Volume III

Codes & Standards (C&S) Programs Impact Evaluation

California Investor Owned Utilities' Codes and Standards Program Evaluation for Program Years 2006-2008

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Final Evaluation Report

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For the
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List of Exhibits:

The following appendices are included in a separate document: *"Codes & Standards (C&S) Programs Impact Evaluation. Appendices to Volume III"*:

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Acronyms

A/C (AC)	Air Conditioning
ACCA	Air Conditioning Contractors of America
ACM	Alternative Calculation Method
ACP	Air Care Plus
ADM	ADM Associates
AEC	Architectural Energy Cooperation
AERS	Automated Energy Review for Schools
AHP	Analytic Hierarchy Process
ARI	Air Conditioning and Refrigeration Institute
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
BEA	Building Efficiency Analysis
Bldg	Building
C&I	Commercial
C&S	Codes & Standards
CASE	Codes and Standards Enhancement Initiative
CATI	Computer Assisted Telephone Interviewing
CBEE	California Board of Energy Efficiency
CEC	California Energy Commission
CFL	Compact Fluorescent Lamp
CF1-R	Title 24 Residential Compliance Form
CfR	Composite for Remainder
CG	Contract Group
CHEERS	California Home Energy Efficiency Rating Services
CIEE	California Institute for Energy Efficiency
CMFNH	California Multifamily New Homes Program
CMMHP	Comprehensive Manufactured-Mobile Home Program
CPUC	California Public Utilities Commission
CRCA	Computerized Refrigerant Charge & Airflow
CTZ	Climate Thermal Zone
CV	Coefficient of Variation
CZ	Climate Zone
DEER	Database for Energy Efficiency Resources
DfC	Designed for Comfort
DHW	Domestic Hot Water
DRET	Demand Response Emerging Technologies
DSA	Division of the State Architect
ECM	Energy Conservation Measure
ED	Energy Division
EE	Energy Efficiency
EEGA	Energy Efficiency Groupware Application
EM&V	Evaluation, Measurement, and Verification
EER	Energy Efficiency Rating
EUL	Economic Useful Life
FLA	Full Load Amps
GWh	Gigawatt Hours
HERS	Home Energy Rating System
HIM	High Impact Measure

Acronyms

HMG	Heschong-Mahone Group
HUD	Housing & Urban Development
HVAC	Heating, Ventilation & Air Conditioning
ICF	ICF International
IDEEA	Innovative Designs for Energy Efficiency Applications
InDEE	Innovative Design for Energy Efficiency
IOU	Investor Owned Utility
IPMVP	International Performance Measurement and Verification Protocol
ISSM	Integrated Standards Savings Model
ITD	Installed To Date
kBtu	Thousand Btu
kW	Kilowatt
kWh	Kilowatt Hour
LADWP	Los Angeles Department of Water & Power
LBNL	Lawrence Berkeley National Laboratory
LEED	Leadership in Energy and Environmental Design
LPD	Lighting Power Density
M&V	Measurement & Verification
MECT	Master Evaluation Contractor Team
MF	Multifamily
MHRA	Manufactured Housing Research Alliance
Mil	Million
MS	Microsoft
Mtherms	Million therms; also MTherms
n	Sample Size
NAC	Normalized Annual Consumption
NC	New Construction
NCCS	New Construction/Codes & Standards
NOMAD	Naturally Occurring Market Adoption
NOSAD	Normally Occurring Standards Adoption
NP	Non Participant
NRNC	Non Residential New Construction
NTG	Net to Gross
NTGR	Net to Gross Ratio
NTP	Notice to Proceed
P	Participant
PG&E	Pacific Gas & Electric
PIER	Public Interest Energy Research
PTAC	Packaged Terminal Air Conditioner
PY	Project Year
Q2	Second Quarter
Q3	Third Quarter
Q4	Fourth Quarter
QA	Quality Assurance
QC	Quality Control
QII	Quality Insulation Installation
RCA	Refrigerant Charge and Airflow

Acronyms

Res	Residential
RFP	Request for Proposal
RH	Relative Humidity
RLA	Rated Load Amps
RMSE	Root Mean Square Error
RNC	Residential New Construction
ROB	Replace on Burnout
RP	Relative Precision
SAS	Statistical Analysis Software
SBD	Savings By Design
SCE	Southern California Edison
SCG	Southern California Gas
SCP	Sustainable Communities Program
SDG&E	San Diego Gas & Electric
SDGE	San Diego Gas & Electric
SEER	Seasonal Energy Efficiency Rating
SES	Savings Estimate Spreadsheet
SF	Single Family
sf	Square Foot
SFA	Single Family Attached
SHGC	Solar Heat Gain Coefficient
SoCalGas	Southern California Gas
SOW	Statement of Work
sqft	Square Foot
T20	Title 20 Appliance Efficiency Standards
T24	Title 24 Building Energy Efficiency Standards
TBD	To Be Determined
TDV	Time-Dependent Valuation
TXV	Thermostatic Expansion Valve
UES	Unit Energy Savings
VFD	Variable Frequency Drive
VSD	Variable Speed Drive
VSP	Verification Service Providers
W/SF	Watts per square foot
WH	Water Heater

Executive Summary

This volume presents the impact evaluation of the California investor owned utilities' (IOUs) statewide Codes and Standards Program (C&S Program, or Program) for the 2006-2008 Program years.[1] The four IOUs implemented similar, coordinated programs to support upgrades of the Title 20 Appliance Efficiency Standards (T20) and Title 24 Building Energy Efficiency Standards (T24). The IOUs have claimed energy savings and demand reduction based on their contribution and support activities to the adoption of these codes and standards[2].

These programs contributed to the adoption of energy-efficiency building codes and appliance standards that went into effect in California between late-2005 and the end of 2008. Table 1 shows the IOUs C&S program projected and claimed expenditures.

Table 1. IOUs' C&S Programs Projected and Claimed Expenditures

Program ID	Program Name	Original Program Projection	Program Claimed Achievement	Percentage Claimed of Program Projected
PGE 2011	Codes & Standards Program	$4,635,754	$4,596,527	99.15%
SCE 2516	Statewide Codes & Standards Program	$5,672,011	$2,454,238	43.27%
SDGE 3004	Codes & Standards Program	$1,188,808	$543,444	45.71%
SCG 3501	Statewide Cross Cutting Codes & Standards	$882,162	$438,663	49.73
Total		**$12,378,735**	**$8,032,872**	**64.89%**

[1] In general, the term "code" refers to regulations applied to the construction of buildings and "standards" apply to appliances. However, the terms are used interchangeably in some venues and the California Code of Regulations, in which Title 24 appears, is known as the California Building Standards Code and the regulations are often referred to as the Title 24 Building Standards or just Title 24.

[2] The IOUs performed a range of activities to support the adoption of new standards such as, conducting research and funding Codes and Standards Enhancement (CASE) studies, working with the CEC and other stakeholders to facilitate the adoption of new standards.

Per California Public Utilities Commission (CPUC) decision[3], verified savings attributed to the C&S Program activities conducted prior to 2006 can be counted toward the utility savings goals:

> "In evaluating whether the 2006–2008 portfolios actually meet or exceed the adopted goals for that program cycle on an ex post basis, the utilities should credit 50% of the verified savings associated with pre-2006 codes and standards advocacy work toward the goals…"

The ex post verified savings associated with the pre-2006 C&S Program activities are the focus of this evaluation. The study's intent is to determine impacts of Program activities conducted prior to 2006 that led to adoption of the standards in effect during the period 2006 through 2008.

Evaluation Methodology Overview

The evaluation methodology is based on the California codes and standards program evaluation protocol. [4] This study was the first employing the protocol, and in the course of the evaluation the evaluation team revised and enhanced the protocol in a few ways to better meet the needs of evaluating the C&S Program. The overall purpose of the evaluation is to determine the energy savings and demand reduction attributable to the IOUs' C&S program activities.

The components of the evaluation are shown graphically in Figure 1.[5] The first step was to estimate the energy savings that would result from all buildings or appliances meeting each code or standard; we referred to this as the "**potential standards energy savings**." Next, these savings were adjusted by the rate of compliance observed in the market to estimate the "**gross standards energy savings**." The next step was to determine the "**net standards energy savings**" by adjusting for naturally occurring market adoption (NOMAD) trends of energy-efficient units in the market. To determine the "**net C&S Program savings**" an adjustment was made to account for the effect of the Program on adoption of each standard. Finally, the **net savings** were allocated to each of the IOUs based on their share of California electricity and gas sales. For purposes of crediting the utilities with savings from the Program, the CPUC has specified that

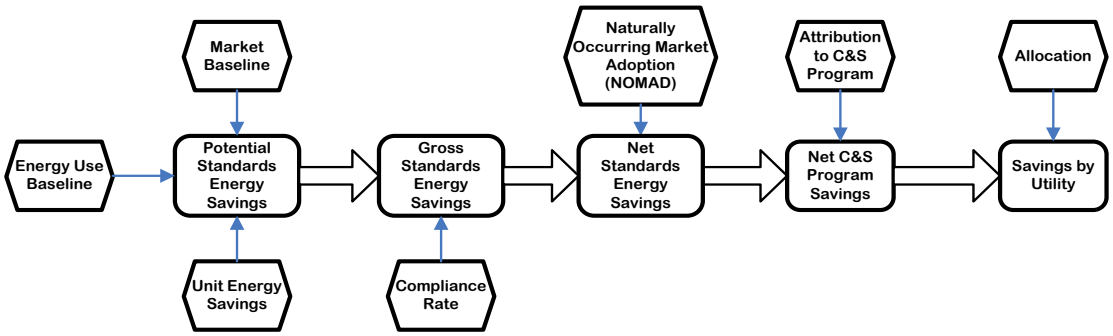
[3] D.05-09-043. Ordering paragraph 14. September 27, 2005

[4] California Public Utilities Commission [CPUC]. 2006. California Energy Efficiency Evaluation Protocols: Technical, Methodological, and Reporting Requirements for Evaluation Professionals.

[5] The steps shown in the Figure 1 are consistent with the existing spreadsheet methodology for estimating C&S impacts (Savings Estimate Spreadsheet, or SES, was developed by HMG). Heschong Mahone Group, Inc. 2005 (Revised November 1). Codes and Standards Program Savings Estimate for 2005 Building Standards and 2006/2007 Appliance Standards.

the verified net savings for each utility estimated for the 2006-08 program cycle are those occurring in IOU service areas and adjusted by a factor of 50%.

Figure 1. C&S Program Evaluation Methodology



Key Evaluation Findings

The codes and standards that are evaluated in this study included a list of T24 and T20 standards which were the focus of the programs' effort and for which the utilities claimed energy and demand savings. This list consists of nine nonresidential building standards and five residential standards which were included in the Savings Estimates spreadsheet (SES). In the original claim, one additional group of building standard was included and referred to as the Composite for Remainder (CfR). This standard was an aggregation of all the adopted Title 24 residential and nonresidential standards that were not covered by C&S Program CASE (Codes and Standards Enhancement Initiative) reports and, thus, were not a major focus of the Program effort. The evaluation included analysis of the CfR.

The original IOUs estimation of energy and demand savings (included in the SES) treated all adopted building standards as if their impacts were independent of all other standards. Because Title 24 permits tradeoffs among measures, however, we developed a method for analyzing impacts at the "Whole Building" level and fully implemented it in the residential Title 24 analysis and to some extent on the nonresidential Title 24 analysis.

Twenty-one appliance standards (Title 20) were analyzed in this evaluation. Some of these standards had two tiers that went into effect at different times. These standards covered appliances and equipment ranging from consumer electronics to large, walk-in freezers.

Potential Standards Energy Savings

In the unadjusted gross savings claims by the IOUs (included in the SES spreadsheet), the analyses sometimes took into account existing market penetration of the efficiency measure and sometimes did not. To establish consistency across the analyses conducted in this impact evaluation, the evaluators did not take initial market penetration into account in the potential savings estimate. Instead, the initial market penetration was accounted for in the evaluation of naturally occurring market adoption (NOMAD). This difference in approach leads, in some cases, to what the evaluation defines as **potential savings** estimates that exceeded the original IOUs' gross savings estimates.

For **appliance standards (Title 20)**, the major findings regarding the potential savings were the following (see Section 5.1.2):

- The largest potential electric savings were for the Metal Halide Tier 1 standards. The Tier 1 External Power Supplies standard produced the next largest potential electricity savings.
- The evaluated potential savings for two standards (Tier 2 Large Packaged Commercial Air Conditioners and Pre-rinse Spray Valves) were estimated to be zero because federal standards established a new baseline.
- The only appliance standard for which there were verified natural gas savings was the standard for Unit Heaters and Duct Furnaces.

For **building standards (Title 24)**, the major findings regarding potential savings were as follows (see Section 5.1.3):

- The potential energy or demand savings were estimated to be zero for the two Time Dependent Valuation (TDV)[6] standards because the evaluation team could find no evidence that the standards would drive building design toward more on-peak savings to meet the requirements of the standards.

[6] Time-Dependent Valuation (TDV) is a method for valuing energy in the performance approach in the 2005 Building Energy Efficiency Standards. Under TDV the value of electricity differs depending on time-of-use (hourly, daily, seasonal), and the value of natural gas differs depending on season. TDV is based on the cost for utilities to provide the energy at different times.

- The Residential Hardwired Lighting standard was the single measure with the largest electricity savings in both the original gross savings analysis and in this evaluation analysis of potential savings.

Compliance Analysis

Appliance Standards

The California Energy Commission (CEC) maintains a database of appliance models complying with the latest Title 20 standards. We found in this study that not all complying models were reported to the CEC. Hence, the appliance compliance evaluation also assessed whether models being sold met the technical requirements of the standards even though they were not listed in the CEC database. This provided a better indication of energy savings than treating all unlisted models as non-complying and producing no energy savings. Major findings from the evaluation of the compliance with the appliance standards (Title 20) included (see Section 5.2.1):

- Compliance of Residential Pool Pumps and Motors, Pre-rinse Spray Valves, Televisions, External Power Supplies, and Duct and Unit Heaters was 93% or higher.
- For nearly all the major energy saving appliance standards, at least 64% of the observed models were found in the California Energy Commission (CEC) compliance databases; on the other hand, up to 36% were not.
- The lighting equipment (General Service Incandescents and Metal Halides) standards exhibited the lowest compliance rates of the major energy savers. Most of the lighting equipment models found in the market were not listed in the CEC databases and the compliance rates were low even after including those that met the technical specifications.

Residential Building Standards

For residential buildings, the major new Title 24 standards that were in effect from 2006 through 2008 were for hardwired lighting in new homes and duct and window installations in existing homes. For new homes, we developed and applied a method to compare whole building space heating and cooling and water heating energy use to the amounts permitted by the standard. To assess compliance with the residential standards, the evaluation team used the compliance software (Micropas) estimates of energy use, combined with the lighting energy use estimates, to determine and compare the as-built, 2005 Title 24, and 2001 Title 24 electricity

and natural gas consumption for space heating and cooling, water heating, and lighting. All values were weighted based on construction volumes by climate zone.

Compliance with the two standards for existing homes was determined from surveys of building code officials and home occupants.

Major evaluation findings from the residential Title 24 compliance analysis were the following:

- Residential compliance with Title 24 was demonstrated most frequently by using the performance rather than prescriptive approach.
- The residential hardwired lighting standard compliance rate was slightly more than 113%, indicating that hardwired lighting was providing savings about 13% more than if the homes simply met the new code.
- At the whole-house level, electricity savings were about 20% on the average more than if the homes simply met the codes for hardwired lighting and space heating and cooling combined (see Table 2).
- At the whole-house level, natural gas savings were about 2.35 times more than if the house simply met the 2005 T24 code (see Table 2). Although this compliance rate was large, it is important to note that the natural gas savings predicted for the 2005 Title 24 were relatively small, so the magnitude of observed savings was not very large.[7]
- Compliance with the duct sealing requirement in existing homes was estimated to be 59%, and compliance with the window retrofit requirements was estimated to be 80%.

[7] We note also that the original analysis assumed that gas water heating would be provided by storage-type water heaters only, but the baseline study showed that up to 40% of homes had instantaneous gas water heaters, which are much more efficient than conventional units. Consequently, gas savings were probably increased by the frequent installation of instantaneous water heaters.

Table 2. Whole House Compliance Estimates

Consumption Category	Sample Size	Method of Compliance	Site Energy Units	Compliance Rate %*
Space Cooling Space Heating Lighting	194	Performance**	kWh	120%
Space Heating Water Heating	194	Performance	Therms	235%

*Whole house compliance rate in this table is defined as the ratio of estimated savings of as-built new homes relative to homes built to just meet the 2001 Title 24 divided by the difference between estimated consumption of the same homes if built to just meet the 2001 Title 24 minus the consumption if built to just meet the 2005 Title 24.
** Performance compliance approach refers to using the compliance software to allow for tradeoff between different requirements for space cooling, heating and water heating; whereas, lighting is accounted for separately through the Whole House approach.

Nonresidential Building Standard Compliance

In the utility claimed savings (included in the SES spreadsheet), the compliance rates were analyzed based on individual compliance estimates for each of the new nonresidential Title 24 requirements. To capture the tradeoff between standards that is allowed under T24, the evaluation intended to use a whole building compliance analysis similar to that used for the whole house compliance approach in the residential standards. However, difficulties encountered in collecting the required data (see discussion in Appendix H) limited our ability to use this approach for nonresidential buildings. Consequently, this evaluation used a measure-by-measure compliance analysis as was used in the IOUs analysis (included in the SES spreadsheet).

In addition, the Whole Building compliance analysis was used in this evaluation to assess whether each building in the sample (where the data were available) met the standard and reported a raw compliance percentage. To determine the raw compliance percentage, the evaluation team modeled each building in the sample using the compliance output from the building simulation model (EnergyPro). For new nonresidential buildings, the evaluation showed that 61.5% complied with the standards as built.

For individual measures, the evaluation showed that compliance ranged from about 8% to *100%. Since the sample sizes we were able to include in this analysis were small in some cases, there is a relatively large range of uncertainty in some of these estimates. Key*100%; key findings included the following:

- Compliance with the nonresidential skylights standard in new buildings was 8.3%, but the uncertainty was high because only four cases were observed.

- Compliance with nonresidential duct sealing requirements in existing buildings was estimated to be 75%.
- Compliance with the cool roof standard on existing nonresidential buildings was estimated to be *75%.*
- Compliance with the bi-level lighting controls standard was estimated to be *79%.*

Naturally Occurring Market Adoption (NOMAD)

The NOMAD analysis produced estimates of market efficiency trends that would have occurred without each of the standards analyzed. The analysis estimated the market penetration of appliances and building measures that would have met the relevant standard if the standard had never been adopted. The initial market penetration was defined as the estimated NOMAD market penetration at the time each standard went into effect. For each appliance and building measure, the NOMAD analysis also produced an estimate of what the maximum market penetration would have been in the future if the standards had not been adopted.

Key evaluation findings from the NOMAD analysis of appliance standards included (see Section 5.3.2):

- The natural market penetration of efficient appliances was estimated to be 57% or more in 2006 for Commercial Refrigeration Equipment (Solid Door), Refrigerated Beverage Vending Machines, Modular Furniture Task Lighting Fixtures, and Televisions.
- Low (9% or less) initial natural market penetration of efficient appliances was estimated for General Service Incandescents (Tier 2), Residential Pool Pumps with Two-speed Motors (Tier 2), and Large Packaged Commercial Air Conditioners (Tier 2). The maximum naturally occurring market penetration of these products was expected not to exceed 11%.

The major findings from the NOMAD analysis for Title 24 included (see Section 5.3.3):

- None of the measures in the building standards were estimated to have a very large initial market penetration.
- The maximum natural market penetration of measures complying with the standards was projected to be 35% or less for Residential Hardwired Lighting, Residential Duct Improvements, Ducts in Existing Commercial Buildings, Bi-level Lighting Controls and Cool Roofs on Existing Nonresidential Buildings.

- The maximum natural market penetration was projected to be more than 50% for Residential Window Replacements and Nonresidential Lighting Controls under Skylights.

Attribution to the C&S Program

The attribution analysis provided estimates of the credit that could be attributed to the C&S Program for savings achieved through the standards. The final credit estimated for the Program's influence on each standard was referred to as the final attribution score, which could range from 0% to 100%.

Key findings from the attribution analysis for appliance standards included (see Section 5.4.3):

- For most of the standards, the attribution score calculated for the Program was at least 50%, and it exceeded 80% in several cases.
- The Program received the lowest attribution scores for Commercial Dishwasher Pre-rinse Spray Valves, External Power Supplies Tier 1 and 2, and Refrigerated Beverage Vending Machines standards, although the value was at least 58% for each of these products.

For building standards, the major attribution findings were:

- The final attribution score was over 70% for all building standards except Window Replacements in Existing Residential Buildings and the Composite for Remainder.
- The Program received the lowest attribution score for the Composite for Remainder. The Program received a total score of about 26% for this group of standards combined.

Summary of Intermediate Evaluation Results

Table 3 presents a summary of the values estimated in each step of the evaluation for appliance standards. Table 4 presents a summary of the values estimated in each step of the evaluation for the building standards.

Table 3. Appliance Standards Intermediate Results

Standard	Potential Savings			Compliance Rate	Natural Market Adoption			Final Attribution Score
	GWh	MW	M-therms		2006	2008	Maxi-mum	
STD 1: Commercial Refrigeration, Solid Door	9.1	1.2	0	70%	56.8%	68.0%	78.7%	80.1%
STD 2: Commercial Refrigeration, Transparent Door	12.2	1.6	0	70%	27.4%	38.3%	49.5%	80.1%
STD 3: Commercial Ice Maker Equipment	6.5	0.9	0	70%	19.6%	22.8%	24.8%	79.8%
STD 4: Walk-In Refrigerators/Freezers	72.1	9.5	0	88%	17.1%	22.7%	41.3%	80.9%
STD 5: Refrigeration Beverage Vending Machines	15.1	2.0	0	37%	70.6%	86.4%	95.7%	62.5%
STD 6: Large Packaged Commercial AC, Tier 1	13.5	7.0	0	70%	20.9%	28.1%	35.0%	76.6%
STD 7: Large Packaged Commercial AC, Tier 2[1]	0	0	0	70%	8.5%	9.3%	10.2%	74.9%
STD 8: Residential, Pool Pumps and Motors Tier 1	35.5	6.8	0	94%	12.2%	13.5%	22.9%	79.6%
STD 9: Residential, Pool Pumps and Motors Tier 2[2]	0	0	0		5.7%	6.7%	10.7%	79.0%
STD 10: Portable Electric Spas	18.04	3.4	0	70%	--[4]	--[4]	--[4]	82.8%
STD 11a: General Service Incandescents Tier 1[3]	0	0	0	69%	3.5%[5]	4.4%[5]	8.6%[5]	73.5%

[1] The potential energy savings for STD 7 is zero because federal standards preempted the Large Packaged Commercial AC Tier 2.

[2] For STD 9 the generated potential savings are out of the scope of this evaluation because it was determined to be the result of post 2006 program activity.

[3] For STD 11a, the main reason for the potential savings to be zero is because the manufactures kept the same wattage and increased lighting lumens to comply resulting in no actual energy savings. (For STD 11 b General Incandescents Tier 2, the generated potential savings are out of the scope of this evaluation because it was determined to be the result of post 2006 program activity).

Standard	Potential Savings			Compliance Rate	Natural Market Adoption			Final Attribution Score
	GWh	MW	M-therms		2006	2008	Maxi-mum	
STD 12a: Pulse Start Metal Halide HID Luminaires, (Vertical Base-Up only)	118.0	21.0	0	48.1%	16.3%	26.8%	73.7%	74.5%
STD 12b: Pulse Start Metal Halide HID Luminaires, (All)	166.6[6]	29.7[6]	0	51.9%	16.3%[5]	26.8%[5]	73.7%[5]	74.5%[4]
STD 13: Modular Furniture Task Lighting Fixtures	5.57	1.0	0	70%	67.1%	78.8%	94.0%	82.6%
STD 14 Commercial, Hot Food Holding Cabinets	6.44	0.9	0	70%	19.8%	38.8%	86.0%	73.0%
STD 15: External Power Supplies Tier 1	103.0	11.7	0	100%	24.9%	38.4%	67.0%	57.7%
STD 16: External Power Supplies Tier 2	121.7[7]	13.9	0	98.7%	10.0%	17.9%	43.3%	57.7%
STD 17: Compact Audio Products	49.3	5.6	0	100%	46.0%	62.6%	79.9%	81.4%
STD 18a: Televisions	62.1	7.1	0	96.1%	63.1%	77.7%	87.2%	81.4%
STD 18b: -DVDs	11.8	1.3	0	31%	46.4%	55.7%	75.4%	81.4%
STD 19: Water Dispensers	6.15	0.8	0	70%	27.8%	39.8%	60.7%	79.5%
STD 20: Unit Heaters and Duct Furnaces	--	--	2.47	100%	25.3%	26.2%	30.7%	72.8%
STD 21: Pre-rinse Spray Valves[8]	0.0	0.0	0.0	100%	16.0%	33.8%	82.7%	64.4%

[4]The original natural market adoption values from the SES analysis were assumed. Refer to Appendix J for further discussion.

[5]Tier 1 values were assumed to be the same as the values estimated for Tier 2.

[6] These numbers represent the total number of potential savings including Tier 1 and Tier 2. The incremental potential savings for Tier 2 are: 48.2 GWh and 8.7 MW.

[7] These numbers represent the total number of potential savings including Tier 1 and Tier 2. The incremental potential savings for Tier 2 are: 18.6 GWh and 2.1 MW.

[8]The potential savings are zero because the federal standards established a new baseline equivalent to STD 21 (pre-rinse spray valves).

Table 4. Building Standards Intermediate Results

Standard	Potential Savings			Compliance Rate	Natural Market Penetration			Final Attribution Score
	GWh	MW	M-Therms		2006	2008	Maxi-mum	
B1: Time Dependent Valuation, Residential[1]	0	0	0	-	-	-	-	82.6%
B2: Time Dependent Valuation, Nonresidential[1]	0	0	0	-	-	-	-	85.2%
B3: Residential Hardwired Lighting	45.0	2.07	0	113 %	8.5%	14.1%	29.5%	87.7%
B4: Ducts in Existing Residential Buildings	6.3	9.4	1.2	59%	9.6%	13.4%	17.5%	69.3%
B5: Window Replacement	25.4	9.7	1.18	80%	29.2 %	36.6%	50.5%	55.2%
B6 NonRes Skylights	12.73	0	0	8.3%	7.5%	13.1%	50.0%	93.9%
B7 NonRes Duct Sealing Alts	11.45	8.7	1.22	75%	12.4%	15.4%	18.0%	73.9%
B8 NonRes Cool Roof	18.3	11.9	-0.252	75%	2.5%	5.6%	35.2%	81.7%
B9 Relocatable Classrooms	2.9	0	0	100%[2]	[3]	[3]	[3]	81.3%
B10 Bi-level Lighting Ctrls	1.65	0	0	78.7%	4.5%	6.1%	26.5%	75.4%
B11 NonRes Duct Sealing NewCon	2.39	1.24	0.012	81.5%	6.1%	13.2%	58.0%	80.5%
B12 NonRes Cooling Towers	3.01	0	0	87.5%	[2]	[2]	[2]	80.3%
B13 MF Res Water Heating	0	0	0.31	78.1%	[2]	[2]	[2]	82.8%
B14 Composite for Remainder	Res: 2.23 Nonres: 85.6	Res: 3.13 Nonres: 21.3	Res: 0.65 NonRes: -0.22	85.3%	[2]	[2]	[2]	26.1%
B15 Whole-House a. Electric b. Natural Gas	47.6	2.77	 0.72	 120% 235%	 1.9%[4] 0.6%[4]	 2.1%[4] 0.8%[4]	 -- --	87.7%[5]

[1] The reason the potential savings are zero is because

[2] None of the relocatable classrooms we investigated had the labels on them required by Title 24 and, thus, technically did not comply with the standards. However, according to the EnergyPro runs conducted for them they all met the performance requirements of Title 24.

[3] The NOMAD values for these standards were set to the values used in the SES and were not estimated as part of this study.

[4] The natural market penetration values for whole house savings are based on what percent of potential savings would have been achieved without the standards.

[5] Attribution for whole house savings was assumed to be the same as the value for the Hardwired Lighting Standard since it was the major standard adopted for residential buildings.

Program Energy Savings and Demand Reductions

The C&S Program, through its activities prior to 2006, produced significant verified energy savings during the period 2006 through 2008.Overall, the evaluated energy savings of the C&S Program were higher for electricity than the value claimed by the utilities and lower for natural gas. The net savings after accounting for all the adjustments to the potential savings are shown in Table 5 along with the savings claimed by the utilities. The savings shown are those achieved in the IOU service areas only and adjusted by the **50% factor** required by the CPUC during this cycle.

In general, the verified electricity savings are slightly more than the claimed savings, while the verified demand and natural gas savings are less than the claimed amounts. In the aggregate, the realization rates were 113%, 80%, and 91% for electricity, demand, and natural gas savings, respectively. Overall, the Program has made a significant contribution toward energy savings in buildings and appliances.

Table 5. Verified and Claimed Savings by Utility

IOU and Year	Electricity (GWh)		Demand (MW)		Natural Gas (MTherms)	
	Verified	Claimed	Verified	Claimed	Verified	Claimed
PG&E						
Period						
2006	45.9	42.9	9.0	12.1	0.8	0.9
2007	57.9	42.7	11.0	11.8	0.8	0.8
2008	54.1	54.6	10.6	14.2	0.7	0.8
2006-08	157.9	140.3	30.6	38.1	2.2	2.4
SDG&E						
2006	10.7	10.1	2.1	2.8	0.09	0.1
2007	13.5	10	2.6	2.8	0.09	0.1
2008	12.7	12.8	2.5	3.3	0.08	0.1
2006-08	37.0	32.8	7.2	8.9	0.25	0.3
SCE						
2006	47.3	44.3	9.3	12.4	N/A	N/A
2007	59.7	44.1	11.3	12.2	N/A	N/A
2008	55.8	56.3	10.9	14.7	N/A	N/A
2006-08	162.9	144.7	31.5	39.3	N/A	N/A
SCG						
2006	N/A	N/A	N/A	N/A	1.2	1.4
2007	N/A	N/A	N/A	N/A	1.2	1.3
2008	N/A	N/A	N/A	N/A	1.1	1.2
2006-08	N/A	N/A	N/A	N/A	3.5	3.9
Total (all IOUs) for 2006-08	**357.8**	**317.8**	**69.2**	**86.3**	**6.0**	**6.6**
Statewide Realization Rates for 2006-08	**113%**		**80.0%**		**90.9%**	
*Note that claimed savings are based on 50% of amounts in the SES and verified savings are also 50% of the ex post evaluated quantity.						

