Appendices to 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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Prepared by
KEMA, Inc.
The Cadmus Group, Inc.
Itron, Inc.
Nexus Market Research, Inc.
ENRG, Inc.

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California Public Utilities Commission
Energy Division

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KEMA

Submitted to:
Ayat Osman, PhD
505 Van Ness Avenue
California Public Utilities Commission
Energy Division
San Francisco, CA 94102

Submitted by:

Allen Lee, Principal
Cadmus, Inc.
720 SW Washington, Suite 400
Portland, OR 97205
503-228-2992

List of Exhibits:

Appendix A. Standards Included in C&S Program Evaluation

The California standards analyzed in this evaluation included the Title 20 Appliance Standards that went into effect between January 2006 and January 2008 and the Title 24 Building Standards that went into effect in October 2005. As noted in Volume III and these appendices, 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. The appliance standards are listed in Table 1 and the buildings standards are shown in Table 2.

Table 1. Appliance Standards

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	Jan-08
Std10	Portable Electric Spas	Jan-06
Std11a	General Service Incandescent Lamps, Tier 1	Jan-06
Std11b	General Service Incandescent Lamps, Tier 2	Jan-08
Std12a	Pulse Start Metal Halide (MH) HID Luminaires (Vertical, Base-Up only)	Jan-06
Std12b	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[1]	Jan-07
Std15b	External Power Supplies, Tier 1[2]	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] External Power Supplies for laptop computers, mobile phones, printers, print servers, PDAs and digital cameras		
[2] External Power Supplies for wire line telephones and all other devices		

Table 2. Building Standards

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

Appendix B. Whole Building Performance Compliance Approach

The following pages present a memorandum submitted to the CPUC documenting the whole building performance compliance approach proposed for this evaluation. This was posted for public review and comment on March 16, 2009.

KEMA

Date: March 16, 2009

Re: Treatment of Whole Building Performance in Codes and Standards Impact Evaluation

Introduction

Background

The existing Codes and Standards (C&S) impact evaluation method was designed based on analyzing individual standards, primarily those for which the California utilities sponsored Codes and Standards Enhancement (CASE) reports. For buildings, the approach addresses each standard adopted in the 2005 Title 24 standards. Specifically, estimates of ex ante gross savings are estimated for each standard and then naturally occurring market adoption (NOMAD), the compliance rate, utility and C&S Program attribution are estimated separately for each standard and used to adjust gross savings to derive the net standards savings and savings attributed to the C&S Program. This approach is embedded in the Heschong Mahone Group's (HMG) Savings Estimate Spreadsheet (SES) and associated methodology.

This approach was applied in the initial analyses of the Program savings because the C&S Program targets specific Title 24 standards and the objective was to estimate the savings from each standard that could be attributed to the Program's efforts. However, this methodology has a limitation due to the variety of compliance options permitted under Title 24. If compliance requirements were strictly prescriptive, i.e., every building had to comply with the standards by incorporating a prescribed set of measures, then the original method (as described above) would work satisfactorily.

Though Title 24 does provide a prescriptive path compliance approach, it also permits compliance through a performance approach, which allows (with the exception of mandatory measures listed in the standards) virtually unlimited variations in options to be incorporated in a building as long as overall calculated energy use does not exceed a performance requirement established by the standard. The performance approach—Alternative Compliance Method (ACM)—establishes energy budgets for space heating, space cooling, water heating, and other end uses and allows trading off building features in these categories against others as long as the overall energy use of the proposed building does not exceed the energy budget for the Standard Building. The Standard Building is one that incorporates all the mandatory measures, prescriptive measures, and a set of features prescribed in the ACM manual.

The Issue

Significant shares of new residential and non-residential buildings use the performance method to comply with Title 24. This has several implications for the Title 24 impact analysis.

For compliance assessment based on the performance approach, it is not appropriate to lower the compliance estimate for a measure covered by the standards when the measure does not meet the efficiency level specified by the Title 24 prescriptive standard. This is because building compliance based on the performance approach permits one or more high efficiency measures to offset less efficient measures. Thus, even though a certain measure may not comply with the prescriptive minimum standards, under performance compliance another measure or measures could provide the required savings and the intent of the standard would be achieved. Similarly, even though the intent may be for a building to comply prescriptively, it is possible that certain measures do not meet their prescriptive requirement, yet the building as a whole satisfies the performance requirement. In these situations, discounting savings due to non-compliance of a specific measure would incorrectly underestimate savings from the standards since equivalent savings are provided by other measures.

In the NOMAD analysis, the naturally occurring trend in the adoption of measures meeting the standard is estimated. The energy savings due to this trend are then subtracted from the savings estimated from the standard for the market as a whole because the NOMAD savings would have occurred without the standards. This is similar to adjusting for naturally occurring savings in DSM programs. For the same reasons that assessing compliance of individual measures is not feasible when buildings comply using the whole building performance approach, it is not practical to make an adjustment for NOMAD at the measure level when compliance is achieved through the performance approach. It is possible, instead, to examine NOMAD from the perspective of whole building performance and possibly estimate and adjust for market trends in overall building efficiency that would have occurred without the new standards.

Taking a whole building performance compliance perspective, however, raises issues in the determination of attribution credit for the C&S Program. To date, all studies have analyzed attribution for individual standards. This is because the CEC sets standards for individual measures and, consequently, the Program has tackled standards for specific measures rather than whole building performance. Since C&S Program activities can be associated with adoption of specific standards, it is reasonable and feasible to examine attribution for each standard. However, if NOMAD and compliance adjustments to gross savings are made at the building level, how credit should be attributed to Program efforts (which are measure-specific) is less clear.

To address these issues, this paper proposes that a whole-building performance perspective be developed to assess impacts of the Program. The approach must be developed in a systematic way that maintains a connection with the existing protocol. It also needs to provide a solid foundation for future impact evaluations of the Program.

The following sections discuss these key issues and our proposed methods for introducing a whole-building performance analysis into the existing impact evaluation framework.

Measures in 2005 Title 24

The 2005 Title 24 standards for which the C&S Program prepared CASE reports are a unique mix of measures, some of which apply to existing buildings:

- Time dependent valuation, residential and non-residential
- Residential hardwired lighting
- Residential duct improvement in existing homes
- Window replacement in existing homes
- Lighting controls under skylights
- Ducts in existing commercial buildings
- Duct testing/sealing in new commercial buildings
- Cool roofs on existing non-residential buildings
- Relocatable classrooms
- Bi-level lighting control credits
- Cooling tower applications
- Multifamily water heating

In addition to these measures, the Composite for Remainder category includes several Title 24 standards that were adopted, but with less direct participation by the utilities through the C&S Program. A partial list of these standards includes:

- Indoor lighting enhancements for commercial buildings
- Outdoor lighting
- Expanded requirements for demand control ventilation
- Variable speed drives required on variable air volume systems with motors of 10 hp or larger

Potential Savings from 2005 Title 24

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.

The original Savings Estimation Spreadsheet (SES) methodology was constructed to estimate savings at the measure level and did not address whole buildings. The perspective taken was that measure *ex ante* gross savings were the difference between the energy use of a baseline measure and a measure meeting the 2005 Title 24. The total gross savings for a Title 24 standard was 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 a compliance rate adjustment; gross savings were based on 100% compliance.

For this evaluation, we introduce a new term to delineate the savings possible assuming 100% compliance with the standards—potential savings. This variable represents the savings possible if all buildings just met the 2005 Title 24 and is equivalent to the original SES definition of gross savings. For this evaluation, we will redefine gross savings to take into account the effect of less than 100% compliance.

Prescriptive Analysis: Compliance, NOMAD, and Attribution

The existing analysis methods to adjust for the effects of compliance rates and NOMAD estimate these parameters separately for each measure covered by new standards. *Ex ante* and *ex post* values of the compliance rate and NOMAD are used to derive *ex ante* and *ex post* estimated savings for individual standards. Consistent with the above discussion, we will define potential savings as savings possible based on the CASE report estimates, adjusted by the findings of our review of these estimates, and assuming 100% compliance. When a building complies using the prescriptive approach, this overall approach is sound and provides meaningful savings estimates. In this situation, attribution to the C&S Program likewise can be estimated for each standard and this adjustment can be applied to standards' savings to estimate net savings attributed to the Program.

Compliance Adjustment

For new buildings that comply prescriptively, we will be estimating 2005 Title 24 compliance rates at the measure level. As the field studies are being conducted, we will first determine which buildings complied using the prescriptive approach and then assess measure level compliance for each building.

Taking the prescriptive compliance perspective, these estimates will be used to adjust potential savings for individual measures to reflect compliance levels and estimate gross savings. The buildings also will be analyzed using the compliance software (EnergyPro) to determine whole-building performance and compliance as described later.

NOMAD Adjustment

We will continue to estimate NOMAD for individual 2005 Title 24 measures using the existing methodology outlined in the evaluation plan. This methodology estimates what the adoption trend of measures equivalent to the efficiency level required by Title 24 would have been if the standard had not been adopted. It does not take into account the distribution of efficiency levels in the market; instead, it assumes that the gross savings simply need to be discounted by the savings from those complying measures that would have been installed if the standard had not been adopted.

An alternative approach would be to estimate the trend in measure average efficiency in the absence of the standard; by subtracting average market efficiency from the efficiency required by the standards, it would be possible to provide a more accurate estimate of the incremental standards savings. This method may be practical for some measures, such as discrete technologies for which extensive data are available. It is likely to be difficult, however, if not virtually impossible, to apply the average efficiency method to some Title 24 measures, such as cool roofs, for which little information is available to characterize the energy performance of the entire market.

Taking the prescriptive compliance perspective, the existing approach will be used to estimate NOMAD trends for each measure and use the NOMAD values to adjust individual measure gross savings. The feasibility of using the average efficiency approach in future C&S Program evaluations will be examined, but due to scope limitations we are not proposing to apply it at the measure level during the current evaluation.

Attribution

Attribution for each Title 24 standard will be estimated using the method we recently developed and presented at a public workshop in September 2008, and re-submitted in March 2009. It is based on the C&S Program's relative contribution to the resolution of three major types of issues addressed before each standard was adopted.

Determining attribution for individual standards is totally consistent with the fact, as noted above, that Title 24 establishes requirements for individual measures. Even though assessing compliance at the measure level is problematic because Title 24 permits compliance based on whole-building performance, attribution is more directly analyzed by investigating the Program's effects on adoption of individual standards that are then used to establish the performance requirement.

Title 24 Prescriptive Analysis Summary

Under the prescriptive scenario, the overall compliance, NOMAD adjustments, and the attribution factors will be derived using methodologies described in prior issue papers. These methods are based on techniques applied in the past and incorporated in the current SES, but enhanced in key areas.

We will assess compliance at the measure level for 2005 Title 24 mandatory measures and other measures required in buildings designed based on prescriptive compliance. These estimates will be combined with NOMAD estimates and attribution factors across all buildings, assuming they complied with the 2005 standards prescriptively, to produce an estimate of net energy savings attributable to the C&S Program. This will be one estimate of net Program savings that is consistent with the method applied in the past.

Performance Analysis: Compliance, NOMAD, and Attribution

Whole building performance analyses will be conducted using the compliance model runs performed for all buildings, based on their as-built features. This approach is a departure from what has been done in the past to provide inputs to the SES analysis of Title 24 savings. In the past, the compliance rates for individual measures were estimated and used to adjust the *ex ante* gross savings estimates for each measure. The 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. The whole building approach requires a different analytic framework than the past approach, and introduces some complexities regarding the Program attribution analysis.

The approach begins with the definition of potential savings. As noted earlier, potential savings are the savings possible if 100% of new buildings just complied with 2005 Title 24:

$$PotSav = Cons2001 - Cons2005$$

where:

PotSav = Potential savings from 2005 Title 24
Cons2001 = Consumption under 2001 Title 24 requirements
Cons2005 = Consumption under 2005 Title 24 requirements

This definition says that, at the building or aggregate level, the potential savings estimated for the 2005 Title 24 are the difference between energy consumption of buildings designed to the 2005 standards and baseline buildings. Ideally, baseline consumption would reflect how buildings were actually being constructed prior to when the 2005 standards went into effect, but (as noted before) this information is not readily available. Consequently, we propose to use the 2001 Title 24 to define baseline buildings. Once the current evaluation is completed, the results could be used in the future to define the baseline for the next round of standards.[1] Using the 2001 Title 24 to define the baseline is consistent with how the potential savings of the complete set of measures in the 2005 standards were calculated in the Eley and ADM reports.

The Eley and ADM reports provide *ex ante* estimates of PotSav. These will be adjusted, as a result of our ongoing review of the assumptions used in the CASE reports and the Eley and ADM studies, to provide an *ex post* estimate of PotSav applied in the remainder of the evaluation.

Compliance and NOMAD Adjustments

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

In the prescriptive case, compliance is calculated as the percent of required efficiency measures actually installed in the field. For the whole building analysis, the analogous quantity is the degree to which savings that should result directly from 2005 changes to Title 24 are actually achieved.

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

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 ConsBuilt. 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 2005 Title 24 then its CR could be greater than 1.0.

For prescriptive measures, NOMAD is defined as the market penetration of complying measures in year t that would have occurred without the standard. The SES adjusts for NOMAD by subtracting savings

[1] If a study were done of buildings *as-built* under the 2001 Title 24, taking into account actual compliance levels, it would be most appropriate to conduct it based on whole building performance because of tradeoffs allowed under the performance compliance approach. If compliance and performance at the whole-building level are analyzed in the current evaluation, then these values can be used to true-up the baseline against which the savings from the next standards can be measured.

attributable to natural market penetration of efficient measures from the potential savings. Net savings due to the standards are then calculated as the product of this difference and the measure compliance rate. However, this is not consistent with approach outlined here; i.e., potential savings are adjusted by the compliance rate first and then the NOMAD adjustment is made.

Applying this approach at the whole building level, we calculate net savings from the standards as follows:

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

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

We propose to estimate whole-building NOMAD using an approach similar to the one used to estimate NOMAD values for individual standards. A group of experts will provide their best estimates of trends in building energy consumption if no new building standards had been adopted after the 2001 Title 24. An iterative procedure will be used to reach consensus on a trend line and the resulting trend will be used to estimate net savings over time.

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).

Attribution

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. This is for the reason noted above: the Program efforts were directed at specific measures and the CEC adopted a package of individual standards, not a specific building performance level.

We propose to develop a whole-building attribution value using the attribution values calculated for each standard as described above. To produce an attribution value at the whole-building level, we will start by calculating what percent the *ex post* potential savings for each measure contributes to the sum of *ex post* potential savings for all measures in the standards. For each measure, the percent that measure contributes to the total *ex post* potential savings will be calculated. These percentages will provide weights to calculate the whole-building Program attribution value. The whole-building attribution value will simply be 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 would be:

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

where:

NetSav = Net savings attributable to C&S Program
Att = Whole-building attribution to C&S Program

Title 24 Whole-building Performance Analysis Summary

Under the whole-building performance scenario, the Title 24 net savings will be calculated based on the outputs of the residential and non-residential compliance software for the samples of buildings in our field study. It will be necessary to estimate consumption based on the 2005 Title 24, consumption as-built, and consumption of each building if it had been built to the 2001 Title 24 requirements. The first two values are readily available from existing software. We are proposing separately an approach to produce the consumption estimate under the 2001 Title 24.

These data will be inputs to calculate net savings. Compliance rates will be calculated based on the compliance software outputs. The whole-building NOMAD trends will be estimated using a process of obtaining expert inputs and the estimates will be entered into the equations to calculate intermediate net savings.

Finally, the individual standard attribution values will be combined to derive an overall whole-building attribution factor. This factor will be used to derive the net energy savings attributable to the C&S Program.

Conclusions

The second approach outlined above (performance analysis) will provide the first whole-building savings impact estimates for Title 24. Given the fact that many buildings use the performance approach to comply with Title 24 and how a building performs as a whole is the critical impact of the standards, we believe it is important to develop and implement the whole-building performance method.

Applying the original approach (prescriptive analysis) will provide estimates using a method consistent with previous studies and the existing SES. Because compliance is frequently demonstrated based on the performance method, however, trying to analyze impacts using prescriptive analysis is insufficient and inconsistent with real-world practices.

We believe it will be useful in the current evaluation to apply both analysis approaches and this will permit comparing them and assessing the differences in the net impact estimates they provide. This study should establish the foundation and experience for applying the performance analysis in all subsequent C&S Program evaluations.

Appendix C. Potential Energy Savings Estimation Methodology for Appliance Standards

The steps the evaluation team employed to assess and revise the potential energy savings estimates for the appliance standards are described below.

Review Potential Savings Estimates

The first step consisted of a thorough review of the CASE report and HMG savings report estimate for each standard. These two sources of information were thoroughly assessed to determine whether the reported potential savings could be replicated and the estimation method was valid.

Per Unit Savings

Validating the per-unit savings involved assessing two specific components: baseline energy consumption (the energy consumption of the unit before the standard was implemented) and unit energy consumption that met the standard.

Baseline Consumption

The appliance baseline consumption was the basis for all energy savings estimates. In general, there were three methods for calculating this value:

1. Standardized energy-efficiency calculation based on the energy consumption of a specific appliance just meeting an existing standard
2. Equipment metered data to determine an overall average baseline consumption
3. Engineering equations involving a number of assumptions to arrive at baseline energy consumption.

The standardized calculation approach typically involved applying a federal standard efficiency level to calculate baseline daily or annual energy consumption of a particular appliance. With some basic assumptions (e.g., days of use in a year), a total baseline annual consumption could be derived. If this method was used in the CASE report, we verified the equations with other sources and repeated the calculations to confirm the baseline energy consumption estimated in the report. Any differences between the evaluation team's estimates and those in the CASE report were noted. When differences or questions occurred, we contacted the report author for clarification.

The second method involved equipment metering. Typically, CASE report authors did not meter equipment, but instead relied on secondary sources for metered values. If the data were currently available, we reviewed the source document to assess the metering methodology. Any concerns about the results of the metering were noted, investigated, revised (if appropriate), and documented.

The third method used engineering equations. When using engineering equations several assumptions were made such as operating hours, typical wattages, and equipment performance characteristics. All the initial assumptions were thoroughly evaluated for accuracy. Initially, we used the stated assumptions and any concerns or discrepancies were documented for subsequent research and revision to determine the revised unit energy consumption.

Unit Energy Savings

The next step involved verifying the proposed standard energy consumption and/or energy savings. Some appliance standards were based on a percentage savings over a baseline model; others involved moving to a third-party Tier 1 or Tier 2 standard; and some involved specified improvements in components that led to the whole unit consuming less energy. Again, the analysis or approach that was used to estimate the unit energy savings was thoroughly investigated for this evaluation.

Each CASE report was thoroughly reviewed to identify the proposed savings calculation method and determine if an alternative method would be more appropriate. One key item evaluated was consistency in the method used for baseline consumption and proposed standard consumption calculations. As an example: if a federal calculation equation was in place to establish the maximum allowable energy consumption under an existing standard and there was a maximum energy consumption equation for the proposed standard, we examined whether the same equations were used for both baseline consumption and the proposed standard baseline consumption. If a different methodology was used, the team presented the finding to the CASE report author(s) to determine why.

If a percentage savings method was used for a standard that addressed multiple components of an appliance, we performed a general review to verify that the savings for the components, including any interactions, equated to the appliance (unit) percentage savings for the proposed standard. Again, the team attempted to replicate the initial CASE report savings estimates, checked whether they were consistent with the SES, and identified and attempted to resolve any discrepancies.

Review Current Sales Data

Once the unit baseline and unit energy savings were evaluated, we reviewed the initial unit sales per year starting with the effective date of the standard. At first, this involved using the data sources identified in the CASE reports or HMG savings estimate report. These sources were assessed to determine if the methodology in the secondary or primary source was accurate and to verify that the analysis was done properly. If any errors were noticed, they were documented and corrected to re-estimate the potential energy savings in year one.

Validate Potential Energy Savings

The team used all of the previously mentioned factors to verify the total potential energy savings expected for the first year of introduction of appliances meeting the standard. The most important factors were the unit sales and energy savings. These values were used to derive the first year potential energy savings as follows:

Potential energy savings in year 1 = unit energy savings * unit sales

Knowing how the potential energy savings were calculated, we identified any remaining CASE report gaps (assumptions not stated in the CASE reports) or areas needing clarification and forwarded them to the CASE report author for response. This step was completed for any discrepancies identified in either the specific CASE report or changes that occurred between the CASE studies and the HMG savings estimate report. When the CASE report author responded, the results were interpreted for accuracy; and any changes to update the potential energy savings in the first year of installation were made in the final step of the potential energy savings evaluation.

Review More Recent Information; Update; Revise Potential Energy Savings

Once we verified the first-year potential energy savings and corrected all the calculations from the CASE reports as needed, the most recent studies and sales data were evaluated. Since most of the work on the Title 20 standards was completed in the 2003 – 2005 timeframe, the team believed better estimates or more recent actual sales data could be available. A search for more recent and better data was performed. If the data turned out to be an update of the source data used in the CASE report, or if the basis for the data was more reliable, we used the new information in the analysis of the potential savings and documented the reasons why. The search for more recent data was carried out for all standards.

The final step in evaluating the potential energy savings per year involved compiling all potential energy savings adjustments mentioned in the previous steps, determining which values were appropriate to change, and documenting the reasons why these changes needed to be made. Essentially, this process involved submitting questions to the CASE report authors, assessing their responses, and incorporating more recent and accurate data. Once these modifications were made, we then adjusted the first-year and forecast potential energy savings estimates.

Appendix D. Potential Energy Savings Estimation Methodology for Building Standards

Reviewing Potential Savings Estimates

We had to review six primary sources that provided the basis for understanding the estimated energy savings impact from individual building code change proposals that were successfully adopted. These included:

1. *The Codes and Standards Savings Spreadsheet* (v3), August 2006. This spreadsheet contains first-year estimated energy impacts for each measure for which Program credit is claimed. Prepared by Heschong Mahone Group for Statewide Code Group and managed by Marian Brown. (CALMAC Study ID SCE0241.02). This spreadsheet is referred to as the SES.
2. *The Evaluation of the 2002 Statewide Codes and Standards Program*, June 2002. This report is a process and impact evaluation of the IOU's role in code development. Prepared by ADM Associates and managed by Heschong Mahone Group. We refer to this as the ADM report.
3. *Process Evaluation of 2003 Statewide Codes and Standards Program*, June 2006. This report is a process evaluation of the IOU's role in code development. Prepared by ADM and managed by The Deringer Group.
4. *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.
5. *Codes and Standards Enhancements Initiatives for 2005 Title 24*, March 2004. This is the final contractor's report for the Codes and Standards work commissioned by PG&E and prepared by Heschong Mahone Group. We refer to these documents as CASE reports or CASE studies.
6. Individual CASE Reports. These are the original consultant reports prepared to justify and defend the code change proposal. Links to these reports are provided at the end of the methodology description.

The savings listed in the Codes and Standards Savings Spreadsheet were typically derived from either the Impact Analysis report (reference 4) or the 2002 Evaluation report (reference 2).

First-Year Energy Savings

Validating the estimated savings involved assessing the underlying assumptions for the first-year savings equation and applying more relevant information to construction activity by sector and climate zone.

The CASE reports were thoroughly reviewed to identify the proposed savings calculation method. Our team used this information to determine whether or not an alternative method would be more appropriate.

Validating Potential Energy Savings

The most important factors in potential energy savings verification were measure energy savings and measure penetrations, which rely heavily on construction estimates. These values were used to calculate the potential energy savings for the first year.

Potential savings in year 1 = Energy savings per measure * number of measures

Any remaining gaps in CASE reports (i.e., assumptions not stated in the report) and all additional questions were sent to the CASE report author. This step was completed for any discrepancies in specific CASE reports and for all changes that occurred between the CASE studies and the Impact Analysis or 2002 Evaluation. After the CASE report author responded, we interpreted these results for accuracy, and the first-year potential energy savings were updated, if necessary, in the final step of the potential energy savings evaluation.

Reviewing More Recent Information; Updating; Revising Potential Energy Savings

After the first-year potential energy savings were verified and all calculations from the CASE reports were corrected as needed, the most recent studies were evaluated.

The final step in evaluating the potential energy savings per year involved compiling all potential energy savings adjustments mentioned above, determining which values should be changed, and documenting the reasoning behind these changes. This process involved submitting questions to CASE report authors, assessing their responses, and incorporating more recent and accurate data. Once we made these modifications, we then adjusted first-year and forecast potential energy savings estimates.

New Building Completions

Building completions for purposes of calculating potential savings are expressed in terms of the number of units for residential, which includes single family and multifamily, and square footage for non residential.

Residential building starts are based on permit data, representing the number of units from the Construction Industry Research Board (CIRB) covering the state of California. These data were analyzed for the years 2005 through 2008. We determined lags between typical building permit date and completed construction date through interviews with code officials. From interviews with code officials we estimated the following construction lags:

- Single family: six months
- Multifamily: eight months
- Nonresidential: nine months

Given that the 2005 Title 24 became effective for all buildings permitted after October 1, 2005, we lagged the permit data starting in October 2005 to estimate the completions covered by the new Title 24. Based on discussions with the data providers and researchers that conducted the original savings estimates used as the basis for the claimed savings, it appears that all multifamily residential, including high-rise apartments, are counted in the multifamily unit counts.[1] Our analyses, therefore, have used the total count of multifamily units when all savings estimates were calculated for residential units.

Determining nonresidential building construction in square footage required a couple of steps. Two different industry data sources were analyzed to derive floor area estimates:

1. CIRB: nonresidential permit data in construction dollars
2. Reed Construction Data: contract award data in construction dollars and square footage

[1] We contacted representatives of CIRB and Reed and Charles Eley, author of the original Eley report, to make this determination.

From the Reed data we estimated average construction dollars per square foot. The average values were then used with the CIRB permit data in construction dollars to derive nonresidential building permits in square footage by construction year as follows:

Non Residential square footage = construction dollars per square foot * construction dollars

Table 3 summarizes the final estimates of buildings constructed, by year, taking into account the estimated lag between permit date and construction completion date.

Table 3 Residential and Nonresidential Building Completions by Year

Building Category	Quantity	Construction Lag Period (months)	2006	2007	2008
Single family	Units	6	97,108	84,507	45,058
Multifamily	Units	8	31,408	52,269	40,461
Total Residential	Units		128,516	136,776	85,519
Non Residential	Square Footage	9	47,334,034	105,423,244	96,053,304

Appendix E. Bass Curve and Delphi Process Description

The Bass curve approach closely followed the guidelines established for the Delphi method originated and documented by researchers at the RAND Corporation in 1958.[1] The Delphi method is an exercise in group communication among a panel of geographically dispersed experts. Strictly speaking, its elements include (1) structuring of information flow, (2) feedback to the participants, and (3) anonymity for the participants. These characteristics offer distinct advantages over the conventional face-to-face conference as a communication tool. The interactions among panel members are controlled by a panel director or monitor who filters out material not related to the purpose of the group. The usual problems of group dynamics are thus completely bypassed. Clearly, another important advantage is avoiding the costs and logistical challenges involved in bringing experts together in one place.

To apply the benefits of a Delphi process to the NOMAD research, the second round of data collection was implemented as follows. First, features were included in the online application that allowed the experts to see all experts' Bass curves (including their own) plus a simple average of all of these curves on a single graph. In addition to the curves, all the first round comments were provided to each expert. To preserve confidentiality, the curves and comments were not identified by author. Next, the experts were asked to return to the online application. When they did, they were given an opportunity to stay with their original estimate, agree with the average estimate, or define a new estimate. In this way, some of the significant gaps between expert opinions were closed and more of a consensus was formed.

This approach, combining the use of Bass market adoption curves and two rounds of expert inputs, is nearly the same as the approach used in the prior study also conducted by The Cadmus Group (then known as Quantec, LLC).[2] For the current evaluation, the online application was enhanced in several ways, the most important being the addition of functions that enabled experts to submit a second market adoption curve once they had seen the other experts' first round submissions.

The standard Bass curve can be represented by the following equation:

$$F(t) = \frac{1 - e^{-(p+q)t}}{1 + (q/p)e^{-(p+q)t}}$$

where

F(t) = the cumulative fraction of adopters,
p = coefficient of innovation,
q = coefficient of imitation, and
t = elapsed time

p captures the effect of consumers who are not influenced by the behavior of others and q captures the effect of consumers who are influenced by prior adopters.

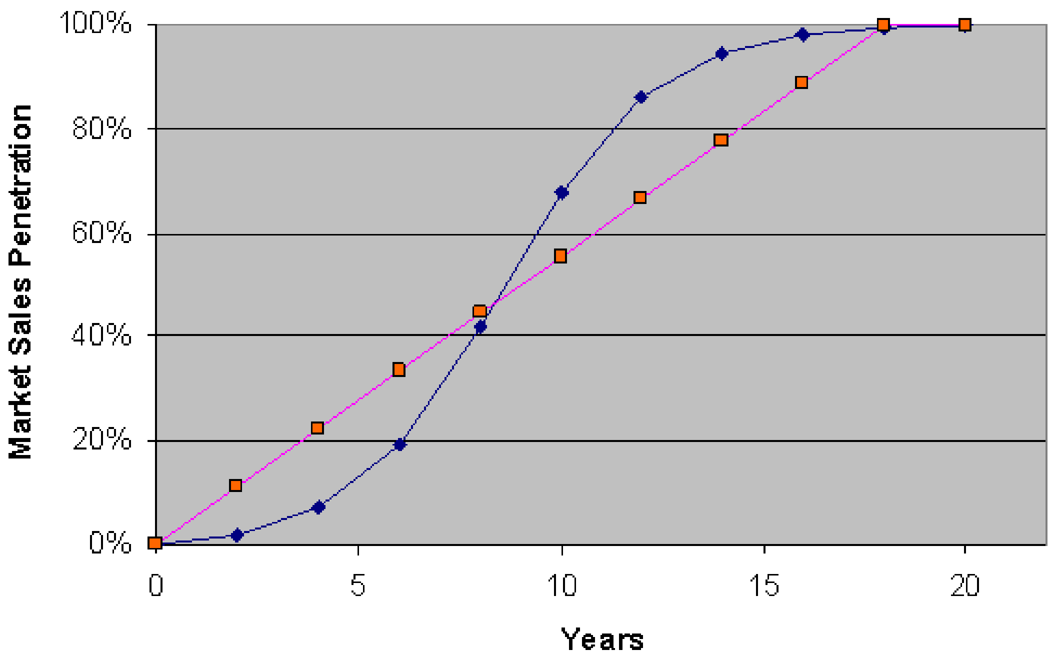
For the purposes of this analysis, the most critical part of the curve to estimate accurately was the part representing the initial years immediately following the introduction of the measure/ appliance because the S-shaped nature of the Bass curve can provide more realistic estimates of naturally occurring market adoption rates during those first years, as products gradually increase their market shares. The differences between the linear and S-shaped adoption curves are illustrated in , which compares a Bass

[1] On the Epistemology of the Inexact Sciences, Rand Corp, AD0224126

[2] *Statewide Codes and Standards Market Adoption and Noncompliance Rates*, Program No. 1134-04, 2007

curve that produces 99% market penetration in 18 years to a linear curve, which was assumed in the initial Savings Estimate Spreadsheet.

Figure 1 Comparison of Typical Bass and Linear Curves for 18-year Market



In the earliest years, the penetration rates based on the Bass curve are slightly less than those based on the linear curve, while they exceed the linear rates in later years. In this example, the naturally occurring adoption adjustment would be less with the Bass curve for about eight years, and more thereafter.

Mathematically, three of the following five parameters are needed to estimate the Bass curve:

1. Time (tmax) when maximum adoption rate will occur
2. Maximum adoption rate
3. Cumulative adoption at the maximum rate
4. Coefficient of innovation (p)
5. Coefficient of imitation (q)

It was essential to determine a start date for the market adoption curve for each efficient appliance or measure. The objective was to identify a date when the efficient appliance or measure started to have a presence in the market that accurately represented the beginning of its market growth. Some items had been available for many years, but experienced little or no market growth. Others had been present for some time and their market shares were already growing before the standards went into effect. Still others had developed little or no notable market presence at the time the standards went into effect. We selected a start date using an iterative process, beginning with a literature review for each item and relying heavily on the information presented in the relevant CASE report. In many cases, we solicited input from experts participating in this process to confirm or modify our proposed start dates.

Appendix F. Attribution Method

This appendix extracts from a memorandum that was submitted by the evaluation team to the CPUC documenting our methodology for determining the C&S Program attribution for each of the standards. The memorandum was submitted and made publicly available on March 9, 2009. It was revised in response to comments and re-posted on March 16, 2009.

The Proposed Cadmus Attribution Methodology (Revised)

Introduction

This document provides further explanation and clarification to the original document titled "The Proposed Cadmus Attribution Methodology" dated September 30, 2008[1]. The IOUs (Investor Owned Utilities) Codes and Standards (C&S) programs (PY 2006-08) evaluation contractor, Cadmus, (under contract to Energy Division (ED) of the California Public Utilities Commission (CPUC) and subcontractor to KEMA[2]) prepared this document to clarify any ambiguity surrounding the methodology described in the original document and the logic behind the improvements made to the Heschong Mahone Group's (HMG) original attribution methodology.[3]

Attribution is the process of determining the credit due the C&S Program for its contribution to the adoption of building and appliance energy-efficiency standards. The attribution methodology is used to quantify the net savings from standards credited to the Program and is the product of an attribution score (a percentage between 0% and 100%) and energy savings from the standard after adjusting gross savings for naturally occurring market adoption (NOMAD) and noncompliance. The attribution methodology described here is based on the California Evaluation Protocols and previous methodologies, but incorporates proposed revisions to address concerns identified during our review of prior analyses.

Background

HMG Original Attribution Methodology

The attribution methodology used by the IOUs for their savings claims was developed by the (HMG). In the HMG approach, the C&S Program receives credit for contributions to standards adoption in five areas referred to as factors:

1) Promoting market readiness of the measure (or appliance);
2) Conducting testing and research;
3) The innovativeness of the proposed standard;
4) Preparing the CASE report; and
5) Promoting a public process including stakeholder outreach.

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[1] http://www.energydataweb.com/cpuc/topicView.aspx

[2] KEMA is the lead contractor to evaluate the IOUs New Construction and Codes and Standards Programs for the PY 2006-08 under contract to the ED of the CPUC.

[3] Mahone, Douglas, HMG Group. *Codes and Standards Program Savings Estimate. For 2005 Building Standards and 2006/2007 Appliance Standards*. Revised November 1, 2005.

For each factor the Program receives a score between zero and one indicating the combined contribution of the utilities. Also, the factors are assigned weights, indicating their relative importance in the codes and standards process. For each standard, the factor weights must sum to one. The attribution score for a standard is the sum of the products of each factor's weight and score, and lies between zero and one. The net energy savings are then multiplied by the attribution score to arrive at the net credit.

In the original HMG attribution methodology, the factor scores and weights were estimated for each of the 2005-2006 building and appliance standards by a group of utility, consultant, and California Energy Commission (CEC) experts. The estimates are contained in the HMG spreadsheet and supporting report.[4]

Problems with HMG Attribution Methodology

Cadmus undertook a careful review of the HMG methodology. Our review involved analysis of the methodology, spreadsheet, and accompanying documents and discussions with the HMG model authors, CEC staff, and other industry experts. We concluded the methodology constitutes a solid foundation for future attribution efforts, but could be improved. In particular, we identified the following areas for improvement:

1. In the original attribution effort, the utilities were directly involved in determining attribution scores, including estimating the factor scores for the utility contribution, thus raising potential conflicts of interest. In the future, an independent party should make judgments about Program contributions based on the historical record.

2. The factor weights are described as capturing the importance of a factor in the regulatory process *and* the effort required to get the standard adopted; importance and effort required are distinct concepts and should be separated.

3. For some factors the weights and scores were defined so that they appear to be measuring the same things. For instance, consider the first factor in the HMG model (market readiness). According to HMG's methodology, the weights were determined as follows:

According to the documentation on the original method:

> *"For some products, such as energy efficient T-8 lamps and electronic ballasts for modular furniture task lighting fixtures, it was crucial that a large number of these product were available in the market and were being routinely installed already; else there would have been a great deal of opposition to making this a standard. Therefore, the weight for this factor for this standard was relatively high (40%). For other kinds of products, such as commercial ice making equipment, there was very little interest in the market for having energy efficient units, and so there was low market penetration. But there were energy efficient models available, and so it was possible to write a standard requiring that they be used. Therefore, the weight for this factor for icemakers was relatively low (10%).[5]"*

[4] Mahone, Douglas, HMG Group. *Codes and Standards Program Savings Estimate. For 2005 Building Standards and 2006/2007 Appliance Standards*. Revised November 1, 2005, pp. 12-15.

[5] Ibid., pp. 12-15.

The scores for market readiness were determined as follows:

> *"In cases where the IOUs had played an important role in bringing a given appliance or building measure into the market, through rebates, training or other efforts, the score was awarded as high as 100%."*

These guidelines ignore the fact that the market penetration of a measure may have been high because of past utility effort in promoting the measure. In this case, the factor weight would be large, but so would the score according to the criteria, both due in part to past utility programs. Similarly, market penetration may have been low because the utilities put little effort in the past into promoting the measure. In this case, the factor weight and score would both be low.

We believe the strong, positive correlation between the factor scores and weights in the HMG spreadsheet is consistent with and follows partly from the overlapping definitions of the factor weights and scores. As noted, the factor weight definition incorporates both the importance of the factor and the effort required to adopt the standard.

4. The scoring criteria for Factor 1 (promoting market readiness) allow credit to be awarded to the C&S Program for impacts of utility incentive, training, and education programs on standards adoption. However, credit for such programs is outside of the scope of this evaluation and should not be included in the model. The CPUC has commissioned a separate study of Residential New Construction programs that considers the impacts of these programs on standards adoption.

5. The factor scores may be redundant. In particular, the innovativeness of a standard will affect the market penetration of the measure, the amount of research and testing, the preparation of the CASE study, and stakeholder outreach conducted. Including innovativeness of the standard as a factor thus introduces potential for redundancy across several factors.

