Y N**	**Y N**	**Y N**	**Y N**	**Y N**
Area per unit	Square feet						
Number of units installed:	=> **Front** wall (or **Roof** if skylight)						
	=> **Left** wall						
	=> **Back** wall						
	=> **Right** wall						
Fill Type	**N**=None **A**=Air **G**=Gas-filled						
Mfr. Or MFR. CODE	(Enter **SB** if it looks like it was site-built)						
SERIES	Enter window series/style						
SHGC	Solar Heat Gain Coefficient						
U-Value	Overall heat transfer coefficient						

* 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

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___

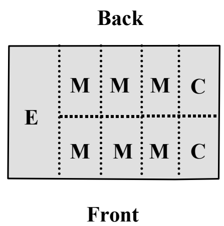
___

Multi-Family Building and Complex Information

Surveyed Residential Unit Characteristics

Residential unit configuration type	B=Back-to-back S=Straight-through H= Hallway (interior) P= Perimeter units (arranged around a central area) O=Other	**B S H P O**
Horizontal/Floorplan Location (figure below)	E=End Unit C=Corner unit M=Middle unit O=Other	**E C M O**
Vertical/Floor Location	Indicate floor/story number or **M** if Multi-floor unit	_____ or **M**
Are all residential units in this building the same size/ft^2?		**Y N**

Horizontal/Floorplan Location within Building



Building Characteristics

Number of floors	
Total number of residential units in this bldg?	
Approx. % of this building that is non-residence type space/activity (i.e. laundry facilities, rec. rooms, etc.)	
Approx **Front/Back** Length of building (Front same as for residential unit)	
Approx **Left/Right** Width of building	
Approx %Glass on => **Front** wall	
=> **Left** wall	
=> **Back** wall	
=> **Right** wall	

Housing Complex Characteristics

Total number of *residential units* in the complex?	
Total # of residential-unit *buildings* in the complex?	
-- # of buildings with this same floor plan?	
-- Typical orientation of other buildings	**S** = Same as surveyed bldg **V** = Varies

Comments: ____

____

____

____

____

Multi-Family Residence Building Sketch

Sketch an outline (i.e. external walls) of the building in which the surveyed residential unit was located. Indicate if there are areas other than residential units located within the building. Note overall dimensions and the *location of the surveyed unit within the building*. 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 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

2000 On-Site Survey Instrument

Site ID #

Residential New Construction
Market Share Tracking Project
On-Site Survey Form

Regional Economic Research, Inc. and Volt VIEWtech

Version: 11/06/2000

Contact Information:

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

* Only needed if different from Street Address

Photo Information

Disposable Camera ID #		# of photos	

Survey Tracking Information:

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

Duct Blaster test site?

Survey and Data Received by RER:	__ / __ / __	__ __ __

Table of Contents

Energy Utility Meters & Accounts

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

If Yes, is the customer aware of electric industry deregulation and the option to switch providers? ☐ Yes ☐ No

-- If Yes, has the customer changed energy providers? ☐ 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 OT**		
2	**E G O**	**SDG&E SCE SCG PG&E OT**		
3	**E G O**	**SDG&E SCE SCG PG&E OT**		
4	**E G O**	**SDG&E SCE SCG PG&E OT**		
5	**E G O**	**SDG&E SCE SCG PG&E OT**		
6	**E G O**	**SDG&E SCE SCG PG&E OT**		

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

Comments
____
____
____
____

General Site Information

Type of residence: (CHECK ONLY ONE. If **MF** indicated, complete pages 18 and 19)

SF ☐ Detached, tract-built single family house
SF ☐ Detached, custom-built single family house
MF ☐ Attached home, Townhome/Condo
MF ☐ Apartment in small complex (fewer than 5 units)
MF ☐ Apartment in large complex (5+ units)
SF ☐ Manufactured housing
SF ☐ Mobile home/trailer
MF ☐ Other, describe ________________________________

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? ☐ Yes ☐ No
(If so, note below what forms were found)

What was the purchase price of the home?

Actual price $____________

OR ☐ Declined to state

OR ☐ Under $100,000
☐ $100,000 - $200,000
☐ $200,000 - $300,000
☐ $300,000 - $400,000
☐ over $400,000

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

- ☐ Don't know
- ☐ Energy Star Home (look for a bronze plaque mounted somewhere on the home)
- ☐ Pacific Gas & Electric (PG&E) Comfort Home
- ☐ Southern California Edison (SCE) ComfortWise Home
- ☐ Southern California Gas (SCG) Energy Advantage Home
- ☐ San Diego Gas & Electric (SDG&E) ComfortWise Home

FOR HOME OWNERS ONLY: 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
- ☐ Other ______________________________________
- ☐ Don't know

Household Characteristics

Please have the respondent 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 __________
22-39 __________
40-64 __________
65 and over __________

Indicate the household's current annual income before taxes?

- ☐ Under $20,000 per year
- ☐ $20,000 - 39,999
- ☐ $40,000 - 59,999
- ☐ $60,000 - 79,999
- ☐ $80,000 - 120,000
- ☐ Over $120,000
- ☐ Refused

<u>NOTE: If any significant devices that affect energy use or conservation (i.e photovoltaic systems, backup generator systems for Y2K, electric automobiles, etc.) are observed during the survey, ask the occupant about them and record relevant notes on the 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 L=LivingRoom **D** = DiningRoom **F** = FamilyRoom **BT** = BathRm w/Toilet **BN** = BathRm NoToilet **MB** = MstrBdRm **OB** = OthrBedRm **H** = Halls/Entry **K** = Kitchen* **N** = BrkfstNook **OT** = Other (describe)								
***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 **IS** = Incandescent Standard, small base **IP** = Incandescent PAR **IR** = Incandescent Reflector	I IS IP IR	I IS IP IR	I IS IP IR	I IS IP IR	I IS IP IR	I IS IP IR	I IS IP IR	I IS IP 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 **UT** = Fluorescent U-tube **OF** = Other Fluorescent (describe in comment block)	F UT OF	F UT OF	F UT OF	F UT OF	F UT OF	F UT OF	F UT OF	F UT 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 **CFC** = CF, w/Capsule-Shaped diffuser **CFR** = CF w/reflector **CF** = Compact Fluorescent, Other **CIR** = Circline	CFG CFC CFR CF CIR	CFG CFC CFR CF CIR	CFG CFC CFR CF CIR	CFG CFC CFR CF CIR	CFG CFC CFR CF CIR	CFG CFC CFR CF CIR	CFG CFC CFR CF CIR	CFG CFC CFR CF 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" **HT** = Halogen Tubular **HL** = Halogen low voltage **HP** = Halogen reflector/PAR	HA HT HL HP	HA HT HL HP	HA HT HL HP	HA HT HL HP	HA HT HL HP	HA HT HL HP	HA HT HL HP	HA HT HL HP
MV = Mercury Vapor **MH** = Metal Halide **HPS** = High Pressure Sodium Vapor **LPS** = Low Pressure Sodium Vapor	MV MH HPS LPS	MV MH HPS LPS	MV MH HPS LPS	MV MH HPS LPS	MV MH HPS LPS	MV MH HPS LPS	MV MH HPS LPS	MV MH HPS LPS
Field Notes: (Counts)								

Indoor & Outdoor Lighting

Item #	9	10	11	12	13	14	15	16
Location: **X** = OutsideLtg **G** = Garage L=LivingRoom **D** = DiningRoom **F** = FamilyRoom **BT** = BathRm w/Toilet **BN** = BathRm NoToilet **MB** = MstrBdRm **OB** = OthrBedRm **H** = Halls/Entry **K** = Kitchen* **N** = BrkfstNook **OT** = Other (describe)								
***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 **IS** = Incandescent Standard, small base **IP** = Incandescent PAR **IR** = Incandescent Reflector	I IS IP IR	I IS IP IR	I IS IP IR	I IS IP IR	I IS IP IR	I IS IP IR	I IS IP IR	I IS IP 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 **UT** = Fluorescent U-tube **OF** = Other Fluorescent (describe in comment block)	F UT OF	F UT OF	F UT OF	F UT OF	F UT OF	F UT OF	F UT OF	F UT 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 **CFC** = CF, w/Capsule-Shaped diffuser **CFR** = CF w/reflector **CF** = Compact Fluorescent, Other **CIR** = Circline	CFG CFC CFR CF CIR	CFG CFC CFR CF CIR	CFG CFC CFR CF CIR	CFG CFC CFR CF CIR	CFG CFC CFR CF CIR	CFG CFC CFR CF CIR	CFG CFC CFR CF CIR	CFG CFC CFR CF 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" **HT** = Halogen Tubular **HL** = Halogen low voltage **HP** = Halogen reflector/PAR	HA HT HL HP	HA HT HL HP	HA HT HL HP	HA HT HL HP	HA HT HL HP	HA HT HL HP	HA HT HL HP	HA HT HL HP
MV = Mercury Vapor **MH** = Metal Halide **HPS** = High Pressure Sodium Vapor **LPS** = Low Pressure Sodium Vapor	MV MH HPS LPS	MV MH HPS LPS	MV MH HPS LPS	MV MH HPS LPS	MV MH HPS LPS	MV MH HPS LPS	MV MH HPS LPS	MV MH HPS LPS
Field Notes: (Counts)								

Indoor & Outdoor Lighting

Item #	__	__	__	__	__	__	__	__
Location: **X** = OutsideLtg **G** = Garage **L**=LivingRoom **D** = DiningRoom **F** = FamilyRoom **BT** = BathRm w/Toilet **BN** = BathRm NoToilet **MB** = MstrBdRm **OB** = OthrBedRm **H** = Halls/Entry **K** = Kitchen* **N** = BrkfstNook **OT** = Other (describe)								
***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 **IS** = Incandescent Standard, small base **IP** = Incandescent PAR **IR** = Incandescent Reflector	I IS IP IR	I IS IP IR	I IS IP IR	I IS IP IR	I IS IP IR	I IS IP IR	I IS IP IR	I IS IP 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 **UT** = Fluorescent U-tube **OF** = Other Fluorescent (describe in comment block)	F UT OF	F UT OF	F UT OF	F UT OF	F UT OF	F UT OF	F UT OF	F UT 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 **CFC** = CF, w/Capsule-Shaped diffuser **CFR** = CF w/reflector **CF** = Compact Fluorescent, Other **CIR** = Circline	CFG CFC CFR CF CIR	CFG CFC CFR CF CIR	CFG CFC CFR CF CIR	CFG CFC CFR CF CIR	CFG CFC CFR CF CIR	CFG CFC CFR CF CIR	CFG CFC CFR CF CIR	CFG CFC CFR CF 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" **HT** = Halogen Tubular **HL** = Halogen low voltage **HP** = Halogen reflector/PAR	HA HT HL HP	HA HT HL HP	HA HT HL HP	HA HT HL HP	HA HT HL HP	HA HT HL HP	HA HT HL HP	HA HT HL HP
MV = Mercury Vapor **MH** = Metal Halide **HPS** = High Pressure Sodium Vapor **LPS** = Low Pressure Sodium Vapor	MV MH HPS LPS	MV MH HPS LPS	MV MH HPS LPS	MV MH HPS LPS	MV MH HPS LPS	MV MH HPS LPS	MV MH HPS LPS	MV MH HPS LPS
Field Notes: (Counts)								

Appliances & Other Equipment

Refrigerators & Freezers - *Manufacturer/Model Data*

Item #1 -- Manufacturer	
-- Model Number	
Item #2 -- Manufacturer	
-- Model Number	
Item #3 -- Manufacturer	
-- 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
Volume/size, ft^3			
Age in years (enter 1 if less than 1 year old)			
EF (Energy Factor, ft^3/kWh/day)			

	Manufacturer	Model Number
Dishwasher		

	Axis Type	Manufacturer	Model Number	Age
Clothes Washer	**V**ert **H**oriz			

	Fuel Type	Manufacturer	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**
Does the water heater serving this dwelling also serve others? Y=Yes N=No	**Y N**	**Y N**
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	# ___		#___	
System Information				
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 RT FR WF HF BB P	EV RW FL WG HR S OT	C RT FR WF HF BB P	EV RW FL WG HR S OT
% of Residence Served by this System				
Location: **G**=Garage **A**=Attic **S**=Cond. Space **M**= Mech. Room/Closet **OT**=Other _____________	**G A S** **M OT**		**G A S** **M OT**	
For **C and **HF** System Types: Estimated straight-line distance from blower to water heating unit in ft	__ __ **ft**		__ __ **ft**	
Heating Equipment				
Manufacturer				
Model Number (include dash numbers)				
Number of units:				
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 (Check units, either 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)				
Number of Units:				
Type: **AC** = A/C (Std DX) **ID** = Indirect/Direct Evap **HP** = Heat Pump **N** = None **EV** = Direct Evap **OT** = Other ____________	**AC** **HP** **EV**	**ID** **N** **OT**	**AC** **HP** **EV**	**ID** **N** **OT**
Output Capacity (kBtuh)				
Efficiency | Efficiency Units (S=SEER E=EER P=% Sat. Eff)		**S E P**		**S E P**
Condenser Type: **A**=Air **E**=Evap **G**=Ground W=Water	**A E G W**		**A E G W**	

* Describe Other types in comments 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 ™ **WH***=Whole-house fan **OT***=Other	SV WH OT	SV WH OT
Thermostat/Controls		
Manufacturer		
Model Number		
Thermostat Type (only if applicable): **EM** = Electromechanical **D** = Digital **H** = Hybrid **HAS** = Home Automation System **OT** = Other _______________	EM D H HAS OT	EM D H HAS OT

* Describe Other types in comments 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

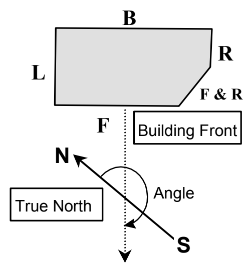
	Supply	Return
Predominant Location of Registers: **F**=Floor **C** =Ceiling **I**=Interior Walls **P**=Perimeter **OT**=Other*	F C I P OT	F C I X OT
Location of Ducts (indicate all that apply): **A**=Attic **CR** =Crawlspace **CS**=Conditioned Space **W**=Wall Cavity **B**=Basement **OT**=Other*	A CR CS W B OT	A CR CS W B OT
Duct Types (indicate 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 (indicate 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), ft^2				
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?		**Y N**
Non-Vaulted Ceiling Height, 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						
Interior Shading Device Type	**D** = Drapes **B** = Blinds (Venetian / vertical/ mini) RollerShades**:** **RO** = Opaque **RT** = Translucent **N** = None **OT** = Other (describe in comments)						
-- IntShadeColor	**L** = Light **M** = Medium **D** = Dark						
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	**O** = Architectural Overhang **A** = Awning C = PatioCover/RecessedEntry **OT** = Other						
Style	**S**=Slider **F**=Fixed **A**=Art glass **D**=Double-hung **B**=Bay/Bow **C**=Casement **W**=Awning **OT**=Other						
Layers of glazing	**S**=Single **D**=Double **T**=Triple						
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**
Area per unit	Square feet						
Number of units installed:	=> **Front** wall (or **Roof** if skylight)						
	=> **Left** wall						
	=> **Back** wall						
	=> **Right** wall						
Fill Type	**A**=Air **G**=Gas-filled (e.g. argon)						

NOTE: If AAMA Permanent Label is found on any windows, please record the Mfr. Or MFR. CODE, SERIES, SHGC, and U-value in theComments block.

* 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						
Interior Shading Device Type	**D** = Drapes **B** = Blinds (Venetian / vertical/ mini) RollerShades**:** **RO** = Opaque **RT** = Translucent **N** = None **OT** = Other (describe in comments)						
-- IntShadeColor	**L** = Light **M** = Medium **D** = Dark						
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	**O** = Architectural Overhang **A** = Awning **C** = PatioCover/RecessedEntry **OT** = Other						
Style	**S**=Slider **F**=Fixed **A**=Art glass **D**=Double-hung **B**=Bay/Bow **C**=Casement **W**=Awning **OT**=Other						
Layers of glazing	**S**=Single **D**=Double **T**=Triple						
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**
Area per unit	Square feet						
Number of units installed:	=> **Front** wall (or **Roof** if skylight)						
	=> **Left** wall						
	=> **Back** wall						
	=> **Right** wall						
Fill Type	**A**=Air **G**=Gas-filled (e.g. argon)						

NOTE: If AAMA Permanent Label is found on any windows, please record the Mfr. Or MFR. CODE, SERIES, SHGC, and U-value in theComments block.

* 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.

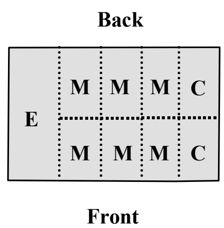
Comments

Multi-Family Building and Complex Information

Surveyed Residential Unit Characteristics

Residential unit configuration type	B=Back-to-back S=Straight-through H= Hallway (interior) P= Perimeter units (arranged around a central area) O=Other	**B S H P O**
Horizontal/Floorplan Location (figure below)	E=End Unit C=Corner unit M=Middle unit O=Other	**E C M O**
Vertical/Floor Location	Indicate floor/story number or **M** if Multi-floor unit	_____ or **M**
Are all residential units in this building the same size/ft^2?		**Y N**

Horizontal/Floorplan Location within Building



Building Characteristics

Number of floors	
Total number of residential units in this bldg?	
Approx. % of this building that is non-residence type space/activity (i.e. laundry facilities, rec. rooms, etc.)	
Approx **Front/Back** Length of building (Front same as for residential unit)	
Approx **Left/Right** Width of building	
Approx %Glass on => **Front** wall	
=> **Left** wall	
=> **Back** wall	
=> **Right** wall	

Housing Complex Characteristics

Total number of *residential units* in the complex?	
Total # of residential-unit *buildings* in the complex?	
-- # of buildings with this same floor plan?	
-- Typical orientation of other buildings	**S** = Same as surveyed bldg **V** = Varies

Comments: ____

Multi-Family Residence Building Sketch

Sketch an outline (i.e. external walls) of the building in which the surveyed residential unit was located. Indicate if there are areas other than residential units located within the building. Note overall dimensions and the *location of the surveyed unit within the building*. 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 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

Appendix D

Duct Blaster Survey Instruments

1999 Duct Blaster Data Collection Form

Duct Blaster Data Collection Form

Site ID:	**Customer Name:**
Address:	**City:**
Date test performed:	**Test Performed by:**
Company Name:	**Duct Blaster Equipment/Model Type:**

HVAC System Type (check one):

- ❑ FAU with Platform Return or Return Air Chase
- ❑ FAU without Platform Return
- ❑ Attic FAU with Return Air Chase
- ❑ FAU with Sealed Blower compartment

TEST RESULTS	COMMENTS/DIAGRAM
Single point @ 25 Pascals: _______ Fan Pressure 1 2 3 Flow Ring (circle one) _______ Fan Flowrate (CFM)	

Duct Blaster Data Collection Form

Site ID:	**Customer Name:**
Address:	**City:**
Date test performed:	**Test Performed by:**
Company Name:	**Duct Blaster Equipment/Model Type:**

HVAC System Type (check one):

- ❑ FAU with Platform Return or Return Air Chase
- ❑ FAU without Platform Return
- ❑ Attic FAU with Return Air Chase
- ❑ FAU with Sealed Blower compartment

TEST RESULTS	COMMENTS/DIAGRAM
Single point @ 25 Pascals: ________ Fan Pressure 1 2 3 Flow Ring (circle one) ________ Fan Flowrate (CFM)	

2000 Duct Blaster Data Collection Form

Duct Blaster Data Collection Form

Site ID:	**Customer Name:**
Address:	**City:**
Date test performed:	**Test Performed by:**
Company Name:	**Duct Blaster Equipment/Model Type:**

TEST FOR EACH SYSTEM: Single point @25 Pa for each system

HVAC SYSTEM #	# 1	# 2	# 3
HVAC System Type (circle one): **PR** = FAU with Platform Return or Return Air Chase **NPR** = FAU without Platform Return **AT** = Attic FAU with Return Air Chase **SB** = FAU with Sealed Blower compartment **OT** = Other (describe in Comments)	**PR** **NPR** **AT** **SB** **OT**	**PR** **NPR** **AT** **SB** **OT**	**PR** **NPR** **AT** **SB** **OT**
Description/Location			
Fan Pressure (Pa)			
Flow Ring used (circle one)	**None 1 2 3**	**None 1 2 3**	**None 1 2 3**
Fan Flowrate (CFM)			

COMMENTS/DIAGRAM

Duct Blaster Data Collection Form

Site ID:	**Customer Name:**
Address:	**City:**
Date test performed:	**Test Performed by:**
Company Name:	**Duct Blaster Equipment/Model Type:**

TEST FOR EACH SYSTEM: Single point @25 Pa for each system

HVAC SYSTEM #	# 1	# 2	# 3
HVAC System Type (circle one): **PR** = FAU with Platform Return or Return Air Chase **NPR** = FAU without Platform Return **AT** = Attic FAU with Return Air Chase **SB** = FAU with Sealed Blower compartment **OT** = Other (describe in Comments)	**PR** **NPR** **AT** **SB** **OT**	**PR** **NPR** **AT** **SB** **OT**	**PR** **NPR** **AT** **SB** **OT**
Description/Location			
Fan Pressure (Pa)			
Flow Ring used (circle one)	**None 1 2 3**	**None 1 2 3**	**None 1 2 3**
Fan Flowrate (CFM)			

COMMENTS/DIAGRAM

Appendix E

Technical Potential Results – Radiant Barriers

E.1 Introduction

This appendix contains the complete set of tables used to assess the technical potential for radiant barriers. Results are presented separately for detached single family homes and multifamily buildings. For each building type, there are five tables. The first table (SF-RB-EF)[1] summarizes the estimated technical potential by end use: cooling (electric savings) and heating (electric savings and gas savings are shown separately). The second table (SF-RB-CL) provides the estimated electric cooling savings as well as cooling saturations for each CEC climate zone. The third and fourth tables (SF-RB-GH and SF-RB-EH) summarize the heating savings by fuel type—electric and gas. The final table (SF-RB-SE) provides the source energy savings as well as the total estimated source energy budget. The remaining tables in this appendix present the same results for multifamily buildings.

The following sections of this appendix, listed below, provide a more detailed description of each table, including its purpose, the data captured in each table, and an explanation of the column/row headers.

- E.2: End-Use/Fuel Energy Savings
- E.3: Energy Savings for Air Conditioned Residences
- E.4: Energy Savings for Gas Heated Residences
- E.5: Energy Savings for Electrically Heated Residences
- E.6: Annual Source Energy Savings

Please note that only homes that do NOT have radiant barriers are included in the technical potential analysis for radiant barriers.

[1] This labeling convention is used for the technical potential tables to avoid confusion. The first two characters of the table label refer to the building type (SF – single family and MF – multifamily), the middle two characters signify the technical potential measure (RB – Radiant Barrier), and the final two characters represent the type of savings estimates that are summarized in the table. (EF – Savings by End-Use/Fuel Type, CL – Cooling Savings, GH – Gas Heating Savings, EH – Electric Heating Savings, and SE – Source Energy Savings).

E.2 Row/Column Titles Common to All Tables

There are several rows and columns of results common to every table. These fields are described below:

RMST CZ. These are the target sample groups used for the Residential Market Share Tracking (RMST) study.[2]

CEC CZ. These are the California Energy Commission climate zones.[3]

MeasRqd ForAB 970 PackageD. A "Yes" in this column indicates that radiant barriers are required in the indicated CEC climate zone as part of the AB 970 Prescriptive Package D.

TotalSavingsAB 970_CZs. Values in this row are totals or averages (depending on the column header) only for those CEC climate zones where radiant barriers are required as part of the AB 970 Prescriptive Package D. For radiant barriers, these CEC climate zones are 2, 4, and 8 through 15.

TotalSavingsIOUServiceArea. Values in this row are totals or averages (depending on the column header) for <u>all</u> CEC climate zones, not just AB 970-specific CEC climate zones.

E.3 End-Use/Fuel Energy Savings Table (Table XX-RB-EF)

These tables present energy savings on an end-use and fuel basis. Savings estimates are presented for space cooling in kWh, gas heating in therms, and electric heating in kWh. Total end-use fuel savings are calculated in two ways: a) the total savings for the homes in all CEC climate zones and b) the total savings for only those homes in the CEC climate zones where the measure is required as part of the AB 970 Prescriptive Package D. An explanation for each of the row and column titles unique to this table are provided below:

Cooling Savings. Cooling savings in kWh are presented for only those homes or multifamily building residential units that had air conditioning systems installed as determined from the onsite survey. Results are presented in three formats, as described below.

- ***(Savings) All Air Cond Homes/ ResUnits.*** This value is the <u>total</u> energy savings for those detached single-family homes (*Homes*) or multifamily residential units (*ResUnits*) *that have the specific equipment installed.*[4]

[2] Regional Economic Research, Inc. *California Residential Efficiency Market Share Tracking – First-Year Interim Report.* Prepared for Southern California Edison. October 2000.

[3] See Section 3 of this report for a map of the CEC climate zones.

- ***(Savings) Average Per Home/ResUnit.*** This value is the average energy savings per detached single-family home (*Per Home*) or multifamily residential units (*Per ResUnit*) *that have the specific equipment installed*. It is obtained by taking the average of the total energy savings divided by the number of detached single-family homes or multifamily residential units *that have the specific equipment installed*.
- ***(Savings) Average Per 1000 ft²*.** This value is the average energy savings per 1,000 square feet of conditioned floor area (CFA) for residences *that have the specific equipment installed*. It is obtained by taking the average of the total energy savings divided by the average conditioned floor area of all detached single-family homes or multifamily residential units *that have the specific equipment installed*.

Gas Heating Savings. Gas heating savings in therms are presented for only those homes or multifamily building residential units that had gas space heating systems installed as determined from the onsite survey. Results are presented on the same three bases as used for the cooling estimates.

Electric Heating Savings. Electric heating savings in kWh are presented for only those homes or multifamily building residential units that had electric space heating systems (baseboard, heat pumps, and electric resistance) installed as determined from the onsite survey. Results are presented on the same three bases as used for the cooling estimates.

E.4 Energy Savings for Air Conditioned Residences (Table XX-RB-CL)

These tables present the data used to assess cooling energy savings. All values in the table are relative to *only those homes or multifamily building residential units that had air conditioning systems installed as determined from the onsite survey*. An explanation for each of the row and column titles in this table is provided below:

Number of Air Cond Homes. Values in this column represent the weighted number of sites that have cooling equipment installed in each CEC Climate Zone[5].

---

[4] The specific equipment here means cooling equipment. For the gas heating and electric heating tables, it means gas or propane heating equipment and electric heating equipment respectively.

[5] Expansion weights were used to expand the sample to the total number of new homes built within the four California IOU service territories between July 1998 and June 1999. The expansion weights are based on RMST climate zone, building type, and the six-month period in which the home was built.

Average ft^2 of Air Cond Homes. These values are the average square footage of homes with cooling equipment, by CEC climate zone.

Saturation of Cooling Equipment in Total Population. Values in this column show the percentage of homes without radiant barriers that have cooling equipment installed.

As-Built Average Cooling % of Total Budget. Values in this column present the estimated cooling usage as a percentage of the total estimated total energy usage for homes with cooling equipment.

Source Energy Cooling Savings (skBtu/yr). These values are the total estimated cooling usage for homes with cooling equipment.

Average Cooling Savings as % of As-Built Cooling Energy. Values in this column show the total estimated electric savings as a percent of the total estimated cooling usage for those homes with cooling equipment.

Cooling Savings

- ***All Air Cond Homes.*** Values in this column show the total estimated electric savings for homes with cooling equipment.
- ***Per Home.*** This presents the average electric savings per home from installing radiant barriers in only those homes with cooling equipment.
- ***Per 1,000 ft^2.*** This presents the average electric savings per 1,000 square feet for only those homes with cooling equipment.

E.5 Energy Savings for Gas Heated Residences (Table XX-RB-GH)

These tables present the data used to assess gas heating energy savings. All values in the table are relative to *only those homes or multifamily building residential units that had gas (or propane) space heating systems installed as determined from the onsite survey*. An explanation for each of the row and column titles in this table is provided below:

Number of Gas Htd Homes. Values in this column represent the weighted number of sites that have gas heating equipment installed in each CEC climate zone.[6]

---

6 Expansion weights were used to expand the sample to the total number of new homes built within the four California IOU service territories between July 1998 and June 1999. The expansion weights are based on RMST climate zone, building type, and the six-month period in which the home was built.

Average ft^2 of Gas Htd Homes. These values are the average square footage of homes with gas heating equipment, by CEC climate zone.

Saturation of Gas Heating Equipment in Total Population. Values in this column show the percentage of homes without radiant barriers that have gas heating equipment installed.

As-Built Average Heating % of Total Budget. Values in this column present the estimated heating usage as a percentage of the total estimated total energy usage for homes with gas heating equipment.

Source Energy Heating Savings (skBtu/yr). These values are the total estimated heating usage for homes with gas heating equipment.

Average Heating Savings as % of As-Built Heating Energy. Values in this column show the total estimated gas savings as a percent of the total estimated heating usage for homes with gas heating equipment.

Gas Heating Savings.

- ***All Gas Htd Homes.*** Values in this column show the total estimated gas savings for homes with gas heating equipment.
- ***Per Home.*** Presents the average gas savings per home from installing radiant barriers in only those homes with gas heating equipment.
- ***Per 1,000 ft^2.*** Presents the average gas savings per 1,000 square feet for only those homes with gas heating equipment.

E.6 Energy Savings for Electrically Heated Residences (Table XX-RB-EH)

These tables present the data used to assess electric heating energy savings. All values in the table are relative to *only those homes or multifamily building residential units that had electric space heating systems installed as determined from the onsite survey*. The explanation for each of the row and column titles in this table are the same as those for the gas heating table except for this table includes data for only those homes with electric space heating equipment.