Recommendations

Our major programmatic recommendations include the following:

- Continue to identify and target both appliance and building standards with large potential energy savings that address needs identified in the California Strategic Energy Plan and the CPUC energy goals.
- Continue coordination of Program among the utilities to leverage resources and expertise.
- Articulate, communicate, and implement a comprehensive strategy linking DSM programs and activities to the C&S Program and long-term strategic goals.
- Fully integrate a process of increasing codes and standards compliance and enforcement into the overall C&S Program approach.
- Encourage the California Energy Commission to increase attention to areas such as appliance and building standard compliance to guarantee that anticipated savings are achieved.
- Document and clarify the role of activities less targeted and focused than the preparation of CASE reports to establish the linkage to the adoption of other standards.
- If codes are to remain an important element in the California Strategic Energy Plan, the CEC, the IOUs, associations of local governments, and the legislature need to collaborate to ensure that the enforcing entities work together with evaluators to allow reliable measurement of energy savings due to compliance. In particular, policies need to be implemented to ensure local code jurisdictions retain essential code compliance documentation. See Appendices G and H for details.

1. Introduction and Purpose of the Study

This document presents results of the California utility statewide Codes and Standards Program evaluation component of the New Construction/Codes and Standards project group for the 2006 through 2008 program years. This project group comprises the California investor owned utilities' (IOUs) extensive new construction portfolio covering the residential, multifamily and nonresidential markets. The IOUs include Pacific Gas and Electric (PG&E), San Diego Gas and Electric (SDG&E), Southern California Electric (SCE), and Southern California Gas (SCG).

As the title of the group implies, the New Construction, Codes and Standards Evaluation group consists of twenty-one utility energy efficiency programs focused on new construction or those supporting the California State Codes and Standards activities. The Programs evaluated by this contract group are broken down into five clusters: Residential New Construction, Nonresidential New Construction, Codes and Standards, Verification-Guided Evaluations and Tracking Only Programs.

This document presents the results for the statewide Codes and Standards Program (C&S Program) program area for 2006-2008 program years[1]. This Program and the evaluation are unique in several respects, including the fact that the 2006 and later impacts of C&S Program activities prior to 2006 are being assessed. This is because the savings are realized only after a code or standard is adopted and implemented in the market, which naturally succeeds the process of developing and adopting a new code or standard. Results for the other segments of the Group can be found in other volumes, the Nonresidential New Construction Volume (II) presents results for that program group and all the other segments are presented in the Residential New Construction Volume (I).

The four IOUs implement similar, coordinated programs to support upgrades of the Title 20 Appliance Efficiency Standards and Title 24 Building Energy Efficiency Standards. The utility programs are treated as a single cluster because of the high degree of coordination among the programs and their similarities. This Program contributed to the adoption of energy-efficiency building codes and appliance standards that went into effect in California between late-2005 and the end of 2008.

[1] In general, the term "code" refers to regulations applied to the construction of buildings and "standards" apply to appliances. However, the terms are used interchangeably in some venues and the California Code of Regulations, in which Title 24 appears, is known as the California Building Standards Code and the regulations are often referred to as the Title 24 Building Standards or just Title 24.

Per California Public Utilities Commission (CPUC) decisions, verified savings attributed to the C&S Program activities conducted prior to 2006 can be counted toward the utility savings goals:

> In evaluating whether the 2006–2008 portfolios actually meet or exceed the adopted goals for that program cycle on an ex post basis, the utilities should credit 50% of the verified savings associated with pre-2006 codes and standards advocacy work toward the goals, subject to the conditions described above.
>
> Whether savings from pre-2006 codes and standards advocacy work should also count toward the updated goals for 2009 and beyond shall be determined after further consideration of the baseline and related issues discussed in this decision.[2]

The ex post verified savings associated with the pre-2006 C&S Program activities are the focus of this evaluation. The study's intent is to determine the impacts of the Program activities conducted prior to 2006 that led to adoption of the standards in effect during the period 2006 through 2008.

1.1 Codes & Standards Program Overview

The utilities conduct several types of activities to support new standards, although individual utilities may emphasize certain activities more than others. The utility efforts include:

- Holding workshops and meetings to identify promising candidates for new standards.
- Performing targeted research that sets the stage for or "enables" the development of new standards.
- Working with California Energy Commission (CEC) staff to resolve specific issues, generate necessary data, and facilitate the adoption process.
- Performing or funding Codes and Standards Enhancement Initiative studies (CASE reports or CASE studies) that analyze and document the key information needed as the basis for adopting a specific standard.
- Participating in public C&S hearings and workshops.
- Identifying testing needed as the basis for a new standard.

[2] CPUC. September 11, 2007. D0509043 Interim Opinion: Energy Efficiency Portfolio Plans and Program Funding Levels for 2006-2008 - Phase 1 Issues.

- Working with industry and other stakeholders to identify and promote opportunities for new standards.
- Implementing acquisition programs that promote technologies for which standards will later be proposed.

The basic C&S program theory links the activities described above to outputs that include CASE studies, test methods, stakeholder outreach, and participation in CEC C&S proceedings. These outputs feed into the CEC proceedings, leading to code adoption. The utilities are also supporting some training and education efforts, which assist with enforcement and compliance. The utilities are also planning to implement compliance enhancement efforts, but these are not being assessed in this current evaluation.

The C&S Program is unique in many respects: a key one for evaluating program impacts is that the codes and standards savings of interest resulted from relevant IOU C&S Program efforts expended mostly prior to 2006. Consequently, the expenditures occurred in the period prior to when the savings were achieved.

The effect of a new code or standard is to place a legal floor on the efficiency level of buildings or appliances that can be sold in the market. Energy-efficiency levels in the market are distributed over a range of values and there is an average efficiency value. In effect, standards should alter the distribution of items in the market to eliminate those using more than a certain amount of energy. This not only reduces the maximum energy consumption allowed, but it also should reduce the average consumption because of the altered distribution of efficiency levels.

Several factors, however, complicate this picture and the assessment of energy savings resulting from codes and standards. Because the energy usage levels in the market are distributed over a range, savings from a standard should be estimated based on the pre- and post-averages; however, sufficiently detailed efficiency data are rarely available to estimate average consumption accurately. Lack of detailed market efficiency data also make it problematic to estimate the aggregate energy consumption of items prohibited by a standard. Also, a new standard may have complicated effects on the market and change the shape of the distribution, not just eliminate part of the distribution. This changes the average energy use beyond the effect of eliminating the least efficient items. In addition, experience shows that assuming all non-complying appliances and buildings are eliminated from the market by a new standard is an overly optimistic assumption.

Finally, building standards pose special complexities because they are not usually limited to setting prescriptive efficiency requirements for building components. Title 24 and most other building efficiency standards with component prescriptive requirements also permit compliance

with “performance” or “tradeoff” approaches. These approaches make it difficult to evaluate the energy impacts of an individual measure covered by the standard because other building components may deliver the savings that would have been provided by that measure.

1.2 Evaluation Objectives and General Approach

The overall purpose of this evaluation is to determine the energy and demand savings attributable to the IOU’s C&S Program activities that were designed to promote adoption of the Title 20 standards and Title 24 codes that went into effect from October 2005 through 2008. The parameters examined in this EM&V study are directly dependent on the methodology used to analyze the Program impacts discussed in the next section and several appendices. The list of codes and standards that are evaluated for the 2006-08 C&S evaluation are shown in Table 6 and Table 7 and are included in Appendix A. Although we analyzed factors related to their savings, energy savings from the Residential Pool Pumps, 2-speed Motors, Tier 2 and General Service Incandescent Lamps, Tier 2 were not included in the evaluation because significant activities leading to their adoption occurred after 2005. These standards will need to be included in the evaluation of the post-2005 C&S during the next evaluation cycle.

Table 6. Appliance Standards Analyzed in Evaluation

Appliance Standard I.D.	Appliance Standard Name	Implementation Date
Std1	Commercial Refrigeration Equipment, Solid Door	Jan-06
Std2	Commercial Refrigeration Equipment, Transparent Door	Jan-07
Std3	Commercial Ice Maker Equipment	Jan-08
Std4	Walk-In Refrigerators / Freezers	Jan-06
Std5	Refrigerated Beverage Vending Machines	Jan-06
Std6	Large Packaged Commercial Air-Conditioners, Tier 1	Oct-06
Std7	Large Packaged Commercial Air-Conditioners, Tier 2	Jan-10
Std8	Residential Pool Pumps, High Efficient Tier 1	Jan-06
Std9	Residential Pool Pumps, 2-speed Motors, Tier 2[1]	Jan-08
Std10	Portable Electric Spas	Jan-06
Std11a	General Service Incandescent Lamps, Tier 1	Jan-06
Std11b	General Service Incandescent Lamps, Tier 2[1]	Jan-08
Std12a	Pulse Start Metal Halide (MH) HID Luminaires (Vertical, Base-Up only) 1	Jan-06
Std 12b	Pulse Start Metal Halide (MH) HID Luminaires (All)	Jan-08
Std13	Modular Furniture Task Lighting Fixtures	Jan-06
Std14	Hot Food Holding Cabinets	Jan-06
Std15a	External Power Supplies, Tier 1[2]	Jan-07
Std15b	External Power Supplies, Tier 1[3]	July-07
Std16	External Power Supplies, Tier 2	Jul-08
Std17	Consumer Electronics – Audio Players	Jan-07
Std18a	Consumer Electronics – TVs	Jan-06
Std18b	Consumer Electronics – DVDs	Jan-06
Std19	Water Dispensers	Jan-06
Std20	Unit Heaters and Duct Furnaces	Jan-06
Std21	Commercial Dishwasher Pre-Rinse Spray Valves	Jan-06

[1] These two standards were post-2005 Tier 2 upgrades of the standard adopted prior to 2006 and their savings are not included in this evaluation.

[2] External Power Supplies for laptop computers, mobile phones, printers, print servers, PDAs and digital cameras

[3] External Power Supplies for wire line telephones and all other devices

Table 7. Building Standards Analyzed in Evaluation

Building Standard ID	Building Standard Name	Implementation Date
StdB1	Time Dependent Valuation, Residential	Oct-05
StdB2	Time Dependent Valuation, Nonresidential	Oct-05
StdB3	Residential Hardwired Lighting	Oct-05
StdB4	Duct Sealing Requirement Upon Residential HVAC or Duct-System Replacement	Oct-05
StdB5	Window Efficiency Requirements Upon Window Replacement Final Report	Oct-05
StdB6	Updates to Title 24 Treatment of Skylights	Oct-05
StdB7	Air Distributing Systems – Retrofit Commercial Ducting	Oct-05
StdB8	Cool Roof	Oct-05
StdB9	High Performance Relocatable Classrooms	Oct-05
StdB10	Lighting Controls – Bi-Level Lighting	Oct-05
StdB11	Air Distributing Systems – New Construction Ducting	Oct-05
StdB12	Cooling Towers	Oct-05
StdB13	Multifamily Water Heating	Oct-05
StdB14	Composite for Remainder	Oct-05

The complex effects of standards, characteristics of the C&S Program, requirements of the evaluation, and the need to focus on past utility activities, introduced differences between the evaluation approach for the C&S Program and the approaches used to evaluate more typical resource acquisition programs. This evaluation is based on the C&S Program Evaluation Protocol,[3] which is consistent with the existing spreadsheet methodology for estimating C&S impacts (the Savings Estimate Spreadsheet, or SES, was developed by HMG).[4] The evaluation follows the EM&V activities described in the evaluation plan[5] published in February 2008 with some modifications as follows:

[3] The TecMarket Works Team. 2006. California Energy Efficiency Evaluation Protocols: Technical, Methodological, and Reporting Requirements for Evaluation Professionals. Prepared for the California Public Utilities Commission.

[4] Heschong Mahone Group, Inc. 2005 (Revised November 1). Codes and Standards Program Savings Estimate for 2005 Building Standards and 2006/2007 Appliance Standards. Prepared for Joint Utilities.

[5] KEMA (formerly RLW Analytics, Inc.), et al. 2008. *New Construction/Codes & Standards Direct Impact Evaluation*. Prepared for California Public Utilities Energy Division.

- A new term, "Potential Standards Energy Savings," was defined as the magnitude of energy savings that would result from every appliance or building standard measure covered by new standards just meeting the standards, assuming that they would have had an efficiency equal to the baseline in the absence of the new standard.
- "Gross Standards Energy Savings" were defined as Potential Standards Energy Savings adjusted by the compliance rate.
- An approach for analyzing Title 24 impacts at the whole-building level was developed.
- The Normally Occurring Standards Adoption factor was eliminated.

The approach requires netting out the effects of natural market trends for adoption of high-efficiency measures. The effect of non-compliance must also be taken into account. Allocation of the overall impacts of the codes and standards must then be assessed to quantify the savings due to the C&S Program. Finally, savings must be allocated to individual utilities.

A cross-cutting activity in the C&S evaluation is the development of an integrated model to conduct the overall impact analyses, much as the existing SES does. Several types of data required for this evaluation are not suitable for conventional uncertainty and sample error analyses; it is important, however, to assess the effects of uncertainties in the key inputs to the analysis and their cumulative effects. Consequently, the integrated model has the capability to incorporate uncertainties in each of the major inputs and estimate their combined effects on the energy savings estimates.

In addition to collecting and analyzing data necessary to estimate the effects of the existing C&S, our activities included ongoing monitoring and documentation of current Program efforts to upgrade both Title 20 and 24. This activity has involved attending workshops and meetings, and reviewing materials and documents prepared in support of C&S enhancements. There are two primary reasons to perform this monitoring and review. First, it will provide a basis, as required by the protocol, for evaluation of current C&S Program efforts. Second, it will help reveal enhancements to the protocol that could be implemented in the future.

2. C&S Evaluation Methodology

This section presents an overview of the methodology used to evaluate the impacts of the utility statewide Codes & Standards Program that promotes adoption of energy-efficiency requirements for buildings and appliances.[13] The methodology employed in this evaluation is based on the adopted California evaluation protocol.[14]

Per California Public Utilities Commission (CPUC) decisions, verified savings attributed to the C&S Program activities conducted prior to 2006 can be counted toward the utility savings goals:

> "In evaluating whether the 2006–2008 portfolios actually meet or exceed the adopted goals for that program cycle on an ex post basis, the utilities should credit 50% of the verified savings associated with pre-2006 codes and standards advocacy work toward the goals, subject to the conditions described above.
>
> "Whether savings from pre-2006 codes and standards advocacy work should also count toward the updated goals for 2009 and beyond shall be determined after further consideration of the baseline and related issues discussed in this decision."[15]

The ex post verified savings associated with the pre-2006 C&S Program activities are the focus of this evaluation. The study's intent is to determine the impacts of the Program activities conducted prior to 2006 that led to adoption of the standards in effect during the period 2006 through 2008.[16] The only savings that can be counted toward utility goals are those in the IOU service areas and, as noted above, the utilities receive credit for only 50% of verified savings during the period 2006-2008.

The California Energy Commission (CEC) has the responsibility and authority to adopt appliance and building standards. The appliance standards are contained in Title 20 of the California Administrative

[13] There is considerable variation among authors in the use of the terms "code" and "standard." The general practice is to use "code" when referring to requirements for buildings and "standard" when referring to appliance requirements. In general, we follow that practice in this report, but use the terms interchangeably in some cases. The building energy codes in California are formally referred to as standards so some overlap is unavoidable.

[14] California Public Utilities Commission [CPUC]. 2006. California Energy Efficiency Evaluation Protocols: Technical, Methodological, and Reporting Requirements for Evaluation Professionals.

[15] CPUC. September 11, 2007. D0509043 Interim Opinion: Energy Efficiency Portfolio Plans and Program Funding Levels for 2006-2008 - Phase 1 Issues.

[16] Note that the Title 24 building standards went into effect for all buildings permitted from October 2005 on.

Code, and the building standards are contained in Title 24, Part 6 of the California Administrative Code. The appliance standards apply to a diverse set of appliances. The building standards apply to both residential and nonresidential new construction and major renovations.

The C&S Program has evolved over several years into a coordinated statewide effort involving all investor owned utilities (IOUs). The Program has played a growing role in the process of advocating for new standards by proposing standards changes to the CEC, providing supporting data and studies, interacting with industry and federal agencies, developing test procedures, and more. One of the primary products of the Program has been a series of Codes and Standards Enhancement (CASE) Initiative Project studies, often referred to as CASE reports or CASE studies. The IOUs have moved toward fully integrating their C&S Program activities into their overall program efforts to increase energy efficiency.

2.1 Evaluation Approach Background

2.1.1 Prior Analyses

The utilities' claimed savings for 2006–2008 from their preceding C&S Program activities are based on the results calculated in a spreadsheet referred to as the Savings Estimate Spreadsheet (SES). The current version of the SES is posted on the CPUC Web site.[17]

The methodology embedded in the SES is documented in a 2005 report,[18] and inputs to the spreadsheet were updated in a 2007 study.[19] The methodology is very similar to the basic approach outlined in the California evaluation protocol.

The SES takes the approach of analyzing savings from each standard individually. Key inputs include estimated unit energy savings and market sales/installations, compliance rates, an adjustment for naturally occurring market adoption, an adjustment for normally occurring standards adoption, measure

[17] http://www.cpuc.ca.gov/NR/rdonlyres/493034FB-7A64-4FEE-BD49-5C98E24DA982/0/TotalCSSavingsHMG_v3forevaluation.xls

[18] Mahone, D. November 1, 2005. *Codes and Standards Program Savings Estimate For 2005 Building Standards and 2006/2007 Appliance Standards.* CALMAC Study ID: SCE0241.01. Prepared for Joint Utilities by Heschong Mahone Group (HMG).

[19] Khawaja, M.S., A. Lee, and M. Levy. 2007. *Statewide Codes and Standards Market Adoption and Noncompliance Rates.* Study ID: SCE0224.01. Prepared for Southern California Edison by Quantec, LLC.

life, and an attribution factor used to calculate what share of the savings are attributable to the C&S Program. The SES also allocates credit for the net Program savings to individual utilities using an allocation based on energy sales.

Analyzing each standard in isolation presents difficulties when trying to estimate savings from the building standards. The reason is that Title 24 permits tradeoffs among measures as long as the building as a whole meets a total budget requirement (performance approach). The SES does not have the capability to accommodate this option. This issue and the evaluation team's approach to addressing it are discussed later in this chapter.

Another complication in the SES methodology is the treatment of building standards for which no CASE report was prepared. The methodology lumps these codes into a catchall category, the Composite for Remainder (CfR). The methodology treats this composite the same as the individual standards and applies a series of factors to the gross CfR savings to estimate net energy savings attributed to the Program. The aggregation of multiple standards, for which the Program made limited contributions to furthering their adoption, complicates the process of developing appropriate values for the adjustment factors listed above.

2.1.2 Overview of Existing California C&S Evaluation Protocol

The California evaluation protocol report presents the C&S evaluation protocol for documenting savings from the California C&S Program.[20] The protocol notes that evaluations of such programs "are best contracted prior to and launched at the same time that the CEC is assessing which technologies should be considered for the next round of codes or standards changes."[21] Given that this evaluation was conducted well after the existing standards were being developed, it was not possible to follow this guidance. Consequently, the approach had to be adapted. Also, this is the first formal evaluation of the C&S Program using the protocol, so it represents a learning experience as well as a test of the protocol. In addition to savings estimates, this evaluation provides recommendations for refinements to the protocol for future applications. The protocol document recognizes this situation and notes, "As [the

[20] CPUC 2006, *op. cit.*., pp.81-104.
[21] *Ibid.*, p. 81.

protocol is] used and tested over the next few program cycles, it will need to be updated to reflect the experiences of the first sets of evaluations conducted…"[22]

The evaluation activities presented in the protocol are discussed briefly below along with focused comments about applicability to this study. The activities include:

i. Assessment of the code and standard change theories
ii. Identification of which codes and standards to evaluate
iii. Assessment of gross market level impacts
iv. Assessment of the Program's effect on standards adoption (attribution)
v. Analysis of naturally occurring market adoption
vi. Analysis of compliance with the codes and standards
vii. Adjustment for normally occurring standards adoption
viii. Other steps

i. Assessment of the Code and Standard Change Theories

The first step is to review the code or standard change theories. Similar to a program theory, these documents focus on the specific measure or technology covered by the standard. The change theory is similar to a program theory, but it focuses on the measures included in the code or standard change, and the theoretical approach that the program is using to bring about the change. The change theory should present a story of how the program moves from the development of a change concept to completion of the code or standard change and a description of the savings expected. It should also include an estimate of the difference in the penetration of the code or standard-covered technologies between the pre-code adoption market and the post-code adoption market. The change theory should identify the activities the Program undertakes to move from a change concept to a successful code or standard change. The theory is intended to be the key document used to guide the evaluation and is the responsibility of the utilities to develop.

Given that this protocol had not been applied before, the utilities had not developed such theories for the standards included in this study when the evaluation began. During the course of our evaluation,

[22] *Ibid.,* p. 82.

the CPUC asked the utilities to develop these documents, and they were prepared and delivered during the course of the evaluation. Given that the code change theories were not available prior to when the evaluation team developed the evaluation plan, it was not possible to use these theories to a significant extent in developing the overall evaluation approach; however, they were used in the attribution analysis, as discussed later.

ii. Identification of Codes and Standard for Evaluation

In each cycle, the CEC typically adopts several standards. Therefore, the C&S Program evaluation needs to identify which standards will be included. The protocol states that the codes and standards to include are those for which:

- The Program has developed a code/standard change theory and logic model,
- The standard has been adopted or is expected to be adopted by at least one public jurisdiction, and
- The change theory provides a reasonable cause and effect relationship indicating the Program's effect on adoption.

For purposes of the current evaluation, we assessed all the codes and standards included in the SES and claimed savings as well others that were implemented during the 2006-08 period.

iii. Assessment of Gross Market-Level Energy Impacts

The protocol requires the evaluator to conduct a load impact evaluation of savings from technologies covered by the code or standard changes and refers to these as gross savings. The protocol indicates the evaluator is to use the Impact Evaluation Protocol. The protocol allows for a less rigorous approach, however, if budget or timeline limits require or if the Program's estimates and supporting documentation are found to be reliable.

iv. Assessment of the Program's Effect on Standards Adoption (Attribution)

The evaluation team must establish a percent attribution factor for the savings from each standard that can be attributed to the Program. The protocol recommends a stakeholder interview-based preponderance of evidence approach, with interviews conducted at different points in time along the adoption path during the pre-adoption and post-adoption period.

Under the protocol, interviews are to be supplemented with information from reviews of program materials and documents as well as attendance at Program events. This information is to be used to assign causation percentages in as objective a manner as possible.

v. Analysis of the Naturally Occurring Market Adoption

Naturally occurring market adoption (NOMAD) is the projected estimate of the market penetration of the energy-efficient products and measures that would have occurred without adoption of the standard. The protocol notes that such adoption rates typically follow an "S" shape pattern over time that never reaches 100% of the market.

The evaluator is to establish expected adoption curves for each technology included. Expert opinions, literature reviews, and other approaches are recommended as resources.

vi. Analysis of Compliance with the Codes and Standards

Gross savings are to be adjusted also for non-compliance because not all buildings or appliances in the market will fully comply with the standard. The evaluator must estimate non-compliance for each technology included.

The non-compliance rates are to be estimated using interviews with key market actors and other assessment approaches. The evaluation should be sensitive to variations across the state and over time.

vii. Adjustment for Normally Occurring Standards Adoption

The protocol also includes an adjustment to savings to reflect the likelihood that the same standards would have been adopted without the Program, but it would have taken a much longer time. This effect is referred to as Normally Occurring Standards Adoption (NOSAD). The protocol indicates the Program should receive credit for savings from a standard only for the period when the covered measure would not have been covered by a revised code or standard during the normal course of the update cycle.

Under the protocol, the evaluator is to establish an expert panel familiar with and involved in code change efforts. A minimum two-round Delphi process is recommended to derive an estimate of when the CEC would have adopted the standard in the absence of the Program.[23]

[23] The Delphi process is an iterative process with feedback. It is described in more detail later.

viii. Other Steps

Building construction rates and appliance sales could differ from the values used in the initial evaluation. The protocol provides for regular updates using actual market data to revise these inputs.

Measure life adjustments are not included in the protocol because it is assumed that once a measure is adopted in response to a code or standard change, the same efficiency level will be repeated until the code or standard is eliminated or updated.

2.1.3 Significant Revisions to Evaluation Methodology

Two notable revisions were made to the original impact evaluation methodology outlined in the protocol during the course of this evaluation and they are described briefly in this section:

(a) Elimination of Adjustment for Normally Occurring Standards Adoption (NOSAD)

(b) Analysis of Title 24 Whole Building Performance

Other refinements or adjustments to the basic methodology occurred during the course of this evaluation and they are described in subsequent sections.

i. Elimination of Adjustment for Normally Occurring Standards Adoption

As noted above, NOSAD was a factor in the original evaluation protocol intended to adjust savings based on when a code/standard would have been adopted if the C&S Program had not existed. A memorandum developed by the evaluation team dated September 5, 2008,[24] and submitted to the CPUC for ED approval presents the case for eliminating this factor in analyzing the C&S Program impacts. The reason NOSAD was eliminated is summarized briefly in the following paragraphs. NOSAD is based on the idea that the C&S Program accelerates adoption of a new code/standard, but without the C&S Program the same code/standard would have been adopted by the CEC at some year in the future. The protocol specifies that the Program should no longer be awarded energy savings credit after that point in time.

The NOSAD adjustment originated in the savings analysis methodology developed by HMG and described in a November 2005 report on the savings analysis.[25] The main consequence of applying

[24] The Cadmus Group. September 5, 2008. "Cadmus's NOSAD Review and Recommendations."
[25] Mahone, *op. cit*.

NOSAD is that savings are no longer credited to the C&S Program once the number of years defined by NOSAD is reached.

As documented in the 2005 report, a group made up of CEC staff, utility personnel, and consultants to the utilities established NOSAD values for each code/standard based on their judgment. As described in the report, NOSAD was implicitly linked to the attribution of credit to the C&S Program because NOSAD would be relatively short for those standards for which the Program would not have to contribute much effort to get them adopted and, conversely, relatively long for standards that would require a fairly intensive Program effort.

Our review raised two primary, interconnected concerns about the application of NOSAD:

- First, the way NOSAD accounts for impacts of the C&S Program does not adequately address how the Program affects the actual process. Specifically, the approach overlooks the practical effect of the C&S Program to free up CEC and other resources to adopt codes/standards. In effect, resources dedicated to the C&S Program do two things: (1) accelerate when a specific standard is adopted and (2) increase the number of standards adopted and, therefore, the total savings achieved from new standards over time. The effect of applying a NOSAD factor is to inappropriately discount impacts of the Program.

- Second, the relationship between C&S Program attribution and the NOSAD value introduces logical problems and can bias the savings credited to the Program. For example, if a standard were on the verge of being adopted, but would not be adopted until three years later without the Program, the Program would receive little attribution credit and savings credited to the Program would be discontinued beyond three years because of NOSAD. This implicit correlation between NOSAD and attribution tends to inappropriately discount the effect twice.

For these reasons and others presented in the memorandum, the CPUC ED has eliminated NOSAD from the C&S Program savings framework and recommended eliminating it from future protocols, when published. The type of effect NOSAD was originally intended to account for is better addressed through the attribution analysis (see Section 2.2.4).

ii. Analysis of Title 24 Whole Building Performance

As described earlier, the original savings analysis for Title 24 used a prescriptive, measure-by-measure analytical approach and did not address performance-based, whole-building compliance with the standards. The evaluation team has developed a methodology to allow for analysis at the whole-

building level by using the basic evaluation protocol and the components embedded in the SES. The methodology is described briefly here and was presented in more detail in a March 16, 2009 memo submitted to the CPUC (see Appendix B*).*[26]

A new term was defined in the course of developing the whole-building compliance method. Gross savings are by convention defined as the change in load or consumption of a program participant. For purposes of analyzing the C&S Program impacts, we can quantify the savings as the difference in load of a building built to the 2005 Title 24 and one built as it would have been without adoption of the 2005 Title 24 (baseline). Defining a program participant is more challenging, however, because there is really no program to which buildings can subscribe or not subscribe—all buildings covered by the code are participants for this purpose.

As noted, the original SES methodology was constructed to estimate savings at the measure level and did not address whole buildings. The perspective taken was that the measure ex ante gross savings was the difference between the energy use of a baseline measure and a measure meeting the 2005 Title 24. Total gross savings for a Title 24 standard were defined as the savings per measure times the projected number of new buildings. The fact that measures not meeting the standard were likely to be installed, despite adoption of the standard, was addressed through the compliance rate adjustment; gross savings were based on 100% compliance.

For this evaluation, the team of evaluators introduced a new term to describe the savings possible assuming 100% compliance with the standards—potential savings. This value represents the savings possible if all buildings just meet the 2005 Title 24 compared to the 2001 Title 24 baseline, and it is equivalent to the original SES gross savings if savings are summed across all measures covered by the new Title 24 standards. For evaluating savings from the C&S Program, the evaluators redefined gross savings to take into account the effect of any non-compliance that occurs. This makes gross savings more consistent with the conventional definition of the term since the "program" applies to all new buildings, but not all buildings fully implement the program measures if compliance is less than 100%.