Cadmus Attribution Methodology

The Cadmus approach builds upon the HMG methodology and enhances it in several ways. One enhancement is an explicit recognition of the process governing the adoption of codes and standards by the CEC. In the Cadmus methodology, the Program will get credit for its contributions towards satisfying the requirements of the CEC for standards adoption. This revision was developed after an in-depth meeting with CEC staff about the standards adoption process.

A second improvement is that credit will be awarded on the basis of a careful and systematic review of public records, supplemented by information provided by the utilities, about Program contributions to standards adoption. Cadmus has developed a long, illustrative list of activities for which the utilities will receive credit. This list is appended to this document (Appendix I).

A third improvement is increased clarity in the definitions of key variables. Our approach avoids ambiguities that can generate dependence between the variables and redundancy in estimating Program contributions.

Finally, independent third parties will determine the Program's contributions to standards adoption, although the utilities and other stakeholders will be asked to provide input about the determination of other variables in our model. This will lessen concerns about potential biases from having utility representatives directly involved in the determination of credit.

Features of the Standards Adoption Process

The assumptions of our attribution model reflect the features of the process used to adopt building and appliance standards in California. The following features of the process and underlying assumptions were developed after a focused meeting with CEC staff about the standards adoption process:

1. A regular process governs the adoption of standards by the CEC. Both formal and informal rules guide this process.

2. One of the informal rules is that before a standard is adopted by the CEC, it must pass a number of explicit or implicit “hurdles” or “tests” (referred to as “factors” in our model). For instance, CEC staff involved in standards adoption indicated that concerns of stakeholders opposed to the standard must be addressed to the satisfaction of the Commission before a standard can be adopted.

3. The main tests or hurdles that must be overcome are: a) a method for determining compliance including any special analytic methods for estimating savings must exist; b) language and technical and cost information related to the standard must be sufficiently developed; and c) the feasibility of meeting the standard must be demonstrated. These tests or criteria are explained in more detail later.

4. Before a standard is adopted, all three hurdles or tests must be satisfactorily addressed. This implies that there is no opportunity for “trading off” one factor against another. Thus, deficiencies in one area, say, lack of a test method for an appliance standard, cannot be compensated for by superior outcomes in another area such as comprehensive documentation of performance and cost. This basic characteristic of the CEC process has the significant implication that, unlike the existing model, the attribution factors cannot be assigned different importance values—essentially, it implies that all factors must be satisfied for the CEC to adopt a standard.[6]

5. Multiple stakeholders, including utilities, are typically involved in overcoming the hurdles. Because of the contributions of multiple stakeholders, the maximum credit utilities can receive through the C&S Program for overcoming a specific barrier is likely to be less than 100%.

The following sections include a description of the main features of the Cadmus Attribution Methodology:

(A) The Attribution Factors;
(B) The Attribution Score;
(C) Data Sources and Collection;
(D) Estimation of Factor Weights and Scores

[6] Originally, we had intended to include “importance” weights in the model, which would have indicated the relative importance of the factor in the CEC’s decision to adopt a standard. However, we abandoned this approach after speaking with CEC staff who said that they were unable to rank the relative importance of the factors and that the factors were equally important in the CEC’s decision-making.

(A) Attribution Factors

In the Cadmus Attribution Methodology, the C&S Program receives credit for contributions to standards development by addressing the three factors discussed below. Based on our research, these are the fundamental requirements that must be met for the CEC to adopt a new standard and Program attribution will be determined by assessing the degree to which it contributed to satisfying each requirement.

Factor (1): Development of Compliance Determination Methods

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.[7] In other cases, it involves having an analysis tool that produces results indicating whether compliance is achieved.[8]

Factor (2): Development of Technical and Cost Information

Significant scientific, engineering, and economic research must be completed before a standard can be adopted. In addition, the standard must be defined in careful technical language. Since implementation of the C&S Program began, much of this research and development has been summarized in Codes and Standards Enhancement (CASE) reports for standards in which utilities played a significant role.

The research usually involves development of three kinds of information. First, the concept of the standard must be developed and the standard must be defined in careful technical or scientific language so compliance can be determined unambiguously by end users and enforcement entities.[9] Second, the energy and peak savings from the proposed standard must be sufficiently well demonstrated through credible analysis or other reliable methods. Third, the costs of meeting the standard must be known, documented, and reasonable given the potential energy savings, and the standard must be cost-effective from a total resource (societal) cost perspective.

Factor (3): Feasibility of Meeting the Standard

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

[7] For example, the 2005 cool roof Title 24 standard, which applies to low-sloped, non-residential 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.

[8] 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.

[9] For instance, Title 24 defines a cool roof as “Any roofing product with an initial thermal emittance greater than or equal to 0.75 when tested in accordance with CRRC-1 (Cool Roof Rating Council) [and] a minimum initial solar reflectance of 0.70 when tested in accordance with CRRC-1.”

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.

(B) The Attribution Score

The attribution score measures the contribution of the C&S Program to adoption of a standard and is used to multiply net energy savings to determine the amount attributable to the C&S Program. Here we define the attribution score and describe how it will be calculated.

As in the HMG model, the attribution score is the sum of the products of a weight and score for each factor. The factor weight indicates the relative effort required in each factor area. The factor score indicates the relative contribution of the C&S Program in the factor area. The factor scores are weighted to give the C&S Program more credit for contributions in factor areas that required the most effort. Determining the attribution score starts with an assessment of the relative level of effort contributed by all proponents to address the three factors defined above.[10]

Calculations

For ease of exposition, denote the three factors (Compliance, Technical, and Feasibility) by A, B, and C, and let the amount of effort required to address each be y_i, where:

y_{A1} = total effort required on factor A
y_{B1} = total effort required on factor B
y_{C1} = total effort required on factor C

Thus, y captures the effort required for the utilities, CEC, and others to overcome each hurdle once targeted standards development began. Conceptually, effort is measured in terms of real resources. Our model does not require measurement of the actual total resources required, but they could be thought of in terms such as labor hours or budgets.

Also, let credit attributed to the Program for addressing each factor be ci (or the factor score), where:

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[10] A difficulty in assessing attribution is how to take into account historical efforts and the effects of non-C&S Program activities that contributed to standards adoption. Research, testing, or efforts to advance market readiness often occur years before a standard is adopted. We developed a separate version of the model that could account for prior efforts, but elected not to pursue this approach because the current study focuses on evaluating impacts of the C&S Program that directly led to adoption of the current Title 20 and 24. In addition, there are inherent conceptual, overlapping, and boundary definition problems in trying to expand and measure the effects of broader efforts. As a consequence, our basic attribution model focuses on marginal contributions to standards development after a point in time when specific concentrated efforts to develop the standard can be identified with the C&S Program.

c_{A1} = proportion of credit C&S Program gets for addressing factor A
c_{B1} = proportion of credit C&S Program gets for addressing factor B
c_{C1} = proportion of credit C&S Program gets for addressing factor C

Then overall C&S Program credit, or the attribution score, for a specific standard is calculated as follows:

$$C = (c_{A1}*y_{A1} + c_{B1}* y_{B1} + c_{C1}* y_{C1}) / (y_{A1}+ y_{B1} + y_{C1})$$

In weighting the ci's by the amount of effort required to address factor i, the model gives the Program more credit for contributions in factor areas where more resources were required. Hence, for a particular standard, a contribution of 50% in a factor area requiring considerable effort will count for more than a 50% contribution in a factor area requiring little effort.

Note also that the attribution score C can be expressed equivalently as a weighted sum of the factor scores, ci:

$$C = c_{A1}*x_{A1} + c_{B1}* x_{B1} + c_{C1}* x_{C1}$$

where:

$$x_{A1} = y_{A1}/ (y_{A1} + y_{B1} + y_{C1})$$
$$x_{B1} = y_{B1}/ (y_{A1} + y_{B1} + y_{C1})$$
$$x_{C1} = y_{C1}/ (y_{A1} + y_{B1} + y_{C1})$$

x_i is the proportion of total effort required to address each barrier or hurdle. We will calculate the attribution score for each standard using this expression by estimating the *c*'s and the *x*'s.

<u>An Example</u>

Suppose the effort to overcome the three categories of hurdles are y_{A1} = 1000, y_{B1} 6000, and y_{C1} = 3000, where the units are some consistent measure of resources used. Note that the relative values of the yi's are needed, not the actual amounts, so for this example the units used to assess effort are not critical. Then x_{A1} = 0.1, x_{B1} =0.6, and x_{C1} = 0.3. Also, suppose the contribution of the C&S Program was 40 percent on Factor A, 80 percent on factor B, and 25 percent on factor C. Then c_A = 0.4 , c_B = 0.8, and c_C = 0.25. Applying the definition of the attribution score above:

$$C = 0.4*0.1 + 0.8* 0.6 + 0.25* .3$$
$$= 0.04 + 0.48 + 0.075$$
$$= 0.595$$

Thus, energy savings attributable to the utility C&S Program would be approximately 60 percent of the net energy savings from the standard.

(C) Data Sources and Collection

Estimating the attribution score for a standard requires information about the efforts of the C&S Program and efforts of other stakeholders to promote adoption of the standard. This information must be collected and then carefully read and analyzed to develop estimates of the key variables in the attribution model, c_i and x_i, i=1 to 3. To conduct this task, we have collected information from a variety of sources, including public documents, surveys, and interviews. This section describes the data sources and data collection and analysis consisting of Surveys of Standards Experts; Review of Public Documents; and Interviews of Participants in Standards Development.

Surveys of Standards Experts

To obtain information about the allocation of resources between the factor areas in the development of a standard, we will survey government, utility, and industry representatives involved in the adoption of the standard. Specifically, for each standard we plan to ask between five and seven experts the following question:

1. When the C&S Program started, what was the relative level of effort or resources needed to address each factor before the standard could be adopted? In other words, what was the percentage allocation of total resources across the factor areas in the development of the standard?

For standards included in the residential Title 24 market effects study, we will also pose the following question:

2. [***To estimate market effects for residential Title 24 standards only***] If the utility non-C&S programs preceding the standard development process had not been implemented, what proportional increase in the standards effort would have been required to address each hurdle, or factor?[11]

To ensure the consistency and comparability of responses, the survey will define resources in terms of the combined budgets of the C&S Program, the CEC, and other stakeholder groups promoting the standard. Defining resources in this way is conceptually straightforward and, in comparison to defining resources in other units such as labor hours, has the advantage of accounting for all overhead, labor, and non-labor expenses incurred in the development of the standard. This approach assumes that resources are used effectively and allocated efficiently to achieve standard adoption.

We plan to ask the questions via a web tool originally developed for NOMAD and modified for use in the attribution analysis. The web tool will include instructions including an explanation of the factors in the model, a list of activities for which the utilities will get credit, and questions about the respondents' involvement in the development of the standard, resource allocation, and market effects. The web tool will ask respondents to answer the questions and explain their answers. For residential Title 24 standards, we will provide the experts summary information on utility DSM programs that were likely to have affected the adoption of these standards.

If there are large discrepancies between experts' responses, Cadmus may follow up with short interviews to understand the differences or, in a Delphi-like process, share the responses and justifications and administer the survey again in attempt to form consensus.

As of March 2009, Cadmus is in the process of identifying experts to consult for the building standards and contacting them about their availability. We have almost finished this process for the appliance standards.

[11] We will pose this question as a counterfactual: "Suppose 100 units of budgetary resources were allocated to each of the factor areas. In the absence of IOU incentive, training, and education programs (listed below), how many units of the resource would have been required in each area? For instance, if your answer for Compliance is 105 units, this would imply that 5 percent more resources would have been required in this area."

Review of Public Documents

To estimate the contributions of the C&S Program to standards adoption, Cadmus will rely principally on a large body of documentation for each standard including the original Code Change Proposal, the CASE report, transcripts of CEC workshops and hearings, oral and written comments to the CEC, and the Code Change Theory reports. We believe these documents present a relatively complete picture of the standards adoption process. In particular, the Code Change Theory reports submitted by the utilities provided the C&S Program with an opportunity to convey contributions to standards development that may not be fully documented in the public record.

We have carefully read the public documents to identify C&S Program and other stakeholder contributions and entered relevant data into Excel spreadsheets for subsequent analysis. There is one spreadsheet for each standard, and each entry of each spreadsheets contains a short description of what was done; the factor area in the model to which the contribution pertains; the data source (e.g., the CASE report) and page number; which parties were responsible; and a short explanation of how the contribution furthered adoption of the standard. Cadmus believes the spreadsheets are a valuable resource for several reasons. First, although all public documents will be made available to evaluators, time and budget constraints would not permit evaluators to read them in their entirety, thus, summarizing the information saves time and money. Second, because the spreadsheets were constructed with the proposed methodology in mind, the spreadsheets can assist evaluators in organizing the large amount of information and thinking critically about the contributions of the C&S Program. Third, many public documents, including the CASE report and Code Change Theory, were written by the utilities and may, therefore, present subjective and limited histories of events leading to standards adoption. Entering information from these documents into the summary spreadsheets provides a broader context and allows reviewers to put these documents into a broader context.

Interviews of Participants in Standards Development

If there are still gaps in our understanding of the development of a standard after reviewing the public documents, we will interview participants in the adoption process. For instance, some important stakeholder concerns were resolved outside of public view and the process was undocumented; in these cases, credit for these efforts cannot be awarded without speaking directly to the participants.

(D) Estimation of Factor Weights and Scores

After collecting information from the data sources described above, Cadmus will estimate the factor weights and scores for each standard. The *factors weights* will be estimated using the survey responses to the question about resource allocation. The responses will be averaged; in some cases, we may weight responses based on the respondents' level of knowledge about standards adoption.

The *factor scores* will be determined using information about the C&S Program and other stakeholders' contributions to standards adoption, based on public documents and interviews with participants. Several principles will guide the scoring:

1. The factor scores will be determined using a well-defined, documentable, consistent, and repeatable method;

2. Factor scores will based on specific C&S Program actions leading to standards adoption. An illustrative list of actions for which the Program will receive credit is in Appendix I;

3. Factor scores will be determined by disinterested, third parties.

Cadmus will convene a panel of senior staff familiar with the adoption of energy-efficiency standards in California for each standard. The panel will be briefed about the objective of the panel, the attribution methodology, and available data sources. The spreadsheets, as well as all primary source materials, will be made available to all members of the panel. The panel will then attempt to reach consensus about the contribution of the C&S Program in each factor area based on careful reading, analysis, and discussion of the data. If the panel cannot achieve consensus, then each panelists will decide upon a score, the lowest and highest scores will be dropped, and the remaining factor score will be averaged.

Illustrative Activities for Which C&S Program Will Get Credit

Factor 1: Development of Compliance Determination Methods (Compliance)

a. Development of reliable test method

- Development of reliable methods for estimating energy consumption of products under prescribed conditions
- Assessment of existing test methods to identify appropriate ones for use with a standard
- Development of reliable methods for estimating performance of building components or equipment

b. Development of method for estimating energy savings

- Development of reliable algorithms for calculating energy use or savings of building components
- Example: Development of adjustment for degradation of cool roofs in calculation of energy savings
- Example: Creating new hourly TDV values for water heaters and other appliances
- Development of compliance software or modules capable of accurately analyzing energy consumption effects of specific building components

Factor 2: Development of Technical Information (Technical)

a. Definition of the standard

- Drafting the standard language
- Defining key words, terms, and concepts used in the standard language
- Presenting ideas or recommendations that shape the standard language, refine it, or make it clearer
    - Example: Making standard language for an appliance consistent with ENERGY STAR requirements for the ease of compliance

b. Energy and peak demand savings

- Market Studies
    - Estimate the number of units in California
    - Estimate the number of units that will be sold annually in California
- Engineering Studies
    - Calculate the baseline energy use of a unit

   - Calculate the energy use of a unit with the energy efficient measures/technologies applied
   - Determine the effects of climate zones on potential savings
- Energy Modeling Calculations
   - Using reliable simulation models to estimate annual energy and peak demand savings of an efficient building component

c. Costs and cost effectiveness

- Cost Research
   - Obtain and document reliable base and incremental cost information from engineering and market studies and interviews with manufacturers
   - Develop and apply verified cost estimating models
- Cost Effectiveness
   - Determine the life expectancy of a unit from market or engineering studies
- Perform climate-zone and state-level cost-benefit calculation by comparing the incremental cost of the measure with expected present discounted value of energy savings

Factor 3: Feasibility of Meeting the Standard (Feasibility)

a. Document market readiness

- Writing and publication of CASE report to demonstrate overall market readiness
- Conduct and report on manufacturer interviews to determine market availability
- Surveys of end users to gauge market penetration and customer acceptance
- Analysis of historical and current state and national sales data
- Analysis of utility and government incentive programs to gauge customer acceptance and market penetration

b. Document standard does not impose unreasonable and avoidable costs on end users, manufacturers, and other stakeholders

- Respond to concerns of stakeholders about costs of compliance with research based evidence
   - Example: Demonstrating that insurance costs on buildings with skylights are affordable and not significantly higher than on buildings without skylights
- Provide studies showing costs of compliance are not burdensome
- Addressing concerns about costs of compliance from research-based evidence or market expertise and suggesting changes to standard language to clarify
   - Example: Explaining cost implication of insulating floors in a walk in freezer, and showing that insulation is not necessary because of the difference in ambient temperature from the freezer floor and the ground it rests on

c. Document no significant negative health and environmental externalities

- Respond to and ease concerns of stakeholders about externalities by presenting clear and compelling evidence that externalities are insignificant

- Example: Researching the levels of mercury in CFLs and showing the minimal affects on humans or allaying concerns about cool roofs blinding pilots

- Preparing reports in support of required environmental impact documents
- Raising concerns about potential externalities that ultimately lead to changes in the standard.

Appendix G. Residential Building Standards Compliance Analysis Issues

Process Description

Each step within the process of developing and building homes must incorporate the Title 24 energy standards in order for implementation, compliance, and eventual energy savings to materialize. Additionally, adequate training and staffing levels within building departments is essential to the enforcement of Title 24 requirements

C&S Program evaluators contacted building code officials for the nonparticipant sample of approximately 304 homes to investigate and document the processes used by building code officials when ensuring compliance with Title 24 requirements within their jurisdictions. The organization of information varied between building departments considerably. The CF-1R form, detailing how the builder will comply with the standards, is typically submitted during plan check to the planning or building department. Some municipalities only had one of these departments, and some had a larger development or community development department, with building and planning as divisions. After the architectural plans are approved, the municipality often requires that the plans be “blue-printed,” or made to be part of the blueprints. These blueprints and CF1-R combination documents were considered by some municipalities to be copyrighted. In many cases, because the architectural plans comply with energy requirements according to the CF-1R, the CF-1R is no longer consulted, is filed away or, in some cases, destroyed. After approval of home plans, the building official then conducts inspections throughout the building process to determine that the building matches the architectural plans. Sometimes approval of the CF-1R forms and the architectural plans is conducted by the planning department, or even an outside consultant hired by a city or county government, and then the blueprints, without any accompanying Title 24 documentation, are passed to the building department.

After the building is built and the remaining compliance documents are generated (if they are generated) the Title 24 documents might reside in the building, planning, or some other department, or no longer exist. These documents also are sometimes considered to be copyrighted, requiring forms be filled out to receive permission from the architect, and a 30-day waiting period must occur before they will be released. They might be on micro-fiche or otherwise organized in such a way that they can only be viewed in person. In some cases public information requests must be filled out, and sometimes copies and staff time paid for. From the overall sample of nonparticipants that applied for building permits after October 1, 2005, there were 53 homes for which Title 24 documents could not be furnished because they were lost or destroyed. Many municipalities stated that they were not required under California law to maintain those records and they destroyed the documents 90 days after final inspection. One municipality cited the 2001 CBC 106.4.2 that called for keeping the forms for no longer than 90 days, and the current 2007 CBC 106.5, requires 180 days.

The discussions and interactions that occurred with the local governments that are charged with enforcement of Title 24 illuminated the processes that occur within government while enforcing Title 24.

The initial phase of building a home or multi-home subdivision is the concept phase. During this initial period, location selection, financing, planning and zoning approvals are met, and architectural plans are selected or generated. The architectural plans represent the first opportunity to apply energy codes to a home. If prescriptive compliance is opted for, those requirements would be reflected in the plans, and if performance-based compliance is undertaken, a certified energy consultant models the home to ensure it complies overall. In either case, a CF-1R detailing the energy compliance is created to accompany or become part of the architectural plans.

The blueprints and Title 24 documents are submitted with other paperwork to a local government in a process known as "plan check." The majority of municipalities consider the Title 24 documents to be conceptually part of the blueprints. For his reason some of the municipalities use the date the plans are submitted to "plan check" as the date that determines which version of Title 24 the builder should comply with.

After the plans and Title 24 CF-1R documents have been approved, the builder obtains the building permits to begin construction. The building inspector, at each phase of construction, focuses on health and safety issues such as structural elements and things like faulty wiring that can pose a safety issue. At this point in time, the original CF-1Rs that informed the plans may have been discarded. Each phase of construction is inspected by building officials for compliance with codes and also so that it matches the approved blue-prints.

After the building is completed, a final inspection occurs, which produces the installation certificate. Ideally this is retained by the building departments, but is often discarded after 90 days or possibly never created. The HERS verification process also occurs at this time. A HERS rater certified with one of the four organizations approved by the California Energy Commission as home energy rating providers conducts testing on the home. Tests include duct blaster and blower door tests, and verification of SEER for air conditioner units. This independent verification results in completion of a CF-4R form and each independent home energy rating organization enters the information into a separate database. Consolidation of these databases into one central location would better facilitate future assessments of compliance.

Training and adoption of standard procedures across the state would assist building officials in navigating the myriad of forms and paperwork that must be created at each step in the process. Building officials would benefit from a grid that shows which paperwork is required for which building components. Plan check staff would benefit from clarification of which date to use and adoption of a standard process for processing and archiving the energy compliance forms.

Observations and Recommendations

Documentation

- Documentation is an important part of compliance with Title 24. If local governments were required to maintain documents longer, finding problems and enforcement would be easier.

- If documentation was standardized, auditing could occur that would increase enforcement of the codes significantly.

- Title 24 compliance documents are not accessible at the local government level for the majority of building departments. The issue of local governments blueprinting the compliance documents onto the blueprints and then having copy-right issues surround the request of those documents should be addressed. This could be done by specifying the location and form the documents need to be archived.

- Consolidation of the HERS registries into one centralized, accessible database would assist compliance efforts in the area of required HERS ratings.

- Compliance for windows is difficult to assess because the stickers that detail the U-value and SHGC are removed soon after installation. Requiring window manufacturers to etch or otherwise permanently identify the window performance would stream line enforcement in this area.

Building Department Processes

- Training is needed to give building officials the tools and knowledge they need to enforce the regulations.

- Adoption of standard procedures across the state would assist building officials in navigating the myriad of forms and paperwork that must be created at each step in the process.

- Building officials would benefit from a grid that shows which paperwork is required for which building components.

- Local governments, particularly plan check staff, would benefit from clarification of which date to use for compliance. It would be advantageous if the date the architectural plans are submitted to the building department was the date that determined which version for the code was to be applied. Having the permit application date dictate which code to use creates issues surrounding enforcement. Once the plans are submitted under the previous building code, it is difficult to enforce newer codes if the building permit is applied for after a later code has taken effect.

Appendix H. Nonresidential Building Standards Compliance Analysis Issues

This appendix documents a range of issues that were encountered in the course of doing the Title 24 nonresidential compliance analysis.

Building Department Contact/Recruitment

This task required significant research prior to obtaining usable data. Numerous calls to each building department were needed to find the one person that might be willing or able to work with us. Building departments regularly cited recent staff cutbacks as a reason for non-response or very long delays. Some departments neither answered their phones nor returned calls, resulting in general difficulty with getting a call back or even a referral to the appropriate personnel. Because of budget cuts, they often cited short staffing as a reason for reluctance or refusal to cooperate. Another reason cited was data confidentiality. Our letter from the CPUC was helpful in some cases, but not all. In some cases, though data were clearly available electronically, the staff were either unwilling or unable (because of lack of facility with the software) to provide it. Occasionally fees were quoted for providing the data. Sometimes the fee represented a reasonable reimbursement for the effort required, other times it was excessive. Due to these challenges, the time and effort required to gain the cooperation of the building departments in sharing the requisite data was much greater than originally anticipated.

Building Department Data Collection

Once we established communication with one or more contacts at the building department, the collection of the raw data presented additional challenges. Several of these were anticipated, but many were not and plans had to be adjusted in process. Downloading the information that we could access at the building departments was time-consuming; saving files onto thumb drives was possible in some places, but in several instances it was not ideal. One example of this was San Francisco – this approach gave us low-resolution digital plans that were not usable because they were illegible when expanded to normal reading size.

There is no universal format used by the various jurisdictions to collect and store their permit data, and many of their systems were antiquated. Often this required the original database programmer to write new code to provide results in a different format than the department's usual protocol, or required us to purchase the same software and database programs that the jurisdiction was using so that data could be transferred in a compatible format. Many times there was only one person who knew how to retrieve the data we needed from the system, and sometimes it needed to be done by a separate department that was not always willing cooperate.

Because we would later be creating computer models of the buildings, we sought to have a copy of the plans for reference. Often, building departments refused to allow us a copy even if no effort was involved on their part, often claiming that copyright restrictions required that they contact the original author for permission.

Some of the documents we were seeking were available on paper, some electronically, while others had been lost or were unavailable because the paper documents had been sent off for imaging, which had not been completed. In some cases, the plans were only available for viewing on an electronic kiosk at the building department. This greatly slowed down the review of the documents. On several occasions we were asked to pay very large amounts of money before the jurisdiction would even attempt to comply with our request, and in two cases, because permit records were only provided in paper form, considerable costs were incurred and time wasted as these data were hand-keyed into a usable database format.

Even when data were available on-site and a building official offered to help us, a half day was often spent in meeting the official, getting oriented at the department, and clarifying and refining our request before useful data acquisition began.

Building Site Owner Recruitment

One of the reasons for obtaining permit data was to identify the appropriate site contact person. In many cases the contact information gleaned from the building department records was obsolete, resulting in the necessity for extensive research to find the correct owner or property manager so that recruitment efforts could begin. Sometimes this was a matter of contacting employees or other tenants at a site, but often it involved internet searches and even inquiring with the offices of the county assessor or recorder to find the owner of a property. Multiple calls were required to identify an appropriate building contact, with still more calls required to reach them and speak to them in person.

The biggest challenge after this was convincing a site contact that this visit was necessary and appropriate for them to spend their time on. A few building contacts were friendly and helpful, but many were unwilling to give us even a few minutes of their time, and the incentive we offered was not enough motivation for these people. Most of the latter type would not have been motivated by any incentive amount - their feeling was that if the state was not requiring them to participate, then they simply would not.

Another recruiting challenge was that sites were identified as appropriate for the initiation of contacting efforts, when in fact many of them were not ideal. This required that the recruiter either have significant expertise with the project background and all the myriad study sample requirements, or that he or she engage in extensive research to be sure that each site was in actuality a viable potential site for data collection.

Obtaining EnergyPro BLD files from engineers and energy consultants also posed a challenge, as some were just not willing to provide them to us. Energy consultants were generally more cooperative than engineering firms. Overall, success in this area was fair, but would have improved if we had been able to get more legible plans from the building departments.

Site Scheduling

Once the primary contact was identified, gaining approval for entry often entailed several days (or weeks) of phone and e-mail correspondence to arrange a visit. A common challenge even for willing study participants was that providing a site contact to meet our technicians and assist them with access and information was not always possible.

To make this approach effective and timely would require dedicating multiple callers to this task.

"Cold Calling"

To circumvent the considerable delays we experienced in attempting to pre-schedule site visits, we initiated "cold calling" of sites that appeared to be low-security sites. While still difficult, visiting sites unannounced and attempting to collect data was a preferred method for many situations. Primary challenges here were encountering neighborhood safety and security issues, limited access to building owners or managers, and technicians not knowing what type of site they were walking in to (i.e., restaurant, apartments, high rise office, etc.). In addition, the length of time since the completion of the permit work was an issue; for example, in a large high-rise building the available maintenance personnel would generally not know the details of an alteration that happened several years prior.

This method was fairly successful with smaller public facilities; however access was generally limited to the public areas or to certain time periods as in the case of restaurants. We were often told to come back later, only to find that the person we needed to speak with had "just left." Larger buildings generally required prior approval. Also, the time needed to complete a thorough analysis of the building measures was more than we could reasonably impose on someone unannounced. While this was a fairly successful method of contacting facilities, a more effective solution in some cases was to contact the facility in-person and schedule a time to come back for the full analysis.

Physical Security Concerns

Physical security was an issue with several sites. Some concerns were related to public security such as aviation sites on secure premises. Others were related to business and information security as in the case of many information technology sites. As one staff member wrote, "I think folks will always be skeptical when they are approached for access to their building in a post 9/11 world."

A few building contacts became hostile when approached with a site visit request, and they were verbally abusive toward the recruiter on the phone, or angry and defensive toward a site technician in person.

Legitimacy and Authority

The CPUC memorandum introducing the project and the contracted entities was helpful, although a shorter and more focused letter directly addressed to building owners and property managers would have been more effective for this phase of the research. While our association with the CPUC did provide legitimacy and gain us access to the site contact for at least long enough to explain our objective, some site contacts had already had negative experiences under similar circumstances and were not positively influenced.

A major concern in this area was apathy toward the work and the organizations sponsoring it – many people just did not care why we were requesting to collect data or who was in charge of the work. Under the present economic conditions, few were of the disposition to make the time to show us around. They expressed that their own challenges and frustrations were overwhelming and they had no patience for extraneous demands. The offer of the $50 gift certificate incentive was more effective with managers and administrative staff, but less effective with owners.

Logistics Issues

Logistics on this project were a significant hurdle. It was difficult to anticipate and plan for the effort that would be required to complete this data collection activity. In the end, we underestimated the resource requirements because of the labor intensive nature of each step in the research, and the detailed effort required to obtain data that were accurate and complete enough to analyze. There were unanticipated hurdles to overcome throughout the project that need to be anticipated in future studies. Key ones are highlighted below.

Building Site Data Collection

One challenge found at many alteration sites was finding a person familiar with the scope of the work for the permit activity we were studying. Another challenge was the difficulty in finding personnel that could provide answers to questions about the building.

Personal Security

At least one site technician was threatened and verbally accosted by an armed security guard after inadvertently traveling onto a secure property while attempting to visit a building site there.

Cost and Time Constraints

To respond to building department invitations it was sometimes necessary to schedule flights with short notice. This practice increased travel costs and rushed the building department recruitment and data analysis process which was necessary to complete before a cost effective trip could be planned. One result was that it was difficult to allow enough time for staff to finish the recruitment and data processing of other jurisdictions in the area, thereby allowing one trip to serve multiple jurisdictions instead of only one. Due to the size of the assessment area being statewide, and the distance between the cities that were sampled, travel time was a big part of the time spent collecting data.

The challenge of time constraints also affected the ability of site technicians to complete thorough data collection at some sites. At large sites, technicians had trouble recording sufficient data to effectively model the building in EnergyPro.

Travel Time and Missed Visits/No-Shows

There were cases where the site contact simply did not keep the appointment. At several sites a technician would speak with what were evidently subordinates representing that they would meet the technician and assist them, only to be told by the supervisors that participation was declined once on site.

Lack of Access or Refusal

Technicians often encountered site contacts who refused or was limited in their ability to allow access to equipment or building areas for data collection. One technician reported that the majority of refusals received were from people who didn't speak English as their first language and did not trust the "establishment." Some site personnel contacted during cold-calling efforts used their purported lack of English language ability as a reason for declining participation. Also, the technician not having a convincing script, in the mind of the site contact, to explain why access to "cold call" sites was needed, was a concern for some.

Limited Ability to Gain Access to Equipment

Technicians reported that they almost always had limited access to equipment onsite for one reason or another. Usually the technicians found that the people willing to work with them did not really know where things were, and even if the technician was able to show them the path they usually did not have keys to the necessary rooms. Some things like the ducts were not always accessible because of their locations.

Physical Constraints of the Site

Lack of roof access was a significant problem, and even more common was sites unwilling to allow any access to the roof for fear of financial liability if an accident were to happen.

Outdoor lights are often mounted very high on the building and would require a bucket truck to access for lamp and ballast confirmation.

Sheer Size and Complexity of the Building

While most technicians did not find building size to be an issue for most of the sites they actually collected data at, this is not to say that size and complexity of the buildings did not present a serious challenge to the project as a whole. The sites that we expected would provide the most data were by far the most difficult to gain access to, both from a management and security standpoint but also from a time and equipment standpoint. Although data collection at simpler sites could be done relatively quickly, large, complex sites required many hours or more than a single day. Although we were evaluating specific building measures, the language of the code is complex and one measure is almost always triggered by many other aspects of the building that are difficult or impossible to know without a full audit of the facility.

Some of the buildings that were visited were quite large and it was difficult for one technician to make detailed notes because of how complex the building was. For example, a medical office building with a maze-like floor plan posed special challenges for trying to count the lights and fixture types.

Challenges of Data Recording and Tracking

Finding staff with enough training and experience to process data from the building departments quickly was a challenge also.

The extensive data collection requirements also were a challenge. We started with Google Sites and Documents as a way to systematically record the data, but we found this approach was problematic, especially for those field staff using the Internet Explorer web browser. Switching to the Firefox web browser eliminated most of those problems, which included computer program and software freezing up frequently, computer crashing requiring restarts when log-in attempts were made, etc.

We used forms to record the data that were designed to be viewed on a PDA, but this was frustrating to some field staff who would have preferred a more viewer friendly format compatible with standard paper size. While the Title 24 measures being evaluated were known, the navigation of different site environments to glean acceptable information seemed to be a bit of a moving target as plans, notes, and pictures were stored in at least three different places (due to limitations encountered on Google sites.)

Data Analysis Hurdles

The customized version of EnergyPro that was developed specifically for this analysis effort also was the source of delays in completing the analysis. Even though substantial beta testing of the software had been completed months prior, just weeks before the deadline it was discovered that on some computers, the software was unable to open and convert data that we had collected from the original authors of the EnergyPro models using previous versions of the software. In the end, the software developer went to great lengths to be sure that a usable version of the software was available by re-implementing the special features in the latest version of EnergyPro, but this resulted in delays completing the initial analyses. Once the working version of the software was provided with the ability to open and convert previous versions of the files, it was discovered that additional corrections to the files had to be performed to work around some of the new code compliance options for the 2008 standards. One of these work-arounds also involved the development of a complete set of occupancy and usage schedules for the 2001 standards after our team determined that occupancy schedules had changes between the 2001 and 2005 Title 24.

Appendix I. Detailed Appliance Standards Potential Energy Savings Results

Standard 1 and 2: Commercial Refrigerator (Solid Door and Transparent Door)

Introduction

California introduced standards for solid and transparent door refrigerators/freezers that went into effect in January 2006 and January 2007, respectively. These requirements changed the minimum allowable efficiency for both types of units from the then current federal standard to the level required by ENERGY STAR®. The equations for the maximum allowable energy consumption under the previous standard and under ENERGY STAR (the 2006/2007 California Title 20) are show in Table 4 for solid door and transparent door refrigerators/freezers; they vary by type (refrigerator versus freezer). The equations provide the allowable daily energy consumption (kWh), where V is equal to the internal volume of the unit in cubic feet.

Table 4: Allowable Daily Energy Consumption for Commercial Refrigerators and Freezers (kWh/day)[1]

Type	Current Federal Standard	ENERGY STAR (California Code)
Solid Door Refrigerator	0.125*V+2.76	0.10*V+2.04
Solid Door Freezer	0.398*V+2.28	0.40*V+1.38
Transparent Door Refrigerator	0.172*V+4.77	0.12*V+3.34
Transparent Door Freezer	0.94*V+5.1	0.75*V+4.1

Unit Energy Savings

The CASE report referenced a secondary data source[2] from ACEEE that analyzed solid door and transparent door refrigerators separately. These two types of commercial refrigerator/freezers were analyzed separately because the energy-efficiency requirements for transparent (glass) door units are less stringent than those for solid door units.

Solid door refrigerators and freezers were evaluated for three different sizes or volumes (V) in both the CASE report and the ACEEE study: 24, 48, and 72 cubic feet. These size increments adequately cover the range of sizes. Two assumptions were used in both the CASE report and the ACEEE study:

> Assumption 1: The unit will be operated for 365 days per year.
>
> Assumptions 2: The average ENERGY STAR qualifying model is 5% more energy efficient than the equation shown in Table 30.

Assumption 1, included in this analysis, states that the unit will be operating continuously; and there was no evidence to contradict this assumption. Because no justification was presented for Assumption 2, we

[1] Source: ACEEE: http://www.cee1.org/com/com-ref/aceee-paper.pdf

[2] Source: ACEEE: http://www.cee1.org/com/com-ref/aceee-paper.pdf

did not include it in this analysis. This assumption was referenced in both studies but was not supported in either. The classification for the ENERGY STAR label does not include a 5% adjustment factor, and the only requirement in California is to meet the specifications in Table 30.

Using the equations shown in Table 4 and Assumption 1, the annual energy consumption for each unit was calculated for both the current federal standard and ENERGY STAR level (the 2006 California Title 20). The results for daily and annual energy consumption by size are shown in Table 5, using the corresponding equation from Table 4 above. The annual energy consumption was calculated as the daily energy consumption multiplied by 365 days per year. The energy savings is the difference between the federal and California standard annual energy consumption.

Table 5: Consumption and Savings for Solid Door Refrigerators and Freezers

Type (Size)	Federal Standard, kWh/day	California Standard, kWh/day	Federal Standard, kWh/year	California Standard, kWh/year	Energy Savings, kWh/year
Refrigerators (24)	5.76	4.44	2102	1621	482
Freezers (24)	11.83	10.98	4319	4008	311
Refrigerators (48)	8.76	6.84	3197	2497	701
Freezers (48)	21.38	20.58	7805	7512	293
Refrigerators (72)	11.76	9.24	4292	3373	920
Freezers (72)	30.94	30.18	11292	11016	276

Similarly for transparent door refrigerators, the CASE report evaluated three different sizes or volumes (V): 24, 48, and 72 cubic feet. Both the CASE report and the ACEEE study cited above evaluated only one average size for transparent door freezers. The justification for this was that the transparent door freezers accounted for the smallest share of the total sales of commercial refrigerators and freezers (see the Unit Sales-CASE report section below). The same assumptions used for solid door calculations were assumed for transparent door refrigerators/freezers. The 5% reduction in consumption for refrigerator/freezers was again excluded from these calculations, while the annual usage of 365 days was included. The results are shown in

Table 6.