E.7 Annual Source Energy Savings (Table XX-RB-SE)

These tables present source energy savings as well as the total estimated energy budget by CEC climate zone. Total source energy savings are calculated in two ways: a) the total savings for the homes in all CEC climate zones and b) the total savings for only those homes in the CEC climate zones where the measure is required as part of the AB 970 Prescriptive Package D. An explanation for each of the row and column titles unique to this table are provided below:

Total # of Homes in IOU Service Area (1,000 skBtu). Values in this column represent the weighted number of sites in each CEC Climate Zone.

Average ft^2 Per Home. These values are the average square footage of homes by CEC climate zone.

Total Title 24 Compliance HVAC Source Energy Budget. Values in this column show the estimated heating and cooling energy usage for homes by CEC climate zone.

Title 24 Compliance Source Energy Savings.

- ***Total for All Homes (1,000 skBtu).*** Values in this column present heating and cooling source energy savings of all homes, including those homes without cooling equipment.[7]
- ***Average Per Home (skBtu).*** These values are the average savings per home using the total savings explained in the bullet above divided by the total number of homes.
- ***Average Per ft2 (skBtu/ft2).*** Values in this column show the average savings per 1,000 square feet using the savings per home explained in the bullet above divided by the average square footage of all homes.

As-Built Source Energy Savings.

- ***Total for All Homes (1,000 skBtu).*** Savings shown in this column include the heating and cooling source energy savings of those homes with cooling equipment and only the heating source energy savings of those homes without cooling equipment.
- ***Average Per Home (skBtu).*** These values are the average savings per home using the total savings explained in the bullet above divided by the total number of homes.

[7] MICROPAS 6.0 models every home as if there is a cooling system installed.

- ***Average Per ft^2 (skBtu/ft2).*** Values in this column present the average savings per 1,000 square feet using the savings per home explained in the bullet above divided by the average square footage of all homes.

Table SF-RB-EF: End-Use/Fuel Energy Savings for Radiant Barriers in Detached Single-Family Homes

RMST CZ	CEC CZ	Meas Req'd. for AB 970 PackageD	Cooling Savings[8] (kWh)			Gas Heating Savings[9] (therms)			Electric Heating Savings[10] (kWh)		
			All Air Cond Homes	Per Home	Per 1,000 ft^2	All Gas Htd Homes	Per Home	Per 1,000 ft^2	All Elec Htd Homes	Per Home	Per 1,000 ft^2
1	1		-	-	-	3,982	4.0	2.11	-	-	-
	2	Yes	378,491	236	98.5	20,018	4.8	2.22	-	-	-
	3		113,743	42	17.5	15,441	2.1	0.92	-	-	-
	4	Yes	668,387	147	57.7	15,221	2.6	1.03	-	-	-
	5		28,347	56	18.3	3,642	3.1	1.37	-	-	-
2	6		127,076	53	18.5	5,141	1.2	0.49	4,569	27	4.9
	7		191,584	93	36.5	7,406	1.6	0.69	-	-	-
3	8	Yes	541,285	159	63.9	5,571	1.6	0.66	-	-	-
	9	Yes	2,109,376	309	109.7	13,367	2.0	0.70	-	-	-
	10	Yes	4,897,434	369	164.7	25,976	1.9	0.87	2,523	17	7.8
4	11	Yes	932,258	368	184.9	9,351	3.1	1.55	-	-	-
	12	Yes	3,423,223	273	130.6	38,925	2.9	1.41	-	-	-
	13	Yes	4,095,601	478	271.1	21,901	2.7	1.53	24,830	49	31.3
5	14	Yes	1,208,221	597	289.3	8,691	3.7	1.74	-	-	-
	15	Yes	3,924,924	1,331	615.4	2,212	0.8	0.35	-	-	-
	16		69,736	108	44.2	6,728	7.4	3.37	-	-	-
TotalSavingsAB 970PkgD_CZs			**22,179,201**	**381**		**161,233**	**2.5**		**27,353**	**42**	
TotalSavingsIOUServiceArea			**22,709,688**	**341**	**149.9**	**203,573**	**2.5**	**1.10**	**31,922**	**39**	**15.6**

8 The basis for Per Home and Per 1000 ft^2 savings is limited to those homes with cooling equipment.

9 The basis for Per Home and Per 1000 ft^2 savings estimates is limited to those homes with gas (natural gas and propane) heating equipment.

10 The basis Per Home and Per 1000 ft^2 savings estimates is limited to only those homes with electric heating equipment.

Table SF-RB-CL: Energy Savings for Radiant Barriers in Air Conditioned Detached Single-Family Homes

RMST CZ	CEC CZ	Meas Req'd. for AB 970 PackageD	Number of Air Cond Homes	Average ft^2 of Air Cond Homes	Saturation of Cooling Equipment in Total Population	As-Built Average Cooling % of Total Budget	Source Energy Cooling Savings (skBtu/yr)	Average Cooling Savings as % of As-Built Cooling Energy	Cooling Savings (kWh)		
									All Air Cond Homes	Per Home	Per 1,000 ft^2
1	1		-	-	0.0%	-	-	-	-	-	-
	2	Yes	1,602	2,398	38.0%	23.5%	3,875,366	9.4%	378,491	236	98.5
	3		2,680	2,422	37.1%	7.0%	1,164,616	10.5%	113,743	42	17.5
	4	Yes	4,558	2,540	76.5%	22.3%	6,843,614	8.7%	668,387	147	57.7
	5		502	3,080	42.6%	5.4%	290,247	17.6%	28,347	56	18.3
2	6		2,385	2,876	54.3%	8.8%	1,301,135	14.2%	127,076	53	18.5
	7		2,064	2,540	43.7%	25.3%	1,961,625	9.1%	191,584	93	36.5
3	8	Yes	3,410	2,483	100.0%	32.9%	5,542,218	9.2%	541,285	159	63.9
	9	Yes	6,831	2,815	100.0%	42.7%	21,597,899	10.0%	2,109,376	309	109.7
	10	Yes	13,270	2,241	98.2%	50.6%	50,144,831	9.2%	4,897,434	369	164.7
4	11	Yes	2,531	1,993	83.4%	40.5%	9,545,392	10.0%	932,258	368	184.9
	12	Yes	12,517	2,094	93.7%	31.0%	35,050,381	10.3%	3,423,223	273	130.6
	13	Yes	8,573	1,762	100.0%	53.2%	41,934,858	9.6%	4,095,601	478	271.1
5	14	Yes	2,024	2,063	86.8%	48.3%	12,370,978	11.1%	1,208,221	597	289.3
	15	Yes	2,948	2,163	100.0%	82.2%	40,187,302	10.6%	3,924,924	1,331	615.4
	16		643	2,451	71.1%	6.7%	714,031	10.8%	69,736	108	44.2
TotalSavingsAB 970PkgD_CZs			**58,264**				**227,092,839**		**22,179,201**	**381**	
TotalSavingsIOUServiceArea			**66,538**	**2,277**			**232,524,492**		**22,709,688**	**341**	**149.9**

Table SF-RB-GH: Energy Savings for Radiant Barriers in Gas-Heated Detached Single-Family Homes

RMST CZ	CEC CZ	Measure Req'd for AB 970 Package D	Number of Gas Htd Homes	Average ft^2 of Gas Htd Homes	Saturation of Gas Heating Equipment in Total Population	As-Built Average Heating % of Total Budget	Source Energy Heating Savings (skBtu/yr)	Average Heating Savings as % of As-Built Heating Energy	Gas Heating Savings (therms)		
									All Gas Htd Homes	Per Home	Per 1,000 ft^2
1	1		986	1,910	100.0%	64.0%	398,184	1.0%	3,982	4.0	2.11
	2	Yes	4,212	2,138	100.0%	50.8%	2,001,830	1.0%	20,018	4.8	2.22
	3		7,232	2,326	100.0%	48.0%	1,544,079	0.8%	15,441	2.1	0.92
	4	Yes	5,958	2,471	100.0%	43.2%	1,522,081	0.8%	15,221	2.6	1.03
	5		1,178	2,261	100.0%	52.9%	364,191	1.1%	3,642	3.1	1.37
2	6		4,227	2,480	96.2%	29.1%	514,107	1.0%	5,141	1.2	0.49
	7		4,721	2,281	100.0%	15.8%	740,616	2.5%	7,406	1.6	0.69
3	8	Yes	3,410	2,483	100.0%	22.9%	557,148	1.3%	5,571	1.6	0.66
	9	Yes	6,831	2,815	100.0%	21.8%	1,336,681	1.2%	13,367	2.0	0.70
	10	Yes	13,362	2,233	98.9%	20.1%	2,597,590	1.2%	25,976	1.9	0.87
4	11	Yes	3,034	1,985	100.0%	33.9%	935,066	1.0%	9,351	3.1	1.55
	12	Yes	13,361	2,065	100.0%	42.0%	3,892,515	0.8%	38,925	2.9	1.41
	13	Yes	8,062	1,775	94.0%	23.6%	2,190,096	1.2%	21,901	2.7	1.53
5	14	Yes	2,333	2,137	100.0%	32.0%	869,118	1.0%	8,691	3.7	1.74
	15	Yes	2,948	2,163	100.0%	3.1%	221,213	1.6%	2,212	0.8	0.35
	16		904	2,211	100.0%	74.8%	672,812	0.7%	6,728	7.4	3.37
TotalSavingsAB 970PkgD_CZs			**63,511**				**16,123,338**		**161,233**	**2.5**	
TotalSavingsIOUServiceArea			**82,759**	**2,238**			**20,357,326**		**203,573**	**2.5**	**1.10**

Table SF-RB-EH: Energy Savings for Radiant Barriers in Electrically Heated Detached Single Family Homes

RMST CZ	CEC CZ	Measure Req'd for AB 970 Package D	Number of Elec Htd Homes	Average ft^2 of Elec Htd Homes	Saturation of Elec Heating Equipment in Total Population	As-Built Average Heating % of Total Budget	Source Energy Heating Savings (skBtu/yr)	Average Heating Savings as % of As-Built Heating Energy	Electric Heating Savings (kWh)		
									All Elec Htd Homes	Per Home	Per 1,000 ft^2
1	1		-	-	0.0%	-	-	-	-	-	-
	2	Yes	-	-	0.0%	-	-	-	-	-	-
	3		-	-	0.0%	-	-	-	-	-	-
	4	Yes	-	-	0.0%	-	-	-	-	-	-
	5		-	-	0.0%	-	-	-	-	-	-
2	6		167	5,607	3.8%	43.9%	46,778	1.0%	4,569	27.4	4.88
	7		-	-	0.0%	-	-	-	-	-	-
3	8	Yes	-	-	0.0%	-	-	-	-	-	-
	9	Yes	-	-	0.0%	-	-	-	-	-	-
	10	Yes	147	2,200	1.1%	14.4%	25,835	1.2%	2,523	17.2	7.80
4	11	Yes	-	-	0.0%	-	-	-	-	-	-
	12	Yes	-	-	0.0%	-	-	-	-	-	-
	13	Yes	511	1,550	6.0%	26.4%	254,236	1.9%	24,830	48.6	31.35
5	14	Yes	-	-	0.0%	-	-	-	-	-	-
	15	Yes	-	-	0.0%	-	-	-	-	-	-
	16		-	-	0.0%	-	-	-	-	-	-
TotalSavingsAB 970PkgD_CZs			**658**				**280,071**		**27,353**	**41.6**	
TotalSavingsIOUServiceArea			**825**	**2,487**			**326,849**		**31,922**	**38.7**	**15.56**

Table SF-RB-SE: Annual Source Energy Savings for Radiant Barriers in Detached Single Family Homes

RMST CZ	CEC CZ	Measure Req'd for AB 970 Package D	Total # of Homes in IOU Service Area	Average ft^2 Per Home	Total Title 24 Compliance HVAC Source Energy Budget (1,000 skBtu)	Title 24 Compliance Source Energy Savings[11]			As-Built Source Energy Savings[12]		
						Total for All Homes (1,000 skBtu)	Average Per Home (skBtu)	Average Per ft^2 (skBtu/ft^2)	Total for All Homes (1,000 skBtu)	Average Per Home (skBtu)	Average Per ft^2 (skBtu/ft^2)
1	1		986	1,910	62,872	414	420	0.22	398	404	0.21
	2	Yes	4,212	2,138	405,756	11,990	2,847	1.33	5,877	1,395	0.65
	3		7,232	2,326	393,867	4,739	655	0.28	2,709	375	0.16
	4	Yes	5,958	2,471	435,244	10,224	1,716	0.69	8,366	1,404	0.57
	5		1,178	2,261	61,730	858	729	0.32	654	556	0.25
2	6		4,394	2,598	187,121	3,069	698	0.27	1,862	424	0.16
	7		4,721	2,281	186,961	5,225	1,107	0.49	2,702	572	0.25
3	8	Yes	3,410	2,483	181,230	6,099	1,789	0.72	6,099	1,789	0.72
	9	Yes	6,831	2,815	495,008	22,935	3,357	1.19	22,935	3,357	1.19
	10	Yes	13,508	2,233	1,082,108	53,499	3,961	1.77	52,768	3,906	1.75
4	11	Yes	3,034	1,985	275,942	12,335	4,065	2.05	10,480	3,454	1.74
	12	Yes	13,361	2,065	1,156,074	41,110	3,077	1.49	38,943	2,915	1.41
	13	Yes	8,573	1,762	816,317	44,379	5,177	2.94	44,379	5,177	2.94
5	14	Yes	2,333	2,137	270,891	15,523	6,654	3.11	13,240	5,675	2.66
	15	Yes	2,948	2,163	459,145	40,409	13,707	6.34	40,409	13,707	6.34
	16		904	2,211	122,616	1,523	1,684	0.76	1,387	1,534	0.69
TotalSavingsAB 970PkgD_CZs			**64,168**		**5,577,716**	**258,501**	**4,029**		**243,496**	**3,795**	
TotalSavingsIOUServiceArea			**83,583**		**6,592,883**	**274,328**	**3,282**		**253,209**	**3,029**	

11 The savings in these three columns include the Heating and Cooling source energy savings of all homes – including those homes without cooling equipment. (MICROPAS 6.0 models every home as if there is a cooling system installed.)

12 The savings in these three columns include the Heating and Cooling source energy savings of those homes with cooling equipment and the Heating source energy savings of those homes without cooling equipment.

Table MF-RB-EF: End-Use/Fuel Energy Savings for Radiant Barriers in Multifamily Building

RMST CZ	CEC CZ	Meas Req'd. For AB 970 PackageD	Cooling Savings[13] (kWh)			Gas Heating Savings[14] (therms)			Electric Heating Savings[15] (kWh)		
			All Air Cond ResUnit	Per ResUnit	Per 1,000 ft²	All Gas Htd ResUnit	Per ResUnit	Per 1,000 ft²	All Elec Htd ResUnit	Per Res Unit	Per 1,000 ft²
1	1		-	-	-	784	4.8	0.80	-	-	-
	2	Yes	-	-	-	5,695	4.7	1.06	308,681	223	11.3
	3		-	-	-	9,877	4.4	0.54	92,541	113	6.2
	4	Yes	897,875	430	12.1	14,156	7.3	0.38	177,382	123	3.3
	5		-	-	-	324	1.4	0.90	-	-	-
2	6		90,863	71	4.2	5,483	3.4	0.23	9,299	42	1.4
	7		173,764	193	12.0	2,756	2.7	0.17	10,524	29	4.9
3	8	Yes	816,803	349	26.7	6,221	2.7	0.28	19,331	41	1.6
	9	Yes	1,545,892	561	31.5	4,387	3.0	0.36	29,912	23	0.8
	10	Yes	360,312	1,024	58.7	1,912	4.6	0.30	-	-	-
4	11	Yes	194,928	388	36.6	1,174	7.0	0.90	28,837	86	7.2
	12	Yes	1,844,525	701	37.8	16,813	7.5	0.79	80,465	198	2.9
	13	Yes	681,686	657	187.6	3,023	3.5	1.28	8,656	51	6.8
5	14	Yes	558,958	1,620	142.5	3,260	9.4	0.83	-	-	-
	15	Yes	164,840	1,895	378.9	87	1.0	0.20	-	-	-
	16		51,787	197	16.5	7,495	28.5	2.38	-	-	-
TotalSavingsAB 970PkgD_CZs			**7,065,819**	**582**		**56,727**	**5.2**		**653,264**	**118**	
TotalSavingsIOUServiceArea			**7,382,234**	**506**	**28.3**	**83,446**	**5.0**	**0.48**	**765,628**	**110**	**4.1**

13 The basis for Per Home and Per 1000 ft^2 savings is limited to those homes with cooling equipment.

14 The basis for Per Home and Per 1000 ft^2 savings estimates is limited to those homes with gas (natural gas and propane) heating equipment.

15 The basis Per Home and Per 1000 ft^2 savings estimates is limited to only those homes with electric heating equipment.

Table MF-RB-CL: Energy Savings for Radiant Barriers in Air Conditioned Multifamily Building

RMST CZ	CEC CZ	Meas Req'd. For AB 970 PackageD	Number of Air Cond ResUnit	Average ft^2 of Air Cond ResUnit	Saturation of Cooling Equipment in Total Population	As-Built Average Cooling % of Total Budget	Source Energy Cooling Savings (skBtu/yr)	Average Cooling Savings as % of As-Built Cooling Energy	Cooling Savings (kWh) All Air Cond ResUnit	Cooling Savings (kWh) Per Res Unit	Cooling Savings (kWh) Per 1,000 ft^2
1	1		-	-	0.0%	-	-	-	-	-	-
	2	Yes	-	-	0.0%	-	-	-	-	-	-
	3		-	-	0.0%	-	-	-	-	-	-
	4	Yes	2,088	35,394	61.7%	7.6%	9,193,337	12.2%	897,875	430	12.1
	5		-	-	0.0%	-	-	-	-	-	-
2	6		1,283	16,837	69.3%	1.6%	930,344	14.0%	90,863	71	4.2
	7		900	16,067	64.3%	7.4%	1,779,174	12.2%	173,764	193	12.0
3	8	Yes	2,340	13,085	85.1%	15.0%	8,363,249	10.3%	816,803	349	26.7
	9	Yes	2,755	17,819	100.0%	19.1%	15,828,388	10.6%	1,545,892	561	31.5
	10	Yes	352	17,441	85.0%	25.0%	3,689,238	9.8%	360,312	1,024	58.7
4	11	Yes	503	10,592	100.0%	18.5%	1,995,864	8.3%	194,928	388	36.6
	12	Yes	2,633	18,548	100.0%	17.5%	18,886,091	9.5%	1,844,525	701	37.8
	13	Yes	1,037	3,503	100.0%	43.7%	6,979,781	9.9%	681,686	657	187.6
5	14	Yes	345	11,368	100.0%	36.9%	5,723,173	10.5%	558,958	1,620	142.5
	15	Yes	87	5,000	100.0%	72.9%	1,687,800	9.0%	164,840	1,895	378.9
	16		263	11,952	100.0%	2.8%	530,251	17.3%	51,787	197	16.5
TotalSavingsAB 970PkgD_CZs			**12,140**				**72,346,921**		**7,065,819**	**582**	
TotalSavingsIOUServiceArea			**14,586**	**17,902**			**75,586,691**		**7,382,234**	**506**	**28.3**

Table MF-RB-GH: Energy Savings for Radiant Barriers in Gas-Heated Multifamily Building

RMST CZ	CEC CZ	Measure Req'd for AB 970 Package D	Number of Gas Htd ResUnit	Average ft^2 of Gas Htd ResUnit	Saturation of Gas Heating Equipment in Total Population	As-Built Average Heating % of Total Budget	Source Energy Heating Savings (skBtu/yr)	Average Heating Savings as % of As-Built Heating Energy	Gas Heating Savings (therms)		
									All Gas Htd ResUnit	Per Res Unit	Per 1,000 ft^2
1	1		163	6,000	100.0%	28.4%	78,382	0.9%	784	4.8	0.80
	2	Yes	1,220	4,418	46.9%	37.0%	569,454	0.8%	5,695	4.7	1.06
	3		2,261	8,038	73.5%	31.3%	987,692	0.9%	9,877	4.4	0.54
	4	Yes	1,944	19,381	57.4%	22.5%	1,415,599	1.1%	14,156	7.3	0.38
	5		240	1,500	100.0%	19.3%	32,431	1.6%	324	1.4	0.90
2	6		1,627	14,398	87.9%	14.9%	548,295	1.3%	5,483	3.4	0.23
	7		1,030	15,817	73.6%	6.5%	275,564	2.1%	2,756	2.7	0.17
3	8	Yes	2,274	9,721	82.7%	11.6%	622,116	1.4%	6,221	2.7	0.28
	9	Yes	1,446	8,332	52.5%	10.2%	438,710	1.7%	4,387	3.0	0.36
	10	Yes	414	15,241	100.0%	8.3%	191,162	1.8%	1,912	4.6	0.30
4	11	Yes	168	7,776	33.2%	27.6%	117,407	1.5%	1,174	7.0	0.90
	12	Yes	2,227	9,603	84.5%	28.3%	1,681,260	0.9%	16,813	7.5	0.79
	13	Yes	866	2,730	83.6%	16.1%	302,308	1.8%	3,023	3.5	1.28
5	14	Yes	345	11,368	100.0%	25.8%	325,974	0.8%	3,260	9.4	0.83
	15	Yes	87	5,000	100.0%	1.7%	8,700	2.0%	87	1.0	0.20
	16		263	11,952	100.0%	57.2%	749,523	0.9%	7,495	28.5	2.38
TotalSavingsAB 970PkgD_CZs			**10,991**				**5,672,689**		**56,727**	**5.2**	
TotalSavingsIOUServiceArea			**16,575**	**10,577**			**8,344,576**		**83,446**	**5.0**	**0.48**

Table MF-RB-EH: Energy Savings for Radiant Barriers in Electrically Heated Multifamily Building

RMST CZ	CEC CZ	Measure Req'd for AB 970 Package D	Number of Elec Htd ResUnit	Average ft^2 of Elec Htd ResUnit	Saturation of Elec Heating Equipment in Total Population	As-Built Average Heating % of Total Budget	Source Energy Heating Savings (skBtu/yr)	Average Heating Savings as % of As-Built Heating Energy	Electric Heating Savings (kWh)		
									All Elec Htd ResUnit	Per Res Unit	Per 1,000 ft^2
1	1		-	-	0.0%	-	-	-	-	-	-
	2	Yes	1,383	19,827	53.1%	50.6%	3,160,584	0.7%	308,681	223.2	11.26
	3		817	18,261	26.5%	24.1%	947,525	0.9%	92,541	113.3	6.20
	4	Yes	1,441	37,142	42.6%	13.1%	1,816,214	2.0%	177,382	123.1	3.31
	5		-	-	0.0%	-	-	-	-	-	-
2	6		224	29,039	12.1%	2.8%	95,216	2.6%	9,299	41.5	1.43
	7		369	5,857	26.4%	7.0%	107,753	4.4%	10,524	28.5	4.87
3	8	Yes	476	24,675	17.3%	6.1%	197,926	1.3%	19,331	40.6	1.65
	9	Yes	1,309	28,301	47.5%	4.3%	306,271	1.3%	29,912	22.9	0.81
	10	Yes	-	-	0.0%	-	-	-	-	-	-
4	11	Yes	336	12,000	66.8%	14.9%	295,262	2.0%	28,837	85.8	7.15
	12	Yes	407	67,500	15.5%	6.0%	823,886	1.7%	80,465	197.7	2.93
	13	Yes	170	7,440	16.4%	12.9%	88,625	1.3%	8,656	50.9	6.84
5	14	Yes	-	-	0.0%	-	-	-	-	-	-
	15	Yes	-	-	0.0%	-	-	-	-	-	-
	16		-	-	0.0%	-	-	-	-	-	-
TotalSavingsAB 970PkgD_CZs			**5,522**				**6,688,769**		**653,264**	**118.3**	
TotalSavingsIOUServiceArea			**6,932**	**26,845**			**7,839,263**		**765,628**	**110.4**	**4.11**

Table MF-RB-SE: Annual Source Energy Savings for Radiant Barriers in Multifamily Building

RMST CZ	CEC CZ	Measure Req'd for AB 970 Package D	Total # of ResUnit in IOU Service Area	Average ft² Per ResUnit	Total Title 24 Compliance HVAC Source Energy Budget (1,000 skBtu)	Title 24 Compliance Source Energy Savings[16]			As-Built Source Energy Savings[17]		
						Total for All ResUnit (1,000 skBtu)	Average Per ResUnit (skBtu)	Average Per ft² (skBtu/ft²)	Total for All ResUnit (1,000 skBtu)	Average Per ResUnit (skBtu)	Average Per ft² (skBtu/ft²)
1	1		2,603	12,606	1,113,980	14,418	5,539	0.44	3,730	1,433	0.11
	2	Yes	3,078	10,753	752,970	3,267	1,061	0.10	1,935	629	0.06
	3		3,385	26,944	2,042,247	15,371	4,541	0.17	12,425	3,671	0.14
	4	Yes	240	1,500	10,453	123	510	0.34	32	135	0.09
	5		1,851	16,172	444,262	1,849	999	0.06	1,574	850	0.05
2	6		1,399	13,193	321,701	3,147	2,249	0.17	2,162	1,546	0.12
	7		2,750	12,311	642,489	10,057	3,657	0.30	9,183	3,339	0.27
3	8	Yes	2,755	17,819	1,114,992	16,573	6,016	0.34	16,573	6,016	0.34
	9	Yes	414	15,241	157,472	4,037	9,752	0.64	3,880	9,373	0.61
	10	Yes	503	10,592	131,536	2,409	4,788	0.45	2,409	4,788	0.45
4	11	Yes	2,633	18,548	1,520,706	21,391	8,124	0.44	21,391	8,124	0.44
	12	Yes	1,037	3,503	164,277	7,371	7,108	2.03	7,371	7,108	2.03
	13	Yes	345	11,368	148,393	6,049	17,534	1.54	6,049	17,534	1.54
5	14	Yes	87	5,000	25,726	1,697	19,500	3.90	1,697	19,500	3.90
	15	Yes	263	11,952	134,970	1,280	4,866	0.41	1,280	4,866	0.41
	16		2,603	12,606	1,113,980	14,418	5,539	0.44	3,730	1,433	0.11
TotalSavingsAB 970PkgD_CZs			**16,512**		**7,061,817**	**99,372**	**6,018**		**84,708**	**5,130**	
TotalSavingsIOUServiceArea			**23,506**		**8,755,957**	**109,116**	**4,642**		**91,771**	**3,904**	

16 The savings in these three columns include the Heating and Cooling source energy savings of all homes – including those homes without cooling equipment. (MICROPAS 6.0 models every home as if there is a cooling system installed.)

17 The savings in these three columns include the Heating and Cooling source energy savings of those homes with cooling equipment and the Heating source energy savings of those homes without cooling equipment.

Appendix F

Technical Potential – Low Solar Heat Gain Fenestration

F.1 Introduction

This appendix contains the complete set of tables used to assess the technical potential for low solar heat gain fenestration. Results are presented separately for detached single-family homes and multifamily buildings. For each building type, there are five tables. The first table (SF-LSGF-EF)[1] summarizes the estimated technical potential by end use: cooling (electric savings) and heating (electric savings and gas savings are shown separately). The second table (SF-LSGF-CL) provides the estimated electric cooling savings as well as cooling saturations for each CEC climate zone. The third and fourth tables (SF-LSGF-GH and SF-LSGF-EH) summarize the heating savings by fuel type—electric and gas. The final table (SF-LSGF-SE) provides the source energy savings as well as the total estimated source energy budget. The remaining tables in this appendix present the same results for multifamily buildings.

The following sections of this appendix provide a more detailed description of each table, including its purpose, the data captured in each table, and an explanation of the column/row headers.

- F.2: End-Use/Fuel Energy Savings
- F.3: Energy Savings for Air Conditioned Residences
- F.4: Energy Savings for Gas Heated Residences
- F.5: Energy Savings for Electrically Heated Residences
- F.6: Annual Source Energy Savings

[1] This labeling convention is used for the technical potential tables to avoid confusion. The first two characters of the table label refer to the building type (SF – single family and MF – multifamily), the middle characters signify the technical potential measure (LSGF-Low Solar Heat Gain Fenestration), and the final two characters represent the type of savings estimates that are summarized in the table. (EF – Savings by End-Use/Fuel Type, CL – Cooling Savings, GH – Gas Heating Savings, EH – Electric Heating Savings, and SE – Source Energy Savings).

F.2 Row/Column Titles Common to All Tables

There are several rows and columns of results common to every table. These fields are described below:

RMST CZ. These are the target sample groups used for the Residential Market Share Tracking (RMST) study.[2]

CEC CZ. These are the California Energy Commission climate zones.[3]

MeasRqd ForAB 970 PackageD. A "Yes" in this column indicates that low solar heat gain fenestration is required in the indicated CEC climate zone as part of the AB 970 Prescriptive Package D.

TotalSavingsAB 970_CZs. Values in this row are totals or averages (depending on the column header) only for those CEC climate zones where low solar heat gain fenestration is required as part of the AB 970 Prescriptive Package D. For low solar heat gain fenestration, these CEC climate zones are 2, 4, and 8 through 15.

TotalSavingsIOUServiceArea. Values in this row are totals or averages (depending on the column header) for all CEC climate zones, not just AB 970 specific CEC climate zones.

