

# **What's a Builder to Do?**

## **Changes in California's Energy Efficiency Programs and Standards: 1995–2005**

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### **ABSTRACT**

The Title 24 low-rise residential building standards were introduced in California in the late 1970s. The most recent round of standards, implemented in 2001, reflects the peak demand concerns resulting from the California energy crisis. In addition, California's investor-owned utilities (IOUs) have designed and implemented energy efficiency programs aimed at the residential new construction market. These two parallel efforts have influenced typical building practices through mandated building requirements, education and training, design assistance, and financial incentives. The result is a continual enhancement of building practices and improvements in the energy efficiency of California's new housing stock.

This paper explores the impact of the Title 24 standards and the statewide California ENERGY STAR New Homes Program on typical building practices in California. The analysis and results presented in the paper are based on a four-year ongoing effort to characterize and track changes in typical building practices and compliance with Title 24 standards. This work includes two rounds of interviews with Title 24 consultants and builders and on-site survey data and building simulations of over 2,000 homes built since 1998. This paper also compares the measures actually installed in homes with the self-reported data from Title 24 consultants and builders. This comparison may be useful in determining the accuracy of self-reported information and how to use this information when it may not be feasible to conduct on-site audits.

### **Introduction**

California's Title 24 residential low-rise building standards (Standards)<sup>A</sup> and the residential new construction (RNC) energy efficiency programs offered by California's IOUs have significantly impacted typical building practices. The periodic revisions of Standards require builders to continually refine and enhance their specification practices. Moreover, programs offered by the IOUs have increased the energy efficiency of newly constructed homes through education and training, design assistance, and financial incentives.

This paper focuses on how single family builders have altered their building practices in response to changes in building standards and changes in the requirements of the ENERGY STAR New Homes Program (CESNHP).<sup>B</sup> This paper also utilizes the results of interviews with Title 24 consultants and builders comparing the measures they report installing/specifying with the measures actually installed in new homes.

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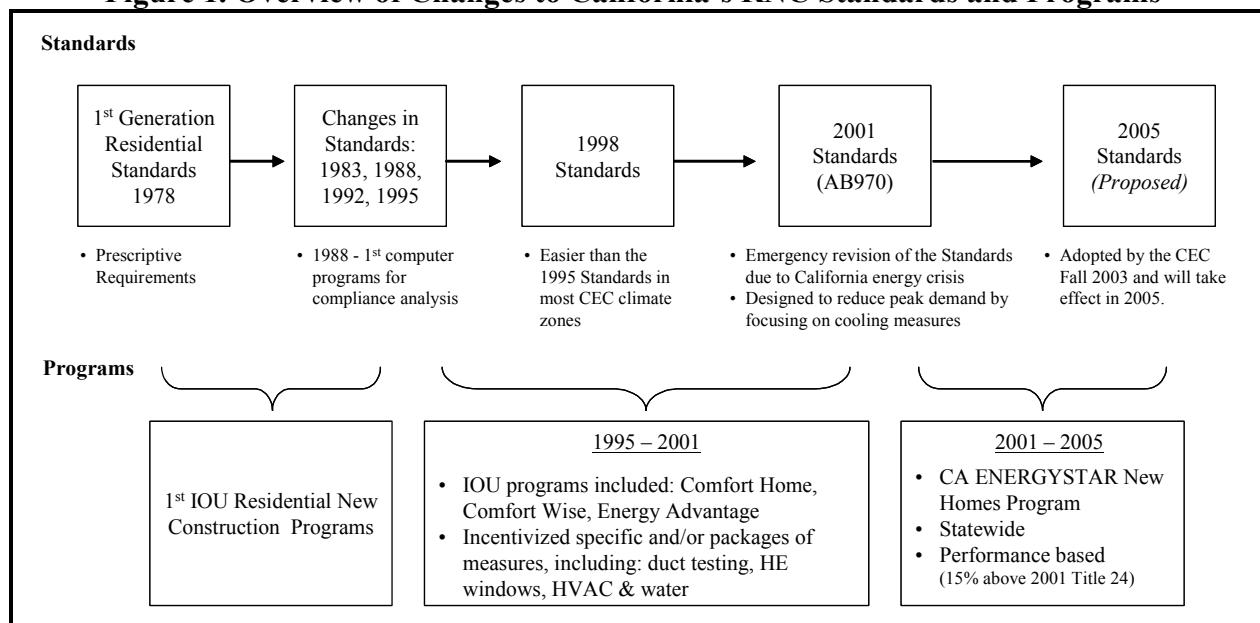
<sup>A</sup> CEC 2000.