Table 6: Consumption and Savings for Transparent Door Refrigerators and Freezers

Type (Size)	Federal Standard kWh/day	California Standard kWh/day	Federal Standard kWh/year	California Standard kWh/year	Energy Savings (kWh/year)
Refrigerator (24)	8.90	6.22	3248	2270	977
Refrigerator (48)	13.03	9.10	4754	3322	1433
Refrigerator (72)	17.15	11.98	6261	4373	1889
Freezer	36.02	30.21	13149	11027	2122

As can be seen in Table 5 and

Table 6, the energy savings, for solid and transparent door refrigerator/freezers, range from 276 to 2122 kWh. The only major modification from the CASE report to this evaluation was the previously mentioned elimination of the 5% reduction in energy consumption for ENERGY STAR (the 2006/2007 California Title 20). All other inputs and equations from the CASE report were accepted as reasonable and as the best data currently available for these two standards (solid and transparent door refrigerator/freezers).

Unit Sales - CASE report

The unit sales data used in the CASE report and the ACEEE study were based on national estimates of equipment stock by size.[3] The CASE report and the ACEEE study assumed a 9 year measure life. To calculate the national sales, both reports estimated that the national equipment stock divided by the measure life equated to the national sales per year. The CASE report estimated California commercial refrigerator/freezer sales were proportional to California's share of national commercial electricity use, which was 9% in 2001(EAI 2001[4]). However, California has significantly lower commercial per-capita electricity consumption than the rest of the U.S.[5] The authors of the current evaluation believe that a better representation of the percent of units sold in California would be one based on population. Approximately 12%[6] of the U.S. population is located in California. Consequently, we used 12% as the share of national commercial refrigerators and freezers sold in California. The revised estimates of California sales of solid door refrigerators and freezers are shown in Table 7.

Table 7: Unit Sales of Solid Door Refrigerators/Freezer—Revised Methodology[7]

Type Size	Sales Per Year National	Percent of Units in California	Sales Per Year California
Refrigerator 24	43,333	12%	5,200
Refrigerator 48	93,889	12%	11,267
Refrigerator 72	7,222	12%	867
Commercial Refrigeration Equipment, Refrigerators Solid Door	144,444	**12%**	**17,333**
Freezers 24	48,889	12%	5,867
Freezers 48	35,556	12%	4,267
Freezers 72	4,444	12%	533
Commercial Refrigeration Equipment, Freezers Solid Door	88,889	**12%**	**10,667**

We applied the same approach to revise the original estimates of commercial transparent door refrigerators and freezers. The CASE report and the ACEEE report used the same methodology to estimate the number of units sold in California. The only modification our team made was in the percent of California sales (12% compared to CASE report of 9%). The results are shown in Table 8.

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[3] Source: Arthur D. Little, Inc. (ADL), in a 1996 study for DOE

[4] Source: EIA 2001. State Energy Data Report 1999. DOE/EIA-0214(99). Washington, DC: U.S. Department of Energy.

[5] Source: GTSP: http://www.pnl.gov/gtsp/workshops/smith_gtsp_%20052407.pdf

[6] Source: http://www.census.gov/population/projections/state/stpjpop.txt - 2005 projection

[7] Source: ACEEE: http://www.cee1.org/com/com-ref/aceee-paper.pdf - National inventory remained the same while increasing the California inventory from 9% to 12%.

Table 8: Unit Sales for Transparent Door Refrigerator/Freezer—Revised Methodology [8]

Type Size	Sales Per Year National	Percent of Units in California	Sales Per Year California
Refrigerator 24	44,444	12%	5,333
Refrigerator 48	40,000	12%	4,800
Refrigerator 72	4,444	12%	533
Commercial Refrigeration Equipment, Refrigerators Transparent Door	**88,889**	12%	**10,667**
Commercial Refrigeration Equipment, Freezers Transparent Door	**19,556**	12%	**2,347**

One main concern raised in this evaluation was that both the CASE report and the ACEEE study referenced a source from 1996,[9] and we believed the sales data were likely outdated. We identified a more recent source of sales data that did not provide detail by size, but did break out sales by refrigerators and freezers. We chose to use the more recent source to update the sales data for transparent and solid door refrigerator/freezers, as discussed in the following sections.

Weighted Average Unit Energy Savings (CASE Report)

To calculate the unit energy savings, the evaluation team used a weighted average by number of units for the energy savings by type. This step was not included in either the CASE report or the ACEEE study, but the sales data were used in both studies.

The results of this analysis are shown inTable 9 for solid door refrigerators/freezers. We used the size distributions used in the CASE report and ACEEE study to determine the sales weights. The weighted average unit energy savings per year for solid door refrigerators is 646 kWh and 302 kWh for freezers.

Table 9: Unit Energy Savings for Solid Door Refrigerators and Freezers

Type Size	% Sales Per Year California	Unit Energy Savings (kWh)
Refrigerator 24	30%	482
Refrigerator 48	65%	701
Refrigerator 72	5%	920
Weighted Average Refrigerator Savings		646
Freezer 24	55%	311
Freezer 48	40%	293
Freezer 72	5%	276
Weighted Average Freezer Savings		302

The results of the same type of analysis are shown in Table 10 for transparent door refrigerators/ freezers. The weighted average unit energy savings per year for refrigerators is 1228 kWh. As no size distribution was provided for transparent door freezers, the average is unchanged from 2122 kWh.

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[8] Source: ACEEE: http://www.cee1.org/com/com-ref/aceee-paper.pdf - National inventory remained the same while increasing the California inventory from 9% to 12%.

[9] Source: Arthur D. Little, Inc. (ADL), in a 1996 study for DOE

Table 10: Unit Energy Savings for Transparent Door Refrigerators and Freezers

Type Size	% Sales Per Year California	Unit Energy Savings (kWh)
Refrigerator 24	50%	977
Refrigerator 48	45%	1433
Refrigerator 72	5%	1889
Average Refrigerator Savings		1228
Average Freezer Savings		2122

New Sales Data

Because the CASE report was completed before 2006 and relied on national stock data estimates from 1996, we believed it was possible to update the estimated sales using more recent national sales data. Although the transparent door refrigerator standard did not go into effect until 2007, 2006 data were deemed more recent information than the data used in the CASE report. We identified a source for 2006 sales data to use in this analysis.[10]

The updated NAFEM sales data for 2006 did not break out solid door versus transparent door sales, but did break out the results by refrigerators and freezers. Because sales data from NAFEM did not include the split between solid and transparent door sales, we chose to use the same distributions used in the CASE report (shown in the previous section). Using the estimates presented above, we calculated the distribution of sales shown in Table 11. In summary, the CASE report estimates of the split between solid and transparent door units were used with the NAFEM data and a California 12% share of sales to derive the updated estimates of California sales in each category.

Table 11: Updated Unit Sales Numbers

Type	Data from CASE Report		NAFEM Report	Updates Made by Cadmus	NAFEM Report	Updates Made by Cadmus
	# of Units Sold in California	% of units Sold by Type	National Number Refrigerator/ Freezer	Percent of Sales in California	Units Sold in California	Total Number of Units
Solid Door Refrigerator	17333	62%	108313	12%	12998	8046
Transparent Door Refrigerator	10667	38%		12%		4951
Solid Door Freezers	10667	82%	132331	12%	15880	13016
Transparent Door Freezers	2347	18%		12%		2864

[10] NAFEM study (North American Association of Food Equipment Manufacturers) written by Fryett Consulting Group and the University of Nevada at Las Vegas (UNLV) titled "2006 Size & Shape of the Industry, Study Results: Refrigeration & Ice Machines."

As can be seen in the results shown in Table 11, the number of freezers (both transparent and solid door) we have estimated is larger, while the number of refrigerators (both transparent and solid door) is smaller compared to the original estimates used in the CASE report.

Final Potential Energy Savings

Using the combined results presented in the preceding tables, potential energy savings can be calculated as follows:

Potential Energy Savings (GWh/year) = Number of Units * Unit Energy Savings (kWh/year) / 1,000,000

Resulting savings are shown in Table 12.

Table 12: Potential Energy Savings for Solid Door Refrigerators/Freezers and Transparent Door Refrigerators/Freezers

Type	Number of Units/Year	Unit Energy Savings (kWh/Year)	Potential Energy Savings (GWh/year)
Solid Door Refrigerator	8,046	646	5.20
Solid Door Freezers	13,016	302	3.93
Solid Door Total	21,062		9.13
Transparent Door Refrigerator	4,951	1228	6.08
Transparent Door Freezers	2,864	2122	6.08
Transparent Door Total	7,815		12.16

As can be seen in Table 12, the total potential energy savings is 9.13 GWh and 12.16 GWh a year for solid door and transparent door refrigerator/freezers, respectively. The CASE report estimated the gross savings as 9.54 and 8.37 GWh for solid and transparent door refrigerator/freezers, respectively. The differences between these estimates and the original CASE report estimates are a result of (1) the initial market penetration of efficient units being subtracted out in the CASE report estimate, but not in our potential savings estimate; (2) updated sales data; and (3) differences in the estimated percent of California sales. In the CASE report the initial market penetration (penetration in first year of introduction) was 45% for solid door and 15% for transparent door refrigerator/freezers. The measure life for both transparent and solid door refrigerator/freezers was 9 years from the CASE report.

Standard 3: Commercial Ice-Maker

Introduction

California introduced a standard for commercial ice-makers that went into effect in January 2008. This requirement established a minimum efficiency requirement for commercial ice-makers based on the CEE Tier 1 energy-efficiency specification. Currently, there is no federal standard for ice-makers. The equation for the commercial ice-maker maximum energy consumption for CEE Tier 1 adopted as the 2008 California Title 20 standard is shown in Table 13; it varies by unit type and size. The equation was based on energy consumption per 100 pounds of ice produced, where H is equal to the harvest rate or pounds of ice produced per 24 hours.

Table 13: Specifications for Maximum Energy Consumption Commercial Ice-Makers[11]

Harvest Rate (lbs of ice/ per 24 hrs.)	Tier	Max. Daily Energy Usage (kWh/100lbs of ice)
Ice-Making Head, Water Cooled		
< 500 lbs./day	1	7.80 - 0.0055*H
>= 500 lbs./day	1	5.58 - 0.0011*H
Ice-Making Head, Air Cooled		
< 450 lbs./day	1	10.26 - 0.0086*H
>= 450 lbs./day	1	6.89 - 0.0011*H
Remote-Condensing, Air Cooled		
< 1000 lbs./day	1	8.85 - 0.0038*H
>= 1000 lbs./day	1	5.1
Self-Contained, Water Cooled		
< 200 lbs./day	1	11.4 - 0.0190*H
>= 200 lbs./day	1	7.6
Self-Contained, Air Cooled		
< 175 lbs./day	1	18.0 - 0.0469*H
>= 175 lbs./day	1	9.8

Unit Energy Savings

The CASE report analyzed five types of commercial ice-makers (water and air cooled ice-making heads, water and air cooled self contained, and air cooled remote condensing ice makers) and two different sizes based on pounds of ice made per day. Due to the fact that no standard existed for commercial ice-makers, the baseline consumption could not be defined by referring to an existing standard. The CASE report referenced a study conducted by ACEEE as the source of baseline consumption[12] and energy savings for this standard.

To calculate the baseline consumption and energy savings for ice-makers, ACEEE analyzed data in the Air-Conditioning and Refrigeration Institute (ARI) directory and developed a set of "best fit" lines for the baseline and the CEE Tier 1 standard (which became the standard California implemented in 2008). These "best fit" lines allowed ACEEE to estimate the baseline consumption and the expected energy savings per unit for the increase in efficiency required by the CEE Tier 1 specification. This information is shown in Table 14.

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11 Source: ACEEE: http://www.cee1.org/com/com-ref/aceee-paper.pdf

12 Ibid.

Table 14: Unit Energy Savings for Ice-Makers

Unit Type and Capacity (Pounds Ice/24 hours)	Energy Use of Average Baseline Model (kWh/year)	Tier 1 kWh Savings Relative to Baseline (kWh/year)
Ice-Making Heads (water cooled)		
200	2213	316
500	4154	578
1000	7373	1028
Ice-Making Heads (air cooled)		
200	2768	349
500	4920	431
1000	8964	765
Remote-condensing (air-cooled)		
400	4257	105
800	7580	998
1200	10056	1389
1600	13596	2039
Self-Contained (water cooled)		
100	1609	264
175	2041	40
250	2847	156
Self-Contained (air cooled)		
50	1260	152
100	2018	133
150	2272	0
200	3066	290

As can be seen in Table 14, the energy savings for the different types and sizes of ice-makers range from 0 to 2,039 kWh/year. We found no gaps or questionable assumptions or analyses in the ACEEE data and analysis. A search did not produce any more recent or comprehensive studies or data. Based on these considerations, the evaluators believed that the estimated energy savings were credible and acceptable.

Unit Sales (CASE report)

The original CASE report referenced the U.S. Census Bureau Current Industrial Reports for national sales of ice-makers per year in 2001 and 2002. The results are shown in Table 15.

Table 15: National Unit Sales by Type for Commercial Ice-Makers Referenced in CASE Report

Equipment Description	2001	2002
Self-contained cubers 200 lb/day and under	124,326	121,007
Self-contained cubers over 200 lb/day	64,405	87,712
Not self-contained (mostly cubers)	45,222	72,986
Self-contained flake machines 300 lb/day and under	3,421	2,752
Self-contained flake machines over 300 lb/day	8,688	11,875
Combination ice machines and ice/drink dispensers	49,506	63,793
TOTAL	**295,568**	**360,125**

The CASE report stated that the first three unit types in the table (ice-makers cubed) are the only ones that would be impacted by the ice-maker standard. These categories comprised total national sales of 234,000 and 282,000 units in 2001 and 2002, respectively, or average national sales of 258,000. The California unit sales data used in the CASE report were based on these average national sales data.[13] The CASE report estimated California commercial ice-maker sales as proportional to California's share of national commercial electricity use, which was 9% in 2001(EAI 2001[14]). As noted before, California has significantly lower commercial per-capita electricity consumption than the rest of the U.S.[15] Consequently; this team believes that a better representation of the percent of units sold in California would be based on population. Approximately 12%[16] of the U.S. population is located in California. Thus, we used 12% as the share of national commercial refrigerators and freezers sold in California. Using the average national sales calculated in the CASE report, this would equate to annual California sales of commercial ice-makers of 30,960 units.

258,000 (average national sales) * 12% = 30,960 (California sales)

Average Unit Energy Savings

The CASE report estimated a weighted average per unit savings by size and type of ice-maker. Sales data were not available at the detailed level shown in Table 14 for the CASE report or the current evaluation. The CASE report and the ACEEE study (cited above) provided sales data by type (self-contained or not self-contained), but not by capacity or amount of ice made per day. In both the CASE report and this analysis, a straight average approach of the different sizes for the two types of units was used to determine the average baseline consumption and savings for both self-contained and not self-contained units (Ice Making Head, IMH, and Remote Condensing Units, RCU), using the values in Table 14. The current evaluators then derived the weighted average consumption and savings based on the percent distribution of sales by self-contained and not self-contained units. The results are shown in Table 16.

[13] Source: ACEEE: http://www.cee1.org/com/com-ref/aceee-paper.pdf

[14] Source: EIA 2001. State Energy Data Report 1999. DOE/EIA-0214(99). Washington, DC: U.S. Department of Energy.

[15] Source: GTSP: http://www.pnl.gov/gtsp/workshops/smith_gtsp_%20052407.pdf

[16] Source: http://www.census.gov/population/projections/state/stpjpop.txt - 2005 projection

Table 16: Average Unit Energy Savings for Commercial Ice-Makers

Unit Type	Share of Units Sold per Year	Average Baseline Consumption (kWh/unit)	Savings Tier 1 (kWh/unit)
Self-Contained	77%	2159	148
Not Self-Contained	23%	6588	800
Weighted Average Savings	--	--	297

As can be seen in Table 16, the weighted average unit energy savings for commercial ice-makers is 297 kWh. This estimate is substantially different from the unit energy savings of 928 kWh stated in the HMG "Codes and Standards Program Savings Estimate" report. Although the CASE report did not calculate a weighted average savings for commercial ice-makers, the savings for self-contained and non-self contained ice-maker savings reported were 148 and 848 kWh, respectively, which are very close to the evaluation team's estimates of 148 and 800 kWh. During discussions with the CASE report author, he was unable to explain how the HMG value was derived; and we believe that this current estimate is more accurate and can be replicated given the inputs to the CASE report.

New Sales Data

Because the CASE report was completed before 2006 and relied on national sales data from 2001 and 2002, we investigated whether more recent sales data were available. We identified a source for 2006 sales data[17] to use in this analysis. Although the commercial ice-maker standard did not go into effect until 2008, 2006 data are still more recent than the data used in the CASE report.

The NAFEM source reported that national sales for commercial cubed ice-makers totaled 181,170 units in 2006. For the reasons mentioned before, we believed that it was more appropriate to use California's population share than the commercial electricity share to estimate ice-maker sales in California. Using an approach similar to the one described above for unit sales (see CASE report section); we chose to estimate California sales as 12% of national sales based on California's population. Applying this percentage to the NAFEM national sales estimate produced the revised California sales number of 21,740 instead of 31,000 units.

Final Potential Energy Savings

Using the combined results described above, the revised estimate of potential energy savings can be calculated as follows:

$$\text{Potential Energy Savings} = \text{\# of Units} * \text{Unit Energy Savings (kWh/year)} / 1{,}000{,}000$$

$$= 21{,}740 * 297/1{,}000{,}000 = 6.47 \text{ GWh/year}$$

The total savings associated with the commercial ice-maker standard are 6.47 GWh per year. This estimate is close to the estimate in the SES document prepared by HMG (6.60 GWh). The CASE report did not provide a comparable savings estimate. Although this estimate agreed closely with the HMG value,

[17] NAFEM study (North American Association of Food Equipment Manufacturers) written by Fryett consulting group and UNLV titled "2006 Size & Shape of the Industry, Study Results: Refrigeration & Ice Machines"

the team's analysis differed in several significant ways as noted above. The estimated per unit savings was reduced from 928 kWh (in the report prepared by HMG) and approximately 667 kWh (CASE report) to 297 kWh (this analysis). The CASE report estimated the initial market penetration of 22%, while the estimate in the SES report prepared by HMG was 30%. Our estimate of potential savings was not adjusted downward by initial market penetration. The NOMAD analysis will estimate and adjust potential energy savings for the initial market penetration. Sales data were revised from the initial CASE report estimate of a total of 36,000 units to 21,470 units using the results from the NAFEM study and an increase in the share of national sales apportioned to California. The expected lifetime for commercial ice-makers is 9 years.

Standard 4: Walk-In Refrigerator/Freezer

Introduction

California adopted a standard for walk-in refrigerator/freezers that went into effect in January 2006. The state set requirements for several key walk-in refrigerator/freezer components that affect energy use. The list of measures included in this standard are:

- automatic door closers
- high-efficiency low/no heat reach-in doors
- increased envelope insulation
- evaporative fan controllers
- high efficiency evaporator/condenser motors
- high efficiency lighting
- defrost controls
- anti-sweat heat controls

Unit Energy Savings

The primary source used in the CASE report to evaluate the unit energy savings for walk-in refrigerator/freezers was a study conducted by Arthur D. Little (ADL) in 1996. The CASE report and this evaluation attempted to find better and more recent information on energy savings, but the ADL study was determined to be the best source of information currently available. When searching for more recent information, we found that several studies refer to the ADL study as the primary source of information for walk-in refrigerator/freezers, including one study performed by ACEEE.[18]

The baseline energy consumption for both walk-in refrigerators and freezers was determined by ADL. ADL created a prototypical model for each type, the characteristics for which are shown in Table 17.

[18] Source: ACEEE: http://www.cee1.org/com/com-ref/aceee-paper.pdf

Table 17: Characteristics of Prototypical Walk-In Freezer and Refrigerator

	Walk-in Freezer	**Walk-in Display Refrigerator (Cooler)**
Floor Size (ft^2)	80	240
Width (ft)	8	24
Depth (ft)	10	10
Height (ft)	7'7"	8'6"
Wall Thickness (in.)	4	4
Wall R-value	30	28.6
Merchandising Doors (ft)	-	2' x 6' 1 5/8"
Number of panes	-	21
Access Doors (ft)	3' x 6' 6"	3' x 6' 6"
Refrigerant Type	404A	R-22[19]
Compressor HP	1 1/2	5
Compressor Type	Semi-Hermetic Reciprocating	Semi- Hermetic Reciprocating (Copeland Discus)
Ambient Temperature (F)	90	95
Walk-in Temperature (F)	-10	35
Condensing Temperature (F)	113	105
Evaporating Temperature (F)	-26	25
Compressor Capacity (kBtuh)	4.929	44.97
Compressor Power (W)	1445	3850
EER (Btuh/W)	3.41	11.7
Liquid Suction Heat Exchanger	Yes	Yes
Antisweat Wattage (W)	2303	3004
Antisweat Control	none	none
Defrost Wattage (W)	1500	-
Defrost Control	Time Initiated / Temperature Terminated	-
Pan Heater Wattage (W)	500	-
Pan Heater Control	Time Initiated / Temperature Terminated	-
Source: http://www.cee1.org/com/com-ref/doe-rep96.pdf		

[19] We note that the use of R-22 in new equipment is banned beginning in January 2010 under the Montreal Protocol and Title VI of the Clean Air Act. It was not possible within the scope of this study to evaluate the effect of switching refrigerants.

Using the prototypes shown above, ADL[20] derived average baseline energy consumptions for both walk-in freezers and refrigerators (coolers). The average baseline consumption estimated for a walk-in freezer and refrigerator (cooler) was 21,400 kWh and 16,200 kWh, respectively.

This standard concentrates on implementing several key measures to reduce the energy consumption of these units. All the estimated measure savings were checked for reasonableness and compared to more recent sources. We found, however, that most newer sources typically referred to the ADL study as the primary source of estimates. Consequently, this team accepted all of the ADL percent savings estimates as the best information currently available.

The CASE report authors did, however, choose to update one input. The CASE report indicated that the average door size for walk-in refrigerators in California is 25% smaller than the door size used in the ADL study. This adjustment was made based on a PG&E study. We believe that this adjustment was appropriate since it relied on more recent data specifically for a portion of the California market.

The percent savings estimates were then multiplied by the total baseline energy consumption to determine the unit energy savings for walk-in freezers and refrigerators (coolers) just meeting the new standard. These results are shown in Table 18 for refrigerators and Table 19 for freezers.

Table 18: Measure and Total Savings for Walk-In Refrigerators, Baseline Consumption=16,200 kWh/year[21]

Walk-In Cooler	Percent Savings	Savings (kWh/year)
1) Anti-sweat Heat Controls	2%	384
2) Evaporator Fan Control	4%	692
3) ECM Evaporator Fan Motors	8%	1366
4) ECM Condenser Fan Motors	2%	353
5) Electronic Ballasts (Lighting)	1%	168
6) Low Heat/No Heat Doors	7%	3130
7) Auto Door Closer	8%	2651
8) Total Savings	**37%**	**5995**

Notes:
1. Total savings are based on the sum of (4,5,7, average of 1and 6, and average of 2 and 3)
2. The ADL data for measures 1 through 6 are based on a 240 square foot walk-in refrigerator.
3. The PG&E data for measure 7 are based on door area and, thus, are not related to walk-in floor area. It is assumed in the CASE report that average door area is 25% smaller than the ADL model due to the difference in size of the ADL walk-in prototype compared to the smaller average California walk-in refrigerator.
4. Low Heat/No Heat Doors savings are based on an overall stock average of 10 linear feet and is estimated as an average of both coolers and freezers assuming one in five walk-ins is a freezer and the other four are coolers. We apply this average to both coolers and freezers in this analysis.

[20] Source: ADL, http://www.cee1.org/com/com-ref/doe-rep96.pdf
[21] Source: Table from CASE report: http://207.67.203.54/Qelibrary4_p40007_documents/Pat%20Eilert%20Codes%20and%20Standards/Final%20Walk-In%20Cooler%20CASE%20Rpt.pdf

Table 19: Measure and Total Savings for Walk-In Freezers, Baseline Consumption=21,400 kWh/year

Walk-In Freezer	Percent Savings	Savings (kWh/year)
1) Anti-sweat Heat Controls	6%	1383
2) Thicker Insulation	4%	776
3) Evaporator Fan Control	4%	866
4) ECM Evaporator Fan Motors	14%	3029
5) ECM Condenser Fan Motors	7%	1464
6) Low Heat/No Heat Doors	20%	4294
7) Auto Door Closer	23%	4849
8) Total Savings	**55%**	**11875**
Notes: 1. Total savings are based on the sum of (2,5,7, average of 3 and 4, and average of 1 and 6) 2. The ADL data (items 1-9) are based on an 80 square foot walk-in freezer. 3. Low Heat/No Heat Doors savings is based on an overall stock average of 10 linear feet and is estimated as an average of both coolers and freezers assuming one in five walk-ins is a freezer and the other four are coolers. We applied this average to both coolers and freezers in this analysis.		

The results in Table 18 and Table 19 match the results shown in the CASE reports. From the team's review, these savings estimates are based on the combination of the most detailed results and the most recent information available at this time. Other studies on walk-in units do not analyze the energy savings in this detail, or they use the results from the ADL study. The total unit energy savings for a walk-in refrigerator and freezer are 5,995 kWh and 11,875 kWh per unit, respectively.

Unit Sales

The unit sales estimates in the SES and listed in the HMG savings report for walk-in refrigerators and freezers sold annually in California were 3,960 and 2,040, respectively. The CASE report referenced the ADL study and approximated the unit sales as 6,000 units. These reports did not provide information about the sources of these estimates, so we were unable to assess their validity. We used more recent sales data in our analysis.

New Sales Data

Because the CASE report was completed before 2006 and relied on 1996 national sales data from the ADL study, we believed it was possible to update the estimated sales using more recent national sales data. We identified a source of 2006 sales data[22] to use in this analysis.

Table 20 compares the unit sales used in the SES report and this team's estimates based on the NAFEM data. As before, we used the share of national population in California, 12%, to apportion national sales to the state. The CASE report used the same 12% share for California sales.

[22] NAFEM study (North American Association of Food Equipment Manufacturers) written by Fryett consulting group and UNLV titled "2006 Size & Shape of the Industry, Study Results: Refrigeration & Ice Machines"

Table 20: Comparison of New Sales Data to Estimates Used in SES Report

	SES Report	NAFEM Report	Updates Made by Cadmus	Cadmus Revised Estimate
Type	# of Units Sold in California	National Number Refrigerator/Freezer	Percent of Sales in California	Units Sold in California
Walk-In Refrigerators	3960	43120	12%	5174
Walk-In Freezers	2040	28825	12%	3459

As can be seen in Table 20, the estimates based on NAFEM sales information represent an increase in the number of walk-in refrigerators and freezers from the values used in the SES.

Final Potential Energy Savings

Using the combined results from the preceding tables, we estimated potential energy savings as follows:

Potential Energy Savings (GWh/year) = # of Units * Unit Energy Savings (kWh/year) / 1,000,000

As can be seen in Table 21, the revised estimated total potential energy savings for walk-in refrigerators and freezers are 31.02 GWh/year and 41.08 GWh/year, respectively. The only significant change this evaluation team made was an increase in the number of units sold in California. For comparison, the SES report estimated the total savings of walk-in refrigerators and freezers to be 24.23 GWh and 23.74 GWh, respectively. The initial market penetration used in the CASE report was 0%. The measure life for walk-in refrigerators and freezers was stated as 10 years in the CASE report.

Table 21: Potential Energy Savings for Walk-In Refrigerator/Freezers

Type	# of Units	Unit Energy Savings (kWh/Year)	Potential Energy Savings (Gwh/year)
Walk-In Refrigerator	5,174	5,995	31.02
Walk-In Freezer	3,459	11,875	41.08
Total	8,633		72.09

Standard 5: Refrigerated Beverage Vending Machines

Introduction

California introduced a standard for refrigerated beverage vending machines that went into effect in January 2006. The CASE report analyzed a list of potential requirements for the key components or measures impacting the energy use of refrigerated beverage vending machines. The CASE report evaluated three proposed new standards for potential requirements ranging in savings from 5% to 15%. The adopted standard for energy savings was Option 2, consisting of a 10% reduction in energy use. The actual standard adopted was specified as 0.55*(8.66+0.009*C) where C is the capacity of 12-ounce cans that the unit can store and the resulting value is the maximum energy consumption per day allowed.[23] The measure used to evaluate the savings for this standard was installation of a new evaporator fan ECM

[23] The equation specified in the CASE report differed slightly, but gave essentially the same results.

motor[24] again taken directly from the CASE report. California had already established a standard for vending machines that required lighting to be either T-8 fluorescent lamps with electronic ballasts or other lighting that was no less efficient.

Unit Energy Savings

The CASE report determined the baseline energy consumption for refrigerated beverage vending machines based on data from five studies. They are listed in Table 22 along with their estimates of annual energy use. As noted later, none of them accounted for the effects of the California standard already in existence.

Table 22: Annual Energy Consumption from Five Previous Studies

Source	Capacity (12 oz. Cans)	Annual UEC (kWh)
US EPA (1996)	N/A	4380
Arthur D. Little Report (1996)	400	2961
Canadian Electricity Association (1996)	N/A	4047
E-Source (1996)	450	3644
Two national laboratories (1997)	N/A	3600
Average Consumption		3726

As can be seen in Table 22, the average of the consumption estimates from these studies was 3726 kWh. As noted above, a previous standard existed in California that was not taken into account in these values, so this average had to be adjusted for the impact of the previous standard. Its impact (replacement of T-12 fluorescents by T-8s) was estimated to reduce usage by approximately 14%.[25] Applying this adjustment would reduce the baseline annual energy consumption to 3,204 kWh. However, the CASE report used a reduced baseline energy consumption of 3,077 kWh instead, or energy savings closer to 17% for the lighting upgrade. The CASE report also stated that it was likely that efficiencies had improved since the sources cited by the CASE report were prepared. The evaluation team agreed with this assessment and believes it was appropriate to use the estimate from the CASE report to evaluate the unit savings.

The unit savings associated with option 2 (evaporator fan ECM motor) reported by Arthur D. Little were estimated to be 14%.[26] The CASE report used a more conservative estimate of 10% for option 2 energy savings. The standard that was approved did not prescribe installation of a certain measure (such as the evaporator fan ECM motor), but set a performance requirement using the equation shown above. For a vending machine with a 400-can capacity, the standard would permit an annual usage up to 2,461 kWh, or a savings of 20% over the CASE report baseline of 3,077 kWh. Given this, we believe the more conservative estimate of 10% savings stated in the CASE report was reasonable and accepted this estimate to calculate savings. Multiplying the baseline energy consumption of 3,077 kWh by a percent savings of 10%, the unit energy savings for refrigerated vending beverage machines are estimated to be 308 kWh per year.

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[24] Source: CASE report: http://207.67.203.54/Qelibrary4_p40007_documents/Pat%20Eilert%20Codes%20and%20Standards/Final%20Refrig%20Vend%20CASE%20Report.pdf

[25] Source: Royal Vendor; http://www.royalvendors.com/html/products/econocool.html

[26] Source: Arthur D Little; http://www.cee1.org/com/com-ref/doe-rep96.pdf

Unit Sales

The CASE report estimated the total national sales for refrigerated vending machines were 477,102 in 1999 and 337,796 in 2000.[27] We were unable to find more recent sales data so used the average value for these two years as the current estimate just as the CASE report did. The CASE report for this standard used a different approach to estimate the California sales share compared to other CASE reports. It estimated that California accounts for 10% of the total market for refrigerated beverage vending machines. Using the average of national unit sales from 1999 and 2000, the CASE report estimated California sales at 41,000 per year. As noted before, we believe that California's share of national population is a better measure of sales than energy usage.[28] Approximately12%[29] of the U.S. population is located in California. Applying this proportion to the average national sales estimate used in the CASE report gives an estimate of California sales of 48,900 refrigerated vending machines.

Final Potential Energy Savings

Using the combined results from above, potential energy savings can be calculated as follows:

Potential Energy Savings (GWh/year) = # of Units * Unit Energy Savings (kWh/year) / 1,000,000

15.05 GWh/year = 48,900*308 kWh/year /1,000,000

This evaluation's estimated total potential energy savings for refrigerated beverage vending machines are 15.05 GWh/year. The SES report and the CASE report estimated the total savings for refrigerated beverage vending machines to be 12.63 GWh/year. The only significant change the evaluation team made to the original estimates was the increase in the number of units sold in California. The CASE report estimated the initial market penetration in year one was 0%. The expected measure life for refrigerated vending machines is 10 years.

Standard 6 and 7: Large Packaged Commercial Air-Conditioners, Tier 1 and 2

Introduction

California introduced a standard for large packaged commercial air-conditioners (20 to 63 tons) that went into effect in January 2007 for Tier 1, with a Tier 2 requirement going into effect in January 2010. The specifications for Tier 1 and Tier 2 are based on a system EER (energy efficiency ratio) value of 10.0 and 10.5 EER, respectively.

Unit Energy Savings

The CASE report determined that the sales weighted average capacity for the units in the 20 to 63 tons size range was 30.67 tons (368,000 Btu/hr). We were unable to find more recent data to revise this estimate and believe the CASE report presented a reasonable estimate. The CASE report estimated the baseline EER level before the new Tier 1 standard was 9.4, which was the average of the efficiency levels required by Title 24 for different unit types (without heat pumps or gas-pack heating units and with heat pumps or gas-pack heating). This estimate seemed reasonable based on the market data available. The engineering relationship to calculate the average peak demand is as follows:

Size (Btu/hr) / EER = average baseline demand load at 95 F

[27] U.S. Census Bureau, 2001

[28] Source: GTSP: http://www.pnl.gov/gtsp/workshops/smith_gtsp_%20052407.pdf

[29] Source: http://www.census.gov/population/projections/state/stpjpop.txt - 2005 projection

368,000(Btu/hr) / 9.4 EER = 39 kW at 95 F

The total number of annual full-load hours used in the CASE report was 1,593.[30] Using this value, the total baseline energy consumption was estimated as follows:

39 kW * 1593 hr/year = 62,400 kWh/year

Total energy savings for a large packaged central air-conditioner can be calculated based on the percentage savings from the baseline efficiency to the specific tier level as follows:

[1- (Baseline Efficiency / Tier Level Efficiency)]*100 = Percent Energy Savings
Energy Savings = Percent Energy Savings * Baseline Energy Consumption

Estimated savings from this equation are shown in Table 23.

Table 23: Unit Energy Savings for Commercial Large Packaged Central AC

Standard Options	Percent Savings	Energy Savings (kWh/year)
Tier 1 EER 10	6%	3742
Tier 2 EER 10.5	10%	6533
Incremental Tier 1 to Tier 2	4%	2792

As can be seen in Table 23, the unit energy savings estimated for going from a baseline 9.4 EER to a 10 EER and a 10.5 EER for this study is 3,742 and 6,533 kWh/year, respectively. The incremental savings due to increasing the efficiency from 10 EER to 10.5 EER were estimated to be 2,792 kWh/year. Both Tier 1 and Tier 2 savings estimated in the CASE report used appropriate engineering calculations and reasonable assumptions, so we accepted them in this evaluation.

Unit Sales

The CASE report estimated the total national sales for large packaged commercial air conditioners were 32,882 in 2002.[31] The CASE report estimated that California accounted for 11% of the U.S. non-residential construction activity in 2001.[32] Applying the 11% share to estimated national sales, we estimated a total of 3,617 units sold in California. The CASE report rounded this value down to 3,600 and this was used in the SES. We were unable to locate any more recent sales estimates and chose to use the 3,617 value in our calculations.

Final Potential Energy Savings

Using the combined results from above, a potential energy savings result can be calculated as follows:

Potential Energy Savings (GWh/year) = Unit Sales * Unit Energy Savings (kWh/year) / 1,000,000

The estimated savings are shown in Table 24.

[30] Source: Full load operating hours: ASHRAE 90.1 1999.

[31] Source: U.S. Census Bureau, 2003

[32] Source: U.S. Census Bureau, 2003

Table 24: Potential Energy Savings for Large Packaged Commercial Air Conditioners

Standard Options	Unit Sales	Unit Energy Savings (kWh/year)	Potential Energy Savings (GWh/year)
Tier 1 EER 10 through 2010	3617	3742	13.53
Tier 1 EER 10 after 2009, Adjusted for Federal Standard	3617	-0-	-0-
Tier 2 EER 10.5	3617	6533	23.63
Tier 2 Adjusted for Federal Standard	3617	-0-	-0-

As can be seen in Table 24, the estimated total potential energy savings for the Tier 1 and Tier 2 standard levels are 13.53 GWh and 23.63 GWh, respectively. However, a Federal standard will go into effect in 2010 that sets the EER level at 10 and it preempts the California standard. Consequently, we eliminated the credit for Tier 1 savings after 2009 and likewise credit no additional savings for Tier 2 since it was preempted. Other than taking the federal standard into account, we made no significant changes from the CASE report analysis prepared for this standard. The one change that occurred between the CASE report estimate and this evaluation was a small increase in the number of units sold in California, from 3,600 units to 3,617 units because we did not round down the annual sales estimate. The SES report estimated the total savings for Tier 1 and Tier 2 to be 13.47 and 10.05 GWh/year, respectively. The CASE report estimated the measure life for large packaged commercial air conditioners to be 15 years.

Standard 8 and 9: Residential Pool Pumps and Motors

Introduction

California introduced Tier 1 and Tier 2 standards for residential pool pumps and motors that went into effect in January 2006 and January 2008, respectively. No efficiency standards were previously in place. Tier 1 required high efficiency motors, prohibiting the sale of split-phase or capacitor start induction run type motors. Tier 2 required all pool pump motors and motor controls with a capacity of 1 horsepower (HP) or more to have the capability of operating at two or more speeds.