F.3 End-Use/Fuel Energy Savings Table (Table XX-LSGF-EF)

These tables present energy savings on an end-use and fuel basis. Savings estimates are presented for space cooling in kWh, gas heating in therms, and electric heating in kWh. Total end-use fuel savings are calculated in two ways: a) the total savings for the homes in all CEC climate zones and b) the total savings for only those homes in the CEC climate zones where the measure is required as part of the AB 970 Prescriptive Package D. An explanation for each of the row and column titles unique to this table are provided below:

Cooling Savings. Cooling savings in kWh are presented for only those homes or multifamily building residential units that had air conditioning systems installed as determined from the onsite survey. Results are presented in three formats, as described below.

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2 Regional Economic Research, Inc. *California Residential Efficiency Market Share Tracking – First-Year Interim Report.* Prepared for Southern California Edison. October 2000.

3 See Section 3 of this report for a map of the CEC climate zones.

- ***(Savings) All Air Cond Homes/ ResUnits.*** This value is the total energy savings for those detached single-family homes (*Homes*) or multifamily residential units (*ResUnits*) *that have the specific equipment installed*.[4]
- ***(Savings) Average Per Home/ResUnit.*** This value is the average energy savings per detached single-family home (*Per Home*) or multifamily residential units (*Per ResUnit*) *that have the specific equipment installed*. It is obtained by taking the average of the total energy savings divided by the number of detached single-family homes or multifamily residential units *that have the specific equipment installed*.
- ***(Savings) Average Per 1000 ft².*** This value is the average energy savings per 1,000 square feet of conditioned floor area (CFA) for residences *that have the specific equipment installed*. It is obtained by taking the average of the total energy savings divided by the average conditioned floor area of all detached single-family homes or multifamily residential units *that have the specific equipment installed*.

Gas Heating Savings. Gas heating savings in therms are presented for only those homes or multifamily building residential units that had gas space heating systems installed as determined from the onsite survey. Results are presented on the same three bases as used for the cooling estimates.

Electric Heating Savings. Electric heating savings in kWh are presented for only those homes or multifamily building residential units that had electric space heating systems (baseboard, heat pumps, and electric resistance) installed as determined from the onsite survey. Results are presented on the same three bases as used for the cooling estimates.

F.4 Energy Savings for Air Conditioned Residences (Table XX-LSGF-CL)

These tables present the data used to assess cooling energy savings. All values in the table are relative to *only those homes or multifamily building residential units that had air conditioning systems installed as determined from the onsite survey*. An explanation for each of the row and column titles in this table is provided below:

[4] The specific equipment here means cooling equipment. For the gas heating and electric heating tables, it means gas or propane heating equipment and electric heating equipment respectively.

Number of Air Cond Homes. Values in this column represent the weighted number of sites that have cooling equipment installed in each CEC Climate Zone[5].

Average ft2 of Air Cond Homes. These values are the average square footage of homes with cooling equipment, by CEC climate zone.

Saturation of Cooling Equipment in Total Population. Values in this column show the percentage of homes that have cooling equipment installed.

As-Built Average Cooling % of Total Budget. Values in this column present the estimated cooling usage as a percentage of the total estimated total energy usage for homes with cooling equipment.

Source Energy Cooling Savings (skBtu/yr). These values are the total estimated cooling usage for homes with cooling equipment.

Average Cooling Savings as % of As-Built Cooling Energy. Values in this column show the total estimated electric savings as a percent of the total estimated cooling usage for those homes with cooling equipment.

Cooling Savings

- ***All Air Cond Homes.*** Values in this column show the total estimated electric savings for homes with cooling equipment.
- ***Per Home.*** This presents the average electric savings per home from installing low solar heat gain fenestration in only those homes with cooling equipment.
- ***Per 1,000 ft^2.*** This presents the average electric savings per 1,000 square feet for only those homes with cooling equipment.

F.5 Energy Savings for Gas Heated Residences (Table XX-LSGF-GH)

These tables present the data used to assess gas heating energy savings. All values in the table are relative to *only those homes or multifamily building residential units that had gas (or propane) space heating systems installed as determined from the onsite survey*. An explanation for each of the row and column titles in this table is provided below:

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[5] Expansion weights were used to expand the sample to the total number of new homes built within the four California IOU service territories between July 1998 and June 1999. The expansion weights are based on RMST climate zone, building type, and the six-month period in which the home was built.

Number of Gas Htd Homes. Values in this column represent the weighted number of sites that have gas heating equipment installed in each CEC Climate Zone.[6]

Average ft² of Gas Htd Homes. These values are the average square footage of homes with gas heating equipment, by CEC climate zone.

Saturation of Gas Heating Equipment in Total Population. Values in this column show the percentage of homes that have gas heating equipment installed.

As-Built Average Heating % of Total Budget. Values in this column present the estimated heating usage as a percentage of the total estimated total energy usage for homes with gas heating equipment.

Source Energy Heating Savings (skBtu/yr). These values are the total estimated heating usage for homes with gas heating equipment.

Average Heating Savings as % of As-Built Heating Energy. Values in this column show the total estimated gas savings as a percent of the total estimated heating usage for homes with gas heating equipment.

Gas Heating Savings

- ***All Gas Htd Homes.*** Values in this column show the total estimated gas savings for homes with gas heating equipment.
- ***Per Home.*** This presents the average gas savings per home from installing low solar heat gain fenestration in only those homes with gas heating equipment.
- ***Per 1,000 ft².*** This presents the average gas savings per 1,000 square feet for only those homes with gas heating equipment.

F.6 Energy Savings for Electrically Heated Residences (Table XX-LSGF-EH)

These tables present the data used to assess electric heating energy savings. All values in the table are relative to only those homes or multifamily building residential units that had electric space heating systems installed as determined from the onsite survey. The explanation for each of the row and column titles in this table are the same as those for the

6 Expansion weights were used to expand the sample to the total number of new homes built within the four California IOU service territories between July 1998 and June 1999. The expansion weights are based on RMST climate zone, building type, and the six-month period in which the home was built.

gas heating table except for this table includes data for only those homes with electric space heating equipment.

F.7 Annual Source Energy Savings (Table XX-LSGF-SE)

These tables present source energy savings as well as the total estimated energy budget by CEC climate zone. Total source energy savings are calculated in two ways: a) the total savings for the homes in all CEC climate zones and b) the total savings for only those homes in the CEC climate zones where the measure is required as part of the AB 970 Prescriptive Package D. An explanation for each of the row and column titles unique to this table are provided below:

Total # of Homes in IOU Service Area (1,000 skBtu). Values in this column represent the weighted number of sites in each CEC Climate Zone.

Average ft^2 Per Home. These values are the average square footage of homes by CEC climate zone.

Total Title 24 Compliance HVAC Source Energy Budget. Values in this column show the estimated heating and cooling energy usage for homes by CEC climate zone.

Title 24 Compliance Source Energy Savings.

- ***Total for All Homes (1,000 skBtu).*** Values in this column present heating and cooling source energy savings of all homes, including those homes without cooling equipment.[7]
- ***Average Per Home (skBtu).*** These values are the average savings per home using the total savings explained in the bullet above divided by the total number of homes.
- ***Average Per ft^2 (skBtu/ ft^2).*** Values in this column show the average savings per 1,000 square feet using the savings per home explained in the bullet above divided by the average square footage of all homes.

As-Built Source Energy Savings

- ***Total for All Homes (1,000 skBtu).*** Savings shown in this column include the heating and cooling source energy savings of those homes with cooling equipment and only the heating source energy savings of those homes without cooling equipment.

[7] MICROPAS 6.0 models every home as if there is a cooling system installed.

- ***Average Per Home (skBtu).*** These values are the average savings per home using the total savings explained in the bullet above divided by the total number of homes.
- ***Average Per ft² (skBtu/ ft²).*** Values in this column present the average savings per 1,000 square feet using the savings per home explained in the bullet above divided by the average square footage of all homes.

Table SF-LSGF-EF: End-Use/Fuel Energy Savings for Low Solar Heat Gain Fenestration in Detached Single-Family Homes

RMST CZ	CEC CZ	Meas Req'd. For AB 970 PackageD	Cooling Savings[8] (kWh)			Gas Heating Savings[9] (therms)			Electric Heating Savings[10] (kWh)		
			All Air Cond Homes	Per Home	Per 1,000 ft^2	All Gas Htd Homes	Per Home	Per 1,000 ft^2	All Elec Htd Homes	Per Home	Per 1,000 ft^2
1	1		-	-	-	4,371	4.4	2.32	-	-	-
	2	Yes	1,804,164	1,126	469.6	27,483	6.5	3.05	-	-	-
	3		745,159	278	114.8	-71,228	-9.8	-4.23	-	-	-
	4	Yes	4,379,833	961	378.3	-6,416	-1.1	-0.44	-	-	-
	5		125,063	249	80.9	-5,797	-4.9	-2.18	-	-	-
2	6		531,763	223	77.5	-47,111	-11.1	-4.49	-50,255	-301	-53.7
	7	Yes	1,338,448	648	255.3	18,345	3.9	1.70	-	-	-
3	8	Yes	2,953,400	866	348.8	-16,038	-4.7	-1.89	-	-	-
	9	Yes	10,179,017	1,490	529.3	-6,021	-0.9	-0.31	-	-	-
	10	Yes	21,558,123	1,625	725.0	-8,770	-0.7	-0.29	-15,139	-103	-46.8
4	11	Yes	3,419,752	1,351	678.1	3,496	1.2	0.58	-	-	-
	12	Yes	14,540,747	1,162	554.8	42,049	3.1	1.52	-	-	-
	13	Yes	12,631,234	1,473	836.2	-24,044	-3.0	-1.68	109,292	214	138.0
5	14	Yes	3,823,468	1,889	915.7	244	0.1	0.05	-	-	-
	15	Yes	8,369,508	2,839	1,312.4	-7,631	-2.6	-1.20	-	-	-
	16		361,881	563	229.6	45,744	50.6	22.88	-	-	-
TotalSavingsAB 970PkgD_CZs			**84,997,694**	**1,409**		**22,698**	**0.3**		**94,153**	**1**	
TotalSavingsIOUServiceArea			**86,761,560**	**1,304**	**572.8**	**-51,324**	**-0.6**	**-0.28**	**43,898**	**53**	**21.4**

8 The basis for Per home and Per 1000 ft^2 savings is limited to those homes that have cooling equipment.

9 The basis for Per home and Per 1000 ft^2 savings estimates is limited to those homes that have gas (natural gas and propane) heating equipment.

10 The basis Per home and Per 1000 ft^2 savings estimates is limited to only those homes that have electric heating equipment.

Table SF-LSGF-CL: Energy Savings for Low Solar Heat Gain Fenestration in Air Conditioned Detached Single-Family Homes

RMST CZ	CEC CZ	Meas Req'd. For AB 970 PackageD	Number of Air Cond Homes	Average ft^2 of Air Cond Homes	Saturation of Cooling Equipment in Total Population	As-Built Average Cooling % of Total Budget	Source Energy Cooling Savings (skBtu/yr)	Average Cooling Savings as % of As-Built Cooling Energy	Cooling Savings (kWh) All Air Cond Homes	Cooling Savings (kWh) Per Home	Cooling Savings (kWh) Per 1,000 ft^2
1	1		-	-	0.0%	-	-	-	-	-	-
	2	Yes	1,602	2,398	38.0%	23.5%	18,472,836	44.7%	1,804,164	1,126	469.6
	3		2,680	2,422	37.1%	7.0%	7,629,679	68.6%	745,159	278	114.8
	4	Yes	4,558	2,540	76.5%	22.3%	44,845,106	56.8%	4,379,833	961	378.3
	5		502	3,080	42.6%	5.4%	1,280,524	77.8%	125,063	249	80.9
2	6		2,385	2,876	54.3%	8.8%	5,444,720	59.5%	531,763	223	77.5
	7	Yes	2,064	2,540	43.7%	25.3%	13,704,373	63.4%	1,338,448	648	255.3
3	8	Yes	3,410	2,483	100.0%	32.9%	30,239,858	50.2%	2,953,400	866	348.8
	9	Yes	6,831	2,815	100.0%	42.7%	104,222,954	48.3%	10,179,017	1,490	529.3
	10	Yes	13,270	2,241	98.2%	50.6%	220,733,622	40.7%	21,558,123	1,625	725.0
4	11	Yes	2,531	1,993	83.4%	40.5%	35,014,845	36.6%	3,419,752	1,351	678.1
	12	Yes	12,517	2,094	93.7%	31.0%	148,882,712	43.7%	14,540,747	1,162	554.8
	13	Yes	8,573	1,762	100.0%	53.2%	129,331,202	29.6%	12,631,234	1,473	836.2
5	14	Yes	2,024	2,063	86.8%	48.3%	39,148,488	35.0%	3,823,468	1,889	915.7
	15	Yes	2,948	2,163	100.0%	82.2%	85,695,392	22.7%	8,369,508	2,839	1,312.4
	16		643	2,451	71.1%	6.7%	3,705,303	55.9%	361,881	563	229.6
TotalSavingsAB 970PkgD_CZs			**60,328**				**870,291,388**		**84,997,694**	**1,409**	
TotalSavingsIOUServiceArea			**66,538**	**2,277**			**888,351,614**		**86,761,560**	**1,304**	**572.8**

Table SF-LSGF-GH: Energy Savings for Low Solar Heat Gain Fenestration in Gas-Heated Detached Single-Family Homes

RMST CZ	CEC CZ	Measure Req'd for AB 970 Package D	Number of Gas Htd Homes	Average ft^2 of Gas Htd Homes	Saturation of Gas Heating Equipment in Total Population	As-Built Average Heating % of Total Budget	Source Energy Heating Savings (skBtu/yr)	Average Heating Savings as % of As-Built Heating Energy	Gas Heating Savings (therms) All Gas Htd Homes	Gas Heating Savings (therms) Per Home	Gas Heating Savings (therms) Per 1,000 ft^2
1	1		986	1,910	100.0%	64.0%	437,120	1.1%	4,371	4.4	2.32
	2	Yes	4,212	2,138	100.0%	50.8%	2,748,253	1.3%	27,483	6.5	3.05
	3		7,232	2,326	100.0%	48.0%	-7,122,846	-3.7%	-71,228	-9.8	-4.23
	4	Yes	5,958	2,471	100.0%	43.2%	-641,555	-0.3%	-6,416	-1.1	-0.44
	5		1,178	2,261	100.0%	52.9%	-579,650	-1.8%	-5,797	-4.9	-2.18
2	6		4,227	2,480	96.2%	29.1%	-4,711,149	-8.8%	-47,111	-11.1	-4.49
	7	Yes	4,721	2,281	100.0%	15.8%	1,834,481	6.1%	18,345	3.9	1.70
3	8	Yes	3,410	2,483	100.0%	22.9%	-1,603,832	-3.8%	-16,038	-4.7	-1.89
	9	Yes	6,831	2,815	100.0%	21.8%	-602,105	-0.6%	-6,021	-0.9	-0.31
	10	Yes	13,362	2,233	98.9%	20.1%	-876,972	-0.4%	-8,770	-0.7	-0.29
4	11	Yes	3,034	1,985	100.0%	33.9%	349,642	0.4%	3,496	1.2	0.58
	12	Yes	13,361	2,065	100.0%	42.0%	4,204,908	0.9%	42,049	3.1	1.52
	13	Yes	8,062	1,775	94.0%	23.6%	-2,404,377	-1.3%	-24,044	-3.0	-1.68
5	14	Yes	2,333	2,137	100.0%	32.0%	24,415	0.0%	244	0.1	0.05
	15	Yes	2,948	2,163	100.0%	3.1%	-763,066	-5.4%	-7,631	-2.6	-1.20
	16		904	2,211	100.0%	74.8%	4,574,383	4.9%	45,744	50.6	22.88
TotalSavingsAB 970PkgD_CZs			**68,232**				**2,269,791**		**22,698**	**0.3**	
TotalSavingsIOUServiceArea			**82,759**	**2,238**			**-5,132,350**		**-51,324**	**-0.6**	**-0.28**

Table SF-LSGF-EH: Energy Savings for Low Solar Heat Gain Fenestration in Electrically Heated Detached Single Family Homes

RMST CZ	CEC CZ	Measure Req'd for AB 970 Package D	Number of Elec Htd Homes	Average ft^2 of Elec Htd Homes	Saturation of Elec Heating Equipment in Total Population	As-Built Average Heating % of Total Budget	Source Energy Heating Savings (skBtu/yr)	Average Heating Savings as % of As-Built Heating Energy	Electric Heating Savings (kWh) All Elec Htd Homes	Electric Heating Savings (kWh) Per Home	Electric Heating Savings (kWh) Per 1,000 ft^2
1	1		-	-	0.0%	-	-	-	-	-	-
	2	Yes	-	-	0.0%	-	-	-	-	-	-
	3		-	-	0.0%	-	-	-	-	-	-
	4	Yes	-	-	0.0%	-	-	-	-	-	-
	5		-	-	0.0%	-	-	-	-	-	-
2	6		167	5,607	3.8%	43.9%	-514,562	-11.1%	-50,255	-300.9	-53.67
	7	Yes	-	-	0.0%	-	-	-	-	-	-
3	8	Yes	-	-	0.0%	-	-	-	-	-	-
	9	Yes	-	-	0.0%	-	-	-	-	-	-
	10	Yes	147	2,200	1.1%	14.4%	-155,010	-7.3%	-15,139	-103.0	-46.81
4	11	Yes	-	-	0.0%	-	-	-	-	-	-
	12	Yes	-	-	0.0%	-	-	-	-	-	-
	13	Yes	511	1,550	6.0%	26.4%	1,119,045	8.6%	109,292	213.9	137.99
5	14	Yes	-	-	0.0%	-	-	-	-	-	-
	15	Yes	-	-	0.0%	-	-	-	-	-	-
	16		-	-	0.0%	-	-	-	-	-	-
TotalSavingsAB 970PkgD_CZs			**658**				**964,034**		**94,153**	**1.4**	
TotalSavingsIOUServiceArea			**825**	**2,487**			**449,472**		**43,898**	**53.2**	**21.39**

Table SF-LSGF-SE: Annual Source Energy Savings for Low Solar Heat Gain Fenestration in Detached Single Family Homes

RMST CZ	CEC CZ	Measure Req'd for AB 970 Package D	Total # of Homes in IOU Service Area	Average ft² Per Home	Total Title 24 Compliance HVAC Source Energy Budget (1,000 skBtu)	Title 24 Compliance Source Energy Savings[11] Total for All Homes (1,000 skBtu)	Title 24 Compliance Source Energy Savings[11] Average Per Home (skBtu)	Title 24 Compliance Source Energy Savings[11] Average Per ft² (skBtu/ft²)	As-Built Source Energy Savings[12] Total for All Homes (1,000 skBtu)	As-Built Source Energy Savings[12] Average Per Home (skBtu)	As-Built Source Energy Savings[12] Average Per ft² (skBtu/ft²)
1	1		986	1,910	62,872	453	459	0.24	437	443	0.23
	2	Yes	4,212	2,138	405,756	47,543	11,288	5.28	21,221	5,038	2.36
	3		7,232	2,326	393,867	13,587	1,879	0.81	507	70	0.03
	4	Yes	5,958	2,471	435,244	55,674	9,344	3.78	44,204	7,419	3.00
	5		1,178	2,261	61,730	1,625	1,380	0.61	701	595	0.26
2	6		4,394	2,598	187,121	5,847	1,331	0.51	219	50	0.02
	7	Yes	4,721	2,281	186,961	31,716	6,718	2.94	15,539	3,291	1.44
3	8	Yes	3,410	2,483	181,230	28,636	8,398	3.38	28,636	8,398	3.38
	9	Yes	6,831	2,815	495,008	103,621	15,169	5.39	103,621	15,169	5.39
	10	Yes	13,508	2,233	1,082,108	223,298	16,531	7.40	219,702	16,265	7.28
4	11	Yes	3,034	1,985	275,942	42,713	14,078	7.09	35,364	11,656	5.87
	12	Yes	13,361	2,065	1,156,074	161,948	12,121	5.87	153,088	11,458	5.55
	13	Yes	8,573	1,762	816,317	128,046	14,936	8.48	128,046	14,936	8.48
5	14	Yes	2,333	2,137	270,891	46,447	19,909	9.32	39,173	16,791	7.86
	15	Yes	2,948	2,163	459,145	84,932	28,810	13.32	84,932	28,810	13.32
	16		904	2,211	122,616	9,587	10,605	4.80	8,280	9,159	4.14
TotalSavingsAB 970PkgD_CZs			**68,889**		**5,764,677**	**954,574**	**13,857**		**873,525**	**12,680**	
TotalSavingsIOUServiceArea			**83,583**		**6,592,883**	**985,672**	**11,793**		**883,669**	**10,572**	

[11] The savings in these three columns include the Heating and Cooling source energy savings of all homes – including those homes without cooling equipment. (MICROPAS 6.0 models every home as if there is a cooling system installed.)

[12] The savings in these three columns include the Heating and Cooling source energy savings of those homes with cooling equipment and the Heating source energy savings of those homes without cooling equipment.

Table MF-LSGF-EF: End-Use/Fuel Energy Savings for Low Solar Heat Gain Fenestration in Multifamily Building

RMST CZ	CEC CZ	Meas Req'd. For AB 970 PackageD	Cooling Savings[13] (kWh)			Gas Heating Savings[14] (therms)			Electric Heating Savings[15] (kWh)		
			All Air Cond ResUnit	Per ResUnit	Per 1,000 ft^2	All Gas Htd ResUnit	Per ResUnit	Per 1,000 ft^2	All Elec Htd ResUnit	Per Res Unit	Per 1,000 ft^2
1	1		-	-	-	14,305	87.8	14.63	-	-	-
	2	Yes	-	-	-	25,072	20.6	4.65	1,083,870	784	39.5
	3		-	-	-	54,837	24.3	3.02	228,095	279	15.3
	4	Yes	4,549,092	2,179	61.6	60,416	31.1	1.60	702,959	488	13.1
	5		-	-	-	-36	-0.2	-0.10	-	-	-
2	6		340,074	265	15.7	-19,173	-11.8	-0.82	21,487	96	3.3
	7	Yes	714,380	794	49.4	10,737	10.4	0.66	10,987	30	5.1
3	8	Yes	4,063,303	1,736	132.7	36,036	15.8	1.63	-23,099	-49	-2.0
	9	Yes	6,711,934	2,436	136.7	34,207	23.7	2.84	445,142	340	12.0
	10	Yes	863,455	2,453	140.6	746	1.8	0.12	-	-	-
4	11	Yes	365,758	727	68.7	391	2.3	0.30	40,634	121	10.1
	12	Yes	7,894,947	2,998	161.7	93,498	42.0	4.37	295,040	725	10.7
	13	Yes	1,700,813	1,640	468.2	5,108	5.9	2.16	28,440	167	22.5
5	14	Yes	1,826,363	5,294	465.7	25,390	73.6	6.47	-	-	-
	15	Yes	347,099	3,990	797.9	-566	-6.5	-1.30	-	-	-
	16		131,292	499	41.8	80,433	305.8	25.59	-	-	-
TotalSavingsAB 970PkgD_CZs			**29,037,144**	**2,227**		**291,035**	**24.2**		**2,583,971**	**215**	
TotalSavingsIOUServiceArea			**29,508,509**	**2,023**	**113.0**	**421,402**	**25.4**	**2.40**	**2,833,553**	**409**	**15.2**

13 The basis for Per home and Per 1000 ft^2 savings is limited to those homes that have cooling equipment.

14 The basis for Per home and Per 1000 ft^2 savings estimates is limited to those homes that have gas (natural gas and propane) heating equipment.

15 The basis Per home and Per 1000 ft^2 savings estimates is limited to only those homes that have electric heating equipment.

Table MF-LSGF-CL: Energy Savings for Low Solar Heat Gain Fenestration in Air Conditioned Multifamily Building

RMST CZ	CEC CZ	Meas Req'd. For AB 970 PackageD	Number of Air Cond ResUnit	Average ft^2 of Air Cond ResUnit	Saturation of Cooling Equipment in Total Population	As-Built Average Cooling % of Total Budget	Source Energy Cooling Savings (skBtu/yr)	Average Cooling Savings as % of As-Built Cooling Energy	Cooling Savings (kWh) All Air Cond ResUnit	Cooling Savings (kWh) Per Res Unit	Cooling Savings (kWh) Per 1,000 ft^2
1	1		-	-	0.0%	-	-	-	-	-	-
	2	Yes	-	-	0.0%	-	-	-	-	-	-
	3		-	-	0.0%	-	-	-	-	-	-
	4	Yes	2,088	35,394	61.7%	7.6%	46,578,155	61.8%	4,549,092	2,179	61.6
	5		-	-	0.0%	-	-	-	-	-	-
2	6		1,283	16,837	69.3%	1.6%	3,482,014	52.5%	340,074	265	15.7
	7	Yes	900	16,067	64.3%	7.4%	7,314,532	50.1%	714,380	794	49.4
3	8	Yes	2,340	13,085	85.1%	15.0%	41,604,156	51.4%	4,063,303	1,736	132.7
	9	Yes	2,755	17,819	100.0%	19.1%	68,723,497	45.9%	6,711,934	2,436	136.7
	10	Yes	352	17,441	85.0%	25.0%	8,840,916	23.6%	863,455	2,453	140.6
4	11	Yes	503	10,592	100.0%	18.5%	3,744,996	15.6%	365,758	727	68.7
	12	Yes	2,633	18,548	100.0%	17.5%	80,836,359	40.7%	7,894,947	2,998	161.7
	13	Yes	1,037	3,503	100.0%	43.7%	17,414,626	24.6%	1,700,813	1,640	468.2
5	14	Yes	345	11,368	100.0%	36.9%	18,700,132	34.2%	1,826,363	5,294	465.7
	15	Yes	87	5,000	100.0%	72.9%	3,553,950	18.9%	347,099	3,990	797.9
	16		263	11,952	100.0%	2.8%	1,344,295	43.8%	131,292	499	41.8
TotalSavingsAB 970PkgD_CZs			**13,040**				**297,311,319**		**29,037,144**	**2,227**	
TotalSavingsIOUServiceArea			**14,586**	**17,902**			**302,137,628**		**29,508,509**	**2,023**	**113.0**

Table MF-LSGF-GH: Energy Savings for Low Solar Heat Gain Fenestration in Gas-Heated Multifamily Building

RMST CZ	CEC CZ	Measure Req'd for AB 970 Package D	Number of Gas Htd ResUnit	Average ft² of Gas Htd ResUnit	Saturation of Gas Heating Equipment in Total Population	As-Built Average Heating % of Total Budget	Source Energy Heating Savings (skBtu/yr)	Average Heating Savings as % of As-Built Heating Energy	Gas Heating Savings (therms) All Gas Htd ResUnit	Per Res Unit	Per 1,000 ft²
1	1		163	6,000	100.0%	28.4%	1,430,476	16.9%	14,305	87.8	14.63
	2	Yes	1,220	4,418	46.9%	37.0%	2,507,239	3.4%	25,072	20.6	4.65
	3		2,261	8,038	73.5%	31.3%	5,483,737	5.2%	54,837	24.3	3.02
	4	Yes	1,944	19,381	57.4%	22.5%	6,041,550	4.9%	60,416	31.1	1.60
	5		240	1,500	100.0%	19.3%	-3,603	-0.2%	-36	-0.2	-0.10
2	6		1,627	14,398	87.9%	14.9%	-1,917,287	-4.7%	-19,173	-11.8	-0.82
	7	Yes	1,030	15,817	73.6%	6.5%	1,073,667	8.2%	10,737	10.4	0.66
3	8	Yes	2,274	9,721	82.7%	11.6%	3,603,609	8.3%	36,036	15.8	1.63
	9	Yes	1,446	8,332	52.5%	10.2%	3,420,651	13.5%	34,207	23.7	2.84
	10	Yes	414	15,241	100.0%	8.3%	74,591	0.7%	746	1.8	0.12
4	11	Yes	168	7,776	33.2%	27.6%	39,136	0.5%	391	2.3	0.30
	12	Yes	2,227	9,603	84.5%	28.3%	9,349,848	4.9%	93,498	42.0	4.37
	13	Yes	866	2,730	83.6%	16.1%	510,841	3.0%	5,108	5.9	2.16
5	14	Yes	345	11,368	100.0%	25.8%	2,538,951	6.5%	25,390	73.6	6.47
	15	Yes	87	5,000	100.0%	1.7%	-56,550	-13.3%	-566	-6.5	-1.30
	16		263	11,952	100.0%	57.2%	8,043,344	10.2%	80,433	305.8	25.59
TotalSavingsAB 970PkgD_CZs			**12,021**				**29,103,532**		**291,035**	**24.2**	
TotalSavingsIOUServiceArea			**16,575**	**10,577**			**42,140,198**		**421,402**	**25.4**	**2.40**

Table MF-LSGF-EH: Energy Savings for Low Solar Heat Gain Fenestration in Electrically Heated Multifamily Building

RMST CZ	CEC CZ	Measure Req'd for AB 970 Package D	Number of Elec Htd ResUnit	Average ft^2 of Elec Htd ResUnit	Saturation of Elec Heating Equipment in Total Population	As-Built Average Heating % of Total Budget	Source Energy Heating Savings (skBtu/yr)	Average Heating Savings as % of As-Built Heating Energy	Electric Heating Savings (kWh)		
									All Elec Htd ResUnit	Per Res Unit	Per 1,000 ft^2
1	1		-	-	0.0%	-	-	-	-	-	-
	2	Yes	1,383	19,827	53.1%	50.6%	11,097,742	2.4%	1,083,870	783.7	39.53
	3		817	18,261	26.5%	24.1%	2,335,465	2.2%	228,095	279.2	15.29
	4	Yes	1,441	37,142	42.6%	13.1%	7,197,593	7.9%	702,959	487.8	13.13
	5		-	-	0.0%	-	-	-	-	-	-
2	6		224	29,039	12.1%	2.8%	220,001	6.0%	21,487	95.9	3.30
	7	Yes	369	5,857	26.4%	7.0%	112,492	4.6%	10,987	29.8	5.08
3	8	Yes	476	24,675	17.3%	6.1%	-236,511	-1.6%	-23,099	-48.5	-1.97
	9	Yes	1,309	28,301	47.5%	4.3%	4,557,805	19.5%	445,142	340.1	12.02
	10	Yes	-	-	0.0%	-	-	-	-	-	-
4	11	Yes	336	12,000	66.8%	14.9%	416,051	2.8%	40,634	120.9	10.08
	12	Yes	407	67,500	15.5%	6.0%	3,020,914	6.1%	295,040	724.9	10.74
	13	Yes	170	7,440	16.4%	12.9%	291,197	4.4%	28,440	167.3	22.49
5	14	Yes	-	-	0.0%	-	-	-	-	-	-
	15	Yes	-	-	0.0%	-	-	-	-	-	-
	16		-	-	0.0%	-	-	-	-	-	-
TotalSavingsAB 970PkgD_CZs			**5,891**				**26,457,284**		**2,583,971**	**215.0**	
TotalSavingsIOUServiceArea			**6,932**	**26,845**			**29,012,749**		**2,833,553**	**408.8**	**15.23**

Table MF-LSGF-SE: Annual Source Energy Savings for Low Solar Heat Gain Fenestration in Multifamily Building

RMST CZ	CEC CZ	Measure Req'd for AB 970 Package D	Total # of ResUnit in IOU Service Area	Average ft^2 Per ResUnit	Total Title 24 Compliance HVAC Source Energy Budget (1,000 skBtu)	Title 24 Compliance Source Energy Savings[16]			As-Built Source Energy Savings[17]		
						Total for All ResUnit (1,000 skBtu)	Average Per ResUnit (skBtu)	Average Per ft^2 (skBtu/ft^2)	Total for All ResUnit (1,000 skBtu)	Average Per ResUnit (skBtu)	Average Per ft^2 (skBtu/ft^2)
1	1		163	6,000	29,785	1,430	8,776	1.46	1,430	8,776	1.46
	2	Yes	2,603	12,606	1,113,980	73,271	28,149	2.23	13,605	5,227	0.41
	3		3,078	10,753	752,970	18,679	6,069	0.56	7,819	2,540	0.24
	4	Yes	3,385	26,944	2,042,247	77,776	22,977	0.85	59,817	17,671	0.66
	5		240	1,500	10,453	292	1,216	0.81	-4	-15	-0.01
2	6		1,851	16,172	444,262	2,238	1,209	0.07	1,785	964	0.06
	7	Yes	1,399	13,193	321,701	13,050	9,328	0.71	8,501	6,076	0.46
3	8	Yes	2,750	12,311	642,489	48,753	17,728	1.44	44,971	16,353	1.33
	9	Yes	2,755	17,819	1,114,992	76,702	27,841	1.56	76,702	27,841	1.56
	10	Yes	414	15,241	157,472	9,620	23,237	1.52	8,916	21,535	1.41
4	11	Yes	503	10,592	131,536	4,200	8,350	0.79	4,200	8,350	0.79
	12	Yes	2,633	18,548	1,520,706	93,207	35,400	1.91	93,207	35,400	1.91
	13	Yes	1,037	3,503	164,277	18,217	17,567	5.01	18,217	17,567	5.01
5	14	Yes	345	11,368	148,393	21,239	61,563	5.42	21,239	61,563	5.42
	15	Yes	87	5,000	25,726	3,497	40,200	8.04	3,497	40,200	8.04
	16		263	11,952	134,970	9,388	35,694	2.99	9,388	35,694	2.99
TotalSavingsAB 970PkgD_CZs			**17,911**		**7,383,518**	**439,533**	**24,540**		**352,872**	**19,701**	
TotalSavingsIOUServiceArea			**23,506**		**8,755,957**	**471,560**	**20,061**		**373,291**	**15,881**	

16 The savings in these three columns include the Heating and Cooling source energy savings of all homes – including those homes without cooling equipment. (MICROPAS 6.0 models every home as if there is a cooling system installed.)