<sup>B</sup> RLW Analytics, Inc. performed the Phase I evaluation, measurement and verification of 2002 California ENERGY STAR New Homes Program. This paper references the findings of their study where applicable.

## Overview of California's Title 24 Building Standards and IOU Residential New Construction Programs

This section provides an overview of California's energy standards and energy efficiency programs for low-rise (three floors or less) residential new construction. Figure 1 provides a timeline view of the residential Standards and publicly funded energy efficiency programs in California since the Standards were first enacted in 1978. As might be expected, the development of energy efficiency standards and new construction programs are interconnected. Since energy efficiency programs strive to increase efficiency above what the Standards mandate, a change to the Standards directly influences the programs. Typically, periodic changes in the Standards incorporate aspects (high efficiency equipment or measures) of the current program. In turn, for the program(s) to continue to be effective, program requirements need to evolve to include even higher efficiency measures.

**Figure 1. Overview of Changes to California's RNC Standards and Programs**



### California's Low-Rise Residential Standards

In California, energy performance requirements for low-rise residential new construction are dictated by the Standards, which are administered by the California Energy Commission (CEC). The Standards referred to apply to low-rise detached single family homes, attached single family homes, and multifamily buildings less than three stories high. Several revisions have been adopted since the original Standards, which, since the late 1980s, have typically been updated on a three-year cycle. This section will focus on changes made to California's low-rise residential Standards between 1995 and the present.

**1995 and 1998 standards.** The overarching objective for revising the Standards is to increase the energy efficiency of newly constructed homes. One would expect that a home built under the 1995 Standards would not be efficient enough to be built under the 1998 Standards. However,

analysis conducted as part of the Residential New Construction Study<sup>C</sup> shows that the 1998 Standards were actually easier than the 1995 Standards for homes in most CEC climate zones.<sup>D</sup> Changes in the water heating component and for some climate zones in the space heating component of the standards contributed to the 1998 Standards being easier.

*Water heating.* The most significant change in residential Standards between 1995 and 1998 pertained to the calculation of the water heating standard budget. Under the 1995 Standards, homes with a water heater blanket installed received a credit. However, the prescriptive water heating requirements did not include a blanket under the 1998 Standards. The proposed water heater will be compared to a minimally complying water heater (0.53 EF). The effect is that applicants who formerly modeled water heating with an R-12 wrap will receive the same credit they have been receiving and no blanket will be required as long as it is 0.58 EF or higher.<sup>E</sup> Nearly 98% of detached single family homes have water heaters that are above standard.<sup>F</sup> Further analysis shows that, overall, 99% of detached single family homes with a gas water heater have an energy factor of 0.58 or higher.<sup>G</sup> Therefore, over three-fourths of homes received the water heater blanket credit.<sup>H</sup>

*Space heating and space cooling.* Additional changes to the residential Standards between 1995 and 1998 involved the space heating and space cooling budgets. These changes were not as straightforward as the water heater blanket credit and included the following.

- **Glazing.** Internal changes on the calculation of solar heat gain.
- **Duct efficiency.** A new duct efficiency component was established to accommodate a credit for duct sealing.
- **Thermal mass.** Changes to thermal mass were adopted, but did not change the compliance margin because the resultant Standard and Proposed energy budgets were affected equally.

**2001 standards.** In response to what the State of California described as “growth trends in electricity peak demand that have strained the adequacy and reliability of California’s electricity system,” the State passed Assembly Bill 970 (AB 970) in September 2000.<sup>I</sup> Among other things, AB 970 directed the CEC to “adopt and implement updated and cost-effective standards...to ensure the maximum feasible reductions in wasteful, uneconomic, inefficient, or unnecessary consumption of electricity.” The CEC considered amendments to the Standards that could be “quickly analyzed and justified, and which would have a clear and significant impact on peak energy demand.” Subsequently, the AB 970 Standards were developed and adopted in January

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<sup>C</sup> RER 2002.

<sup>D</sup> RER 2001 and RER 2002.

<sup>E</sup> [http://www.energy.ca.gov/title24\\_1998\\_standards/summary\\_changes.html](http://www.energy.ca.gov/title24_1998_standards/summary_changes.html)

<sup>F</sup> RER 2002.