Unit Energy Savings

The baseline unit energy consumption for pool pumps was determined based on several studies. The results from these studies are summarized in Table 25 and also in the CASE report..

Table 25: Unit Energy Consumption Estimates

Source[33]	UEC (kWh/yr)
DOE-2001, p.62	725
CEC-2000, p.2	2749
EIA-1997, p.17	792
PG&E-1994, p.27	2297
DEG-1994, p.8	2220-3980
SCE-1992, p.6-5	1962
SCE-1991, p.5-8	2105
CEC-1991, form 2.1	2795-2803
RAS-1990, p.1	2622

The CASE report estimated the baseline annual unit energy consumption for capacitor start motors to be 2600 kWh. This figure is based on the average of the estimates presented above. The two lowest and the CEC estimates (which may have included other pool-related energy use) were excluded. Since these estimates do not accurately reflect the energy use by pool pumps in California, excluding them is appropriate. The CASE report estimate also applies the highest value of the DEG range (3980 kWh/year). We propose using an estimate based on the average of all estimates, including the average of the range presented by the DEG report. Using the proposed method, we estimate the baseline annual unit energy consumption to be 2417 kWh, a 7% reduction compared to the CASE report estimate.

The CASE report estimated that the elimination of low-efficiency motors, such as the capacitor start, would result in a 10% reduction in unit energy use. It also estimated that the average savings from the application of two-speed motors is approximately 40%, based on the findings of a Southern California Edison report.[34] Table 26 demonstrates these savings based on the CASE report and our proposed baseline energy consumption estimates. The SES used the CASE report estimates and summed the estimated unit savings to estimate total savings when Tier 2 went into effect. We believed a more conservative and accurate estimate would use the estimated 40% reduction for Tier 2 as the total savings of both the more efficient motor and two-speed requirement. Another issue was whether two and variable speed motors were actually being used as assumed, but there was no recent information available to confirm or contradict this assumption. We believe this issue is one that merits additional field research.

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[33] Sources: DOE-2001: Department of Energy, Office of Building Research and Standards, *2002 Priority Setting for New Products*, October 26, 2001; CEC-2000: California Energy Commission, *California Energy Demand 2000*; EIA-1997: *A Look at Residential Energy Consumption in 1997*, Energy Information Administration, 1997; DEG-1994: Davis Energy Group, *Two-Speed Pool Pump Project for Southern California Edison*, December 1994; SCE-1992: *1992 Residential Appliance End Use Study*, Quantum Consulting, Dec 1993; SCE-1991: *1991 Residential Appliance End Use Survey*, Quantum Consulting, November 1992.

[34] The DEG reports found that energy savings ranged from 38% to 65% and demand savings were 71% to 73%, and pump controls. Given the variability in implementation, the CASE estimates a savings ranging from 20% to 60%. Sources: DEG-1994: Davis Energy Group, *Two-Speed Pool Pump Project for Southern California Edison*, December 1994; DEG-1996: David Springer, Davis Energy Group, and Fred Rohe, Southern California Edison, *Field Studies of Two-Speed and PV-Powered Pumps and Advanced Controls for Swimming Pools*, ACEEE, 1996.

Table 26: Unit Energy Savings, CASE Report and Evaluation

Option	Baseline Use (kWh/yr)	Percentage Savings	Annual Savings from Baseline
CASE			
Tier 1: High Efficiency Motor	2600	10%	260
Tier 2: Two Speed Motor/Controls	2600	40%	1040
Evaluation			
Tier 1: High Efficiency Motor	2417	10%	242
Tier 2: Two Speed Motor/Controls	2417	40%	967

Unit Sales

California's market penetration of pool pumps used in the CASE report is based on data from the California Energy Commission (CEC).[35] The CASE report estimated that 1.2 million residences (9.8%) in California have swimming pools with a pool pump and motor. The average service life of a pool pumps and motors is ten years, so the current annual replacement is 120,000 units per year (1.2 million x 1/10).[36] The CASE report estimated an annual growth rate of new pump sales of 1.7%.[37] The total sales of new and replacement pumps is estimated to be 142,700 in the first year after implementation of the standard (year 2006) then remain flat after that.

Final Potential Energy Savings

As noted above, we believe a lower baseline unit energy use estimate is more appropriate than the CASE report value and propose a different value, resulting in lower potential energy savings. The potential energy savings is determined by the following calculation.

$$\text{Potential Energy Savings (GWh)} = \frac{\text{California Sales} \times \text{Protoyypical Unit Annual Savings (kWh)}}{1{,}000{,}000}$$

$$\text{2006 estimate} = \frac{142{,}700 \times 242}{1{,}000{,}000} = 34.5\,(\text{GWh})$$

The potential energy savings by year and tier are represented in Table 27. The savings associated with Tier 2 are relative to Tier 1 high efficiency pumps and motors rather than the baseline estimate for low-efficiency pumps. Since the Tier 2 standards were developed, in part, as a result of efforts conducted after 2005 and adopted during the post-2005 period, the savings attributed to these standards in this evaluation are set to zero.

[35] Source: CEC-2000: California Energy Commission, *California Energy Demand 2000*.

[36] Source: DOE-2001: Department of Energy, Office of Building Research and Standards, *2002 Priority Setting for New Products*, October 26, 2001.

[37] This is based on an estimate from CEC-2000: California Energy Commission, *California Energy Demand 2000.*

Table 27: Potential Energy Savings of Pool Pumps and Motors

Year	Tier	Unit Sales	Unit Energy Savings (kWh)	Potential Savings (GWh)
2006	Tier 1	142,700	242	34.5
2008	Tier 2	142,700	725	103.5 (incremental) 0 (attributable to C&S Program prior to 2006)
Total	**(Tier 1 and 2)**			**140**

Our estimate of potential savings is not adjusted downward by initial market penetration of high efficiency motors, which was estimated to be 50% in the HMG report. The NOMAD analysis will estimate and adjust potential energy savings to consider market penetration.

Standard 10: Portable Electric Spas

Introduction

California adopted a standard for portable electric spas that went into effect in January 2006. This standard applied to portable electric spas over 75 gallons and did not include in-ground spas. The approved standard set a maximum average standby power in Watts at 60°F of [5 * (spa volume)$^{2/3}$] where spa volume is expressed in gallons.

Unit Energy Savings

The CASE report determined the baseline energy consumption for portable electric spas using data from several studies. Their results are summarized in Table 28.

Table 28: Annual Energy Consumption Estimates from Previous Studies[38]

Source	Energy Consumption (kWh)	More Detail
Rainer, Leo, Steve Greenberg and Alan Meier 1990 "The Miscellaneous Electrical Energy Use in Homes" ACEEE Summer Study 1990.	Range:1,500-4,000 Average. 2,300	Subsequently referenced in the ESource Tech Atlas (1996), ACEEE Consumer Guide to Home Energy Savings (1999), and various other
DOE RECS (1997)	2,300	Source quoted in RECS: "Elect. Consumption by small end uses in Residential Buildings" A.D. Little, Inc., 1998
PG&E R&D, "Spa Testing Report" Report 008.1-89.9	Standby use only: 970; 2,370; 4,200	Calculated by the authors from this report. Based on results of one test over 54 hours, for

[38] Source: CASE report: http://207.67.203.54/Qelibrary4_p40007_documents/Pat%20Eilert%20Codes%20and%20Standards/Final%20Portable%20Spa%20CASE%20Report.pdf

Source	Energy Consumption (kWh)	More Detail
(1989)		three specific spas from three different manufacturers. Spas were fully covered and unused during test period.
J-Rad Engineering "Energy Consumption Analysis of Watkins 115V Classic and 230V Classic Spa Models (1992, Sponsored by Watkins)	San Francisco: 2,214; 2,999 Sacramento: 2,136; 2,890	Model of annual use based on chamber data collected at 0, 20, 40 and 70°F. Includes daily use of 1 hour with cover off and 30 minutes with jets running.
Manufacturer Data (1992-2002)	2,232 @ 60ºF ambient	www.hotspring.com; tests reported were done by Exponent Inc. Usage regimen: 6 times per week; 30 min. with cover off and 15 min. jet use.
A.D. Little (2001)	Average: 2,600	Quoted 10/24/02 by Joe Stone, Balboa Instruments, President of the Hot Tub Council. The report was commissioned by the NSPI and is confidential so details were not available.
PG&E (2004) Field Tests of Ten Portable Electric Spas	Standby use only: Range: 1,127 - 2,392 Average: 1,879	Measured standby energy use of ten new spas extrapolated to average California outdoor temperature.

Most of the studies shown in Table 28 documented a baseline consumption of around 2,300 kWh. The PG&E study listed last in the table, which was originally designed to provide information for the CASE report, metered 10 spas in California ranging from 210 to 525 gallons. The spas were monitored for three days at a constant water temperature with the cover on. These results were then extrapolated to represent annual spa consumption. The 1,879 kWh standby estimate did not include consumption for startup cycles (70 kWh) or spa use (565 kWh). Adding these usages brings the total consumption to 2,514 kWh for a typical portable electric spa in California. This estimate is in line with all the other studies referenced in Table 28 (most of which were not specific to California), and this evaluation team accepted these value of standby and total usage as the best estimates for an electric portable spa for this evaluation. Although the total baseline energy consumption estimated from the metering study was 2,514 kWh, the standard addressed only standby energy consumption.

The CASE report analyzed four specific measures that could be used to reduce standby losses for a typical portable electric spa to satisfy the maximum standby energy consumption equation and estimated the savings percent for each measure. These measures included a spa cover (10% energy savings), improved insulation (10% energy savings), improved motors (15% energy savings), and spa controls (5% energy savings). The CASE report also assumed that interactions among the measures reduced the total combined savings by 50%. No specific data were provided on the effect of interactions among these measures, but the CASE report author stated that this was a conservative assumption; and the authors of this evaluation agreed that it was appropriate. Applying the percent savings estimates by measure and the 50% interaction factor, we calculated the combined energy savings from all of the measures in portable electric spas to estimate annual average energy savings of 376 kWh per unit as shown in Table 29.

Table 29: Energy Savings for Portable Electric Spas, Consumption=1,879 kWh/year

Improvement Options	Estimated Unit Savings	Energy Savings, kWh/year
Cover	10%	187.9
Insulation	10%	187.9
Motor	15%	281.85
Controls	5%	93.95
Individual Measure Total	40%	751.6
Total Savings Discounted Assuming 50% Measure Interaction	**20%**	**375.8**

The CASE report estimated the total savings for portable electric spas to be 500 kWh/year per unit, basing its calculation on the standby plus start-up and use consumption, not just standby consumption. As the standard addresses only standby losses, we believe calculating savings based on only the standby consumption is a more appropriate approach. The SES document estimated a savings of 138 kWh. The CASE study authors indicated that the SES report authors made an adjustment to the savings estimated in the CASE report, but when we contacted them they could not determine exactly what this adjustment factor was or why it was applied. Using the approach described above, the evaluation authors believe the average savings of 376 kWh/unit is the best estimate of total potential energy savings for this standard.

Unit Sales (CASE report)

The CASE report estimated the total national sales for portable electric spas were 370,000 in 2000.[39] It also estimated that California accounts for 13% of the national market. This estimate was based on the assumption that the proportion of spa sales in California were likely to be slightly more than the proportion of the population (12%). Given that California has a warmer climate than many states and pools have traditionally been very common, we agreed that the presence of spas was likely to be higher than the average across the U.S. and accepted the CASE report assumption. Using the results contained in the CASE report, the total unit sales for portable electric spas are estimated at 48,000 units.

Final Potential Energy Savings

Using the information presented above, potential energy savings can be calculated as follows:

Potential Energy Savings (GWh/year) = # of Units * Unit Energy Savings (kWh/year) / 1,000,000

18.04 (GWh/year) = 48,000*376 (kWh/year) /1,000,000

As can be seen in the equation above, this team's estimated total potential energy savings for portable electric spas are 18.04 GWh/year. The one significant change that occurred from the CASE report/SES (prepared by HMG) document estimate to this evaluation is the change in unit energy savings. As noted earlier, the SES document estimated the unit savings to be 138 kWh and total savings for portable electric spas to be 6.6 GWh/year.

[39] Source: National Spa and Pool Association (NSPI)

Standard 11: General Service Incandescent Lamps, Tier 1 and Tier 2

Introduction

The CEC adopted the standards for general service incandescent lamps in two tiers, the first going into effect in January 2006 and the second in January 2008. The standards (see Table 30) apply to standard incandescent or halogen type lamps that: are intended for general service applications; have a medium screw base; have a wattage rating no less than 25 watts and no greater than 150 watts; have a rated voltage range at least partially within 110 and 130 volts; have a A-15, A-19, A-21, A-23, A-25, PS-25, PS-30, BT-14.5, BT-15, CP-19, TB-19, CA-22, or equivalent shape as defined in ANSI C78.20-2003; and have a bulb finish of the frosted, clear, or soft white type.[40]

Table 30: General Service Incandescent Standards

Frost or Clear		
	Maximum Allowable Power Use (watts)	
Lumens (L)	**Tier 1, January 1, 2006**	**Tier 2, January 1, 2008**
L < 340	(0.0500 * Lumens) + 21	(0.0500 * Lumens) + 21
340 ≤ L < 562	(0.0500 * Lumens) + 21	38
562 ≤ L < 610	(0.0500 * Lumens) + 21	0.2400 * Lumens) -97
610 ≤ L < 760	(0.0500 * Lumens) + 21	(0.0500 * Lumens) + 19
760 ≤ L < 950	(0.0500 * Lumens) + 21	57
950 ≤ L < 1013	(0.0500 * Lumens) + 21	(0.2000 * Lumens) -133
1013 ≤ L < 1040	(0.0500 * Lumens) + 21	(0.0500 * Lumens) + 19
1040 ≤ L < 1300	(0.0500 * Lumens) + 21	71
1300 ≤ L < 1359	(0.0500 * Lumens) + 21	(0.2700 * Lumens) -280
1359 ≤ L < 1520	(0.0500 * Lumens) + 21	(0.0500 * Lumens) + 19
1520 ≤ L < 1850	(0.0500 * Lumens) + 21	95
1850 ≤ L < 1900	(0.0500 * Lumens) + 21	(0.4200 * Lumens) - 682
L ≥ 1900	(0.0500 * Lumens) + 21	(0.0500 * Lumens) + 21

Soft White		
	Maximum Allowable Power Use (watts)	
Lumens (L)	**Tier 1, January 1, 2006**	**Tier 2, January 1, 2008**
L < 310	(0.0500 * Lumens) + 22.5	(0.0500 * Lumens) + 22.5
310 ≤ L < 514	(0.0500 * Lumens) + 22.5	38
514 ≤ L < 562	(0.0500 * Lumens) + 22.5	0.2200 * Lumens) -75
562 ≤ L < 730	(0.0500 * Lumens) + 22.5	(0.0500 * Lumens) + 20.5
730 ≤ L < 909	(0.0500 * Lumens) + 22.5	57
909 ≤ L < 963	(0.0500 * Lumens) + 22.5	(0.2200 * Lumens) -143
963 ≤ L < 1010	(0.0500 * Lumens) + 22.5	(0.0500 * Lumens) + 20.5
1010 ≤ L < 1250	(0.0500 * Lumens) + 22.5	71
1250 ≤ L < 1310	(0.0500 * Lumens) + 22.5	(0.2500 * Lumens) - 241.5
1310 ≤ L < 1490	(0.0500 * Lumens) + 22.5	(0.0500 * Lumens) + 20.5
1490 ≤ L < 1800	(0.0500 * Lumens) + 22.5	95
1800 ≤ L < 1850	(0.0500 * Lumens) + 22.5	(0.4000 * Lumens) - 625

[40] Source: "Appliance Efficiency Regulation", CEC, December 2006

L ≥ 1850	(0.0500 * Lumens) + 22.5	(0.0500 * Lumens) + 22.5

Unit Energy Savings

Tier 1 Standard

The standards for these products that ultimately went into effect are different than those assumed in the CASE report and the HMG report. The Tier 1 standards proposed and analyzed in these reports are shown in

Table 31 along with estimated savings. Note that the Tier 1 Soft White standard is the one that was made more lenient in the enacted version (0.0500 * Lumens + 22.5). By plugging different values in the calculations in Table 30 and

Table 31 it is possible to show that the adopted Tier 1 standard was less stringent than the proposed one for soft white light outputs above about 300 lumens. This change resulted in reducing energy savings by about 2.6W for 100-watt lamps, 2.1W for 75-watt lamps, and 1.7W for 60-watt lamps.

Table 31: Proposed Tier 1 Standards

Lamp Type	Maximum Power Use (Watts)	Average Savings (Watts)
Tier-1 Frost or Clear	Watts = 0.0500 * Lumens + 21	2.1 watts
Tier-1 Soft White	Watts = 0.0480 * Lumens + 23	2.2 watts
Tier-1 Vibration Lamps	Watts = 0.0730 * Lumens + 13.5	2.0 watts

The reports estimated overall Tier 1 savings of 3.6 percent. The CASE report noted that there was uncertainty about how manufacturers would comply with the new standard. The CASE report authors concluded that 38% of the clear and frost models could meet the proposed Tier 1 standard and 73% of the soft white models could meet the proposed Tier 1 standard. When the standard for soft white models became more lenient as enacted, the percentage already meeting the standard approached 80%.

Estimating unit energy savings hinges on the difference between power consumption of the lamps in each wattage category before and after the standard. As noted, a significant number of models already met the standard, and manufacturers had two choices for the other models – increase the lumen output of the product (which typically reduces lifetime) or maintain the lumen levels and reduce power consumption. Our research indicated that products that already met the standard tended to be the shorter lifetime models.[41]

The CASE study authors reduced their estimated total annual savings from the proposed Tier 1 standard by 50% because of “light output take-back.” This is the equivalent of saying that manufacturers would respond to the standard by increasing light output (and reducing lifetime) and maintaining power consumption. The savings estimated in the CASE report for the *proposed* Tier 1 standard were 80 GWh/year.

The data from our appliance standard compliance research in 2008-09 (discussed later) provides supporting evidence for the observation that producers were likely to increase output without reducing wattage. We found, more than two years after the Tier 1 standard went into effect, that between 56% and 63% of bulbs sold had the same wattage as the traditional wattage category they were in; that is, 75

[41] Personal communication, Chris Calwell, Ecos Consulting.

watt bulbs were still being sold and, to comply, their lumen output was increased.[42] There are no unit savings associated with these bulbs.

As noted above, the *adopted* Tier 1 standard was less stringent than the *proposed* Tier 1 standard. Based on our analysis, the result of the two outcomes—unchanged wattage with reduced lumens and a less stringent standard—was that there were essentially no energy savings from the adopted Tier 1 standard.

Tier 2 Standard

The proposed Tier 2 standards are shown in Table 32. The reports mentioned earlier estimated overall Tier 2 savings of 10 percent for the proposed standards. The adopted Tier 2 was significantly different from the one proposed, being less stringent (see Table 30) and providing estimated overall savings of 5 percent. Table 33 shows the maximum watts allowed for each traditional bulb wattage category and the savings.

Table 32: Proposed Tier 2 Standards

Lamp Type	Maximum Power Use (Watts)	Average Savings (Watts)
Tier-2 Frost or Clear	Watts = 0.0485 * Lumens + 15	6.2 watts
Tier-2 Soft White	Watts = 0.0490 * Lumens + 15.5	5.8 watts
Tier-2 Vibration Lamps	Watts = 0.0740 * Lumens + 9	5.1 watts

Table 33: Adopted Tier 2 Standards for Incandescent Lamps (Frost, Clear, and Soft White)

Current Watts	2008 Max. Watts Allowed	2008 Unit Power Reduction (watts)
40	38	2
60	57	3
75	71	4
100	95	5

Unit annual energy savings were calculated as follows:

Unit annual energy savings = Power reduction per lamp x average annual hours of operation

The CASE report suggested several values of annual hours of operation for these products. The most common assumption was 1,000 hours. In other places in the report, a unit lifetime of 1.1 years was assumed, which suggests 909 annual operating hours for a product with a rated lifetime of a nominal 1,000 hours, or 682 annual operating hours for a product with a rated lifetime of a nominal 750 hours. Elsewhere, the report suggests 3 hours per day of operation, which would be 1,095 annual hours. We chose to use the 1,000 hours of annual operation in our analysis, in part because this seems to be what was assumed in all of the previous annual savings work for this product and standard, and in part because we believe this is reasonable, given our knowledge from other program work in the residential lighting area. This yields straight-forward unit savings estimates as follows:

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[42] Note that, as discussed later, a significant proportion of bulbs sold in 2009 were still not complying with the Tier 1 standard.

Table 34: Unit Annual Savings Estimates

Current Watts	2008 Max. Watts Allowed	2008 Unit Power Reduction (watts)	2008 Unit Energy Savings (kWh)
40	38	2	2
60	57	3	3
75	71	4	4
100	95	5	5

Annual Unit Sales

Both the CASE report and HMG report used year 2000 annual sales data. The data were drawn primarily from self-reported sales through large retailers. The sources of some national chain lamps sales are no longer reporting, which makes an update of even this conservative estimate impossible. Ecos Consulting has created a residential "sockets model" that uses a somewhat different methodology to back into incandescent socket numbers, but, as of this writing, this analysis has not been done so we have no better estimate of lamp sales than used in 2004 during the standards process.

We chose to use these sales data, shown in detail in Table 35, in our analysis.

Table 35: California Sales of Included Lamp Types in 2000

Watts	Soft White	Vibration Resistant	Standard Clear	Total
40	6,913,961	327,785	2,807,771	**10,049,517**
60	25,402,783	435,953	6,312,060	**32,150,796**
75	15,131,053		3,196,726	**18,327,779**
100	9,338,296		4,071,127	**13,409,423**
150	283,948	24,601	70,824	**379,373**
Total	**57,070,041**	**788,339**	**16,458,508**	**74,316,888**
% of Sales	**77%**	**1%**	**22%**	**100%**

Potential First Year Energy Savings

Potential first year energy savings for the *proposed* Tier 1 and Tier 2 standards were estimated in the CASE study at 80 GWh and 441 GWh, respectively. The SES uses 79.2 GWh for Tier 1 savings and does not include any savings from Tier 2. Our evaluated estimate of Tier 1 and Tier 2 potential energy savings are zero and 254.5 GWh, respectively, with Tier 2 going into effect in 2008.

For both the Tier 1 and Tier 2 standards, it should be remembered that the CASE report savings estimates are based on the standard proposed at the time, and not the less stringent standards actually adopted. The HMG report adopted the methodology from the CASE report, reducing by half the Tier 1 full potential savings. They rounded down rather than up, however, so their Tier 1 savings estimate is recorded as 79 GWh and this is the value in the SES.

The HMG report also adopted the CASE report's Tier 2 savings, estimated to be 10 percent of base case (pre-2006) energy consumption.

We estimated potential Tier 2 savings by multiplying the unit sales in each category of covered lamp times the unit annual energy savings for each type of covered lamp assuming 1,000 hours of use per socket. The details for each lamp type are shown in Table 36. Table 37 compares our potential savings estimate with the gross savings estimated in the CASE report and the values in the SES. Since the Tier 2 standards were developed, in part, as a result of efforts conducted after 2005 and adopted during the post-2005 period, the savings attributed to these standards in this evaluation are set to zero.

Table 36: First Year Tier 2 Potential Energy Savings (GWh)

Watts	Soft White	Standard Clear	Total
40	13.83	5.62	**19.45**
60	76.21	18.94	**95.15**
75	56.74	11.99	**68.73**
100	46.69	20.36	**67.05**
150	2.13	0.53	**2.67**
Total	195.60	57.43	**254.5**

Table 37: Energy Savings Estimates for General Service Incandescent Standard

Effective Date	Tier	CASE Report Gross Savings (GWh)	SES Gross Savings (GWh)	Potential Savings (GWh)
2006	Tier 1	80	79.2	0
2008	Tier 2	441	--	254.5 0 (attributable to C&S Program prior to 2006)

Standard 12: Pulse Start Metal Halide

Introduction

California introduced a standard for pulse start metal halides that went into effect in two stages. In January 2006, the standard set requirements for vertical (base-up) lamps in the 150 to 500 wattage range; in the second stage in January 2008, the requirement was extended to all metal halide lamps in this wattage range. The standard disallowed probe-start metal halide ballasts. In addition to extending the requirement to all orientations, the second standard also stated that metal halide luminaires had to contain ballasts with a minimum ballast efficiency of 88 percent. The requirements of these two stages were largely set forth in a 2004 CASE report.

Unit Energy Savings

The baseline energy consumption for metal halide lamps was determined by using engineering equations. The results are shown in Table 38. The equation in the CASE report that was used to calculate the annual energy usage is shown below:
Energy Consumption (2015 kWh/year) = Typical System Wattage (460W[43]) * 12 hours/day * 365 days/year

Table 38: Baseline Annual Energy Consumption for Metal Halides (MH)

	Value	Units
Typical MH lamp	400	Watts

[43] According to data in the *U.S. Lighting Market Characterization* (DOE 2002), the weighted average system wattage for metal halides was 437W. For the CASE report, the closest sized typical metal halide system was selected (i.e., 400W lamp with magnetic ballast)

Typical System Wattage	460	Watts
Typical Operating Hours	12	Hours/day
Annual Energy Usage	2014.8	kWh/unit

The first standard stated that vertical (base-up) metal halides must not contain a probe-start ballast. The estimated savings derived in the CASE report for each unit using a pulse-start ballast instead of a probe-start ballast are shown in
Table 39. The typical unit estimated annual energy savings were 307 kWh (2014.8 – 1708.2).

Table 39: Annual Energy Savings – Pulse Start MH

Pulse Start MH w/ Magnetic Ballast	Value	Units
Lamp Wattage	350	Watts
System Wattage	390	Watts
Typical Operating Hours	12	Hours/day
Annual Energy Use	1708.2	kWh/unit
Annual Electricity Savings	306.6	kWh/unit

The second standard specifically set ballast efficiency requirements and extended the pulse start requirements to all fixture orientations. The standard stated that the ballast must have a minimum efficiency of 88%. The typical efficiency in the existing market for magnetic ballast was estimated to be 86%. This would equate to 2.3% energy savings over pulse-start magnetic ballasts. The equation below shows the unit energy savings for this standard:

40 kWh/year savings = 1708.2 kWh/year * 2.3%

All the assumptions above were determined to be credible and accurate representations of the energy savings for this particular standard. Consequently, the evaluation team accepted the unit savings estimates from the CASE report.

Unit Sales

The CASE report estimated the total national sales for HID (high intensity discharge) lamps were 12.6 million in 2000 and 11.7 million in 2001.[44] The CASE report estimated that California accounts for 9% of the total market, based on California's proportion of the national commercial electricity load. As noted earlier, California has significantly lower commercial per-capita electricity consumption than the rest of the U.S.[45] This evaluation's authors believe that a better representation of the percent of units sold in California would be one based on population. Approximately 12%[46] of the U.S. population is located in California. Consequently, we chose to use 12% to estimate California's share of national metal halide sales based on California accounting for 12% of the national population.

Using information presented in the CASE report, the total national unit sales for HIDs were estimated as 12.15 million (the average of 2000 and 2001 sales of 12.6 and 11.7, respectively). We were unable to locate any more recent sources of sales data to update these estimates so assumed they were appropriate. Using the 12% estimate for California, this would produce an estimate of total sales in

[44] National Electrical Manufactures Association (NEMA) 2003
[45] Source: GTSP: http://www.pnl.gov/gtsp/workshops/smith_gtsp_%20052407.pdf
[46] Source: http://www.census.gov/population/projections/state/stpjpop.txt - 2005 projection

California of 1.46 million HIDs per year. The 2002 U.S. Lighting Market Characterization report indicated that 33% of all HID lamps are metal halides.[47] Applying this factor to the estimated HID sales in California produces an estimate of annual metal halide lamp sales in California of 481,140. The CASE report estimated sales of 363,000 units per year. The only major difference between the CASE report estimate and this evaluation's estimate is the factor used to estimate California sales from national sales data.

The estimate of MH sales includes all metal halides and does not distinguish between vertical (base-up) and all other metal halides. The CASE report estimated that 80% of all metal halide lamps are vertical. We were unable to find any data to update this value and accepted the estimate in the CASE report. Applying this figure to the revised annual sales estimate gives a total of 384,912 vertical metal halide fixtures and 96,228 other metal halide fixtures sold per year in California.

Final Potential Energy Savings

Using the results from above, the potential energy savings can be estimated as follows:

Potential Energy Savings (GWh/year) = # of Units * Unit Energy Savings (kWh/year) / 1,000,000

The estimates are shown in Table 40. .

Table 40: Metal Halides Potential Energy Savings

Standard	Sales, # of Units/year	Unit Energy Savings (kWh/year)	Measure Lifetime	Potential Energy Savings (GWh/year)
Vertical MH	384,912	307	13	118.01
Energy Savings January 2006			13	118.01
All Other MH	96,228	307	13	29.50
Magnetic to Electronic Ballast – All MH	481,140	40	13	19.11
Incremental Energy Savings January 2008			13	48.62

As can be seen in

Table 40, the estimated total potential energy savings for vertical metal halide lamps (January 2006) and all other metal halide lamps plus the ballast savings (January 2008) are 118.01 and 48.62 GWh, respectively. The significant changes that were made in this evaluation compared with the CASE report/ SES document estimate were the change in unit energy savings, the increase in number of units sold in California, and elimination of an adjustment for initial market penetration in this evaluation's estimate. The HMG SES report and the CASE report estimated the total savings of metal halide lamps in 2006 and 2008 to be 49.26 and 56.57 GWh, respectively. The initial market penetration adjustment assumed in both the CASE report and the SES document estimated the initial market penetration for Tier 1 and Tier 2 as 48% and 41.2%, respectively. The value in the SES was 89.15 GWh for Tier 1 and no additional value for Tier 2. The measure lifetime used in the CASE report was 13 years.

[47] U.S. Department of Energy. 2002. *U.S. Lighting Market Characterization, Volume 1: National Lighting Inventory and Energy Consumption Estimate.* September. Prepared by Navigant Consulting, Inc. Washington, D.C.

Standard 13: Modular Furniture Task Lighting Fixtures

Introduction

California adopted a standard for modular furniture task lighting fixtures that went into effect in January 2006. This standard applies to all under-cabinet luminaires equipped with T-8 fluorescent lamps that are attached to office furniture. This standard states that all T-8 fixtures shall be equipped with ballasts that have an efficiency factor not less than the applicable values shown in Table 41.

Table 41: Standard Specifications for Modular Furniture Task Lighting Fixtures

Lamp Length (inches)	Minimum Ballast Efficiency Factor, 1-Lamp	Minimum Ballast Efficiency Factor, 2-Lamp
<= 29	4.70	2.80
> 29 and <= 35	3.95	2.30
> 35 and <= 41	3.40	1.90
> 41 and <= 47	3.05	1.65
>= 47	2.80	1.45

Unit Energy Savings

The baseline energy consumption for modular furniture task lighting was determined in the CASE report by referencing the energy consumption of a T-8 with magnetic ballast as the baseline lamp, based on market data from the CASE report. The results are shown in Table 42 based on the following equation:

Annual Energy Use (kWh) = Input System Wattage * Annual Operation Hours/1000

Table 42: Annual Energy Consumption from Previous Studies

Assumptions	T-8 Magnetic Ballast
Typical Fluorescent Lamp (Rated) (Watts)	32
Input System Wattage (Watts)	35
Annual Operating Hours (hours)	2000
Annual Energy Use (kWh)	70

As can be seen in Table 42, the baseline energy consumption of a 1-lamp T-8 with magnetic ballast was estimated to be 70 kWh. These estimates appeared to be reasonable based on typical product data, so the results were accepted and used in this evaluation.

To estimate energy savings associated with the standard (T-8 with electronic ballast), several combinations of 1-lamp, 2-lamp, 2-foot, 3-foot, and 4-foot fixtures needed to be analyzed. These results were used in the CASE report and are summarized in Table 43.

Table 43: Energy Savings for Modular Furniture Task Lighting Fixtures

	1 Lamp			2 lamp			
Variables	**2 foot**	**3 foot**	**4 foot**	**2 foot**	**3 foot**	**4 foot**	**Average**
Demand Savings (Watts)	4	4	4	13	12	11	
Annual Operating Hours	2000	2000	2000	2000	2000	2000	2000
Energy Savings per year (kWh/year)	8	8	8	26	24	22	16

The CASE report estimated the average savings for modular furniture task lighting fixtures to be 16 kWh/year, taking into account the possible combinations of lamp sizes and number of lamps per fixture. These savings were checked for reasonableness and determined to be an accurate representation of the average energy savings for different combinations of this style of lighting fixture, so we used them in this evaluation.

Unit Sales

The CASE report estimated the total national sales for modular furniture task lighting fixtures to be 3.1 million and 2.7 million in 2000 and 2001,[48] respectively. The CASE report estimated that California accounted for 9% of the total market based on the assumption that California comprises 9% of the total national commercial electricity consumption. As with other standards, we believe that the proportion of U.S. population in California is a better measure of the proportion of national sales of such fixtures. The reason for this is that the California energy-efficiency programs and codes and standards have reduced electricity sales compared to other states. Because of this, we again used a factor of 12% to estimate California sales based on the percent of U.S. population. Using the average values for 2000 and 2001 contained in the CASE report, the CASE report estimated total unit sales for products covered by this standard in California at 260,000 units. The HMG estimate used only the higher national sales volume from 2000 and estimated 280,000 units sold in California using the same 9% ratio for national sales converted to California sales. The reason for this change was not determined. We elected to use the 12% share of national sales and the average national sales in 2000 and 2001 to estimate total sales in California of 348,000 units for this evaluation.

Final Potential Energy Savings

Using the information presented above, we calculated potential energy savings using the following equation:

Potential Energy Savings (GWh/year) = # of Units * Unit Energy Savings (kWh/year) / 1,000,000
5.57 (GWh/year) = 348,000 * 16 (kWh/year)/1,000,000

Our estimate of annual savings from modular furniture task lighting sold each year is 5.57 GWh. The two significant changes that we made to the CASE report/HMG savings report estimates were (1) not including the initial market penetration (81% was factored into the SES report estimate) and (2) increasing the number of estimated California unit sales. Although the estimate from the SES document used a higher value than the CASE report, the total estimated unit sales were still lower than this team's estimate. This is due to the change in percent of national sales assumed in California (9% compared to our estimate of 12%). The HMG savings report estimated total savings of modular furniture task lighting fixtures to be 0.83 GWh; but, as noted above, this value was discounted by the estimated 81% initial penetration of complying fixtures. The CASE report did not estimate the total energy savings in year 1 of installation. The measure lifetime for this standard was 15 years.

Standard 14: Commercial Hot Food Holding Cabinets

Introduction

The state of California introduced a standard for commercial hot food holding cabinets that went into effect in January of 2006. This requirement established the ENERGY STAR insulated equipment requirement as the standard. The efficiency level initially analyzed in the CASE report was slightly less stringent than the ENERGY STAR requirement. The standard was set in terms of the maximum idle energy

[48] The Census Bureau 2002

consumption. The CASE report proposed standard and the adopted standard are shown in Table 44 for commercial hot food holding cabinets. Regardless of unit size, Title 20 California code maximum volume-normalized idle energy rate is 40 watts/ft^3. Since the Title 20 adopted ENERGY STAR requirements but the CASE report analyzed a different level, this review examines both analyses.

Table 44: Allowable Idle Energy Rate for Commercial Hot Food Holding Cabinets (watts/ft^3)

CASE Report Proposed	Adopted Standard (ENERGY STAR)
42 (watts/ft^3)	40 (watts/ft^3)

Unit Energy Savings

The CASE report surveyed eight California hot food holding cabinet manufacturers and based its analysis on the manufacturers' comments. The CASE report estimated the idle energy rate and annual energy use for six prototypical models: three sizes with an insulated and non-insulated version of each. As stated in the report, product research suggested the following heating element wattage assumptions were representative: full-, ¾-, and ½-size cabinets use 1,800, 1,400, and 1,000 watt heating elements, respectively. Idle energy rate (essentially average power demand) was then calculated by multiplying the heating element rating by cycle time fraction plus a constant fan load of 50 watts. The report assumed a prototypical unit operates 12 hours per day and for 363 days per year.[49] The annual energy use estimates are shown in Table 45.

Table 45: CASE Report Product Research Analysis of Idle Energy Rate and Annual Energy Consumption

Cabinet Type	Cabinet Size	Idle Energy Rate (W/cu ft)	Volume (cu ft)	Idle Energy Rate (watts)	Annual Energy Consumption (kWh/y)
Insulated	Full-Size	20	22	445	1938
	3/4-size	24	15	357	1555
	1/2-size	34	8	269	1173
Non-Insulated	Full-Size	58	22	1273	5544
	3/4-size	67	15	1001	4361
	1/2-size	91	8	729	3177

The CASE report estimated the distribution of the sales and stock of insulated and non-insulated cabinets. The report did not provide specific market shares for any manufacturer, only an average estimate, and we were unable to identify other sources of information. The results presented here will not include this saturation or the weighted saturation the CASE report presented, but rather total unit savings.

According to the CASE report, manufacturers' typically sell 50% full-size units, 25% ¾-size units, and 25% ½-size units and assumes this is consistent with the current stock as well. The annual energy consumption, shown in Table 46, is weighted by unit size.

[49] Sources vary regarding the annual hours of operation, even within ENERGY STAR documents the hours range from 12 hour per day to 15. The ENERGY STAR's calculator assumptions for hot food holding cabinets assume 15 hours per day for 365 days per year based on 2004 Food Service Technology Center (FSTC) data while other documents state 12 hours per day. Without sufficient data, the hours of operation remain the same as stated in the CASE report.