17 The savings in these three columns include the Heating and Cooling source energy savings of those homes with cooling equipment and the Heating source energy savings of those homes without cooling equipment.

Appendix G

Technical Potential – Thermostatic Expansion Valve

G.1 Introduction

This appendix contains the complete set of tables used to assess the technical potential for thermostatic expansion valves. Results are presented separately for detached single-family homes and multifamily buildings. For each building type, there are five tables. The first table (SF-TXV-EF)[1] summarizes the estimated technical potential by end use: cooling (electric savings) and heating (electric savings and gas savings are shown separately). The second table (SF-TXV-CL) provides the estimated electric cooling savings as well as cooling straitens for each CEC climate zone. The third and fourth tables (SF-TXV-GH and SF-TXV-EH) summarize the heating savings by fuel type—electric and gas. The final table (SF-TXV-SE) provides the source energy savings as well as the total estimated source energy budget. The remaining tables in this appendix present the same results for multifamily buildings.

The following sections of this appendix provide a more detailed description of each table, including its purpose, the data captured in each table, and an explanation of the column/row headers.

- G.2: End-Use/Fuel Energy Savings
- G.3: Energy Savings for Air Conditioned Residences
- G.4: Energy Savings for Gas Heated Residences
- G.5: Energy Savings for Electrically Heated Residences
- G.6: Annual Source Energy Savings

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1 This labeling convention is used for the technical potential tables to avoid confusion. The first two characters of the table label refer to the building type (SF – single family and MF – multifamily), the middle characters signify the technical potential measure (TXV – Thermostatic Expansion Valve), and the final two characters represent the type of savings estimates that are summarized in the table. (EF – Savings by End-Use/Fuel Type, CL – Cooling Savings, GH – Gas Heating Savings, EH – Electric Heating Savings, and SE – Source Energy Savings).

G.2 Row/Column Titles Common to All Tables

There are several rows and columns of results common to every table. These fields are described below.

RMST CZ. These are the target sample groups used for the Residential Market Share Tracking (RMST) study.[2]

CEC CZ. These are the California Energy Commission climate zones.[3]

MeasRqd ForAB 970 PackageD. A "Yes" in this column indicates that thermostatic expansion valves (TXVs) are required in the indicated CEC climate zone as part of the AB 970 Prescriptive Package D.

TotalSavingsAB 970_CZs. Values in this row are totals or averages (depending on the column header) only for those CEC climate zones where thermostatic expansion valves are required as part of the AB 970 Prescriptive Package D. For thermostatic expansion valves, these CEC climate zones are 2, 4, and 8 through 15.

TotalSavingsIOUServiceArea. Values in this row are totals or averages (depending on the column header) for all CEC climate zones, not just AB 970 specific CEC climate zones.

G.3 End-Use/Fuel Energy Savings Table (Table XX-TXV-EF)

These tables present energy savings on an end-use and fuel basis. Savings estimates are presented for space cooling in kWh, gas heating in therms, and electric heating in kWh. Total end-use fuel savings are calculated in two ways: a) the total savings for the homes in all CEC climate zones and b) the total savings for only those homes in the CEC climate zones where the measure is required as part of the AB 970 Prescriptive Package D. An explanation for each of the row and column titles unique to this table are provided below:

Cooling Savings. Cooling savings in kWh are presented for only those homes or multifamily building residential units that had air conditioning systems installed as determined from the onsite survey. Results are presented in three formats, as described below:

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2 Regional Economic Research, Inc. *California Residential Efficiency Market Share Tracking – First-Year Interim Report.* Prepared for Southern California Edison. October 2000.

3 See Section 3 of this report for a map of the CEC climate zones.

- ***(Savings) All Air Cond Homes/ ResUnits.*** This value is the total energy savings for those detached single-family homes (*Homes*) or multifamily residential units (*ResUnits*) *that have the specific equipment installed*.[4]
- ***(Savings) Average Per Home/ResUnit.*** This value is the average energy savings per detached single-family home (*Per Home*) or multifamily residential units (*Per ResUnit*) *that have the specific equipment installed*. It is obtained by taking the average of the total energy savings divided by the number of detached single-family homes or multifamily residential units *that have the specific equipment installed*.
- ***(Savings) Average Per 1000 ft^2.*** This value is the average energy savings per 1,000 square feet of conditioned floor area (CFA) for residences *that have the specific equipment installed*. It is obtained by taking the average of the total energy savings divided by the average conditioned floor area of all detached single-family homes or multifamily residential units *that have the specific equipment installed*.

Gas Heating Savings. Gas heating savings in therms are presented for only those homes or multifamily building residential units that had gas space heating systems installed as determined from the onsite survey. Results are presented on the same three bases as used for the cooling estimates.

Electric Heating Savings. Electric heating savings in kWh are presented for only those homes or multifamily building residential units that had electric space heating systems (baseboard, heat pumps, and electric resistance) installed as determined from the onsite survey. Results are presented on the same three bases as used for the cooling estimates.

G.4 Energy Savings for Air Conditioned Residences (Table XX-TXV-CL)

These tables present the data used to assess cooling energy savings. All values in the table are relative to *only those homes or multifamily building residential units that had air conditioning systems installed as determined from the onsite survey*. An explanation for each of the row and column titles in this table is provided below:

[4] The specific equipment here means cooling equipment. For the gas heating and electric heating tables, it means gas or propane heating equipment and electric heating equipment respectively.

Number of Air Cond Homes. Values in this column represent the weighted number of sites that have cooling equipment installed in each CEC climate zone[5].

Average ft^2 of Air Cond Homes. These values are the average square footage of homes with cooling equipment, by CEC climate zone.

Saturation of Cooling Equipment in Total Population. Values in this column show the percentage of homes that have cooling equipment installed.

As-Built Average Cooling % of Total Budget. Values in this column present the estimated cooling usage as a percentage of the total estimated total energy usage for homes with cooling equipment.

Source Energy Cooling Savings (skBtu/yr). These values are the total estimated cooling usage for homes with cooling equipment.

Average Cooling Savings as % of As-Built Cooling Energy. Values in this column show the total estimated electric savings as a percent of the total estimated cooling usage for those homes with cooling equipment.

Cooling Savings

- ***All Air Cond Homes.*** Values in this column show the total estimated electric savings for homes with cooling equipment.
- ***Per Home.*** This presents the average electric savings per home from installing TXV valves in only those homes with cooling equipment.
- ***Per 1,000 ft^2.*** This presents the average electric savings per 1,000 square feet for only those homes with cooling equipment.

G.5 Energy Savings for Gas Heated Residences (Table XX-TXV-GH)

These tables present the data used to assess gas heating energy savings. All values in the table are relative to *only those homes or multifamily building residential units that had gas (or propane) space heating systems installed as determined from the onsite survey*. An explanation for each of the row and column titles in this table is provided below:

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5 Expansion weights were used to expand the sample to the total number of new homes built within the four California IOU service territories between July 1998 and June 1999. The expansion weights are based on RMST climate zone, building type, and the six-month period in which the home was built.

Number of Gas Htd Homes. Values in this column represent the weighted number of sites that have gas heating equipment installed in each CEC Climate Zone.[6]

Average ft^2 of Gas Htd Homes. These values are the average square footage of homes with gas heating equipment, by CEC climate zone.

Saturation of Gas Heating Equipment in Total Population. Values in this column show the percentage of homes that have gas heating equipment installed.

As-Built Average Heating % of Total Budget. Values in this column present the estimated heating usage as a percentage of the total estimated total energy usage for homes with gas heating equipment.

Source Energy Heating Savings (skBtu/yr). These values are the total estimated heating usage for homes with gas heating equipment.

Average Heating Savings as % of As-Built Heating Energy. Values in this column show the total estimated gas savings as a percent of the total estimated heating usage for homes with gas heating equipment.

Gas Heating Savings.

- ***All Gas Htd Homes.*** Values in this column show the total estimated gas savings for homes with gas heating equipment.
- ***Per Home.*** This presents the average gas savings per home from installing TXV valves in only those homes with gas heating equipment.
- ***Per 1,000 ft^2.*** This presents the average gas savings per 1,000 square feet for only those homes with gas heating equipment.

G.6 Energy Savings for Electrically Heated Residences (Table XX-TXV-EH)

These tables present the data used to assess electric heating energy savings. All values in the table are relative to *only those homes or multifamily building residential units that had electric space heating systems installed as determined from the onsite survey*. The explanation for each of the row and column titles in this table are the same as those for the

6 Expansion weights were used to expand the sample to the total number of new homes built within the four California IOU service territories between July 1998 and June 1999. The expansion weights are based on RMST climate zone, building type, and the six-month period in which the home was built.

gas heating table except for this table includes data for only those homes with electric space heating equipment.

G.7 Annual Source Energy Savings (Table XX-TXV-SE)

These tables present source energy savings as well as the total estimated energy budget by CEC climate zone. Total source energy savings are calculated in two ways: a) the total savings for the homes in all CEC climate zones and b) the total savings for only those homes in the CEC climate zones where the measure is required as part of the AB 970 Prescriptive Package D. An explanation for each of the row and column titles unique to this table are provided below:

Total # of Homes in IOU Service Area (1,000 skBtu). Values in this column represent the weighted number of sites in each CEC Climate Zone.

Average ft^2 Per Home. These values are the average square footage of homes by CEC climate zone.

Total Title 24 Compliance HVAC Source Energy Budget. Values in this column show the estimated heating and cooling energy usage for homes by CEC climate zone.

Title 24 Compliance Source Energy Savings.

- ***Total for All Homes (1,000 skBtu).*** Values in this column present heating and cooling source energy savings of all homes, including those homes without cooling equipment.[7]
- ***Average Per Home (skBtu).*** These values are the average savings per home using the total savings explained in the bullet above divided by the total number of homes.
- ***Average Per ft^2 (skBtu/ft^2).*** Values in this column show the average savings per 1,000 square feet using the savings per home explained in the bullet above divided by the average square footage of all homes.

As-Built Source Energy Savings

- ***Total for All Homes (1,000 skBtu).*** Savings shown in this column include the heating and cooling source energy savings of those homes with cooling equipment and only the heating source energy savings of those homes without cooling equipment.

[7] MICROPAS 6.0 models every home as if there is a cooling system installed.

- ***Average Per Home (skBtu).*** These values are the average savings per home using the total savings explained in the bullet above divided by the total number of homes.
- ***Average Per ft^2 (skBtu/ft^2).*** Values in this column present the average savings per 1,000 square feet using the savings per home explained in the bullet above divided by the average square footage of all homes.

Table SF-TXV-EF: End-Use/Fuel Energy Savings for Thermostatic Expansion Valve in Detached Single-Family Homes

RMST CZ	CEC CZ	Meas Req'd. For AB 970 PackageD	Cooling Savings[8] (kWh)			Gas Heating Savings[9] (therms)			Electric Heating Savings[10] (kWh)		
			All Air Cond Homes	Per Home	Per 1,000 ft^2	All Gas Htd Homes	Per Home	Per 1,000 ft^2	All Elec Htd Homes	Per Home	Per 1,000 ft^2
1	1		-	-	-	0	0.0	0.00	-	-	-
	2	Yes	399,549	249	104.0	0	0.0	0.00	-	-	-
	3		110,744	39	15.9	0	0.0	0.00	-	-	-
	4		763,065	167	65.9	0	0.0	0.00	-	-	-
	5		15,577	31	10.1	0	0.0	0.00	-	-	-
2	6		88,430	37	12.9	0	0.0	0.00	0	0	0.0
	7		209,972	102	40.0	0	0.0	0.00	-	-	-
3	8	Yes	582,673	171	68.8	0	0.0	0.00	-	-	-
	9	Yes	2,088,241	306	108.6	0	0.0	0.00	-	-	-
	10	Yes	5,246,038	395	176.4	0	0.0	0.00	0	0	0.0
4	11	Yes	1,102,937	384	193.3	0	0.0	0.00	0	0	0.0
	12	Yes	3,393,784	264	126.3	0	0.0	0.00	-	-	-
	13	Yes	4,623,043	485	271.8	0	0.0	0.00	0	0	0.0
5	14	Yes	1,082,776	535	259.3	0	0.0	0.00	-	-	-
	15	Yes	3,796,812	1,226	556.7	0	0.0	0.00	-	-	-
	16		64,343	100	40.8	0	0.0	0.00	-	-	-
TotalSavingsAB 970PkgD_CZs			**22,315,854**	**402**		**0**	**0.0**		**0**	**0**	
TotalSavingsIOUServiceArea			**23,567,983**	**344**	**151.4**	**0**	**0.0**	**0.00**	**0**	**0**	**0.0**

8 The basis for Per Home and Per 1000 ft^2 savings is limited to those homes that have cooling equipment.

9 The basis for Per Home and Per 1000 ft^2 savings estimates is limited to those homes that have gas (natural gas and propane) heating equipment.

10 The basis Per Home and Per 1000 ft^2 savings estimates is limited to only those homes that have electric heating equipment.

Table SF-TXV-CL: Energy Savings for Thermostatic Expansion Valve in Air Conditioned Detached Single-Family Homes

RMST CZ	CEC CZ	Meas Req'd. For AB 970 PackageD	Number of Air Cond Homes	Average ft^2 of Air Cond Homes	Saturation of Cooling Equipment in Total Population	As-Built Average Cooling % of Total Budget	Source Energy Cooling Savings (skBtu/yr)	Average Cooling Savings as % of As-Built Cooling Energy	Cooling Savings (kWh)		
									All Air Cond Homes	Per Home	Per 1,000 ft^2
1	1		-	-	0.0%	-	-	-	-	-	-
	2	Yes	1,602	2,398	38.0%	23.5%	4,090,981	9.9%	399,549	249	104.0
	3		2,854	2,446	38.5%	6.7%	1,133,903	9.9%	110,744	39	15.9
	4		4,558	2,540	76.5%	22.3%	7,813,019	9.9%	763,065	167	65.9
	5		502	3,080	42.6%	5.4%	159,490	9.7%	15,577	31	10.1
2	6		2,385	2,876	54.3%	8.8%	905,431	9.9%	88,430	37	12.9
	7		2,064	2,540	43.7%	25.3%	2,149,898	9.9%	209,972	102	40.0
3	8	Yes	3,410	2,483	100.0%	32.9%	5,965,990	9.9%	582,673	171	68.8
	9	Yes	6,831	2,815	100.0%	42.7%	21,381,504	9.9%	2,088,241	306	108.6
	10	Yes	13,270	2,241	98.2%	50.6%	53,714,183	9.9%	5,246,038	395	176.4
4	11	Yes	2,871	1,987	85.1%	41.3%	11,292,973	9.9%	1,102,937	384	193.3
	12	Yes	12,858	2,090	93.8%	31.0%	34,748,955	9.9%	3,393,784	264	126.3
	13	Yes	9,540	1,783	100.0%	52.7%	47,335,337	9.9%	4,623,043	485	271.8
5	14	Yes	2,024	2,063	86.8%	48.3%	11,086,545	9.9%	1,082,776	535	259.3
	15	Yes	3,097	2,202	100.0%	81.9%	38,875,562	9.9%	3,796,812	1,226	556.7
	16		643	2,451	71.1%	6.7%	658,805	9.9%	64,343	100	40.8
TotalSavingsAB 970PkgD_CZs			**55,503**				**228,492,029**		**22,315,854**	**402**	
TotalSavingsIOUServiceArea			**68,509**	**2,272**			**241,312,576**		**23,567,983**	**344**	**151.4**

Table SF-TXV-GH: Energy Savings for Thermostatic Expansion Valve in Gas-Heated Detached Single-Family Homes

RMST CZ	CEC CZ	Measure Req'd for AB 970 Package D	Number of Gas Htd Homes	Average ft^2 of Gas Htd Homes	Saturation of Gas Heating Equipment in Total Population	As-Built Average Heating % of Total Budget	Source Energy Heating Savings (skBtu/yr)	Average Heating Savings as % of As-Built Heating Energy	Gas Heating Savings (therms)		
									All Gas Htd Homes	Per Home	Per 1,000 ft^2
1	1		986	1,910	100.0%	64.0%	0	0.0%	0	0.0	0.00
	2	Yes	4,212	2,138	100.0%	50.8%	0	0.0%	0	0.0	0.00
	3		7,406	2,338	100.0%	48.1%	0	0.0%	0	0.0	0.00
	4		5,958	2,471	100.0%	43.2%	0	0.0%	0	0.0	0.00
	5		1,178	2,261	100.0%	52.9%	0	0.0%	0	0.0	0.00
2	6		4,227	2,480	96.2%	29.1%	0	0.0%	0	0.0	0.00
	7		4,721	2,281	100.0%	15.8%	0	0.0%	0	0.0	0.00
3	8	Yes	3,410	2,483	100.0%	22.9%	0	0.0%	0	0.0	0.00
	9	Yes	6,831	2,815	100.0%	21.8%	0	0.0%	0	0.0	0.00
	10	Yes	13,362	2,233	98.9%	20.1%	0	0.0%	0	0.0	0.00
4	11	Yes	3,204	1,972	95.0%	34.1%	0	0.0%	0	0.0	0.00
	12	Yes	13,701	2,062	100.0%	42.0%	0	0.0%	0	0.0	0.00
	13	Yes	9,030	1,796	94.6%	23.9%	0	0.0%	0	0.0	0.00
5	14	Yes	2,333	2,137	100.0%	32.0%	0	0.0%	0	0.0	0.00
	15	Yes	3,097	2,202	100.0%	3.2%	0	0.0%	0	0.0	0.00
	16		904	2,211	100.0%	74.8%	0	0.0%	0	0.0	0.00
TotalSavingsAB 970PkgD_CZs			**59,180**				**0**		**0**	**0.0**	
TotalSavingsIOUServiceArea			**84,560**	**2,235**			**0**		**0**	**0.0**	**0.00**

Table SF-TXV-EH: Energy Savings for Thermostatic Expansion Valve in Electrically Heated Detached Single Family Homes

RMST CZ	CEC CZ	Measure Req'd for AB 970 Package D	Number of Elec Htd Homes	Average ft^2 of Elec Htd Homes	Saturation of Elec Heating Equipment in Total Population	As-Built Average Heating % of Total Budget	Source Energy Heating Savings (skBtu/yr)	Average Heating Savings as % of As-Built Heating Energy	Electric Heating Savings (kWh) All Elec Htd Homes	Electric Heating Savings (kWh) Per Home	Electric Heating Savings (kWh) Per 1,000 ft^2
1	1		-	-	0.0%	-	-	-	-	-	-
	2	Yes	-	-	0.0%	-	-	-	-	-	-
	3		-	-	0.0%	-	-	-	-	-	-
	4		-	-	0.0%	-	-	-	-	-	-
	5		-	-	0.0%	-	-	-	-	-	-
2	6		167	5,607	3.8%	43.9%	0	0.0%	0	0.0	0.00
	7		-	-	0.0%	-	-	-	-	-	-
3	8	Yes	-	-	0.0%	-	-	-	-	-	-
	9	Yes	-	-	0.0%	-	-	-	-	-	-
	10	Yes	147	2,200	1.1%	14.4%	0	0.0%	0	0.0	0.00
4	11	Yes	170	2,160	5.0%	28.9%	0	0.0%	0	0.0	0.00
	12	Yes	-	-	0.0%	-	-	-	-	-	-
	13	Yes	511	1,550	5.4%	26.4%	0	0.0%	0	0.0	0.00
5	14	Yes	-	-	0.0%	-	-	-	-	-	-
	15	Yes	-	-	0.0%	-	-	-	-	-	-
	16		-	-	0.0%	-	-	-	-	-	-
TotalSavingsAB 970PkgD_CZs			**828**				**0**		**0**	**0.0**	
TotalSavingsIOUServiceArea			**995**	**2,431**			**0**		**0**	**0.0**	**0.00**

Table SF-TXV-SE: Annual Source Energy Savings for Thermostatic Expansion Valve in Detached Single Family Homes

RMST CZ	CEC CZ	Measure Req'd for AB 970 Package D	Total # of Homes in IOU Service Area	Average ft² Per Home	Total Title 24 Compliance HVAC Source Energy Budget (1,000 skBtu)	Title 24 Compliance Source Energy Savings[11]			As-Built Source Energy Savings[12]		
						Total for All Homes (1,000 skBtu)	Average Per Home (skBtu)	Average Per ft² (skBtu/ft²)	Total for All Homes (1,000 skBtu)	Average Per Home (skBtu)	Average Per ft² (skBtu/ft²)
1	1		986	1,910	62,872	0	0	0.00	0	0	0.00
	2	Yes	4,212	2,138	405,756	4,091	971	0.45	4,091	971	0.45
	3		7,406	2,338	403,543	1,134	153	0.07	1,134	153	0.07
	4		5,958	2,471	435,244	7,813	1,311	0.53	7,813	1,311	0.53
	5		1,178	2,261	61,730	159	135	0.06	159	135	0.06
2	6		4,394	2,598	187,121	905	206	0.08	905	206	0.08
	7		4,721	2,281	186,961	2,150	455	0.20	2,150	455	0.20
3	8	Yes	3,410	2,483	181,230	5,966	1,750	0.70	5,966	1,750	0.70
	9	Yes	6,831	2,815	495,008	21,382	3,130	1.11	21,382	3,130	1.11
	10	Yes	13,508	2,233	1,082,108	53,714	3,976	1.78	53,714	3,976	1.78
4	11	Yes	3,375	1,982	313,858	11,293	3,346	1.69	11,293	3,346	1.69
	12	Yes	13,701	2,062	1,184,927	34,749	2,536	1.23	34,749	2,536	1.23
	13	Yes	9,540	1,783	900,963	47,335	4,962	2.78	47,335	4,962	2.78
5	14	Yes	2,333	2,137	270,891	11,087	4,752	2.22	11,087	4,752	2.22
	15	Yes	3,097	2,202	478,142	38,876	12,553	5.70	38,876	12,553	5.70
	16		904	2,211	122,616	659	729	0.33	659	729	0.33
TotalSavingsAB 970PkgD_CZs			**60,007**		**5,312,884**	**228,492**	**3,808**		**228,492**	**3,808**	
TotalSavingsIOUServiceArea			**85,554**		**6,772,970**	**241,313**	**2,821**		**241,313**	**2,821**	

[11] The savings in these three columns include the Heating and Cooling source energy savings of all homes – including those homes without cooling equipment. (MICROPAS 6.0 models every home as if there is a cooling system installed.)

[12] The savings in these three columns include the Heating and Cooling source energy savings of those homes with cooling equipment and the Heating source energy savings of those homes without cooling equipment.

Table MF-TXV-EF: End-Use/Fuel Energy Savings for Thermostatic Expansion Valve in Mulitfamily Building

RMST CZ	CEC CZ	Meas Req'd. For AB 970 PackageD	Cooling Savings[13] (kWh)			Gas Heating Savings[14] (therms)			Electric Heating Savings[15] (kWh)		
			All Air Cond ResUnit	Per ResUnit	Per 1,000 ft^2	All Gas Htd ResUnit	Per ResUnit	Per 1,000 ft^2	All Elec Htd ResUnit	Per Res Unit	Per 1,000 ft^2
1	1		-	-	-	0	0.0	0.00	-	-	-
	2	Yes	-	-	-	0	0.0	0.00	0	0	0.0
	3		-	-	-	0	0.0	0.00	0	0	0.0
	4		719,273	344	9.7	0	0.0	0.00	0	0	0.0
	5		-	-	-	0	0.0	0.00	-	-	-
2	6		66,817	52	3.1	0	0.0	0.00	0	0	0.0
	7		140,480	156	9.7	0	0.0	0.00	0	0	0.0
3	8	Yes	780,085	333	25.5	0	0.0	0.00	0	0	0.0
	9	Yes	1,447,315	525	29.5	0	0.0	0.00	0	0	0.0
	10	Yes	364,569	1,036	59.4	0	0.0	0.00	-	-	-
4	11	Yes	229,191	456	43.0	0	0.0	0.00	0	0	0.0
	12	Yes	1,902,207	722	38.9	0	0.0	0.00	0	0	0.0
	13	Yes	613,045	591	168.7	0	0.0	0.00	0	0	0.0
5	14	Yes	530,172	1,537	135.2	0	0.0	0.00	-	-	-
	15	Yes	181,409	2,085	417.0	0	0.0	0.00	-	-	-
	16		29,574	112	9.4	0	0.0	0.00	-	-	-
TotalSavingsAB 970PkgD_CZs			**6,047,994**	**602**		**0**	**0.0**		**0**	**0**	
TotalSavingsIOUServiceArea			**7,004,137**	**480**	**26.8**	**0**	**0.0**	**0.00**	**0**	**0**	**0.0**

13 The basis for Per Home and Per 1000 ft^2 savings is limited to those homes that have cooling equipment.

14 The basis for Per Home and Per 1000 ft^2 savings estimates is limited to those homes that have gas (natural gas and propane) heating equipment.

15 The basis Per Home and Per 1000 ft^2 savings estimates is limited to only those homes that have electric heating equipment.