<sup>G</sup> The percentage of homes with a 0.58 EF or higher water heater could be greater since 1.9% of homes were given the default standard water heater due to inaccessibility.

<sup>H</sup> RER 2002.

<sup>I</sup> CEC 2000.

2001. Under these Standards, statewide annual source energy savings are estimated at 14% from the 1998 Standards, which includes a 39% or 155 MW reduction in cooling energy use on a statewide basis.<sup>J</sup>

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

**2005 standards.** The CEC adopted the 2005 Building Energy Efficiency Standards in the fall of 2003. The primary objectives for these new revisions are to respond to California's energy crisis to reduce energy bills, increase the reliability of the energy system, and contribute to an improvement in California's economic condition.<sup>O</sup>

The revisions to the low-rise residential Standards include the following.<sup>P</sup>

- Time-dependent valuation will replace source energy in determining compliance using the performance method. In other words, high efficiency measures that reduce peak energy (i.e., air conditioners) will be favored over those that reduce non-peak energy (i.e., furnaces).
- The standard energy factor for 50-gallon gas water heaters increases from 0.53 to 0.58 EF.
- R-6 and R-8 duct insulation will be required in some CEC climate zones.
- Third party verification protocols and procedures will be changed to encourage quality installation.

## California's Residential New Construction Programs

Publicly funded residential new construction programs have undergone a major transformation over the past decade in response to changes in California Public Utilities Commission's (CPUC) policy objectives and as a result of years of program and process evaluations. Before 2001, IOU programs were individually developed and administered, meaning they were unique to each utility. These programs were prescriptive-based; offering rebates for the installation of specific measures and/or packages of measures, such as high efficiency HVAC systems and tight ducts. Throughout the 1990s, residential new construction programs adopted strategies to produce increased energy efficiency in the short run, and sustainable changes in building practices in the long run. In addition to financial incentives, the ComfortHome, ComfortWise, and Energy Advantage Home programs provided design

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<sup>J</sup> CEC 2000.

<sup>K</sup> A radiant barrier is a reflective foil or metal-coated surface usually placed on or against the underside of a roof.

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

<sup>M</sup> Duct sealing involves actively testing and sealing a duct system with a "duct blaster" or equivalent apparatus.

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

<sup>O</sup> CEC 2003.

<sup>P</sup> Eley 2003.

assistance, marketing and advertising support, homebuyer education, and training. Program offerings targeted not only builders, but others involved in critical aspects of design, specification, and construction, including architects, energy consultants, and engineers.

Programs developed in the late 1990s began to move toward improving whole-building efficiency. This recognition and acceptance of the benefits of integrated design began the migration to the infusion of ENERGY STAR into residential new construction programs in 2001. The national ENERGY STAR program requires homes to exceed the Model Energy Code by at least 30% and does not dictate which measures must be installed to meet those goals. While homes qualifying for the ComfortHome program did not necessarily meet the ENERGY STAR threshold (though many did), the upgrades required by the program helped to move homes toward the ENERGY STAR level. The ComfortWise program actually used ENERGY STAR as a benchmark and involved inspection of all energy-related components of the house.

The migration toward developing consistent statewide programs in 2001 furthered the natural progression toward a fully integrated ENERGY STAR platform for the residential new construction program. The development of a California-specific ENERGY STAR benchmark linked the program directly to California's Title 24 Standards and provided builders with the flexibility to meet program requirements in the most cost-effective manner. The following section summarizes California's current residential new construction program.

### **Current new construction program – California ENERGY STAR New Homes Program.**

The basic premise of California's current statewide ENERGY STAR New Homes Program (CESNHP) is to stimulate the energy efficient design and construction practices for single and multifamily new construction. The program targets various professionals involved in all aspects of the residential new construction market – builders/developers, architects, energy consultants, and others - with education, design assistance, and financial incentives.

The program is performance-based rather than prescriptive – the program rewards builders for increasing whole-building efficiency rather than incentivizing the installation of specific measures. This approach is consistent with premise of the ENERGY STAR program, so it made sense to build the new statewide program upon the ENERGY STAR platform. The minimum requirement for participation is a total source energy use reduction of at least 15%. By configuring the program to increase whole-building efficiency, the incentive structure automatically accounts for differences in energy efficiency requirements across California's 16 unique climate zones.