Table 46: Annual Energy Consumption Weighted by Unit Size

Cabinet / Standard Type	Idle Energy Rate (W/cu ft)	Volume (cubic ft)	Idle Energy Rate (watts)	Annual Energy Consumption (kWh/y)
Average Insulated	24.5	16.75	379	1651
Average Non-Insulated	68.5	16.75	1069	4657
Title 20 Standard	40	16.75	617	2704
CASE Proposed Standard	42	16.75	648	2839

The annual savings of a prototypical sized unit is shown in the two standards is 135 kWh. Table 47, where the additional savings is presented from Title 20 since it adopted ENERGY STAR requirements versus the CASE report proposed standard. The difference in savings between the two standards is 135 kWh.

Table 47: Prototypical Per Unit Annual Savings (kWh/year)

Category	CASE Report Savings	Potential Title 20 Savings
Hot Food Holding Cabinet	1817 (kWh/year)	1953 (kWh/year)

The above potential Title 20 results for yearly energy savings follow the same methodology as the results used for the CASE report studies. These results use the most thorough and updated values available at this time.

Unit Sales

California's market penetration of hot food holding cabinets used in the CASE report is based on communications with Charles Bohlig of the Food Service Technology Center in 2003. An estimated 50,000 hot food holding cabinets are in service in California. This data could not be verified or denied and assumed the number of hot food holding cabinets did not increase over time.

The unit sales data used for the evaluation from the CASE report relies on taking the stock estimate dividing by the useful life of the unit as shown in the calculation below. Based on communications with manufacturers, the design measure life is 15 years or more.[50] The California unit sales are roughly 3300 units per year.

$$\text{California Unit Sales per Year} = \frac{\text{Estimated California Inventory}}{\text{Measure Life}}$$

Final Potential Energy Savings

The potential energy savings are determined by the following calculation.

[50] According to the CASE report 15 years is expected but would be shorter if the heating element is exposed to water. It is worth noting that ENERGY STAR assumes 12 year lifetime based on Food Service Technology Center, 2004.

$$\text{Potential Energy Savings (GWh/yr)} = \frac{\text{CaliforniaUnit Sales} \times \text{Protoypical Unit Annual Savings (kWh/yr)}}{1{,}000{,}000}$$

The prototypical or weighted average unit savings multiplied by annual unit sales results in the gross energy savings as represented in Table 48. The SES gross energy savings estimate takes into account an adjustment based on the assumption that 75% of units sold already met the standard. Our potential savings estimate does not include that adjustment; it is addressed in the NOMAD analysis presented later.

Table 48: Potential Energy Savings of Commercial Hot Food Holding Cabinets

Product	Unit Sales	Prototypical Per Unit Annual Savings (kWh/year)		SES Gross Savings (GWh/year)	Potential Energy Savings (GWh/year)
		CASE Report Savings	*Potential Title 20 Savings*		
Hot Food Holding Cabinet	3300	1817	1953	1.5	6.44

The difference between the two annual savings estimates is a result of the change from the proposed 42 watts/ft^3 analyzed in the CASE report to the adopted standard of 40 watts/ft^3.

Standard 15 and 16: External Power Supplies

Introduction

California adopted two standards for single voltage external AC/DC power supplies. Tier 1 and Tier 2 went into effect in January 1, 2007 and July 1, 2008, respectively. The CEC phased in the Tier 1 requirements: external power supplies used with laptop computers, mobile phones, printers, print servers, scanners, personal digital assistants (PDAs), and digital cameras had to meet Tier 1 on January 1 and power supplies used with wireline telephones and all other applications had to meet Tier 1 by July 1, 2007.

No external power supply standard was in place prior to adoption of these standards. There are two main technologies in use—linear, where 40% to 75% is heat energy loss, and switching where only 10% to 40% is lost as heat. The standard in the CASE report for Tier 1 was not the adopted standard, while the proposed Tier 2 standard was the same as the adopted standard. Title 20 standard levels are shown in Table 49 for external power supplies.

Table 49: Title 20 Standards for Single Voltage External Power Supplies in Active Mode

Tier Standard[51]	Minimum Efficiency in Active Mode[52]		
Tier 1	≤1 Watt	> 1 ≤ 49 Watts	> 49 Watts
	0.49 * Nameplate Output	0.09 Ln (Nameplate Output) + 0.49	0.84
Tier 2	≤1 Watt	> 1 ≤ 51 Watts	> 51 Watts

[51] The CASE report originally proposed that Tier 1 represents the top 40% of the market and Tier 2 represents the top 25% of the market.

[52] Ln (Nameplate Output) = Natural Logarithm of the nameplate output expressed in watts.

	0.50 * Nameplate Output	0.09 Ln (Nameplate Output) + 0.50	0.85

In addition to the active mode requirements in the table, the Tier 1 no load requirements are that power consumption shall be no more than 0.5 watts in units with a nameplate output power of 0 to 10 watts and no more than 0.75 watts in units with a nameplate output power of more than 10 watts (max. 250 watts). The Tier 2 no load requirements are power consumption shall be no more than 0.5 watts for all covered units. As noted, the CASE report recommended slightly different Tier 1 efficiency requirements and these are shown in Table 50.

Table 50: CASE Report Initial Proposed Tier Regulation

CASE Report	Minimum Efficiency in Active Mode		
Tier 1	**≤1 Watt**	**> 1 ≤ 60 Watts**	**> 60 Watts**
	0.48 * Nameplate Output	0.89 Ln (Nameplate Output) + 0.48	0.84

Unit Energy Savings

The CASE report authors obtained 134 different external power supply models and directly measured their efficiency. Many of the power supplies were "universal" designs, capable of operating at multiple output voltages, yielding 197 efficiency plots. In addition, the CASE report reviewed other measurement studies that were included in their final data assessment.[53,54,55,56,57] Table 51 summarizes the results from the CASE report of the average energy savings per power supply.

Table 51: CASE Report Annual Energy Savings Estimates

Standard Level	Mode of Operation	Savings Per Unit (kWh)
Tier 1	Active mode	2.75
	No load	1.01
	Total	3.76
Tier 2	Active mode	3.37
	No load	1.07
	Total	4.44

[53] LBNL: Electricity Used by Office Equipment and Network Equipment in the U.S., LBNL-45917, August 2000

[54] Energy Consumption by Office and Telecommunications Equipment in Commercial Buildings Volume 1: Energy Consumption Baseline, 2002.

[55] Energy Information Administration, A Look at Residential Energy Consumption in 1997, 2000.

[56] Darnell Group Inc., External AC/DC Power Supplies: Global Market Forecasts and Competitive Environment, July 2000.

[57] Power Supplies: A Hidden Opportunity for Energy Savings, Natural Resources Defense Council, 2002.

The CASE report calculated savings not on the basis of barely meeting the proposed standards levels, but based on the difference between the average measured efficiency of products that would be compliant and ones that would be non-compliant. We found no gaps or questionable assumptions in the CAASE report. A search did not produce any more recent or comprehensive studies or data other than additional presentations and papers referencing the same data used in the CASE report. Based on the report's methodology and the quality of the data used, the evaluators believe that the estimated energy savings per unit are credible and acceptable.

Unit Sales

California's market penetration of external power supplies used in the CASE report is based on national estimates proportioned to California on a population basis. The CASE reports starts with 1.3 billion power supplies estimated to be in the U.S. with 145.1 million units in California.[58] The CASE report used market research obtained from Darnell Group and other research conducted by Ecos Consulting to initially estimate that the North American market for external power supplies was about 250 million units per year and the California market was about 27.5 million units per year.

Ecos adjusted the market estimate and assumed penetration of qualifying units increased over the period it took to implement the standard.[59] The final savings estimate in the SES incorporated assumptions about the proportion of the market that would have met the standard if it had not been adopted. We take account of this in the natural adoption analysis instead (NOMAD).

The CASE report's useful design life for power supplies was assumed to be 7 years when determining the life cycle cost. According to the CASE report, the external power supplies may become obsolete and fall into disuse when consumers upgrade to newer computers and telephones. Taking this into account, the HMG report stated the typical design lifetimes are between 3 and 10 years and used the 7 year average.

Final Potential Energy Savings

The potential energy savings are determined by the following calculation. The equation shown uses the values for Tier 2 energy savings and does not deduct market penetration of qualifying units.

$$\text{Potential Energy Savings (GWh)} = \frac{\text{California Sales} \times \text{Protoyypical Unit Annual Savings (kWh)}}{1{,}000{,}000}$$

$$= \frac{27{,}500{,}000 \times 4.44}{1{,}000{,}000} = 121.66\text{(GWh)}$$

Our estimate of potential energy savings by tier is represented in Table 52.

Table 52: Potential Energy Savings of External Power Supplies

Product	Tier	Unit Savings (kWh/year)	SES Gross Savings (GWh/year)	Potential Energy Savings (GWh/year)
External Power Supplies	1	3.76	47.8	103.02
External Power Supplies	2	0.68	8.6	18.63
External Power Supplies	1 & 2	4.44	56.4	121.66

58 According to the CASE report the market estimates made by Travis Reeder and Chris Calwell, Ecos Consulting and Carrie Webber, LBNL. August 2003.

59 Communications with Chris Calwell from Ecos Consulting, April 2008.

The total first year Tier 1 potential energy savings for external power supplies is about 103 GWh and increases to nearly 122 GWh when Tier 2 goes into effect. It was not possible to adjust the savings for the change in the phasing in of the standard in the first year because no data were available on the savings by application. We assume the effect is relatively small. Our estimate of potential savings was not adjusted downward by initial market penetration. The NOMAD analysis will estimate and adjust potential energy savings for the initial market penetration. The CEC revised the requirements for certain technologies and the market penetration by technology (i.e., wireline telephones and all other applications) will be considered within the NOMAD analysis.

Standard 17: Consumer Electronics Compact Audio Products

Introduction

California introduced a standard for consumer compact audio products that went into effect on January 1, 2007. The CEC describes the product covered by the standard as a "compact audio product," also known as a mini, mid, micro, or shelf audio system, which means an integrated audio system encased in a single housing that includes an amplifier and radio tuner, attached or separable speakers, and can reproduce audio from one or more of the following: media magnetic tape, CD, DVD, or flash memory.[60] The standard stipulates that the "idle" or standby-passive mode[61] of the product must be within the maximum power usage requirements.

This standard provides an efficiency requirement for which none existed. The Title 20 standard is broken out into two categories—products with and without a permanently illuminated clock display, as presented in Table 53

Table 53: Title 20 Standards for Compact Audio Products in Standby-Passive Mode

Product	Maximum Power Usage (Watts) in Standby-Passive Mode	
Compact Audio Products	Without clock display	2 Watts
	With clock display	4 Watts

The CASE report does not distinguish between audio products with and without clock displays. The potential savings estimate and proposed standard is solely based on products having a maximum power usage of no more than 2 watts.

Unit Energy Savings

The CASE report relies for estimated unit energy savings on a Department of Energy standby report from 2002. While there have been more recent reports on standby operation of consumer products, we were unable to find many newer sources that referenced compact audio products. Table 54 summarizes the CASE report results for the average standby energy use for compact audio equipment.

[60] CEC 2006 Appliance Standard. As part of the requirements, compact audio products do not include products that can be independently powered by internal batteries or that have a powered external satellite antenna, or that can provide a video output signal.

[61] CEC states that the standby-passive mode refers to the appliance as being connected to a power source, produces neither sound nor performs any mechanical function (e.g. playing, recording) but can be switched into another mode with the remote control unit or an internal signal.

Table 54: CASE Report: Average Compact Audio Products Standby Operation[62]

Product	Average Power (Watts)	Hours (per year)	Standby Energy Use (kWh)
Compact Audio System	9.8	6570	64.4

The CASE report calculated savings based on the proposed requirement of maximum power usage of no more than 2 watts. They did not provide data for or analyze units with illuminated displays. After reviewing the CASE report sources, we were unable to find any data available to break out average consumption of compact audio systems with and without displays. We conclude that 9.8 watts is a reasonable, conservative estimate for both types of units. Using this value, the standby energy savings we estimated are shown in Table 55, where compact audio products without permanently illuminated clock displays have an annual savings of 51.2 kWh per unit and units with such displays save 38.1 kWh per unit.

Table 55: Compact Audio Products Standby Energy Savings

Product	Title 20 Maximum Power Usage (kWh)	Standby Energy Savings (kWh)
Compact Audio without clock display	13.1	51.2
Compact Audio with clock display	26.3	38.1
Average	19.7	44.7

Without additional data we make the conservative assumption that half the systems have permanently illuminated clocks and half do not.

Unit Sales

The CASE report referenced DOE (2002) stock and sales estimates for California. This source stated that the stock of compact audio products is over 7.7 million and annual sales are over 1.1 million in California. No new stock information was found and included in this analysis.

The CASE report assumed a useful design life for compact audio products of 5 years.

Final Potential Energy Savings

The only difference this study makes in the analysis compared to the CASE report or HMG study is adjusting the savings potential for compact audio products that have permanently illuminated display clocks. The CASE and HMG reports estimated savings without the clock displays, most likely because they were prepared before the final standard was adopted, which specified the difference for units with and without illuminated clock displays.

The potential energy savings are determined by the following calculation.

$$\text{Potential Energy Savings (GWh)} = \frac{\text{California Sales} \times \text{Unit Annual Savings (kWh)}}{1{,}000{,}000}$$

The potential energy savings are presented in Table 56.

[62] CASE Report sourced: DOE, 2002. *Standby-Power-Energy Demand and Cost Impacts in the U.S.*: U.S. Department of Energy National Energy Technology Laboratory.

Table 56: Potential Energy Savings of Compact Audio Products

Product	Unit Savings (kWh/year)	SES Gross Savings (GWh/year))	Potential Energy Savings (GWh/year
Compact Audio without clock display	51.2	--	28.3
Compact Audio with clock display	38.1	--	21.0
Average	44.7	56.1	49.3

We estimate the total first year potential energy savings for compact audio systems are 49.3 GWh. Neither the SES estimate nor ours included any assumed market penetration of qualified units in the first year if the standard had not been adopted.

Standard 18a: Consumer Electronics Televisions

Introduction

California adopted a standard for televisions that went into effect on January 1, 2006. The standard set a maximum standby power usage of 3 watts for televisions.

Unit Energy Savings

The CASE report bases the unit energy savings on a Department of Energy report from 2002. Table 57 summarizes the CASE report estimates of the baseline standby energy use for analog color televisions.

Table 57: Television Standby Energy Use Estimate[63]

Product	Average Power (Watts)	Hours (per year)	Standby Energy Use (kWh)
Analog color television	**7.3**	**6205**	**45.3**

The CASE report calculated savings based on the proposed requirement of maximum standby power usage of no more than 3 watts. The unit energy savings are shown in Table 58. Based on our review, this methodology is reasonable and the estimated savings are credible.

Table 58: Annual Energy Savings

Product	Baseline Power Usage (kWh)	Title 20 Maximum Power Usage (kWh)	Unit Energy Savings (kWh)
Televisions	**45.3**	**18.6**	**26.7**

Unit Sales

The CASE report referenced DOE (2002) stock and sales estimates for California. At the time of the DOE report, there was a stock of 18.6 million residential televisions and annual sales of over 2.3 million in California. No new stock information was found and included in this analysis.

Final Potential Energy Savings

[63] CASE Report sourced: DOE, 2002. *Standby-Power-Energy Demand and Cost Impacts in the U.S.*: U.S. Department of Energy National Energy Technology Laboratory.

The potential energy savings are determined by the following calculation.

$$\text{Potential Energy Savings (GWh)} = \frac{\text{California Sales} \times \text{Unit Annual Savings (kWh)}}{1{,}000{,}000}$$

The potential annual energy savings from televisions are estimated as just over 62 GWh as shown in Table 59.

Table 59: Potential Annual Energy Savings of Televisions

Product	Unit Savings (kWh/year)	Potential Energy Savings (GWh/year)
Televisions	26.7	62.1

Our estimate of potential savings was not adjusted downward by initial market penetration of Energy Star products, which was estimated to be over 57% by the HMG report. The gross savings estimate taking penetration of Energy Star into account was 26.3 GWh in the first year. However, this was not reflected in the SES, which uses a savings estimate of 67.5 GWh; no explanation was available to explain this difference.[64] This evaluation does not include penetration of efficient products in the potential savings estimate; this adjustment is made through the NOMAD analysis. The CASE report's useful design life for televisions was 7 years.

Standard 18b: Consumer Electronics DVD Players

Introduction

California adopted a standard for consumer Digital Versatile Disk (DVD) players that went into effect in January 1, 2006. The standard set a maximum standby power usage of 3 watts for DVD players.

Unit Energy Savings

The CASE report identifies a 2002 Department of Energy report on standby energy use as the source of data used in the report. The CASE report baseline standby energy use for DVD players is shown in Table 60 below.

Table 60: DVD Player Standby Energy Use Estimate[65]

Product	Average Power (Watts)	Hours (per year)	Standby Energy Use (kWh)
DVD Players	4.2	6307	26.5

The CASE report calculated savings based on a maximum standby power usage of no more than 3 watts. The annual unit energy savings of 7.6 kWh based on the data shown in Table 60 is presented in Table 61. The methodology and data used appeared to be reasonable and we concluded that the CASE report estimated unit savings are credible.

Table 61: Annual Energy Savings

Product	Baseline Power Usage	Title 20 Maximum Power	Unit Energy Savings

[64] Personal communication, email from Ted Pope, Energy Solutions, May 18, 2008, to Allen Lee, Cadmus.

[65] CASE Report sourced: DOE, 2002. *Standby-Power-Energy Demand and Cost Impacts in the U.S.*: U.S. Department of Energy National Energy Technology Laboratory.

	(kWh)	Usage (kWh)	(kWh)
DVD Players	**26.5**	**18.9**	**7.6**

Unit Sales

The CASE report referenced the same DOE (2002) report for unit sales. It estimated that there was a stock of over 3 million DVD players in California and annual sales over 1.5 million. We were unable to identify any more recent sales data and accepted this estimate. The CASE report estimated the useful design life for DVD players was 5 years.

Final Potential Energy Savings

The potential energy savings is determined by the following calculation.

$$\text{Potential Energy Savings (GWh)} = \frac{\text{California Sales} \times \text{Unit Annual Savings (kWh)}}{1{,}000{,}000}$$

Table 62 presents the potential annual energy savings estimate for the DVD player standard. Our potential savings estimate is very close to the SES estimate.

Table 62: Potential Annual Energy Savings of DVD Players

Product	Unit Savings (kWh/year)	Potential Energy Savings (GWh/year)
DVD Players	**7.6**	**11.8**

As noted for televisions, a revised estimate of gross savings in the CASE report was developed for DVDs but was not incorporated in the SES. This CASE report estimate took Energy Star sales into account and reduced first year gross savings to 4.2 GWh.[66] Our estimate of potential savings was not adjusted downward by initial market penetration of ENERGY STAR products, which is estimated to be 64% by the HMG SES report. The NOMAD analysis will estimate and adjust potential energy savings for the initial market penetration.

Standard 19: Water Dispensers

Introduction

California adopted a standard for water dispensers that went into effect in January 2006. This standard sets an efficiency requirement to limit standby energy losses. It limits standby energy consumption of bottle-type water dispensers and point-of-use water dispensers dispensing both hot and cold water to 1.2 kWh per day, which is the ENERGY STAR qualifying level.

Unit Energy Savings

The baseline energy use of hot and cold water dispensers estimated in the CASE report was based on a 2000 report by Cadmus.[67] The amount of energy used will vary with the demand for water; the CASE report assumed the demand to be 3 gallons per day. The total annual unit energy use is calculated by adding the daily useful cooling energy, useful heating energy, and standby losses. Baseline annual energy use is the sum of the energy use on days when the unit is providing hot and cold water and the standby

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[66] Personal communication, email from Ted Pope, Energy Solutions, May 18, 2008, to Allen Lee, Cadmus.

[67] Source: Cadmus. 2000. *Product Testing and Analysis of Water Dispensers*, The Cadmus Group, US EPA Energy Star Program, February 8, 2000.

use alone on days when buildings are unoccupied. We took into account school seasonality, weekends, and holidays to estimate the average number of days water dispensers would be used. According to the California State Broad of Education the number of school days varies from a 175 to more than 200 days per year. Office buildings typically operate around 250 to 260 days per year. Based on this information, we assume water dispensers are used an average of 250 days per year. Using these figures, annual baseline energy use is the sum of standby losses 365 days per year heating and cooling energy use 250 days per year. The estimated baseline use is shown in Table 63 below.

Table 63: Water Dispenser Unit Energy Use

Product	Cooling Energy (kWh/day)	Heating Energy (kWh/day)	Standby Losses (kWh/day)	Cooling/ Heating Days per Year	Days of Standby Use per Year	Total Energy Use (kWh/yr)
Water Dispensers	0.18	0.23	1.93	250	365	807.0

The CASE report calculated savings based on a maximum standby energy usage of 1.2 kWh per day. Multiplying the reduction in standby losses by 365 days per year produced estimated savings of 266.5 kWh, as shown in Table 64. Subtracting the savings from the total estimated baseline consumption provides an estimate of 540.5 kWh consumption per year for a unit meeting the standard[68.]

Table 64: Annual Energy Savings

Product	Baseline Energy Usage (kWh)	Title 20 Maximum Power Usage (kWh)	Unit Energy Savings (kWh)
Water Dispensers	807.0	540.5	266.5

Unit Sales

The CASE report estimated that approximately 210,000 water dispensers are sold annually in the U.S. based on the 2000 Cadmus study. Assuming the California market share is 11% of total U.S. sales, the CASE report estimated annual sales in California. To estimate the California stock of water dispensers, equipment sales were multiplied by the useful life of water dispensers – 8 years.[69] Table 65 summarizes the estimates of California stock and annual sales.

Table 65: Estimated Water Dispenser Stock and Sales

Product	Annual U.S. Sales	Annual CA Sales	California Stock
Dispensers	210,000	23,100	184,800

The CASE reported estimated that the stock of water dispensers would increase 6% per year, thereby increasing annual sales and increasing total annual savings. However, this growth was not reflected in the final analysis and the SES, and is not included in our analysis.

Final Potential Energy Savings

The potential energy savings is determined by the following calculation.

[68] Efficient dispenser use = 587.7 kWh/year = (.18 kWh/day + .23 kWh/day + 1.2 kWh/day) x 365 days

[69] ENERGY STAR's estimated design measure life is 10 years based on LBNL, 2007.

$$\text{Potential Energy Savings (GWh)} = \frac{\text{California Sales} \times \text{Unit Annual Savings (kWh)}}{1{,}000{,}000}$$

Using this equation, the potential first year energy savings from water dispensers are estimated to be just over 6.15 GWh, which is shown in Table 66. The CASE report and SES do not incorporate any effect of initial market penetration and since we agree with the unit savings and sales, our potential savings estimate equals the SES gross savings value.

Table 66: Potential First Year Energy Savings of Water Dispensers

Product	Unit Savings (kWh/year)	Potential Energy Savings (GWh/year)
Water Dispensers	**266.5**	**6.15**

Standard 20: Unit Heaters and Duct Furnaces

Introduction

California adopted a standard for unit heaters and duct furnaces that went into effect in January 2006. This standard provides a prescriptive requirement that all natural gas-fired unit heaters and duct furnaces have either power venting or an automatic flue damper to address off-cycle stack losses. This standard effectively eliminated standing pilot lights in gas-fired unit heaters and duct furnaces in California.

Unit Energy Savings

The baseline energy use of unit heaters and duct furnaces provided in the CASE report was based on estimates from several studies. Typical furnace technologies that affect energy efficiency include conventional pilot gravity vent; Intermittent Ignition Device (IID), gravity vent; IID with power vent; separated combustion; and pulse combustion. The thermal and seasonal efficiencies of these devices are shown in Table 67.

Table 67: CASE Report Typical Steady State and Seasonal Efficiencies[70]

Technology	Thermal Efficiency	Seasonal Efficiency
Pilot, gravity vent	78-82%(1)	63%(1)
IID, gravity vent	78-82%(1)	66%(3)
IID, power vent	80-83%(1)	80%(1)
Separated combustion	80-83%(1)	80%(1)
Pulse combustion	90%(2)	82%(2)
Condensing	>90%(1)	90%(1)

(1) ACEEE, 2003; (2) DOE, 2002; (3) DEG estimate

The CASE report estimated the average baseline energy use of conventional pilot gravity vent units in California, which is shown in Table 68. The CASE report referenced an ACEEE study as its source[71]. The

[70] Sources: ACEEE, 2003: Sachs, Harvey M., Unit Heaters Deserve Attention for Commercial Programs, ACEEE, April 2003; DOE, 2002: http://www.eren.doe.gov/buildings/codes_standards/notices /notc0044/heaters.xls.

[71] ACEEE, 2003: http://www.aceee.org/pubs/a031full.pdf

ACEEE estimate is based on median unit heater input capacity of 220,000 Btu per hour, and assumed that unit heaters are typically oversized by 100%. The CASE report further assumed that California applications average 1,000 annual full-load hours. A 66% efficiency rate was applied, which was the standard in California at the time of the ACEEE study. We were not able to locate any better source of comparable information.

Table 68: Typical California Gravity Vent Unit Heater Energy Use Estimate

Gravity Vent Characteristics	Value	Unit
Median unit heater input capacity	220,000	Btu/h
Typical oversizing	100%	
Diversified peak load	110,000	Btu/h
Estimated CA heating load hours	1,000	hours
Heat delivered to space	693	therms
Annual efficiency	66%	
Annual baseline use	**1,056**	**therms/year**

The unit energy savings resulting from the use of power vent, pulse combustion, and condensing technologies relative to gravity vent units is shown in Table 69below.

Table 69: Annual Energy Savings Estimates for High Efficiency Options

Option	Estimated Seasonal Efficiency	Estimated Gas Use (therms)	Baseline Gas Use (therms)	Gas Savings (therms)
Power Vent	80%	866	1056	190
Pulse Combustion	82%	845	1056	211
Condensing	90%	770	1056	286

Unit Sales

The CASE report estimates that there were 3.2 million unit heaters and 239 thousand duct furnaces in the U.S. in 2003.[72] Economic census data indicated that 12% of commercial establishments that typically use unit heaters are located in California.[73] Finally, 18% of commercial spaces were estimated to be heated by unit heaters[74], and 38% of the commercial heat load was estimated to be supplied by natural gas-fired unit heaters[75]. Thus 182,000 units (3,200,000 x 12% x 18%/38% = 182,000) were estimated to be in California. Using this same calculation methodology, the CASE report estimated annual sales of unit heaters in California were 12,200 units in 2000 and 9,400 in 2001.[76] Using these values, average annual sales were estimated to be about 10,800 units. The design life for this measure was assumed by the CASE

[72] DOE 2002: http://www.eren.doe.gov/buildings/codes_standards/notices /notc0044/heaters.xls.

[73] USCB 1997. Economic Census 1997. http://www.census.gov/epcd/www/econ97.html. United States Census Bureau. 1997.

[74] CBECS, 1999.

[75] Manix et al, 1997. Manix, A., M. McElhattan, and P. McGreevy, 1997. Topical Report: Commercial Space Heating Equipment Market. GRI 97/0100.

[76] According to GAMA, 2001 annual U.S. sales were 216,000 in 2000 and 166,000 in 2001. See GAMA, 2001: Gas Appliance Manufacturers Association, Statistical highlights, 10-Year Summary 1992-2001: http://www.gamanet.org/member/statistics/TYS1992-2001.pdf

report to be 15 years.[77]

Final Potential Energy Savings

The potential energy savings are determined by the following calculation.

$$\text{Potential Energy Savings (Mtherms/yr)} = \frac{\text{California Unit Sales} \times \text{Protoypical Savings (therms/yr)}}{1{,}000{,}000}$$

Our estimates of the potential annual savings from the sale of each of high efficiency unit heaters type are shown in Table 70. No sales data were available to estimate the mix of heater types used to meet the standards. To be conservative, we used the unit savings for the power vent type as our estimate. This is consistent with the approach used in the SES.

Table 70: Unit Heater and Duct Furnace Potential Annual Energy Savings

Option	Unit Savings (therms)	Annual Sales (Units)	Energy Savings (Mtherms)
Power Vent	190	10,800	2.06
Pulse Combustion	211		2.29
Condensing	286		3.10

Note: Value for power vent units used for conservative savings estimate.

Standard 21: Commercial Dishwasher Pre-Rinse Spray Valves

Introduction

California adopted a standard for commercial dishwasher pre-rinse spray valves that went into effect on January 1, 2006. Commercial dishwasher pre-rinse spray valves (pre-rinse valves) use hot water under pressure to clean plates, flatware, and other kitchen items before they are placed into a commercial washer. The valves typically use between 1 and 5 gallons of water per minute (GPM) at 60 pounds per square inch (psi).[78] The proposed standard was 1.6 GPM. The proposed standard required that they be capable of cleaning 60 plates at an average time of 30 seconds or less per plate.[79] The CASE report assessed the impact of the standard assuming a cleaning rate of 21 seconds per plate.

Prior to adoption of this standard there was no efficiency requirement for these products.

Unit Energy Savings and Unit Sales

The standard reduces energy use by reducing the amount of hot water used. The CASE report did not distinguish between the electricity and gas savings associated with reduced use of heated water. Instead, it attributes all energy savings to reduced gas usage.

[77] The average life of a gas-fired unit heater is approximately 20 years (ACEEE, 2003). The average life of a duct furnace ranges from 15 to 20 years according to DOE (DOE, 2002).
[78] Food Service Technology Center (2003). Pre-rinse spray valve test results, May 7, 2003.

[79] CEC 2006 Appliance Standard.

The CASE report estimated there were 90,000 commercial pre-rinse spray valves used in conjunction with commercial dishwashers in California. This estimate was based on best professional judgment. It estimated there were an additional 60,000 to 110,000 used for other purposes. The estimated savings were attributed to the 90,000 used with a commercial dishwasher only. The report stated the savings associated with the other uses were likely to be significant, but did not attempt to calculate and include the impact of applying the standard to these other spray valves. The annual replacement was assumed to be 18,000 units. The design measure life of pre-rinse spray valves (PRSV) was estimated to be 5 years.

The CASE report assumed the current inventory of PRSV used an average of 3.15 GPM.[80] It estimated that 10 percent of the market was high efficiency valves and estimated the baseline UEC to be 1566 therms/ year as shown in Table 71.

Table 71: CASE Report Baseline UEC and AEC

1	**GPM**		3.15
2	**Minutes per day of Use**		240
3	**Gallons per Day**	Row 1 X Row 2	756
4	**Days per Year**		363
5	**Gals per Year**	Row 4 X Row 5	274,428
6	**Lbs/ Gallon**		8.34
7	**Lbs**	Row 5 X Row 6	2,288,730
8	**Delta T**		52
9	**Btu**	Row 7 X Row 8	1.19E+08
10	**Water Heater Efficiency**		0.76
11	**Annual UEC (Therms)**	(Row 9/Row 10)/100,000	1,565.97
12	**Total Units**		90,000
13	**Annual AEC (Mtherms)**	(Row 11 X Row 12)/1,000,000	140.94

The CASE report calculations did not explicitly account for the 10 percent of units that the report indicated were high efficiency valves. The baseline estimate of 3.15 GPM for the current inventory appears to be a weighted average.

The CASE report assumed after the standard was adopted some valves would perform better than the standard of 1.6 GPM. Authors of the report expected a mix of products would exist ranging from 1.2 to 1.6 GPM since these were available in the market. The report assumed the average usage after standard adoption would be 1.5 GPM.[81] This is a reduction of 52 percent from the baseline value, producing per unit savings of 820 therms (1,566 X 0.52). When we reviewed these assumptions, we updated the minutes per day of use based on information from the Northwest Power and Conservation Council's Regional Technical Forum where various low flow pre-rinse spray valves studies were evaluated. They concluded that the average use per day was 44.4 minutes, versus 240 minutes as assumed in the CASE report.[82] Another adjustment was for the number of units that provided only cold water, thereby reducing the number of units that would save water heating energy. SBW Consulting's evaluation of California Urban Water Conservation Council's program for PRSV showed that over 50% were installed in

[80] Food Service Technology Center (2003). Pre-rinse spray valve test results, May 7, 2003.

[81] Based on communications with the authors of the 2004 CASE report.

[82] Northwest Power and Conservation Council's Regional Technical Forum, "Low Flow Pre-Rinse Spray Valves", a presentation of their review of 5 studies, April 20, 2009

cold water applications. We applied these updated assumptions resulting in revised energy savings estimates presented in Table 72.

Table 72: Revised Estimates of Pre-rinse Spray Valve Gas Savings

	Flow rate (GPM)	UEC (Therms)
Baseline Usage (Therms)	3.15	290
Measure Usage (Therms)	1.5	138
Savings (Therms)		152

The CASE report did not estimate electric savings for PRSV, The California Energy Commission estimated the savings based on a split of 25% electric and 75% gas water heaters. We used this assumption with the revised assumptions stated above to estimate the electric savings as presented in Table 73.

Table 73: Revised Estimates of Pre-rinse Spray Valve kWh Savings

	Flow rate (GPM)	UEC (kWh)
Baseline Usage (kWh)	3.15	2,694
Measure Usage (kWh)	1.5	1,283
Savings (kWh)		1,411

California Energy Commission Adjustments

The California Energy Commission (CEC) reviewed and revised the CASE report estimated unit energy savings and unit sales. The CEC adjusted the unit therm savings from 820 therms to 336 therms, a reduction of 59%. The unit sales were adjusted from 18,000 units to 13,500 units, a reduction of 25%. The CEC also broke savings out by electricity and natural gas. As stated earlier the CEC estimated a 25% electric and 75% gas water heater split. These estimates are from the CEC and no supporting information was available to explain these changes.

Final Potential Energy Savings

The potential electric energy savings are determined by the following calculation.

$$\text{Potential Electric Energy Savings (GWh/yr)} = \frac{\text{CaliforniaUnit Sales} \times \text{Protoypical Unit Annual Savings (kWh/yr)}}{1{,}000{,}000}$$

Gas savings are calculated similarly. Based on the updated assumptions and using the CEC's sales estimate, discounted 50% for the proportion that used cold water, we estimated the final potential first-year energy savings. However, an equivalent federal was adopted that went into effect at the same the California standard did. Our study scope was based on estimating savings relative to baseline energy use and once a federal standard went into effect it became the new baseline. In this case, the net effect was that no potential energy savings were counted for the PRSV standard. These results are shown in

Table 74.

Table 74: Pre-Rinse Spray Valve (PRSV) Potential Annual Energy Savings

Product	Unit Savings (kWh/year or Therms/year)	Annual Sales (Units)	Potential Energy Savings (GWh/year or MTherms/year)
Pre-Rinse Spray Valve (PRSV) - GAS	152	6,750	1.02
Pre-Rinse Spray Valve (PRSV) - Electric	1,411	2,250	3.18
Net Effect, Taking into Account Federal Standard Baseline	0 kWh/year and Therms/year	13,000	0 kWh/year and Therms/year

Appendix J. Detailed Building Standards Potential Energy Savings Results

Standards B1 and B2: Time Dependent Valuation, Residential and Nonresidential

Description

Time Dependent Valuation (TDV) is a methodology for valuing energy savings in terms of the real resources used in energy production. It is unlike any of the other Title 24 standards in that it is a calculation procedure, rather than a performance or prescriptive requirement for a building component. Since TDV employs the same concept to both the residential (Standard B1) and nonresidential (Standard B2) building standards, this assessment discusses them both together.

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.

With the 2005 updates to the Title 24 building standards, TDV was integrated into compliance software to assist designers in evaluating the energy cost performance of their buildings during peak times and in understanding the potential tradeoffs between measures. Basically, in the TDV methodology, the hourly base (kWh, therm, etc.) energy savings are multiplied by hourly cost factors. These cost factors represent the time-dependent real resource costs that are reduced by energy savings during the specific time period.

Claimed Energy Savings – Initial First-Year Impact Estimates

First-year impact estimates are presented in Table 75. These values are presented in the ADM report[1] and the savings shown in the table are consistent with the savings estimates in the SES. The claimed demand savings are very large, as would be expected for a procedure that was intended to give more credit to peak savings, and the electricity savings are moderate.

Table 75: First-Year Savings Claimed

Standard	First-year GWh	First-year MW
STD B1: Time Dependent Valuation, Residential	6.7	27.2
STD B2: Time Dependent Valuation, Nonresidential	4.3	18.7

Method Used to Estimate Claimed Savings

No standard CASE report was prepared for this measure, but there was a Code Change Proposal[2] and an implementation guide.[3] These documents thoroughly explained the logic of the methodology and how it

[1] ADM, Inc. *Evaluation of Statewide Codes and Standards Program, Final Report.* Prepared for SCE: June 2004.

[2] Pacific Gas & Electric. 2002. *Time Dependent Valuation (TDV)—Economics Methodology*.

would place a higher value on savings achieved during peak periods. The ADM report mentioned above described the approach used to estimate the savings from these two standards:

Although TDV may affect the choice of equipment that is installed in new houses and commercial buildings, estimating the extent to which energy will be saved and peak demand reduced is somewhat speculative given the information at hand. Heschong Mahone Group has developed some preliminary estimates of the savings impacts of TDV. To develop their savings estimates, HMG used the impact of EER requirements for small air conditioners as the proxy for assessing the overall impact of developing and applying the TDV methodology. With this approach, the assumption made is that TDV will encourage increased use of air conditioners with higher EERs (e.g., air conditioners with SEER of 13 and EER of 11 over air conditioners with SEER of 13 and EERs less than 11). Building on this basic assumption, HMG used detailed simulations of energy use for air conditioning in different climate zones in California to develop estimates of the savings that would result from increased sales of air conditioners with EERs of 11 or higher.[4]

In 2009, our team received an internal report from HMG that basically concurred with this description of the methodology. HMG also provided the evaluation team with computer runs that were used to estimate the energy savings.

Revised Statewide Potential Energy Savings Estimates

To evaluate the energy savings attributable to TDV, we thoroughly reviewed the documents describing the origins of the TDV methodology, the underlying procedures, and the savings estimates. We found the basic principle sound. In typical cost effectiveness analyses, energy savings are usually valued based on the temporal avoided costs of energy so the concept of valuing on-peak energy savings more than off-peak savings appeared consistent with good practice. However, creation of an artificial energy metric ("TDV energy") appeared to have the potential to create confusion.