Table MF-TXV-CL: Energy Savings for Thermostatic Expansion Valve in Air Conditioned Mulitfamily Building

RMST CZ	CEC CZ	Meas Req'd. For AB 970 PackageD	Number of Air Cond ResUnit	Average ft^2 of Air Cond ResUnit	Saturation of Cooling Equipment in Total Population	As-Built Average Cooling % of Total Budget	Source Energy Cooling Savings (skBtu/yr)	Average Cooling Savings as % of As-Built Cooling Energy	Cooling Savings (kWh)		
									All Air Cond ResUnit	Per Res Unit	Per 1,000 ft^2
1	1		-	-	0.0%	-	-	-	-	-	-
	2	Yes	-	-	0.0%	-	-	-	-	-	-
	3		-	-	0.0%	-	-	-	-	-	-
	4		2,088	35,394	61.7%	7.6%	7,364,631	9.8%	719,273	344	9.7
	5		-	-	0.0%	-	-	-	-	-	-
2	6		1,283	16,837	69.3%	1.6%	684,137	10.3%	66,817	52	3.1
	7		900	16,067	64.3%	7.4%	1,438,379	9.9%	140,480	156	9.7
3	8	Yes	2,340	13,085	85.1%	15.0%	7,987,292	9.9%	780,085	333	25.5
	9	Yes	2,755	17,819	100.0%	19.1%	14,819,060	9.9%	1,447,315	525	29.5
	10	Yes	352	17,441	85.0%	25.0%	3,732,826	10.0%	364,569	1,036	59.4
4	11	Yes	503	10,592	100.0%	18.5%	2,346,689	9.8%	229,191	456	43.0
	12	Yes	2,633	18,548	100.0%	17.5%	19,476,697	9.8%	1,902,207	722	38.9
	13	Yes	1,037	3,503	100.0%	43.7%	6,276,963	8.9%	613,045	591	168.7
5	14	Yes	345	11,368	100.0%	36.9%	5,428,433	9.9%	530,172	1,537	135.2
	15	Yes	87	5,000	100.0%	72.9%	1,857,450	9.9%	181,409	2,085	417.0
	16		263	11,952	100.0%	2.8%	302,804	9.9%	29,574	112	9.4
TotalSavingsAB 970PkgD_CZs			**10,052**				**61,925,409**		**6,047,994**	**602**	
TotalSavingsIOUServiceArea			**14,586**	**17,902**			**71,715,361**		**7,004,137**	**480**	**26.8**

Table MF-TXV-GH: Energy Savings for Thermostatic Expansion Valve in Gas-Heated Mulitfamily Building

RMST CZ	CEC CZ	Measure Req'd for AB 970 Package D	Number of Gas Htd ResUnit	Average ft² of Gas Htd ResUnit	Saturation of Gas Heating Equipment in Total Population	As-Built Average Heating % of Total Budget	Source Energy Heating Savings (skBtu/yr)	Average Heating Savings as % of As-Built Heating Energy	Gas Heating Savings (therms)		
									All Gas Htd ResUnit	Per Res Unit	Per 1,000 ft²
1	1		163	6,000	100.0%	28.4%	0	0.0%	0	0.0	0.00
	2	Yes	1,220	4,418	46.9%	37.0%	0	0.0%	0	0.0	0.00
	3		2,261	8,038	73.5%	31.3%	0	0.0%	0	0.0	0.00
	4		1,944	19,381	57.4%	22.5%	0	0.0%	0	0.0	0.00
	5		240	1,500	100.0%	19.3%	0	0.0%	0	0.0	0.00
2	6		1,627	14,398	87.9%	14.9%	0	0.0%	0	0.0	0.00
	7		1,030	15,817	73.6%	6.5%	0	0.0%	0	0.0	0.00
3	8	Yes	2,274	9,721	82.7%	11.6%	0	0.0%	0	0.0	0.00
	9	Yes	1,446	8,332	52.5%	10.2%	0	0.0%	0	0.0	0.00
	10	Yes	414	15,241	100.0%	8.3%	0	0.0%	0	0.0	0.00
4	11	Yes	168	7,776	33.2%	27.6%	0	0.0%	0	0.0	0.00
	12	Yes	2,227	9,603	84.5%	28.3%	0	0.0%	0	0.0	0.00
	13	Yes	866	2,730	83.6%	16.1%	0	0.0%	0	0.0	0.00
5	14	Yes	345	11,368	100.0%	25.8%	0	0.0%	0	0.0	0.00
	15	Yes	87	5,000	100.0%	1.7%	0	0.0%	0	0.0	0.00
	16		263	11,952	100.0%	57.2%	0	0.0%	0	0.0	0.00
TotalSavingsAB 970PkgD_CZs			**9,047**				**0**		**0**	**0.0**	
TotalSavingsIOUServiceArea			**16,575**	**10,577**			**0**		**0**	**0.0**	**0.00**

Table MF-TXV-EH: Energy Savings for Thermostatic Expansion Valve in Electrically Heated Mulitfamily Building

RMST CZ	CEC CZ	Measure Req'd for AB 970 Package D	Number of Elec Htd ResUnit	Average ft^2 of Elec Htd ResUnit	Saturation of Elec Heating Equipment in Total Population	As-Built Average Heating % of Total Budget	Source Energy Heating Savings (skBtu/yr)	Average Heating Savings as % of As-Built Heating Energy	Electric Heating Savings (kWh)		
									All Elec Htd ResUnit	Per Res Unit	Per 1,000 ft^2
1	1		-	-	0.0%	-	-	-	-	-	-
	2	Yes	1,383	19,827	53.1%	50.6%	0	0.0%	0	0.0	0.00
	3		817	18,261	26.5%	24.1%	0	0.0%	0	0.0	0.00
	4		1,441	37,142	42.6%	13.1%	0	0.0%	0	0.0	0.00
	5		-	-	0.0%	-	-	-	-	-	-
2	6		224	29,039	12.1%	2.8%	0	0.0%	0	0.0	0.00
	7		369	5,857	26.4%	7.0%	0	0.0%	0	0.0	0.00
3	8	Yes	476	24,675	17.3%	6.1%	0	0.0%	0	0.0	0.00
	9	Yes	1,309	28,301	47.5%	4.3%	0	0.0%	0	0.0	0.00
	10	Yes	-	-	0.0%	-	-	-	-	-	-
4	11	Yes	336	12,000	66.8%	14.9%	0	0.0%	0	0.0	0.00
	12	Yes	407	67,500	15.5%	6.0%	0	0.0%	0	0.0	0.00
	13	Yes	170	7,440	16.4%	12.9%	0	0.0%	0	0.0	0.00
5	14	Yes	-	-	0.0%	-	-	-	-	-	-
	15	Yes	-	-	0.0%	-	-	-	-	-	-
	16		-	-	0.0%	-	-	-	-	-	-
TotalSavingsAB 970PkgD_CZs			**5,522**				**0**		**0**	**0.0**	
TotalSavingsIOUServiceArea			**6,932**	**26,845**			**0**		**0**	**0.0**	**0.00**

Table MF-TXV-SE: Annual Source Energy Savings for Thermostatic Expansion Valve in Mulitfamily Building

						Title 24 Compliance Source Energy Savings[16]			As-Built Source Energy Savings[17]		
RMST CZ	**CEC CZ**	**Measure Req'd for AB 970 Package D**	**Total # of ResUnit in IOU Service Area**	**Average ft² Per ResUnit**	**Total Title 24 Compliance HVAC Source Energy Budget** (1,000 skBtu)	**Total for All ResUnit** (1,000 skBtu)	**Average Per ResUnit** (skBtu)	**Average Per ft²** (skBtu/ft²)	**Total for All ResUnit** (1,000 skBtu)	**Average Per ResUnit** (skBtu)	**Average Per ft²** (skBtu/ft²)
1	1		163	6,000	29,785	0	0	0.00	0	0	0.00
	2	Yes	2,603	12,606	1,113,980	0	0	0.00	0	0	0.00
	3		3,078	10,753	752,970	0	0	0.00	0	0	0.00
	4		3,385	26,944	2,042,247	7,365	2,176	0.08	7,365	2,176	0.08
	5		240	1,500	10,453	0	0	0.00	0	0	0.00
2	6		1,851	16,172	444,262	684	370	0.02	684	370	0.02
	7		1,399	13,193	321,701	1,438	1,028	0.08	1,438	1,028	0.08
3	8	Yes	2,750	12,311	642,489	7,987	2,904	0.24	7,987	2,904	0.24
	9	Yes	2,755	17,819	1,114,992	14,819	5,379	0.30	14,819	5,379	0.30
	10	Yes	414	15,241	157,472	3,733	9,016	0.59	3,733	9,016	0.59
4	11	Yes	503	10,592	131,536	2,347	4,665	0.44	2,347	4,665	0.44
	12	Yes	2,633	18,548	1,520,706	19,477	7,397	0.40	19,477	7,397	0.40
	13	Yes	1,037	3,503	164,277	6,277	6,053	1.73	6,277	6,053	1.73
5	14	Yes	345	11,368	148,393	5,428	15,735	1.38	5,428	15,735	1.38
	15	Yes	87	5,000	25,726	1,857	21,350	4.27	1,857	21,350	4.27
	16		263	11,952	134,970	303	1,151	0.10	303	1,151	0.10
TotalSavingsAB 970PkgD_CZs			**13,127**		**5,019,570**	**61,925**	**4,717**		**61,925**	**4,717**	
TotalSavingsIOUServiceArea			**23,506**		**8,755,957**	**71,715**	**3,051**		**71,715**	**3,051**	

16 The savings in these three columns include the Heating and Cooling source energy savings of all homes – including those homes without cooling equipment. (MICROPAS 6.0 models every home as if there is a cooling system installed.)

17 The savings in these three columns include the Heating and Cooling source energy savings of those homes with cooling equipment and the Heating source energy savings of those homes without cooling equipment.

Appendix H

Technical Potential – Duct Sealing

H.1 Introduction

This appendix contains the complete set of tables used to assess the technical potential for duct sealing. Results are presented separately for detached single-family homes and multifamily buildings. For each building type, there are five tables. The first table (SF- DS -EF)[1] summarizes the estimated technical potential by end use: cooling (electric savings) and heating (electric savings and gas savings are shown separately). The second table (SF- DS -CL) provides the estimated electric cooling savings as well as cooling saturations for each CEC climate zone. The third and fourth tables (SF- DS -GH and SF- DS -EH) summarize the heating savings by fuel type—electric and gas. The final table (SF- DS -SE) provides the source energy savings as well as the total estimated source energy budget. The remaining tables in this appendix present the same results for multifamily buildings.

The following sections of this appendix provide a more detailed description of each table, including its purpose, the data captured in each table, and an explanation of the column/row headers.

- H.2: End-Use/Fuel Energy Savings
- H.3: Energy Savings for Air Conditioned Residences
- H.4: Energy Savings for Gas Heated Residences
- H.5: Energy Savings for Electrically Heated Residences
- H.6: Annual Source Energy Savings

Please note that only homes that do have duct systems are included in the technical potential analysis for duct sealing.

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[1] This labeling convention is used for the technical potential tables to avoid confusion. The first two characters of the table label refer to the building type (SF – single family and MF – multifamily), the middle characters signify the technical potential measure (DS – Duct Sealing), and the final two characters represent the type of savings estimates that are summarized in the table. (EF – Savings by End-Use/Fuel Type, CL – Cooling Savings, GH – Gas Heating Savings, EH – Electric Heating Savings, and SE – Source Energy Savings).

H.2 Row/Column Titles Common to All Tables

There are several rows and columns of results common to every table. These fields are described below.

RMST CZ. These are the target sample groups used for the Residential Market Share Tracking (RMST) study.[2]

CEC CZ. These are the California Energy Commission climate zones.[3]

MeasRqd ForAB 970 PackageD. A "Yes" in this column indicates that duct sealing is required in the indicated CEC climate zone as part of the AB 970 Prescriptive Package D.

TotalSavingsAB 970_CZs. Values in this row at the bottom of the table are totals or averages (depending on the column header) only for those CEC climate zones where duct sealing is required as part of the AB 970 Prescriptive Package D. However, duct sealing is required in all CEC climate zones.

TotalSavingsIOUServiceArea. Values in this row at the bottom of the table are totals or averages (depending on the column header) for all CEC climate zones, not just AB 970 specific CEC climate zones.

H.3 End-Use/Fuel Energy Savings Table (Table XX-DS-EF)

These tables present energy savings on an end-use and fuel basis. Savings estimates are presented for space cooling in kWh, gas heating in therms, and electric heating in kWh. Total end-use fuel savings are calculated in two ways: a) the total savings for the homes in all CEC climate zones and b) the total savings for only those homes in the CEC climate zones where the measure is required as part of the AB 970 Prescriptive Package D. An explanation for each of the row and column titles unique to this table are provided below:

Cooling Savings. Cooling savings in kWh are presented for only those homes or multifamily building residential units that had air conditioning systems installed as determined from the onsite survey. Results are presented in three formats, as described below:

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2 Regional Economic Research, Inc. *California Residential Efficiency Market Share Tracking – First-Year Interim Report.* Prepared for Southern California Edison. October 2000.

3 See Section 3 of this report for a map of the CEC climate zones.

- ***(Savings) All Air Cond Homes/ ResUnits.*** This value is the total energy savings for those detached single-family homes (*Homes*) or multifamily residential units (*ResUnits*) *that have the specific equipment installed*.[4]
- ***(Savings) Average Per Home/ResUnit.*** This value is the average energy savings per detached single-family home (*Per Home*) or multifamily residential units (*Per ResUnit*) *that have the specific equipment installed*. It is obtained by taking the average of the total energy savings divided by the number of detached single-family homes or multifamily residential units *that have the specific equipment installed*.
- ***(Savings) Average Per 1000 ft^2.*** This value is the average energy savings per 1,000 square feet of conditioned floor area (CFA) for residences *that have the specific equipment installed*. It is obtained by taking the average of the total energy savings divided by the average conditioned floor area of all detached single-family homes or multifamily residential units *that have the specific equipment installed*.

Gas Heating Savings. Gas heating savings in therms are presented for only those homes or multifamily building residential units that had gas space heating systems installed as determined from the onsite survey. Results are presented on the same three bases as used for the cooling estimates.

Electric Heating Savings. Electric heating savings in kWh are presented for only those homes or multifamily building residential units that had electric space heating systems (baseboard, heat pumps, and electric resistance) installed as determined from the onsite survey. Results are presented on the same three bases as used for the cooling estimates.

H.4 Energy Savings for Air Conditioned Residences (Table XX-DS-CL)

These tables present the data used to assess cooling energy savings. All values in the table are relative to *only those homes or multifamily building residential units that had air conditioning systems installed as determined from the onsite survey*. An explanation for each of the row and column titles in this table is provided below.

4 The specific equipment here means cooling equipment. For the gas heating and electric heating tables, it means gas or propane heating equipment and electric heating equipment respectively.

Number of Air Cond Homes. Values in this column represent the weighted number of sites that have cooling equipment installed in each CEC climate zone.[5]

Average ft2 of Air Cond Homes. These values are the average square footage of homes with cooling equipment, by CEC climate zone.

Saturation of Cooling Equipment in Total Population. Values in this column show the percentage of homes that have cooling equipment installed.

As-Built Average Cooling % of Total Budget. Values in this column present the estimated cooling usage as a percentage of the total estimated total energy usage for homes with cooling equipment.

Source Energy Cooling Savings (skBtu/yr). These values are the total estimated cooling usage for homes with cooling equipment.

Average Cooling Savings as % of As-Built Cooling Energy. Values in this column show the total estimated electric savings as a percent of the total estimated cooling usage for those homes with cooling equipment.

Cooling Savings.

- ***All Air Cond Homes.*** Values in this column show the total estimated electric savings for homes with cooling equipment.
- ***Per Home.*** Presents the average electric savings per home from sealing ducts in only those homes with cooling equipment.
- ***Per 1,000 ft^2.*** Presents the average electric savings per 1,000 square feet for only those homes with cooling equipment.

H.5 Energy Savings for Gas Heated Residences (Table XX- DS -GH)

These tables present the data used to assess gas heating energy savings. All values in the table are relative to *only those homes or multifamily building residential units that had gas (or propane) space heating systems installed as determined from the onsite survey*. An explanation for each of the row and column titles in this table is provided below:

5 Expansion weights were used to expand the sample to the total number of new homes built within the four California IOU service territories between July 1998 and June 1999. The expansion weights are based on RMST climate zone, building type, and the six-month period in which the home was built.

Number of Gas Htd Homes. Values in this column represent the weighted number of sites that have gas heating equipment installed in each CEC Climate Zone.[6]

Average ft2 of Gas Htd Homes. These values are the average square footage of homes with gas heating equipment, by CEC climate zone.

Saturation of Gas Heating Equipment in Total Population. Values in this column show the percentage of homes that have gas heating equipment installed.

As-Built Average Heating % of Total Budget. Values in this column present the estimated heating usage as a percentage of the total estimated total energy usage for homes with gas heating equipment.

Source Energy Heating Savings (skBtu/yr). These values are the total estimated heating usage for homes with gas heating equipment.

Average Heating Savings as % of As-Built Heating Energy. Values in this column show the total estimated gas savings as a percent of the total estimated heating usage for homes with gas heating equipment.

Gas Heating Savings.

- ***All Gas Htd Homes.*** Values in this column show the total estimated gas savings for homes with gas heating equipment.
- ***Per Home.*** Presents the average gas savings per home from sealing ducts in only those homes with gas heating equipment.
- ***Per 1,000 ft^2.*** Presents the average gas savings per 1,000 square feet for only those homes with gas heating equipment.

H.6 Energy Savings for Electrically Heated Residences (Table XX-DS -EH)

These tables present the data used to assess electric heating energy savings. All values in the table are relative to *only those homes or multifamily building residential units that had electric space heating systems installed as determined from the onsite survey*. The explanation for each of the row and column titles in this table are the same as those for the

6 Expansion weights were used to expand the sample to the total number of new homes built within the four California IOU service territories between July 1998 and June 1999. The expansion weights are based on RMST climate zone, building type, and the six-month period in which the home was built.

gas heating table except for this table includes data for only those homes with electric space heating equipment.

H.7 Annual Source Energy Savings (Table XX- DS -SE)

These tables present source energy savings as well as the total estimated energy budget by CEC climate zone. Total source energy savings are calculated in two ways: a) the total savings for the homes in all CEC climate zones and b) the total savings for only those homes in the CEC climate zones where the measure is required as part of the AB 970 Prescriptive Package D. An explanation for each of the row and column titles unique to this table are provided below:

Total # of Homes in IOU Service Area (1,000 skBtu). Values in this column represent the weighted number of sites in each CEC Climate Zone.

Average ft2 Per Home. These values are the average square footage of homes by CEC climate zone.

Total Title 24 Compliance HVAC Source Energy Budget. Values in this column show the estimated heating and cooling energy usage for homes by CEC climate zone.

Title 24 Compliance Source Energy Savings.

- ***Total for All Homes (1,000 skBtu).*** Values in this column present heating and cooling source energy savings of all homes – including those homes without cooling equipment.[7]
- ***Average Per Home (skBtu).*** These values are the average savings per home using the total savings explained in the bullet above divided by the total number of homes.
- ***Average Per ft2 (skBtu/ft2).*** Values in this column show the average savings per 1,000 square feet using the savings per home explained in the bullet above divided by the average square footage of all homes.

As-Built Source Energy Savings

- ***Total for All Homes (1,000 skBtu).*** Savings shown in this column include the heating and cooling source energy savings of those homes with cooling equipment and only the heating source energy savings of those homes without cooling equipment.

[7] MICROPAS 6.0 models every home as if there is a cooling system installed.

- ***Average Per Home (skBtu).*** These values are the average savings per home using the total savings explained in the bullet above divided by the total number of homes.
- ***Average Per ft2 (skBtu/ft2).*** Values in this column present the average savings per 1,000 square feet using the savings per home explained in the bullet above divided by the average square footage of all homes.

Table SF-DS-EF: End-Use/Fuel Energy Savings for Duct Sealing in Detached Single-Family Homes

RMST CZ	CEC CZ	Meas Req'd. For AB 970 PackageD	Cooling Savings[8] (kWh)			Gas Heating Savings[9] (therms)			Electric Heating Savings[10] (kWh)		
			All Air Cond Homes	Per Home	Per 1,000 ft^2	All Gas Htd Homes	Per Home	Per 1,000 ft^2	All Elec Htd Homes	Per Home	Per 1,000 ft^2
1	1	Yes	-	-	-	32,367	32.8	17.19	-	-	-
	2	Yes	378,588	236	98.5	188,451	44.7	20.93	-	-	-
	3	Yes	78,903	28	11.3	156,419	21.6	9.51	-	-	-
	4	Yes	524,313	115	45.3	158,643	26.6	10.78	-	-	-
	5	Yes	10,353	21	6.7	29,609	25.1	11.12	-	-	-
2	6	Yes	66,467	28	9.7	41,982	9.9	4.01	35,635	213	38.1
	7	Yes	131,614	64	25.1	21,617	4.6	2.01	-	-	-
3	8	Yes	420,436	123	49.6	33,224	9.7	3.92	-	-	-
	9	Yes	1,986,786	291	103.3	92,182	13.5	4.79	-	-	-
	10	Yes	5,708,353	430	192.0	182,241	13.6	6.11	17,662	120	54.6
4	11	Yes	1,343,337	468	235.4	91,079	28.4	14.41	59,951	353	163.3
	12	Yes	3,576,014	278	133.1	430,484	31.8	15.33	-	-	-
	13	Yes	5,143,784	539	302.4	184,503	20.4	11.37	116,331	228	146.9
5	14	Yes	1,517,289	750	363.4	89,477	38.4	17.95	-	-	-
	15	Yes	5,786,692	1,868	848.4	13,491	4.4	1.98	-	-	-
	16	Yes	45,034	70	28.6	96,120	106.3	48.09	-	-	-
TotalSavingsAB 970PkgD_CZs			**26,717,961**	**390**		**1,841,889**	**21.9**		**229,580**	**231**	
TotalSavingsIOUServiceArea			**26,717,961**	**390**	**171.7**	**1,841,889**	**21.9**	**9.80**	**229,580**	**231**	**94.9**

8 The basis for Per Home and Per 1000 ft^2 savings is limited to those homes that have cooling equipment.

9 The basis for Per Home and Per 1000 ft^2 savings estimates is limited to those homes that have gas (natural gas and propane) heating equipment.

10 The basis Per Home and Per 1000 ft^2 savings estimates is limited to only those homes that have electric heating equipment.

Table SF-DS-CL: Energy Savings for Duct Sealing in Air Conditioned Detached Single-Family Homes

RMST CZ	CEC CZ	Meas Req'd. For AB 970 PackageD	Number of Air Cond Homes	Average ft^2 of Air Cond Homes	Saturation of Cooling Equipment in Total Population	As-Built Average Cooling % of Total Budget	Source Energy Cooling Savings (skBtu/yr)	Average Cooling Savings as % of As-Built Cooling Energy	Cooling Savings (kWh)		
									All Air Cond Homes	Per Home	Per 1,000 ft^2
1	1	Yes	986	1,910	100.0%	64.0%	3,236,657	7.9%	32,367	32.8	17.19
	2	Yes	4,212	2,138	100.0%	50.8%	18,845,124	9.1%	188,451	44.7	20.93
	3	Yes	7,232	2,274	100.0%	47.9%	15,641,891	8.2%	156,419	21.6	9.51
	4	Yes	5,958	2,471	100.0%	43.2%	15,864,328	8.4%	158,643	26.6	10.78
	5	Yes	1,178	2,261	100.0%	52.9%	2,960,881	9.0%	29,609	25.1	11.12
2	6	Yes	4,227	2,480	96.2%	29.1%	4,198,181	7.8%	41,982	9.9	4.01
	7	Yes	4,721	2,281	100.0%	15.8%	2,161,685	7.2%	21,617	4.6	2.01
3	8	Yes	3,410	2,483	100.0%	22.9%	3,322,419	7.9%	33,224	9.7	3.92
	9	Yes	6,831	2,815	100.0%	21.8%	9,218,192	8.5%	92,182	13.5	4.79
	10	Yes	13,362	2,233	98.9%	20.1%	18,224,080	8.4%	182,241	13.6	6.11
4	11	Yes	3,204	1,972	95.0%	34.1%	9,107,891	9.1%	91,079	28.4	14.41
	12	Yes	13,531	2,076	100.0%	42.1%	43,048,393	8.6%	430,484	31.8	15.33
	13	Yes	9,030	1,796	94.6%	23.9%	18,450,348	9.0%	184,503	20.4	11.37
5	14	Yes	2,333	2,137	100.0%	32.0%	8,947,702	10.2%	89,477	38.4	17.95
	15	Yes	3,097	2,202	100.0%	3.2%	1,349,108	8.9%	13,491	4.4	1.98
	16	Yes	904	2,211	100.0%	74.8%	9,612,026	10.3%	96,120	106.3	48.09
TotalSavingsAB 970PkgD_CZs			**68,509**				**273,565,208**		**26,717,961**	**390**	
TotalSavingsIOUServiceArea			**68,509**	**2,272**			**273,565,208**		**26,717,961**	**390**	**171.7**

Table SF-DS-GH: Energy Savings for Duct Sealing in Gas-Heated Detached Single-Family Homes

RMST CZ	CEC CZ	Measure Req'd for AB 970 Package D	Number of Gas Htd Homes	Average ft^2 of Gas Htd Homes	Saturation of Gas Heating Equipment in Total Population	As-Built Average Heating % of Total Budget	Source Energy Heating Savings (skBtu/yr)	Average Heating Savings as % of As-Built Heating Energy	Gas Heating Savings (therms)		
									All Gas Htd Homes	Per Home	Per 1,000 ft^2
1	1	Yes	986	1,910	100.0%	64.0%	3,236,657	7.9%	32,367	32.8	17.19
	2	Yes	4,212	2,138	100.0%	50.8%	18,845,124	9.1%	188,451	44.7	20.93
	3	Yes	7,232	2,274	100.0%	47.9%	15,641,891	8.2%	156,419	21.6	9.51
	4	Yes	5,958	2,471	100.0%	43.2%	15,864,328	8.4%	158,643	26.6	10.78
	5	Yes	1,178	2,261	100.0%	52.9%	2,960,881	9.0%	29,609	25.1	11.12
2	6	Yes	4,227	2,480	96.2%	29.1%	4,198,181	7.8%	41,982	9.9	4.01
	7	Yes	4,721	2,281	100.0%	15.8%	2,161,685	7.2%	21,617	4.6	2.01
3	8	Yes	3,410	2,483	100.0%	22.9%	3,322,419	7.9%	33,224	9.7	3.92
	9	Yes	6,831	2,815	100.0%	21.8%	9,218,192	8.5%	92,182	13.5	4.79
	10	Yes	13,362	2,233	98.9%	20.1%	18,224,080	8.4%	182,241	13.6	6.11
4	11	Yes	3,204	1,972	95.0%	34.1%	9,107,891	9.1%	91,079	28.4	14.41
	12	Yes	13,531	2,076	100.0%	42.1%	43,048,393	8.6%	430,484	31.8	15.33
	13	Yes	9,030	1,796	94.6%	23.9%	18,450,348	9.0%	184,503	20.4	11.37
5	14	Yes	2,333	2,137	100.0%	32.0%	8,947,702	10.2%	89,477	38.4	17.95
	15	Yes	3,097	2,202	100.0%	3.2%	1,349,108	8.9%	13,491	4.4	1.98
	16	Yes	904	2,211	100.0%	74.8%	9,612,026	10.3%	96,120	106.3	48.09
TotalSavingsAB 970PkgD_CZs			**84,216**				**184,188,908**		**1,841,889**	**21.9**	
TotalSavingsIOUServiceArea			**84,216**	**2,232**			**184,188,908**		**1,841,889**	**21.9**	**9.80**

Table SF-DS-EH: Energy Savings for Duct Sealing in Electrically Heated Detached Single Family Homes

RMST CZ	CEC CZ	Measure Req'd for AB 970 Package D	Number of Elec Htd Homes	Average ft^2 of Elec Htd Homes	Saturation of Elec Heating Equipment in Total Population	As-Built Average Heating % of Total Budget	Source Energy Heating Savings (skBtu/yr)	Average Heating Savings as % of As-Built Heating Energy	Electric Heating Savings (kWh) All Elec Htd Homes	Electric Heating Savings (kWh) Per Home	Electric Heating Savings (kWh) Per 1,000 ft^2
1	1	Yes	-	-	0.0%	-	-	-	-	-	-
	2	Yes	-	-	0.0%	-	-	-	-	-	-
	3	Yes	-	-	0.0%	-	-	-	-	-	-
	4	Yes	-	-	0.0%	-	-	-	-	-	-
	5	Yes	-	-	0.0%	-	-	-	-	-	-
2	6	Yes	167	5,607	3.8%	43.9%	364,872	7.9%	35,635	213.4	38.06
	7	Yes	-	-	0.0%	-	-	-	-	-	-
3	8	Yes	-	-	0.0%	-	-	-	-	-	-
	9	Yes	-	-	0.0%	-	-	-	-	-	-
	10	Yes	147	2,200	1.1%	14.4%	180,845	8.5%	17,662	120.2	54.61
4	11	Yes	170	2,160	5.0%	28.9%	613,841	9.1%	59,951	352.7	163.27
	12	Yes	-	-	0.0%	-	-	-	-	-	-
	13	Yes	511	1,550	5.4%	26.4%	1,191,112	9.1%	116,331	227.7	146.87
5	14	Yes	-	-	0.0%	-	-	-	-	-	-
	15	Yes	-	-	0.0%	-	-	-	-	-	-
	16	Yes	-	-	0.0%	-	-	-	-	-	-
TotalSavingsAB 970PkgD_CZs			**995**				**2,350,670**		**229,580**	**230.7**	
TotalSavingsIOUServiceArea			**995**	**2,431**			**2,350,670**		**229,580**	**230.7**	**94.91**

Table SF-DS-SE: Annual Source Energy Savings for Duct Sealing in Detached Single Family Homes

RMST CZ	CEC CZ	Measure Req'd for AB 970 Package D	Total # of Homes in IOU Service Area	Average ft² Per Home	Total Title 24 Compliance HVAC Source Energy Budget (1,000 skBtu)	Title 24 Compliance Source Energy Savings[11]			As-Built Source Energy Savings[12]		
						Total for All Homes (1,000 skBtu)	Average Per Home (skBtu)	Average Per ft² (skBtu/ft²)	Total for All Homes (1,000 skBtu)	Average Per Home (skBtu)	Average Per ft² (skBtu/ft²)
1	1	Yes	986	1,910	62,872	3,239	3,285	1.72	3,237	3,283	1.72
	2	Yes	4,212	2,138	405,756	28,226	6,701	3.14	22,721	5,394	2.52
	3	Yes	7,232	2,274	391,073	17,724	2,451	1.08	16,450	2,275	1.00
	4	Yes	5,958	2,471	435,244	22,715	3,813	1.54	21,233	3,564	1.44
	5	Yes	1,178	2,261	61,730	3,137	2,663	1.18	3,067	2,603	1.15
2	6	Yes	4,394	2,598	187,121	5,894	1,341	0.52	5,244	1,193	0.46
	7	Yes	4,721	2,281	186,961	5,190	1,099	0.48	3,509	743	0.33
3	8	Yes	3,410	2,483	181,230	7,627	2,237	0.90	7,627	2,237	0.90
	9	Yes	6,831	2,815	495,008	29,561	4,327	1.54	29,561	4,327	1.54
	10	Yes	13,508	2,233	1,082,108	77,781	5,758	2.58	76,853	5,689	2.55
4	11	Yes	3,375	1,982	313,858	25,754	7,631	3.85	23,476	6,956	3.51
	12	Yes	13,531	2,076	1,176,873	81,694	6,038	2.91	79,663	5,887	2.84
	13	Yes	9,540	1,783	900,963	72,309	7,580	4.25	72,309	7,580	4.25
5	14	Yes	2,333	2,137	270,891	27,206	11,661	5.46	24,483	10,494	4.91
	15	Yes	3,097	2,202	478,142	60,599	19,567	8.88	60,599	19,567	8.88
	16	Yes	904	2,211	122,616	10,255	11,344	5.13	10,073	11,143	5.04
TotalSavingsAB 970PkgD_CZs			**85,210**		**6,752,446**	**478,912**	**5,620**		**460,105**	**5,400**	
TotalSavingsIOUServiceArea			**85,210**		**6,752,446**	**478,912**	**5,620**		**460,105**	**5,400**	

11 The savings in these three columns include the Heating and Cooling source energy savings of all homes – including those homes without cooling equipment. (MICROPAS 6.0 models every home as if there is a cooling system installed.)