### **Changes in Builder Practices to Meet Standards and Program Requirements**

As part of the ongoing statewide RNC study,<sup>Q</sup> on-site surveys of newly constructed homes and interviews with builders and Title 24 consultants have been conducted over the last four years. Specifically, three rounds of on-site surveys of homes built under the 1995, 1998, and 2001 Standards have been completed. During each of the first two years of the study, on-site surveys were completed for 800 residential buildings, including detached and attached single family homes, and multifamily buildings (1995 and 1998 Standards). The third on-site survey effort included 600 detached single family homes (2001 Standards). In addition to the on-site

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<sup>Q</sup> RER 2001 and RER 2002.

surveys, results of RLW Analytics analysis of the compliance documentation for 2002 California ENERGY STAR new homes are used to characterize energy efficient measures installed in those homes.<sup>R</sup> In-depth interviews and telephone interviews with builders and Title 24 consultants have also proved invaluable due to the lag time in surveying newly built residential buildings. The combination of these data sources allows for detailed analysis of the measures being installed in new homes since 1998 and those specified in the new homes to be built through early 2004. These research efforts provide interesting insights into the changes in building practices between the 1998 and 2001 Standards and the strategies utilized by builders to upgrade “standard” homes (those that just comply with the Standards) to qualify for the CESNHP.

Analysis of the 2001 Standards suggested that builders in most CEC climate zones would have to change their building practices in order for their homes to comply with the new Standards. In addition, since CESNHP homes need to surpass the 2001 Standards by at least 15%, builders would have to change their building practices even further to comply with the CESNHP. To investigate these hypotheses, the on-site survey results for detached single family homes built between July 1999 and June 2000 (1998 Standards) were compared to the results of on-sites surveys of detached single family homes built between January 2003 and June 2003 (2001 Standards), and results of the compliance documentation analysis conducted as part of the 2002 CESNHP Evaluation. The remainder of this section discusses changes in building practices due to the 2001 Standards and the CESNHP. The following is presented by measure and includes the four *biggest players* in terms of compliance: glazing, HVAC, water heating, and ducts.

## Glazing

Table 1 presents the percentage of homes with low-E glass windows and the percentage of homes with vinyl-framed windows built under the 1998 Standards and under the 2001 Standards. As shown, the percentage of homes with low-E windows increased dramatically after the implementation of the 2001 Standards. This corresponds with the results of interviews with Title 24 consultants in 2001 who anticipated that builders would opt for high performance windows as a first option for complying with the more difficult Standards. In fact, recent interviews with both builders and Title 24 consultants suggest that low-E windows are becoming the standard in most regions of California. Table 1 reveals that the percentage of homes with vinyl-framed windows has also increased at the statewide level.

**Table 1. Percent of Homes with High Performance Glazing**

Window Type	Standards	Statewide	North Coastal	South Coastal	South Inland	Central Valley	Desert & Mountains
Low-E	1998	10%	8%	0%	1%	21%	0%
	2001	81%	68%	61%	70%	92%	92%
Vinyl-framed	1998	84%	94%	100%	99%	64%	97%
	2001	92%	95%	84%	92%	93%	97%

\*On-site survey data.

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<sup>R</sup> RLW 2004.

The frame type and glass type of each window is not typically indicated on the compliance documentation for a home; instead, C-2Rs typically include the U-value and SHGC of each window. For this reason, a comparison of window types in the above table was impossible for CESNHP homes. To compare the performance of windows installed in the three groups of homes, Table 2 presents the average U-values of the windows installed in homes built under the 1998 Standards, 2001 Standards, and CESNHP and the average SHGC installed in homes built under the 2001 Standards and CESNHP. As shown, the average U-value of the windows installed in homes built under the 2001 Standards decreased drastically when compared to the windows installed in homes built under the 1998 Standards, which emphasizes the above mentioned conclusion that vinyl framed, low-e windows are becoming more common across the state. This table also shows that the average U-value is even lower in CESNHP homes. The lower average U-value and lower average SHGC indicate that even higher performance windows are being installed in CESNHP homes.