We focused most of our investigation on how the savings were calculated originally, including the underlying assumptions and the methodology. As noted above, the original savings estimate was calculated by assuming that in residential buildings the standards would lead to installation of air conditioners with an EER of 11, rather than an assumed base level of 10. Our team examined in two ways whether this assumption was valid. First, we reviewed the field data used to determine compliance. These data included information on the installed air conditioner SEER and EER. From these data, we estimated that 54% of the air conditioners had an EER of 11 or higher. Second, during surveys conducted for the residential market effects study, energy consultants were asked what measures were used most often to meet the TDV requirement[5]. Based on their reports, the most common approach was with more efficient windows or shading. Efficient HVAC equipment was rated second most common. Just fewer than 50% of the respondents, however, said the approach varied or they did not know.

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[3] Heschong Mahone Group and Energy and Environmental Economics. 2002. *Time Dependent Valuation of Energy for Developing Building Efficiency Standards—Time Dependent Valuation (TDV) Formulation 'Cookbook.* Submitted to Pacific Gas & Electric.

[4] ADM *op.cit.*, p. 4-4.

[5] KEMA et al. 2009. *Residential New Construction (Single Family Home) Market Effects Study, Phase I Report.* Prepared for the California Public Utilities Commission, Energy Division.

Table 76. Reported Most Common Ways to Meet TDV Requirements

Building Measure	N	Percent
Windows/shading	11	24%
Efficient HVAC	8	18%
Envelope	6	13%
Varies	4	9%
Other/Don't know	16	36%
Total	45	100%

The first finding demonstrated that higher EERs were becoming fairly common in the California new home market, but provided no evidence this was because of the TDV requirement. The second finding suggested that higher EERs were being used to meet the TDV requirement, but in as little as 18% of the cases.

Additional research raised significant questions about the effectiveness of the TDV requirement in general. One concern was that no documentation was provided that described how the savings were estimated for nonresidential buildings. Though both energy and demand savings for nonresidential buildings were estimated to be less than for residential buildings, the estimated demand savings were still significant. It was unclear if they were estimated based on the assumptions used to estimate residential building savings.

The most significant concern was that the way the TDV methodology is implemented it does not appear to require significant peak savings for compliance, even though the underlying methodology provides more credit for on-peak energy savings. This can be demonstrated by noting that residential building prescriptive Package D is the basis upon which the energy budget is established that must be met through the performance compliance approach. Package D, however, requires an air conditioner with an EER of only 10. Consequently, a residential building can comply under the performance approach *without* having an air conditioner EER of 11 if it just meets all the Package D requirements. If an EER 11 unit were installed in the building, the performance approach would permit other measures that save peak energy equivalent to the difference between the EER 10 and 11 to be eliminated and the building would still comply. Even more notable, the methodology would permit measures that reduce electricity demand to be downgraded if efficient natural gas equipment, such as high efficiency furnaces, were installed and they would contribute little or no peak demand savings.

Given these findings, the evaluation team could not find sufficient evidence that the approach used to estimate savings was consistent with the impacts of the TDV requirements. Consequently, we did not have a sufficient basis for crediting the TDV standards with energy or demand savings. These results are shown in Table 77.

Table 77. Final TDV Savings Estimates

Standard	ADM/HMG/SES Gross Savings		Final Potential Savings	
	GWh	MW	GWh	MW
STD B1: Time Dependent Valuation, Residential	6.7	27.2	0	0
STD B2: Time Dependent Valuation, Nonresidential	4.3	18.7	0	0

Standard B3: Residential Hardwired Lighting

Description

This standard is a mandatory measure that applies to new residential construction, including additions and alterations, low-rise multifamily and high-rise residential living quarters, and hotel/motel guest rooms. This standard:

1. Now covers more specific building types (e.g., high-rise residential).
2. Now includes more stringent requirements for efficacy in lamps (e.g., higher LPW, increases with watts).
3. Now bases kitchen requirements for high-efficacy luminaires on 50 percent of installed watts.
4. Allows some exceptions for dimmers and sensors in certain low burn-hour rooms.
5. Requires ICAT fixtures for lights recessed in insulated ceilings (i.e., attics and other plenums at the exterior building envelope).

Claimed Energy Savings – Initial First-Year Impact Estimates

First-year impact estimates are presented in Table 78

Table 78: First-Year Savings Claimed

	Eley[6]/ADM[7]
GWh savings	64.6
MW demand reduction	2.97
MTherm savings	-

These values were taken from the ADM report, which adopted findings from the Eley report without modification. CASE Report [8] claims savings of 0.55 therms per year per fixture from the increased stringency of the ICAT requirement, but no statewide projections were made.

Per Unit Savings Analysis

Baseline lighting energy use was based on *Statewide Lighting Baseline Study*,[9] which was extrapolated to spreadsheet models of typical single-family and multifamily dwellings. The prototype dwellings' characteristics (i.e., 32 fixtures per single-family home and 11 fixtures per multifamily dwelling) were based on CEC/CBIA estimates. Highlights of these estimates appear in Table 4, and they appear to be reasonable. Hours of use vary for each room type.[10]

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[6] Eley Associates. *Impact Analysis for Residential and Nonresidential Buildings*. June 2003.

[7] ADM, Inc. *Evaluation of Statewide Codes and Standards Program, Final Report.* Prepared for SCE: June 2004.

[8] Pacific Gas & Electric. *CASE Initiative, Code Change Proposal for Residential Hardwired Lighting*. May 2002.

[9] The Heschong Mahone Group, Inc. *Lighting Efficiency Report, Volume I, California Baseline*. 1997.

[10] *Ibid.*

Table 79: Breakdown of Lighting Fixtures

Building Type	Code	Unit Size (sq. ft.)	Fixtures (#)	Fluorescent	Recessed	Controls Used
Single family	2001	2200	32	8	20	0
	2005	2200	32	13	20	19
Multifamily	2001	Not specified	11	6	8	0
	2005	Not specified	11	7	8	4

Eley calculated demand savings by climate zone. These estimates are summarized in Table 80. The per-unit electricity savings estimated seemed reasonable.

Table 80: Summary of Per-Unit Savings for Single-Family and Multifamily Dwellings

Building Type	Per-Unit Demand Savings (kW)
Single Family	22-35
Multifamily	7-9

Light source improvements were based on per-luminaire savings calculations and engineering estimates, as shown in Table 81.

Table 81: Lighting Energy Savings from 2005 Code Update

Building Type	Baseline Usage (2001) (kWh/yr)	2005 Title 24 Usage (kWh/yr)	Per-Unit Energy Savings (kWh/yr)
Single Family	2153	1642	511
Multifamily	939	720	219

In the CASE report, therm savings from light fixture air leakage reduction were based on engineering estimates and field studies of building envelope reductions. Eley and ADM both chose not to calculate therm savings. It may be that per-fixture therm savings are offset by an increase in the number of recessed lighting fixtures. However, no justification was presented for excluding the therm savings from statewide projections, and the lighting models assume that the same number of recessed lighting fixtures will be installed in homes built to 2005 code as were in previously constructed homes.

If we assume that CASE estimate of savings of 0.55 therms per year per ICAT fixture is accurate, and, based on experience, conservatively assume that 25 percent of recessed fixtures are in the thermal boundary and affected by this measure, we can calculate a per-unit savings estimate as shown in Table 82.

Table 82: Savings from the Use of ICAT Recessed Lights

Building Type	Recessed Lights in Prototype Model	ICAT Recessed Lights	Savings per ICAT (therms/yr)	Savings per House or Unit (therms/yr)
Single Family	20	5	0.55	2.75
Multifamily	8	2	0.55	1.1

The validity of the per house/unit savings estimates depends on the number of affected recessed lights in newly constructed homes. If more recessed lights are installed in insulated ceilings, associated thermal losses will offset the savings realized by substituting ICAT fixtures. In the same way, savings from efficient lights can be negated if a greater number of lights are installed (e.g. if homes are larger).

No attempt was made to characterize savings from alterations and additions, and we do not have the necessary data to do so. No attempt was made to characterize savings from high-rise residential living quarters or hotel/motel guest rooms, and we do not have the necessary data to do so. Estimates do not take into account cooling savings or heating losses due to reduction in lighting power.

Number of Affected Units

Eley and ADM used CIRB projections for housing starts, which we updated with CIRB data on 2006 housing permits issued (see Table 83).

Table 83: Housing Statistics for 2006

Building Type	Projected 2006 Housing Starts	Actual 2006 Housing Permits	Difference
Single Family	108,468	108,021	-0.41%
Multifamily	41,732	56,259	34.81%

After this preliminary analysis was completed, we conducted a study of lag times between permitting and construction and these data allowed us to estimate actual home completions during 2006, rather than housing permits. We estimated a lag of six months between permitting and completion of construction for single-family homes and eight months for multifamily units. Our estimates of actual completions are shown in Table 84 (see Appendix D).

Table 84. Estimated Housing Completions

Building Type	2006	2007	2008
Single Family	97,108	84,507	45,058
Multifamily	31,408	52,269	40,461
Total Units	128,516	136,776	85,519

Additions, alterations, and hotel/motel guest rooms were not counted, but we assumed that low-, medium, and high-rise residential units are included.[11]

Market Penetration

Because this is a new construction and alteration measure, its applicability is not affected by existing installations of high-efficacy fixtures.

Revised Statewide Potential Energy Savings Estimates

Statewide savings estimates are based on spreadsheet calculations of savings for modeled prototype buildings multiplied by estimates of new residential construction activity.

[11] It appeared that the housing statistics used in the Eley and ADM reports included high-rise multifamily units and this is the assumption we made as well. By personal communication with Charles Eley, April 2, 2010, we were unable to determine for certain whether high-rise units were, in fact, included, but the values reported are consistent with including them based on the permit data we had available.

Statewide savings = (2001 prototype electric usage – 2005 prototype electric usage) * number of new housing units

This calculation was performed separately for prototypical single-family homes and multifamily homes.

While therm savings should be added to these estimates, we did not have sufficient information to quantify them. We also did not have adequate data to estimate savings from additions, alterations, hotel/motel guest rooms, or space heating and cooling interactions; ideally, these adjustments would be included.

In addition to adjusting for the change from permits to estimated home completions, we adjusted the original gross savings per home based on the data found in the field during site visits to 194 homes. From the field data, we estimated unit savings weighted by construction in different climate zones was 81.4% of the original estimate. Table 85 presents our revised savings estimates and the original values provided by ADM, which were used in the HMG SES. The evaluated savings were not calculated for single-family and multifamily homes separately, but the average savings were applied to all units.

Table 85: Revised Statewide Savings Estimates[12]

Building Type	ADM Usage Savings (GWh/yr)	ADM Demand Savings (MW)	Final Usage Savings (GWh/yr)	Final Demand Savings (MW)
Single Family	55.4	2.7	--	--
Multifamily	9.1	0.27	--	--
Total	64.6	2.97	45.0	2.07

Using the per-unit therm savings calculated above, we can also estimate therm savings. However, because therm savings are relatively small, and because there is so much uncertainty about the number of recessed lights being installed in the thermal boundary, we do not recommend adding the therm savings estimates to the statewide total savings projections shown in Table 86.

Table 86: Final Statewide Residential Hardwired Lighting Savings Estimates[13]

	Eley /ADM Gross Savings	Final Potential Savings
GWh Savings	64.6	45.0
MW Demand Reduction	2.97	2.07
MTherm Savings	0	0

[12] The GWh, MW, and therm savings used in the final analysis differ as described in Section 2.2.2 of the main report based on the field data collection and analysis conducted after this initial analysis was conducted.

[13] See prior footnote.

Standard B04 – Ducts in Existing Residential Buildings

Description

This is a prescriptive measure that applies to alterations of existing residential buildings under certain conditions described below. This measure requires ducts to be sealed and insulation to be added to ductwork so that:

- Ducts are insulated to the current prescriptive Package D code level:
    a. R-4.2 in CZ 6-8.
    b. R-6 in CZ 1-5 and 9-13.
    c. R-8 in CZ 14-16.

b. In climate zones 2 and 9-16,:

i. Leakage must be less than 15 percent, reduced by 60 percent, or less than 10 percent to outside.

ii. If new ducts form an entirely new system, the measured leakage cannot exceed 6 percent of fan flow.

The duct sealing requirement is triggered by installation or replacement of any of the following.

- A furnace
- A packaged indoor/outdoor unit
- An air handler
- Cooling or heating coil
- An outdoor condensing unit
- A furnace heat exchanger

In addition, the duct insulation upgrade requirement is triggered by any of the following events.

- The installation of an entirely new duct system
- The addition or replacement of at least 40 feet of ducts in unconditioned space

Duct leakage rates must be certified by the installing contractor and verified by an independent HERS rater.

In response to stakeholder input, the California Energy Commission inserted numerous exceptions into the approved code language in the form of alternative compliance approaches. These changes were documented in the CEC's Blueprint periodical, and they largely consisted of trade-offs between improved equipment efficiency in lieu of duct leakage testing and sealing. These changes were not expected to alter the energy savings estimated for this measure in the CASE report because the trade-offs (e.g., improved SEER rating) were deemed equivalent to the energy savings resulting from duct testing and sealing requirements.

Energy Savings – Initial First-Year Impact Estimates

The following table documents the initial first-year savings impacts of this measure in the SES.

Table 87: First-Year Savings

GWh Savings	5.7
MW Demand Reduction	8.5
MTherm Savings	1.1

Per-Unit Savings Equation

Eley had developed an earlier estimate of per-unit savings, using Micropas thermal modeling of a prototype single-family home built to pre-1978 standards to determine per-unit energy savings. The final values used in the SES were based on an ADM study methodology that inferred the kWh and kW reduction per house from the Eley report and an earlier CASE report.

ADM looked at DEER data and estimated the average value weighted across CEC forecasting climate zones and housing vintages. The weighted average per home for savings across climate zones and vintages was 114 kWh/year and 22 therms/year. The DEER savings estimates, however, seem to be based on duct sealing only, and do not appear include duct insulation upgrade savings. Because we do not have information about the rate of duct replacements that would result in insulation upgrades, and because we were not able to rerun the original runs, we did not attempt to provide a more thorough estimate of impacts resulting from duct insulation upgrades. We assume that prior research did not include duct insulation upgrade savings because they concluded that such savings were insignificant compared to duct sealing savings.

Per-unit savings were not estimated for multifamily units. Again, we assume that the prior research left out multifamily savings because they were deemed to be an insignificant piece of the overall energy savings, and we did not attempt to model multifamily units.

Because duct insulation upgrades and multifamily energy savings were not included in the previous evaluations, we consider the 114 kWh and 22 therms per home savings conservative, and we accept them.

Table 88: Duct Insulation Unit Savings

	SES Value	Final
kWh Savings per House	114	114
Therm Savings per House	22	22

Number of Affected Units

The ADM analysis agreed with the Eley estimates on the number of single-family homes and the number of affected homes that undergo HVAC work that would trigger this requirement.

Number of homes affected = Number of existing, owner-occupied, SF houses in affected climate zones X Percentage of homes having qualifying work done each year

The Eley and ADM reports reference the American Housing Survey, which showed that 3.85 percent of all single family housing units undergo alterations that trigger this measure each year. When reporting the estimated number of duct alterations, however, the previous studies rounded down to an even 50,000 units, instead of approximately 55,500. This corresponds to an upgrade rate of 3.5 percent. Because the study cited for this value actually found it to be 3.85 percent, we believe that it was more appropriate to use the empirical percent and the estimate of statewide upgrades of 55,000 per year.

Market Penetration

A SMUD study referenced by ADM and the CASE report found that only 85 percent of existing houses need duct sealing, because 15 percent already have duct leakage below target rates. This corresponds to a 15 percent pre-existing market penetration.[14] This adjustment was not included in the Eley and ADM estimates, though it was published in the original CASE report.

Revised Statewide Potential Energy Savings Estimates

Per-unit energy savings are multiplied by the number of impacted homes. Because the NOMAD adjustment accounts for the effect of initial market penetration, our results do not include an adjustment for market penetration. Table 89 presents the verified potential savings estimates and the values in the SES.

[14] Jump and Modera. *Energy Impacts of Attic Duct Retrofits in Sacramento Houses*. 1994.

Table 89: Statewide Ducts in Existing Residential Buildings Savings Estimates

	SES Value (Gross Savings)	Final (Potential Savings)
Number of Impacted Houses	50,000	55,000
kWh Savings per House	114	114
Total GWh Savings	5.7	6.3
MW Demand Reduction	8.5	7.9
Therm Savings per House	22	22
Total MTherm Savings	1.1	1.2

Standard B05 – Window Replacement

Description

This is a prescriptive measure that requires windows replaced in existing homes to meet the same prescriptive standard for efficiency as windows installed in new homes (see Table 90).

Table 90: Title 24, Prescriptive Window Requirements

CZ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Max U-factor	0.57	0.57	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.57	0.57	0.57	0.57	0.57	0.57	0.55
Max SHGC	NR	0.4	NR	NR	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	NR

Energy Savings – Initial First-Year Impact Estimates

Table 91 summarizes the first-year savings impacts estimated for the window measure in the SES.

Table 91: First-Year Savings Estimate in SES

GWh Savings	6.34
MW Demand Reduction	2.4
MTherm Savings	0.3

Per-Unit Savings Equation

The CASE study used DEER estimates for baseline usage[15] and MICROPAS modeling of a typical pre-1978 single-family house to estimate savings. Eley used the same methodology with somewhat different results, perhaps due to more carefully weighted averaging across climate zones.

ADM found more varied per-unit savings estimates with RCP econometric analysis. Results were higher in some climate zones and lower in others. The SES values were based on Eley's per-unit savings numbers. Baseline usage and savings are summarized in Table 92.

[15] Xenergy. *2001 DEER Update Study*. California Energy Commission: August 2001.

Table 92: Per-Unit Savings Comparison

	PG&E CASE Report	Eley	ADM
Baseline Cooling (kWh)	1,619	1,691	-
Cooling kWh Savings	20%	15%	-
Unit kWh Savings	324	254	118 – 1,048
Baseline Cooling Demand kW	1.9	1	-
Cooling Demand Savings	10%	9%	-
Unit kW Savings	0.19	0.1	-
Baseline Heating Therms	164	118	-
Heating Therm Savings	10%	10%	-
Unit Therm Savings	16	12	-251

No per-unit savings estimates were made for multifamily units or additions. Time and budget constraints were cited by study authors.

Number of Affected Units

The CASE study based the estimated number of window replacements on an industry study of the replacement window market.[16] The replacement market in California is 1.5 million windows per year, which roughly translates to 100,000 homes.

The CASE report discounted this number by estimating the penetration of qualifying windows in the replacement market, resulting in an estimate of about 31,000 single-family homes replacing their windows each year. ADM and Eley estimated that about 25,000 homes replace their windows each year.

Only owner-occupied, single-family homes were considered in these estimates. Inclusion of rental properties and multifamily units would increase the savings estimates.

Revised Statewide Potential Energy Savings Estimates

The per-unit energy savings are multiplied by the number of impacted homes to estimate statewide potential energy savings (see Table 93). The SES savings estimates are based on an adjusted number of houses affected and penetration of high-efficiency windows in the market. Our final savings estimate is higher because naturally occurring market penetration is not deducted here since this adjustments is made in the NOMAD analysis later.

[16] AAMA/WDMA. *Study of the U.S. and Canadian Market for Windows and Doors*. April 2000.

Table 93: Final Statewide Residential Window Replacement Savings Estimates

	SES Values (Gross Savings)	Final Values (Potential Savings)
Number of Impacted Houses	25,000	100,000
Market Penetration	(accounted for in number of impacted houses)-	-
kWh Savings per House	254	254
Total GWh Savings	6.34	25.4
MW Demand Reduction	2.4	9.6
Therm Savings per House	12	12
Total MTherm Savings	0.3	1.2

Standard B06 - Lighting Controls under Skylights

Description

This measure is a prescriptive standard that requires skylights and automatic lighting controls in certain large (larger than 25,000 sq. ft.) single-story, non-residential buildings, such as warehouses and retail buildings in climate zones 2 though 15. The measure also defines mandatory requirements for the installation of controls for lighting under sky-lit areas and defines the performance characteristics of skylights (e.g., must have greater-than-specified minimum haze value) and controls characteristics. This measure also adds a compliance option for the prescriptive envelope-only compliance approach involving lighting power adjustments for use of automatic daylighting controls.

Energy Savings – First-Year Impact Estimates

The CASE[17] study did not calculate statewide savings estimates. The Eley study[18] did not disaggregate savings due to this measure from other Title 24 measures. A subsequent HMG[19] analysis did develop disaggregated savings estimates. An ADM study revised these estimates, and these values are in the SES. The HMG study and ADM estimates (in the SES) are shown in Table 94.

Table 94: Initial Savings Estimates

	HMG	SES (ADM)
GWh Savings	23.5	25.46
MW Demand Reduction	5.01	-
MTherm Savings	-	-

[17] Heschong Mahone Group, Inc. *CASE Report: Updates to Title 24 Treatment of Skylights, Final Report*. Prepared for PG&E, May 2002.

[18] Eley Associates. *Impact Analysis for Residential and Nonresidential Buildings*. June 2003.

[19] Heschong Mahone Group, Inc. *Codes and Standards Enhancement Initiatives for 2005 Title 24, Final Report*. Prepared for PG&E, March 2004.

Per-Unit Savings Equation

The CASE study used SkyCalc simulations for a prototypical retail store and warehouse, and it used TDV weighting to estimate savings.[20] Eley also modeled prototypical buildings, but did not disaggregate savings due to this measure from other CASE measures. HMG used modeling, but did not present any details besides total savings. ADM used lighting power density (LPD) and hours estimates from utility studies.[21]

ADM's estimates are based on estimated savings per square foot derived from the power adjustment factors calculated in the CASE[22] study report. The power adjustment factor (PAF) is an estimate of the savings ratio one can expect from controlling a fixture in a daylit zone, based on building conditions and skylight geometry. These adjustment factors are applied to the LPD of the space and the hours of operation to calculate a kWh annual savings per square foot.

kWh savings per sq. ft. = Annual hours of use * controlled LPD * PAF

This equation was used to estimate savings for warehouses and retail buildings, and the values are shown in Table 95.

Table 95: Factors for Per-Unit Savings Calculations

Building Type	Controlled LPD	PAF	Hourly (kWh savings/sq.ft.)	Annual Hours of Use
Retail - New Construction	1.44	0.412	0.593	Varies by region
Warehouse - New Construction	0.63	0.574	0.362	Varies by region

We did not find better estimates for these parameters. It does, however, appear that these calculations assume optimal daylight conditions for all full-load lighting hours and optimal weather conditions. Because of these assumptions, the estimates could overestimate savings. However, we did not have the necessary data to make adjustments.

Number of Affected Units

Estimates of area of new construction activity in the warehouse and retail categories were derived from a study of the new construction market.[23] PG&E's Commercial Building Survey Report was used to capture estimates of the percentage of construction that was in buildings larger than 25,000 sq. ft.[24] We were not able to identify any better sources of this data.

We did find that the estimates were overstated, because the requirement is for 50 percent daylighting, but the savings calculations assume that 100 percent of the lighting will be in a daylit area and will fully benefit from controls. Therefore, affected square footage should be reduced by 50 percent, as shown in Table 96.

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[20] TDV is time dependent valuation, which is designed to give more credit to electricity savings on peak.

[21] Xenergy, Inc. *California Statewide Commercial Sector Energy Efficiency Potential Study: Final Report*. Prepared for PG&E, July 2002.

[22] Heschong Mahone Group, Inc. *CASE Report: Updates to Title 24 Treatment of Skylights, Final Report*.

[23] NRNC Market Characterization and Program Activities Tracking Reports for PY 2001 and PY 2002.

[24] Pacific Gas and Electric Co. *Commercial Building Survey Report.* 1999.

Table 96: Retail and Warehouse New Construction Square Footage Affected

	SES (ADM)	Final
Retail - New Construction	4,410	2,205
Warehouse - New Construction	16,816	8,408

The affected square footage estimates may also be overstated—a significant amount of warehouse space will fall below the 0.5 watts/sq. ft. threshold, given that the average controlled LPD is 0.63. However, because we did not have access to data that would allow us to adjust the percentage of warehouse space with LPD below the threshold, no adjustment was made.

The two following factors may have affected the accuracy of the estimates, but we were unable within the scope of this study acquire the data required to analyze these factors in detail:

It does not appear that an adjustment was made for the refrigerated warehouse exemption.

It appears that no correction was made for multistory buildings. The calculations assume that all retail and warehouse buildings larger than 25,000 sq. ft. are single story, and this assumption may overstate the affected floor area.

Revised Statewide Potential Energy Savings Estimates

The only adjustment we made to the SES estimate was a correction for the affected floor area, as described above. Table 97 presents the SES estimate and our adjusted, final estimate.

Table 97: Final Statewide Lighting Controls under Skylights Potential Savings Estimate

	SES (ADM) Gross Savings	Final Potential Savings
GWh Savings	25.46	12.73

Standard B07 - Ducts in Existing Commercial Buildings

Description

This standard is a prescriptive measure that applies to the alteration of existing unitary, single-zone HVAC equipment in existing commercial buildings under certain specific conditions (see Table 98).

This measure applies to duct systems on unitary HVAC units serving up to 5,000 square feet of space and systems with at least 25 percent of ducts located outside the thermal boundary or in ventilated space. This measure requires ducts to be insulated to the current code level (currently R-8), duct sealing that keeps leakage below 15 percent (or reduces leakage by 60 percent with no visible leaks), and, if new ducts form an entirely new system, measured leakage cannot exceed 6 percent of fan flow.

The duct insulation portion of this measure is triggered by the installation of any new or replacement ducts in unconditioned space or inadequately insulated plenums. The duct sealing portion of this measure is triggered by replacement or installation of a furnace, a packaged indoor/outdoor unit, an air handler, cooling or heating coil, an outdoor condensing unit, a furnace heat exchanger, or a duct system.

This requirement is impacted by a related code change, which requires building envelope insulation to be installed in direct contact with the exterior building shell and does not recognize any insulating value for insulation on top of suspended T-bar ceilings. Installations are to be self-certified (tested) by the installing contractor and verified by a HERS rater. Table 98 summarizes the requirements.

Table 98: Code Requirements and Trigger Events

Duct Insulation and Sealing Requirements for New Systems and Replacements in Existing Buildings			
	Equipment	**Zone Size**	**Duct Location**
Applicable HVAC Systems	Packaged unitary single-zone	5000 sq. ft. (max)	25% or more in unconditioned space
Requirement	**Existing Ducts**	**New Ducts**	**Notes**
Duct insulation	R-8 (min)	R-8 (min)	
Duct Sealing	15% leakage (max) or	6% leakage (max)	
	60% reduction (min) and no visible leaks		
	Tested by installer	Tested by installer	Prescriptive minimum
	HERS rater verified	HERS rater verified	
Trigger Events	**Existing Ducts**	**New Ducts**	**Related Code Change**
Duct insulation required for	Any replacement ducts outside conditioned space	Any new ducts outside conditioned space	Insulation on T-bar ceiling no longer considered "in conditioned space"
Applicable Equipment	**New HVAC Systems and Replacements in Existing Buildings**		
Installation (new equipment) or replacement of any of the following equipment:	furnace, packaged indoor/outdoor unit, air handler, cooling or heating coil, outdoor condensing unit, furnace heat exchanger, or new duct system		

Energy Savings – First-Year Impact Estimates

Table 99 documents the initial first year savings impacts of the CASE measure according to the various studies conducted. The values shown in the Eley/ADM column were adopted in the SES. The derivation of these estimates is presented in the following sections.

Table 99: First-Year Savings Impact

	PG&E CASE[25]	**Eley[26]/ADM[27]**
GWh Savings	46	9.73
MW Demand Reduction	35	7.36
MTherm Savings	0.5	1.04

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25 Pacific Gas & Electric. *CASE Initiative, Duct Sealing for Commercial HVAC Alterations Final Report*. March 2004.

26 Eley Associates. *Impact Analysis, 2005 Update to the California Energy Efficiency Standards*. June 2003.

27 ADM, Inc. *Evaluation of Statewide Codes and Standards Program, Final Report*. Prepared for SCE: June 2004.

Per-Unit Savings Equation

To estimate savings, both the CASE report and the Eley report used similar techniques. A representative sampling of buildings was modeled (buildings with qualifying criteria weighted by type across all climate zones). They used DOE-2 to model heating and cooling loads and ASHRAE 152 calculations of duct efficiencies under standard heating and cooling conditions to modify the heating and cooling loads to account for duct losses. Calculations were made for buildings meeting 2001 codes, with and without the 2005 duct improvement measure. The difference represents the savings.

Per-unit savings were calculated separately for heating and cooling, and also for each climate zone.

Savings per unit = 2001 usage * (2005 seasonal duct efficiency - 2001 seasonal efficiency)

Table 100: Eley Report Seasonal Duct Efficiency Results

Table 53 – Alterations to Existing Nonresidential Building – Seasonal Duct Efficiency Assumptions

Climate zone	Heating Seasonal Duct Zone Temp	Cooling Seasonal Duct Zone Temp	2001 Heating Seasonal Efficiency	2001 Cooling Seasonal Efficiency	2005 Heating Seasonal Efficiency	2005 Cooling Seasonal Efficiency	Heating Savings	Cooling Savings
1	47.3	81.4	0.769	0.816	0.862	0.888	10.7%	8.1%
2	41.8	97.1	0.761	0.665	0.858	0.802	11.4%	17.1%
3	47.8	86.6	0.770	0.765	0.862	0.859	10.7%	10.9%
4	43.9	92.0	0.764	0.714	0.859	0.830	11.1%	14.0%
5	46.2	86.0	0.768	0.772	0.861	0.863	10.8%	10.6%
6	50.8	87.3	0.775	0.759	0.864	0.856	10.3%	11.3%
7	49.3	88.7	0.772	0.746	0.863	0.848	10.5%	12.1%
8	47.3	93.1	0.769	0.703	0.862	0.824	10.7%	14.7%
9	48.7	94.4	0.771	0.690	0.862	0.817	10.6%	15.5%
10	45.7	98.2	0.767	0.654	0.861	0.796	10.9%	17.9%
11	43.9	98.4	0.764	0.652	0.859	0.795	11.1%	18.0%
12	44.2	97.3	0.764	0.662	0.860	0.801	11.1%	17.3%
13	43.3	103.6	0.763	0.601	0.859	0.766	11.2%	21.5%
14	37.2	102.7	0.754	0.611	0.855	0.772	11.9%	20.9%
15	47.2	104.3	0.769	0.595	0.861	0.763	10.7%	22.0%
16	37.9	96.3	0.755	0.672	0.856	0.807	11.8%	16.6%
Average							11.0%	15.5%

Table 101: Eley Report Building Type Distribution

Table 54 – Fraction of Existing Building Floor Space with Equipment Affected by the Duct Sealing Provision

Building Type	Fraction of Existing Building Floor Space Served by Equipment Covered by Duct Sealing Provision
Large Offices	0.119
Small Offices	0.322
Restaurants	0.652
Retail	0.328
Food Stores	0.198
Warehouses	0.071
Schools	0.574
Colleges	0.037
Hospital/ Healthcare	0.118
Hotels/ Motels	0.135
Miscellaneous	0.330

Table 102: Eley Report Electricity Savings Calculations

Table 56 – First-Year Energy Savings from Duct Sealing in Alterations to Existing Nonresidential Buildings

Commercial Occupancy Types	Floor Area (million ft²)	Floor space affected (million ft²)	Cooling (kWh/sf-yr)	Heating (kWh/sf-yr)	Total Cooling Consumption of affected systems (GWh)	Total Cooling Savings (GWh)	Total Heating Consumption of affected systems (GWh)	Total Heating Savings (GWh)	Total Energy Savings (GWh)	Total TDV (kBtu)
Large Offices	1,024.28	3.238	4.17	0.45	13.83	2.14	1.46	0.16	2.30	43,621,808
Small Offices	361.03	3.091	2.52	0.17	2.81	0.44	0.53	0.06	0.49	9,762,568
Restaurants	145.17	2.516	4.42	0.45	1.61	0.25	1.13	0.12	0.37	8,837,690
Retail	882.35	7.687	1.4	0.1	9.50	1.47	0.77	0.08	1.56	29,044,692
Food Stores	230.52	1.211	2.54	0.33	0.71	0.11	0.40	0.04	0.15	3,500,718
Warehouses	787.43	1.494	0.35	0.13	0.41	0.06	0.19	0.02	0.09	1,886,110
Schools	457.47	6.977	0.74	0.24	2.36	0.37	1.67	0.18	0.55	13,001,053
Colleges	270.13	0.263	2.35	0.79	0.17	0.03	0.21	0.02	0.05	1,266,517
Hospital/ Healthcare	278.57	0.872	8.53	0.73	2.07	0.32	0.64	0.07	0.39	8,166,247
Hotels/ Motels	270.87	0.971	2.35	1.97	0.62	0.10	1.91	0.21	0.31	9,144,576
Miscellaneous	992.52	8.694	2.37	0.31	20.45	3.17	2.70	0.30	3.47	66,598,769
Total	5,700.34	37.015	2.5	0.39	54.54	8.45	14.44	1.28	9.73	172,236,965

Table 103: Eley Report Gas Savings Calculations

Table 58 – First-Year Gas Savings from Duct Sealing in Alterations to Existing Buildings

Commercial Occupancy Types	Floor Area (Millions SF)	Floor space affected (mSF)	Heating (kBtu/SF)	Total Heating Consumption of affected systems (kTherm)	Gas Savings (kTherm)	Total TDV kBtu
Large Offices	1,024.28	3.238	22.42	726	80	8,225,958
Small Offices	361.03	3.091	22.42	693	76	7,852,661
Restaurants	145.17	2.516	16.36	412	45	4,663,527
Retail	882.35	7.687	18.74	1,441	158	16,321,357
Food Stores	230.52	1.211	21.73	263	29	2,980,843
Warehouses	787.43	1.494	26.67	398	44	4,514,890
Schools	457.47	6.977	26.16	1,825	201	20,680,490
Colleges	270.13	0.263	19.31	51	6	575,136
Hospital/ Healthcare	278.57	0.872	60.48	528	58	5,977,341
Hotels/ Motels	270.87	0.971	20.36	198	22	2,239,927
Miscellaneous	992.52	8.694	33.08	2,876	316	32,583,585
Total	5,700.34	37.015		9,410	1,035	106,615,716

The CASE report and Eley report have similar per-unit savings estimates for electricity. Eley's estimates for natural gas savings, however, are considerably larger per unit. There was insufficient information available to fully explain the per-unit therm savings discrepancy. Given the more complete information presented on the Eley estimates, we accepted the Eley report values.

Number of Affected Units

The original CASE study projected 74,000 new unit installations per year. Eley did a more detailed analysis of NRNC data to project 37 million sq. ft. or (implied) 15,650 units per year. Because the Eley estimate took more factors into account, we believe it is more accurate.

Existing building stock and end-use intensity (EUI) data were obtained from the CEC.[28] The NRC database was used to estimate fraction of floor space served by equipment addressed by the standard by building type. The potentially affected area was calculated as follows:

Potentially affected area = Existing building area * percent of floor area served by qualifying equipment * fraction with duct outside conditioned space * Annual frequency of HVAC component replacement
Table 104 summarizes the data used in the calculation and estimated affected area.

Table 104: Potentially Affected Area

	Eley
Existing Building Stock (sq. ft.)	5,700,340,000
HVAC System Replacement Frequency	5%
Fraction With Ducts Outside Conditioned Spaces[29]	62.5%
Floor Area Served by Qualifying Equipment	24.45%
Potentially Affected Area (sq. ft.)	43,547,059

Market Penetration

Both the original CASE report and the Eley report take into account the estimated penetration of this measure in the market without the standard. Both use 15 percent as the share of all eligible duct systems that are tight enough to be exempt from the sealing requirement.[30] The final CASE report cited a larger study indicating that the figure is 18 percent.[31] The affected square footage from the Eley report is shown in Table 105, along with our estimate. In our study approach, the market penetration is taken into account, not in this step, but in the NOMAD adjustment.

Table 105: Affected Square Footage

	Eley	**Recommended**
Potentially Affected Area (sq. ft.)	43,547,059	43,547,059
Adjustment for Market Penetration	85%	N/A
Affected Area (sq. ft.)	37,015,000	43,547,059

Revised Statewide Potential Energy Savings Estimates

Total savings = Sum of building energy savings weighted by type and climate zone

We were unable to identify more accurate data than used in these past studies and the prior estimates appeared reasonable, although documentation was not sufficient. We used the gross savings values in the SES, based on the Eley and ADM reports, and adjusted them by taking out the initial market penetration assumed in the prior studies. As noted, our evaluation addresses the underlying market penetration in the

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[28] Quantec. *Statewide Codes and Standards Market Adoption and Noncompliance Rates*. 5/10/2007.

[29] Delp, W. W., et al. *Field Investigation of Duct System Performance in California Light Commercial Buildings*, ASHRAE Trans. 104(II). June 1998.

[30] M.P. Modera and J. Proctor. *Combining Duct Sealing and Refrigerant Charge Testing to Reduce Peak Electricity Demand in Southern California*. July 2002.

[31] M.P. Modera and J. Proctor. *A Campaign to Reduce Light Commercial Peak Load in the Southern California Edison Service Territory through Duct Sealing and A/C Tune-ups.* 2003.

NOMAD analysis. The SES values of gross savings and our estimates of potential savings are presented in Table 106.

Table 106: Final Statewide Ducts in Existing Commercial Buildings Savings Estimates

	SES (Eley/ADM) Gross Savings	Final Potential Savings
GWh Savings	9.73	11.45
MW Demand Reduction	7.36	8.66
MTherm Savings	1.04	1.22

Standard B08 – Cool Roofs

Description

The cool roofs requirement is a prescriptive measure that applies to all new and replacement roofs on space conditioned, nonresidential buildings with low sloped roofs of 2:12 or less. The code revisions changed what used to be an energy *compliance credit* for cool roofs in the 2001 Title 24 to a *prescriptive requirement* in the 2005 Title 24.