Whole building performance analyses were conducted as part of this evaluation using the compliance model runs performed for all buildings, based on their as-built features. This new approach has the fundamental advantage of addressing energy savings for buildings as a whole without having to make assumptions about tradeoffs among efficiency measures.

[26] See http://www.energydataweb.com/cpuc/topicAdmin.aspx

The approach begins with the definition of potential savings:

$$PotSav = Cons2001 - Cons2005$$

where:

PotSav = Potential savings from 2005 Title 24

Cons2001 = Consumption under 2001 Title 24 requirements

Cons2005 = Consumption under 2005 Title 24 requirements

At the building or aggregate level, potential savings estimated for the 2005 Title 24 are the difference between energy consumption of buildings designed to meet 2005 standards and baseline buildings. For this evaluation cycle, 2001 Title 24 is used to define baseline buildings.[27]

Whole-building compliance and NOMAD must be analyzed differently than they were in the prescriptive case, but they can be analyzed in a way that is consistent with the SES. For the whole building analysis:

$$CR(t) = \frac{Cons2001 - ConsBuilt2005(t)}{PotSav} = \frac{GS}{PotSav}$$

where:

CR = Compliance rate in year t

ConsBuilt2005(t) = Consumption estimate of as-built building built in year t

GS = Gross savings

The time, t, is included because compliance with Title 24 could vary for buildings built in different years and would be reflected in ConsBuilt2005. Given the outputs produced by the compliance software, all the required quantities are available to calculate CR for individual buildings. Typically, CR would be less than 1.0, but if a building is more efficient than required by the 2005 Title 24 then its CR could be greater than 1.0.

Net savings from the 2005 Title 24 are then calculated as follows:

$$NetSavT24(t) = [GS - NOMAD(t)]$$

[27] *The results of the current evaluation could be used in the future to define the baseline for the next round of standards evaluation.*

where:

NetSavT24 = Net savings for whole buildings in year t due to the 2005 Title 24

NOMAD(t) = Natural energy savings that would have occurred without 2005 Title 24

The approach to estimate whole-building NOMAD is similar to the one used to estimate NOMAD values for individual standards described later. A group of experts provided their best estimates of trends in building energy consumption as if no new building standards had been adopted after the 2001 Title 24.

This approach to calculate compliance, NOMAD, and net savings before attribution is straightforward and very consistent with the methodology applied to individual measures (or appliances).

From the whole-building performance perspective, estimating attribution of net savings to the C&S Program is not as direct as assessing attribution for individual standards simply because the Program focused on individual measures. For this evaluation, therefore, attribution at the whole-building level relied on the attribution values calculated as described later for each measure. Then, the percent the ex post potential savings each measure contributes to the sum of ex post potential savings for all measures was calculated. These percentages provide weights to calculate the whole-building Program attribution value, which are simply the sum of the products of the attribution value for each Title 24 standard multiplied by its respective weight.

The net savings attributable to the C&S Program then are:

$$NetSav = (GS - NOMAD) * Att$$

where:

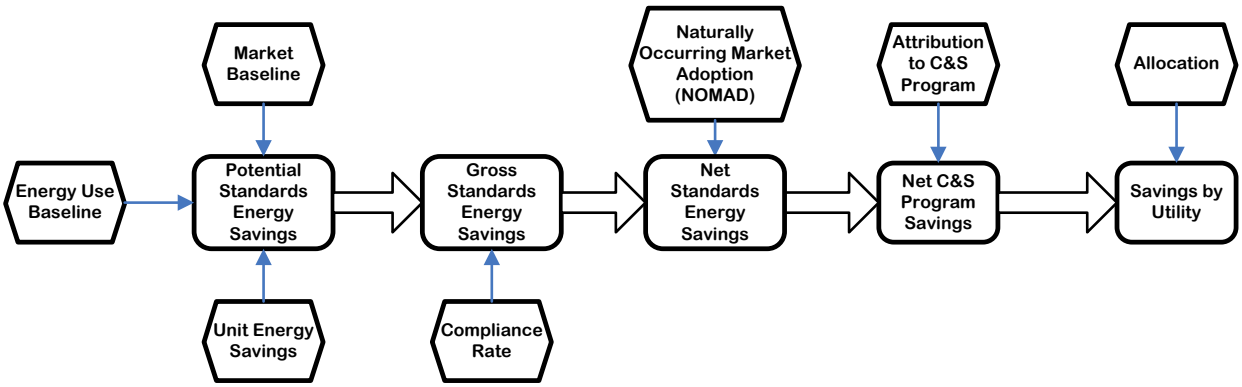
NetSav = Net savings attributable to C&S Program

Att = Whole-building attribution to C&S Program

2.2 2006-2008 C&S Program Evaluation Methodology

The C&S Program evaluation approach is illustrated in Figure 2. The components of the analysis were introduced briefly above. Each is summarized below the figure. More details are provided along with results of each analysis in subsequent sections.

Figure 2: Evaluation Methodology



The potential standards energy savings are based on the estimated unit energy savings and number of measures or appliances entering the market each year. Potential savings are adjusted by the compliance rate to derive gross standards energy savings. Net savings result from adjusting gross savings by the market penetration of measures or appliances (NOMAD) that would have occurred in the market without adoption of the code or standard. The resulting savings credited to the C&S Program are determined by calculating the attribution adjustment and the net Program savings are then allocated to individual IOUs. For purposes of crediting the utilities with savings from the Program, the CPUC has specified that the verified net savings by utility estimated by this evaluation be adjusted by a factor of 50% to determine the amount credited to each IOU. The analysis is implemented using an Integrated Standards Savings Model that incorporates all the data from the evaluation as inputs.

This section includes a detailed description of the evaluation methodology presented as follows:

- Potential Standards Energy Savings Analysis (Section 2.2.1)
- Compliance Analysis (Section 2.2.2)
- NOMAD Assessment (Section 2.2.3)

- Attribution Assessment (Section 2.2.4)
- Integrated Standards Savings Model Description (Section 2.2.5)
- Allocation Analysis (Section 2.2.6)

2.2.1 Potential Standards Energy Savings Analysis

For appliances and measures studied, the evaluators reviewed information presented in the sources used to estimate the inputs to the SES. Specifically, the original data and methodologies used to estimate the market baseline, energy/demand baseline, and unit energy/demand savings were assessed. Any errors, gaps, or inconsistencies were addressed.

For the building standards, data that could be used to estimate actual building starts were researched. For appliance standards, we attempted to obtain data on actual sales during the period analyzed, but, as discussed later, the only data available were typically more recent estimates than those used originally but from years prior to the effective date of the standard. As appropriate, data and inputs were updated and revised. The revised data were used to modify potential energy savings estimates for each standard.

Appliance Standards: The steps in this analysis were the following:

- Review potential savings in the SES. Review the CASE report for each appliance standard and the information presented in the HMG SES report.[28]
- Review per unit savings estimates: The per unit savings are the estimated reduction in energy consumption associated with moving from the existing baseline energy consumption to the energy consumption consistent with the proposed standard. The baseline is energy consumption of the appliance before the proposed standard went into effect, with initial values to be taken from the CASE reports. Savings include electricity, demand, and natural gas.
- Review sales data: Review sales data values and the sources used in the individual appliance CASE reports and/or the HMG savings estimate report.

[28] The spreadsheet was prepared by the Heschong Mahone Group (HMG) and is referred to as the Savings Estimation Spreadsheet (SES). HMG prepared a report documenting the savings calculations: *Codes and Standards Program Savings Estimate*, CALMAC Study ID: SCE0241.01, June 30, 2005. Most of the information on appliance standards is taken from the appendix to the HMG report, *Codes and Standards Enhancement Initiative For PY2003 - 2005: Title 20 Standards Development* prepared by Energy Solutions et al., June 9, 2005.

- Clarify methodology: Before making any adjustments to the potential energy savings estimates, submit questions to CASE report authors regarding all assumptions and estimates that cannot be determined from the CASE reports or that differ from what is presented in either the CASE report or the spreadsheet.
- Replicate first-year total potential energy savings, i.e., ensure all information is available to produce the same values calculated previously.
- Conduct thorough research to identify and obtain more recent data/information on all inputs where available. This includes sales data, savings estimates, etc.
- Revise potential savings estimates in those cases where more accurate methodologies and/or updated data are available.

The methods for analyzing potential energy savings from the appliance standards are presented in more detail in Appendix C.

Building Standards: The steps in this analysis were the following:

- Review potential savings in the SES by examining the CASE report for each building standard and the information presented in the HMG SES report.
- Locate the source of the savings estimate.
- Recreate the energy savings equation found in the CASE report.
- Apply assumed savings to the market data provided in the Impact Analysis and Evaluation reports.[29]
- Review recent data and information and update savings estimates as appropriate.

The details of the methodology for estimating potential energy savings from the building standards are presented in Appendix D.

[29] *The Impact Analysis of 2005 Update to the Building Energy Efficiency Standards*, June 2003. This report is an analysis of the statewide impact of the entire Codes and Standards Program, including components contributed by the California Energy Commission and its consultant, the IOUs, and other organizations that created and put forth code change proposals. Prepared by Eley Associates (Eley) and managed by the California Energy Commission. This document is referred to as the Eley report here.

2.2.2 Compliance Analysis

The compliance analysis consisted of two separate components: Title 20 appliance standards and Title 24 buildings standards. The approaches used differed between the two sets of standards.

i. Appliance Standards Compliance (Title 20)

This section discusses the methodology used to assess compliance of appliances covered by the new Title 20 standards in effect during the period 2006 through 2008. The evaluation team's approach for assessing Title 20 compliance was based on the methodology used in the 2007 compliance evaluation and the protocol presented in the California evaluation protocol document.[30,31] The scope of the 2007 study was expanded to include most appliances covered.[32]

Analysis of compliance with Appliance Standards included the following steps:

(1) Obtaining a list of complying appliances compiled in the CEC online database

(2) Prioritizing the evaluation activities on high impact energy savings appliances based on the SES estimates

(3) Obtaining the contact list for vendors that sell or distribute the regulated products

(4) Stratifying the list of vendors to categorize sites into three geographic regions: southern, central, and northern

(5) Visiting vendor sites to collect product specifications when available

(6) Populating a spreadsheet database with product details such as model number, specifications etc. and comparing the details with the CEC database to determine whether the model was listed indicating it was in compliance with Title 20

(7) Determining whether unlisted models being sold complied with the technical requirements of the standard

[30] Khawaja, M.S., A. Lee, and M. Levy. 2007. *Statewide Codes and Standards Market Adoption and Noncompliance Rates,* SCE0224.01, Prepared for Southern California Edison.
[31] The TecMarket Works Team. 2006. California Energy Efficiency Evaluation Protocols: Technical, Methodological, and Reporting Requirements for Evaluation Professionals. Prepared for the California Public Utilities Commission.
[32] The study scope did not permit detailed compliance analysis of every standard, so the research focused on the standards providing the greatest energy savings.

(8) Determining which models were non-compliant

(9) Extrapolating the individual vendor data to the statewide level

(10) Calculating the compliance rate

The first step involved obtaining and reviewing all information on complying appliances compiled by the California Energy Commission (CEC) in its online databases. The data identify appliances that have been certified by manufacturers as complying with the standards. When the 2007 study was conducted, only a small number of such databases existed. When the evaluation team started this current study, we found that compliance databases were available for all appliance standards except two, walk-in refrigerators/freezers and external power supplies. This was due to the unique nature of each of these products.

- Walk-ins are custom built and, therefore, not identified by manufacturer model numbers.
- External power supplies cover a wide range of appliances, spanning numerous industries, which adds complexity to requiring individual model registration.

Throughout this evaluation, the team periodically checked for updates to the databases and downloaded the most recent version.

Based on the SES estimated savings from the appliances covered in the 2006 Title 20, we prioritized the appliances being evaluated by their ex ante energy savings impact. The top ten energy-saving appliances comprised 97% of the total savings estimated for the appliances covered. Taking this into account, we chose to focus the data collection effort on the top ten standards. This group consisted of (listed in order of potential energy savings):

- Residential pool pumps (Tier 1 and 2)
- Walk-in refrigerators and freezers
- Pulse start metal halide HID luminaires (Tier 1 and 2)
- General service incandescent lamps (Tier 1 and 2)
- Commercial dishwasher pre-rinse spray valves
- Audio players
- TV's
- External power supplies (Tier 1 and 2)
- Unit heaters and duct furnaces

With the focus on the appliance standards with the largest savings, significant effort was not placed on collecting data for the remaining Title 20 appliances (see Appendix M).

The next step in the evaluation approach was becoming familiar with the standards and purchasing a contact list of vendors that sell or distribute the products regulated by the standards. The list of vendors Cadmus received varied by appliance, but mainly included distributors, wholesalers, and retailers throughout California. This list was based on Standard Industrial Classification (SIC) codes and we attempted to include retailers, manufacturers, and wholesalers. To reduce the number of unusable contacts, the lists were screened manually and business listings that were identified as not selling the Title 20 appliances were removed. The contacts were then stratified by size to account for differences between small and large vendors. The number of employees was used as the size stratification variable and two strata were created: those below and those above the 50th percentile in total employment. The resulting groups were reviewed and modified to ensure adequate numbers of sites were in each category. After dividing the state into three geographic regions—southern, central, and northern—the team's data collection efforts were planned to spread out equally across all three, attempting to collect data from at least two different cities in each of the regions. The evaluation team obtained data from two small stratum vendors and two large stratum vendors for each appliance in each region for a total of twelve data points per standard as shown in the equation below.

3 (regions) * 2 (strata) * 2 (average # vendors in each stratum) = 12 vendors total

Table 8 shows the actual distribution of vendors visited for site visits, by appliance, size, and location. The table shows how many sites were visited and also how many sites we were able to include in the analysis. Data from several sites were unusable due to the lack of product specification data.

Although the data collected for each appliance differed slightly due to the specifics of the standard, the data required to determine compliance consisted primarily of the brand, model number, quantity of each model in stock, the vendor's total sales of the product, and the vendor's total sales per model. If the sales staff permitted us to spend enough time in the store and the information was available, product specifications were also recorded. The ability to record these data depended on the vendor's willingness to cooperate with the data collection team and company policies on releasing sales data.

Table 8. Distribution of Site Visits by Appliance and Location

Appliance		Southern		Central		Northern		Total	
	Stratum	Total Number of Site Visits	Number of Usable Site Visits	Total Number of Site Visits	Number of Usable Site Visits	Total Number of Site Visits	Number of Usable Site Visits	Total Number of Site Visits	Number of Usable Site Visits
Residential Pool Pumps	Small	3	3	1	1	3	3	7	7
	Large	2	1	2	2	1	1	5	4
Metal Halide Luminaires	Small	2	2	2	1	0	0	4	3
	Large	2	1	2	1	1	0	5	2
Gen. Service Incandescents	Small	2	0	2	2	1	0	5	2
	Large	2	2	2	2	3	3	7	7
Commercial dishwasher pre-rinse spray valves	Small	2	2	2	2	1	1	5	5
	Large	2	2	2	2	2	2	6	6
Audio players	Small	1	1	1	1	2	2	4	4
	Large	2	2	2	2	2	2	6	6
TV's	Small	1	1	2	2	2	2	5	5
	Large	2	2	2	2	2	2	6	6
External Power Supplies	Small	1	1	2	2	3	3	6	6
	Large	2	2	2	2	1	1	5	5
Unit Heaters and Duct Furnaces	Small	1	0	2	2	3	2	6	4
	Large	1	1	1	1	1	1	3	3
Totals		**28**	**23**	**29**	**27**	**28**	**25**	**85**	**75**

Because walk-in refrigerators/freezers are customized and lack specific model numbers, we had to develop a different approach for this product. Due to the unique nature of the way this product is built and distributed, we focused our efforts on manufacturers that do the custom builds. For walk-ins, we initially attempted to collect data on the specifics of each model ordered in California in 2008 from each manufacturer we contacted. We planned to use this information to determine if the walk-in refrigerators/ freezers being built met the code. Unfortunately, this approach was largely unsuccessful due to the unwillingness of manufacturers to cooperate and customer privacy policies preventing the release of this information.

When the original plan to determine compliance for walk-in refrigerators/freezers proved unsuccessful, a new plan was developed. Phone interviews with several manufacturers were conducted to gain a better understanding of the chain of distribution, compliance in the market, and where the non-compliance issues were. In addition to these case study interviews, we also visited one of the walk-in refrigerators built by one of the manufacturers we interviewed to determine the unit's compliance. To supplement this data collection, onsite data were collected for several more walk-in units during the Title 24 commercial new building construction site visits when a location was identified as having a walk-in refrigerator or freezer.

For the rest of the appliances, the team created a general data collection plan and began calling the vendors from the SIC code contact lists to see if they would either be willing to provide data through a phone interview or agree to an onsite visit. During this process, we found that many of the contacts on the purchased contact list did not sell the specific products covered by the standards or they only serviced these products. Therefore, we decided to conduct outside research to supplement the contact list and to find manufacturers. The vendors were selected by a clustering approach to enable the data collection team to be able to visit a large number of locations in less time. Calls were made to confirm that each vendor actually sold the appliance at hand and to find out the total number of employees at the location to enable us to classify by stratum. Attempts were also made to collect as much data by phone as possible for appliances whose characteristics were suitable for this form of data collection, such as the pre-rinse spray valves and unit heaters and duct furnaces.

Pre-rinse spray valves were a good candidate for data collection by phone due to the low number of unique models available in the market and also due to the willingness of restaurant suppliers to provide sales data. Collecting data by phone for unit heaters and duct furnaces was, in many cases, equally as successful as collecting data onsite because these products are very large and are often stored in warehouses that are difficult to gain access to. These vendors were often willing to provide all information needed through a phone interview and in some cases were more willing to discuss over the phone instead of having a field technician come to their site.[33]

Once the data were collected, they were entered into a spreadsheet for additional research. The model numbers collected from each vendor were compared against the CEC lists of registered products to determine whether the model was registered with the CEC and, therefore, in compliance with Title 20. If

[33] To avoid bias and the risk of data being withheld, the data collection was described to the vendors using non-specific terms such as "study" and "research."

the model was not listed with CEC, additional research was conducted to determine whether the model met the energy-efficiency requirements of the standard even though it was not registered.

The product specifications needed to determine compliance were researched for each unlisted model through online searches, review of manufacturer websites, and calls to the product manufacturers. When the standard-regulated product specifications were found, they were compared to the standard and, in many cases, additional calculations were done to determine whether the model met the requirements of the standard. If the product met the requirements, it was classified as "unlisted compliant," meaning that although the model was not registered with the CEC, it still met the requirements. If the unlisted product was found to not meet the standard, it was classified as "non-compliant." For most appliance types, there were some models for which product specifications needed to determine compliance were not available. These models went into a fourth category, "unable to determine compliance." A large amount of effort went into making inquiries about the product specifications for the "unable to determine compliance" group. Our team made calls to manufacturers and conducted extensive internet research.

Once compliance was determined for each model collected, additional calculations were used to extrapolate the data to the statewide level. The rate of compliance was calculated separately for vendors in the small and large strata. Sales and stock data were very hard to obtain, and available data were often incomplete or limited. For this reason, the analysis primarily depended on the models present at each store location. Each model at a specific store location was regarded as one unit, and we were typically unable to obtain actual sales volume for that model.

Compliance rates were then calculated in aggregate including all stores for each appliance type using the above methodology for compliance. Units where compliance could not be determined were omitted from the total unit value calculations. The one exception was pre-rinse spray valves, where we did have reliable and complete sales data; therefore, the compliance totals for spray valves does incorporate sales estimates. The overall compliance rate was then calculated by weighting the rate for the small and large strata based on the data we had for the number of employees at all sites within each strata. The final compliance rate was determined by taking the sum of the weighted compliance rates for each stratum and aggregating the results at the state level.

The 90% confidence intervals were calculated when the required data were available. In most cases, the information required included the sales within each stratum represented by the sampled vendors, total sales for the population within the stratum, and variance of the compliance rates across the sampled vendors. Since not all these data were available for every product, it was necessary to estimate sales values based on the available data. In many cases, the average sales-per-store within a stratum was

assumed for stores where sales data were unavailable. All of these assumptions and approximations, of course, affected the accuracy of the confidence interval calculations, but on the whole we believe the confidence intervals are fairly representative for individual products.

ii. Building Standards Compliance (Title 24)

For Title 24, compliance analysis was conducted at the measure and whole-building level for both residential and nonresidential buildings. Data for the residential compliance review were collected under the Residential New Construction Program evaluation in conjunction with the collection of baseline construction characteristics data (see Residential New Construction Volume). Data for the nonresidential compliance analysis were collected as part of the C&S Program evaluation. Both compliance analyses were based on actual construction characteristics data obtained through site visits.

The goal of this analysis was to determine a compliance factor for Title 24 nonresidential and residential building standards applied to new construction permitted after October 2005. The compliance factor was used to modify the estimated potential savings (see Section 2.2.1), to provide a savings estimate comparable to gross savings. The degree of compliance was determined by an analysis of buildings constructed and permitted under the 2005 Title 24 standards. These buildings were modeled using the compliance software to estimate their energy consumption as if they had been built to just comply with the 2001 Title 24 standards; this established the baseline for comparison against both the same buildings modeled to just meet the 2005 Title 24 standards and as-built.

Residential New Construction and Alterations

This section discusses the methodology used to assess compliance of residential buildings covered by the new Title 24 standards in effect during late 2005 through 2008.The evaluation team's approach for assessing Title 24 compliance was based on the methodology used in the 2007 compliance evaluation and the protocol presented in the California evaluation protocol document.[34.35]

The C&S Program evaluation team assessed compliance of new residential buildings with the Residential Hardwired Lighting standard and whole-building compliance with Title 24. Our team used a sample of

[34] Khawaja, M.S., A. Lee, and M. Levy. 2007. *Statewide Codes and Standards Market Adoption and Noncompliance Rates,* SCE0224.01, Prepared for Southern California Edison.
[35] The TecMarket Works Team. 2006. California Energy Efficiency Evaluation Protocols: Technical, Methodological, and Reporting Requirements for Evaluation Professionals. Prepared for the California Public Utilities Commission.

buildings that had not participated in utility energy-efficiency programs that were the baseline sample studied in the Residential New Construction Program evaluation.

Whole-building and Residential Hardwired Lighting standard compliance were analyzed using field data collected from the same sample. These data were analyzed using Micropas software at the whole house level. Lighting energy consumption and compliance levels were calculated as described later. Compliance levels for window replacement and duct improvement measures applying to existing residential buildings were estimated from interviews with building code officials and a large survey of residential occupants.

Analysis of compliance with Residential Building Standards included the following steps:

(1) Obtaining from the Residential New Construction Program evaluation team a list of potential non-participant site visits.

(2) Contacting California building departments to determine which homes were permitted under the 2001 Title 24 and which were permitted under the 2005 Title 24. Additional inquiries were made to the building departments to determine if the 2005 Title 24 homes complied under the prescriptive or performance approach.

(3) Providing the filtered list of 2005 Title 24 program non-participants homes to the Residential New Construction Program evaluation team for use in scheduling site visits.

(4) Obtaining a list of completed site visits and contacting building departments to obtain information about the code enforcement process for a sample of these homes.

(5) Deriving a sample for energy and compliance analysis.

(6) Checking for the presence of HERS measures in the sample homes by obtaining HERS registry information from HERS providers.

(7) Analyzing data from Micropas runs for the sample homes.

(8) Analyzing lighting site survey data from site visits to the sample homes.

(9) Conducting and analyzing code official and IOU customer surveys to estimate window replacement and duct improvement measure compliance.

(10) Calculating compliance rates.

The first step involved coordinating efforts between the C&S Program evaluation and the Residential New Construction Program Evaluation (RNC Evaluation) teams. The RNC evaluators analyzed a sample of homes to represent the baseline for assessing impacts of the RNC programs. The program non-

participants were used to provide Title 24 compliance data for the C&S Program evaluation since they represented typical construction occurring outside of utility efficiency programs. C&S Program evaluators called and emailed building departments and searched online databases to determine permit dates for homes in the baseline sample and passed this information along to ensure that only homes that permits were applied for after October 1, 2005 (thus subject to the 2005 Title 24) were included in the study. Evaluators also attempted to learn if the permitted method of compliance was prescriptive or performance. Contacting the building departments based on sample addresses became a very time consuming process, at times requiring multiple call backs to elicit a single response. Many department contacts knew the permit issue date but not the application date, and no building department contacted provided the prescriptive or performance method without a written public information request.

We contacted the building departments also to request the Title 24 compliance documentation for all sample homes. The varying structures and processes of local municipalities required differing approaches with each municipality. Obtaining compliance documents involved phone calls to municipalities; determining the correct department and even in some cases determining the correct jurisdiction when both city and county governments failed to locate a parcel within their jurisdiction; utilizing contact information provided by the California Building Officials organization; sending emails to local building officials; submitting public information requests; paying for copies and staff time, and satisfying local governments that the requested information was not copy-righted. In some cases personal contacts within a local government were utilized in order to obtain documents that otherwise would not have been provided. Through this effort it was discovered that the data establishing Title 24 compliance within local municipalities were often inaccessible, resulting in a relatively high attrition rate. In the end, we obtained compliance documentation for only 30 homes, or about one tenth of our total sample. More details on this process are presented in Appendix G.

The initial sample of 304 residential sites was filtered to a usable sample of 194. Table 9 shows the attrition statistics. Occupants of nearly one-third of the homes in the sample either refused to allow site visits or were not available when the visit was attempted. Eleven sites were surveyed, but lighting data were not collected. Of the remaining sites, nine were permitted prior to October 2005 and, thus, did not have to comply with the 2005 Title 24.

Table 9. Residential Baseline Compliance Sample

RNC Non-Participants	Number of Sites Unwilling to Participate	Number of Site Visits With No Lighting Data	Number of Site Visits Permitted Prior to Oct 2005	Number of Usable Site Visits
304	90	11	9	194

The sample of 194 homes was modeled with site survey data through Micropas to derive annualized source kBtu expressions for space cooling, space heating, and domestic hot water. Micropas is one of the CEC approved Title 24 residential energy modeling software applications. Sites were modeled to just comply with the 2001 Title 24 prescriptive standards as a baseline. Then they were modeled to meet the 2005 Title 24 prescriptive standards (this is a basic step in Micropas runs) and, finally, modeled under the 2005 Title 24 as-built (site surveyed) conditions.

The first Micropas model runs produced a Micropas compliance result of 46%. Micropas non-complying results occur when the Proposed Design result (as-built) shows a higher modeled energy use than the Standard Design result (prescriptive standards based) using the TDV energy values[36]. We determined that it was likely that the field data collection was unable to obtain some information that affected compliance and could possibly affect the compliance level. We investigated two characteristics the survey data could not account for: window efficiencies and whether HERS verifications had occurred at the time of construction. The actual window efficiency factors U-value and SHGC (solar heat gain coefficient) were not recorded during the site visits since the original identifying stickers on the windows were removed prior to the time the site visits were conducted. Since these data were not available, the default values specified by the CEC were used and these values are very conservative to ensure compliance. Consequently, if more efficient windows were actually installed this was not being captured in the Micropas runs. Second, the site visit survey was unable to account for the possibility that some HERS measures might have been installed that would have increased compliance, but home owners typically had lost, not received, or had no knowledge of HERS documentation.

To examine these issues, we decided to investigate in more detail a subset of 30 sites from our sample of 194. Building departments were contacted in a time-consuming document request process, through which we obtained CF1R's (also a Micropas output) filed at the time of permit application. By comparing these to the site input modeled CF1R's, we found original SHGC efficiencies averaged at least 16% better than those modeled from site survey data using default values. We also knew based on other information that typical practice was to install windows more efficient than the minimal requirements.

[36] Time-Dependent Valuation (TDV) is a method for valuing energy in the performance approach in the 2005 Building Energy Efficiency Standards. Under TDV the value of electricity differs depending on time-of-use (hourly, daily, seasonal), and the value of natural gas differs depending on season. TDV is based on the cost for utilities to provide the energy at different times.

To account for this, we modified the modeled window efficiencies to be consistent with the values reported in an LBNL residential window study.[37]

The original CF1R's our team obtained also showed HERS verifications were triggered by the installation of HERS measures at 49% of these sites. Because this proportion was large, we made the effort required to obtain HERS data from HERS providers. We contacted the two largest HERS registry providers in California, CHEERS and Calcerts, to determine which of the 194 surveyed sites were listed in their HERS registry, and what the predominant HERS measures were. Both providers confirmed that duct sealing was the dominant HERS measure. This measure was then enabled in the model runs where HERS registries had been verified. These changes to window efficiencies and the appropriate inclusion of HERS verifications, substantially improved the Micropas compliance result to 75% from 46%.

Satisfied with the integrity of the model runs, we then analyzed the outputs to derive kWh and therm savings at the whole house level. The following are the major steps in the analysis of these data:

- Micropas results in source kBtu/sf are produced in four cardinal orientations (North, East, South, West), covering the three uses of space heating, space cooling, and water heating. To account for average energy consumption, we averaged the values for all four cardinal orientations for each modeled site for production home building. In cases of custom homes, we used the actual orientation values.
- All site ID's were matched by address to verify the correct identity tracking of the sample through the stages of building department data checks, site survey execution, and sites run through the model.
- Source kBtu/sf was converted to site kWh and Therms, depending on the electricity or gas end use, as described in Table 10.
- The sample site energies were weighted using the number of residential new meter hook-ups by climate zone across the state. This process involved taking the ratios of new meter to survey site populations, per climate zone, as an energy multiplier to improve the representative nature of the sample.