**Table 2. Glazing: Average SHGC and U-Values**

Window Type	Standards	Statewide	North Coastal	South Coastal	South Inland	Central Valley	Desert & Mountains
Ave U-Value	1998	0.60	0.58	0.59	0.59	0.60	0.60
	2001	0.43	0.46	0.48 <sup>S</sup>	0.45	0.40	0.39
	ENERGY STAR	0.39	0.43	0.36	0.41	0.36	0.35
Ave SHGC	2001	0.46	0.49	0.50	0.48	0.43	0.43
	ENERGY STAR	0.35	0.46	0.34	0.36	0.33	0.34

## HVAC

Table 3 presents the percentage of homes built under the 1998 Standards, 2001 Standards, and CESNHP that have high efficiency HVAC equipment. As shown, the percentage of homes with high efficiency central air conditioners increased from 3% to 34%. This is not surprising since the 2001 Standards were intended to decrease the summer peak load, comprised primarily of cooling loads. Also shown is that the percent of CESNHP homes with high efficiency central air conditioners is only slightly higher than that of homes built to just comply with the 2001 Standards. The saturation of high efficiency furnaces also increased somewhat from 3% to 10% statewide in response to the 2001 Standards, with the largest increases in the saturation of high efficiency furnaces observed in the North Coastal region. CESNHP homes in the Central Valley and Mountain regions have the highest saturation of high efficiency furnaces.

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<sup>S</sup> Please note that even though the percentage of vinyl windows in the South Coast decreased somewhat (100% to 84%), the percentage of low-e windows increased dramatically (0% to 61%). This increase in low-e windows is the reason for the increase in the average window performance (decrease in SHGC and U-Value).

**Table 3. Percent of Homes with High Efficient HVAC Equipment**

Measure	Standards	Statewide	North Coastal	South Coastal	South Inland	Central Valley	Desert & Mountains
<b>CACs &gt; 11 SEER</b>	1998*	3%	3%	0%	0%	6%	1%
	2001*	34%	30%	13%	17%	42%	62%
	ENERGY STAR	40%	0%	0%	17%	85%	62%
<b>Furnaces &gt; 90 AFUE</b>	1998*	3%	4%	0%	0%	5%	1%
	2001*	10%	38%	14%	-	11%	-
	ENERGY STAR	16%	10%	0%	3%	38%	20%

\*On-site survey data.

## Water Heating

Table 4 presents the average energy factor of the water heaters installed in homes built under the 1998 Standards, 2001 Standards, and CESNHP. As shown, the average efficiency of water heaters has remained constant over the last few years at 0.60 EF and even the average efficiency of the water heaters installed in CESNHP homes is not much higher (0.61 EF). This is not surprising considering a water heater with an EF of 0.60 is already approximately 15% above the prescriptive water heater efficiency of 0.53.

**Table 4. Water Heating: Average Energy Factor**

Measure	Standards	Statewide	North Coastal	South Coastal	South Inland	Central Valley	Desert & Mountains
<b>Average EF</b>	1998*	0.60	0.59	0.59	0.59	0.61	0.60
	2001*	0.60	0.62	0.60	0.59	0.61	0.60
	ENERGY STAR	0.61	0.60	0.60	0.61	0.62	0.61

\*On-site survey data.

## Ducts

Since tight ducts are not observable during an on-site inspection and would require a costly duct blaster test, this section focuses on responses from interviews with Title 24 consultants and specifications from compliance documentation. Table 5 presents the statewide average percent of homes that are specified to have tight ducts under the 1998 Standards, the 2001 Standards, and the CESNHP. As shown, interviews with Title 24 consultants in 2001 indicated that duct sealing was specified for approximately 9% of the homes that they conducted compliance analysis for in 2000 (under the 1998 Standards). Consultants also believed that duct sealing might not be specified as often as high performance windows and high efficiency air conditioners to achieve compliance once the new 2001 Standards were implemented. Doing so would require builders to coordinate with third party inspectors, which would lengthen the overall construction schedule. More recent interviews support this early sentiment; in 2003 Title 24 consultants estimate that approximately 16% of the homes they conducted compliance analysis for in 2002 (under the 2001 Standards) included sealed ducts.



**Table 5. Tight Duct Credits**

Measure	Standards	Statewide
Tight Ducts	1998	9%
	2001	16%
	ENERGY STAR	87%

In comparison, the results from the CESNHP Evaluation indicate that approximately 87% of the CESNHP homes statewide used the tight duct credit to comply with the program. This is not surprising since participant builders have to have a CHEERS rater inspect CESNHP homes to comply with the program anyway, having them perform a duct test while they are there is not as big of an added inconvenience as it is when building a non-CESNHP home. In fact, during the Title 24 Consultant interviews, one consultant specifically mentioned that duct sealing is the *first* measure used and another pointed out that duct sealing *alone* would elevate homes in some CEC climate zones to the ENERGY STAR threshold.