The code changes also included a mandatory measure related to the alteration of buildings triggered when more than 50 percent or 2,000 sq. ft (whichever is less) of the existing roof membrane is replaced. This requirement cannot be traded off against other improvements if only the roof repair and replacement is included in the scope of work of the building permit. Consequently, this is arguably a much more stringent requirement than the new construction requirement with potentially much greater and far-reaching impacts, if fully enforced.

This change also defines mandatory performance criteria and product package labeling requirements for cool roof coatings that apply to certain roofing materials. A cool roof is defined as a roofing material having an initial reflectance of at least 70 percent and a thermal emittance greater than 75 percent. Clay and concrete tiles (initial solar reflectance of 40 percent or greater and a thermal emittance of 75 percent or greater) are allowed on roofs with a slope greater than 2:12. Metallic roofs are allowed a lower thermal emittance, as long as they have a higher solar reflectance [0.70 + {0.34 x (0.75 – initial emittance)}]. The Cool Roof Rating Council (CRRC) is responsible for certificating roofing products that comply with the above standards. Qualification as an ENERGY STAR roof is not an automatic qualification as a cool roof under Title 24 because of differing qualification criteria.

Energy Savings – First-Year Impact Estimates

Table 107 shows the first-year savings impacts of the measure, according to the CASE report and Eley report.

Table 107: First-Year Savings Estimates

	PG&E CASE	Eley
GWh Savings	43	14.6
MW Demand Reduction	26.7	9.5
MTherm Savings	-0.577	-0.203

Per-Unit Savings Equation

The Eley method used PG&E CASE report DOE-2 modeling data for cool roofs in all 16 California climate zones (Eley, Table 59, p.52), but differed from the CASE report with respect to assumptions about the number of square feet of applicable nonresidential roof. Eley calculated the roof area that the standard would affect using assumptions listed in Table 60 (p. 52) of the report.

Eley report savings per unit = 2005 CASE roof modeled with a solar reflectance of 55% - 2001 CASE roof modeled with a solar reflectance of 30%

Eley report total savings = savings per unit * cool roof replacement market

Number of Affected Units

Savings estimates vary substantially between the PG&E CASE report and the Eley report, primarily because of differences in the amount of building stock assumed to be affected by this measure. The CASE report based estimates of aggregate savings on new construction data from the NRNC database and applied a multiplier of 2.9 to reach a 134 million sq. ft. of existing non-cool roof. The factor of 2.9 was derived from the proportion of re-roof to new roof sales—$4.1 billion and $1.4 billion (Western Roofing, 1999). The Eley report began with an estimated 5.7 billion sq. ft. of nonresidential building stock and applied several multipliers to arrive at 45 million sq. ft. of roof that would not otherwise have met the requirement. The roof percentage was calculated with the following equation.

Eley report qualifying percentage = nonres ft² floor area * % roof to floor area * % of non-cool roof installed * % of conditioned space * % exempt or unpermitted * replacement rate.

Table 108: Eley Report, Table 60: Cool Roofs First-Year Savings Calculations Assumptions (p. 52)

Assumptions	
Existing building stock	5,700,340,000 ft²
Frequency of roof replacement	15 years
Percent low-slope application	80%
Percent exempted built-up roof	50%
Market penetration of non-cool roof products.	80%
Ratio of roof area to floor area	80%
Ratio of daytime conditioned sq. ft. to total sq. ft.	46%
Total cool roof replacement market	44,751,469 ft²/year
Unit Energy and Demand Savings	
Unit electricity savings	327 kWh/1,000 ft²
Unit demand savings	0.21 kW/1,000 ft²
Unit gas impact	-4.5 therms/1000 ft²
Statewide Impact	
Electricity savings	14.6 GWh
Demand savings	9.5 MW
Gas Impact	-203,465 therms

Because the SES uses values from the Eley report, our review focused on this study.

Market Penetration

The Eley report assumes that 20 percent of the qualifying roof area would have a cool roof. In our analysis, no market penetration is assumed at this stage, as the adjustment is made through the NOMAD analysis.

Revised Statewide Potential Energy Savings Estimates

The Eley report used a detailed screen to arrive at total eligible square footage for replacement roofs. Table 109 shows saving estimates from the Eley report used in the SES. Our estimates differ only by eliminating the estimated 20 percent market penetration factor from the potential savings calculation.

Note that the SES does not include a natural gas consumption penalty though the studies discussed above estimated an increase in gas consumption, and no explanation was found for not including a consumption increase in the SES.

Table 109: Final Statewide Cool Roofs Savings Estimates

	SES (Eley[32]) Gross Savings	Final Potential Savings
GWh Savings	14.6	18.3
MW Demand Reduction	9.5	11.9
MTherm Savings	--	-0.252

Standard B09 – Relocatable Classrooms

Description

This standard is developed for factory-built classrooms for which the ultimate location is not known. The requirement outlines a new prescriptive package, including envelope and lighting measures, specifically targeting modular classrooms. Heat pump efficiency references the NAECA requirements, which also were assumed to increase when this code change took effect.

Energy Savings – Initial First-Year Impact Estimates

The following table documents the initial first-year savings impacts of this measure according to the studies conducted by various authors and reviewers. The ADM values were adopted in the SES.

Table 110: First-Year Savings

	Eley[33]	AEC/HMG[34]	ADM[35]
GWh Savings	3.1	5.6	2.9
MW Demand Reduction	-	0.32	-
MTherm Savings	-	-	-

Per-Unit Savings Equation

Per-unit (800 sq. ft. modular classroom) energy savings were estimated using EnergyPro and DOE-2. The baseline common practice modeling assumptions used in the original CASE report[36] and Eley report are presented in Table 111. The common practice assumptions appear to be reasonable.

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[32] Eley Associates. *Impact Analysis: 2005 Update to the California Energy Efficiency Standards for Residential and Non-Residential Buildings*. June 2003.

[33] Eley and Associates. *Impact Analysis for Residential and Nonresidential Buildings*. June 2003.

[34] Heschong Mahone Group, Inc. *Codes and Standards Enhancement Initiatives for 2005 Title 24, Final Report*. March 2004.

[35] ADM Associates. *Evaluation of 2002 Statewide C&S Program*. June 2004.

[36] Pacific Gas & Electric Co. *Code Change Proposal for High Performance Relocatable Classrooms*. June 2002.

Table 111: Summary of Baseline Assumption for Relocatable Classrooms.

Wall insulation	R-11 (no insulation on beams)
Floor insulation	R-1
Ceiling insulation	R-19
Glass type	2-pane standard
Lighting power density	1.71 W/sq. ft.
Hear pump efficiency	10 SEER

Buildings were modeled in five climate zones, and the difference in energy use between the baseline and proposed building is the following.

Unit savings = Energy usage for common practice building – Energy usage for 2005 compliant building

ADM used population estimates for each climate zone from Table 49 in the Eley report to calculate a weighted average savings of 970 kWh/yr.

Number of Affected Units

The case report assumed that 3,000 new relocatable classrooms are built each year. Having no revised data on construction rates, we believe this number is reasonable.

Market Penetration

The estimates assume no naturally occurring market adoption. Consequently, no adjustment was made, and this assumption is consistent with our approach estimating market penetration in the NOMAD analysis.

Revised Statewide Potential Energy Savings Estimates

Based on the information presented above, we believe the ADM estimate adopted in the SES is reliable. Potential savings are shown in Table 112.

Table 112: Final Statewide
Relocatable Classrooms Savings Estimates.

	SES (ADM) Gross Savings	Final Potential Savings
GWh Savings	2.9	2.9
MW Demand Reduction	-	-
MTherm Savings	-	-

Standard B10 – Bi-Level Lighting

Description

The measure provides a credit when a qualified bi-level occupancy sensor is installed in certain types of qualified spaces. New technologies that incorporate bi-level lighting in intermittently-occupied spaces will be encouraged through control credits in the form of a Power Adjustment Factor, or PAF. The PAF is calculated to provide credit for only a portion of the energy saved. The PAF represents the potential savings that can be traded off while the remaining savings are realized. The three spaces identified as eligible for PAFs are corridors, library and warehouse stacks, and small offices. Qualified controls include automated bi-level controls and manual-on bi-levels controls. Qualified space types include the general lighting of any enclosed space 100 sq. ft. or larger in which the connected lighting includes more than one fixture and exceeds 0.8 watts per sq. ft. The standard specifies more details.

Energy Savings – First-Year Impact Estimates

Table 113 presents the initial estimates of first year savings for this measure, according to the prior studies. The Eley report[37] made no estimate of savings from this measure. None of the prior authors evaluated the interaction between lighting and space heating and cooling impacts.

Table 113: First-Year Savings Estimates

	PG&E CASE[38] and AEC/HMG[39]	ADM[40]
GWh Savings	1.2	12.14
MW Demand Reduction	0.54	-
MTherm Savings	-	-

As the table shows, ADM's savings estimate is ten times higher than the CASE estimate. The HMG report uses the same lower numbers as the CASE report.

Per-Unit Savings Equation

Net savings are calculated by subtracting the PAF (which can be thought of as the percent of savings that will be traded off and consequently unrealized) from the total potential savings from the use of the qualifying controls. The equation for calculating the net savings percentage is:

Net savings percentage = potential savings % - PAF

The CASE report calculated potential savings for the types of spaces under consideration, as well as the net realized savings after PAF credits are taken, as shown in Table 114.

Table 114. CASE Report Net Savings for Space Types

Type of Space	Potential Savings per Watt Controlled	Power Adjustment Factor	Net Savings
Office	32%	20%	12%
Corridors	50%	25%	25%
Library Stacks	50%	15%	35%
Warehouse Spaces	30%	15%	15%
Classrooms	32%	20%	12%

[37] Eley Associates. *Impact Analysis for Residential and Nonresidential Buildings*. June 2003.

[38] Pacific Gas & Electric. CASE Initiative, Bi-Level Control Credits Final Report. March 2004

[39] Heschong Mahone Group, Inc. *Codes and Standards Enhancement Initiatives for 2005 Title 24, Final Report.* Prepared for PG&E: March 2004.

[40] ADM, Inc. *Evaluation of Statewide Codes and Standards Program, Final Report*. Prepared for SCE: June 2004.

ADM used a PAF of 25% percent for library stacks, thereby reducing the net savings to 25 percent. It is not clear whether they used the same estimates for the number of hours controlled annually.

To estimate energy savings, the following equations were used:

Baseline usage (kWh/sf) = LPD * annual hours controlled / 1000 w/kW
Savings per unit = Baseline usage * net savings percentage

The CASE report per unit savings estimates are shown in Table 115.

Table 115: Per-Unit Savings Calculations

Type of Space	LPD	Annual Hours Controlled	Baseline Usage (kWh/sf)	Net Savings	Savings (kWh/sf)
Office	1.2	1,014	1.22	0.12	0.146
Corridors	0.6	4,368	2.62	0.25	0.655
Library Stacks	1.5	1,690	2.54	0.35	0.887
Warehouse Spaces	0.6	1,170	0.7	0.15	0.105
Classrooms	1.2	1,014	1.22	0.12	0.146

Because allowed LPD is mandated, the only variable open to further research is hours controlled. For this study, we found no data that would suggest we use different hours controlled.

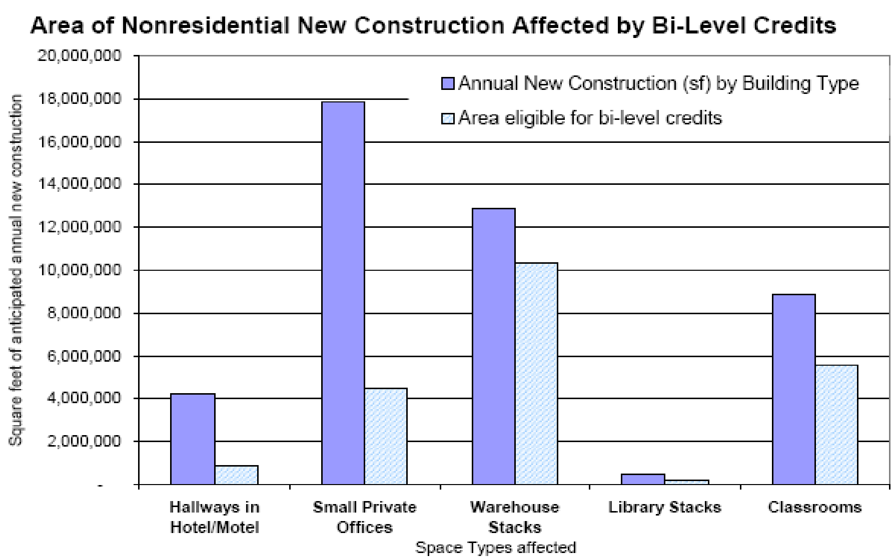
Number of Affected Units

Statewide savings estimates are based on eligible areas of buildings and the square footage of these areas within nonresidential buildings, as per the CEC NRNC database. The calculation is as follows.

Number of units = square footage under controls * % wattage controlled

The CASE report assumed that half of the wattage was controlled. The CASE report estimated eligible area for each building type (including classrooms), as shown in Figure 2.

Figure 2: CASE Report's Estimate of the Square Footage of Eligible Areas



The CASE report used CEC data to determine total square footage of new construction eligible for control credits and used both CEC data and NRNC data to determine the percentage of building areas eligible for control credits, broken down by building type. The ADM report, however, used NRNC data to estimate square footage of construction and used the NRNC database to determine the percentage of spaces with lighting controls installed.

ADM did not state how much area was assumed to be under controls, but instead estimated the expected annual lighting use for spaces of each type likely to be controlled. Assuming that ADM used the same assumptions as the CASE report for savings per unit, the ADM's assumed eligible areas can be calculated and compared to those in the CASE report, as shown in Table 116.

Table 116: Comparison of Eligible Areas Estimated

Space Types Eligible for Credit	CASE Eligible Area Under Control (sq. ft.)	% Wattage Controlled	CASE Effective Area Under Control (sq. ft.)	Implied ADM Effective Area Under Control (sq. ft.)
Small private offices	4,476,410	50%	2,238,205	63,194,592
Corridors	842,740	50%	421,370	159,405
Library stacks	221,348	50%	110,674	1,233,124
Warehouse stacks	10,313,200	50%	5,156,600	19,301,098
Classrooms	5,577,957	50%	2,788,979	-
Total			10,715,828	83,888,219

ADM's apparent square footage controlled is ten times higher than that in the CASE report. In addition to much higher estimates of eligible areas, ADM appears to be assuming that all of the eligible wattage in those areas would be controlled. By contrast, the CASE report estimates less eligible areas and assumes that only half the wattage in those areas would be under controls.

The large discrepancy in estimates of eligible areas should be resolved with further research. Because this measure is a voluntary credit, and because it seems likely that the wattages controlled that ADM assumed are implausibly high, we believe that the CASE report's more conservative estimates for affected area should be used.

Market Penetration

None of the studies cited specifically addressed market penetration, so we have to assume that the calculations are based on an initial market penetration of zero for bi-level lighting controls in eligible spaces. ADM describes using the NRNC database to calculate the percentage of spaces that have lighting controls installed (or would be likely to). However, no figures are given, and no sources are cited. For our purposes, the initial market penetration is addressed in the NOMAD analysis, so initial market penetration is not a factor in calculating the potential savings.

Demand Savings

ADM claimed that no energy saving from this measure would be during peak hours, while the CASE report estimated that some savings from offices, libraries, and warehouses would be realized during peak. The peak coincident energy savings for libraries and warehouses should be the subject of further research, but it seems clear that office savings would be realized during peak. We recommend that the office demand savings be included. In the CASE report they are calculated as follows:

Demand savings = wattage under control * net peak coincident demand savings percentage

The CASE report estimates 2.69 MW under control for offices. Using the net savings calculation for offices, which is 12 percent, the demand reduction would be 0.32 MW.

Revised Statewide Potential Energy Savings Estimates

Table 117 shows the savings estimates by space type for the original CASE report, ADM report, and our revised savings estimates based on the CASE report information. We found a mathematical error in the CASE report calculation. Correcting that error accounts for the difference in our estimate. The ADM estimate is used in the SES.

Table 117: Revised Savings by Space Type

Type of Space	CASE (GWh)	ADM (GWh)	CASE Effective Area Under Control (sq. ft.)	Savings (kWh/sf)	Final (GWh)	Final Demand Reduction (MW)
Office	0.326	9.227	2,238,205	0.146	0.327	0.32
Corridors	0.092	0.104	421,370	0.655	0.276	-
Library stacks	0.112	0.781	110,674	0.887	0.098	-
Warehouse spaces	0.18	2.032	5,156,600	0.105	0.543	-
Classrooms	0.52	-	2,788,979	0.146	0.407	-
TOTALS	**1.23**	**12.1**			**1.65**	**0.32**

Although there are interaction effects between lighting controls and space heating and cooling energy use, significant effort would be required to estimate the impacts, and this was beyond the scope of the current evaluation. The potential interaction effects on peak electricity demand are probably more significant than the effects on space heating and would be worthy of further research. Table 118 summarizes the final statewide energy and demand savings.

Table 118: Final Statewide Bi-Level Lighting Savings Estimates

	SES (ADM) Gross Savings	Final Potential Savings
GWh Savings	12.14	1.65
MW Demand Reduction	-	0.32
MTherm Savings	-	-

Standard B11 – Ducts in New Commercial Buildings

Description

This measure is a prescriptive requirement that applies to new commercial buildings and requires duct sealing and insulation so that leakage is below 6 percent and ducts are insulated to the prescriptive requirement (currently R-8).

The duct sealing portion of this measure applies to duct systems on constant volume unitary HVAC units serving up to 5,000 sq. ft. of space in a single zone, with at least 25 percent of the ducts located outside the thermal boundary or in ventilated space.

Energy Savings – Initial First-Year Impact Estimates

Table 119 displays the first year savings impacts of the CASE measure according to several reports. The CASE report[41] did not estimate statewide savings, and the Eley report estimates were aggregated with other new construction measures. The ADM estimates were adopted in the SES.

Table 119: First-Year Savings Estimates

	AEC/HMG[42]	ADM[43]
GWh Savings	4.14	8.01
MW Demand Reduction	4.17	-
MTherm Savings	0.04	-

Per-Unit Savings Equation

Although the Eley report did not break out savings for this measure, it established several conditions used in other analyses. The Eley report modeled a representative building sample made up of buildings from the NRNC database, with qualifying criteria weighted by type across all climate zones. They used DOE-2 to model heating and cooling loads and ASHRAE 152 calculations of duct efficiencies under heating and cooling conditions to modify the heating and cooling loads to account for duct losses. Calculations were made for buildings meeting the 2001 and 2005 Title 24 with the basic assumptions shown in Table 120. The difference represents the savings for whole buildings and all measures combined. ADM used Eley's methodology, and calculated electricity savings for the cooling season, but did not calculate heating savings.

Table 120: Eley Report Modeling Assumptions.

	2001	2005
Duct Leakage	36% (12)	8%
Duct Insulation	R-4.2	R-8
Roof	Non-cool	Cool

ADM's estimated seasonal savings for each climate zone are shown in Table 121. The savings percentage was calculated using the equation below.

Savings % = (2005 duct efficiency - 2001 duct efficiency) / 2005 duct efficiency

[41] Pacific Gas & Electric Co. *Codes and Standards Enhancement Initiative (CASE): 2005 Title 24 Building Energy Efficiency Standards Update, Code Change Proposal for Non-Residential Duct Sealing and Insulation*. July 2002.

[42] Heschong Mahone Group, Inc. *Codes and Standards Enhancement Initiatives for 2005 Title 24, Final Report*. Prepared for PG&E: March 2004.

[43] ADM Associates. *Evaluation of 2002 Statewide Codes and Standards Program*. June 2004.

Table 121: Seasonal Savings Based on Duct Efficiency Improvements.

Climate Zone	Heating Season Savings	Cooling Season Savings
1	16%	14%
2	16%	27%
3	16%	18%
4	16%	22%
5	16%	18%
6	15%	19%
7	16%	20%
8	16%	23%
9	16%	24%
10	16%	27%
11	16%	27%
12	16%	27%
13	16%	32%
14	17%	31%
15	16%	32%
16	17%	26%
Average	**16%**	**24%**

ADM did not present details by climate zone or building type, but a statewide average for baseline unit usage can be inferred to be 1.4 kWh/sf. The savings per unit are calculated as follows.

Savings per unit = 2001 usage/sf * seasonal savings %

Using this equation, ADM's average cooling savings per unit were 0.34 kWh/sf (1.4 kWh/sf * 24%). ADM did not estimate unit electric demand or heating savings from this measure.

Number of Affected Units

Only a portion of ducts in newly constructed spaces will be affected by this measure.

Number of units = new construction area * fraction with ducts outside conditioned spaces

The Eley report presented estimates of floor area affected, but the AEC/HMG report did not. We used the ratio between the new commercial floor area used in the Eley report (159,000,000 sq.ft.) and our estimate of commercial floor area actually completed in 2006 that would be covered by the 2005 Title 24 (47,334,034 sq.ft.) to derive the potential savings.

Market Penetration

No adjustments were made to account for market penetration. Eley states that 15 percent of duct systems in existing commercial buildings are tight enough to be exempt from the sealing requirement. That suggests that some duct systems are already being installed with adequate sealing. However, the tightness requirements are more stringent for new construction. For the purposes of our analyses, we do not take any initial market penetration into account.

Revised Statewide Potential Energy Savings Estimates

ADM only attributed saving from this measure to reduced electricity usage. However, this measure does reduce peak and natural gas consumption. The AEC/HMG report presents estimates of peak demand and gas savings. Its estimate of electricity savings is substantially more conservative than ADM's, so we assume that the other estimates are also conservative. We recommend including the estimated gas and demand savings from the AEC/HMG study, and we recommend using ADM's estimate for GWh savings because it is well documented and uses a sound estimation approach. The alternative estimates and the final evaluation estimates are shown in Table 122. The final potential savings estimates take into account the estimated floor area constructed during 2006 that was covered by the 2005 Title 24.

Table 122: Final Statewide Ducts in New Commercial Buildings Savings Estimates

	AEC/HMG	SES (ADM) Gross Savings	Final Potential Savings
GWh Savings	4.14	8.01	2.39
MW Demand Reduction	4.17	-	1.24
MTherm Savings	0.04	-	0.012

Standard B12 – Cooling Towers

Description

This measure is a prescriptive requirement that applies to the design of central chiller plants for nonresidential new construction. HVAC system replacement or expansion could also trigger this measure.

There are three changes to the standard affecting chiller system design:

1. Central chiller plants above 300 tons must limit air-cooling to 100 tons; the rest must be water-cooled.
2. Cooling towers rated above 300 tons must accommodate variations in flow to take advantage of increased efficiency at part-load conditions.
3. In chiller plants above 300 tons, propeller fans must be used in cooling towers, not centrifugal, with the exception of low-profile applications, high-static pressure conditions, and noise-sensitive environments.

Energy Savings – First-Year Impact Estimates

The savings claims shown below in Table 123 and contained in the SES come from the ADM report. The original CASE report did not address statewide savings. No reports addressed electricity demand (MW) savings. There are no natural gas therm savings because any potential natural gas savings from efficiency gains of gas-fired chillers is nominal, as the market penetration of gas-fired chillers is very small. Table 124 shows the estimated savings from each requirement.

Table 123: Initial Savings

	ADM
GWh Savings	3.01
MW Demand Reduction	-
MTherm Savings	-

Table 124: Savings Attributable to Each Submeasure

Attributed To	Savings (GWh)	Demand (MW)	Therms
Limitation on air-cooling	1.01	-	0
Chiller plant flow turn-down	-	-	0
Limitation on centrifugal fans	2	-	0
Total	**3.01**	**-**	**0**

Per-Unit Savings Equations

Although the CASE report does not provide statewide savings estimates, it does estimate unit savings. Per-unit energy savings are based on DOE-2 simulations of four chiller configurations for a generic 10-story, 100,000 sq. ft. office building in three representative climate zones. The modeling assumptions for each of the 12 parametric runs are well documented in the CASE report. Results were interpolated to estimate savings per unit in different climate zones. Savings per square foot were estimated as follows:

> Savings per sq. ft. = Cooling energy use of baseline building with air-cooled chiller kWh/sq. ft. – cooling energy use for proposed water-cooled chiller system kWh/sq. ft

Eley performed an independent DOE-2 analysis of these measures in a similar manner, but no estimate for the cooling tower requirement or any of its subcomponents, was provided separately from the overall savings for all standards combined.

ADM evaluated two of the three subcomponent measures recommended in the CASE report using customized reports based on data extracted from the NRNC database. The ADM approach does not lend itself to an analysis on a per-unit basis because the energy savings (kWh) and numbers of units (square footage of two types of nonresidential buildings) are part and parcel of the NRNC database from which the savings were estimated.

The ADM savings estimates were based on limited data and relied on key unverified assumptions, so their accuracy is questionable without additional research and data.

Number of Affected Units

The base unit used in this analysis is square footage of nonresidential buildings and kWh of cooling energy associated with a range of building types deemed to be constructed with 300 ton or larger chillers.

> Number of Units = square footage of nonres construction with air-cooled chillers > 300 tons

Of the ten types of nonresidential buildings included in the NRNC database, ADM reported that only two of these types showed that they had air-cooled central chillers larger than 300 tons—medical/clinical and library buildings. These data were used to estimate both the square footage and energy savings from cooling tower measures prescribed by the CASE report.

Rather than attempt to count the number of chiller plants expected to be found and apply a per-chiller savings estimate, the ADM statewide savings estimates are based on the deemed square footage of applicable buildings and affected kWh serving the applicable building types as reported in the NRNC database.

Market Penetration

No clear information was provided on the penetration of these measures in the market or how that effect was taken into account in the analysis. For our purposes, we account for initial market penetration in the NOMAD analysis.

Demand Savings

Demand savings are claimed in the CASE report but remain unsubstantiated. The ADM report does not estimate demand savings.

Revised Statewide Potential Energy Savings Estimates

Although the estimates from these various studies differ, the modeling results indicate credible potential savings from this standard. Consequently, we accept the ADM estimates included in the SES. The ADM study identified energy savings but provided no estimate of demand savings.

Table 125 summarizes the savings estimates and our recommended values.

Table 125: Final Statewide Cooling Towers Savings Estimates

	SES (ADM) Gross Savings	Final Potential Savings
GWh Savings	3.01	3.01
MW Demand Reduction	-	0
MTherm Savings	-	0

Standard B13 – Multifamily Water Heating

Description

This is a prescriptive measure that changes the computer modeling rules for multifamily buildings. The standard energy budget for water heating is based on the same type of system as the proposed water heater. In the past, the proposed design was compared against a standard design that was always a 50-gallon individual water heater in each dwelling unit, and distribution losses were not adequately included in the calculation of water heating impacts. Because central water heaters tend to appear more energy efficient under these modeling conditions, buildings with central systems were credited with unrealistically large energy savings.

Energy Savings – First-Year Impact Estimates

Table 126 shows the first-year savings impacts of this measure according to previous studies. The CASE report[44] did not estimate statewide savings. Only therm savings result from this measure, as it is based on gas water heating.

Table 126: First-Year Savings Impact.

	AEC/HMG[45]	Eley[46]/ADM[47]
GWh Savings	-	-
MW Demand Reduction	-	-
MTherm Savings	0.89	1.54

Per-Unit Savings Equation

To estimate the savings per dwelling unit, the Eley report used a prototype model with a central boiler as a standard design. The difference between the 2001 code standard design, which included modeling a single 50-gallon water heater in each dwelling unit, and this prototype yielded the energy savings estimate per dwelling unit. The 2001 and 2005 DHW therm usage results from the modeling were not presented.

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[44] Pacific Gas & Electric. *CASE Initiative: Code Change Proposal for Multifamily Water Heating*. May 2002.

[45] Heschong Mahone Group, Inc. *Codes and Standards Enhancement Initiatives for 2005 Title 24, Final Report*. Prepared for PG&E: March, 2004.

[46] Eley Associates. *Impact Analysis for Residential and Nonresidential Buildings*. June 2003.

[47] ADM, Inc. *Evaluation of Statewide Codes and Standards Program, Final Report*. Prepared for SCE: June 2004.

No information is available on the per-unit savings calculations used by AEC.

Number of Affected Units

Eley obtained estimates of new construction activity by climate zone through the Construction Industry Research Board (CIRB).

A phone survey was used to determine how many multifamily buildings would be constructed with central boilers and individual water heaters. In climate zones 6-10, it was estimated that 40 percent of the multifamily buildings would have central boiler systems. In the remaining climate zones, it was estimated that 15 percent of the multifamily buildings would have central boiler systems. The number of affected units in each zone was calculated as follows:

Number of affected units = number newly constructed dwelling units * percentage of units with central DHW systems

The estimated number of new multifamily dwelling units was 41,734. It did not appear that the information on the percent of units with central systems was used to adjust the estimated savings. The evaluation team applied these adjustments to the original estimates by climate zone as shown in Table 127.

Table 127. Revised Savings Estimates by Climate Zone

CEC Climate Zone	Multi-Family Units	% Central DHW	Applicable Units	Therm Savings/Unit	Therm Savings/CZ
1	627	15%	94	30.85	2,901
2	1,364	15%	205	31.26	6,396
3	4,260	15%	639	31.26	19,975
4	10,471	15%	1,571	31.44	49,381
5	238	15%	36	31.27	1,116
6	1,938	40%	775	41.86	32,450
7	2,833	40%	1,133	42.10	47,708
8	747	40%	299	42.19	12,606
9	2,423	40%	969	42.35	41,046
10	1,665	40%	666	42.40	28,238
11	881	15%	132	31.67	4,185
12	11,166	15%	1,675	31.47	52,709
13	851	15%	128	32.16	4,105
14	236	15%	35	31.89	1,129
15	1,334	15%	200	34.66	6,935
16	697	15%	105	30.56	3,195
Statewide Total	41,732		8,661		314,077

No information was available about the number of units used in AEC’s calculations.

Market Penetration

No market penetration was assumed. For the purposes of our evaluation approach, we take market penetration into account in the NOMAD analysis, so would not include it here.

Revised Statewide Potential Energy Savings Estimates

Based on the information provided, we believe the Eley savings estimate is reasonable. This is the value used in the SES. The two prior savings estimates and our final evaluated estimate are presented in Table 128. The Eley/ADM value is included in the SES.

Table 128: Final Statewide Multifamily Water Heating Savings Estimates

	AEC/HMG Gross Savings	SES (Eley/ADM) Gross Savings	Final Potential Savings
GWh Savings	-	-	-
MW Demand Reduction	-	-	-
MTherm Savings	0.89	1.54	0.31

Standard B14 – Composite for Remainder

Overview and Description

The measures adopted in the 2005 Title 24 Standards can be separated into two groups—those for which the IOUs created CASE reports and those for which they did not. The current SES and documentation prepared by HMG estimate savings for each of the individual standards for which a CASE report was prepared; for all remaining building standard measures they provide an estimate of savings for them combined. These other measures are aggregated as the "Composite for Remainder" (CfR) in the SES and supporting documents.

To estimate savings attributable to the C&S Program, the CfR is treated the same way in the SES as all the individual measures described above. Gross savings are adjusted for compliance, naturally occurring market adoption, and attribution to the utility C&S Program. There is little or no documentation readily available, however, on what measures comprise the composite, the gross savings of the individual measures, and the contribution of the C&S Program to the adoption of individual measures. Our evaluation applies a systematic approach to assess the verified savings that can be credited to these measures using all the information available.

Methodology

Because of the nature of the CfR category, the approach used to analyze the savings was different than the one used to review the other measures. The steps in the approach are presented below, followed by the results of our analysis.

Step 1: Initial identification of measures in composite for remainder

The first step in the evaluation process of the composite for remainder gross energy savings is to determine what specific measures were included. There are two separate documents available to determine the list of measures. The first was published by the California Energy Commission and we refer to it as the CEC document.[48] The second was provided by HMG in response to a request to the utilities and we refer to it as the HMG document.[49] We reviewed these documents and cross-reference them as discussed below to determine the measures included in the composite group.

The CEC document provides a brief overview of all the changes in the 2006 building standards. We compared all these changes to the standards analyzed in our evaluation. If the measure did not

[48] California Energy Commission (CEC). "Summary of the 2005 Changes to the California Building Energy Efficiency Standards Title 24, Parts 1 and 6, of the California Code of Regulations," Version: October 19, 2004.

[49] List of measures supplied by HMG to Cadmus; received via e-mail on April 23, 2008.

correspond to one of the building standards addressed by CASE reports and discussed above, we assigned it to the CfR group. This became the preliminary list of measures to be evaluated as the CfR.

The HMG document was compared to the list of measures developed using the CEC document. Ideally, there would be a one-to-one relationship.

Once we had a comprehensive list of measures, it was possible to begin an assessment of total gross energy savings. A third reference, the ADM report,[50] disaggregated the savings estimates presented in the Eley report[51] into specific building standards, although the disaggregation methodology was not clearly defined. The Eley report estimated savings from the 2005 standards by simulating buildings built to the 2001 and 2005 Title 24 and taking the difference in consumption as the savings. We reviewed the Eley report to determine how the savings for the CfR group was determined (claimed gross first-year energy savings of 322 GWh).

We made an effort to duplicate these estimated savings by using the values shown in the ADM report. The comparison was made as shown below, where the value for 2005 residential and nonresidential code revisions indicate all the energy savings for the sector while the residential and nonresidential C&S Program code revisions include only the energy savings claimed for a specific building standard for which a CASE report was prepared. Conceptually, the difference would be the savings attributable to the CfR.

(All 2005 residential code revisions - Residential C&S Program code revisions) + (All 2005 Nonresidential code revisions - Nonresidential C&S Program code revisions) = Composite for Remainder Group Gross Energy Savings in Year 1

Once a complete list of measures in the composite group was determined and the total gross energy savings were replicated, an evaluation of the gross energy savings by measure was conducted.

Step 2: Final identification of measures in CfR and savings adjustment

The first step in the final identification of the CfR savings adjustment was to compile a list of all the simulation model modifications made in the Eley report to analyze the 2005 Title relative to the 2001 Title 24. This list was then reviewed to identify measures that corresponded to specific standards for which CASE reports were prepared. The measures in CASE reports were dropped from the list of all measures included in the Eley report analysis. The measures left over were those that produced the savings in the ADM report tabulated as the CfR savings.

Next, we compare this list of composite measures with the list created in Step 1. For any measures from the Eley report that did not correspond to a specific measure in the list created in Step 1 an adjustment or reduction was made as described next, if possible. An example of such measures that could drop out from the list includes federal efficiency standards for air conditioners since their savings were included in the Eley report estimate, but they were not a standard adopted by California.

Gross energy savings were adjusted by modifying the savings in the Eley report for those end uses affected by the measures that were dropped based on the Step 1 list. The Eley report derived the total end-use consumption by taking a weighted average of all the climate zones in California. We estimated the reduction(s) in the gross savings value by using secondary data sources to determine a percent savings for the specific measure. The preferred approach was to use a source specific to California. If no suitable

[50] ADM Associates, "Evaluation of 2002 Statewide Codes and Standards Program," June 2004.

[51] Eley Associates, "Impact Analysis: 2005 Update to the California Energy Efficiency Standards for Residential and Nonresidential Buildings," June 20, 2003.

California source was available, either a source for a similar climate was used or a national average study was used after adjusting the values to account for the California climate.

Results

Table 129 summarizes how the CfR gross energy savings quantities reported in the SES were estimated. The values shown in the bottom row of the table are those reported as first-year gross savings in the SES.

Table 129. Original Composite for Remainder Energy Savings Estimates

	Estimates from Eley Report		
Title 24 Code Category	Electricity (GWh)	Peak (MW)	Natural Gas (million Therms)
Residential C&S CASE Report Standards	83.34	41.07	2.90
All 2005 Residential Title 24 Standards	117.27	104.5	6.89
Difference = CfR Residential Standards	33.93	63.43	3.98
Nonresidential C&S CASE Report Standards	80.15	35.56	1.04
All 2005 Nonresidential Title 24 Standards	367.76	107	0.30
Difference = CfR Nonresidential Standards	287.61	71.44	-0.74
All C&S CASE Report Standards	163.49	76.63	3.94
All 2005 Title 24 Standards	485.03	211.5	7.19
All CfR 2005 code revisions	**321.54**	**134.87**	**3.25**

The next step identified measures included in the CfR for which savings were analyzed with those actually adopted and reported in the CEC document and with those that were adopted as federal standards. Table 130 summarizes the measures analyzed in the Eley report that were either not adopted or for which the C&S Program should not have received energy savings credit since they had become federal standards.

Table 130. Measures to Delete from Composite for Remainder Savings

End Use	Measure	Description	Comment
HVAC	Space Heating and Space Cooling [§151(f)7].	Air conditioners and heat pumps will be required to meet new federal appliance standards as specified in the Appliance Efficiency Regulations.	Adopted as federal standard
Water Heat	Water-Heating Systems [§151(f)8].	Water heaters will be required to meet new federal appliance standards. For systems serving individual dwelling units, either a single gas storage type water heater, 50 gallons or smaller, with no recirculation pumps and meeting the mandatory insulation requirements for storage tanks and hot water pipes to the kitchen, or instantaneous gas water heaters will be required. For systems serving multiple dwelling units, a central recirculating water heating system with gas water heaters with timer controls will be required. Hot water pipes from the water heater to the kitchen fixtures that are ¾ inches or greater in diameter will be required to be insulated.	Adopted as federal standard; only multifamily standard applied
Building Shell	Metal Building Roofs §143(a)	Metal building roofs are no longer allowed to use the R-value method, which makes the standard more stringent for this class of construction. The U-factors used for the 2001 and 2005 standards are shown in Table 25.	Not adopted by CEC

In addition to measures included in the CfR savings estimates based on the Eley report, there were measures adopted in Title 24 that were not analyzed in the Eley report. These are shown in Table 131. Based on our assessment, these measures had a relatively small effect on the total CfR savings and it was not feasible to analyze their savings within the scope of this study.