[37] http://windows.lbl.gov/EStar2008/

Table 10. Consumption Source to Site Energy Conversions

End Use	Method	Source Energy units	Conversion to Site Energy	Site Energy Units
Space Cooling	Micropas model of surveyed sites	kBtu	kWh = [source elec energy (kBtu/ft2) x floor area (ft2)] / [(3 (CEC source electric multiplier) x 3.413 (kBtu/kWh)]	kWh
Space Heating (Gas)	Micropas model of surveyed sites	kBtu	therms = [source gas energy (kBtu/ft2) x floor area (ft2)] / [1 (CEC source gas multiplier) x 100 (kBtu/therm)]	Therms
Space Heating (heat pump)			kWh = [source elec energy (kBtu/ft2) x floor area (ft2)] / [(3 (CEC source electric multiplier) x 3.413 (kBtu/kWh)]	kWh
Domestic HW	Micropas model of surveyed sites	kBtu	therms = [source gas energy (kBtu/ft2) x floor area (ft2)] / [1 (CEC source gas multiplier) x 100 (kBtu/therm)]	Therms
Lighting	Engineering Estimates of surveyed sites	kWh (site)	NA	kWh

We next determined the overall compliance ratio (as described in Section 2.1.3ii and examined the appropriateness of adjusting the compliance ratio for the effect of removing the savings due to the two federal standards that were adopted between 2001 and 2005. One was for gas water heaters and the other was the increase in air conditioner minimum SEER ratings from 10.0 to 13.0. As described in Appendix J, the savings associated with these standards were deducted from the value assumed in the SES for the Composite for Remainder energy savings because the C&S Program did not receive credit for these changes. This same adjustment was made for the residential whole house potential energy savings but no adjustment was made to the compliance ratio analysis under the assumption that the relative level of compliance was not affected by these standards and that potential savings and compliance were independent.

Lighting as an end use was included in both the whole house energy analysis, and separately for the residential hardwired lighting measure analysis. Micropas does not model lighting, however, so a separate lighting energy analysis was performed using the sample sites surveyed for use in the Micropas

modeling runs. The site survey collected information on lighting inventory per room, site ID, and climate zone. The 2005 Eley Impact Study's lighting analysis formed the basis of data incorporated to analyze each site based on requirements of the 2001 and 2005 Title 24 prescriptive standards. The following were the basic steps in this process.

- Create analysis spreadsheet from lighting survey database.
- Incorporate all field data parameters for site ID, room location, fixture type, control type, fixture count, lamp per fixture, lamp type, watts per lamp.
- Incorporate 2005 Eley Impact Analysis Table, Lighting Energy and Power First-Year Savings for Typical Single-Family Home. All operating hours were adopted from this Eley study.[38]
- The Eley report lighting table 2005 prescriptive standard values for controls and wattage, were assumed when as-built data were missing from field survey inputs.
- Validate the site ID's for permit dates and matching to the 194 site ID's used in the Micropas analysis.
- Calculate per site lighting kWh for as-built, 2005 Standard, and 2001 Standard energy use.
- Adjust the percent Eley report's estimated savings by the ratio of the evaluated percent savings divided by the Eley report's estimated percent savings. This step accounted for factors such as the use of prototype buildings in the Eley study while we used a large sample of actual buildings in the evaluation.

Table 10 provides details on how each end use source kBtu was converted to respective expressions for site annualized energy use. Whole house performance compliance was calculated from the combination of space cooling, space heating, domestic hot water, and lighting. The compliance rate methodology is covered in Section 2.1.3(b). Consumption for each site under the three conditions—2001 Standard, 2005 Standard, and 2005 Proposed—was then entered into the following calculation for compliance. Title 24 compliance is assumed to be constant over the evaluation period, thus time, t, would equal one.

[38] *The Impact Analysis of 2005 Update to the Building Energy Efficiency Standards*, June 2003. This report is an analysis of the statewide impact of the entire Codes and Standards Program, including components contributed by the California Energy Commission and its consultant, the IOUs, and other organizations that created and put forth code change proposals. Prepared by Eley Associates (Eley) and managed by the California Energy Commission. This document is referred to as the Eley report here.

$$CR(t) = \frac{\sum Cons2001 - \sum ConsBuilt2005(t)}{\sum Cons2001 - \sum Cons2005}$$

As noted above, one complication in this approach was how to deal with the increase in federal standards (particularly for air conditioners) between the 2001 and 2005 Title 24. These standards raised the efficiency of most air conditioners installed, but this change was not linked to the California standards. As pointed out previously, we chose to calculate the compliance rate without trying to adjust the consumption in this equation and relying on the decrease in estimated whole house potential energy savings to account for removing the savings due to these standards

Residential Hardwired Lighting is a specific standard in the 2005 Title 24. The data analyzed to determine a compliance rate were the same used for the lighting component of the whole house analysis. These engineering lighting estimates were used to support the summed consumption levels in the following calculation.

$$CR(Lighting)(t) = \frac{\sum Cons2001(Lighting) - \sum ConsBuilt2005(t)(Lighting)}{\sum Cons2001(Lighting) - \sum Cons2005(Lighting)}$$

Compliance levels for window replacement and duct improvement measures were the two alterations analyzed based on data from two different sources. The first was a survey of 110 homeowners who were asked about their experience with window replacement and duct work.[39] First, occupants who had replaced windows or had HVAC equipment or duct work done since 2005, were identified by screening questions. Then they were asked whether they did the work themselves or hired a contractor, and if anyone had acquired a permit for the work. The second source was a survey of code officials and their estimates of unpermitted window and HVAC system/duct replacements in their jurisdiction, and whether this work was likely to be Title 24 code compliant.

Compliance rates are applied to the potential energy savings to derive the gross standards energy savings, followed then by the additional components and analysis steps outlined in Figure 2 earlier in Section 2. The potential energy savings in our analysis were calculated by taking the ratio of our relative whole house and hardwired lighting savings percent to the percent savings reported in the 2005 Eley Impact Analysis study. This ratio was then used as a multiplier to adjust savings as reported in the 2005

[39] This survey was conducted as part of another impact evaluation. We added specific questions to the survey to address questions of compliance with the Title 24 requirements for retrofits.

Eley Impact Analysis study. These values were then adjusted for two factors: 1) the difference in the number of new buildings used in the Eley analysis and the current evaluation and 2) the savings from measures originally included in the Composite for Remainder savings in the SES analysis that were attributable to federal standards (as described above and in Appendix J).

Table 11 shows the savings ratio multiplier used and the results of these calculations to arrive at our estimated potential savings.

Table 11.Potential Energy Savings

Analysis Type or Measure	Ratio of C&S % Savings to Eley % Savings	Eley Gross Savings	C&S Potential Savings
Whole House	0.93	98.7 (GWh)	47.6 (GWh)
Whole House	0.80	5.5 (Mtherms)	0.72 (Mtherms)
Hardwired Lighting	0.81	64.6 (GWh)	45.0 (GWh)

Nonresidential New Construction and Alterations

The methodology for analyzing compliance with the 2005 Title 24 Nonresidential Buildings Standards is described below. The steps in the analysis were the following:

(1) Defining the population of buildings from which to draw a sample for analysis. This process started with collection of new hookup data from the IOUs and program participant buildings were eliminated.

(2) Matching utility data to building department information for nonresidential buildings permitted after October 1, 2005. This information was used to identify alterations as well as new construction.

(3) Selecting the sample. An initial sample of both new buildings and alterations was selected.

(4) Contacting California building departments to obtain data on the sample buildings. Information was collected both electronically and in hard copy.

(5) Conducting building site visits. Information on the building construction or alteration was collected and entered into a database.

(6) Analyzing new building compliance and compliance rates. The basic compliance of each building with Title 24 was determined from compliance software runs. The compliance rate was calculated using the whole building analysis methodology.

(7) Analyzing alteration compliance. The degree of compliance was assessed in the field.

Defining the Population

To ensure that data collection activities were representative of all IOU service territories and climate zones, a stratified random sample of building departments with the greatest construction activity[40] was chosen for subsequent data collection activities. The original sampling plan called for a sample of 20 building departments but this was later reduced to 12 because of the unanticipated level of effort required to collect the necessary information. Next, the permit databases of the sample jurisdictions were obtained and cleaned to identify the population of construction activity at each jurisdiction. Then these data were cross-referenced with a database of IOU incentive "program participants" and the incentive program participant buildings were eliminated from the population. Building types such as Hospitals and Public Schools which were not subject to the permitting process of the local jurisdictions were not included the population because permit data on such buildings generally is not found at the local building department.[41]

Defining the Sample

Characteristics of the non-participant buildings from the IOU database were attached to the permit database to aid in the determination of our sample. The database of permits was divided into "Alterations" and "New Construction" sites based upon a description of the scope of work provided in the permit database. Each of these lists was sorted by a weighting factor which represented the potential energy footprint of the building.[42] All of the buildings with an energy footprint in the upper quartile were selected with certainty and a random sample of the remaining buildings was included in

[40] As determined by construction activity provided by CIRB.

[41] Such buildings are not required by State Law to comply with Title 24, Part 6, nevertheless; these standards are commonly enforced by the Office of the State Architect (OSA). Therefore, the compliance rate developed by this evaluation may not be applicable to the energy savings impacts of buildings which fall under the jurisdiction of the OSA. Because buildings permitted by the OSA are public buildings which tend to be much larger than the average building permitted by the local building department, the exclusion of OSA-permitted buildings could affect estimates of statewide savings.

[42] The energy footprint weighting factor included the building floor area, permit valuation, utility rate tariff and other indicators of total annual energy consumption and peak demand.

the sample. The sample of "new construction" was then further refined by reviewing aerial photographs to ensure that each new building site was a "green field" site and to ascertain if construction had actually occurred. These checks were necessary to improve the chances that the subsequent, resource-intensive visits to the building departments were successful at obtaining design documents that actually met the criteria for our evaluation, namely buildings that did not participate in the utility-sponsored incentive programs and were required to be constructed in compliance with the 2005 Title 24.Our original target sample size was 180 new buildings and 150 alterations from 20 building departments. The ultimate sample was reduced considerably because of a wide range of limitations and difficulties including the following:

- problems identifying eligible buildings for the sample ,
- steps required to verify the buildings met all criteria,
- obtaining the necessary building department data, and
- challenges conducting site visits.

Data Collection

The final sample size was reduced to 80 new buildings and 140 alterations at 12 building departments. The evaluation team initiated contact at 14 building departments with some web-based and in-person data collection activities. However, extensive review of building permit data occurred at only 12 building departments due to refusal of two to participate or allow data collection. Due to problems with the data management practices of several building departments, our building department sample was reduced further to only 9 from which we could collect the required data. Three building departments either refused access or made it so difficult to collect data that the quality and quantity of data was insufficient to collect data from on-site visits. With the exception of SDG&E, all of the utility company service territories were adequately represented. The challenges encountered during the data collection process are discussed in Appendix H.

Anticipating potential problems in our data collection efforts, we used permit records to identify 533 candidate building sites (including over-sample). Detailed data collection included viewing and/or obtaining copies of building plans to identify which measures were installed in each candidate building. For most building departments this required energy analysts to visit the building department to physically obtain the data. Some jurisdictions were willing to send the data on CD-ROM or provide

access to building permit data via Internet download. Data made available to us varied from nothing[43] to PDF copies of entire building submittal drawings. These data were used to obtain owner and designer contact information for scheduling purposes and to identify which specific 2005 Title 24 measures were designed into and meant to be part of the construction of the building. For 13 buildings, we were successful in obtaining the original Title 24 compliance documentation "EnergyPro" input file (.BLD) from the documentation author. These data further improved our understanding of the intended design and somewhat reduced the effort to develop the building simulation models. Table 12 summarizes the factors affecting attrition at different stages in the data collection process.

Table 12. Building Sample Attrition by Stage

Description of Effort	Number of Buildings
Total sites identified and researched	533
Sites recruited in advance	51
Refusal to allow site access at recruitment stage	20
Total sites visited	108
Refusal to allow site access at site	24
Disqualifications during/after site visit	3
Successful site visits	81

Field data collection activities focused on the Title 24 measures documented in the Program CASE reports and other building features which the evaluation team deemed to have the greatest impact on the building (or alteration to the building) as compared to the requirements of the 2001 Title 24 standards. Overall building characteristics such as window to wall area ratio, window type, building orientation, floor area, lighting power density, water heating system, and HVAC system type and efficiency were verified. Digital photographs were taken and used as supporting evidence of the compliance or lack of compliance with the standards. In cases where it was not possible to observe specific characteristics in the field (such as window U-values), it was assumed the building was

[43] Two large Southern California jurisdictions were willing to provide permit activity information on paper even though clearly this information was tabulated in an electronic database. The financial burden of our data requests were minimized by providing qualified technical staff to perform the data collection activities. No effort on the part of the staff of the local building department was required to comply with our data requests.

constructed to include the required minimum 2005 building features. Table 13 summarizes the counts of specific measures reviewed during the site visits.

New Construction Compliance Assessment Methodology

For new construction sites, the data collected at the building department and on-site were used to create or update an EnergyPro (DOE-2) model of the sample buildings. The EnergyPro BDL files served as the primary digital repository of the as-built condition of the sample buildings. A custom version of EnergyPro was created for evaluating the energy impacts. This version contained the algorithms for 2005 Standards as well as the 2001 Standards and standard building construction features. For estimating the impacts of the Program and determining savings relative to predicted savings from the

Table 13. Count of On-Site Data Collection Activities by Standard

Standard ID and Description	Number of Alterations Evaluated	Number of New Construction Features Evaluated	Total
B03 MF Res Hardwired Lighting	0	6	6
B04 MF Res Duct Sealing for Alt	0	0	0
B05 MF Res Window Replacements	2	0	2
B06 NonRes Skylights	1	3	4
B07 NonRes Duct Sealing Alts	2	0	2
B08 NonRes Cool Roof	5	23	28
B09 Relocatable Classrooms	0	1	1
B10 Bi-level Lighting Ctrls	0	24	24
B11 NonRes Duct Sealing NewCon	1	16	17
B12 NonRes Cooling Towers	1	2	3
B13 MF Res Water Heating	0	8	8
B14a NonRes Indoor Lighting	10	34	44
B14b NonRes VAV Systems	1	10	11
B14c NonRes Outdoor Lighting	8	37	45
Total Measure Observations	31	164	195
Total Buildings	26	48	74

2005 Standards, the baseline was assumed to be a building constructed to be "minimally-compliant" with the 2001 Standards. The EnergyPro software automatically created this building by replacing any

features that exceeded the 2001 Title 24 requirements with an equivalent description that just met the prescriptive and minimum requirements of the 2001 Standards. The as-built energy savings were calculated by subtracting the as-built energy consumption estimate of the documented building from the consumption estimate for the 2001 minimally-compliant standard building. To determine the potential predicted energy savings for each building, the 2005 minimally-compliant standard building energy consumption was subtracted from the 2001 minimally-compliant standard building energy use. The goal was to calculate the whole building compliance rate as described in Section 2.1.3(b).

Measures and Alterations Compliance Assessment Methodology

An alteration is defined as anything that is not new construction nor an addition. The 2005 Standards expanded in scope to cover more types of alterations than previously covered under the 2001 Standards. The use of the whole building analysis methodology is not usually appropriate for alterations due to the fact that alterations are generally more limited in scope and by definition do not include the alteration of the entire building.

For alteration sites, a compliance assessment survey was conducted by the field inspector to ascertain the degree of compliance for a targeted selection of measures that were new to the 2005 Standards as well as other measures identified on the plans or on site.

Compliance assessment was conducted using an onsite data collection form and a set of detailed flow charts that laid out the decision process with which compliance for each measure was to be assessed. On these forms, each measure was evaluated separately.

In the case of new construction, all measures identified from the earlier plan review process were evaluated. This was used as an aid in creating EnergyPro models, and, in the case of prescriptively compliant buildings, it was used as a direct assessment of the degree of compliance with the standards.

For alterations, only the target measure(s) of the alteration was evaluated. For example, on a re-roof permit, only the cool roof measure was evaluated. Lighting and other measures would not be assessed for that building unless they also were part of the alteration permit. Data might be gathered for the purpose of estimating savings due to the target measure, but the degree of compliance of other measures would not be used to assess the compliance of that building.

These assessments were made in three stages:

1. If present or required – This is a preliminary assessment of what measures would be required or applicable to the site based on brief permit descriptions from the building department. The value for this assessment was either a “yes”, indicating that this measure may apply to this

building and subsequent evaluations (columns) should address it, or “no” it is clear from the outset that this measure does not apply to this building and subsequent evaluations need not address it. This column was filled out based on information available before the building site visit.

2. As found on plans or T-24 docs – This assessment of measure compliance was based on the construction plans and submitted Title 24 documentation for the building. This represented what the builders intended or claimed to build.
3. As found at building – This assessment was based on observations of the actual building after construction was completed (including improved as-built drawings "approved for construction").

Findings for each measure were scored as follows:

Compliance Metrics for Plans and Compliance Documents

0 = unable to determine if measure shown on plans (i.e., plans not available)
1 = measure on plans, but no attempt to comply with efficiency standards or misrepresentation
2 = measure present on plans but fails to comply,
3 = measure shown on plans, complies but with minor omissions and/or errors, or measure present but unable to test/evaluate compliance
4 = measure shown on plans, generally complies and complete
5 = measure shown on plans in perfect compliance

Compliance Metrics for Building Construction as Observed

0 = not able to evaluate if measure is installed (e.g, inaccessible location, refusal to allow access, etc.)
1 = measure not installed
2 = measure installed but doesn't work
3 = measure installed and works, but doesn't provided intended functionality, or measure present but unable to test/evaluate compliance
4 = measure installed and works, but could not verify correct functionality
5 = measure installed correctly and works as intended

Compliance was rated on a 5-point scale and assigned the compliance scores shown in Table 14. The overall score for each measure was the weighted average “as found at building” score for the measures

across all buildings where that measure was identified to be present or required. The "As found on plans or T-24 docs" scores were not used in this evaluation due to a lack of information.

Table 14.Nonresidential Measure Compliance Assessment

Compliance Assessment Criterion	5-point Compliance Rating Scale	Compliance Score
Unable to assess compliance	0	blank
Measure not installed	1	0%
Measure installed but doesn't work	2	25%
Measure installed and works, but doesn't provided intended functionality	3	50%
Measure installed and works, but could not verify correct functionality	4	75%
Measure installed correctly and works as intended	5	100%

2.2.3 Naturally Occurring Market Adoption (NOMAD) Analysis

This section presents the methodology to estimate the Naturally Occurring Market Adoption (NOMAD) trend for each of the products or technologies regulated by the 2006 Title 20 and 2005 Title 24 standards. The natural market is an important factor in determining the net savings from the adoption of new standards.

The implementation of the NOMAD approach included the following steps:

(1) Prioritization

(2) Development of the web-based NOMAD application

(3) Recruitment of experts

(4) Two rounds of data collections from experts

This section is organized as follows: definition of basic terms, description of the methodology, and then an illustration of the approach.

i. Definitions

Two terms are used throughout the NOMAD discussion, so it is important to understand their meaning. Both terms are applied to product sales in a specified period of time.

- **Naturally occurring market adoption.** The naturally occurring market adoption is a projection of what the annual sales or installations of items that meet the standard would have been if the standard had not been adopted. The naturally occurring market adoption is an estimate of energy-efficient product sales or installations over time. Once the standard is in effect, the natural market no longer exists in reality. However, the evaluation methodology requires that the naturally occurring market trend be estimated to derive the net savings for each standard.
- **Initial market penetration.** The initial market penetration represents the state of the market at the time the standard became effective; in other words, it is the share of annual installations or purchases already meeting the requirements of the standard. Note that initial market penetration is an estimate for a specific point in time. In practice this value represents the sales of a qualifying product or installation of a measure complying with the standard over a fairly short period of time just before the standard took effect.

ii. NOMAD Estimation Methodology

Our approach for estimating both initial market penetration and naturally occurring market adoption was to solicit expert opinions to estimate a market diffusion curve. Each expert was asked to participate in two rounds of data collection. In the first round, each expert defined the parameters of a market adoption Bass curve (discussed in detail in Appendix E) for each standard using an online application and provided some comments that explained his/her reasoning or market knowledge upon which the estimate was based.

The investor owned utilities (IOUs) often implement resource acquisition programs for energy-efficiency measures or efficient appliances that are adopted as requirements in subsequent Title 24 or 20 regulations. Such programs have frequently had a significant effect on the market in terms of product or measure sales and installations over several years; therefore, we chose to regard them as a part of the naturally occurring market when we solicited expert opinions on the market trends but account for them as discussed below. In addition, the evaluation team determined it would be too complex and introduce too much uncertainty to try to estimate market trends as if these programs had not existed because adjusting for such program effects would require extensive knowledge of the programs on the part of the experts providing estimates of the NOMAD curve (as discussed later). Using this approach, the naturally occurring market is directly observable up until the time the standards became effective (October 2005 for Title 24 and January 2006 and beyond for Title 20).

Including the market penetration effects of prior IOU programs in the NOMAD estimate raises the issue of how prior programs affect projections into the future of the naturally occurring market. This is

illustrated in Figure 3 by a hypothetical example. The line labeled "NOMAD w/IOU Program" represents the estimate of the NOMAD curve based on observations about past market trends, including the effects of utility programs, and expectations about future trends. Prior to 2006, some portion of the market penetration was due to utility programs and the utilities were credited with savings from these programs. From 2006 on, the "NOMAD w/IOU Program" curve implicitly has the market penetration effects of prior IOU programs embedded in it as an upward shift in the curve. Since NOMAD constitutes a deduction from the saving credited to the C&S Program, use of this NOMAD estimate effectively penalizes the IOUs for the shift in the curve due to programs run in previous years since a higher estimate means lower savings credited to the Program (this is explained further below).

Table 15 presents three hypothetical scenarios for initial market penetration, the NOMAD estimate of the future change in market penetration, and the resulting implications for net savings that could be credited to the standard. Since the NOMAD quantities are defined as representing market penetration in the absence of the standard, their associated energy savings are not counted toward the savings attributed to the standard. These scenarios provide some context for understanding the significance of these market estimates and projections.

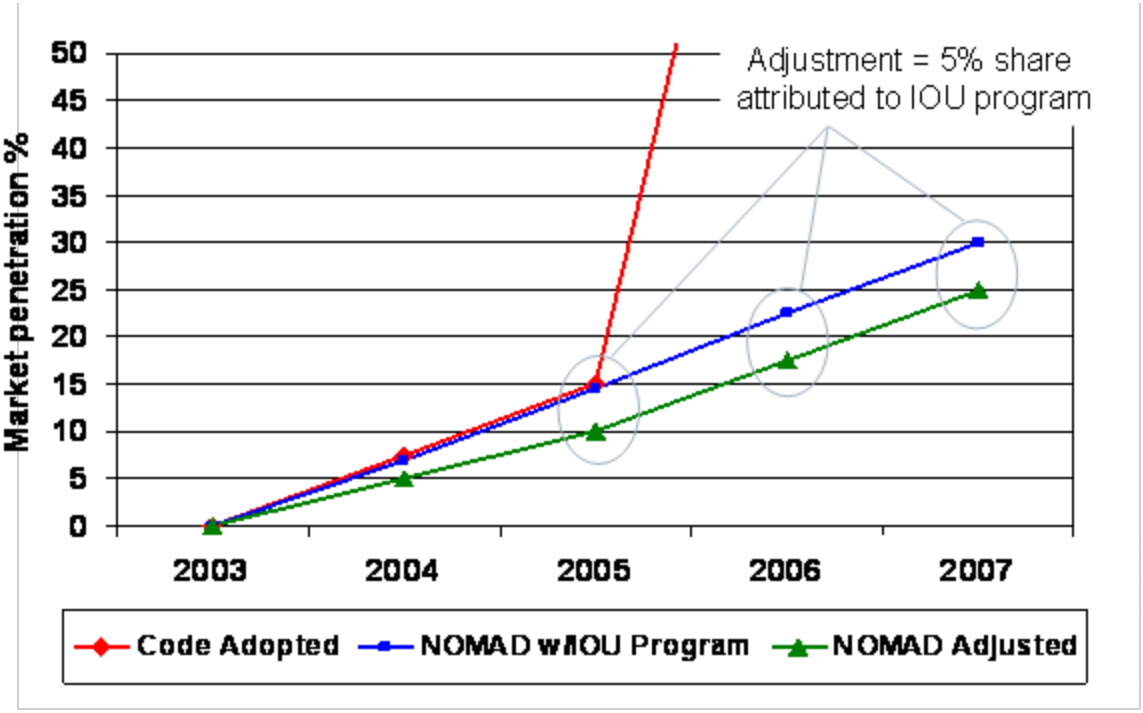
Table 15: Three Market Scenarios

Hypothetical Scenarios	Initial Market Penetration	NOMAD Estimate	Implications for Savings
Scenario 1	5%	Growth from 5% to 10%	Large potential for savings as a new standard can impact nearly the entire market
Scenario 2	50%	Flat at 50%	Medium potential for savings as half the market can be impacted by a new standard
Scenario 3	95%	Growth from 95% to 100%	Very limited potential for savings as almost all of the market is already using the more efficient products required by the standard

To correct for the possible inappropriate deduction due to the effects of prior IOU programs, we made an adjustment to each NOMAD estimate. At our request, the IOUs provided data from their records on every program that affected the product volumes of appliances and measures regulated by the 2005/2006 Codes and Standards. We used these data to adjust each NOMAD estimate as shown in Figure 3. In this way, the methodology took into account the fact that prior utility programs may have had a persistent impact on the market for each efficient appliance or measure. In most cases, the correction was zero or very small because most prior programs did not result in large market penetrations of efficient appliances or measures. The utility data showed only one appliance standard, Pulse Start Metal Halides, where the prior programs had a significant impact on the market. For the

building standards, however, there were a number of cases where the utility programs had a 10% to 20% impact on the market at the time the standard was adopted. These included lighting, window replacement, and ducts in new commercial buildings. Originally, we had intended to hold this impact of prior programs constant over time. As the work progressed and we considered this assumption at the end of the evaluation period in 2018, we decided to limit the ongoing adjustment for these prior utility programs to ten years. In the Integrated Standards Savings Model (ISSM), we are reducing the impact by 10% of the original total each year. In this way, the impact is still nearly the same over the first three years but does not continue indefinitely as it did in the original model.

Figure 3: NOMAD Estimate and Adjustment for Prior IOU Programs



Implementation of the plan to obtain the initial market penetration and naturally occurring market adoption curve for each of the standards consisted of three distinct steps. They included prioritization of the many standards since not all have equal importance in terms of their associated savings; recruitment of experts to provide knowledge of each market; and data collection, which depended on development of an online application to collect each expert's estimated curves and commentary. Each of the steps is described in some detail below.

Prioritization: In terms of scope, the plan was to develop NOMAD estimates for all relevant Title 20 and Title 24 standards. The only exceptions were the two building standards that address Time Dependent Valuation (TDV) for the residential and nonresidential sectors.

The evaluation team prioritized the effort spent on each standard according to its relative ex ante contribution to the total claimed savings. The ranked list is shown for Title 20 standards in Table 16 and for Title 24 standards in Table 17. Although the ranking was done by net electrical energy (GWh) saved, demand savings were also reviewed.[44]

Table 16: Title 20 Appliance Standards Ranked by Relative Net Savings

Ref.	Ranked by 2006 Net Energy (GWh) Savings	GWh 2006	% of Total	Cum %	MW 2006	% of Total	Cum %	Therms 2006
Std4	Walk-In Refrigerators / Freezers	31.3	20.8%	21%	4.1	18%	18%	-
Std12	Pulse Start Metal Halide HID Luminaires, Tier 1	28.6	19.0%	40%	5.1	22%	40%	-
Std11	General Service Incandescent Lamps, Tier 2	20.7	13.7%	53%	2.6	11%	51%	-
Std21	Commercial Dishwasher Pre-Rinse Spray Valves	19.7	13.1%	67%	4.2	18%	69%	2.6
Std15	External Power Supplies, Tier 1	14.3	9.5%	76%	1.6	7%	76%	-
Std8	Residential Pool Pumps, High Eff Motor, Tier 1	14.2	9.4%	86%	2.7	12%	87%	-
Std18a	Consumer Electronics - TVs	7.9	5.2%	91%	0.9	4%	91%	-
Std10	Portable Electric Spas	3.8	2.5%	93%	0.7	3%	94%	-
Std1	Commercial Refrigeration Equipment, Solid Door	3.5	2.3%	96%	0.5	2%	96%	-
Std19	Water Dispensers	2.5	1.7%	97%	0.3	1%	98%	-
Std5	Refrigerated Beverage Vending Machines	1.7	1.2%	98%	0.2	1%	99%	-
Std18b	Consumer Electronics - DVDs	1.3	0.9%	99%	0.1	1%	99%	-
Std14	Hot Food Holding Cabinets	0.8	0.5%	100%	0.1	0%	100%	-
Std13	Modular Furniture Task Lighting Fixtures	0.3	0.2%	100%	0.0	0%	100%	-
Std2	Comm. Refrigeration Equip., Transparent Door	-	0.0%	100%	-	0%	100%	-
Std3	Commercial Ice Maker Equipment	-	0.0%	100%	-	0%	100%	-
Std6	Large Packaged Comm. Air-Conditioners, Tier 1	-	0.0%	100%	-	0%	100%	-
Std7	Large Packaged Comm. Air-Conditioners, Tier 2	-	0.0%	100%	-	0%	100%	-
Std9	Residential Pool Pumps, 2-speed Motors, Tier 2	-	0.0%	100%	-	0%	100%	-
Std16	External Power Supplies, Tier 2	-	0.0%	100%	-	0%	100%	-
Std17	Consumer Electronics - Audio Players	-	0.0%	100%	-	0%	100%	-
Std20	Unit Heaters and Duct Furnaces	-	0.0%	100%	-	0%	100%	0.4

For the Title 24 standards, a review of the ranked list revealed several unique issues. By far the most significant was that the savings associated with Standard B14, the so-called Composite for Remainder (CfR), represented more than 50% of the electrical energy (GWh) and Demand (MW) savings claimed by the IOUs. The evaluation team identified the specific measures that this composite standard represented and analyzed the main ones.

[44] For the Title 20 standards, demand savings were closely correlated to electrical energy savings, so the ranking method is adequate to address demand savings as well.