## **Conclusion**

Reciprocal changes in California's residential building energy efficiency standards and revisions in residential new construction programs over the past decade have increased the energy efficiency of the residential building stock throughout the state. Moreover, the evolution of the utility-specific prescriptive rebate programs to a statewide performance-based program has further enhanced standard practices of the building industry. The current California ENERGY STAR New Homes Program benefits from the nationally esteemed ENERGY STAR brand and a benchmark established specifically to account for California's stringent building energy efficiency requirements. Evaluations of California's residential new construction programs have revealed methods builders have adopted to adjust to changes in the Standards and for participating in the programs. Recent research suggests that commonly specified measures to qualify a home for ENERGY STAR in California include duct sealing, building envelop sealing, and high performance windows.

## **Self Reported Measures Specified for New Homes vs. Measures Found in New Homes**

As previously explained, in January 2001 the CEC adopted new energy efficiency standards (AB970) in response to the California's "energy crisis" in the summer of 2000. As a result of the new, more stringent Standards, it was clear that the RNC programs would have to change in order to stay ahead of the Standards. To develop cost-effective and viable RNC programs across the state, the RNC program managers first needed to know which measures would be installed in "standard" homes under the 2001 Standards. The RNC program managers could then develop builder training programs and builder incentive programs that encourage builders to adopt energy efficiency measures that exceeded AB 970 standards. However, since the Standards would not go into effect for tract homes for another year, and then it would take an additional year for those homes to be built, it was impossible to determine which measures builders would use to make the homes comply with the new Standards.

Midway through the first year of the RNC Study, an additional objective was added to the goals of the study to survey Title 24 consultants and builders about 1) their knowledge of the proposed 2001 Standards and 2) if they were knowledgeable, which measures they anticipated using under the new Standards to make the homes comply. RNC program managers used these results in RNC program planning.<sup>T</sup>

Nearly three years later, initial results of the compliance documentation for CESNHP homes indicated that the measures the Title 24 consultants anticipated specifying did not match the measures on the compliance documentation.<sup>U</sup> As part the third year of the RNC Study, Title 24 consultants were again interviewed.<sup>V</sup> This time, they were asked to note what percentage of homes they performed compliance analysis on in 2002 (under the 2001 Standards) had high efficiency measures specified. This survey was done to gauge differences between what they thought they would do two years earlier and what they actually specified. In addition, Title 24 consultants and turn-key providers that performed analysis of a large number of 2002 CESNHP homes were interviewed to estimate which measures were being specified in participating homes and for evaluation of CESNHP. Finally, as part of the CESNHP EM&V study conducted by RLW Analytics, participant and nonparticipant builders were surveyed. The participant builders were asked which high efficiency measures were installed in their CESNHP homes.

Now that time has past, two current studies have the results of which measures were actually installed/specified.

- **The 2003 RNC Study** (Itron) includes on-sites of 600 single family “standard” homes built under the 2001 Standards to determine which measures were actually installed in nonparticipant homes.
- **The 2002 CESNHP EM&V Study** (RLW) includes an analysis of compliance documentation for 2002 CESNHP homes to determine which measures were actually specified in participant homes.

This section compares the results of these initial interviews. The results of these comparisons and the experiences of the project teams will help RNC program managers across the country decide whether to rely on interviews to predict which high efficiency measures will be installed at a future date and which group of market actors to interview for the most reliable predictions.

## Measures in “Standard” Homes

This subsection compares the statewide results of three surveys of measures specified/installed in “standard” homes built under the 2001 Standards. Table 6 presents the statewide results of these three surveys by high efficiency measure.

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<sup>T</sup> The initial plan was to conduct 10 in-depth interviews with builders and then 50 telephone interviews with builders. However, during the in-depth interviews it became clear that most builders did not know enough details regarding the efficiency of the measures installed to make the telephone interviews valuable, so these interviews were not conducted.

<sup>U</sup> Please note that in the initial interviews during the 2000 RNC Study, Title 24 consultants were asked to which measures they anticipated specifying for homes to just comply, not for overly compliant homes.

<sup>V</sup> Of the 41 Title 24 consultants interviewed as part of the 2003 RNC Study, 26 had been interviewed in the 2000 RNC Study.