12 The savings in these three columns include the Heating and Cooling source energy savings of those homes with cooling equipment and the Heating source energy savings of those homes without cooling equipment.

Table MF-DS-EF: End-Use/Fuel Energy Savings for Duct Sealing in Multifamily Building

RMST CZ	CEC CZ	Meas Req'd. For AB 970 PackageD	Cooling Savings[13] (kWh)			Gas Heating Savings[14] (therms)			Electric Heating Savings[15] (kWh)		
			All Air Cond ResUnit	Per ResUnit	Per 1,000 ft^2	All Gas Htd ResUnit	Per ResUnit	Per 1,000 ft^2	All Elec Htd ResUnit	Per Res Unit	Per 1,000 ft^2
1	1	Yes	-	-	-	0	0.0	0.00	-	-	-
	2	Yes	-	-	-	51,684	57.9	14.01	-	-	-
	3	Yes	-	-	-	59,311	35.0	4.31	-	-	-
	4	Yes	73,671	114	3.6	90,867	46.7	2.41	-	-	-
	5	Yes	-	-	-	-	-	-	-	-	-
2	6	Yes	42,733	33	2.0	27,168	16.7	1.16	17,103	76	2.6
	7	Yes	87,311	117	6.1	10,170	9.9	0.62	11,904	55	6.2
3	8	Yes	504,066	215	16.5	26,666	11.7	1.21	121,218	255	10.3
	9	Yes	570,783	278	34.9	19,875	13.7	1.65	28,802	47	6.7
	10	Yes	393,846	1,119	64.2	9,207	22.2	1.46	-	-	-
4	11	Yes	0	0	0.0	0	0.0	0.00	-	-	-
	12	Yes	1,366,150	519	28.0	161,844	72.7	7.57	0	0	0.0
	13	Yes	774,182	747	213.1	15,416	17.8	6.52	58,116	342	45.9
5	14	Yes	738,853	2,142	188.4	39,204	113.6	10.00	-	-	-
	15	Yes	274,451	3,155	630.9	348	4.0	0.80	-	-	-
	16	Yes	20,335	77	6.5	87,973	334.5	27.99	-	-	-
TotalSavingsAB 970PkgD_CZs			**4,846,379**	**405**		**599,732**	**38.8**		**237,143**	**113**	
TotalSavingsIOUServiceArea			**4,846,379**	**405**	**28.4**	**599,732**	**38.8**	**3.55**	**237,143**	**113**	**4.5**

13 The basis for Per Home and Per 1000 ft^2 savings is limited to those homes that have cooling equipment.

14 The basis for Per Home and Per 1000 ft^2 savings estimates is limited to those homes that have gas (natural gas and propane) heating equipment.

15 The basis Per Home and Per 1000 ft^2 savings estimates is limited to only those homes that have electric heating equipment.

Table MF-DS-CL: Energy Savings for Duct Sealing in Air Conditioned Multifamily Building

RMST CZ	CEC CZ	Meas Req'd. For AB 970 PackageD	Number of Air Cond ResUnit	Average ft^2 of Air Cond ResUnit	Saturation of Cooling Equipment in Total Population	As-Built Average Cooling % of Total Budget	Source Energy Cooling Savings (skBtu/yr)	Average Cooling Savings as % of As-Built Cooling Energy	Cooling Savings (kWh)		
									All Air Cond ResUnit	Per Res Unit	Per 1,000 ft^2
1	1	Yes	-	-	0.0%	-	-	-	-	-	-
	2	Yes	-	-	0.0%	-	-	-	-	-	-
	3	Yes	-	-	0.0%	-	-	-	-	-	-
	4	Yes	647	31,498	33.3%	4.7%	754,321	4.6%	73,671	114	3.6
	5	Yes	-	-	0.0%	-	-	-	-	-	-
2	6	Yes	1,283	16,837	69.3%	1.6%	437,540	6.6%	42,733	33	2.0
	7	Yes	747	19,036	60.0%	6.9%	893,978	6.5%	87,311	117	6.1
3	8	Yes	2,340	13,085	85.1%	15.0%	5,161,129	6.4%	504,066	215	16.5
	9	Yes	2,055	7,962	100.0%	21.2%	5,844,246	7.0%	570,783	278	34.9
	10	Yes	352	17,441	85.0%	25.0%	4,032,590	10.8%	393,846	1,119	64.2
4	11	Yes	168	7,776	100.0%	19.5%	0	0.0%	0	0	0.0
	12	Yes	2,633	18,548	100.0%	17.5%	13,988,005	7.0%	1,366,150	519	28.0
	13	Yes	1,037	3,503	100.0%	43.7%	7,926,845	11.2%	774,182	747	213.1
5	14	Yes	345	11,368	100.0%	36.9%	7,565,112	13.8%	738,853	2,142	188.4
	15	Yes	87	5,000	100.0%	72.9%	2,810,100	15.0%	274,451	3,155	630.9
	16	Yes	263	11,952	100.0%	2.8%	208,206	6.8%	20,335	77	6.5
TotalSavingsAB 970PkgD_CZs			**11,957**				**49,622,072**		**4,846,379**	**405**	
TotalSavingsIOUServiceArea			**11,957**	**14,268**			**49,622,072**		**4,846,379**	**405**	**28.4**

Table MF-DS-GH: Energy Savings for Duct Sealing in Gas-Heated Multifamily Building

RMST CZ	CEC CZ	Measure Req'd for AB 970 Package D	Number of Elec Htd ResUnit	Average ft^2 of Elec Htd ResUnit	Saturation of Elec Heating Equipment in Total Population	As-Built Average Heating % of Total Budget	Source Energy Heating Savings (skBtu/yr)	Average Heating Savings as % of As-Built Heating Energy	Electric Heating Savings (kWh) All Elec Htd ResUnit	Electric Heating Savings (kWh) Per Res Unit	Electric Heating Savings (kWh) Per 1,000 ft^2
1	1	Yes	163	6,000	100.0%	28.4%	0	0.0%	0	0.0	0.00
	2	Yes	893	4,132	100.0%	37.1%	5,168,395	9.0%	51,684	57.9	14.01
	3	Yes	1,694	8,127	100.0%	32.1%	5,931,102	7.3%	59,311	35.0	4.31
	4	Yes	1,944	19,381	100.0%	22.5%	9,086,664	7.3%	90,867	46.7	2.41
	5	Yes	-	-	100.0%	-	-	-	-	-	-
2	6	Yes	1,627	14,398	87.9%	14.9%	2,716,810	6.6%	27,168	16.7	1.16
	7	Yes	1,030	15,817	82.7%	6.5%	1,016,998	7.8%	10,170	9.9	0.62
3	8	Yes	2,274	9,721	82.7%	11.6%	2,666,624	6.1%	26,666	11.7	1.21
	9	Yes	1,446	8,332	70.4%	10.2%	1,987,456	7.8%	19,875	13.7	1.65
	10	Yes	414	15,241	100.0%	8.3%	920,682	8.6%	9,207	22.2	1.46
4	11	Yes	168	7,776	100.0%	27.6%	0	0.0%	0	0.0	0.00
	12	Yes	2,227	9,603	84.5%	28.3%	16,184,356	8.5%	161,844	72.7	7.57
	13	Yes	866	2,730	83.6%	16.1%	1,541,605	9.1%	15,416	17.8	6.52
5	14	Yes	345	11,368	100.0%	25.8%	3,920,424	10.1%	39,204	113.6	10.00
	15	Yes	87	5,000	100.0%	1.7%	34,800	8.2%	348	4.0	0.80
	16	Yes	263	11,952	100.0%	57.2%	8,797,267	11.1%	87,973	334.5	27.99
TotalSavingsAB 970PkgD_CZs			**15,441**				**59,973,184**		**599,732**	**38.8**	
TotalSavingsIOUServiceArea			**15,441**	**10,935**			**59,973,184**		**599,732**	**38.8**	**3.55**

Table MF-DS-EH: Energy Savings for Duct Sealing in Electrically Heated Multifamily Building

RMST CZ	CEC CZ	Measure Req'd for AB 970 Package D	Number of Gas Htd ResUnit	Average ft^2 of Gas Htd ResUnit	Saturation of Gas Heating Equipment in Total Population	As-Built Average Heating % of Total Budget	Source Energy Heating Savings (skBtu/yr)	Average Heating Savings as % of As-Built Heating Energy	Gas Heating Savings (therms) All Gas Htd ResUnit	Gas Heating Savings (therms) Per Res Unit	Gas Heating Savings (therms) Per 1,000 ft^2
1	1	Yes	-	-	0.0%	-	-	-	-	-	-
	2	Yes	-	-	0.0%	-	-	-	-	-	-
	3	Yes	-	-	0.0%	-	-	-	-	-	-
	4	Yes	-	-	0.0%	-	-	-	-	-	-
	5	Yes	-	-	0.0%	-	-	-	-	-	-
2	6	Yes	224	29,039	12.1%	2.8%	175,120	4.8%	17,103	76.4	2.63
	7	Yes	215	8,880	17.3%	5.5%	121,889	6.9%	11,904	55.4	6.24
3	8	Yes	476	24,675	17.3%	6.1%	1,241,149	8.2%	121,218	254.7	10.32
	9	Yes	609	7,083	29.6%	5.6%	294,899	5.1%	28,802	47.3	6.68
	10	Yes	-	-	0.0%	-	-	-	-	-	-
4	11	Yes	-	-	0.0%	-	-	-	-	-	-
	12	Yes	407	67,500	15.5%	6.0%	0	0.0%	0	0.0	0.00
	13	Yes	170	7,440	16.4%	12.9%	595,054	9.1%	58,116	341.9	45.95
5	14	Yes	-	-	0.0%	-	-	-	-	-	-
	15	Yes	-	-	0.0%	-	-	-	-	-	-
	16	Yes	-	-	0.0%	-	-	-	-	-	-
TotalSavingsAB 970PkgD_CZs			**2,101**				**2,428,112**		**237,143**	**112.9**	
TotalSavingsIOUServiceArea			**2,101**	**25,324**			**2,428,112**		**237,143**	**112.9**	**4.46**

Table MF-DS-SE: Annual Source Energy Savings for Duct Sealing in Multifamily Building

RMST CZ	CEC CZ	Measure Req'd for AB 970 Package D	Total # of ResUnit in IOU Service Area	Average ft² Per ResUnit	Total Title 24 Compliance HVAC Source Energy Budget (1,000 skBtu)	Title 24 Compliance Source Energy Savings[16]			As-Built Source Energy Savings[17]		
						Total for All ResUnit (1,000 skBtu)	Average Per ResUnit (skBtu)	Average Per ft² (skBtu/ft²)	Total for All ResUnit (1,000 skBtu)	Average Per ResUnit (skBtu)	Average Per ft² (skBtu/ft²)
1	1	Yes	163	6,000	29,785	0	0	0.00	0	0	0.00
	2	Yes	893	4,132	158,756	8,838	9,897	2.40	5,168	5,788	1.40
	3	Yes	1,694	8,127	271,889	6,925	4,088	0.50	5,931	3,501	0.43
	4	Yes	1,944	19,381	742,727	11,730	6,034	0.31	9,841	5,062	0.26
	5	Yes	-	-	-	-	-	-	-	-	-
2	6	Yes	1,851	16,172	444,262	3,388	1,830	0.11	3,329	1,799	0.11
	7	Yes	1,246	14,619	314,037	2,493	2,001	0.14	2,033	1,632	0.11
3	8	Yes	2,750	12,311	642,489	9,552	3,474	0.28	9,069	3,298	0.27
	9	Yes	2,055	7,962	404,600	8,127	3,955	0.50	8,127	3,955	0.50
	10	Yes	414	15,241	157,472	5,175	12,500	0.82	4,953	11,964	0.79
4	11	Yes	168	7,776	27,617	0	0	0.00	0	0	0.00
	12	Yes	2,633	18,548	1,520,706	30,172	11,459	0.62	30,172	11,459	0.62
	13	Yes	1,037	3,503	164,277	10,064	9,704	2.77	10,064	9,704	2.77
5	14	Yes	345	11,368	148,393	11,486	33,291	2.93	11,486	33,291	2.93
	15	Yes	87	5,000	25,726	2,845	32,700	6.54	2,845	32,700	6.54
	16	Yes	263	11,952	134,970	9,005	34,241	2.86	9,005	34,241	2.86
TotalSavingsAB 970PkgD_CZs			**17,543**		**5,187,704**	**119,801**	**6,829**		**112,023**	**6,386**	
TotalSavingsIOUServiceArea			**17,543**		**5,187,704**	**119,801**	**6,829**		**112,023**	**6,386**	

16 The savings in these three columns include the Heating and Cooling source energy savings of all homes – including those homes without cooling equipment. (MICROPAS 6.0 models every home as if there is a cooling system installed.)

17 The savings in these three columns include the Heating and Cooling source energy savings of those homes with cooling equipment and the Heating source energy savings of those homes without cooling equipment.

Appendix I

Technical Potential – All Measures

I.1 Introduction

This appendix contains the complete set of tables used to assess the technical potential for using all four measures (radiant barriers, duct sealing, TXV valves, and Low Solar Heat Gain Fenestration). Results are presented separately for detached single-family homes and multifamily buildings. For each building type, there are five tables. The first table (SF-AM-EF)[1] summarizes the estimated technical potential by end use: cooling (electric savings) and heating (electric savings and gas savings are shown separately). The second table (SF- AM - CL) provides the estimated electric cooling savings as well as cooling saturations for each CEC climate zone. The third and fourth tables (SF- AM -GH and SF- AM -EH) summarize the heating savings by fuel type—electric and gas. The final table (SF- AM -SE) provides the source energy savings as well as the total estimated source energy budget. The remaining tables in this appendix present the same results for multifamily buildings.

The following sections of this appendix provide a more detailed description of each table, including its purpose, the data captured in each table, and an explanation of the column/row headers.

- I.2: End-Use/Fuel Energy Savings
- I.3: Energy Savings for Air Conditioned Residences
- I.4: Energy Savings for Gas Heated Residences
- I.5: Energy Savings for Electrically Heated Residences
- I.6: Annual Source Energy Savings

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[1] This labeling convention is used for the technical potential tables to avoid confusion. The first two characters of the table label refer to the building type (SF – single family and MF – multifamily), the middle characters signify the technical potential measure (AM – ALL Measures), and the final two characters represent the type of savings estimates that are summarized in the table. (EF – Savings by End-Use/Fuel Type, CL – Cooling Savings, GH – Gas Heating Savings, EH – Electric Heating Savings, and SE – Source Energy Savings).

I.2 Row/Column Titles Common to All Tables

There are several rows and columns of results common to every table. These fields are described below.

RMST CZ. These are the target sample groups used for the Residential Market Share Tracking (RMST) study.[2]

CEC CZ. These are the California Energy Commission climate zones.[3]

MeasRqd ForAB970 PackageD. A "Yes" in this column indicates that at least one of the measures is required in the indicated CEC climate zone as part of the AB 970 Prescriptive Package D.

TotalSavingsAB970_CZs. Values in this row are totals or averages (depending on the column header) only for those CEC climate zones where at least one of the measures is required as part of the AB 970 Prescriptive Package D.

TotalSavingsIOUServiceArea. Values in this row are totals or averages (depending on the column header) for <u>all</u> CEC climate zones, not just AB 970 specific CEC climate zones.

I.3 End-Use/Fuel Energy Savings Table (Table XX-AM-EF)

These tables present energy savings on an end-use and fuel basis. Savings estimates are presented for space cooling in kWh, gas heating in therms, and electric heating in kWh. Total end-use fuel savings are calculated in two ways: a) the total savings for the homes in all CEC climate zones and b) the total savings for only those homes in the CEC climate zones where the measure is required as part of the AB 970 Prescriptive Package D. An explanation for each of the row and column titles unique to this table are provided below:

Cooling Savings. Cooling savings in kWh are presented for only those homes or multifamily building residential units that had air conditioning systems installed as determined from the onsite survey. Results are presented in three formats, as described below.

- ***(Savings) All Air Cond Homes/ ResUnits.*** This value is the <u>total</u> energy savings for those detached single-family homes (*Homes*) or multifamily residential units (*ResUnits*) *that have the specific equipment installed.*[4]

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[2] Regional Economic Research, Inc. *California Residential Efficiency Market Share Tracking – First-Year Interim Report.* Prepared for Southern California Edison. October 2000.

[3] See Section 3 of this report for a map of the CEC climate zones.

- ***(Savings) Average Per Home/ResUnit.*** This value is the average energy savings per detached single-family home (*Per Home*) or multifamily residential units (*Per ResUnit*) *that have the specific equipment installed*. It is obtained by taking the average of the total energy savings divided by the number of detached single-family homes or multifamily residential units *that have the specific equipment installed*.
- ***(Savings) Average Per 1000 ft^2.*** This value is the average energy savings per 1,000 square feet of conditioned floor area (CFA) for residences *that have the specific equipment installed*. It is obtained by taking the average of the total energy savings divided by the average conditioned floor area of all detached single-family homes or multifamily residential units *that have the specific equipment installed*.

Gas Heating Savings. Gas heating savings in therms are presented for only those homes or multifamily building residential units that had gas space heating systems installed as determined from the onsite survey. Results are presented on the same three bases as used for the cooling estimates.

Electric Heating Savings. Electric heating savings in kWh are presented for only those homes or multifamily building residential units that had electric space heating systems (baseboard, heat pumps, and electric resistance) installed as determined from the onsite survey. Results are presented on the same three bases as used for the cooling estimates.

I.4 Energy Savings for Air Conditioned Residences (Table XX-AM-CL)

These tables present the data used to assess cooling energy savings. All values in the table are relative to *only those homes or multifamily building residential units that had air conditioning systems installed as determined from the onsite survey*. An explanation for each of the row and column titles in this table is provided below:

Number of Air Cond Homes. Values in this column represent the weighted number of sites that have cooling equipment installed in each CEC Climate Zone.[5]

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[4] The specific equipment here means cooling equipment. For the gas heating and electric heating tables, it means gas or propane heating equipment and electric heating equipment respectively.

[5] Expansion weights were used to expand the sample to the total number of new homes built within the four California IOU service territories between July 1998 and June 1999. The expansion weights are based on RMST Climate Zone, building type, and the six-month period in which the home was built.

Average ft2 of Air Cond Homes. These values are the average square footage of homes with cooling equipment, by CEC climate zone.

Saturation of Cooling Equipment in Total Population. Values in this column show the percentage of homes that have cooling equipment installed.

As-Built Average Cooling % of Total Budget. Values in this column present the estimated cooling usage as a percentage of the total estimated total energy usage for homes with cooling equipment.

Source Energy Cooling Savings (skBtu/yr). These values are the total estimated cooling usage for homes with cooling equipment.

Average Cooling Savings as % of As-Built Cooling Energy. Values in this column show the total estimated electric savings as a percent of the total estimated cooling usage for those homes with cooling equipment.

Cooling Savings.

- ***All Air Cond Homes.*** Values in this column show the total estimated electric savings for homes with cooling equipment.
- ***Per Home.*** This presents the average electric savings per home with cooling equipment.
- ***Per 1,000 ft^2.*** This presents the average electric savings per 1,000 square feet for only those homes with cooling equipment.

I.5 Energy Savings for Gas Heated Residences (Table XX-AM-GH)

These tables present the data used to assess gas heating energy savings. All values in the table are relative to *only those homes or multifamily building residential units that had gas (or propane) space heating systems installed as determined from the onsite survey*. An explanation for each of the row and column titles in this table is provided below.

Number of Gas Htd Homes. Values in this column represent the weighted number of sites that have gas heating equipment installed in each CEC Climate Zone.[6]

[6] Expansion weights were used to expand the sample to the total number of new homes built within the four California IOU service territories between July 1998 and June 1999. The expansion weights are based on RMST Climate Zone, building type, and the six-month period in which the home was built.

Average ft2 of Gas Htd Homes. These values are the average square footage of homes with gas heating equipment, by CEC climate zone.

Saturation of Gas Heating Equipment in Total Population. Values in this column show the percentage of homes that have gas heating equipment installed.

As-Built Average Heating % of Total Budget. Values in this column present the estimated heating usage as a percentage of the total estimated total energy usage for homes with gas heating equipment.

Source Energy Heating Savings (skBtu/yr). These values are the total estimated heating usage for homes with gas heating equipment.

Average Heating Savings as % of As-Built Heating Energy. Values in this column show the total estimated gas savings as a percent of the total estimated heating usage for homes with gas heating equipment.

Gas Heating Savings

- ***All Gas Htd Homes.*** Values in this column show the total estimated gas savings for homes with gas heating equipment.
- ***Per Home.*** This presents the average gas savings per home with gas heating equipment.
- ***Per 1,000 ft^2.*** This presents the average gas savings per 1,000 square feet for only those homes with gas heating equipment.

I.6 Energy Savings for Electrically Heated Residences (Table XX-AM-EH)

These tables present the data used to assess electric heating energy savings. All values in the table are relative to *only those homes or multifamily building residential units that had electric space heating systems installed as determined from the onsite survey*. The explanation for each of the row and column titles in this table are the same as those for the gas heating table except for this table includes data for only those homes with electric space heating equipment.

I.7 Annual Source Energy Savings (Table XX-AM-SE)

These tables present source energy savings as well as the total estimated energy budget by CEC climate zone. Total source energy savings are calculated in two ways: a) the total savings for the homes in all CEC climate zones and b) the total savings for only those homes in the CEC climate zones where the measure is required as part of the AB 970 Prescriptive Package D. An explanation for each of the row and column titles unique to this table are provided below:

Total # of Homes in IOU Service Area (1,000 skBtu). Values in this column represent the weighted number of sites in each CEC Climate Zone.

Average ft2 Per Home. These values are the average square footage of homes by CEC climate zone.

Total Title 24 Compliance HVAC Source Energy Budget. Values in this column show the estimated heating and cooling energy usage for homes by CEC climate zone.

Title 24 Compliance Source Energy Savings.

- ***Total for All Homes (1,000 skBtu).*** Values in this column present heating and cooling source energy savings of all homes – including those homes without cooling equipment.[7]
- ***Average Per Home (skBtu).*** These values are the average savings per home using the total savings explained in the bullet above divided by the total number of homes.
- ***Average Per ft2 (skBtu/ft2).*** Values in this column show the average savings per 1,000 square feet using the savings per home explained in the bullet above divided by the average square footage of all homes.

As-Built Source Energy Savings.

- ***Total for All Homes (1,000 skBtu).*** Savings shown in this column include the heating and cooling source energy savings of those homes with cooling equipment and only the heating source energy savings of those homes without cooling equipment.
- ***Average Per Home (skBtu).*** These values are the average savings per home using the total savings explained in the bullet above divided by the total number of homes.
- ***Average Per ft2 (skBtu/ft2).*** Values in this column present the average savings per 1,000 square feet using the savings per home explained in the bullet above divided by the average square footage of all homes.

[7] MICROPAS 6.0 models every home as if there is a cooling system installed.

Table SF-AM-EF: End-Use/Fuel Energy Savings for All Measures in Detached Single-Family Homes

RMST CZ	CEC CZ	Meas Req'd. For AB970 PackageD	Cooling Savings[8] (kWh)			Gas Heating Savings[9] (therms)			Electric Heating Savings[10] (kWh)		
			All Air Cond Homes	Per Home	Per 1,000 ft^2	All Gas Htd Homes	Per Home	Per 1,000 ft^2	All Elec Htd Homes	Per Home	Per 1,000 ft^2
1	1	Yes	-	-	-	47,908	48.6	25.45	-	-	-
	2	Yes	2,682,635	1,675	698.3	219,102	52.0	24.34	-	-	-
	3	Yes	857,153	300	122.8	178,978	24.2	10.34	-	-	-
	4	Yes	5,601,634	1,229	483.9	179,509	30.1	12.19	-	-	-
	5	Yes	151,995	303	98.3	32,575	27.7	12.23	-	-	-
2	6	Yes	640,888	269	93.4	28,608	6.8	2.73	-7,310	-44	-7.8
	7	Yes	1,641,267	795	313.0	38,623	8.2	3.59	-	-	-
3	8	Yes	4,126,454	1,210	487.3	18,914	5.5	2.23	-	-	-
	9	Yes	14,698,958	2,152	764.4	108,464	15.9	5.64	-	-	-
	10	Yes	32,001,727	2,412	1,076.2	193,126	14.5	6.47	27,440	187	84.8
4	11	Yes	6,873,499	2,394	1,204.6	124,766	38.9	19.75	35,181	207	95.8
	12	Yes	23,010,658	1,790	856.2	552,182	40.3	19.54	-	-	-
	13	Yes	25,154,953	2,637	1,478.7	181,256	20.1	11.17	267,140	523	337.3
5	14	Yes	6,605,369	3,264	1,581.9	113,961	48.8	22.86	-	-	-
	15	Yes	18,290,402	5,906	2,681.7	21	0.0	0.00	-	-	-
	16	Yes	461,240	717	292.7	148,616	164.4	74.35	-	-	-
TotalSavingsAB970PkgD_CZs			**142,798,834**	**2,084**		**2,166,610**	**25.6**		**322,451**	**324**	
TotalSavingsIOUServiceArea			**142,798,834**	**2,084**	**917.5**	**2,166,610**	**25.6**	**11.46**	**322,451**	**324**	**133.3**

8 The basis for Per Home and Per 1000 ft^2 savings is limited to those homes that have cooling equipment.

9 The basis for Per Ho me and Per 1000 ft^2 savings estimates is limited to those homes that have gas (natural gas and propane) heating equipment.

10 The basis Per Home and Per 1000 ft^2 savings estimates is limited to only those homes that have electric heating equipment.