Table 17: Title 24 Building Standards Ranked by Relative Net Savings

Ref.	Ranked by 2006 Net Energy (GWh) Savings	GWh 2006	% of Total	Cum %	MW 2006	% of Total	Cum %	Therms 2006
Std B14	Composite for Remainder	66.0	54.4%	54%	27.7	52%	52%	0.7
Std B3	Res. Hardwired lighting	24.9	20.5%	75%	1.1	2%	54%	-
Std B6	Lighting controls under skylights	11.3	9.3%	84%	-	0%	54%	-
Std B10	Bi-level lighting control credits	5.5	4.6%	89%	-	0%	54%	-
Std B8	Cool roofs	4.3	3.6%	92%	2.8	5%	60%	-
Std B1	Time dependent valuation, Residential	2.9	2.4%	95%	11.7	22%	82%	-
Std B2	Time dependent valuation, Nonresidential	1.8	1.5%	96%	8.0	15%	97%	-
Std B9	Relocatable classrooms	1.4	1.1%	97%	-	0%	97%	-
Std B12	Cooling tower applications	1.4	1.1%	98%	-	0%	97%	-
Std B5	Window replacement	1.0	0.8%	99%	0.4	1%	98%	0.0
Std B4	Duct improvement	0.9	0.7%	100%	1.3	2%	100%	0.2
Std B11	Duct testing/sealing in new commercial buildings	-	0.0%	100%	-	0%	100%	-
Std B13	Multifamily Water Heating	-	0.0%	100%	-	0%	100%	0.8
Std B7	Ducts in existing commercial buildings	-	0.0%	100%	-	0%	100%	-

In a few cases, ranking by ex ante energy savings (in GWh) did not provide a ranking consistent with the other savings categories. The two TDV standards would be ranked much higher if the analysis were based on demand savings rather than electricity savings. However, because of their nature, it was not appropriate to estimate a NOMAD curve for TDV standards; so Standards B1 and B2 were not included in this analysis.[45] Although Multifamily Water Heating (B13) contributed no electricity savings, it represented nearly half of all therm savings, so it merited a relatively high ranking for analysis purposes.

Recruitment of Experts: In the recruiting process, we first considered which perspectives and organizations should ideally be requested to provide their inputs. From Cadmus' prior C&S Program analyses, we were aware that some experts tended to develop biases about the natural market that are often consistent with the interests of the organizations they represent. For this reason, we sought a broad range of organizations. The target list included representatives of manufacturers, industry consultants, as well as staff from the CEC and the IOUs. With a reasonably large number of expert opinions, the team expected that strong biases would be more visible as outliers in the context of most other experts' opinions. Addressing this situation was one of the desired outcomes of using a Delphi process.

Two primary sources were tapped to develop a master list of the expert candidates: the CEC dockets from the meetings where each specific standard was on the agenda and the IOU Codes and Standards

[45] TDV is a calculation procedure rather than an appliance or building product. Consequently, the concept of a market penetration trend was not relevant.

Enhancement (CASE) reports. Numerous other candidates were added to the list based on the broad experience of evaluation team members with the codes and standards process.

The initial work to recruit experts was focused on individuals with knowledge of the markets for appliances regulated by the Title 20 regulations. When the NOMAD focus shifted to the Title 24 building codes, there was a significant effort to recruit experts with knowledge in these markets. In this effort, the goal was to find consultants and contractors with direct knowledge of building practices in California. To this end, we recruited from an online contractor's database (thebluebook.com) and the membership of the California Association of Building Energy Consultants (CABEC) Altogether, 22 additional experts were recruited specifically for their knowledge of building construction and Title 24.

While the team created the expert candidate list, other pre-recruiting tasks were underway. We defined an incentive structure for individuals who were able to accept compensation. The application developers provided a working "demo" version of the online application that could be accessed through a Web link. In addition, we wrote an introductory message describing the overall evaluation and the need for the experts' help to define the naturally occurring market.

With these preparations completed, we contacted each person on the master list using email messages and telephone calls to persuade the candidate to participate. We had the most success in recruiting manufacturers' representatives/employees and industry consultants. The CEC staff members to whom we spoke declined to participate. Although the team spent considerable effort trying to recruit utility representatives, in the end, NOMAD estimates for only a small number of standards were provided by IOU participants.

In a 2008 statewide review of the expert candidate list offered by the CPUC, the IOU representatives present asked for greater utility representation. Cadmus requested contact information for specific individuals from each of the four IOUs. PG&E provided a contact list, and we followed up with the individuals. All agreed to participate in this study, but only two of the five actually provided input.

The recruiting process produced these results for twenty one of the Title 20 appliance standards:

- 294 NOMAD inputs were requested from the experts on the master list.
- 117 NOMAD inputs were provided by the experts during our telephone conversations.
- 78 NOMAD inputs were received in the online application

In discussions with the CPUC, we established a target of four inputs for each standard and agreed that the standards with higher relative savings would be given priority in terms of our efforts to recruit experts. The results summarized below reflect success in meeting this target and the additional effort spent on the higher ranked standards.

- 4 or more NOMAD inputs were provided for nine Title 20 standards that represent 78% of the claimed savings.
- 3 NOMAD inputs were received for three Title 20 standards that represent an additional 8% of claimed savings

For one appliance, Portable Electric Spas, we were not able to recruit qualified experts to provide NOMAD estimates and reverted back to the values used in the SES.

Of the fourteen Title 24 building standards, there were five for which data collection was either not attempted or not effective. These included the two dealing with TDV, which, as noted above, are concerned with a calculation procedure and so the concept of market penetration is not relevant. For two others, Relocatable Classrooms (B9) and Cooling Tower Applications (B12), the evaluation team was unable to find experts who were able to provide insight into the natural market adoption of efficiency regulations. Since these two standards together represented only about 2% of total Title 24 GWh savings (net in 2006), the definition of a natural market adoption curve would not have much impact on the total estimated Title 24 savings.

The fifth standard for which NOMAD inputs were not collected was the Composite for Remainder (CfR) (B14). Uncertainty over the specific measures included in the CfR delayed the recruitment of experts. Since the savings within the CfR were from a large number of standards, the estimation of a market adoption curve for each component was clearly impractical. We had intended to estimate NOMAD for the largest components of the CfR, but this was not done due to the time it took to determine what measures constituted the CfR and schedule constraints. For all building standards for which we were unable to estimate the NOMAD curve, including the CfR, we reverted back to the values used in the SES.

We used our methodology to estimate market adoption curves for nine of the Title 24 building standards. All of the inputs were provided from the pool of 22 experts described above. These individuals were recruited for their knowledge of lighting technology, building energy management, and construction practices. The recruiting process produced these results for the Title 24 standards:

- 125 NOMAD inputs were requested from the experts on the master list.
- 70 NOMAD inputs were provided by the experts during our telephone conversations.
- 35 NOMAD inputs were received in the online application for the nine Title 24 standards

Development of the Web-Based Market Adoption Application: The traditional methods of estimating the parameters to generate the Bass curve are to use values derived from curves for similar existing products, rely on market research, or apply expert judgment. Based on prior research and input from

outside reviewers, we selected an innovative approach that relied on inputs from industry experts using a visual tool developed specifically for this purpose.

This visual approach maximized the efficacy of data collection regarding the parameters since it provided direct feedback, educated the participants on the concept, and was more intuitive and appealing to use. To implement this approach, we developed an interactive Web site as an effective and efficient way to obtain expert opinions on the inputs. The Web site was designed to introduce the process we were using and the overall approach. It presented an explanation of the inputs and parameters of the market-specific adoption curve, as well as a discussion of the influences that the experts should take into account in their assessments.

Application developers on Cadmus' staff customized a JavaScript charting tool to create the data collection tool known internally as the Market Adoption application. This application included an interactive display that the respondents could adjust to reflect the innovative and imitative parameters used in the Bass model equation. For purposes of this exercise, we modified the terminology and referred to these parameters as "leading" and "following" behavior, respectively. Based on our pretests, these terms were deemed more understandable for participants. It was not necessary for anyone to understand the details of the model in order to select appropriate values. Adjustable sliders were provided for the experts to vary until the curve best depicted their expectations about how market adoption would have occurred in the absence of the standards.

To supplement the process described above (experts using the online application to provide input), we contacted a number of individuals directly and used brief interviews to collect additional input. There were three specific cases where this was done due to the importance of the expert input to the overall evaluation:

- Pool pumps. Our efforts did not generate many inputs through the online application although potential savings on the pool pump standards are significant. We prepared a short interview guide and contacted a number of the experts we had previously recruited. Our experience throughout was that it was relatively easy to recruit an expert but then many of those recruited did not log in to the online tool. The direct contact and interview approach was one approach to solving this problem.
- Residential hardwired lighting. In this case, we collected input from ten experts, which provided a strong basis for the NOMAD curve. We interviewed several of these individuals to support related research (on indirect impact) for the CPUC Market Effects study.

- Whole Building. To conduct a whole building analysis for residential buildings, it was necessary to develop an approach for estimating NOMAD forecasts of trends in residential energy efficiency. In this case, we used direct elicitations of the NOMAD estimates rather than apply the online tool for two reasons. First, the form of the efficiency trend was not as likely to follow the Bass model which was built into the online application. Second, direct contact is much faster than the recruit-and-remind cycle required to obtain input using the online application.

The whole house NOMAD estimation was carried out by presenting experts with a brief questionnaire that showed the predicted aggregate savings from the 2005 Title 24 relative to the 2001 Title 24. The experts were then asked for their estimate of what percent of those savings would have been achieved in 2006, 2012, and 2018 if the 2005 standards had not been adopted. The evaluators averaged the results and used these data to estimate the expected trend. The NOMAD estimate in this case was a percent that could be multiplied by the potential savings to estimate the savings due to projected market trends in the absence of the 2005 standards.

iii. Example of Methodology—Commercial Dishwasher Pre-Rinse Spray Valves[46]

First Round Input: Eight individuals provided first-round market adoption estimates for pre-rinse spray valves. This included three industry consultants, two people from the Food Service Technology Center (FSTC), a manufacturer, a technical expert from Lawrence Berkeley National Laboratory (LBNL), and a program expert from East Bay Municipal Utility District (EBMUD). Three of these individuals had gained direct knowledge of the market when they worked on a California Urban Water Conservation Council (CUWCC) program to give away and install efficient valves between 2002 and 2005.

During the first round, experts provided their inputs defining a market adoption curve using the graphical application and their commentary regarding the factors that determined their estimates. Six of these estimates were generally similar to one another and could be viewed as a cluster or near-consensus among the majority. The other two inputs were significantly outside this cluster, so we examined them in some detail. One of these experts estimated that efficient valves would make up 67% of the market in 2005 and 85% by 2006, which seemed a very aggressive increase in market share for a product that had been at only about 10% of the market according to several sources between the late-

[46] Although we determined that the C&S Program should receive no credit for savings from pre-rinse spray valves because a federal standard went into effect at the same time as the Title 20 standard, this product provides a good illustration of the NOMAD estimation method.

1980s and 2001. The other input that was well outside the cluster reflected the opinion that market share would have stayed at the 10% level indefinitely without the standard. Like the first outlier, this seemed unlikely given the increase in awareness that the statewide CUWCC program had created—prior reports and observations from experts familiar with the program suggested that market share was well above 10% in the years between 2002 and 2005 in large part due to the CUWCC direct install giveaway program. As noted earlier, we defined the natural market to include the effects of utility and municipal programs.

Second Round Input: We invited all experts to return to the online application to review the first round inputs and consider whether any change to their inputs was warranted. In the first round, each expert worked in isolation and could not see the other experts' inputs. For the second round, all first round inputs and an average curve were shown to the returning expert as well as all the comments (without identification). The response rate for the second round was low, with only two of the eight experts returning to the application. Of these two, one chose to revise the first round input to agree with the first round average. The move was significant as the expert revised the maximum market share from 90% down to 75% as a result of seeing the other experts' estimates. The other returning expert chose not to revise his first round input, which was near, but somewhat below, most others. Both experts chose to reiterate their views and argue that other experts' estimates were too high:

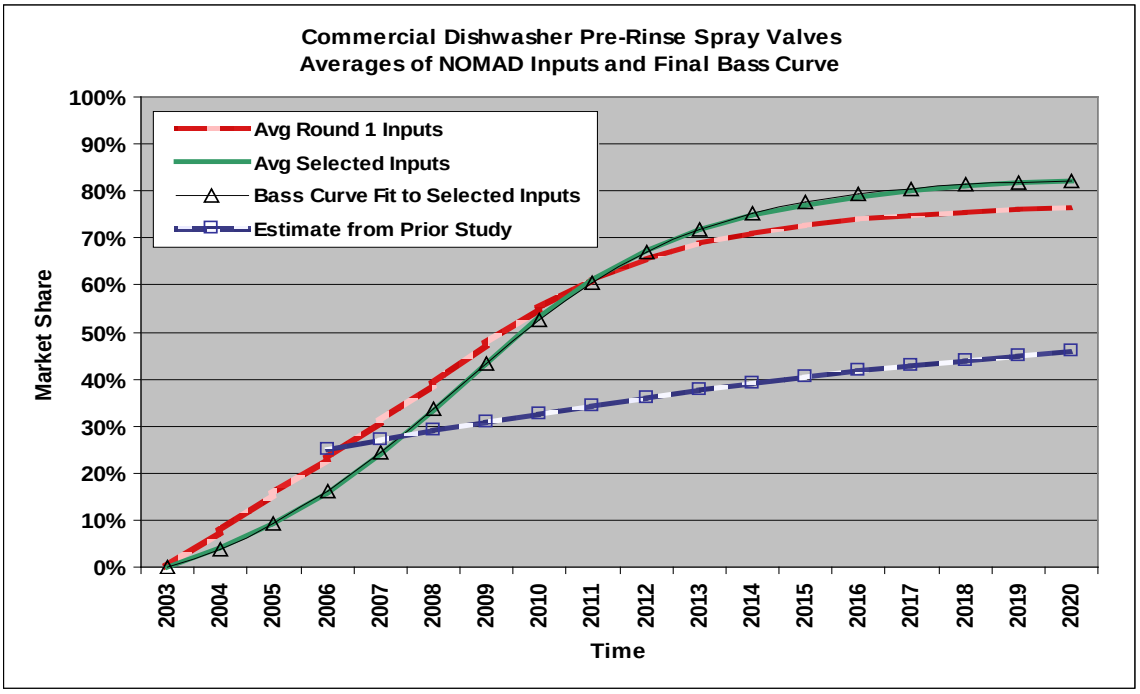
> "I think those that expect a high penetration rate don't have much experience promoting efficient measures! Good ideas don't just jump to 100% saturation because utilities promote them or because they make good economic sense, especially, because with this measure there aren't significant non-energy/non-water savings benefits. In fact to some customers, the utility of the compliance spray valve is lower because it is no good for pot filling. Utility incentive programs rarely yield impacts in over 50% of the market. The CUWCC direct install programs were quite successful in penetrating the market, but they'd have a tough time getting that last 25% AND that program could not be sustained as saturation closed in on 100%. It would then be continued and as spray valves started being replaced, it wouldn't be there to prevent reversion."

To increase the second round response rate, the evaluation team contacted every expert numerous times that had not provided second round input, first through email messages and then with telephone calls. These follow-up efforts were successful in that more second round inputs were received and incorporated in the analysis, but the overall response rate for second round input was less than 50% for experts that provided first round input.

Figure 4 summarizes the results of the NOMAD evaluation for pre-rinse spray valves. From top to bottom of the legend, the data shown include:

- The Avg Round 1 Inputs represents the average when all eight inputs were included.
- The Avg Selected Inputs represents the average when the two outliers are not included. It also uses the second round input for those two experts who provided it.
- Once this second average was known, a nonlinear curve fit technique was used to fit a Bass curve to the average points. This function is labeled as the Bass Curve Fit to Selected Inputs and is nearly identical to the Average of Selected Inputs, but has the advantage of being a mathematical function rather than simply a set of points.
- The Estimate from Prior Study shows the results from the earlier study. In the years 2006 and 2007, the new Bass Curve estimate is somewhat below the prior estimate and slightly above it in 2008.

Figure 4: Summary of NOMAD Results for Pre Rinse Spray Valves



Another comment from an expert whose adoption curve was very close to the overall average provided further support for the rapid increase from a small market presence before 2005 to the consensus penetration rate of over 75%.

> "This estimate assumes (informally) that water prices are going up along with natural gas and that the market will see the short paybacks involved with upgrading. If the economics weren't so good, 75% might be too high an assumption. It's hard to properly account for the voluntary programs run in 2002 through 2005. Since these were direct install programs, it is hard to tell how permanent a market change they would have caused in absence of standards.
>
> We believed the initial market share in the early 2000s was on the order of 10%. Lots of people were worried about cleaning performance and were concerned that efficient spray valves would double the labor involved in cleaning dishes, so there was definitely resistance to the idea in the market place and it would have taken time. We assume only 75% adoption because there are no doubt customers worried about pot filling and other applications for the spray valve that militate against purchasing high-efficiency units."

2.2.4 Attribution to C&S Program

Attribution refers to the portion of energy savings that can be credited to utilities' C&S Program efforts in enabling or assisting the adoption of each appliance or building standard. The attribution methodology adopted follows the California evaluation protocol and is described in detail in a memorandum submitted to the CPUC.[47] The result of the attribution analysis is an attribution score (a percentage between 0% and 100%) that represents the relative contribution of the Program to adoption of the standard and that is multiplied by the energy savings from the standard after adjusting potential savings for NOMAD and compliance.

The process of determining attribution credit was guided by the principles set forth in the CPUC Evaluation Protocol. The assessment of attribution included the following steps:

(A) First, an attribution model characterizing how C&S Program activities contributed to the adoption of the codes and standards was developed.

[47] The Cadmus Group. March 9, 2009. **"**The Proposed Cadmus Attribution Methodology (Revised)." This document is available at http://www.energydataweb.com/cpuc/default.aspx

(B) Then data on stakeholder activities from a range of sources, including stakeholder interviews, were collected.

(C) Stakeholders provided estimates of the effort required in three areas determined to be needed to provide the necessary and sufficient conditions for adoption of a new standard.

(D) Finally, independent third parties assessed the Program's contributions to the adoption of each standard based on a careful and systematic review of the evidence. The evaluation of Program contributions by independent parties lessened concerns about potential biases from having utility representatives directly involved in determining credit for their own efforts.

i. The Attribution Model

The section summarizes the model underlying the attribution methodology. A more complete description of the model and its development is contained in the memorandum cited above and in Appendix F.

The model sets forth specific criteria for evaluating the contributions of the Codes and Standards Program to standards development and adoption. The model focuses on three areas of activity representing the fundamental requirements that must be met for the California Energy Commission to adopt a standard; these are referred to as "factors" in the model. The factors are:

(1) The Development of Compliance Determination Methods and Other Special Analytic Techniques

End users must be able to determine that they are in compliance with the standards. Similarly, code officials (in the case of building standards) or the CEC or manufacturers (for appliance standards) must have tools or methods that allow them to verify compliance with the standards. In some cases, determining compliance entails having a reliable test method.[48] In other cases, it involves having an analysis tool that produces results indicating whether compliance is

[48] For example, the 2005 cool roof Title 24 standard, which applies to low-sloped, nonresidential buildings, has a well-defined test method in place. Section 10-113 of the standards requires that cool roofs be tested and labeled by the Cool Roof Rating Council. The testing and labeling of cool roofs by the CRRC provides the information needed to affirm compliance and permit enforcement of the standard.

achieved.[49] In addition, some standards require the development of new analytic methods to estimate energy and demand savings.

(2) The Development of Code Language and Technical, Scientific, and Economic Information in Support of the Standard

The standard must be defined in careful technical language that spells out covered products, effect dates, and required efficiency levels. Also, significant scientific, engineering, and economic research must be completed before a standard can be adopted. This research typically concerns estimates of energy and peak demand savings and the cost-effectiveness of measures. Since implementation of the C&S Program began, much of this research and development has been summarized in Codes and Standards Enhancement (CASE) reports funded by the utilities for standards in which they played a significant role.

(3) Demonstrating the Feasibility of Standard Adoption

An implicit requirement for adopting a new standard is that compliance with the standard be practical and feasible. Supporters of the standard must address stakeholder concerns and demonstrate through market research that stakeholders can comply with the standard. There are a number of conditions that must be met to satisfy this requirement. First, the market must be capable of supplying the products and services necessary to comply with the standard. If a product is not readily available in the marketplace, the technology must be well developed and manufacturers capable of increasing supply before the standard goes into effect. Second, the standard must not impose unreasonable and avoidable costs on end-users, manufacturers, and other stakeholders. Like most regulation, the benefits and costs of energy-efficiency standards may be distributed unevenly; the CEC does not require complete support among all stakeholders before standards adoption, but it must be able to defend the standard against opponents. Third, the standard must not create significant negative externalities related to human health or the environment.

[49] For example, the key requirement may be for a reliable method of estimating energy and peak demand savings associated with measures. This is typically the case with building standard measures and could lead to incorporation of special analytic procedures in the building standards compliance software.

To account for the distribution of effort among these three factors, a percentage weight between 0% and 100% was determined for each factor. The weight represented the relative amount of effort required to address the factor for adoption of the standard. The weights were estimated based on an average of expert opinions about the distribution of resources between the factors in the development of the standard.

A percentage score between 0% and 100% reflecting the contribution of the C&S Program to the factor in the development of the standard was determined based on evidence in the public record or obtained in interviews with stakeholders. The factor score indicated the percentage contribution of the C&S Program to the factor area.

The attribution score for a standard was then estimated as a weighted average of the factor scores. Each factor score was multiplied by the respective weight and the sum was the attribution score.

ii. Development of Information

The actual determination of C&S Program credit was based on a systematic and thorough review of available evidence about Program activities. The evaluators collected information from a variety of sources, including public documents, surveys and interviews. This section describes the sources relied on.

Review of Public Documents: The evaluation team collected information about Program and other stakeholder contributions to development and adoption of each standard from a large number of primary and secondary public sources, including the Code Change Theory, the CASE report, transcripts of CEC hearings and workshops, and stakeholder letters, e-mails, and comments to the CEC. These sources were carefully read and information about C&S Program and other stakeholder activities was extracted and entered into a spreadsheet for future reference in determining C&S Program credit.

Request for Information about Codes and Standards Program Undocumented Activities: In conversations and interviews with stakeholders, it became clear that some activities for which the Program might receive credit were not documented in the Code Change Theory, the CASE Report, or other written sources. In July of 2009, Cadmus requested that the California IOUs provide information about the following undocumented activities of the Codes and Standards Program:

1. How support of key stakeholders such as manufacturers, trade associations, etc. for the adoption of the standard was obtained.
2. The funding or other support of research by third parties that was critical to the development of the standard but not noted in the CASE report or other public documents.

3. Other instances of undocumented activity that contributed to the development of the standards in a significant way.

The IOUs responded to this request with two memos covering undocumented activities related to the following Title 20 and Title 24 standards:

- Title 20: Residential Pool Pumps, Portable Electric Spas, General Service Incandescent Lamps, External Power Supplies, and Pulse Metal Halide HID Luminaires.
- Title 24: Time Dependent Valuation, Residential Hardwired Lighting, Duct Improvement in Existing Residential and Commercial Buildings, Cooling tower Applications, Composite for Remainder.

Information from the memos was used in the determination of Program credit for applicable standards.

Stakeholder Interviews: The evaluation team also conducted interviews with key stakeholders to fill in remaining gaps in its understanding of the development of standards. Thirteen stakeholders closely involved in the development of the standards were interviewed. Most of the interviews covered Title 24 standards and focused on Codes and Standards Program activities related to stakeholder outreach. An obstacle to the use of interviews as a source of information about the Program was the amount of time that had elapsed between Program activities in 2001-2004 and the interviews. Many respondents could not remember the details of the development of the standard or got them confused with more recent proceedings.

iii. Survey of Experts about Stakeholder Resource Allocation

A spreadsheet-based survey tool was created to obtain information about the allocation of resources across the factor areas in the development of a standard. This information was used to develop the factor weights for each standard. The survey was distributed to 10 utility staff and consultants intimately involved in the adoption of the Title 20 and Title 24 standards.[50] Utility staff and consultants were offered a $400 incentive for participating, though some participants declined to accept the

[50] The evaluators attempted to recruit a larger number of experts representing different stakeholder groups but found that only utility staff and consultants believed they could answer the question.

payment. For each standard, we asked between 3 and 6 qualified utility staff or consultants the following question:[51]

> What was the percentage allocation of total stakeholder resources across the factor areas in the development of the standard, where resources are defined in terms of budgets?

To increase the probability of obtaining reliable and consistent answers, Cadmus distributed to potential respondents a list illustrating stakeholder activities in each factor area. In addition, respondents were asked to justify their answers. If large discrepancies existed between respondents in their answers, Cadmus followed up with questions to understand the differences.

For most standards, we received between three and five responses.[52] The survey responses were analyzed and the factor weights for each standard were estimated as a weighted average of the responses. A weight was assigned to each respondent reflecting the involvement of the respondent in the development of the standard and his or her presumed knowledge of stakeholder activities.[53] As the results of the survey (presented in Section 5.4.3) demonstrate, there was strong agreement between respondents in how resources were allocated between the factors for almost all standards.

iv. Estimation of Codes and Standards Program Credit

Cadmus developed a protocol for estimating the credit that the C&S Program would receive for its contributions to standards development. Three principles guided the determination of credit:

> 1. Attribution would be determined by disinterested third parties who did not have a stake in the amount of credit that was awarded.

[51] The survey also includes a question about the impacts of IOU incentive, training, and education programs on the adoption of the residential hardwired lighting standard. This question was asked for the CPUC residential new construction market effects study.

[52] However, for a small number of standards, we received only one or two responses. These standards were Large Packaged Commercial Air-Conditioners, Tier 2, Modular Furniture Task Lighting Fixtures, Water Dispensers, Duct Improvement, Lighting Controls under Skylights, Ducts in Existing Commercial Buildings, Duct Testing/Sealing in New Commercial Buildings, and Cooling Tower Applications. For such standards, Cadmus developed an independent estimate of the factor weights based on information in our databases. In every case, our estimate of how resources were allocated among factor areas agreed closely with the input from the outside respondents.

[53] Only one respondent was significantly less involved in the development of the standards than the other respondents. This respondent's answers received half the weight of the answers of the other respondents.

2. Credit would be awarded on the basis of evidence about Codes and Standards Program activities obtained from written sources and interviews.

3. The scoring process would be transparent, documented, and repeatable.

Cadmus convened a panel of independent evaluators familiar with the development and adoption of California Title 20 and Title 24 standards to decide C&S Program credit. The panel members convened in person and by teleconference for five sessions to complete their work. Cadmus also appointed a facilitator, who was not a member of the panel and who was responsible for presenting evidence about C&S Program contributions to the panel and recommending a score for each factor. Cadmus designated the C&S Program evaluation attribution task manager as the facilitator.

Before each meeting, the facilitator drew up an agenda with between 5 and 8 standards for the panel to consider. The facilitator also prepared a slide presentation for each standard, which summarized evidence about C&S Program and other stakeholder contributions to the development of the standard and recommended a score for each factor. The presentations, the Code Change Theory, the CASE Report, and the spreadsheet summarizing stakeholder contributions were distributed to the panel at least 24 hours before the meeting was scheduled for members to review.

At the first meeting of the panel, the facilitator explained the attribution model and the scoring protocol and instructed the panelists about the kinds of evidence they should consider and the determination of the factor scores. The panelists were told that the contribution of the Program to each factor was to be judged relative to the contributions of other stakeholders including the CEC. In addition, the panelists were told that the amount of effort required for a factor should not influence the determination of the factor score. For example, the panel considered a large number of standards for which the CEC adopted existing test methods. The C&S Program and other stakeholders did not need to devote many resources to the development of compliance methods (factor 1) in such cases. However, the Program could still receive a high score for the factor if the Program identified and proposed the test method and the CEC accepted the method.[54]

The deliberations of the panel began with a short presentation by the facilitator. The facilitator briefly explained the development of the standard, including the prescriptive or performance requirements,

[54] The C&S Program would receive a high factor score in this case, but the score would count for relatively little because the weight for this factor would be small.

the key stakeholders, and the history of the development of the standard. The facilitator then presented evidence about the C&S Program contributions and a proposed score between 0% and 100% for each factor.

The panel then considered the recommended score. The panel could accept or reject the score. If the panel accepted, the recommendation became the final factor score. If the panel rejected the recommendation, it could decide on an alternative score by mutual agreement, which would become the final score, or the panel could ask the facilitator for more information and an opportunity to reach agreement at a later time in light of new information. The facilitator would attempt to obtain the requested information and then revise and resubmit the factor score to the panel for re-consideration.

If the panel could not agree on a factor score, each member of the panel would explain his view. The panel would then have a second opportunity to reach agreement. If the panel still could not agree, the final factor score would be an average of the preferred factor scores of the members.

The panel was able to reach agreement about the factor scores for each standard it considered. In a few instances, the panel asked the facilitator for more information about the development of a standard. The facilitator obtained the information and presented it to the panel, which then agreed on a score.

v. Special Case: Composite for Remainder

As noted earlier, the Composite for Remainder (CfR) consisted of Title 24 standards for which the Program did not prepare a CASE report. Although the Program did not create a CASE report for the standards in the CfR, the Program contributed significantly to the development of several standards in the CfR by performing technical analyses, stakeholder outreach, or advocacy.

Because of the large number of standards in the CfR, Cadmus did not evaluate the contribution of the Codes and Standards Program to each CfR standard. Instead, a separate attribution analysis was performed for the CfR standards in three groups: indoor lighting, outdoor lighting, and HVAC/envelope. Cadmus relied on the Composite for Remainder Code Change Theory, CEC staff reports, transcripts of CEC hearings and workshops, public comments, and interviews with stakeholders to evaluate the contribution of the C&S Program to each group of standards. The same evaluation criteria were applied as in the evaluation of standards for which the Program prepared a CASE report.

The final score for each factor in the CfR was calculated as a weighted average of the factor scores of the standards groups in the CfR. The weights were the percentages of gross savings in the CfR for each group of standards.

2.2.5 Integrated Standards Savings Model

A software model was developed to compile all the inputs and outputs of the analyses described above. The model embodied the basic structure and relationships of the existing SES, but with additional capabilities for sensitivity analysis and assessment of the effects of uncertainty associated with various inputs.