**Table 6. High Efficiency Measures in “2001 Standard” Homes – Statewide**

	Title 24 Surveys Measures Predicted (2000)	Title 24 Surveys Measures Predicted (2003)	On-Site Surveys Measures Installed (2003)
<b># of Respondents/Plans</b>	<b>53</b>	<b>40</b>	<b>600</b>
High performance windows (Low-e, Vinyl)	3.92 <sup>c</sup>	66%	82%
Higher efficiency water heater ( $\geq 0.60$ EF)	3.85	91%	94%
Higher efficiency CAC ( $\geq 12$ SEER)	3.74	43%	34%
Higher efficiency furnace ( $\geq 90$ AFUE)	3.48	13%	10%
Increased roof/wall insulation ( $>$ prescriptive <sup>a</sup> )	3.35	66%	4%
Radiant barriers	3.18	10%	2%
HERS-certified sealed ducts	2.68	16%	?
TXV / Ref charge air flow test	2.27	25%	16% <sup>b</sup>

a. Prescriptive insulation R-values change by CEC Climate Zone.

b. Note that checking the existence of a TXV is difficult – surveyors could only identify the existence, or non-existence, of a TXV for 48% of the CACs. 16% indicates the percent of all CACs where a TXV was found.

c. Answered using a scale of 1 to 5 with 1 meaning “not at all likely” and 5 meaning “very likely.”

- **Title 24 Surveys – 2000: Measures Predicted (Itron).** Consultants were asked “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.” The values in the second column represent the average likeliness that they anticipate specifying the measure. For example, in 2000, Title 24 consultants projected that high performance windows (3.92) and high efficiency water heaters (3.85) would most likely be used to comply with the proposed 2001 Standards.
- **Title 24 Surveys – 2003: Measures Specified (Itron).** Consultants were asked in what percentage of the homes that they performed compliance analysis for in 2002 had the following measures specified. The values in the third column represent the weighted percentage of homes analyzed by Title 24 consultants in 2002 that were specified to have the following measures. For example, in 2003, Title 24 consultants reportedly specified high efficiency water heaters (91%), high performance windows (66%), and increased insulation (66%) most often.
- **On-Site Surveys – 2003: Measures Installed (Itron).** On-site surveys of 600 single family homes built between January and June 2003 were conducted. The values in the fourth column represent the percentage of homes with the following measures installed. For example, 94% of the homes surveyed have high efficiency water heaters and 82% have high performance windows. (Note that since duct testing was not included in the on-sites due to cost constraints and compliance documentation for homes already constructed is difficult to obtain from building departments, it is impossible to estimate the percentage of homes that used the duct testing credit to comply.)

When the measures are sorted by their average predicted likelihood, the percentages found installed during the on-sites are, for the most part, sorted also. The exception is TXVs, which Title 24 consultants in 2000 did not think were likely to be installed due to the required HERS certification. However, TXVs are tricky to report for a few reasons. First, it is difficult to verify if a TXV is installed. Secondly, during the on-sites, surveyors simply looked for the existence of the TXV and there was no way to determine if credit was taken on the compliance

documentation. For these reasons, the percentage of homes taking credit for the TXV might be higher or lower than the 16% that reportedly had them installed.

When comparing the self reports from the surveyors to the actual incidence of the measures found during the on-sites, most of the percentages line up well. The percentages of high efficiency water heaters, central air conditioners (CACs), and furnaces installed are very close to reports from Title 24 consultants. While Title 24 consultants estimated that 66% of homes had high performance windows, surveyors found them in approximately four-fifths of the homes surveyed. This is not surprising given prior research. In the 2000 RNC study, compliance documentation (C2Rs) was collected for approximately 40 of the homes surveyed. Many of these homes, when surveyed, had better windows than indicated on the C2R. Most C2Rs indicated metal windows, but vinyl windows were installed. The theory at that time was that the window industry was evolving and that the typical window installed was becoming more efficient. Over the last several years, instead of vinyl windows gaining market share over metal, it is the spectrally selective glass (i.e., low-e) windows that have become more common.

The results of the interviews and the on-site surveys differ only in roof and wall insulation values. Title 24 consultants anticipated and self-reported specifying increased insulation values. However, according to the recent on-site surveys, this is not the case. There are several possible explanations for these discrepancies. Title 24 consultants may be seeing the average roof insulation R-value increase somewhat, but it is still near the prescriptive R-value.<sup>W</sup>

### Measures Specified in CESNHP Homes vs. Measures Specified

This subsection compares the statewide results of three surveys of measures specified/installed in 2002 CESNHP homes built in 2003. Table 7 presents the statewide results of these three surveys by high efficiency measure.