Table SF-AM-CL: Energy Savings for All Measures in Air Conditioned Detached Single-Family Homes

RMST CZ	CEC CZ	Meas Req'd. For AB970 PackageD	Number of Air Cond Homes	Average ft^2 of Air Cond Homes	Saturation of Cooling Equipment in Total Population	As-Built Average Cooling % of Total Budget	Source Energy Cooling Savings (skBtu/yr)	Average Cooling Savings as % of As-Built Cooling Energy	Cooling Savings (kWh) All Air Cond Homes	Cooling Savings (kWh) Per Home	Cooling Savings (kWh) Per 1,000 ft^2
1	1	Yes	-	-	0.0%	-	-	-	-	-	-
	2	Yes	1,602	2,398	38.0%	23.5%	27,467,501	66.5%	2,682,635	1,675	698.3
	3	Yes	2,854	2,446	38.5%	6.7%	8,776,388	77.0%	857,153	300	122.8
	4	Yes	4,558	2,540	76.5%	22.3%	57,355,135	72.6%	5,601,634	1,229	483.9
	5	Yes	502	3,080	42.6%	5.4%	1,556,277	94.5%	151,995	303	98.3
2	6	Yes	2,385	2,876	54.3%	8.8%	6,562,054	71.7%	640,888	269	93.4
	7	Yes	2,064	2,540	43.7%	25.3%	16,804,930	77.7%	1,641,267	795	313.0
3	8	Yes	3,410	2,483	100.0%	32.9%	42,250,762	70.1%	4,126,454	1,210	487.3
	9	Yes	6,831	2,815	100.0%	42.7%	150,502,630	69.7%	14,698,958	2,152	764.4
	10	Yes	13,270	2,241	98.2%	50.6%	327,665,688	60.4%	32,001,727	2,412	1,076.2
4	11	Yes	2,871	1,987	85.1%	41.3%	70,377,756	61.8%	6,873,499	2,394	1,204.6
	12	Yes	12,858	2,090	93.8%	31.0%	235,606,129	67.3%	23,010,658	1,790	856.2
	13	Yes	9,540	1,783	100.0%	52.7%	257,561,565	53.9%	25,154,953	2,637	1,478.7
5	14	Yes	2,024	2,063	86.8%	48.3%	67,632,372	60.5%	6,605,369	3,264	1,581.9
	15	Yes	3,097	2,202	100.0%	81.9%	187,275,430	47.7%	18,290,402	5,906	2,681.7
	16	Yes	643	2,451	71.1%	6.7%	4,722,639	71.2%	461,240	717	292.7
TotalSavingsAB970PkgD_CZs			**68,509**				**1,462,117,258**		**142,798,834**	**2,084**	
TotalSavingsIOUServiceArea			**68,509**	**2,272**			**1,462,117,258**		**142,798,834**	**2,084**	**917.5**

Table SF-AM-GH: Energy Savings for All Measures in Gas-Heated Detached Single-Family Homes

RMST CZ	CEC CZ	Measure Req'd for AB 970 Package D	Number of Gas Htd Homes	Average ft² of Gas Htd Homes	Saturation of Gas Heating Equipment in Total Population	As-Built Average Heating % of Total Budget	Source Energy Heating Savings (skBtu/yr)	Average Heating Savings as % of As-Built Heating Energy	Gas Heating Savings (therms) All Gas Htd Homes	Gas Heating Savings (therms) Per Home	Gas Heating Savings (therms) Per 1,000 ft²
1	1	Yes	986	1,910	100.0%	64.0%	4,790,810	11.6%	47,908	48.6	25.45
	2	Yes	4,212	2,138	100.0%	50.8%	21,910,238	10.5%	219,102	52.0	24.34
	3	Yes	7,406	2,338	100.0%	48.1%	17,897,836	9.0%	178,978	24.2	10.34
	4	Yes	5,958	2,471	100.0%	43.2%	17,950,890	9.6%	179,509	30.1	12.19
	5	Yes	1,178	2,261	100.0%	52.9%	3,257,461	9.9%	32,575	27.7	12.23
2	6	Yes	4,227	2,480	96.2%	29.1%	2,860,766	5.3%	28,608	6.8	2.73
	7	Yes	4,721	2,281	100.0%	15.8%	3,862,331	12.8%	38,623	8.2	3.59
3	8	Yes	3,410	2,483	100.0%	22.9%	1,891,398	4.5%	18,914	5.5	2.23
	9	Yes	6,831	2,815	100.0%	21.8%	10,846,443	10.0%	108,464	15.9	5.64
	10	Yes	13,362	2,233	98.9%	20.1%	19,312,597	8.9%	193,126	14.5	6.47
4	11	Yes	3,204	1,972	95.0%	34.1%	12,476,629	12.4%	124,766	38.9	19.75
	12	Yes	13,701	2,062	100.0%	42.0%	55,218,210	11.0%	552,182	40.3	19.54
	13	Yes	9,030	1,796	94.6%	23.9%	18,125,580	8.8%	181,256	20.1	11.17
5	14	Yes	2,333	2,137	100.0%	32.0%	11,396,071	13.0%	113,961	48.8	22.86
	15	Yes	3,097	2,202	100.0%	3.2%	2,103	0.0%	21	0.0	0.00
	16	Yes	904	2,211	100.0%	74.8%	14,861,614	15.9%	148,616	164.4	74.35
TotalSavingsAB970PkgD_CZs			**84,560**				**216,660,979**		**2,166,610**	**25.6**	
TotalSavingsIOUServiceArea			**84,560**	**2,235**			**216,660,979**		**2,166,610**	**25.6**	**11.46**

Table SF-AM-EH: Energy Savings for All Measures in Electrically Heated Detached Single Family Homes

RMST CZ	CEC CZ	Measure Req'd for AB 970 Package D	Number of Elec Htd Homes	Average ft^2 of Elec Htd Homes	Saturation of Elec Heating Equipment in Total Population	As-Built Average Heating % of Total Budget	Source Energy Heating Savings (skBtu/yr)	Average Heating Savings as % of As-Built Heating Energy	Electric Heating Savings (kWh) All Elec Htd Homes	Electric Heating Savings (kWh) Per Home	Electric Heating Savings (kWh) Per 1,000 ft^2
1	1	Yes	-	-	0.0%	-	-	-	-	-	-
	2	Yes	-	-	0.0%	-	-	-	-	-	-
	3	Yes	-	-	0.0%	-	-	-	-	-	-
	4	Yes	-	-	0.0%	-	-	-	-	-	-
	5	Yes	-	-	0.0%	-	-	-	-	-	-
2	6	Yes	167	5,607	3.8%	43.9%	-74,845	-1.6%	-7,310	-43.8	-7.81
	7	Yes	-	-	0.0%	-	-	-	-	-	-
3	8	Yes	-	-	0.0%	-	-	-	-	-	-
	9	Yes	-	-	0.0%	-	-	-	-	-	-
	10	Yes	147	2,200	1.1%	14.4%	280,956	13.2%	27,440	186.7	84.85
4	11	Yes	170	2,160	5.0%	28.9%	360,218	5.3%	35,181	206.9	95.81
	12	Yes	-	-	0.0%	-	-	-	-	-	-
	13	Yes	511	1,550	5.4%	26.4%	2,735,244	20.9%	267,140	522.8	337.28
5	14	Yes	-	-	0.0%	-	-	-	-	-	-
	15	Yes	-	-	0.0%	-	-	-	-	-	-
	16	Yes	-	-	0.0%	-	-	-	-	-	-
TotalSavingsAB970PkgD_CZs			**995**				**3,301,573**		**322,451**	**324.1**	
TotalSavingsIOUServiceArea			**995**	**2,431**			**3,301,573**		**322,451**	**324.1**	**133.30**

Table SF-AM-SE: Annual Source Energy Savings for All Measures in Detached Single Family Homes

RMST CZ	CEC CZ	Measure Req'd for AB 970 Package D	Total # of Homes in IOU Service Area	Average ft^2 Per Home	Total Title 24 Compliance HVAC Source Energy Budget (1,000 skBtu)	Title 24 Compliance Source Energy Savings[11]			As-Built Source Energy Savings[12]		
						Total for All Homes (1,000 skBtu)	Average Per Home (skBtu)	Average Per ft^2 ($skBtu/ft^2$)	Total for All Homes (1,000 skBtu)	Average Per Home (skBtu)	Average Per ft^2 ($skBtu/ft^2$)
1	1	Yes	986	1,910	62,872	4,806	4,875	2.55	4,791	4,859	2.54
	2	Yes	4,212	2,138	405,756	86,788	20,605	9.64	49,378	11,723	5.48
	3	Yes	7,406	2,338	403,543	40,165	5,423	2.32	26,674	3,602	1.54
	4	Yes	5,958	2,471	435,244	89,893	15,088	6.11	75,306	12,639	5.12
	5	Yes	1,178	2,261	61,730	5,843	4,960	2.19	4,814	4,086	1.81
2	6	Yes	4,394	2,598	187,121	15,667	3,566	1.37	9,348	2,127	0.82
	7	Yes	4,721	2,281	186,961	39,583	8,385	3.68	20,667	4,378	1.92
3	8	Yes	3,410	2,483	181,230	44,142	12,945	5.21	44,142	12,945	5.21
	9	Yes	6,831	2,815	495,008	161,349	23,620	8.39	161,349	23,620	8.39
	10	Yes	13,508	2,233	1,082,108	352,019	26,060	11.67	347,259	25,708	11.51
4	11	Yes	3,375	1,982	313,858	93,936	27,833	14.05	83,215	24,656	12.44
	12	Yes	13,701	2,062	1,184,927	304,686	22,238	10.78	290,824	21,227	10.29
	13	Yes	9,540	1,783	900,963	278,422	29,185	16.37	278,422	29,185	16.37
5	14	Yes	2,333	2,137	270,891	90,082	38,612	18.07	79,028	33,874	15.85
	15	Yes	3,097	2,202	478,142	187,278	60,471	27.46	187,278	60,471	27.46
	16	Yes	904	2,211	122,616	21,295	23,556	10.65	19,584	21,664	9.80
TotalSavingsAB970PkgD_CZs			**85,554**		**6,772,970**	**1,815,955**	**21,226**		**1,682,080**	**19,661**	
TotalSavingsIOUServiceArea			**85,554**		**6,772,970**	**1,815,955**	**21,226**		**1,682,080**	**19,661**	

[11] The savings in these three columns include the Heating and Cooling source energy savings of all homes – including those homes without cooling equipment. (MICROPAS 6.0 models every home as if there is a cooling system installed.)

[12] The savings in these three columns include the Heating and Cooling source energy savings of those homes with cooling equipment and the Heating source energy savings of those homes without cooling equipment.

Table MF-AM-EF: End-Use/Fuel Energy Savings for All Measures in Multifamily Building

RMST CZ	CEC CZ	Meas Req'd. For AB970 PackageD	Cooling Savings[13] (kWh)			Gas Heating Savings[14] (therms)			Electric Heating Savings[15] (kWh)		
			All Air Cond ResUnit	Per ResUnit	Per 1,000 ft^2	All Gas Htd ResUnit	Per ResUnit	Per 1,000 ft^2	All Elec Htd ResUnit	Per Res Unit	Per 1,000 ft^2
1	1	Yes	-	-	-	15,089	92.6	15.43	-	-	-
	2	Yes	-	-	-	78,593	64.4	14.58	1,328,225	960	48.4
	3	Yes	-	-	-	126,230	55.8	6.95	867,832	1,062	58.2
	4	Yes	6,224,957	2,981	84.2	171,136	88.0	4.54	1,092,310	758	20.4
	5	Yes	-	-	-	504	2.1	1.40	-	-	-
2	6	Yes	438,741	342	20.3	31,296	19.2	1.34	47,889	214	7.4
	7	Yes	1,046,396	1,163	72.4	24,919	24.2	1.53	37,704	102	17.4
3	8	Yes	5,592,575	2,390	182.7	56,601	24.9	2.56	113,227	238	9.6
	9	Yes	9,340,059	3,390	190.3	62,838	43.5	5.22	557,871	426	15.1
	10	Yes	1,633,311	4,640	266.0	11,377	27.5	1.80	-	-	-
4	11	Yes	739,307	1,470	138.8	1,696	10.1	1.30	73,403	218	18.2
	12	Yes	11,711,951	4,448	239.8	290,449	130.4	13.58	348,684	857	12.7
	13	Yes	3,293,193	3,176	906.5	22,289	25.7	9.43	96,449	567	76.3
5	14	Yes	3,184,740	9,231	812.1	73,071	211.8	18.63	-	-	-
	15	Yes	806,358	9,268	1,853.7	44	0.5	0.10	-	-	-
	16	Yes	210,267	799	66.9	167,216	635.8	53.19	-	-	-
TotalSavingsAB970PkgD_CZs			**44,221,856**	**3,032**		**1,133,346**	**68.4**		**4,563,595**	**658**	
TotalSavingsIOUServiceArea			**44,221,856**	**3,032**	**169.4**	**1,133,346**	**68.4**	**6.46**	**4,563,595**	**658**	**24.5**

13 The basis for Per Home and Per 1000 ft^2 savings is limited to those homes that have cooling equipment.

14 The basis for Per Home and Per 1000 ft^2 savings estimates is limited to those homes that have gas (natural gas and propane) heating equipment.

15 The basis Per Home and Per 1000 ft^2 savings estimates is limited to only those homes that have electric heating equipment.

Table MF-AM-CL: Energy Savings for All Measures in Air Conditioned Multifamily Building

RMST CZ	CEC CZ	Meas Req'd. For AB970 PackageD	Number of Air Cond ResUnit	Average ft^2 of Air Cond ResUnit	Saturation of Cooling Equipment in Total Population	As-Built Average Cooling % of Total Budget	Source Energy Cooling Savings (skBtu/yr)	Average Cooling Savings as % of As-Built Cooling Energy	Cooling Savings (kWh) All Air Cond ResUnit	Cooling Savings (kWh) Per Res Unit	Cooling Savings (kWh) Per 1,000 ft^2
1	1	Yes	-	-	0.0%	-	-	-	-	-	-
	2	Yes	-	-	0.0%	-	-	-	-	-	-
	3	Yes	-	-	0.0%	-	-	-	-	-	-
	4	Yes	2,088	35,394	61.7%	7.6%	63,737,335	84.6%	6,224,957	2,981	84.2
	5	Yes	-	-	0.0%	-	-	-	-	-	-
2	6	Yes	1,283	16,837	69.3%	1.6%	4,492,272	67.7%	438,741	342	20.3
	7	Yes	900	16,067	64.3%	7.4%	10,714,052	73.4%	1,046,396	1,163	72.4
3	8	Yes	2,340	13,085	85.1%	15.0%	57,262,371	70.8%	5,592,575	2,390	182.7
	9	Yes	2,755	17,819	100.0%	19.1%	95,632,869	63.8%	9,340,059	3,390	190.3
	10	Yes	352	17,441	85.0%	25.0%	16,723,468	44.6%	1,633,311	4,640	266.0
4	11	Yes	503	10,592	100.0%	18.5%	7,569,766	31.6%	739,307	1,470	138.8
	12	Yes	2,633	18,548	100.0%	17.5%	119,918,671	60.4%	11,711,951	4,448	239.8
	13	Yes	1,037	3,503	100.0%	43.7%	33,719,005	47.7%	3,293,193	3,176	906.5
5	14	Yes	345	11,368	100.0%	36.9%	32,608,552	59.6%	3,184,740	9,231	812.1
	15	Yes	87	5,000	100.0%	72.9%	8,256,300	44.0%	806,358	9,268	1,853.7
	16	Yes	263	11,952	100.0%	2.8%	2,152,921	70.1%	210,267	799	66.9
TotalSavingsAB970PkgD_CZs			**14,586**				**452,787,583**		**44,221,856**	**3,032**	
TotalSavingsIOUServiceArea			**14,586**	**17,902**			**452,787,583**		**44,221,856**	**3,032**	**169.4**

Table MF-AM-GH: Energy Savings for All Measures in Gas-Heated Multifamily Building

RMST CZ	CEC CZ	Measure Req'd for AB 970 Package D	Number of Gas Htd ResUnit	Average ft^2 of Gas Htd ResUnit	Saturation of Gas Heating Equipment in Total Population	As-Built Average Heating % of Total Budget	Source Energy Heating Savings (skBtu/yr)	Average Heating Savings as % of As-Built Heating Energy	Gas Heating Savings (therms)		
									All Gas Htd ResUnit	Per Res Unit	Per 1,000 ft^2
1	1	Yes	163	6,000	100.0%	28.4%	1,508,858	17.8%	15,089	92.6	15.43
	2	Yes	1,220	4,418	46.9%	37.0%	7,859,259	10.5%	78,593	64.4	14.58
	3	Yes	2,261	8,038	73.5%	31.3%	12,622,982	11.9%	126,230	55.8	6.95
	4	Yes	1,944	19,381	57.4%	22.5%	17,113,622	13.8%	171,136	88.0	4.54
	5	Yes	240	1,500	100.0%	19.3%	50,448	2.5%	504	2.1	1.40
2	6	Yes	1,627	14,398	87.9%	14.9%	3,129,595	7.6%	31,296	19.2	1.34
	7	Yes	1,030	15,817	73.6%	6.5%	2,491,932	19.0%	24,919	24.2	1.53
3	8	Yes	2,274	9,721	82.7%	11.6%	5,660,076	13.1%	56,601	24.9	2.56
	9	Yes	1,446	8,332	52.5%	10.2%	6,283,797	24.8%	62,838	43.5	5.22
	10	Yes	414	15,241	100.0%	8.3%	1,137,651	10.7%	11,377	27.5	1.80
4	11	Yes	168	7,776	33.2%	27.6%	169,588	2.2%	1,696	10.1	1.30
	12	Yes	2,227	9,603	84.5%	28.3%	29,044,919	15.2%	290,449	130.4	13.58
	13	Yes	866	2,730	83.6%	16.1%	2,228,856	13.2%	22,289	25.7	9.43
5	14	Yes	345	11,368	100.0%	25.8%	7,307,117	18.8%	73,071	211.8	18.63
	15	Yes	87	5,000	100.0%	1.7%	4,350	1.0%	44	0.5	0.10
	16	Yes	263	11,952	100.0%	57.2%	16,721,585	21.1%	167,216	635.8	53.19
TotalSavingsAB970PkgD_CZs			**16,575**				**113,334,633**		**1,133,346**	**68.4**	
TotalSavingsIOUServiceArea			**16,575**	**10,577**			**113,334,633**		**1,133,346**	**68.4**	**6.46**

Table MF-AM-EH: Energy Savings for All Measures in Electrically Heated Detached Single Family ResUnit

RMST CZ	CEC CZ	Measure Req'd for AB 970 Package D	Number of Elec Htd ResUnit	Average ft^2 of Elec Htd ResUnit	Saturation of Elec Heating Equipment in Total Population	As-Built Average Heating % of Total Budget	Source Energy Heating Savings (skBtu/yr)	Average Heating Savings as % of As-Built Heating Energy	Electric Heating Savings (kWh) All Elec Htd ResUnit	Electric Heating Savings (kWh) Per Res Unit	Electric Heating Savings (kWh) Per 1,000 ft^2
1	1	Yes	-	-	0.0%	-	-	-	-	-	-
	2	Yes	1,383	19,827	53.1%	50.6%	13,599,695	2.9%	1,328,225	960.4	48.44
	3	Yes	817	18,261	26.5%	24.1%	8,885,732	8.5%	867,832	1,062.2	58.17
	4	Yes	1,441	37,142	42.6%	13.1%	11,184,165	12.3%	1,092,310	758.0	20.41
	5	Yes	-	-	0.0%	-	-	-	-	-	-
2	6	Yes	224	29,039	12.1%	2.8%	490,337	13.4%	47,889	213.8	7.36
	7	Yes	369	5,857	26.4%	7.0%	386,054	15.8%	37,704	102.2	17.44
3	8	Yes	476	24,675	17.3%	6.1%	1,159,334	7.7%	113,227	237.9	9.64
	9	Yes	1,309	28,301	47.5%	4.3%	5,712,043	24.4%	557,871	426.2	15.06
	10	Yes	-	-	0.0%	-	-	-	-	-	-
4	11	Yes	336	12,000	66.8%	14.9%	751,576	5.0%	73,403	218.5	18.21
	12	Yes	407	67,500	15.5%	6.0%	3,570,171	7.2%	348,684	856.7	12.69
	13	Yes	170	7,440	16.4%	12.9%	987,537	15.0%	96,449	567.3	76.26
5	14	Yes	-	-	0.0%	-	-	-	-	-	-
	15	Yes	-	-	0.0%	-	-	-	-	-	-
	16	Yes	-	-	0.0%	-	-	-	-	-	-
TotalSavingsAB970PkgD_CZs			**6,932**				**46,726,644**		**4,563,595**	**658.3**	
TotalSavingsIOUServiceArea			**6,932**	**26,845**			**46,726,644**		**4,563,595**	**658.3**	**24.52**

Table MF-AM-SE: Annual Source Energy Savings for All Measures in Detached Single Family ResUnit

RMST CZ	CEC CZ	Measure Req'd for AB 970 Package D	Total # of ResUnit in IOU Service Area	Average ft² Per ResUnit	Total Title 24 Compliance HVAC Source Energy Budget (1,000 skBtu)	Title 24 Compliance Source Energy Savings[16]			As-Built Source Energy Savings[17]		
						Total for All ResUnit (1,000 skBtu)	Average Per ResUnit (skBtu)	Average Per ft² (skBtu/ft²)	Total for All ResUnit (1,000 skBtu)	Average Per ResUnit (skBtu)	Average Per ft² (skBtu/ft²)
1	1	Yes	163	6,000	29,785	1,509	9,257	1.54	1,509	9,257	1.54
	2	Yes	2,603	12,606	1,113,980	97,531	37,469	2.97	21,459	8,244	0.65
	3	Yes	3,078	10,753	752,970	32,945	10,703	1.00	21,509	6,988	0.65
	4	Yes	3,385	26,944	2,042,247	115,605	34,152	1.27	92,035	27,189	1.01
	5	Yes	240	1,500	10,453	350	1,456	0.97	50	210	0.14
2	6	Yes	1,851	16,172	444,262	8,680	4,689	0.29	8,112	4,383	0.27
	7	Yes	1,399	13,193	321,701	18,669	13,345	1.01	13,592	9,716	0.74
3	8	Yes	2,750	12,311	642,489	69,029	25,102	2.04	64,082	23,302	1.89
	9	Yes	2,755	17,819	1,114,992	107,629	39,067	2.19	107,629	39,067	2.19
	10	Yes	414	15,241	157,472	18,807	45,428	2.98	17,861	43,143	2.83
4	11	Yes	503	10,592	131,536	8,491	16,881	1.59	8,491	16,881	1.59
	12	Yes	2,633	18,548	1,520,706	152,534	57,932	3.12	152,534	57,932	3.12
	13	Yes	1,037	3,503	164,277	36,935	35,618	10.17	36,935	35,618	10.17
5	14	Yes	345	11,368	148,393	39,916	115,698	10.18	39,916	115,698	10.18
	15	Yes	87	5,000	25,726	8,261	94,950	18.99	8,261	94,950	18.99
	16	Yes	263	11,952	134,970	18,875	71,766	6.00	18,875	71,766	6.00
TotalSavingsAB970PkgD_CZs			**23,506**		**8,755,957**	**735,765**	**31,301**		**612,849**	**26,072**	
TotalSavingsIOUServiceArea			**23,506**		**8,755,957**	**735,765**	**31,301**		**612,849**	**26,072**	

[16] The savings in these three columns include the Heating and Cooling source energy savings of all homes – including those homes without cooling equipment. (MICROPAS 6.0 models every home as if there is a cooling system installed.)

[17] The savings in these three columns include the Heating and Cooling source energy savings of those homes with cooling equipment and the Heating source energy savings of those homes without cooling equipment.

Appendix J

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 Regional Economic Research (RER). I'm conducting a survey on behalf of the California utilities to assess how implementation of the Title 24 1998 Residential Standards has impacted compliance methods and building practices used in <u>Residential</u> New Construction. We are also researching attitudes about the emergency revision of the Standards under Assembly Bill AB 970. Do you perform Title 24 compliance analysis for <u>low-rise residential projects</u>?

If **Yes***: continue*
If **No***: thank and terminate*

Would you be interested in participating in our survey? Your input will remain confidential.

If **Yes***: continue*
If **No***: thank and terminate*

Is now a good time to talk? (If asked, this will take about 20 minutes.)

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.

Background

I would first like to ask you a few background questions about you and your company.

1. Do you work independently or as the employee of a company? *(Chose one)*

   ☐ Independent contractor
   ☐ Employee of a company specializing in Title 24 compliance
   ☐ Employee of a builder
   ☐ Employee of an HVAC services company
   ☐ Employee of an engineering firm
   ☐ Other

   1A. *If other, please explain*:

   ____

2. How long have you been a Title 24 consultant?

   ____ Years

(If the answer to Q1 was Independent contractor then skip to Q5)

3. How many Title 24 consultants work in your company?

   _____ Title 24 consultants

4. What services other than compliance analysis does your company offer? *(Read List - Check all that apply)*

   ☐ Home inspections
   ☐ HVAC services
   ☐ Architectural services
   ☐ Support Utility Program Participation documentation
   ☐ Duct Blaster/Blower Door testing
   ☐ None
   ☐ Other

   4A. *If other, please explain:*

   ____

5. What percentage of the plans you analyzed in the past year were for residential homes? For commercial buildings? *(The answers should add to 100%)*

   _______% residential homes
   _______% commercial buildings

   5A. What percentage of the residential plans you analyzed in the past year were for detached single family homes? *(The answers should add to 100%)*

   _______% detached single family homes
   _______% multifamily homes

   5A1. Detached single family homes are often classified as tract or custom. Of the detached single family home plans you analyzed in the past year, approximately what percentage were for tract homes?

   _______ % detached single family tract homes

6. How many different residential builders or other subcontractors did you perform compliance work for over the past year?

   ______ # of builders/subcontractors

7. How many residential building plans did you perform compliance analysis for over the past year? How many residential buildings did these plans cover?

   ______ Total # of residential building plans
   ______ Total # of residential buildings represented

   7A. Please list the builders you have worked with during the last year.

   ____
   ____
   ____
   ____

8. What CEC climate zones do you predominantly practice in? *(Do NOT Read List - Check all that apply)*

☐ CEC Climate Zone #1
☐ CEC Climate Zone #2
☐ CEC Climate Zone #3
☐ CEC Climate Zone #4
☐ CEC Climate Zone #5
☐ CEC Climate Zone #6
☐ CEC Climate Zone #7
☐ CEC Climate Zone #8
☐ CEC Climate Zone #9
☐ CEC Climate Zone #10
☐ CEC Climate Zone #11
☐ CEC Climate Zone #12
☐ CEC Climate Zone #13
☐ CEC Climate Zone #14
☐ CEC Climate Zone #15
☐ CEC Climate Zone #16
☐ Other

8A. *If other, please explain:*

____

9. Are you a CABEC (California Association of Building Energy Consultants) member?
☐ Yes
☐ No

General Compliance Issues

Now I would like to ask you some questions about general compliance issues.

10. In your opinion, how influential are you in the planning process of the **tract** homes you perform compliance analysis for? Answer using a scale of 1 to 5, with 1 meaning Not at all Influential and 5 meaning Very Influential.

    _____

    10A. In your opinion, how influential are you in the planning process of the **custom** homes you perform compliance analysis for? Answer using a scale of 1 to 5, with 1 meaning Not at all Influential and 5 meaning Very Influential

    _____

11. For single family homes, how much of an impact do the following design features have in achieving Title 24 compliance? Answer using a scale of 1 to 5, with 1 meaning No Impact and 5 meaning a Large Impact.

    ___ Large glazing areas
    ___ Metal frame construction
    ___ Climate zone specific requirements
    ___ Number of stories
    ___ Orientation

    11A. *If other features, please explain:*

    ____

    11B. How often do use the following measures to overcome these conditions in order to achieve compliance? Answer using a scale of 1 to 5, with 1 meaning Never and 5 meaning Very Often.

    ___ Higher efficiency water heater
    ___ Higher efficiency central air conditioner
    ___ Higher efficiency furnace
    ___ Higher efficiency windows
    ___ Increase insulation levels
    ___ Change the design

    11B1. Do you typically use any other methods not listed above?

    11B1a. *If yes, please explain:*

    ____

11C. Are the methods you currently use different from those used prior to implementation of the 1998 Standards?

☐ Yes
☐ No

If no, skip to Q12.

11C1. Which methods do you use **less** now than you did prior to implementation of the 1998 Standards? *(Do NOT Read List - Check all that apply)*

☐ Higher efficiency water heater
☐ Higher efficiency central air conditioner
☐ Higher efficiency furnace
☐ Higher efficiency windows
☐ Increase insulation levels
☐ Change the design

11C2. Which methods do you use **more** now than you did prior to implementation of the 1998 Standards? *(Do NOT Read List - Check all that apply)*

☐ Higher efficiency water heater
☐ Higher efficiency central air conditioner
☐ Higher efficiency furnace
☐ Higher efficiency windows
☐ Increase insulation levels
☐ Change the design

12. For multi family homes, how much of an impact do the following design features have in achieving Title 24 compliance? Answer using a scale of 1 to 5, with 1 meaning No Impact and 5 meaning a Large Impact.

___ Large glazing areas
___ Metal frame construction
___ Climate zone specific requirements
___ Number of stories
___ Orientation

12A. *If other features, please explain:*

____

If all answers to Q12 are 1, skip to Q13.

12B. How often do you use the following measures to overcome these conditions in order to achieve compliance? Answer using a scale of 1 to 5, with 1 meaning Never and 5 meaning Very Often.

___ Higher efficiency water heater
___ Higher efficiency central air conditioner
___ Higher efficiency furnace
___ Higher efficiency windows
___ Increase insulation levels
___ Change the design

12B1. Do you typically use any other methods not listed above?

12B1b. *If yes, please explain:*

____

12C. Are the methods you currently use different from those used prior to implementation of the 1998 Standards?

☐ Yes
☐ No

If no, skip to Q13.

12C1. Which methods do you use **less** now than you did prior to implementation of the 1998 Standards? *(Do NOT Read List - Check all that apply)*

☐ Higher efficiency water heater
☐ Higher efficiency central air conditioner
☐ Higher efficiency furnace
☐ Higher efficiency windows
☐ Increase insulation levels
☐ Change the design

12C2. Which methods do you use **more** now than you did prior to implementation of the 1998 Standards? *(Do NOT Read List - Check all that apply)*

- ☐ Higher efficiency water heater
- ☐ Higher efficiency central air conditioner
- ☐ Higher efficiency furnace
- ☐ Higher efficiency windows
- ☐ Increase insulation levels
- ☐ Change the design

Use of Performance and Prescriptive Compliance Methods

Now I would like to ask you some questions about your use of the Performance and Prescriptive compliance methods.