The Integrated Standards Savings Model (ISSM) is a flexible Excel-based model for estimating net energy and demand savings attributable to the California IOUs' C&S Program. The model has a dynamic user interface to allow standards to be grouped by sector, segment, or end use when analyzing and estimating savings. It also contains a built-in Monte Carlo simulation tool to allow for uncertainty in inputs such as per unit savings, attribution score, compliance, and NOMAD and quantify the effects on the confidence and precision of final savings estimates. The model focuses on savings occurring from 2006 to 2020 resulting from the Title 20 and 24 standards adopted that went into effect during the period October 2005 through 2008.

The model inputs can be separated into static inputs, time dependent inputs, NOMAD inputs, and attribution inputs. Static inputs do not vary by year, only by standard. These include:

- Codes & Standards implementation month/year
- Attribution to the C&S Program
- Effective measure life
- First year potential energy savings per unit
- First year potential demand savings per unit
- First year potential gas savings per unit

Time dependent inputs are allowed to vary by year and include:

- Annual compliance rate
- Volume of units in marketplace

The model includes a Bass model curve generator which requires the following as inputs:

- NOMAD start year
- Maximum achievable penetration

- Leading behavior coefficient
- Following behavior coefficient

Finally, the model contains the attribution score inputs for each standard. As described in Section 2.1.2iv, the attribution score is developed by combining the weights assigned to three factors for each standard and a measure of the credit the C&S Program receives for its contribution toward adoption of the standard. These inputs are incorporated in the ISSM.

Based on these inputs, the model calculates the C&S Program net standards energy, demand, and gas savings for a single standard or a group of standards (depending on the user selection). First, the model calculates the total potential savings of a standard by multiplying the volume of units in the marketplace in each year times the per unit potential energy savings. After this, a series of adjustments are made to account for non-compliance, naturally occurring market adoption, the effect of utility programs on market adoption, measure life, and the attribution credit utilities receive for their contribution to the adoption of standards.

Basic savings analysis can be done using expected values for each of the inputs. However, there is some degree of uncertainty in the value for most of the inputs. To account for this, the model has a built in Monte Carlo simulator to allow sensitivity analysis to be conducted on the program savings. Probability distributions can be input into the model for each standard's per unit savings, volume of units in the marketplace, attribution score, annual compliance rate, and NOMAD parameters (including maximum penetration as well as the shape of the Bass curve). For the NOMAD parameters, it is also possible to use the inputs of each of the experts and vary the selection. The user decides at run time which of the input variables to model as uncertain. The model outputs tables and graphs showing confidence intervals and probability distributions for savings.

2.2.6 Allocation to Individual Utilities

The net Program savings were allocated to the individual utilities. The SES makes this allocation based on utility sales, which has been acceptable to the utilities and the CPUC. The same approach was used in this evaluation.

3. Validity and Reliability

This section discusses steps taken to increase both the validity and reliability of key measurements and parameter estimates. It also discusses for each of the key evaluation components how the types and levels of uncertainty affect study findings and presents recommendations for improving reliability and increasing cost efficiency for future studies.

3.1 Potential Energy Savings

For the standards evaluated in this study, we conducted research to improve the accuracy of the quantities used to estimate potential energy savings. Potential savings are the initial component in the Program savings calculation (see Figure 2) and reflect uncertainties in the unit savings and quantities that determine potential savings. Any uncertainties in these values get carried through as uncertainties in the final Program savings estimates.

3.1.1 Building Standards

For the building measures analyzed, we conducted research to identify more recent and accurate unit energy savings estimates than those used in the CASE reports and as the basis for savings estimates in the SES. Accuracy of whole building potential energy savings estimates was improved by using the characteristics of an actual sample of buildings constructed since the 2005 Title 24 went into effect. Accuracy of estimates of number of buildings affected was improved by obtaining actual permit data for buildings to estimate new buildings.

Overestimates of building construction or unit measure savings would overestimate savings credited to the Program. Uncertainties in building standards potential savings values could be reduced by:

- Using metered data to verify unit savings estimates
- Collecting information on actual number of buildings constructed and major renovations

These types of data quality improvements are likely to be fairly costly to implement, particularly collecting metered data. Some of the information could be collected as part of other efficiency or research programs. Overall, the improved accuracy would need to be assessed relative to the data collection expenditures to determine whether it was cost effective to pursue.

3.1.2 Appliance Standards

For the appliance standards analyzed, we conducted research to identify more recent and accurate unit energy savings estimates than those used in the CASE reports and as the basis for savings estimates in the SES. Accuracy of estimates of number of units affected was improved by using sources presenting more recent sales data, when available.

Uncertainties in potential savings values could be reduced by taking the following steps:

- Increasing the accuracy of unit savings estimates
- Determining average efficiency levels in the market
- Collecting actual sales data

These types of data quality improvements are likely to be fairly costly to implement, particularly developing sales data for all appliances. Some of the information could be collected as part of other efficiency or research programs. Overall, the improved accuracy would need to be assessed relative to the data collection expenditures to determine whether it was cost effective to pursue.

3.2 Compliance Rates

Compliance rates are used in the evaluation to calculate gross savings from potential savings. Uncertainties in compliance rate estimates, therefore, introduce uncertainty in the gross savings estimates, and these uncertainties carry over to the net savings estimates. Overestimates of compliance rates increase the savings attributed to the Program. The main way we attempted to increase compliance rate validity and reliability was by including as large a sample of buildings and appliances as we could with the available time and resources. [55]

3.2.1 Building Standards Compliance Rates

For residential buildings, we had data from a representative sample of 194 buildings and whole house compliance could be determined very accurately. At the measure level, we had data on hardwired

[55] In general, the term "code" refers to regulations applied to the construction of buildings and "standards" apply to appliances. However, the terms are used interchangeably in some venues and the California Code of Regulations, in which Title 24 appears, is known as the California Building Standards Code and the regulations are often referred to as the Title 24 Building Standards or just Title 24.

lighting compliance for the same 194 homes; this measure produced the single largest estimated energy savings in new residential buildings. We found from a subsample of approximately 50 buildings that none used prescriptive, measure-level compliance and our field data collection did not provide information on whether buildings used the prescriptive compliance approach. However, most residential standards for which CASE reports were prepared applied to existing buildings so information on retrofits was most relevant. We used two approaches to estimate retrofit compliance—a homeowner survey and a survey of code officials—but the accuracy was inherently limited because there was no direct way to verify the estimates. Overall, the reliability and validity of whole house compliance was quite good, while it was considerably less for compliance with prescriptive requirements.

For nonresidential buildings, the difficulties of identifying a building sample and collecting compliance data limited the size of the building sample we were able to analyze (see Appendix H). Consequently, the reliability and validity of estimated compliance rates were reduced.

Accuracy in the building compliance rates could be increased by expanding the field data collection. Our experience, however, indicates this can be relatively costly to conduct and difficult to implement. Estimating compliance levels for standards applying to residential retrofits is especially challenging.

3.2.2 Appliance Standards Compliance Rates

For appliances, in many cases we were able to document the characteristics of scores or hundreds of units so the accuracy of compliance rates was quite high. In other cases, though, we were able to document characteristics of only a small quantity of units so the reliability and validity were diminished.

The major way the compliance analysis could be improved and simplified would be for all manufacturers to list their compliant products with the CEC. To ensure this happened would probably require an orchestrated enforcement effort that would identify and prohibit the sale of all unlisted items.

3.3 NOMAD

Uncertainties in the NOMAD estimates affect the net savings estimates. Overestimates of NOMAD market penetration reduce the savings credited to the Program. However, the uncertainty tends to be the least in the initial period, 2006 through 2008.

Several steps were taken to increase the validity and reliability of NOMAD estimates for both appliances and buildings. First, the prior approach using a linear market penetration growth rate was replaced with an S-shaped curve that is more characteristic of actual markets. Second, experts on each appliance or

building measure were sought out for their input rather than relying on the judgment of utility representatives or analysts. Third, we attempted to include as many experts as possible in the estimation process, targeting a minimum of four for each appliance or building standard. Fourth, the initial market penetration estimates were compared to information from other sources and we maintained consistency with the assumptions used in the potential energy savings analysis.

The NOMAD uncertainties could be reduced by acquiring actual market penetration data and trends in years prior to standard adoption. A variant on this approach would be to establish average efficiencies of products and whole buildings and their trends. This would be consistent with an impact evaluation methodology that compares the average efficiency of products after a standard goes into effect with what the average would have been without the standard. This approach was not used in the current study, but is discussed more later.

3.4 Program Attribution

Uncertainties in the attribution estimates affect the reliability and validity of the net savings attributed to the Program. Overestimates of attribution create an upward bias in the savings credited to the Program.

The reliability and validity of attribution estimates were improved using some of the same approaches described for the NOMAD analysis. In addition, using a team of experts who were not involved in the standard development reduced the likelihood of biases in the estimates.

The most significant way the attribution analysis accuracy could be increased would be through direct observation and documentation of the standard development and adoption process by outside observers. As part of our evaluation effort, we did monitor development of some of the next round of standards and compiled information from these processes so this information will be available for the next evaluation.

3.5 Utility Allocation

No specific steps were taken to enhance the reliability and validity of the utility allocation of savings credit. The utilities agreed to allocate credit based on energy sales. Uncertainties arise in this approach when savings are not distributed strictly proportional to utility sales. For example, if swimming pools are more common in warmer climates, the savings from more efficient pool pumps would be proportionately larger than in cool climates and would understate the savings attributable to a utility serving primarily warm climate zones.

The allocation of savings could be done more accurately if sufficient information was available to distribute the savings for each appliance and building type by utility area. This would require considerable effort and data that are likely to be difficult to obtain.

4. Confidence and Precision

As shown in Figure 2, the process of estimating energy and demand savings attributable to the C&S Program involves starting with unit savings estimates and then making a complex series of adjustments to these estimates. This process does not lend itself to a simple approach of developing confidence level/precision estimates based on sampling statistics. The parameter values estimated in each analysis step are derived by applying different methodologies. Therefore, each evaluation component is subject to different kinds of uncertainties and measurement errors that affect the confidence/precision associated with the estimated value.

For discussion purposes, we describe the confidence and precision associated with each component of the savings estimates and the factors that determine them. In general, we describe the confidence and precision qualitatively for each component. We categorize each component as low, medium, or high precision where, in our judgment, at the 90% confidence level:

- Low precision is 30% or more,
- Medium precision is between 10% and 30%, and
- High precision is 10% or better.

In addition, we developed quantitative confidence and precision estimates using the Monte Carlo method built into ISSM to explore the effects of uncertainties in each component of the evaluation to derive the verified Program savings. These estimates are based on probability distributions for each variable used in ISSM to develop overall confidence and precision bounds for the final verified savings. This is discussed at the end of this section.

4.1 Potential Energy Savings

Potential energy savings are determined by unit energy savings and the number of units affected.

4.1.1 Appliances and Building Standard Measure Unit Energy Savings

The measure and appliance unit energy savings estimated in our evaluation were based on CASE report values, adjusted with more recent data when possible as described later. In most cases, the original estimates or the updated values were derived using engineering analysis; in some cases, measured data were used. The sources of these data did not report confidence/precision values so we relied on our team's expert judgment to assign best estimates for each measure and appliance. In general, we found that precision of the building measure and appliance unit savings were at the medium level. We

assumed unit energy savings followed a triangular distribution around the verified expected unit savings value.

4.1.2 Whole Building Energy Savings

Our estimates of potential savings at the whole building level were based on the results of simulation model runs (Micropas for residential buildings and EnergyPro for nonresidential buildings). There is little information available to determine the confidence/precision applicable to energy consumption estimates from the two building analysis models used to estimate residential and nonresidential building energy use. Past studies have shown, however, that such models tend to overestimate energy savings. In the case of residential buildings, the Residential New Construction study calibrated energy use using a sample of end-use metered data. However, this was not done for the data used in the Title 24 analysis. For nonresidential buildings, resources were not available to calibrate the model runs. For both residential and nonresidential buildings we estimate the precision level is medium. In both cases, we used a triangular distribution to represent the uncertainty in the whole building savings estimate.

4.1.3 New Building Quantities

The market baseline captures the number of new appliances sold or buildings constructed per year. For buildings, we used building permit data as the estimate of new buildings constructed. For nonresidential buildings, the permit data available were provided in dollars rather than units or square feet. We converted these values to square feet of buildings constructed using another database that provided both building floor area and cost. For residential buildings, these data quite accurately report the number of buildings permitted.

Although the building permit data were available and were likely to be quite accurate, permits count probable building construction at a future date, not actual building completions. To estimate building completions, we converted permit volumes to building starts using building officials' estimates of the average lag time between permit and occupancy dates and assuming that all permitted buildings were constructed. Given that some error was introduced by the lag between permitting and occupancy, some buildings were not constructed, and the conversion of valuation to square footage was based on an average ratio, we believe the estimates have a medium level of precision. We assumed a triangular distribution about the mean value in our uncertainty analysis.

4.1.4 Appliance Sales

For appliances, there were no actual sales data available for the years analyzed for any appliances. Our estimates were based on CASE report values or more recent sales estimates from other sources. Overall, the precision of these estimates was at the medium level and we assumed the estimate has a triangular distribution.

4.2 Compliance Rates

4.2.1 Building Standards Compliance

The precision of building standard compliance rates at the whole–building level was determined primarily by the sample size and representativeness of the buildings analyzed. For residential buildings, the precision was high because we were able to analyze a large, well distributed building sample. For nonresidential buildings, the sample was small and we estimate the precision was at the low level. We used data from the whole-building compliance analyses to define the distribution of compliance rate for each building category.

For compliance by building standard measure, the sample size was relatively small. Consequently, we believe the precision of the compliance rate for most measures was low, though it was medium for measures found in abundance. We used a triangular distribution to represent the probability distribution of measure compliance in the Monte Carlo simulations.

4.2.2 Appliance Standards Compliance

For appliances, compliance rate precisions varied. In many cases, it was high because we had very large samples of a product. In other cases, the precision was medium because we were able to examine fewer individual units or had to rely on indirect compliance assessments. We assumed triangular distributions for appliance compliance rates using the estimated standard errors in the mean compliance rates estimated.

4.3 NOMAD

To improve the quality of the NOMAD estimates, we attempted to recruit as many experts as possible to provide estimates for the appliance and building standards. The precision of NOMAD estimates is probably best judged by the spread in the experts' estimates, particularly during the 2006-08 period during which savings estimates are most critical. Precision was improved by using a Delphi approach

and, in a few cases, by removing the estimates of outliers. For most appliances and building standard measures, the precision was high over the years of most interest (2006-08). For several appliances and building measures, we judged the precision of the NOMAD estimates to be at the medium level.

For the Monte Carlo simulations, we used the NOMAD values provided by individual experts to represent the probability distribution. Ultimately, however, NOMAD estimates a counterfactual quantity, thus making it very difficult to assign a testable precision value to the estimates.

4.4 Program Attribution

As described earlier, one component of attribution estimates was based on input from experts familiar with the adoption of each standard. These inputs were obtained from several experts who were among the small set of individuals most familiar with each standard. Assessment of the role of the C&S Program in adoption of each standard was made by a disinterested group from the evaluation team, relying on an extensive record for each standard; this process eliminated potential biases in the estimation of the Program's effects. Steps were taken throughout the process to implement a comprehensive, consistent, and unbiased methodology to ensure accurate estimates. Given the number of respondents and range of estimates, we believe the precision of the attribution estimates is at the medium range.

For the Monte Carlo simulations, we used the attribution values provided by individual experts to represent the probability distribution as we did for the NOMAD estimates.

4.5 Utility Allocation

Allocation of Program savings to individual utilities was based on each utility's proportion of statewide energy sales. This distribution was proposed and agreed to by the utilities. To produce a very accurate determination of where the attributable savings were generated would require a detailed analysis of building construction and appliance sales. Given that the utilities agreed to allocation based on sales, we accept this approach and assume that it provides high precision.

4.6 Overall Confidence and Precision Estimates

As noted earlier, we used the ISSM to estimate overall confidence and precision levels for the verified energy savings attributed to the C&S Program. This analysis was conducted using a Monte Carlo simulation approach. The distributions used for factors based on experts' inputs (e.g., NOMAD) were defined as a range established by the lowest and highest estimates. The values of each of the key inputs were entered as a distribution with associated probabilities and the model was run hundreds of times to generate a distribution of net savings attributed to the Program for each standard and overall.

Overall results showing the width of the 90% confidence interval are presented in Table 18. The table shows the width of the confidence interval for each of the components estimated to calculate the energy savings and the width of the confidence interval for the primary energy and demand savings estimates.

Table 18.Overall Uncertainty Analysis Results

Estimated Inputs and Outputs	90% Confidence Interval, Plus and Minus %
ENERGY - GWh	
Potential Energy Savings	4%
Adjustment for Non-Compliance	16%
Gross Energy Savings	5%
Adjustment for Net NOMAD	15%
Net Energy Savings	7%
Adjustment for Attribution	9%
Program Net Energy Savings	8%
DEMAND - MW	
Potential Energy Savings	4%
Adjustment for Non-Compliance	16%
Gross Energy Savings	6%
Adjustment for Net NOMAD	14%
Net Energy Savings	7%
Adjustment for Attribution	9%
Program Net Energy Savings	7%
GAS- Mtherms	
Potential Energy Savings	4%
Adjustment for Non-Compliance	26%
Gross Energy Savings	5%
Adjustment for Net NOMAD	14%
Net Energy Savings	6%
Adjustment for Attribution	9%
Program Net Energy Savings	6%

5. Detailed Findings

This chapter presents the primary findings from each of the steps in the evaluation.

5.1 Analysis of Potential Energy Savings

5.1.1 Introduction

The first step in evaluating impacts attributable to the Program was to estimate the savings possible for each appliance sold (in the case of Title 20 standards) and each building constructed or renovated (in the case of Title 24 standards). These savings were then multiplied by the actual quantity of appliances sold and buildings constructed, respectively. We refer to this quantity as the potential savings for each standard.

For both the appliance and building standards, this evaluation started with the unit savings and unit quantities used by the utilities to estimate claimed savings. In most cases, these values were presented in the CASE reports prepared to support adoption of each standard. This step in the evaluation reviewed both the unit savings and the sales and construction quantities, making adjustments to the original values where appropriate.

One critical change in this analysis was how the initial penetration factor (percent of units already meeting the specific standard in the first year the standard goes into effect) was treated. The CASE reports adjusted the first-year savings to account for the estimated first-year market penetration of complying appliances or measures and referred to the result as the "gross savings." As the current evaluation includes a separate task to estimate naturally occurring market adoption (NOMAD) of efficient appliances and building measures meeting the proposed standards, this team's approach relied on the NOMAD analysis to provide the estimate of market penetration in the first year as well as subsequent years. The value from the NOMAD analysis was applied in a subsequent step to reduce the potential savings estimated for each standard in all years analyzed.

5.1.2 Appliance Standards

In 2005, California adopted 20 appliance standards with most scheduled to go into effect in 2006, but the effective date for a few was as late as January 2010. We refer to these as the 2006 Title 20 Standards. Table 6 showed all the appliance standards and their effective dates. The table included two standards adopted during the 2006-08 period as Tier 2 versions. Savings for these additional standards were partially analyzed here and, though they were implemented prior to 2009, their savings are not

being counted in this evaluation, because they represent post-2005 efforts whose impacts are to be counted in the next program/evaluation cycle per Decision .05-09-043, Attachment 10 (p.5).

CASE reports were prepared under IOU auspices for all of these appliance standards. The Title 20 reviews began with a critical and thorough review of these CASE reports.

As described earlier, we analyzed the potential energy savings for these standards based on a review of the savings claimed for these standards. The results for each specific appliance standard are summarized in Table 19**.** Information on the individual standards is presented in Appendix C. As noted before, one significant change that occurred in this analysis compared to the analyses conducted as the basis for the SES savings estimates was removing initial market penetration from the potential savings estimate. In those cases where the original SES estimate of gross savings accounted for initial market penetration, this team's estimates of potential savings are not directly comparable.

Major findings from our analysis include:

- The largest claimed gross electricity savings were for the Tier 2 Residential Pool Pumps and Motor standard, but this standard was not included in our analysis for the reasons discussed before.
- The largest appliance standard potential electricity savings from this evaluation were for the Metal Halide Tier 1 standards. The Tier 1 External Power Supplies standard produced the next largest potential electricity savings.
- The evaluated potential savings for two standards were estimated to be zero because federal standards established a new baseline: Tier 2 Large Packaged Commercial Air Conditioners and Pre-rinse Spray Valves.
- In a few cases, the potential energy savings were evaluated to be larger than the original estimates of gross savings: External Power Supplies, Commercial Hot Food Holding Cabinets, Metal Halides, Portable Electric Spas, Refrigerated Beverage Vending Machines, Walk-in Refrigerators/Freezers, and Transparent Door Commercial Refrigeration. In most cases, the change was due to the elimination of an adjustment here for initial market penetration.
- The only appliance standard for which there were verified natural gas savings was the standard for Unit Heaters and Duct Furnaces.

Table 19: Potential Energy Savings for Appliance Standards

Standard	SES Gross Energy Savings		Potential Savings		
	GWh	Mtherms	GWh	MW	Mtherms
STD 1: Commercial Refrigeration, Solid Door	9.54	-	9.1	1.2	0
STD 2: Commercial Refrigeration, Transparent Door	8.36	-	12.2	1.6	0
STD 3: Commercial Ice Maker Equipment	6.60	-	6.5	0.9	0
STD 4: Walk-In Refrigerators / Freezers	47.97	-	72.1	9.5	0
STD 5: Refrigerated Beverage Vending Machines	12.63	-	15.1	2.0	0
STD 6: Large Packaged Commercial Air-Conditioners, Tier 1	13.47	-	13.5	7.0	0
STD 7: Large Packaged Commercial Air-Conditioners, Tier 2	10.05 (incremental) 23.52 (total)	-	0 (incremental) 0.0 (total due to federal standard)	0 (incremental) 0.0 (total due to federal standard)	0
STD 8: Residential Pool Pumps and Motors Tier 1	18.6	-	35.5	6.8	0
STD 9: Residential Pool Pumps and Motors Tier 2	148.7 (incremental) 167.3 (total)	-	0	0	0
STD 10: Portable Electric Spas	6.60	-	18.04	3.4	0
STD 11: General Service Incandescents Tier 1	79.2	-	0	0	0
STD 12a: Pulse Start Metal Halide HID Luminaires, (Vertical Base-Up only)	89.15	-	118.0	21.0	0
STD 12b: Pulse Start Metal Halide HID Luminaires, (All)	0 (incremental) 89.15 (total)	-	48.62 (incremental) 166.6 (total)	8.7 (incremental) 29.7 (total)	0
STD 13: Modular Furniture Task Lighting Fixtures	0.83	-	5.57	1.0	0
STD 14: Commercial Hot Food Holding Cabinets	1.5	-	6.44	0.9	0
STD 15: External Power Supplies Tier 1	47.8	-	103.0	11.7	0
STD 16: External Power Supplies Tier 2	8.6 (incremental) 56.4 (total)	-	18.6 (incremental) 121.7 (total)	2.1 (incremental) 13.9 (total)	0
STD 17: Compact Audio Products	56.1	-	49.3	5.6	0
STD 18a: Consumer Electronics--Televisions	67.5	-	62.1	7.1	0

Standard	SES Gross Energy Savings		Potential Savings		
	GWh	Mtherms	GWh	MW	Mtherms
STD 18b: Consumer Electronics--DVDs	12.0	-	11.8	1.3	0
STD 19: Water Dispensers	6.14	-	6.15	0.8	0
STD 20: Unit Heaters and Duct Furnaces	-	2.05	--	--	2.47
STD 21: Pre-rinse Spray Valves	34.3 GWH	4.54	0.0 GWH	0.0	0.0

5.1.3 Building Standards

In 2005, California implemented a set of residential and commercial building standards that went into effect in October 2005. We refer to these as the 2005 Title 24 standards. Table 7 showed the building standards that the C&S Program initiated as code change proposals and that were subsequently adopted.

CASE reports were prepared under IOU auspices for all of these building standards except the one referred to as the Composite for Remainder, or CfR. Three of the standards shown in this table were unique and are described briefly before the estimated potential savings are presented.

Standard B1 (residential) and B2 (nonresidential), Time Dependent Valuation (TDV), represent a new methodology for valuing energy savings in terms of the real resources used in energy production. They are unlike any of the other Title 24 standards in that the standard is a calculation procedure, rather than a performance or prescriptive requirement for a building component. TDV recognizes, in particular, that the marginal costs of electricity production and the benefits of load reductions vary over time. The marginal costs of production and the benefits of demand reductions are highest during system peaks, typically the summer months in California. Before the TDV concept was introduced, energy savings were treated as if they had the same value regardless of when they occurred. Savings were estimated originally for these two standards based on the presumption that implementing these calculation methods would lead to building measures that reduced peak usage more than other possible measures.

The final standard in Table 7, Composite for Remainder, is an aggregation of all standards for which the Program did not develop CASE reports. The utilities claimed that the Program influenced the adoption of some of the standards in this remainder, but the role of the Program was less formal.

We conducted a thorough review of each of the building standards to estimate the potential savings. This was more challenging than the analysis of the Title 20 standards because the estimated building standard savings were often based on multiple sources and results of building simulation analyses. The results for each building standard are summarized in Table 20. Information on the individual standards

is presented in Appendix D and Appendix J. As noted before, one significant change that occurred in this analysis compared to the analyses conducted as the basis for the SES savings estimates was removing initial market penetration from the potential savings estimate. In those cases where the original SES estimate of gross savings accounted for initial market penetration, this team's estimates of potential savings are not directly comparable.

Key findings from this analysis include:

- The potential energy or demand savings were estimated to be zero for the two Time Dependent *Valuation* (TDV) standards (residential and nonresidential) though the original gross energy savings estimated for these standards were relatively large. The rationale for this revision is presented fully in Appendix J. The basic reason was that the evaluation team could find no evidence that the standards would drive building design toward more on-peak savings to meet the requirements of the standards.
- The Residential Hardwired Lighting standard was the single measure with the largest electricity savings in both the original gross savings analysis and in this evaluation analysis of potential savings.
- The evaluation potential savings estimates for some standards were larger than the corresponding gross savings estimates. In the case of Window Replacements in residential buildings, our estimated savings were about four times the original estimate, primarily because the potential savings were not reduced by initial market penetration, but are accounted for in the subsequent NOMAD analysis.
- The potential savings estimate for Cool Roofs included a penalty for natural gas heating (negative savings), but the gross savings estimate did not. The studies that were used as the basis for the cool roof savings identified such a penalty, but it was dropped from the final gross savings values.
- Electricity savings for the Composite for Remainder (standards for which the C&S Program did not prepare CASE reports) were dominated by nonresidential building standards, but gas consumption increases in this category due to interactions almost equaled estimated gas savings for residential building standards in this category.

Table 20. Potential Energy Savings for Building Standards

Standard	SES Gross Savings		Potential Savings		
	GWh	MTherms	GWh	MW	MTherms
STD B1: Time Dependent Valuation, Residential	6.7	0	0	0	0
STD B2: Time Dependent Valuation, Nonresidential	4.3	0	0	0	0
STD B3: Residential Hardwired Lighting	64.6	0	45.0	2.07	0
STD B4: Ducts in Existing Residential Buildings	5.7	1.1	6.3	9.4	1.2
STD B5: Window Replacement	6.3	0.3	25.4	9.7	1.18
STD B6: Lighting Controls Under Skylights	25.5	0	12.73	0	0
STD B7: Ducts in Existing Commercial Buildings	9.7	1	11.45	8.7	1.22
STD B8: Cool Roofs	14.6	0	18.3	11.9	-0.252
STD B9: Relocatable Classrooms	2.9	0	2.9	0	0
STD B10: Bi-Level Lighting	12.1	0	1.65	0	0
STD B11: Ducts in New Commercial Buildings	8.01	0	2.39	1.24	0.012
STD B12: Cooling Towers	3.01	0	3.01	0	0
STD B13: Multifamily Water Heating	0	1.54	0	0	0.31
STD B14: Composite for Remainder	321.5	3.25	Res: 2.23 Nonres: 85.6	Res: 3.13 Nonres: 21.3	Res: 0.65 Nonres: -0.22
STD B15: Whole House a. Electric b. Natural Gas	98.7	5.5	47.6	2.77	0.72

5.2 Compliance Analysis Results

5.2.1 Appliance Standards Compliance Results

This section provides information on the nature of the appliance standards data sample and resulting compliance rates. Specific detailed information about each appliance is presented in Appendix M.

Primary Appliance Standards

We collected primary data on the appliances for which the estimated energy savings of the standards were the largest. The left section of Table 21 provides basic sampling data on each of the appliances, including the number of stores visited for each appliance, the number of unique models observed (therefore not including duplicates), the total number of units observed (including duplicates), a calculation for the percentage of the sample that had to be omitted, and finally the actual number of total units used for analysis of compliance. It was necessary to omit some models from the sample for each appliance type due to unavailability of the data needed to determine compliance. In-depth web searches and calls to manufacturers were conducted to find all necessary specifications for these models, but for some products these efforts were largely unsuccessful. The compliance rates were, therefore, computed only using the portion of the sample that provided the relevant energy consumption information. A different approach was taken with walk-in refrigerators and freezers and the compliance rate was estimated based on more limited data.