- **Title 24 Surveys – 2003: Measures Specified (Itron).** Consultants were asked to note the percentage of CESNHP homes for which they performed compliance analysis in 2002 that had the following measures specified. The values in the second column represent the weighted percentage of homes analyzed by Title 24 consultants in 2002 that were specified to have the following measures. For example, in 2003, Title 24 consultants reportedly specified high efficiency water heaters (97%) and high performance windows (95%) most often.
- **Builder Surveys – 2003: Measures Installed (RLW).** Builders were asked which measures they started using that they did not use before participating in the CESNHP program. For example, in 2003, 88% of builders reportedly started using high performance windows as a result of the CESNHP program. (Please note that these values are not intended to provide a direct comparison. However, they are interesting insight into how participant builders view various measures.)
- **Compliance Documentation Summary -- 2003: Measures Specified (RLW).** Compliance documentation for 692 plans representing homes that participated in the 2002 CESNHP program was reviewed and average building characteristics were developed. The values listed in the fourth column represent the weighted percentage of homes that had the following measures specified on their compliance documentation.

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<sup>W</sup> During the 2000 RNC Study, it was found that homes, on average, have roof insulation R-values that are 9% worse than the prescriptive R-value.

For example, 100% of the homes participating in the 2002 CESNHP program had high performance windows specified.

As shown in Table 7, the “high volume” CESNHP consultants interviewed provided a fairly accurate assessment of actual energy efficiency measures installed in CESNHP homes. This is especially true in estimating the percent of CESNHP homes that specified sealed ducts, building envelope sealing, high performance windows, radiant barriers, and high efficiency water heaters. However, like the results for “standard” homes, the consultants’ estimates of specifying TXVs and increased roof and wall insulation are very different from the results of the compliance documentation review. Possible reasons for why the consultants overestimated the use of both of these measures are reviewed above and would also apply to this comparison. In addition, these “high volume” CESNHP consultants also somewhat overestimated the use of high efficiency CACs and under-estimated the use of the ACCA Manual D duct design, but these differences could be explained by the weighting used in calculating the averages.

**Table 7. Self-Reported Incidence of High Efficiency Measures Specified in CESNHP Homes Statewide**

	<b>Title 24 Surveys Measures Specified (2003)</b>	<b>Builders Surveys Measures Installed (2003)<sup>a</sup></b>	<b>Measures Specified per Compliance Documentation (2003)</b>
# of Respondents/Plans	3	44	692
HERS-certified sealed ducts	88%	41%	87%
TXV/Ref charge air flow test	79%		48%
ACCA Manual D duct design	37%		56%
Bldg. envelope sealing (blower door)	55%		65%
High performance windows	95%	88%	100% <sup>b</sup>
Radiant barriers	7%		5%
Higher efficiency water heater	97%		98%
Higher efficiency CAC	67%	38%	40%
Higher efficiency furnace	8%	38%	16%
Increased roof/wall insulation	76%	84%	5%

a. The Builders surveys asked which measures the builders started using as a result of the CESNHP.

b. Based on the average u-value of the windows per home.

## Conclusion

If it is not feasible to conduct on-site surveys, the results from Title24 consultants’ interviews will provide a fairly accurate assessment of actual energy efficiency measures installed in new homes. As shown in Table 6, Title 24 consultants were able to provide a fairly accurate prediction of which measures builders would generally install in response to the 2001 code changes. The Title 24 consultants were also able to provide an accurate assessment of actual building practices, excluding roof insulation. However, the responses from Title 24 consultants were less accurate in predicting or assessing measures builders would install to meet the CESNHP requirements. Therefore, interviewing Title 24 consultants would provide accurate information on general building practices and a less accurate assessment in practices used to meet the requirements of energy efficiency programs. Although interviews with builders provided less reliable information than interviews with Title 24 consultants on the efficiency of

measures installed in homes, the results are useful for defining barriers to energy efficiency and program participation.

In determining actual building conditions, it is the authors' recommendation to perform on-site surveys if possible. However, if there are time or budget constraints and you need detailed information on the efficiency of measures installed in new homes, interviewing the compliance analysis consultants would provide more reliable information than interviewing builders.

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