13. For the homes analyzed within the last year, what percentage of newly constructed single-family homes used the following compliance methods? *(Ask again for multifamily)*

	Single Family	**Multifamily**
Performance based *[Uses an energy budget and allows certain building trade-offs]*	_______%	_______%
Prescriptive Package D *[Requires moderately high insulation levels for more window area in most climate zones]*	_______%	_______%
Prescriptive Package A *[a passive solar strategy requiring significant amount of south glass, small amount of non-south glass, and a large area of exposed thermal mass]*	_______%	_______%
Prescriptive Package B *[Allows a fairly small area of fenestration and requires shading in some climate zones. Most climate zones require R-19 wall insulation. Light mass and heavy mass R-value requirements are available as alternatives to frame wall insulation requirements. Continuous infiltration barriers and air-to-air heat exchangers are also required in CZ 1, 14, 15, and 16]*	_______%	_______%
Prescriptive Package C *[Only package to allow electric-resistance space heating]*	_______%	_______%

14. If you have used the Performance method of compliance for Low-Rise Residential projects, which computer compliance programs have you used in the last year? *(Do NOT Read List - Check all that apply)*

- ☐ CALRES
- ☐ EnergyPro
- ☐ MICROPAS
- ☐ Other

14A. *If other, please describe:*

____

14B. Which have you used most often? *(Chose one)*

☐ CALRES

☐ EnergyPro

☐ MICROPAS

☐ Other

14B1. *If other, please describe:*

____

Duct Efficiency, Building Envelope Sealing, and Other Feature Credits

Now I would like to ask you some questions about your use of the duct efficiency and building envelope sealing credits available in the 1998 Standards. There are a variety of credits for duct efficiency and building envelope sealing that were implemented under the 1998 Standards. These can be discussed in terms of two groups: those requiring certification by a HERS (Home Energy Rating System) rater, and those that only need to be verified by a building inspector *(for examples of each see Questions 15 and 16 below).* Regarding your use of these credits for compliance analyses that you performed within the last year:

15. Did you use the duct efficiency and/or building envelope sealing credits that <u>require HERS certification</u> for any of the compliance analyses you performed last year?

    ☐ Yes
    ☐ No

If Question 15 is No, skip to Question 16.

15A-E. Please indicate which credits were used and the corresponding % of residences which utilized the credit. *(If the credit has not been used in the last year, mark 0%)*

15A. ___ % of residences that used **Duct Sealing** (duct blaster testing)
15B. ___ % of residences that used **Duct Design per ACCA Manual D**
15C. ___ % of residences that used **Duct Location** (crawlspace, basement, conditioned space)
15D. ___ % of residences that used **Duct Surface area** (low % of ducts in attic)
15E. ___ % of residences that used **Building Envelope Sealing** via blower door test

(If the 15E was not 0%)
15E1. ___ % of residences where building envelope sealing was used that also utilized **mechanical ventilation**

16. The following is a list of duct efficiency and/or building envelope sealing credits that <u>only require building inspector verification (i.e. do not require HERS certification).</u> Please indicate which credits you have used in the last year and the corresponding % of residences which utilized the credit. *(If the credit has not been used in the last year, mark 0%)*

    16A. ___ % of residences that used Duct Insulation (> 4.2 R-value)
    16B. ___ % of residences that used Radiant Barriers (in attic)
    16C. ___ % of residences that used Default Duct Location (ducts in crawlspace, basement, or conditioned space)
    16D. ___ % of residences that used Default Building Envelope Sealing credit for **duct sealing**
    16E. ___ % of residences that used Default Building Envelope Sealing credit for **housewrap**

17. How influential, in your opinion, were each of the following in the decision not to utilize the duct efficiency and/or building envelope sealing credits more? Answer using a scale of 1 to 5, with 1 meaning Not Influential and 5 meaning Very Influential.

    ___ Less cost effective then other measures *(such as high efficiency windows or high efficiency air conditioners.)*
    ___ Not cost effective in the climate zones you work in.
    ___ The impact on builders' completion schedule.
    ___ Availability of HERS raters.

    17A. In your opinion, is there any other reason for not utilizing the duct efficiency and/or building envelope sealing credits more?

    17A1. *If yes, please explain:*

    ____

Now I would like to ask you some questions about your use of other features of the Standards for which compliance credit is available.

18. For compliance analyses performed within the last year, please indicate which credits were used in the past year and the corresponding % of residences which used the credit.

	Yes	**No**	**Single Family**	**Multifamily**
Zonal control credit	___	___	_______%	_______%
Evaporative cooling system credit	___	___	_______%	_______%
Hydronic or combined hydronic heating system credit	___	___	_______%	_______%
Interior shading credit	___	___	_______%	_______%
Water heating controls credit	___	___	_______%	_______%

19. Did your use of these other features change significantly after the 1998 Standards were implemented?

☐ Yes
☐ No

19A. *(If yes)* For which credits? *(Do NOT read from the list). For each credit listed*, what % of residences used the credit prior to the implementation of the 1998 standards?

	Single Family	**Multifamily**
Zonal control credit	_______%	_______%
Evaporative cooling system credit	_______%	_______%
Hydronic or combined hydronic heating system credit	_______%	_______%
Interior shading credit	_______%	_______%
Water heating controls credit	_______%	_______%

Knowledge of AB 970 Issues

Now I would like to ask you a few questions to determine what you know about the emergency revision of the Residential Standards being enacted under AB (Assembly Bill) 970.

20. How knowledgeable are you with the proposed changes to the Residential Standards proposed under AB 970 – The Managed Emergency Review of Title 24 Standards? Answer using a scale of 1 to 5 with 1 representing Not At All Knowledgeable and 5 being Very Knowledgeable

    ____

If Q20 is 4 or 5, then skip to Q21, otherwise read the following before continuing.

AB 970, which was approved in January of this year, includes revisions to the Residential Standards. The major revision is that radiant barriers, low-E windows, HERS-certified duct sealing and TXV valves for air conditioners are now part of the Prescriptive Package D for some climate zones, and not just credits. Addition of these features to the Prescriptive Package D will also affect the Standard budgets used for Performance method calculations, and will make it much tougher to achieve compliance.

Another change is that an alternative to Package D is offered. This prescriptive package does not require HERS-certified duct sealing or the TXV valves for air conditioners, by instead requiring higher performance windows and high-efficiency HVAC equipment (these requirements change by climate zone). In addition, prescriptive packages A and B have been dropped.

If the respondent requests more information on these new standards, tell them to go to the following Web site: http://www.cabec.org

Given this background information, I'd now like to ask you a few questions about how you might deal with the revised more stringent standards.

21. How likely are you to use the following when performing compliance analysis under these new standards? Answer using a scale of 1 to 5 with 1 meaning Not at all Likely and 5 meaning Very Likely.

    ____ HERS Certified sealed ducts
    ____ TXV (Thermostatic Expansion Valve)
    ____ More stringent window performance SHGC and U-values.
    ____ Radiant barriers - in the climate zones they are required.
    ____ All four measures listed above.

If the answer to "All four measures listed above" is not a 5, then continue, otherwise skip to Q22.

21A. Given that you do not expect to always use all four of the measures listed above, how likely are you to have to use the following measures to meet the more stringent compliance standards? Answer using a scale 1 to 5 with 1 meaning Not at all Likely and 5 meaning Very Likely.

____ Higher efficiency water heater
____ Higher efficiency central air conditioner
____ Higher efficiency furnace
____ Higher efficiency windows
____ Increase insulation levels

If Q20 is 4 or 5, then skip to Q22, otherwise read the following before continuing.

In addition to the changes listed above, AB 970 also eliminated the interior shading credit.

22. In your opinion, how difficult will it be for the builders to adapt to the following? Answer using a scale of 1 to 5 with 1 representing Not Difficult and 5 being Very Difficult.

____ The elimination of the interior shading credit
____ Mandatory duct construction requirements
____ Requirement of more stringent window performance SHGC and U-values
____ Higher efficiency heating equipment (for Alternative Package)
____ Higher efficiency cooling equipment (for Alternative Package)
____ The requirement of radiant barriers in some climate zones
____ Certified sealed ducts (for Prescriptive Package D)
____ TXV (for Prescriptive Package D)
____ Increased documentation and inspection requirements

23. How can the electric/gas utilities most effectively assist the builders, Title 24 consultants, and other compliance industry professionals in meeting the more stringent requirements of the AB 970 standards?

____

24. Are there any energy efficiency features for residential new construction that in your opinion should be added to the new standards?

- ☐ Yes
- ☐ No

24A. *If Yes, please explain:*

____

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.

25. How knowledgeable are you of the following new construction energy efficiency programs? Answer using a scale of 1 to 5 with 1 representing Not At All Knowledgeable and 5 being Very Knowledgeable.

___ Comfort Home (PG&E)

(Web site http://www.pge.com/003_save_energy/003b_bus/003b1b1a_prog_info.shtml)

___ ComfortWise (SCE and SDG&E)

(Web site http://www.comfortwise.com/)

___ Energy Advantage (SoCalGas)

(Web site http://www.socalgas.com/residential/savemoney/homebuilders.html)

___ EnergyStar New Homes Program (Federal)

(Web site http://yosemite.epa.gov/appd/eshomes/eshomes.nsf/WebDocsLookup/Background)

26. What percentage of the homes for which you provided a compliance analysis within the last year participated in these programs?

___% Comfort Home
___% ComfortWise
___% Energy Advantage
___% EnergyStar New Homes Program

If the respondent is at all familiar with any of the programs in Q27 continue, otherwise skip to Q30.

27. How significant of a barrier are each of the following to builders participating in the RNC New Construction Programs? Answer using a scale of 1 to 5, with one meaning Not Significant and 5 meaning Very Significant.

___ Complex documentation
___ Volume of required documentation
___ Required verification process
___ Insufficient incentives to participants
___ Not cost effective

27A. In your opinion, are there any other barriers to builders participating in the RNC New Construction Programs?

27A1. *If yes, please explain:*

____

28. Do you have any suggestions for improving participation in the RNC programs?

28A. *If yes, please explain:*

____

If Q20 is 1, 2, or 3, skip to Q 30.

29. In your opinion, how will the implementation of AB 970 affect the RNC programs?

____

30. Do you have any final thoughts or comments regarding the Title 24 1998 Residential Standards or the AB 970 Emergency Standards as they affect residential new construction?

____

____

____

____

31. We are in the process of compiling a contact list of individuals working for the various builders in order to obtain their views on the new standards and information on their compliance practices. We would greatly appreciate it if you would provide us with the names, titles, and phone numbers of anyone you think would be able to answer our questions.

____

____

____

Note: If the consultant is uncomfortable providing information regarding the builders he/she works for, please ask that they offer the following contact information to the builders so they are able to contact us if they are willing to participate in the study.

Contact: Rachel Weber
Email: Rachel@RER.com
Phone: (858) 481-0081

Appendix K

Interview Guide for Title 24 Consultants

Interview Guide for Title 24 Consultants on PG&E Residential New Construction and Title 24 Compliance

Draft Document

Research Objectives:

Title 24 Consultants work with builders and architects to ensure compliance with local building codes. Title 24 Consultants, along with builders, will be interviewed to help in the assessment of ten research objectives. These objectives include:

1. Identify T-24 compliance barriers.
2. Determine which energy credits are commonly used.
3. Determine which energy credits are underutilized.
4. Identify changes in practices and compliance behavior attributable to implementation in July 1999 of the Title 24 1998 Residential Standards.
5. Compare attitudes between builders and Title 24 consultants and address how they relate to key compliance issues.
6. Analyze the role of building departments in the design and compliance of new buildings.
7. Attitudes and perceptions of Energy Star New Homes Program
8. Incentives required for participation in Energy Star New Homes Program.
9. Measures and areas for potential savings in new home construction
10. Awareness of AB970 (emergency review of building standards).

FIRM NAME:________________________ CONTACT: __________________________

PHONE #: __________________________ TITLE: ______________________________

ADDRESS: ____

CITY/ZIP: ____

Introduction

PREFACE: "Hello, my name is __________ and I'm with Regional Economic Research (RER). I'm conducting a survey on behalf of the California Energy Commission to assess how implementation of the Title 24 1998 Residential Standards has impacted compliance methods and building practices used in Residential New Construction. Do you perform Title 24 compliance analysis for low-rise residential projects?

If **Yes***: continue*
If **No***: thank and terminate*

Would you be interested in participating in our survey? Your input will remain confidential.

If **Yes***: continue*
If **No***: thank and terminate*

Are you the best person to talk to regarding the impacts of the Title 24 1998 Residential Standards on compliance methods and building practices?

If **Yes***: continue*
If **No***: identify correct person and their phone number*
Proper Contact: ________________________
Phone: ______________________

Is now a good time to talk? (If asked, this will take about 20 minutes.)

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.

Background

<u>FOR IN-DEPTH INTERVIEW ONLY cover the following topics/questions</u>

Do you work independently or for a firm specializing in Title 24 compliance/ engineering firm/builder/HVAC services company? How long have you been conducting Title 24 compliance analysis? How many plans (discuss translation to number of residences) have you reviewed? How many single family (custom and tract) and multifamily(low-rise only) plans? What services other than compliance analysis does your firm offer? Are you familiar with updated 1998 Title 24 requirements? Are you familiar with AB970 emergency updates to Title 24? Are you a CABEC member? Typically in which geographical regions are the homes you analyze located?

I would first like to ask you a few background questions about you and your company.

1. Do you work independently or as the employee of a company?
   - ☐ Independent contractor
   - ☐ Employee of a company specializing in Title 24 compliance
   - ☐ Employee of a builder
   - ☐ Employee of an HVAC services company
   - ☐ Employee of an engineering firm
   - ☐ Other ______________________________

   1A. How long have you been with your present company? ____________________
   (if not long, probe for how long respondent has been an Title 24 consultant)

   1B. Is Title 24 compliance analysis your main job?
   - ☐ Yes
   - ☐ No

   If **No**: What else do you do? ______________________________

   1C. How many Title 24 consultants work in your company? ______ Title 24 consultants

2. What services other than compliance analysis does your company offer?
   - ☐ Home inspections
   - ☐ HVAC services
   - ☐ Architectural services
   - ☐ Support Utility Program Participation documentation
   - ☐ Duct Blaster/Blower Door testing
   - ☐ Other ______________________________

3. How many different residential builders or other subcontractors did you or your company perform compliance work for over the past year?

   ______ # of builders/subcontractors

4. How many residential building plans did you or your company perform compliance analysis for over the past year? How many residential buildings did these plans cover?

   ______ Total # of residential building plans
   ______ Total # of residential buildings represented

   4A. What percentage of the plans you analyzed in the past year were for detached single family homes? _______% detached single family homes

   4B. Detached single family homes are often classified as tract or custom. Of the detached single family home plans you analyzed in the past year, approximately what percentage were for tract homes? _______ % detached single family tract homes

5. Are you a CABEC (California Association of Building Energy Consultants) member?
   ☐ Yes
   ☐ No

General Compliance Issues

FOR IN-DEPTH INTERVIEW ONLY Cover the following topics/questions
Have you had difficulty meeting Title 24 requirements. What features of Title 24 compliance requirements present significant barriers to design? How would you characterize (or which features cause) SF/MF homes that are difficult to obtain compliance.

Now I would like to ask you some questions about general compliance issues.

6. On a scale of 1 to 5 with 1 meaning not at all and 5 meaning severe, how great of an obstacle are each of the following factors in completing Title 24 compliance analysis?

    ___ Difficulty interpreting Title 24 requirements
    ___ Differences in requirements between climate zones
    ___ The performance compliance computer software is difficult to use or understand
    ___ Difficult to find contractors who can perform the work required to use new credits
    ___ Builders have been difficult to work with
    ___ Building departments have been difficult to work with
    ___ Don’t recall
    ___ Other ____
    ____

7. <u>For single family homes</u>, what design features or characteristics typically cause the most difficulty in achieving Title 24 compliance?

    ☐ Large glazing areas
    ☐ Metal frame construction
    ☐ Climate zone specific requirements
    ☐ Number of stories
    ☐ Orientation
    ☐ Other features ____

    7A. What methods do you typically use to overcome these conditions in order to achieve compliance?

- ☐ Higher efficiency water heater
- ☐ Higher efficiency central air conditioner
- ☐ Higher efficiency furnace
- ☐ Higher efficiency windows
- ☐ Increase insulation levels
- ☐ Use Title 24 credits (specify which ones)
- ☐ Change the design
- ☐ Other ______________________________

7B. Are the methods you currently use different from those used prior to implementation of the 1998 Standards?

7C. If yes, how were methods used prior to implementation of the 1998 Standards different than those used now?

8. For multi family homes, what design features or characteristics typically cause the most difficulty in achieving Title 24 compliance?

- ☐ Large glazing areas
- ☐ Metal frame construction
- ☐ Climate zone specific requirements
- ☐ Number of stories
- ☐ Orientation
- ☐ Other features ______________________________

8A. What methods do you typically use to overcome these conditions in order to achieve compliance?

- ☐ Higher efficiency water heater
- ☐ Higher efficiency central air conditioner
- ☐ Higher efficiency furnace
- ☐ Higher efficiency windows
- ☐ Increase insulation levels
- ☐ Use Title 24 credits (specify which ones)
- ☐ Change the design
- ☐ Other ______________________________

8B. Are the methods you currently use different from those used prior to implementation of the 1998 Standards?

8C. If yes, how were methods used prior to implementation of the 1998 Standards different than those used now?

Use of Performance and Prescriptive Compliance Methods

FOR IN-DEPTH INTERVIEW ONLY cover the following topics/questions

Which of the two compliance methods (performance/prescriptive) are used? Which compliance methods are used most often? What are the advantages/disadvantages of prescriptive versus performance? Have the compliance methods used changed since the updated 1998 standards were implemented? If so why? Have the advantages/disadvantages of prescriptive versus performance changed with the enactment of the 1998 Standards? If so why? Which performance based model is used? Do any of the models handle the use of credits better than the others? Have you changed compliance software since the new standards were enacted?

Now I would like to ask you some questions about your use of the Performance and Prescriptive compliance methods.

9. For the homes analyzed within the last year, what percentage of single-family and multi-family homes used the following compliance methods?

	Single Family	Multifamily
Performance based *[Uses an energy budget and allows certain building trade-offs]*	_______%	_______%
Prescriptive Package D *[Requires moderately high insulation levels for more window area in most climate zones]*	_______%	_______%
Prescriptive Package A *[a passive solar strategy requiring significant amount of south glass, small amount of non-south glass, and a large area of exposed thermal mass]*	_______%	_______%
Prescriptive Package B *[Allows a fairly small area of fenestration and requires shading in some climate zones. Most climate zones require R-19 wall insulation. Light mass and heavy mass R-value requirements are available as alternatives to frame wall insulation requirements. Continuous infiltration barriers and air-to-air heat exchangers are also required in CZ 1, 14, 15, and 16]*	_______%	_______%
Prescriptive Package C *[Only package to allow electric-resistance space heating]*	_______%	_______%

10. If you have used the Performance method of compliance for <u>Low-Rise Residential</u> projects, which computer compliance programs have you used in the last year? *[More than one can be selected]*
    - ☐ CALRES
    - ☐ EnergyPro
    - ☐ MICROPAS
    - ☐ Other ____________________

    10A. Which have you used most often?
    - ☐ CALRES
    - ☐ EnergyPro
    - ☐ MICROPAS
    - ☐ Other ____________________

Use of New 1998 Standard Credits

FOR IN-DEPTH INTERVIEW ONLY cover the following topics/questions
Have you used any of the new performance based credits? If so which ones and how often? In your opinion, which of the credits offer the most bang for the buck (most cost effective)? Does the use of credits differ from single family to multifamily? Does the use of the credits depend on other factors (such as single versus multi, size of the equipment, size of home, percent glazing, custom vs. tract)? Are there any significant barriers to the use of the new credits (such as verification, complex requirements, and required documentation)? If so, for which of the credits? Do you use any of the existing credits? Has the use of these credits changed since the new credits were offered?

Now I would like to ask you some questions about your use of the new compliance credits available in the 1998 Standards.

11. If you have used the performance-based compliance method within the last year, in what percent of homes did you use the following credits?

	Yes	Single Family	Multifamily	No
Ducting credit	___	_______%	_______%	___
Reduced envelope leakage credit	___	_______%	_______%	___
Continuous mechanical ventilation credit	___	_______%	_______%	___
Ducting credit without testing through reduced envelope leakage if compliance credit is not taken for reduced building envelope air leakage through diagnostic testing	___	_______%	_______%	___
Air retarding wrap credit	___	_______%	_______%	___
Ducting credit plus continuous mechanical ventilation credit	___	_______%	_______%	___

12. If you have used the performance-based compliance within the last year, have you used any of the other energy conservation credits?

	Yes	Single Family	Multifamily	No
Zonal control credit	___	_______%	_______%	___
Hydronic or combined hydronic heating system credit	___	_______%	_______%	___
Interior shading credit	___	_______%	_______%	___
For high mass buildings, the compliance credit for increased free ventilation window area and increased ventilation height	___	_______%	_______%	___
Water heating credit	___	_______%	_______%	___
Water heating penalty	___	_______%	_______%	___

13. In what percent of homes has the use of any of the credits changed significantly since the 1998 Standards were implemented?

	Decreased	**Increased**
Zonal control credit	_______%	_______%
Hydronic or combined hydronic heating system credit	_______%	_______%
Interior shading credit	_______%	_______%
For high mass buildings, the compliance credit for increased free ventilation window area and increased ventilation height	_______%	_______%
Water heating credit	_______%	_______%
Water heating penalty	_______%	_______%

14. Have you used the lighting alternative to fluorescent lighting in rooms with showers or bathtubs?
    - ☐ Yes, often
      In what percent of homes? _____% SF _____% MF
    - ☐ Yes, occasionally
      In what percent of homes? _____% SF _____% MF
    - ☐ No

Perception of Changes in Residential Home Builder Practices

FOR IN-DEPTH INTERVIEW ONLY cover the following topics/questions
How have the Title 24 1998 Standards affected builder's practices (construction or Title 24 compliance)? Are the standards tougher to pass? Is more give-and-take between the builder and Title 24 consultant required? Do the builders automatically install high-efficiency water heaters and water heater blankets in all homes? If more builders are doing duct testing/sealing, is this the result of the credit given by Title 24, a general interest in building quality homes, or some other reason?

Now I would like to ask you some questions about your perceptions of how implementation of the 1998 Standards have affected residential home builder practices.

15. Did implementation of the 1998 Standards affect single family home builder's construction or compliance practices?
    - ☐ If yes, how?
      ____
      ____
      ____
    - ☐ No change in practices

16. Did implementation of the 1998 Standards affect multifamily home builder's construction or compliance practices?
    - ☐ If yes, how?
      ____
      ____
      ____
    - ☐ No change in practices

17. What other changes in builder construction or compliance practices not attributable to implementation of the 1998 Standards have you seen?
    - ☐ Describe ______________________________
      ____
      ____
      ____
    - ☐ No other changes

Interaction with Building Departments

<u>*FOR IN-DEPTH INTERVIEW ONLY cover the following topics/questions*</u>

What role do building departments play in the design phase relating to compliance issues? During the permitting process, do the building departments play a role in promoting or assisting in meeting Title 24? Does this differ across Building Departments? Are Building Departments timely in their review of permit applications? Can the building Departments play a role in promoting energy efficiency? If so how? Has the building departments' role change since the new standards were enacted?

Now I would like to ask you some questions about your interactions with building departments.

18. Do you work closely with the local building departments to ensure Title 24 compliance?
    - ☐ Yes
    - ☐ No (If no, why not?) ____

      ____

19. Do local building departments make design suggestions to secure compliance and to identify available energy credits?
    - ☐ Yes, all
    - ☐ Yes, some (provide examples, note which bldg depts) ____________________________

      ____
    - ☐ None

20. Do you know of any building departments that take an active roll in making design suggestions or identifying available energy credits?
    - ☐ If Yes, note which building departments these are ______________________________

      ____

21. On a scale of 1 to 5 with 1 representing Very Responsive and 5 representing Very Unresponsive, how **timely** are local building departments in completing their reviews and inspections to ensure Title 24 compliance?

    If Unresponsive or Very Unresponsive (4 or 5), please indicate why.

    ____

    ____

22. On a scale of 1 to 5 with 1 representing Very Reasonable and 5 representing Very Unreasonable, are local building departments **fair** in their reviews and inspections to ensure Title 24 compliance?

If Unreasonable or Very Unreasonable (4 or 5), please indicate why.

____

____

Energy Efficiency Programs

FOR IN-DEPTH INTERVIEW ONLY cover the following topics/questions
Which energy efficiency programs are you familiar with? Have you taken advantage of these programs (what percentage of homes, are these single family or multi family)? Are these programs more or less effective given the new standards? What are the barriers to participating in these programs (complex documentation, verification, not cost effective etc.)? Do you have suggestions to change these? Should the incentives to participate in the programs change? If so how? In particular, how do these issues relate to the energy star new homes program?

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.

23. On a scale of 1 to 5 with 1 representing Very Knowledgeable and 5 being Not At All Knowledgeable, how knowledgeable are you of the following new construction energy efficiency programs?
    - ☐ Comfort Home (PG&E)
    - ☐ Comfort Home Plus (PG&E)
    - ☐ ComfortWise (SCE and SDG&E)
    - ☐ Energy Advantage (SoCalGas)
    - ☐ EnergyStar New Homes Program (Federal)
    - ☐ Other (specify) ____

24. What percentage of the homes for which you provided a compliance analysis within the last year participated in these programs?
    - ___% Comfort Home
    - ___% Comfort Home Plus
    - ___% ComfortWise
    - ___% Energy Advantage
    - ___% EnergyStar New Homes Program
    - ___% Other (specify) ____

25. *(If the respondent is at all familiar with EnergyStar Program)*

    In your opinion what are the major barriers to builders participating in the EnergyStar New Construction Program?

    - ☐ Complex documentation
    - ☐ Volume of required documentation
    - ☐ Required verification process
    - ☐ Insufficient incentives to participants
    - ☐ Not cost effective
    - ☐ Other (explain) ____
      ____

26. Do you have any suggestions for improving participation in this program?

    ____
    ____
    ____
    ____

(Repeat question for each program)

Knowledge of AB 970 Issues

FOR IN-DEPTH INTERVIEW ONLY cover the following topics/questions
How much do you know about the AB 970 emergency revisions to the Title 24 requirements? If knowledgeable about AB 970, what requirements will present the most significant barriers to compliance? Which compliance option is most likely to be used by builders and why? Which option will most likely be shunned by builders and why? Are there any features of AB 970 that will be easiest to sell to the builders? Which options are you most likely to use and encourage builders to use and why? Which options will be hardest to sell to builders?

Now I would like to ask you a few questions to determine what you know about the AB (Assembly Bill) 970 emergency energy efficiency standards.

27. How familiar are you with the proposed changes to the Residential Standards proposed under AB 970 – The Managed Emergency Review of Title 24 Standards? (*will need to provide some info about them in case they ask, or at least provide the web site address*).

☐ Very Familiar (knowledge of details)
☐ Somewhat Familiar (knows something is being done but does not know the details)
☐ Unfamiliar with AB970 (never heard of AB 970 or emergency revisions to Title 24)

If **Somewhat familiar** or **Unfamiliar with AB 970**: Skip to Question 13.

(***If Very Familiar with AB 970 standards, then proceed***)

28. Which of the features of the AB 970 Standards do you think will be most difficult to implement and why? ____
____
____

☐ Mandatory Duct Construction
☐ Interior Shading Devices (credit for interior devices eliminated)
☐ More stringent window performance SHGC and U-values (for Alternative Package)
☐ Higher efficiency heating equipment (for Alternative Package)
☐ Higher efficiency cooling equipment (for Alternative Package)
☐ Deletion of Prescriptive Packages A & B
☐ Radiant barriers in some climate zones (for Prescriptive Package D)
☐ Certified sealed ducts (for Prescriptive Package D)
☐ TXV (for Prescriptive Package D)
☐ Increased documentation and inspection requirements
☐ Other ____

29. Are there any energy efficiency features for residential new construction that were not included as part of the AB 970 Standards, but should have been? ____________________

____

____

30. Which of the compliance methods proposed under the AB 970 Standards do you think will be most typically requested by builders?
    - ☐ Basic Prescriptive Package D (sealed ducts and TXV valve required)
    - ☐ Alternative Package (sealed ducts and TXV valve <u>not</u> required)
    - ☐ Performance Method
    - ☐ Not sure

    30A. If the Performance Method is the preferred method, what features do you anticipate having to use to meet the more stringent compliance standards?

    - ☐ No change in current practices will be required
    - ☐ Higher efficiency water heater
    - ☐ Higher efficiency central air conditioner
    - ☐ Higher efficiency furnace
    - ☐ Higher efficiency windows
    - ☐ Increase insulation levels
    - ☐ Use Title 24 credits (specify which ones)
    - ☐ Change the design
    - ☐ Other ____

    30B. Will this be a change from current practices used to achieve compliance? If so, how? ____

    ____

High Potential Areas of Energy Savings

FOR IN-DEPTH INTERVIEW ONLY cover the following topics/questions
In your opinion what are the high potential energy saving areas in the design of new homes? The issue is to probe for design measures that could be incorporated in new construction design practices that will save significant energy. The purpose of this question is to help develop a working list of measure for the potential savings analysis.

And finally, I would like to solicit your thoughts on methods of achieving increased energy savings in new homes.

31. In your opinion, what features or design methods offer the best potential for further increasing energy savings in new home construction?

- ☐ High-Efficiency Cooling Systems
- ☐ Gas Cooling Systems
- ☐ High-Efficiency Heating Systems
- ☐ Hydronic Heating Systems
- ☐ Certified Duct Sealing
- ☐ High-Performance Windows
- ☐ Increased Ceiling Insulation
- ☐ Radiant Barriers
- ☐ Other Technologies (describe) ____

____

____

32. Do you have any final thoughts or comments regarding the Title 24 1998 Residential Standards or the AB 970 Emergency Standards as they affect residential new construction?

____

____

____

____