Table 21. Sample Data Details and Compliance Results for Primary Appliance Standards

	Sample Data Details					Compliance Results		
Appliance	# of Sites Visited	# of Unique Models	Total Units Sampled	% of Sample Omitted	# of Units for Analysis	% CEC Listed Compli-ant	% Compli-ant - Unlisted	% Non-Compli-ant
STD9: Pool Pumps	12	86	152	28.9%	108	89.8%	3.8%	6.4%
STD4: Walk-in Refrigerators & Freezers	3	N/A	3	N/A	3	N/A	88%	12%
STD12: Metal Halide Luminaires	9	13	18	11.1%	16	0.0%	51.9%	48.1%
STD11: Genl. Service Incandescent Lamps Tier 2	9	145	176	16.5%	147	13.5%	30.1%	56.4%
STD21: Pre-Rinse Spray Valves	11	11	31	3.2%	30	70.5%	29.5%	0.0%
STD17: Audio Players	10	78	97	61.9%	37	78.2%	21.8%	0.0%
STD18a: Televisions	11	235	293	6.5%	274	64.2%	31.9%	3.9%
STD16: External Power Supplies Tier 2	11	180	208	42.3%	120	N/A	98.7%	1.3%
STD20: Duct and Unit Heaters	9	53	59	5.1%	56	82.7%	17.3%	0.0%

The right section of Table 21 shows the statewide compliance rates of each appliance with the current Title 20 standard. In the case of pool pumps, metal halides, general service incandescents, and external power supplies, the compliance estimate is relative to Tier 2 standards since those standards were in effect when we collected field data.

It is important to note the difference between the columns displaying CEC listed compliance and unlisted compliance, as these represent different ways that the products were determined to be in compliance with the standard and are defined to be mutually exclusive. The value under CEC-listed compliance represents the percentage of units that were included in the CEC compliance list, whereas the unlisted compliance shows the percentage of units that did, in fact, meet the energy-efficiency requirements of the standard, but were not listed in the CEC compliance

database. For an appliance to comply with Title 20, it has to meet all standard requirements, and have been certified and listed in the CEC database[1]. These "unlisted compliant" products are not officially in compliance with Title 20, but for the purpose of this evaluation, compliance with the efficiency requirements of the standards was important to note as well.[2] The non-compliant column represents the estimated statewide percent of units that were not listed in the CEC database and upon inspection of technical specifications did not meet the current standards. These three compliance breakouts sum to 100% per appliance, therefore encompassing the entire sample.

Within the non-compliance results, for appliances where the standards were implemented in tiers, we assessed current compliance with Tiers 1 and 2. To provide a better understanding of non-compliance with Tier 1, the proportion of units that satisfied the 2006 requirements while failing to meet the Tier 2 standards is shown in Table 22.

Table 22. Tier 1 and Tier 2 Compliance

Appliance	% Not Complying with Tier 2	% Tier 1 Compliant but Not Tier 2 Compliant	% Not Compliant with Tier 1 or Tier 2
STD8/9: Pool Pumps	6.4%	6.4%	0%
STD12a/b: Metal Halide Luminaires	48.1%	48.1%	0%
STD11: GS Incandescent Lamps	56.4%	25.1%	31.3%
STD15/a6: External Power Supplies	1.3%	1.3%	0%

Table 22 shows the four appliances that had tiers of the standard implemented in separate years, 2006 and 2008. The second column is simply a repeat of the information on non-compliance in Table 21. Column three shows the percentage of the overall sample that met the 2006 Tier 1 standards, but fell short of the more stringent 2008 standards. The fourth column simply shows the difference between these 2008 Tier 2 non-compliance and 2006 Tier 1 compliance values which therefore shows the percentage of the sample compliant with neither the 2008 nor 2006 standards. This finding is very significant because it shows that in the case of GS Incandescent Lamps, 31.3% of the units did not meet the efficiency requirements of the 2006

[1] 2007 Appliance Efficiency Regulations, Section 1606 (a) p. 133.
[2] Neither walk-in refrigerators/freezers nor external power supplies are required to be listed in CEC databases. Consequently, the compliance rate was determined strictly on the basis of specifications of observed units.

Tier 1 standards.[3] On the other hand, for Pool Pumps, Metal Halide Luminaires and External Power Supplies, all the units that failed the 2008 standards did in fact meet the 2006 standards.

Table 23 gives the total compliance of each appliance, determined as the sum of the CEC listed units and the unlisted units that were found to be compliant with the efficiency requirements of the standard. The 90% confidence intervals are presented. This confidence was determined by scaling the compliance rates and units per store up to the state level by expanding to the known number and size of stores that sell each appliance type in California. Confidence could not be assigned to walk-in refrigerators and freezers due to the limited number of sites in the sample.

Table 23. Total Compliance Rates and 90% Confidence Intervals for Primary Appliance Standards

Appliance	Total Compliance Rate	90% Confidence Intervals
STD9: Pool Pumps	93.6% ± 4.0%	89.6% - 97.6%
STD12a: Metal Halide Luminaires Tier 1	48.1%*	--
STD12b: Metal Halide Luminaires Tier 2	51.9% ± 11.8%	40.1% - 63.7%
STD11: GS Incandescent Lamps Tier 1	69%*	--
STD11: GS Incandescent Lamps Tier 2	43.6% ± 7.6%	36.0% - 51.2%
STD21: Pre-Rinse Spray Valves *	100% ± 0%	100%
STD17: Audio Players	100% ± 0%	100%
STD18a: Televisions	96.1% ± 1.2%	94.9% - 97.3%
STD15: External Power Supplies Tier 1	100%*	--
STD16: External Power Supplies Tier 2	98.7% ± 1.1%	97.6% - 99.8%
STD20: Duct and Unit Heaters	100% ± 0%	100%
STD4: Walk-in Refrigerators & Freezers	88%	--
*The precision was not calculated for this appliance.		

Remaining Appliance Standards

The results presented above were for the top energy-saving appliance standards, comprising 97% of the total savings estimated for Title 20 standards. Our evaluation data collection and analysis efforts were concentrated on these standards because of the magnitude of their likely

[3] We reviewed the data that produced this number. We found that nearly 90% of the bulbs that did not comply with the 2006 Title 20 were of the Reveal brand made by General Electric. It was unclear from the regulations whether they covered these bulbs, but it was not critical to determine this for the current analysis because they resulted in essentially no energy savings.

savings. Due to scope limitations and their minimal savings, we did not conduct primary compliance analyses on the remaining appliance standards that made up the additional 3% of estimated savings.

These remaining appliance standards and our estimates of their compliance rates are shown in Table 24. The compliance rate estimates presented are from the latest version of the SES. The original compliance rates used in the SES were 70% for all products, but some were revised based on a study conducted in 2007.

Table 24. Compliance Estimates for Standards Not Analyzed Using Primary Data Collection

Appliance	Compliance Estimate
STD1: Commercial Refrigeration Equipment, Solid Door	70%
STD2: Commercial Refrigeration Equip., Transparent Door	70%
STD3: Commercial Ice Maker Equipment	70%
STD5: Refrigerated Beverage Vending Machines	37%
STD6: Large Packaged Comm. Air-Conditioners, Tier 1	70%
STD7: Large Packaged Comm. Air-Conditioners, Tier 2	70%
STD10: Portable Electric Spas	70%
STD13: Modular Furniture Task Lighting Fixtures	70%
STD14: Hot Food Holding Cabinets	70%
STD18b: DVD Players	31%
STD19: Water Dispensers	70%

Summary of Findings

The key findings from this compliance analysis include:

- With two exceptions, for the major energy saving appliance standards, at least 64% of the observed models were found in the CEC compliance databases.
- The majority of luminaires regulated by these standards that were for sale were not listed in the CEC databases. This included General Service Incandescents and Metal Halides.
- Just fewer than 14% of General Service Incandescents we observed for sale were listed in the CEC database. Even after thoroughly researching the characteristics of General Service Incandescents sold, we found the total compliance to be only 43.6%.
- Nearly a third of General Service Incandescents being sold did not comply with the 2006 Tier 1 standard either.

- None of the Metal Halides we observed in the market were listed in the CEC database and only slightly more than half complied with Title 20 based on their characteristics.
- Compliance of Residential Pool Pumps and Motors, Pre-rinse Spray Valves, Televisions, External Power Supplies, and Duct and Unit Heaters was 93% or higher.

5.2.2 Building Standards Compliance Results

Residential Building Standard Compliance

For residential buildings, we had data from a sample of 194 homes that had not participated in utility programs (referred to as non-participant homes) using a combination of modeling and engineering estimates, we estimated the whole house compliance rates for residential buildings using the method described in Section 2.1.3(b). This calculation produced an estimate of compliance using the ratio of the energy use of buildings built to just meet the 2001 Title 24 minus their consumption as-built under the 2005 Title 24, divided by their energy use if built to just meet the 2001 Title 24 minus their consumption if built to just meet the 2005 Title 24.

The evaluation team used the baseline Micropas run results and combined them with the lighting energy use data (see next paragraph) to determine and compare the as-built, 2005 Title 24 and 2001 Title 24 electricity consumption for space heating and cooling, water heating, and lighting. All values were weighted based on construction volumes by climate zone. Our analysis showed that the electricity compliance ratio was 120%, or new homes saved about 20% more electricity than projected. The whole house compliance ratio calculated for residential natural gas savings indicated, on average, new homes saved 2.35 times the amount projected initially. It is important to note that since the 2005 Title 24 did not make major efficiency changes in residential buildings other than the hardwired lighting requirement, the significant increase in natural gas savings did not represent large reductions in consumption. In addition, the Residential New Construction baseline study found from 15% to 40% of new homes had instantaneous water heaters, which were not assumed in the original gas energy savings estimates and could have contributed to the larger savings.

The analysis of the Residential Hardwired Lighting standard was also based on the sample of 194 homes. Engineering estimates were calculated from these site samples and, together with the 2005 Eley Impact analysis to establish a baseline, showed a compliance rate of 113%; i.e., that observed energy savings were 13% more than the savings originally predicted.

A combination of responses to a home owner survey of 110 people and interviews with 14 code officials was used to provide an estimate of the compliance rate for residential duct sealing and window replacement measures for alterations. Duct sealing showed a compliance rate of 59% and the compliance rate for window replacement was 80%.

Residential building new construction and alteration compliance results are summarized in Table 25.

The use of performance and prescriptive compliance for residential buildings was investigated through direct contact with over two hundred building departments across various county and city jurisdictions in California. We learned through phone contacts that most building department staff are not familiar with this area of information or even the nature of Title 24 documents. Contact with code officials or the 30 responses to the evaluation team's public information requests, showed that nearly all residential compliance is through the performance approach.

Matching our sample of 194 site visits to the databases of the two major HERS providers revealed that 46% of homes had HERS verifications for duct sealing. This finding was also consistent with the HERS verification rate we found for 30 original compliance CF1-R's at 49%.

Table 25. Residential New Construction & Alteration Compliance Rates[4]

Analysis Type or Measure	Consumption Category	Sample Size	Method of Compliance	Site Energy Units	Compliance Rate %
Whole House (kWh)	Space Cooling Space Heating (heat pump)	194	Performance	kWh	120%
	Lighting				
Whole House (Therms)	Space Heating Domestic HW	194	Performance	Therms	235%
StdB3 Residential Hardwired Lighting	Lighting	194	Prescriptive	kWh	113%

[4] Whole building compliance rate in this table is defined as the ratio of estimated savings of as-built new homes relative to homes built to just meet the 2001 Title 24 divided by the difference between estimated consumption of the same homes if built to just meet the 2001 Title 24 minus the consumption if built to just meet the 2005 Title 24.

Analysis Type or Measure	Consumption Category	Sample Size		Method of Compliance	Site Energy Units	Compliance Rate %
StdB4 Duct Sealing	HVAC	Home Owner 104	Code Official 14	Prescriptive	Therms	59%
StdB5 Window Replacement	HVAC	Home Owner 110	Code Official 14	Prescriptive	Therms	80%
Std B14a Composite for Remainder	Used Whole House KWh Value					120%

How and for how long residential Title 24 documentation was stored varied significantly among building jurisdictions. Some provided this information in response to the evaluation team's simple request. Others required we pay them for the Title 24 documents; others insisted these documents were copyrighted and could not be shared without the architect's permission. Others destroyed these documents 90 days after construction was completed.

Summary of Findings

The key findings from this residential compliance analysis include:

- Whole house electricity (kWh) and natural gas (therms) end use types showed average compliance above 100%
- Residential hardwired lighting compliance also was above 100%
- With no exceptions all 30 qualifying samples for which we received Title 24 CF1-R documentation showed performance listed as the method of compliance.
- HERS verifications were successfully identified for 46% of our sample. This allowed us to improve the accuracy of the energy modeling
- Retention policies for Title 24 compliance documents varied greatly.
- A majority of home owners knew that permits were required and indicated they were obtained for both duct work and window replacements. Compliance in existing homes with the duct standard was estimated to be 59% and compliance with the window replacement standard was estimated at 80%.

Nonresidential Building Standard Compliance

For nonresidential buildings, we had data from a sample of 81 buildings with "Compliance Assessment Forms" and EnergyPro-based whole building compliance models. For nonresidential buildings, the difficulties of identifying a building sample and collecting compliance data limited the size of the sample we were able to analyze (see Appendix H). We encountered a wide range of difficulties acquiring the necessary information including:

- Building departments not saving the information after a relatively short time
- Claims that the information was copyrighted and, therefore, not available for review for this study
- Information available only on outdated media such as microfiche
- Building departments unwilling to provide access to the information or requesting excessive charges to provide it

Consequently, the reliability and validity of estimated compliance rates were reduced.

For this report, whole building compliance was assessed based on the usual compliance findings from EnergyPro runs indicating that a building either passed or failed the standard. The results are tabulated according to four general building types in Table 26: Nonresidential Alterations, Nonresidential New Construction, Multifamily New Construction, and Relocatable Classrooms. The majority of relocatable classrooms are found at public schools which fall under the jurisdiction of the Office of the State Architect. The relocatable classrooms in the sample were associated with private schools subject to the local building codes.

Table 26. Nonresidential Compliance for Whole Buildings

Building Type	# Buildings	% Compliant Buildings
Nonresidential Alterations	4	25%
Nonresidential New Construction	26	61.5%
Multifamily New Construction	3	25%
Re-locatable Classrooms	4	100%

The percent of buildings complying with the standard by itself does not provide information about the energy savings of nonresidential buildings. To assess the energy impacts, the evaluation team attempted to implement the whole building analysis methodology discussed in Section 2.1.3(b). However, the sample of buildings for which sufficient data were available was too small to produce reliable results. Nevertheless, this approach showed promise and should be explored further in the future.

In lieu of the whole building method that was applied to residential buildings, we documented compliance by measure as described in Section 2.2.2ii. Table 27 presents the compliance level for individual nonresidential measures included in the 2005 Title 24. The number of buildings where each measure was observed is shown in the column of total observations. These compliance results were then input to the ISSM analysis tool and used to calculate gross savings of each of the nonresidential measures.

Table 27. Compliance Level for Individual Measures

Measure ID and Description	Alteration Compliance Rate	Alteration Compliance Observations	New Construction Compliance	New Construction Compliance Observations	Total Observations
B06 NonRes Skylights	0.0%	1	8.3%	3	4
B07 NonRes Duct Sealing Alts	75.0%	2	No observations	0	2
B08 NonRes Cool Roof	75.0%	5	89.6%	24	29
B09 Relocatable Classrooms	No observations	0	0.0%	3	3
B10 Bi-level Lighting Ctrls	No observations	0	78.7%	27	27
B11 NonRes Duct Sealing NewCon	75.0%	1	81.9%	18	19
B12 NonRes Cooling Towers	75.0%	1	91.7%	3	4
B13 MF Res Water Heating	No observations	0	78.1%	8	8
B14a NonRes Indoor Lighting	80.0%	10	81.8%	37	47
B14b NonRes VAV Systems	100.0%	1	90.0%	10	11

Measure ID and Description	Alteration Compliance Rate	Alteration Compliance Observations	New Construction Compliance	New Construction Compliance Observations	Total Observations
B14c NonRes Outdoor Lighting	77.8%	9	78.8%	39	48
Total	-	32	-	179	211

Table 28 presents the summarized compliance level estimates. Those where data were gathered from both new buildings and alterations were weighted by the number of observations in each category to derive a weighted average. We investigated the possibility of weighting the compliance levels by a proxy for energy impacts, but insufficient data were available to do this for any of the measures. The Composite for Remainder value was based on the ex ante energy savings estimates for the three components of the CfR that saved the most energy (indoor lighting, outdoor lighting, and VAV measures).

Table 28. Compliance Level for Specific Measures

Measure ID and Description	Compliance Level
B06 NonRes Skylights	8.3%
B07 NonRes Duct Sealing Alts	75.0%
B08 NonRes Cool Roof	75.0%
B09 Relocatable Classrooms	100.0%*
B10 Bi-level Lighting Ctrls	78.7%
B11 NonRes Duct Sealing NewCon	81.5%
B12 NonRes Cooling Towers	87.5%
B13 MF Res Water Heating	78.1%
* None of the relocatable classrooms we investigated had the labels on them required by Title 24 and, thus, technically did not comply with the standards. However, according to the EnergyPro runs conducted for them they all met the performance requirements of Title 24.	

Compliance rates based on this method suggest that 61.5% of nonresidential buildings met or exceeded minimum 2005 Title 24 performance requirements. We used these results as an indicator of the level of compliance with the nonresidential Title 24, but this value did not provide specific insights about the effect of compliance on energy savings.

5.3 Naturally Occurring Market Adoption Results

5.3.1 Introduction

This section presents a brief summary of findings from the evaluation team's research to estimate the Naturally Occurring Market Adoption (NOMAD) rate for each of the products or technologies regulated by the 2006 Title 20 and 2005 Title 24 standards.

5.3.2 Title 20 Appliance Standards

The results of the research done for the Title 20 standards are shown in Table 29. For a number of standards our team had to conduct research during and after the data collection process to clarify standards, seek more expert input, and analyze the collected inputs. Where this research had particular impact on the final results, it has been described in the text that follows.

Key findings from the NOMAD analysis of appliance standards include:

- The natural market penetration of models meeting the standards in 2006 exceeded 50% for several appliances including Commercial Refrigeration Equipment (Solid Door), Refrigerated Beverage Vending Machines, Modular Furniture Task Lighting Fixtures, and Televisions.
- The natural market penetration of models meeting the standards in 2006 was less than 10% for several appliances including General Service Incandescents (Tier 2), Residential Pool Pumps with Two-speed Motors (Tier 2), and Large Packaged Commercial Air Conditioners (Tier 2).
- Expected naturally occurring maximum penetration for Solid Door Commercial Refrigeration Equipment, Refrigerated Beverage Vending Machines, Modular Furniture Task Lighting Fixtures, Hot Food Holding Cabinets, Audio Players, Television, DVDs, and Pre-rinse Spray Valves meeting their respective standards was forecast to eventually exceed 75%.
- Several products were expected to have very low ultimate natural market adoption of complying units without the standards: Large Packaged Commercial Air Conditioners (Tier 2), Two-speed Residential Pool Pumps, and Tier 2 General Service Incandescents.

Specific details on the data collection and analysis process for the appliance standards NOMAD estimation are presented in Appendix K. The NOMAD curves developed from the experts' inputs are presented in Appendix O.

Table 29. Appliance Standards NOMAD Results

Standard Number	Title 20 Appliance Standard	Market Intro	Natural Market Adoption		
			2006	2008	Maximum Penetration
Std1	Commercial Refrigeration Equipment, Solid Door	1995	56.8%	68.0%	78.7%
Std2	Commercial Refrigeration Equip., Transparent Door	1995	27.4%	38.3%	49.5%
Std3	Commercial Ice Maker Equipment	1995	19.6%	22.8%	24.8%
Std4	Walk-In Refrigerators / Freezers	1995	17.1%	22.7%	41.3%
Std5	Refrigerated Beverage Vending Machines	1998	70.6%	86.4%	95.7%
Std6	Large Packaged Comm. Air-Conditioners, Tier 1	1990	20.9%	28.1%	35.0%
Std7	Large Packaged Comm. Air-Conditioners, Tier 2	1990	8.5%	9.3%	10.2%
Std8	Residential Pool Pumps, High Eff Motor, Tier 1	1965	12.2%	13.5%	22.9%
Std9	Residential Pool Pumps, 2-speed Motors, Tier 2	1975	5.7%	6.7%	10.7%
Std10	Portable Electric Spas	*	*	*	*
Std11	General Service Incandescent Lamps, Tier 2	1970	3.5%	4.4%	8.6%
Std12	Pulse Start Metal Halide HID Luminaires, Tier 1	1992	16.3%	26.8%	73.7%
Std13	Modular Furniture Task Lighting Fixtures	2000	67.1%	78.8%	94.0%
Std14	Hot Food Holding Cabinets	2000	19.8%	38.8%	86.0%
Std15	External Power Supplies, Tier 1	2000	24.9%	38.4%	67.0%
Std16	External Power Supplies, Tier 2	2000	10.0%	17.9%	43.3%
Std17	Consumer Electronics - Audio Players	2000	46.0%	62.6%	79.9%
Std18a	Consumer Electronics - TVs	2000	63.1%	77.7%	87.2%
Std18b	Consumer Electronics - DVDs	2000	46.4%	55.7%	75.4%
Std19	Water Dispensers	2000	27.8%	39.8%	60.7%
Std20	Unit Heaters and Duct Furnaces	1965	25.3%	26.2%	30.7%
Std21	Commercial Dishwasher Pre-Rinse Spray Valves	2003	16.0%	33.8%	82.7%
*The values used in the original analysis for the SES were assumed for this standard.					

5.3.3 Title 24 Building Standards

The results of the NOMAD research done for the Title 24 standards are shown in Table 30. As described in the NOMAD methodology section earlier, a broad recruiting approach was used to locate and contact experts to provide input on the building standards. However, at the end of the first round of recruiting, we had only a few building standard experts agree to participate. A focused effort driven in part by the parallel Residential Market Effects study did yield a

respectable number of about 20 experts on lighting standards. These experts helped provide a robust set of inputs on the three Title 24 standards that involved lighting technologies and building practices.

For the other building standards, it was more challenging to find individuals with broad enough knowledge of standards and practices to provide expert input. In most cases, the process received input from three or four experts. The evaluation team reviewed comments and in many cases a divergent input was identified as an outlier due to an apparent bias or misunderstanding of the basic assumptions and the respondent's input was not included.

Key findings from the Title 24 NOMAD analysis include:

- None of the building standards were estimated to have significant initial market penetration without the standards. The largest natural market penetration estimated for measures complying with the standards in 2006 was for Residential Window Replacement, with an estimated natural market penetration of a little less than 30% estimated for 2006.
- Maximum natural market adoption of several measures complying with the standards was projected to be 35% or less including Residential Hardwired Lighting, Residential Duct Improvements, Ducts in Existing Commercial *Buildings,* Bi-level Lighting Controls, and Cool *Roofs.*
- As noted earlier, we did not estimate a NOMAD curve for the two TDV standards since they are methodologies, rather than building requirements. Implicitly, the NOMAD value would be 0% market penetration over the period of analysis.
- The whole house NOMAD curves (electricity and natural gas) were estimated based on what percent of the potential savings resulting from the 2005 Title 24 relative to the 2001 Title 24 would have been observed in the market if the 2005 standard had not been adopted.

The NOMAD curves produced with inputs from the experts consulted are presented in Appendix O.

Table 30. Building Standards NOMAD Results

Standard Number	Title 24 Building Standard	Market Intro	Natural Market Penetration		
			2006	2008	Max
Std B3	Residential Hardwired Lighting	2000	8.5%	14.1%	29.5%
Std B4	Residential Duct Improvement	1990	9.6%	13.4%	17.5%
Std B5	Window Replacement	2000	29.2%	36.6%	50.5%
Std B6	Lighting Controls under Skylights	2000	7.5%	13.1%	50.0%
Std B7	Ducts in Existing Commercial Buildings	1990	12.4%	15.4%	18.0%
Std B8	Cool Roofs on Existing Nonresidential Buildings	1998	2.5%	5.6%	35.2%
Std B10	Bi-level Lighting Control Credits	2000	4.5%	6.1%	26.5%
Std B11	Duct Testing/Sealing in New Commercial Buildings	2000	6.1%	13.2%	58.0%
B15	a. Whole-House Electric b. Whole House Natural Gas	N/A N/A	1.9%* 0.6%	2.1%* 0.8%*	N/A N/A

* The natural market penetration values for whole house savings are based on what percent of potential savings would have been achieved without the standards.

5.4 Attribution Analysis Results

5.4.1 Introduction

This section presents results from the attribution analysis. The attribution analysis involved a survey of utility staff and consultants about the allocation of budgetary resources between the factors in the attribution model. As described in the methodology section, information from the survey was used to calculate weights to assess the effort required in three areas (factors) to develop and adopt each standard. The attribution analysis also involved the estimation of the contributions of the Program to the development of each standard. The estimation was undertaken by a panel of independent analysts and resulted in a factor score for each factor and standard.

5.4.2 Survey of Utility Staff and Consultants

In the attribution model, the weight for a factor represents the relative amount of stakeholder resources devoted to the factor in the development of the standard. For each standard, Cadmus surveyed between one and four experts about the allocation of stakeholder resources, with more than three surveyed for over 72% of the standards. Table 31 shows the number of standards according to how many experts provided their inputs.

Table 31. Number of Experts Surveyed

Number of Experts	Standards	Percent
1	1	2.8
2	9	25.0
3	14	38.9
4	12	33.3

Our intention was to have four or more experts provide input for each standard. With that idea in mind, our team contacted a large pool of potential experts including industry and public interest stakeholders, but it became clear that only CEC and utility staff and consultants closely involved in the development of the standards had the knowledge to answer the questions. Therefore, the number of experts surveyed was relatively small.

The detailed results from the expert surveys are presented in Appendix N. The weighted mean response for each factor and standard are presented as well as the standard deviation, minimum response, and maximum response.[5]

As indicators of how resources were allocated among the factors, the respondents' answers corresponded well with what Cadmus learned about stakeholder activities in the development of the standards. For example, in general the mean response for the allocation of resources to the compliance factor for appliance standards should be small and less than the mean response for the allocation of resources to compliance for building standards because most appliance standards, unlike building standards, specified the use of existing test methods and thus did not require the development of new methods. The results were consistent with this empirical observation—the mean compliance response for appliance standards was small and significantly less than that for building standards in most cases.

In addition, stakeholders appeared to have agreed fairly closely about the relative allocation of resources among the factors. The standard deviation of the responses is a measure of how closely the experts agreed about resource allocation.[6] There were a total of 105 factors (35 standards x 3 factors) for which at least 2 experts responded and the standard deviation could be estimated. Table 32 shows the distribution of the standard deviation of the responses for these factors across ranges indicating different levels of agreement on the 0 to 10 scale.

Table 32. Agreement between Experts about Resource Allocation

Agreement between Experts	Definition	Factors	Percent
High	s.d. <0.05	45	42.9
Moderate	0.05 <= s.d. < 0.10	49	46.7
Low	s.d.>=0.10	11	10.5
N/A		3	

In 43 percent of the cases, there was strong agreement between the respondents about the allocation of resources, where strong agreement was defined as a standard deviation of less

[5] The responses were weighted to reflect the involvement of the stakeholder in the development of the standard. See the methodology section for more details.

[6] Let x_i denote the response of respondent i and n the number of respondents. The standard deviation is defined as $s_n = \text{sqrt}((1/n)*\Sigma_{i=1}^{n} (x_i - \text{mean of } x)^2)$. For example, with two respondents, responses of .4 and 0.5 would generate a standard deviation of exactly 0.05.

than 0.05.[7] In 47 percent of cases, there was moderate agreement about the allocation of resources, defined as a standard deviation between 0.05 and 0.10. In only ten percent of cases (11 factors) the standard deviation was 0.10 or larger and evidence of significant disagreement existed.

Disagreement between respondents about the allocation of resources could reflect differences between respondents in their perceptions or memory of events. It could also reflect differences in responsibilities or experiences during code development. For factors for which there was significant disagreement about how resources were allocated, the evaluation team checked the validity of the mean response as an indicator of resource allocation. We independently estimated the factor weight based on information obtained from its research and based on our assessment could not reject the mean as a measure of resource allocation.

5.4.3 Factor Scores and Final Attribution Values

Appliance Standards Attribution Results

Table 33 reports the factors scores for each of the appliance standards. The factor scores indicate the percentage contributions of the C&S Program to the development of the standards in each factor area. As described in the attribution methodology discussion, the factor scores represent the consensus estimates of a panel of independent analysts of Program contributions. For convenience, Table 33 also reports the factor weights and the final attribution score. The final attribution score is the weighted average of the factor scores.

[7] It was possible that some of this agreement might have resulted from the respondents coordinating their responses, though we had no knowledge that this occurred.

Table 33. Appliance Standard Final Factor Scores, Weights, and Attribution Scores

Appliance Standard	Factor score			Weight			Final attribution score
	Compli-ance	Technical	Feasibility	Compli-ance	Technical	Feasibility	
Std1. Comm. Refrig. Equip. Solid Door	50.0%	80.0%	85.0%	5.9%	56.7%	37.4%	80.1%
Std2. Comm. Refrig Equip.Trans. Door	50.0%	80.0%	85.0%	5.9%	57.3%	36.8%	80.1%
Std3. Comm. Ice Maker Equip.	90.0%	75.0%	85.0%	11.5%	57.4%	31.1%	79.8%
Std4. Walk-In Refrig. / Freezers	10.0%	90.0%	75.0%	7.1%	69.8%	23.1%	80.9%
Std5. Refrig. Bev. Vending Machines	90.0%	60.0%	55.0%	12.9%	59.8%	27.3%	62.5%
Std6. Lrg. Packaged Comm. Air-Cond., Tier 1	10.0%	75.0%	85.0%	3.0%	61.7%	35.3%	76.6%
Std7. Lrg. Packaged Comm. Air-Cond., T2	10.0%	75.0%	85.0%	4.8%	65.0%	30.3%	74.9%
Std8. Res. Pool Pumps, High Eff. Motor, T1	75.0%	80.0%	80.0%	7.9%	52.9%	39.2%	79.6%
Std9. Res. Pool Pumps, 2-speed Motors, T2	75.0%	80.0%	80.0%	20.4%	38.3%	41.3%	79.0%
Std10. Port. Elec. Spas	90.0%	90.0%	70.0%	33.3%	30.4%	36.3%	82.8%
Std11. Gen. Service Incan. Lamps, T1	90.0%	75.0%	60.0%	5.8%	78.3%	15.8%	73.5%
Std12. Pulse Start Metal Halide HID Lum., T1	90.0%	75.0%	60.0%	14.4%	67.8%	17.8%	74.5%
Std13. Mod. Furn. Task Lighting Fix.	90.0%	85.0%	70.0%	3.0%	80.0%	17.0%	82.6%
Std14. Hot Food Holding Cabinets	90.0%	70.0%	75.0%	10.0%	69.8%	20.2%	73.0%
Std15. Ext. Pwr. Supplies, Tier 1	10.0%	75.0%	65.0%	22.5%	50.8%	26.7%	57.7%
Std16. Ext. Pwr. Supplies, Tier 2	10.0%	75.0%	65.0%	22.5%	50.8%	26.7%	57.7%
Std17. Cons. Electronics - Audio Players	90.0%	80.0%	80.0%	14.2%	55.4%	30.4%	81.4%

Appliance Standard	Factor score			Weight			Final attribution score
	Compli-ance	Technical	Feasibility	Compli-ance	Technical	Feasibility	
Std18a. Cons. Electronics - TVs	90.0%	80.0%	80.0%	14.2%	57.5%	28.3%	81.4%
Std18b. Cons. Electronics - DVDs	90.0%	80.0%	80.0%	14.2%	59.6%	26.3%	81.4%
Std19. Water Dispensers	90.0%	75.0%	85.0%	20.0%	65.0%	15.0%	79.5%
Std20. Unit Heaters and Duct Furnaces	10.0%	80.0%	70.0%	4.8%	62.5%	31.9%	72.8%
Std21. Comm. Dishwasher Pre-Rinse Spray Valves	80.0%	65.0%	45.0%	22.5%	57.5%	20.0%	64.4%

Key attribution findings for the appliance standards include:

- The score for the Program's contribution to the technical factor was relatively large in most cases. It was not less than 60% for any of the standards and in most cases exceeded 80%.
- The score for the Program's contribution to the compliance factor, on the other hand, varied considerably, ranging from as low as 10% for some standards to 90% for others.
- For all but two standards, the largest weight for resources dedicated to standard development was estimated to be on the technical factor.
- For two standards—Portable Electric Spas and Residential Pool Pumps Tier 2—the weights were distributed relatively evenly across the three factor areas.
- For all but four standards, the overall factor score calculated for the Program was at least 70% and over 80% in several cases.
- The Program received the lowest factor scores for four standards: Commercial Dishwasher Pre-rinse Spray Valves, External Power Supplies Tier 1 and 2, and Refrigerated Beverage Vending Machines. There was no consistent pattern that accounted for the lower score on these standards.

Building Standards Attribution Results

Table 34 presents the factor scores, weights, and final attribution values for each of the Title 24 standards.

Table 34. Building Standard Final Factor Scores, Weights, and Attribution Scores

Standard Number	Building Standard	Factor score			Weight			Final Attribution Score
		Compliance	Technical	Feasibility	Compliance	Technical	Feasibility	
Std B1	Time dependent valuation, Residential	90.0%	90.0%	65.0%	31.7%	38.5%	29.8%	82.6%
Std B2	Time dependent valuation, Nonresidential	90.0%	90.0%	65.0%	42.9%	37.9%	19.2%	85.2%
Std B3	Res. Hardwired lighting	75.0%	95.0%	90.0%	28.3%	38.3%	33.5%	87.7%
Std B4	Duct improvement	65.0%	75.0%	65.0%	35.0%	42.5%	22.5%	69.3%
Std B5	Window replacement	10.0%	75.0%	65.0%	26.7%	48.3%	25.0%	55.2%
Std B6	Lighting controls under skylights	95.0%	95.0%	90.0%	45.0%	32.5%	22.5%	93.9%
Std B7	Ducts in existing commercial buildings	75.0%	75.0%	70.0%	35.0%	42.5%	22.5%	73.9%
Std B8	Cool roofs	70.0%	95.0%	85.0%	46.7%	36.7%	16.7%	81.7%
Std B9	Relocatable classrooms	50.0%	95.0%	70.0%	12.5%	55.0%	32.5%	81.3%
Std B10	Bi-level lighting control credits	10.0%	85.0%	80.0%	10.0%	47.5%	42.5%	75.4%
Std B11	Duct testing/sealing in new commercial buildings	85.0%	85.0%	65.0%	35.0%	42.5%	22.5%	80.5%

Standard Number	Building Standard	Factor score			Weight			Final Attribution Score
		Compliance	Technical	Feasibility	Compliance	Technical	Feasibility	
Std B12	Cooling tower applications	90.0%	80.0%	75.0%	20.0%	45.0%	35.0%	80.3%
Std B13	Multifamily Water Heating	85.0%	80.0%	85.0%	36.3%	45.0%	18.8%	82.8%
Std B14	Composite for Remainder	19.8%	29.7%	27.9%	31.0%	39.7%	29.3%	26.1%

Key attribution findings for the building standards include:

- For all but one building standard, the Program received a score of at least 75% on the technical factor and a score over 90% for many of the standards.
- Scores for the Program on the two other factors—Compliance and Feasibility—were also quite large in most cases.
- The weights, representing the distribution of resources required to adopt the standard, were quite evenly distributed among the three factor areas.
- The final attribution score was over 70% for most of the standards. One exception was Residential Window Replacement where the Program received a score of only 10% on the Compliance factor.
- The standard for which the Program received the uniformly lowest score was the aggregate standard, the Composite for Remainder. The Program received scores of less than 30% on each of the three factors. Given that the Program dedicated the least directed efforts at this combination of standards, these results were consistent with expectations.

5.5 Final Savings Estimates

This section presents the final evaluated savings estimates for the C&S Program statewide for the period 2006 through 2008. Net verified savings for each utility are presented in Chapter 6. Evaluated net electricity and gas savings for each year, 2006 through 2008 cumulative, and the estimated 2006 value from the SES for comparison are presented in Table 35 through Table 40. In the tables presenting Title 24 results, estimates from the residential whole house analysis are presented along with the estimates based on individual measures. The totals were calculated using the residential whole-building values because this analysis more accurately captures the integrated effects of the standards.

The utility claimed savings are based on the values from the SES. The values in the tables are all statewide and have not been adjusted by the 50% factor required by the CPUC. In most cases, the evaluated estimates are very similar to the SES values. When significant differences occur, they can be explained by tracing through the changes in each of the components that were analyzed.

Table 35 shows the evaluated appliance standards electricity savings. Our combined appliance standards savings in 2006 were 26% more than the SES estimate.

Table 36 presents the same results for Title 24 building standards. The evaluated savings for individual standards differ from the SES estimate in many cases, again explained by changes in the components used to analyze the savings. The evaluated savings estimate for 2006 is about 3% larger than the SES estimate.

Table 35. Evaluated Appliance Standards Electricity Savings, GWh/year*

Standard	Description	Evaluated, Cumulative			SES
		2006	2007	2008	2006
Std 1	Commercial Refrigeration Equipment, Solid Door	2.21	4.09	5.73	3.5
Std 2	Commercial Refrigeration Equipment, Transparent Door	0.00	4.55	8.74	0.0
Std 3	Commercial Ice Maker Equipment	0.00	0.00	2.79	0.0
Std 4	Walk-In Refrigerators / Freezers	42.61	83.80	123.58	31.3
Std 5	Refrigerated Beverage Vending Machines	1.08	1.82	2.34	1.7
Std 6	Large Packaged Commercial Air-Conditioners, Tier 1	1.46	6.94	12.19	0.0
Std 7	Large Packaged Commercial Air-Conditioners, Tier 2	0.00	0.00	0.00	0.0
Std 8	Residential Pool Pumps, High Eff Motor, Tier 1	24.77	49.32	73.62	14.2
Std 9	Residential Pool Pumps, 2-speed Motors, Tier 2	0.00	0.00	0.00	0.0
Std 10	Portable Electric Spas	9.58	18.29	26.12	3.8
Std 11	General Service Incandescent Lamps, Tier 1	0.00	0.00	0.00	20.7
Std 11	General Service Incandescent Lamps, Tier 2	0.00	0.00	0.00	0.0
Std 12a	Pulse Start Metal Halide HID Luminaires, Tier 1(Vertical Lamps)	83.75	162.18	234.61	28.6
Std 12b	Pulse Start Metal Halide HID Luminaires, Tier 1(All other MH)	0.00	0.00	15.98	0.0
Std 13	Modular Furniture Task Lighting Fixtures	0.00	0.00	0.68	0.3
Std 14	Hot Food Holding Cabinets	2.85	5.40	7.58	0.8
Std 15	External Power Supplies, Tier 1	0.00	40.63	77.25	14.3
Std 16	External Power Supplies, Tier 2	0.00	0.00	4.38	0.0
Std 17	Consumer Electronics - Audio Players	0.00	17.98	32.97	0.0
Std 18a	Consumer Electronics - TVs	17.98	31.78	42.70	7.9
Std 18b	Consumer Electronics - DVDs	1.60	3.05	4.38	1.3
Std 19	Water Dispensers	2.47	4.72	6.77	2.5
Std 20	Unit Heaters and Duct Furnaces	0.00	0.00	0.00	0.0
Std 21	Commercial Dishwasher Pre-Rinse Spray Valves	0.00	0.00	0.00	19.7
All Combined		190.4	434.6	682.4	150.6

*Savings include non-IOU areas and are not adjusted for the CPUC 50% adjustment.

Table 36. Evaluated Building Standards Electricity Savings, GWh/year*

Standard	Description	Evaluated, Cumulative			SES 2006
		2006	2007	2008	
Std B1	Time Dependent Valuation, Residential	0.00	0.00	0.00	2.9
Std B2	Time Dependent Valuation, Nonresidential	0.00	0.00	0.00	1.8
Std B3	Res. Hardwired Lighting	44.59	90.70	119.74	24.9
Std B4	Duct Improvement	2.56	5.12	7.68	0.9
Std B5	Window Replacement	8.21	16.13	23.75	1.0
Std B6	Lighting Controls under Skylights	0.99	1.98	2.98	11.3
Std B7	Ducts in Existing Commercial Buildings	6.34	12.68	19.00	0.0
Std B8	Cool Roofs	8.90	17.44	25.69	4.3
Std B9	Relocatable Classrooms	0.94	3.04	5.01	1.4
Std B10	Bi-level Lighting Control Credits	0.92	1.83	2.74	5.5
Std B11	Duct testing/sealing in New Commercial Buildings	1.58	5.11	8.28	0.0
Std B12	Cooling Tower Applications	1.94	3.70	5.28	1.4
Std B13	Multifamily Water Heating	0.00	0.00	0.00	0.0
Std B14a	Composite for Remainder (Res)	0.64	1.26	1.61	33.93
Std B14b	Composite for Remainder (Non-Res)	17.48	52.86	81.87	66.0
Std B15a	Residential Whole House	49.15	101.41	134.04	N/A
Combined		100.3	222.6	317.6	96.5

*Savings include non-IOU areas and are not adjusted for the CPUC 50% adjustment. Combined values are based on Residential Whole House estimates.

Demand savings are presented in Table 37 for the appliance standards. They follow a pattern similar to the electricity savings for the appliance standards, with the evaluated first-year demand savings about 35% more than the SES value.

Building standards demand savings are shown in Table 38. The evaluated savings in 2006 are 80% less than the SES estimate. The largest contributor to this is the elimination of savings from measures captured in the original Composite for Remainder. The second largest contributor is elimination of savings attributable to TDV.

Table 37. Evaluated Appliance Standards Demand Savings, MW*

Standard	Description	Evaluated, Cumulative			SES 2006
		2006	2007	2008	
Std 1	Commercial Refrigeration Equipment, Solid Door	0.29	0.54	0.75	0.5
Std 2	Commercial Refrigeration Equipment, Transparent Door	0.00	0.60	1.15	0.0
Std 3	Commercial Ice Maker Equipment	0.00	0.00	0.39	0.0
Std 4	Walk-In Refrigerators / Freezers	5.61	11.04	16.28	4.1
Std 5	Refrigerated Beverage Vending Machines	0.14	0.24	0.31	0.2
Std 6	Large Packaged Commercial Air-Conditioners, Tier 1	0.75	3.59	6.31	0.0
Std 7	Large Packaged Commercial Air-Conditioners, Tier 2	0.00	0.00	0.00	0.0
Std 8	Residential Pool Pumps, High Eff Motor, Tier 1	4.75	9.45	14.10	2.7
Std 9	Residential Pool Pumps, 2-speed Motors, Tier 2	0.00	0.00	0.00	0.0
Std 10	Portable Electric Spas	1.81	3.45	4.92	0.7
Std 11	General Service Incandescent Lamps, Tier 1	0.00	0.00	0.00	2.6
Std 11	General Service Incandescent Lamps, Tier 2	0.00	0.00	0.00	0.0
Std 12a	Pulse Start Metal Halide HID Luminaires, Tier 1(Vertical Lamps)	14.90	28.86	41.75	5.1
Std 12b	Pulse Start Metal Halide HID Luminaires, Tier 1(All other MH	0.00	0.00	2.85	0.0
Std 13	Modular Furniture Task Lighting Fixtures	0.00	0.00	0.12	0.0
Std 14	Hot Food Holding Cabinets	0.40	0.75	1.06	0.1
Std 15	External Power Supplies, Tier 1	0.00	4.61	8.77	1.6
Std 16	External Power Supplies, Tier 2	0.00	0.00	0.49	0.0
Std 17	Consumer Electronics - Audio Players	0.00	2.04	3.74	0.0
Std 18a	Consumer Electronics - TVs	2.06	3.63	4.88	0.9
Std 18b	Consumer Electronics - DVDs	0.18	0.34	0.48	0.1
Std 19	Water Dispensers	0.32	0.62	0.88	0.3
Std 20	Unit Heaters and Duct Furnaces	0.00	0.00	0.00	0.0
Std 21	Commercial Dishwasher Pre-Rinse Spray Valves	0.00	0.00	0.00	4.2
All Combined		31.2	69.8	109.3	23.1

*Savings include non-IOU areas and are not adjusted for CPUC 50%.

Table 38. Evaluated Building Standards Demand Savings, MW*

Standard	Description	Evaluated, Cumulative			SES 2006
		2006	2007	2008	
Std B1	Time Dependent Valuation, Residential	0.00	0.00	0.00	11.7
Std B2	Time Dependent Valuation, Nonresidential	0.00	0.00	0.00	8.0
Std B3	Res. Hardwired Lighting	2.05	4.17	5.50	1.1
Std B4	Duct Improvement	3.82	7.64	11.47	1.3
Std B5	Window Replacement	3.13	6.15	9.06	0.4
Std B6	Lighting Controls under Skylights	0.00	0.00	0.00	0.0
Std B7	Ducts in Existing Commercial Buildings	4.82	9.64	14.43	0.0
Std B8	Cool Roofs	5.79	11.34	16.71	2.8
Std B9	Relocatable Classrooms	0.00	0.00	0.00	0.0
Std B10	Bi-level Lighting Control Credits	0.00	0.00	0.00	0.0
Std B11	Duct testing/sealing in New Commercial Buildings	0.81	2.63	4.26	0.0
Std B12	Cooling Tower Applications	0.00	0.00	0.00	0.0
Std B13	Multifamily Water Heating	0.00	0.00	0.00	0.0
Std B14a	Composite for Remainder (Res)	0.90	1.77	2.26	63.43
Std B14b	Composite for Remainder (Non-Res)	4.34	13.13	20.34	27.7
Std B15a	Residential Whole House	2.92	6.03	7.97	N/A
Combined		25.6	56.6	84.2	116.4

*Savings include non-IOU areas and are not adjusted for CPUC 50%. Combined values are based on Residential Whole House estimates.

Error! Reference source not found. presents the natural gas savings estimates for the appliance standards. The evaluated savings in 2006 are a little more than half the SES estimate. This is due to the exclusion of savings from pre-rinse spray valves because of the federal standard, partially offset by a larger savings estimate for the unit heater/duct furnaces.

Table 39. Evaluated Appliance Standards Natural Gas Savings, Mtherms*

Standard	Description	Evaluated, Cumulative			SES
		2006	2007	2008	2006
Std 1	Commercial Refrigeration Equipment, Solid Door	0.00	0.00	0.00	0.00
Std 2	Commercial Refrigeration Equipment, Transparent Door	0.00	0.00	0.00	0.00
Std 3	Commercial Ice Maker Equipment	0.00	0.00	0.00	0.00
Std 4	Walk-In Refrigerators / Freezers	0.00	0.00	0.00	0.00
Std 5	Refrigerated Beverage Vending Machines	0.00	0.00	0.00	0.00
Std 6	Large Packaged Commercial Air-Conditioners, Tier 1	0.00	0.00	0.00	0.00
Std 7	Large Packaged Commercial Air-Conditioners, Tier 2	0.00	0.00	0.00	0.00
Std 8	Residential Pool Pumps, High Eff Motor, Tier 1	0.00	0.00	0.00	0.00
Std 9	Residential Pool Pumps, 2-speed Motors, Tier 2	0.00	0.00	0.00	0.00
Std 10	Portable Electric Spas	0.00	0.00	0.00	0.00
Std 11	General Service Incandescent Lamps, Tier 1	0.00	0.00	0.00	0.00
Std 11	General Service Incandescent Lamps, Tier 2	0.00	0.00	0.00	0.00
Std 12a	Pulse Start Metal Halide HID Luminaires, Tier 1(Vertical Lamps)	0.00	0.00	0.00	0.00
Std 12b	Pulse Start Metal Halide HID Luminaires, Tier 1(All other MH	0.00	0.00	0.00	0.00
Std 13	Modular Furniture Task Lighting Fixtures	0.00	0.00	0.00	0.00
Std 14	Hot Food Holding Cabinets	0.00	0.00	0.00	0.00
Std 15	External Power Supplies, Tier 1	0.00	0.00	0.00	0.00
Std 16	External Power Supplies, Tier 2	0.00	0.00	0.00	0.00
Std 17	Consumer Electronics - Audio Players	0.00	0.00	0.00	0.00
Std 18a	Consumer Electronics - TVs	0.00	0.00	0.00	0.00
Std 18b	Consumer Electronics - DVDs	0.00	0.00	0.00	0.00
Std 19	Water Dispensers	0.00	0.00	0.00	0.00
Std 20	Unit Heaters and Duct Furnaces	1.34	2.67	4.00	0.40
Std 21	Commercial Dishwasher Pre-Rinse Spray Valves	0.00	0.00	0.00	2.60
All Combined		1.34	2.67	4.00	3.00

*Savings include non-IOU areas and are not adjusted for CPUC 50% credit.

Table 40 presents the estimated natural gas savings for the building standards. The evaluated first-year savings are about 45% of the SES estimate.

Table 40. Evaluated Building Standards Natural Gas Savings, MTherm*

Standard	Description	Evaluated, Cumulative			SES 2006
		2006	2007	2008	
Std B1	Time Dependent Valuation, Residential	0.00	0.00	0.00	0.00
Std B2	Time Dependent Valuation, Nonresidential	0.00	0.00	0.00	0.00
Std B3	Res. Hardwired Lighting	0.00	0.00	0.00	0.00
Std B4	Duct Improvement	0.49	0.99	1.48	0.20
Std B5	Window Replacement	0.27	0.53	0.79	0.00
Std B6	Lighting Controls under Skylights	0.00	0.00	0.00	0.00
Std B7	Ducts in Existing Commercial Buildings	0.67	1.35	2.02	0.00
Std B8	Cool Roofs	-0.15	-0.31	-0.46	0.00
Std B9	Relocatable Classrooms	0.00	0.00	0.00	0.00
Std B10	Bi-level Lighting Control Credits	0.00	0.00	0.00	0.00
Std B11	Duct testing/sealing in New Commercial Buildings	0.01	0.02	0.04	0.00
Std B12	Cooling Tower Applications	0.00	0.00	0.00	0.00
Std B13	Multifamily Water Heating	0.18	0.35	0.50	0.80
Std B14a	Composite for Remainder (Res)	0.19	0.37	0.47	3.98
Std B14b	Composite for Remainder (Non-Res)	-0.05	-0.16	-0.26	0.700
Std B16a	Residential Whole House	1.47	3.04	4.02	N/A
All Combined		2.89	5.81	8.13	5.7

*Savings include non-IOU areas and are not adjusted for CPUC 50% credit. Combined values are based on Residential Whole House estimates.

The following tables present cumulative annual savings estimates, starting with the potential energy savings. Net Energy Savings takes into account compliance and NOMAD effects, and Program Energy Savings are the amount attributable to the C&S Program. These tables include only savings that occur in the IOU service areas, but they do not take into account the CPUC 50% adjustment.

Table 41 shows the results for electricity savings. After adjusting for compliance, NOMAD, and attribution, the savings attributable to the C&S Program were nearly half the potential savings. Table 42 shows the results for demand savings. Over 40% of the potential energy savings were attributed to the Program after these adjustments. Table 43 shows that nearly two-thirds of natural gas potential savings were attributed to the Program after the adjustments.

Table 41. Cumulative Electricity Savings in IOU Areas

Year count	Potential Energy Savings (GWh/Yr)	Net Energy Savings (GWh/Yr)	Program Energy Savings (GWh/Yr)	Program Savings as % of Potential
2006	405	293	204	51%
2007	1020	704	467	46%
2008	1659	1085	712	43%

Table 42. Cumulative Demand Savings in IOU Areas

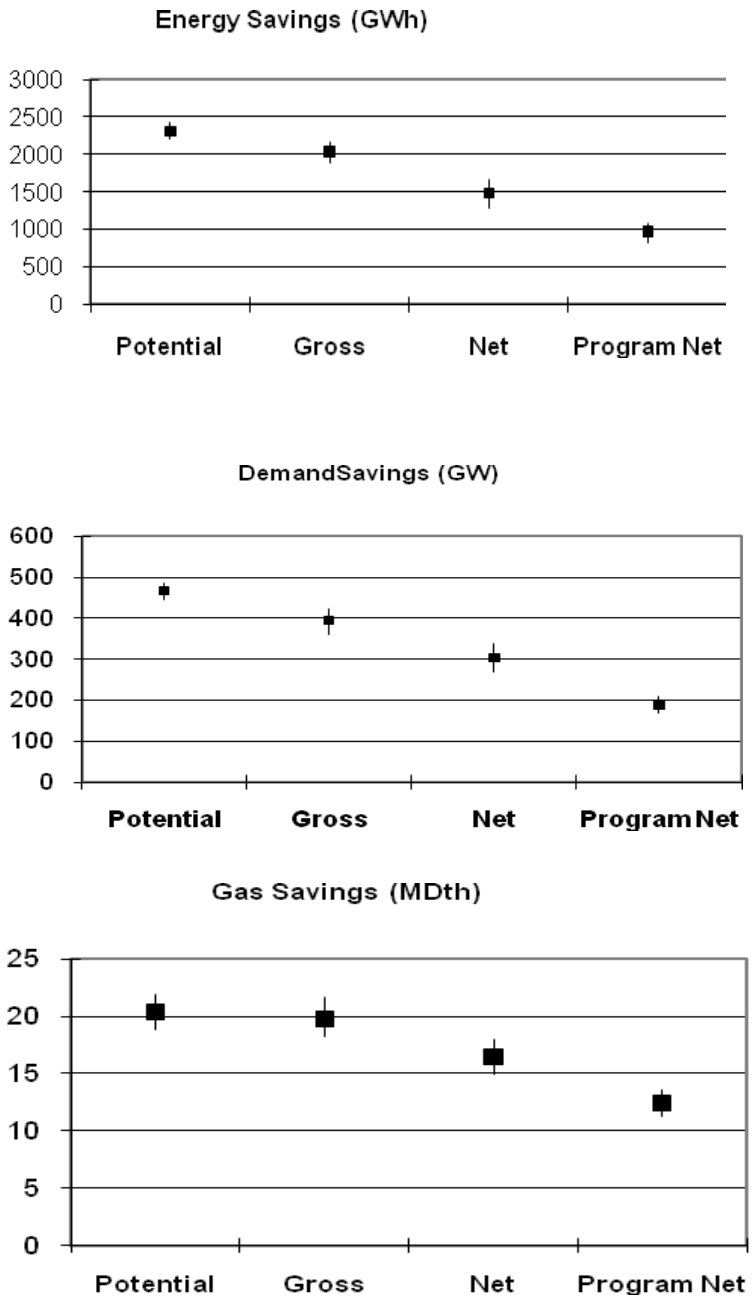
Year count	Potential Energy Savings (MW)	Net Energy Savings (MW)	Program Energy Savings (MW)	Program Savings as % of Potential
2006	83	59	39	47%
2007	206	142	88	43%
2008	334	219	136	41%

Table 43. Cumulative Natural Gas Savings in IOU Areas

Year count	Potential Energy Savings (MTherms)	Net Energy Savings (MTherms)	Program Energy Savings (MTherms)	Program Savings as % of Potential
2006	5.9	4.9	3.8	64%
2007	12.3	10.2	8.0	65%
2008	18.4	14.8	11.6	63%

To illustrate the confidence levels for these estimates, Figure 5 displays the confidence intervals for the evaluated savings categories by step in the analysis.

Figure 5. 90% Confidence Intervals for Savings Type and Evaluation Component



6. Summary and Recommendations

This report presents the first comprehensive impact evaluation of the California IOU Codes and Standards Program. It applies the California evaluation protocol, adjusted during the course of the study as needed to increase the accuracy, make it more flexible, and improve the effectiveness. The evaluation team added a whole-building approach to analyze the impacts of building standards and was able to implement it successfully with residential buildings. We encountered significant difficulties, however, conducting the compliance analysis for both the residential and nonresidential building standards. The main difficulties resulted from problems obtaining required information from building departments; these issues are fully discussed in Appendices G and H. The evaluators believe substantial changes need to be made in how compliance information is documented and retained to facilitate assessment of building compliance.

This chapter presents major findings first. Our recommendations are then presented in two categories: (1) ways to increase the effectiveness of the Program and (2) ways to improve the evaluation protocol and process.

6.1 Major Findings

The C&S Program through its activities prior to 2006 produced significant verified energy savings during the period 2006 through 2008. The net savings after accounting for all the adjustments to the potential savings are shown in Table 44 along with the savings claimed by the utilities The savings shown are those achieved in the IOU service areas only and adjusted by the 50% factor required by the CPUC during this cycle.

In general, the verified electricity savings are slightly more than the claimed savings, while the verified demand and natural gas savings are less than the claimed amounts. In the aggregate, the realization rates were 113%, 80%, and 90.9% for electricity, demand, and natural gas savings, respectively. Overall, the Program has made a significant contribution toward energy savings in both buildings and appliances.

Table 44. Final Verified and Claimed Savings*

IOU and Year	Electricity (GWh)		Demand (MW)		Natural Gas (MTherms)	
	Verified	Claimed	Verified	Claimed	Verified	Claimed
PG&E						
Period						
2006	45.9	42.9	9.0	12.1	0.8	0.9
2007	57.9	42.7	11.0	11.8	0.8	0.8
2008	54.1	54.6	10.6	14.2	0.7	0.8
2006-08	157.9	140.3	30.6	38.1	2.2	2.4
SDG&E						
2006	10.7	10.1	2.1	2.8	0.09	0.1
2007	13.5	10	2.6	2.8	0.09	0.1
2008	12.7	12.8	2.5	3.3	0.08	0.1
2006-08	37.0	32.8	7.2	8.9	0.25	0.3
SCE						
2006	47.3	44.3	9.3	12.4	N/A	N/A
2007	59.7	44.1	11.3	12.2	N/A	N/A
2008	55.8	56.3	10.9	14.7	N/A	N/A
2006-08	162.9	144.7	31.5	39.3	N/A	N/A
SCG						
2006	N/A	N/A	N/A	N/A	1.2	1.4
2007	N/A	N/A	N/A	N/A	1.2	1.3
2008	N/A	N/A	N/A	N/A	1.1	1.2
2006-08	N/A	N/A	N/A	N/A	3.5	3.9
Total (all IOUs) for 2006-08	**357.8**	**317.8**	**69.2**	**86.3**	**6.0**	**6.6**
Statewide Realization Rates for 2006-08	**113%**		**80.0%**		**90.9%**	

*Note that claimed savings are based on 50% of amounts in the SES and verified savings are also 50% of the ex post evaluated quantity.

6.2 Program Effectiveness Recommendations

This study did not include a process evaluation, but insights were gained during the study about what has worked well in the Program. Although the Program has been effective, the evaluation team identified a few ways in which we believe the Program can continue to ensure its success and increase its effectiveness. These include the following:

- Continue to identify and target both appliance and building standards with large potential energy savings.
- Continue coordination of Program among the utilities to leverage resources and expertise.
- Articulate, communicate, and implement a comprehensive strategy linking DSM programs and activities to the C&S Program and long-term goals for standard adoption.
- Fully integrate a process of increasing codes and standards compliance and enforcement into the overall C&S Program approach.
- Encourage the California Energy Commission to increase attention to areas such as appliance and building standard compliance to guarantee that anticipated savings are achieved.
- Document and clarify the role of activities less targeted and focused than the preparation of CASE reports to establish the linkage to the adoption of other standards.

6.3 Evaluation Process Recommendations

Based on this evaluation we make several recommendations about the evaluation protocol and steps related to the evaluation process:

- If codes are to remain an important element in the California Strategic Energy Plan, the CEC, the IOUs, associations of local governments, and the legislature need to collaborate to ensure that the enforcing entities work together with evaluators to allow reliable measurement of energy savings due to compliance. In particular, policies need to be implemented to ensure local code jurisdictions retain essential code compliance documentation. See Appendices G and H for details.

- The Normally Occurring Standards Adoption (NOSAD) adjustment in the original protocol raises significant logical and methodological issues and the protocol is improved by eliminating it.
- When a building performance compliance approach is an option, the whole-building evaluation analysis approach for the building standards should be applied because it offers advantages over an approach based on assuming that individual standards measures can be analyzed in isolation and added to determine the effects of a standard. The whole-building analysis approach does pose challenges by requiring more complete building information and modeling; however, it treats the impacts of the building standards more realistically and accurately, particularly when compliance is not strictly prescriptive as is usually the case in California for both residential and nonresidential buildings.