Table 131. Measures Adopted but Not Included in Estimated Composite for Remainder Savings

End Use	Measure	Description
HVAC_Aux	Natural Ventilation [§121(b)1].	Current requirements for natural ventilation will be clarified and the depth of spaces allowed to be naturally ventilated in high-rise residential dwelling units and hotel/motel guest rooms is extended to 25 feet.
Building Shell	Placement of Insulation at the Roof/Ceiling [§118(e)].	Insulation will be required to be placed directly in contact with a continuous roof or ceiling. Placement on top of a suspended ceiling with removable ceiling panels will be deemed to have no insulative effect except in very limited situations.
HVAC	Economizer Acceptance [§144(e)4].	Acceptance requirements will be established to insure that economizers are tested before occupancy to determine that they meet Standards requirements.
HVAC	Space Conditioning Controls Acceptance [§122(h)].	Acceptance requirements also will be established to insure that space conditioning controls are tested before occupancy to determine that they meet Standards requirements.

The major adjustments we were able to make to the original CfR savings estimates within the scope of this study were to estimate and deduct the savings due to the two federal residential standards for which savings were quantified in the Eley report. The estimates were derived based on information in the Eley report or from materials provided by one of the analysts who worked on the original study.[52]

The estimated savings attributable to the air conditioners standard are shown in Table 132. The savings from the water heater standard are shown in Table 133.

Table 132. Energy Savings for Increased Central Air Conditioner Efficiency

Building Type	Unit Savings		Gross Energy Savings	
Single Family	216	kWh/unit	23.43	GWh
Single Family	665	W/unit	46.88	MW
Multifamily	189	kWh/unit	7.89	GWh
Multifamily	475	W/unit	12.89	MW
All Residential			31.32	GWh
All Residential			59.77	MW

[52] Cadmus authors worked closely with Peter Jacobs, consultant to the CPUC familiar with the original analysis, to determine how to account for these changes.

Table 133. Energy Savings for Hot Water Heaters

Building Type	Unit Savings		Gross Energy Savings (million Therms)	
Single Family	28	therms/unit	3.04	million therms
Single Family		-	-	-
Multifamily	35	therms/building	0.18	million therms
Multifamily		-	-	-
All Residential			3.22	million therms
All Residential			-	-

We deducted the savings from these two standards that were included in the original Eley report to derive the evaluated potential energy savings. Table 134 presents our final evaluation estimates of savings for the CfR measures.

Table 134. Final CfR Energy Savings

	SES Gross Savings			Final Potential Savings		
CfR	Electric Energy (GWH)	Demand (MW)	Gas (million therms)	Electric Energy (GWH)	Demand (MW)	Gas (million therms)
Residential	33.93	63.43	3.98	2.23	3.13	0.65
Nonresidential	287.61	71.44	-0.74	85.6	21.3	-0.22
Total	321.5	134.9	3.25	87.83	24.43	0.43

Standard B15 – Residential Whole Building

Overview and Description

Potential savings at the whole building level were estimated as an alternative to summing the potential savings for each measure adopted in Title 24 separately. For residential buildings, the savings were dominated by effects of the hardwired lighting standard and the CfR as described above.

Methodology

The analysis began with the estimated residential gross savings in GWh, MW, and Mtherm from from the Eley report. These estimates were adjusted next using the ratio between the Eley percent savings and the evaluated percent savings. The resulting values were then converted to a savings per residential unit by dividing by the number of residential units used in the Eley report.

The resulting values were next adjusted to account for the revisions made to the residential CfR SES gross savings to produce the final potential savings as described above. This adjustment accounted for the fact that savings assumed from certain measures in the original analysis were actually the result of federal standards when the 2005 Title 24 went into effect. Finally, the per unit adjusted savings were multiplied by the number of residential units.

Results

The estimated residential whole-building first-year estimated gross and evaluated potential savings for the first year (2006) are shown in Table 135.

Table 135. Final Residential Whole Building Potential Savings

SES Gross Savings			Final Potential Savings		
Electric Energy (GWH)	**Demand (MW)**	**Gas (million therms)**	**Electric Energy (GWH)**	**Demand (MW)**	**Gas (million therms)**
98.7	66.4	5.5	47.6	2.77	0.72

Appendix K. NOMAD Analysis Details for Appliance Standards

This appendix provides additional information on the NOMAD analysis conducted on a group of appliance standards.

Commercial Refrigeration Equipment, Solid and Transparent Door

Experts generally agreed that the initial market penetration and natural market adoption of energy-efficient units were higher for solid door refrigeration equipment than transparent door equipment. We included all inputs received although, based on his comments and responses, one expert appeared to have strong sentiments against the need for regulations and estimated the market would naturally produce a significant proportion of energy-efficient units.

Commercial Ice Makers

Of the inputs received, one expert cited the research done for the CASE study which found a 22% market share for compliant icemakers. Another had a different perspective and commented that a Federal standard would have been adopted regardless of the actions of California and other states and the "natural" adoption would have increased rapidly without a California standard. This expert's adoption curve showed market penetration of 75% in 2005, which differed substantially from other respondents and appeared to be contrary to other available data. For this reason, this expert's input was disregarded and the results relied more heavily on the expert citing specific knowledge and others with similar estimates.

Walk-In Refrigerators / Freezers

Of the inputs received, four were clustered in a narrow band with maximum values around 40%. A fifth expert misunderstood the question and gave input far above the others. This input was disregarded. There were some challenges in the evaluation of this standard since it regulates both motor efficiency and insulation requirements. There was general agreement that the motors would be adopted more quickly since the energy savings were sufficient to justify additional cost. Insulation was regarded as less likely to be upgraded in the absence of regulation. Ultimately, the NOMAD curve reflected the experts' input on the adoption of both aspects of the standard.

Large Packaged Commercial Air-Conditioners, Tier 1 and Tier 2

For Tier 1, experts' input varied over a wide range. Some had knowledge of research done for the CASE report and cited a market share of ~20% in 2006. Another respondent stated an expectation that superseding Federal standards would increase the market share to 100% in the future but the adoption curve submitted showed market penetration of 98% by 2004. This input was disregarded.

For Tier 2, the effective date at the beginning of 2010 makes the NOMAD estimate less critical for the current study, but the experts agreed that market share would be less than 10% in the near term.

Pool Pumps, Tier 1 and Tier 2

The evaluation team contacted 13 experts and 6 agreed to provide input. When only a few inputs were received, the team made an extra effort to check the inputs in light of the significant savings associated with these standards. The additional experts from a utility and a manufacturer provided corroborating evidence in short phone interviews that were used to supplement the original set of expert inputs.

General Service Incandescents, Tier 2

Initial confusion about Tier 1 and Tier 2 was resolved and several responses were received providing input specifically on the Tier 2 standard. All agreed that there would have been little market presence of the lower wattage bulbs in the absence of the standard.

External Power Supplies. Tier 1 and Tier 2

Our team received a wide range of inputs initially from the experts' comments and other sources that the market was changing in advance of and in anticipation of the standard. So the identification of a natural market was especially difficult. We also received input on the Tier 1 standard from a consumer electronics manufacturer that assured us that all products from that company were meeting the standard two years before the regulation took effect. Based on the other inputs received, we judged that a single manufacturer did not represent the market and that input was not used.

Consumer Electronics: Audio players, TVs, and DVDs

The process appeared to work well for all of these products as we received input from many experts. In their comments, the experts cited EPA data and studies from Lawrence Berkeley National Laboratory to support their estimates. The market adoption estimates and the secondary sources all supported the position that 46-63% of the market was already complying with these standards when each was adopted in 2006. The experts also raised a point that could have a bearing on the market trends that observers estimated—specifically, some commented that the market was changing in advance of the standard going into effect, probably in anticipation of the mandatory standards. If this is true then it would appear that the "natural" market for some products was affected by the pending adoption of regulations.

Appendix L. NOMAD Analysis Details for Residential Hardwired Lighting Building Standard

This appendix discusses the NOMAD estimation process and findings for the Residential Hardwired Lighting Title 24 standard.

Residential Hardwired Lighting

Many inputs on residential hardwired lighting were received as a direct result of a focused recruiting effort that included email and telephone contact with nearly all of the experts. Although the inputs were distributed over a wide range, the only significant outlier revealed in a comment that the estimate included the impact of the regulation so this one was easy to disregard. Of the others most had a final value above 20% and below 40% which made the 30% market maximum penetration reasonable. The diversity of backgrounds of these experts also lent some confidence to the final estimate. Whether they were laboratory scientists, lighting contractors, or energy consultants, most agreed that residential homeowners generally did not prioritize high efficiency lighting and that contractors favored least-cost solutions so the natural market adoption of high-efficacy residential lighting was likely to be relatively low.

Appendix M. Appliance Standards Compliance Results Details

The details of the compliance analysis for the appliance standards are presented in this appendix.

Pool Pumps

Compliance results for pool pumps are presented in Table 136.

Table 136. Pool Pump Compliance Results

Sample Data Details					Compliance Results		
# of Stores Visited	# of Unique Models	Total Units Sampled	% of Sample Omitted	# of Units for Analysis	% Compliant with CEC	% Compliant - Unlisted	% Non-Compliant
12	86	152	28.9%	108	89.8%	3.8%	6.4%

Total Compliance Rate	90% Confidence Intervals
93.6% ± 4.0%	89.6% - 97.6%

Of the appliance standards analyzed, pool pumps provided the largest potential savings. Out of the 11 stores visited, 86 unique models were observed with a total of 152 units. Over 70% of the sample provided reliable data from which to determine compliance, but 28.9% of the sample had to be removed from the analysis because compliance could not be determined. Nearly 90% of the sample was listed as compliant with the CEC and another 3.8% were found to meet most of the technical requirements of the standard, but were unlisted with CEC.[150] Of the sample, 6.4% did not meet 2008 standards, but it was determined that all of these units did comply with the 2006 standards due to motor efficiency. We calculated a 4.0% uncertainty in our overall compliance rate of 93.6% and thus produced a 90% confidence interval of 89.6% to 97.6% statewide 2008 compliance for pool pumps available for sale in early 2009.

Metal Halide Luminaires

Compliance results for metal halide luminaires are presented in Table 137.

[150] It is important to note that although this 3.8% of unlisted compliant products were classified this way, we were unable to confirm the rotation rate, default circulation, or high speed override capabilities, which are all regulated by the standard. Consequently, labeling these models as unlisted compliant makes an assumption that they meet these characteristics.

Table 137. Metal Halide Luminaire Compliance Results

Sample Data Details					Compliance Results		
# of Stores Visited	# of Unique Models	Total Units Sampled	% of Sample Omitted	# of Units for Analysis	% Compliant with CEC	% Compliant - Unlisted	% Non-Compliant
9	13	18	11.1%	16	0.0%	51.9%	48.1%

Total Compliance Rate	90% Confidence Intervals
51.9% ± 11.8%	40.1% - 63.7%

The sample of metal halide luminaires was very limited and was the smallest sample of all of the appliances. Of the units sampled, 89% were used in analysis. Interestingly, not a single unit sampled was listed in the CEC database due to only a limited number of brands being represented in the CEC database. Compliance was determined through online research and calling manufacturers to obtain technical specifications. From the responses, the compliance was calculated using weighted averages of small and large strata stores within California and yielded only about a 52% compliance rate. The very small sample size produced a wide confidence interval. The 90% confidence interval for 2008 compliance ranges from 40.1% to 63.7% for metal halide luminaires.

The main determining factor for non-compliance was the use of a probe starter, which violated the 2008 standards. Of the 48.1% of the sample that did not meet 2008 standards, all units did meet 2006 standards.

General Service Incandescent Lamps

Compliance results for general service incandescents are presented in Table 138.

Table 138. General Service Incandescents Compliance Results

Sample Data Details					Compliance Results		
# of Stores Visited	# of Unique Models	Total Units Sampled	% of Sample Omitted	# of Units for Analysis	% Compliant with CEC	% Compliant - Unlisted	% Non-Compliant
9	145	176	16.5%	147	13.5%	30.1%	56.4%

Total Compliance Rate	90% Confidence Intervals
43.6% ± 7.6%	36.0% - 51.2%

General service incandescent lamps provided the most surprising compliance results. Of the 9 stores included in the sample, 176 total units were catalogued and 145 of these were unique models. Over 80% of the sample provided reliable data from which to determine compliance. One store was excluded from the sample because the lamps were manufactured before 2006. Only 13.5% of the sample was registered and listed in the CEC database as compliant with Tier 2. The unlisted compliant units totaled 30.1% and compliance was determined by comparing the rated watts and lumen output for each bulb to the standard requirements. The remaining 56.4% fell below the calculated cut offs for watts and lumen output. It is interesting to note that 25.1% of the total sample were compliant with the 2006 Tier 1 standard alone; therefore, roughly one quarter of the non-compliant units were

2006 compliant, and three quarters of the non-compliant group, or 31.3% of the entire sample did not comply with either the 2006 or the current 2008 standards.[151]

The overall Tier 2 compliance percentage was calculated as 43.6% with a 90% confidence interval of 36.0% - 51.2% compliance when aggregated to the state level. These findings showed that even at best, over half of the incandescent lamps being sold in early 2009 were not compliant with 2008 standards.

Pre-Rinse Spray Valves

Compliance results for pre-rinse spray valves are presented in Table 139.

Table 139. Pre-rinse Spray Valve Compliance Results

Sample Data Details					Compliance Results		
# of Stores Visited	# of Unique Models	Total Units Sampled	% of Sample Omitted	# of Units for Analysis	% Compliant with CEC	% Compliant - Unlisted	% Non-Compliant
11	11	31	3.2%	30	70.5%	29.5%	0.0%

Total Compliance Rate	90% Confidence Intervals
100% ± 0%	100%

Pre-rinse spray valves were the only appliance type where complete sales data were available for all stores to use in the analysis. Therefore, a different approach was taken for the analysis. The number of units sampled was multiplied by annual sales data and the compliance results were calculated based on the sales data. As can be seen above, 70.5% of the units sold were listed in the CEC database and the remaining 29.5% were determined to be compliant through internet research and manufacturer interviews. Of the sample, none had non-complying specifications and thus our 90% confidence interval is simply the point estimate of 100% compliance.

Audio Players

Compliance results for audio players are presented in Table 140.

[151] We reviewed the data that went into 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.

Table 140. Audio Player Compliance Results

Sample Data Details					Compliance Results		
# of Stores Visited	# of Unique Models	Total Units Sampled	% of Sample Omitted	# of Units for Analysis	% Compliant with CEC	% Compliant - Unlisted	% Non-Compliant
10	78	97	61.9%	37	78.2%	21.8%	0.0%

Total Compliance Rate	90% Confidence Intervals
100% ± 0%	100%

Audio players proved to be another appliance category with 100% compliance rate between those units listed in the CEC database and the remainder we confirmed were compliant with the efficiency requirements of the standard. Of the 10 stores visited a fairly large sample was collected, but upon analysis, the data needed to determine compliance was not available for nearly two thirds of the sample. Extensive research was conducted to reduce this number, including contacting manufacturers for product specifications. The large proportion of the sample omitted implicitly decreases certainty; however, the fact that we were able to determine a 100% compliance rate for those units where information was available suggested that it was unlikely that the remaining units were non-compliant. Of the sample we were able to analyze, 78.2% were listed in the CEC database, and we confirmed through secondary data that the remaining 21.8% of the sample complied with the 2008 standards.

Televisions

Compliance results for televisions are presented in Table 141.

Table 141.Television Compliance Results

Sample Data Details					Compliance Results		
# of Stores Visited	# of Unique Models	Total Units Sampled	% of Sample Omitted	# of Units for Analysis	% Compliant with CEC	% Compliant - Unlisted	% Non-Compliant
11	235	293	6.5%	274	64.2%	31.9%	3.9%

Total Compliance Rate	90% Confidence Intervals
96.1% ±1.2%	94.9% - 97.3%

Of the 11 stores visited, a very large sample of unique models and total units was collected. We were able to use 93.5% of the sample to provide reliable data used in the analysis. Of the units sampled, 64.2% were listed in the CEC database with another 31.9% determined to be in compliance with the efficiency requirements of the standard, but unlisted with the CEC. Only 3.9% of the sample exhibited standby wattages that exceeded the 2008 standard, making them non-compliant. The overall compliance rate estimate for the state of California was determined to be 96.1% with a narrow confidence interval from 94.9% to 97.3% for televisions sold in early 2009.

External Power Supplies

Compliance results for external power supplies are presented in Table 142.

Table 142. External Power Supply Compliance Results

Sample Data Details					Compliance Results		
# of Stores Visited	# of Unique Models	Total Units Sampled	% of Sample Omitted	# of Units for Analysis	% Compliant with CEC	% Compliant - Unlisted	% Non-Compliant
11	180	208	42.3%	120	N/A	98.7%	1.3%

Total Compliance Rate	90% Confidence Intervals
98.7% ± 1.1%	97.6% - 99.8%

External power supplies were challenging to analyze. Our evaluation team visited 11 stores and documented a large sample. About 58% of the sample provided definitive compliance information. This appliance category was not required to have a CEC database list of registered models, so we did not have this for comparison. We determined 98.7% compliance for the sample primarily by using a technical specifications list provided by ENERGY STAR. In this particular case, the ENERGY STAR standard was more stringent than the California 2008 standard; thus, if the model was found on the ENERGY STAR list, it was compliant with California's Title 20 standard. If the model was not listed with ENERGY STAR, additional research was conducted to determine compliance. The remaining 1.3% that were non-compliant with the 2008 standard were all compliant with the 2006 standard. The 90% confidence interval was fairly narrow, ranging from 97.6% to 99.8%

Duct and Unit Heaters

Compliance results for duct and unit heaters are presented in Table 143.

Table 143.Duct and Unit Heaters Compliance Results

Sample Data Details					Compliance Results		
# of Stores Visited	# of Unique Models	Total Units Sampled	% of Sample Omitted	# of Units for Analysis	% Compliant with CEC	% Compliant - Unlisted	% Non-Compliant
9	53	59	5.1%	56	82.7%	17.3%	0.0%

Total Compliance Rate	90% Confidence Intervals
100% ± 0%	100%

Though the sample of duct and unit heaters was relatively small, the majority of units were unique and provided reliable compliance data. Of the sample, 95% were used in the analysis and we found that the majority of the models were listed with the CEC and all of the available models being sold were in compliance with the efficiency requirements of the standard. This degree of certainty yielded 100% compliance with a 0% confidence interval, when combining the models registered and listed with CEC to those that were determined to be in compliance with the efficiency requirements of the standard from online and manufacturer research.

Walk-in Refrigerators & Freezers

The unique nature of walk-in refrigerators and freezers made it difficult to assess compliance for these products. Walk-in refrigerators and freezers are most often custom made for each location. Therefore, model registration with CEC is not mandatory and obtaining sales information from distributors and manufacturers is very complicated and rarely possible. After several attempts proved unsuccessful to collect data by the means explained earlier, other methods of data collection were attempted. This included in-depth interviews with manufacturers and assessment of actual units in the field.

The manufacturer interviews, although providing no analyzable data, provided some interesting information. We interviewed two large manufacturers and one self-described small scale manufacturer. It is important to note that there is a large number of manufacturers in this industry and that market share for those that are the largest manufacturers is still relatively small. Also, all of the manufacturers we spoke with were very familiar with the standards and claimed that their company only manufactured efficient, compliant models. The two large manufacturing companies interviewed both indicated that their companies strove to be ahead of the current Title 20 standard in the efficiency of their products.

Some comments from these interviews about the general market indicated that non-compliance with Title 20 was the most prevalent with small “garage shop” types of businesses. The interviewees said that many of these types did not install insulation with a compliant R-value due to the cost; however, all manufacturers agreed that the evaporator and condenser fans being installed were probably variable speed and likely to meet the standards. These respondents also said that smaller walk-ins, like those in small grocery stores, often do not have automatic door closers, while larger walk-ins typically do. This was consistent with what we discovered at the sites that we visited.

In addition to these interviews, we also went to several sites that recently installed walk-in refrigerators and freezers and checked the units for compliance. We went to a total of three locations and found the walk-ins at these sites be compliant with most of the requirements of both tiers of the standard. Two locations, both restaurants, were lacking automatic door closers on their walk-in refrigerators and freezers and we could not determine the R-value of the insulation for a unit at another location, but the thickness of the walls indicated possible compliance.

Based on the CASE report prepared for walk-ins, the automatic door closer was estimated to provide about 35% of total savings. Based on our interviews and field experience, we estimated that units contributing about one-third of the energy use of new units were installed without automatic door closers. With these assumptions, our estimated compliance rate based on likely energy savings impacts was 88% (100% minus 35%/3). We were unable to assign confidence intervals to this estimate due to the limited number of sites we were able to visit.

Appendix N. Attribution Factor Weight Details

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. By definition, the sum of the weights equals 1.0. For each standard, Cadmus surveyed experts about the allocation of stakeholder resources. The weighted mean response for each attribution factor and the standard deviation, minimum response, and maximum response are presented in Table 144 for each appliance standard.[152]

Table 144. Summary of Appliance Standard Survey Results for Factor Weights

Standard Number	Standard Name	Factor	N	Mean Weight	Std Dev	Minimum	Maximum
Std1	Commercial Refrigeration Equipment, Solid Door	Compliance	4	0.059	0.020	0.03	0.1
		Technical	4	0.567	0.057	0.45	0.65
		Feasibility	4	0.374	0.037	0.32	0.45
Std2	Commercial Refrigeration Equipment, Transparent Door	Compliance	4	0.059	0.020	0.03	0.1
		Technical	4	0.573	0.060	0.45	0.67
		Feasibility	4	0.368	0.040	0.3	0.45
Std3	Commercial Ice Maker Equipment	Compliance	4	0.115	0.051	0.05	0.25
		Technical	4	0.574	0.087	0.375	0.7
		Feasibility	4	0.311	0.044	0.25	0.45
Std4	Walk-In Refrigerators / Freezers	Compliance	4	0.071	0.014	0.05	0.1
		Technical	4	0.698	0.074	0.45	0.8
		Feasibility	4	0.231	0.061	0.15	0.45
Std5	Refrigerated Beverage Vending Machines	Compliance	4	0.129	0.026	0.1	0.2
		Technical	4	0.598	0.104	0.35	0.75
		Feasibility	4	0.273	0.088	0.15	0.55
Std6	Large Packaged Commercial Air-Conditioners, Tier 1	Compliance	4	0.030	0.017	0	0.1
		Technical	4	0.617	0.093	0.4	0.75
		Feasibility	4	0.353	0.097	0.22	0.6

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

Standard Number	Standard Name	Factor	N	Mean Weight	Std Dev	Minimum	Maximum
Std7	Large Packaged Commercial Air-Conditioners, Tier 2	Compliance	2	0.048	0.030	0.03	0.1
		Technical	2	0.650	0.087	0.5	0.7
		Feasibility	2	0.303	0.056	0.27	0.4
Std8	Residential Pool Pumps, High Eff Motor, Tier 1	Compliance	3	0.079	0.017	0.05	0.1
		Technical	3	0.529	0.049	0.45	0.6
		Feasibility	3	0.392	0.035	0.35	0.45
Std9	Residential Pool Pumps, 2-speed Motors, Tier 2	Compliance	3	0.204	0.059	0.1	0.3
		Technical	3	0.383	0.062	0.3	0.55
		Feasibility	3	0.413	0.026	0.35	0.45
Std10	Portable Electric Spas	Compliance	4	0.333	0.072	0.1	0.5
		Technical	4	0.304	0.034	0.25	0.45
		Feasibility	4	0.363	0.043	0.25	0.45
Std11	General Service Incandescent Lamps, Tier 1	Compliance	3	0.058	0.013	0.05	0.1
		Technical	3	0.783	0.105	0.45	0.85
		Feasibility	3	0.158	0.092	0.1	0.45
Std12	Pulse Start Metal Halide HID Luminaries, Tier 1	Compliance	3	0.144	0.094	0.05	0.333
		Technical	3	0.678	0.172	0.333	0.85
		Feasibility	3	0.178	0.078	0.1	0.333
Std13	Modular Furniture Task Lighting Fixtures	Compliance	2	0.030	0.000	0.03	0.03
		Technical	2	0.800	0.000	0.8	0.8
		Feasibility	2	0.170	0.000	0.17	0.17
Std14	Hot Food Holding Cabinets	Compliance	4	0.100	0.038	0.05	0.2
		Technical	4	0.698	0.138	0.4	0.9
		Feasibility	4	0.202	0.104	0.05	0.45
Std15	External Power Supplies, Tier 1	Compliance	3	0.225	0.040	0.1	0.25
		Technical	3	0.508	0.013	0.5	0.55
		Feasibility	3	0.267	0.026	0.25	0.35

Standard Number	Standard Name	Factor	N	Mean Weight	Std Dev	Minimum	Maximum
Std16	External Power Supplies, Tier 2	Compliance	3	0.225	0.040	0.1	0.25
		Technical	3	0.508	0.013	0.5	0.55
		Feasibility	3	0.267	0.026	0.25	0.35
Std17	Consumer Electronics - Audio Players	Compliance	3	0.142	0.066	0.05	0.25
		Technical	3	0.554	0.118	0.4	0.75
		Feasibility	3	0.304	0.067	0.2	0.45
Std18a	Consumer Electronics - TVs	Compliance	3	0.142	0.066	0.05	0.25
		Technical	3	0.575	0.105	0.45	0.75
		Feasibility	3	0.283	0.062	0.2	0.45
Std18b	Consumer Electronics - DVDs	Compliance	3	0.142	0.066	0.05	0.25
		Technical	3	0.596	0.093	0.45	0.75
		Feasibility	3	0.263	0.061	0.2	0.45
Std19	Water Dispensers	Compliance	2	0.200	0.100	0.1	0.3
		Technical	2	0.650	0.150	0.5	0.8
		Feasibility	2	0.150	0.050	0.1	0.2
Std20	Unit Heaters and Duct Furnaces	Compliance	4	0.048	0.026	0	0.1
		Technical	4	0.625	0.070	0.45	0.75
		Feasibility	4	0.319	0.082	0.2	0.5
Std21	Commercial Dishwasher Pre-Rinse Spray Valves	Compliance	3	0.225	0.040	0.1	0.25
		Technical	3	0.575	0.040	0.45	0.6
		Feasibility	3	0.200	0.079	0.15	0.45

The weighted mean response for each attribution factor and the standard deviation, minimum response, and maximum response are presented in Table 145 for each building standard. [153]

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

Table 145. Summary of Survey Results for Building Standard Factor Weights

Standard Number	Standard Name	Factor	N	Mean Weight	Std Dev	Minimum	Maximum
Std B1	Time dependent valuation, Residential	Compliance	4	0.317	0.095	0.1	0.5
		Technical	4	0.385	0.034	0.3	0.45
		Feasibility	4	0.298	0.067	0.2	0.45
Std B2	Time dependent valuation, Nonresidential	Compliance	3	0.429	0.074	0.2	0.5
		Technical	3	0.379	0.049	0.3	0.45
		Feasibility	3	0.192	0.073	0.1	0.4
Std B3	Res. Hardwired lighting	Compliance	4	0.283	0.064	0.1	0.4
		Technical	4	0.383	0.018	0.33	0.4
		Feasibility	4	0.335	0.062	0.2	0.5
Std B4	Duct improvement	Compliance	2	0.350	0.050	0.3	0.4
		Technical	2	0.425	0.075	0.35	0.5
		Feasibility	2	0.225	0.025	0.2	0.25
Std B5	Window replacement	Compliance	3	0.267	0.148	0.05	0.55
		Technical	3	0.483	0.073	0.35	0.6
		Feasibility	3	0.250	0.104	0.1	0.45
Std B6	Lighting controls under skylights	Compliance	2	0.450	0.050	0.4	0.5
		Technical	2	0.325	0.075	0.25	0.4
		Feasibility	2	0.225	0.025	0.2	0.25
Std B7	Ducts in existing commercial buildings	Compliance	2	0.350	0.050	0.3	0.4
		Technical	2	0.425	0.075	0.35	0.5
		Feasibility	2	0.225	0.025	0.2	0.25
Std B8	Cool roofs	Compliance	3	0.467	0.033	0.4	0.5
		Technical	3	0.367	0.033	0.3	0.4
		Feasibility	3	0.167	0.033	0.1	0.2
Std B9	Relocatable classrooms	Compliance	2	0.125	0.025	0.1	0.15
		Technical	2	0.550	0.050	0.5	0.6
		Feasibility	2	0.325	0.075	0.25	0.4

Standard Number	Standard Name	Factor	N	Mean Weight	Std Dev	Minimum	Maximum
Std B10	Bi-level lighting control credits	Compliance	2	0.100	0.000	0.1	0.1
		Technical	2	0.475	0.025	0.45	0.5
		Feasibility	2	0.425	0.025	0.4	0.45
Std B11	Duct testing/sealing in new commercial buildings	Compliance	2	0.350	0.050	0.3	0.4
		Technical	2	0.425	0.075	0.35	0.5
		Feasibility	2	0.225	0.025	0.2	0.25
Std B12	Cooling tower applications	Compliance	1	0.200	.	0.2	0.2
		Technical	1	0.450	.	0.45	0.45
		Feasibility	1	0.350	.	0.35	0.35
Std B13	Multifamily Water Heating	Compliance	4	0.363	0.095	0.1	0.6
		Technical	4	0.450	0.079	0.25	0.6
		Feasibility	4	0.188	0.061	0.1	0.45
Std B14	Composite for Remainder	Compliance	3	0.310	0.059	0.2	0.4
		Technical	3	0.397	0.032	0.34	0.45
		Feasibility	3	0.293	0.047	0.2	0.35

Appendix O. Naturally Occurring Market Adoption Details

This appendix presents the NOMAD curves that were created for each of the standards analyzed based on the expert inputs solicited for this evaluation.

Figure 3: Commercial Refrigeration Equipment, Solid Door (Standard 1)

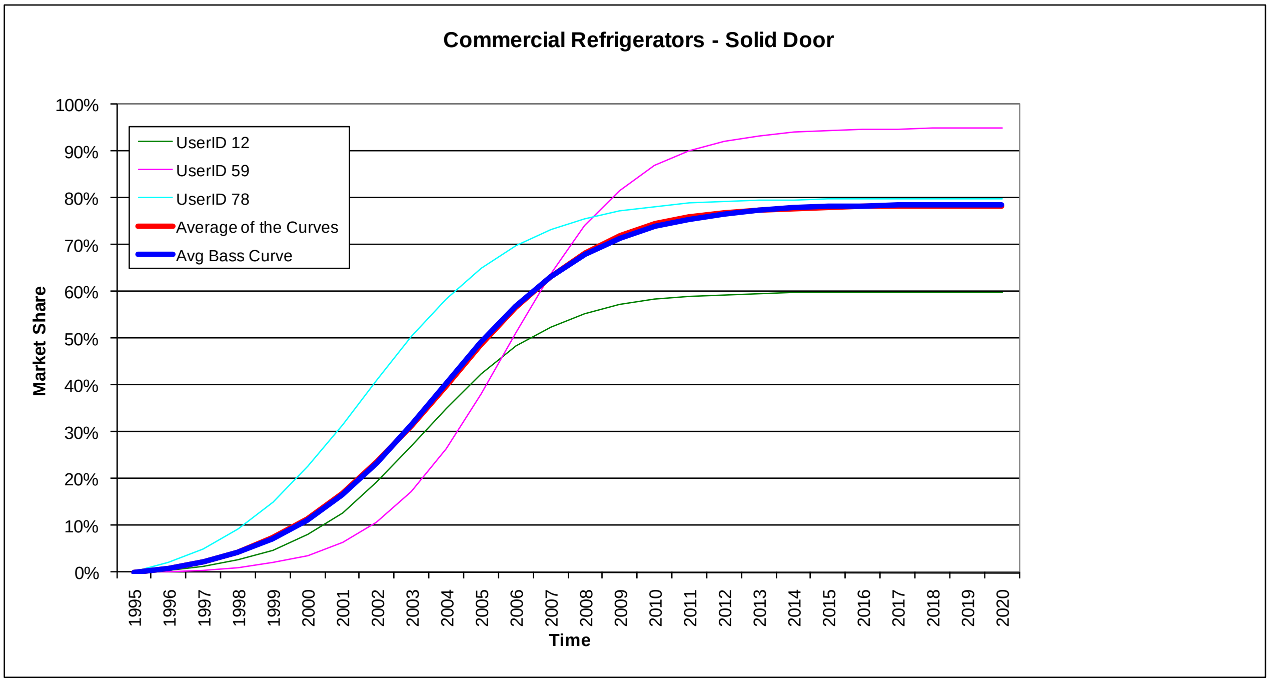


Figure 4: Commercial Refrigeration Equipment, Transparent Door (Standard 2)

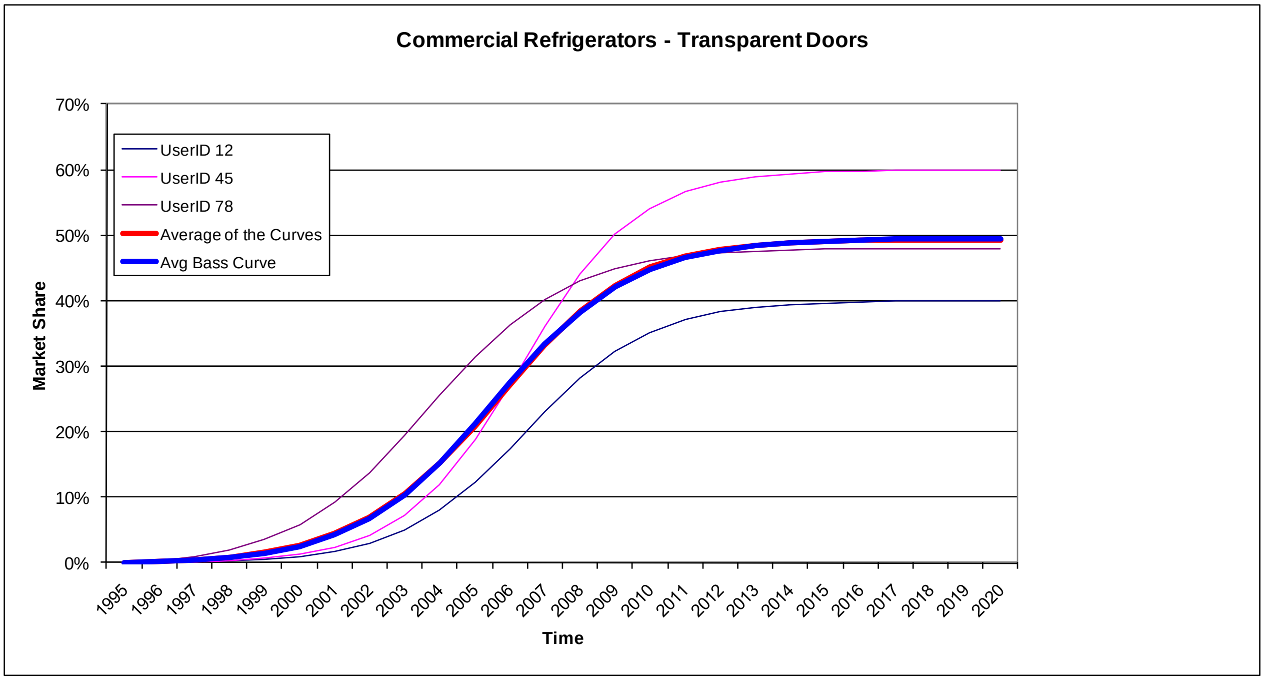


Figure 5: Commercial Ice Maker Equipment (Standard 3)

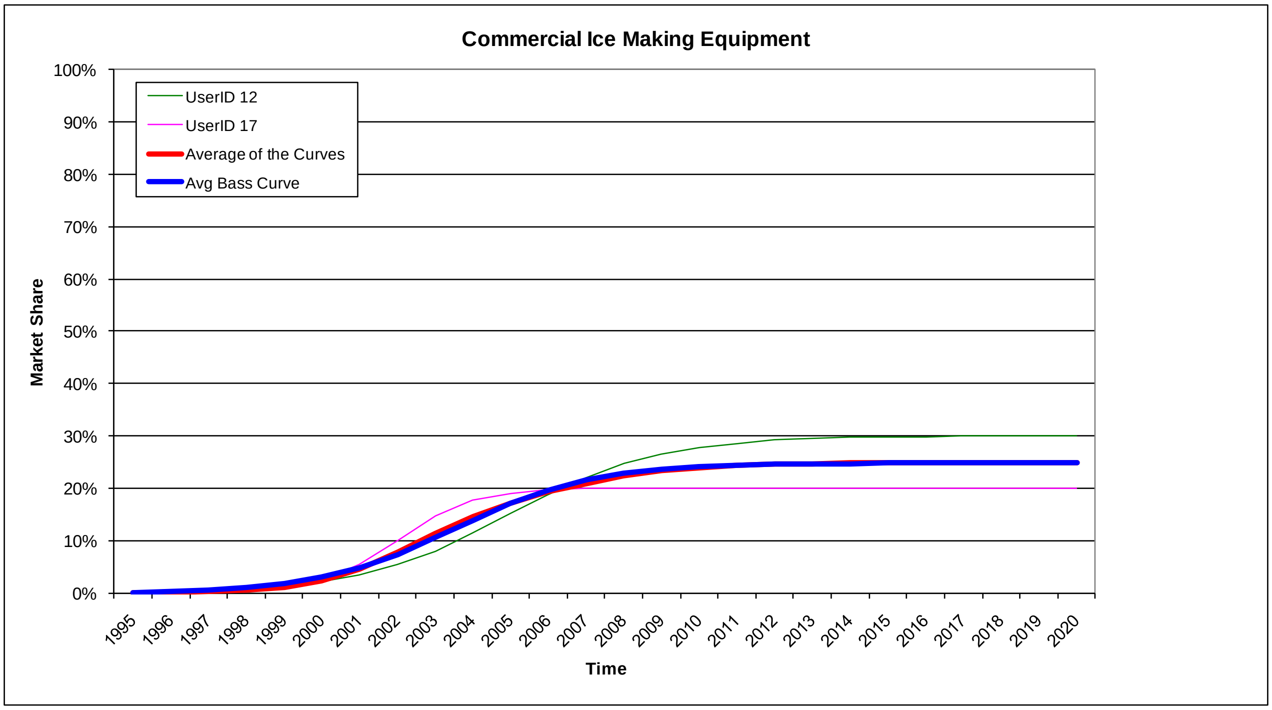


Figure 6: Walk-In Refrigerators / Freezers (Standard 4)

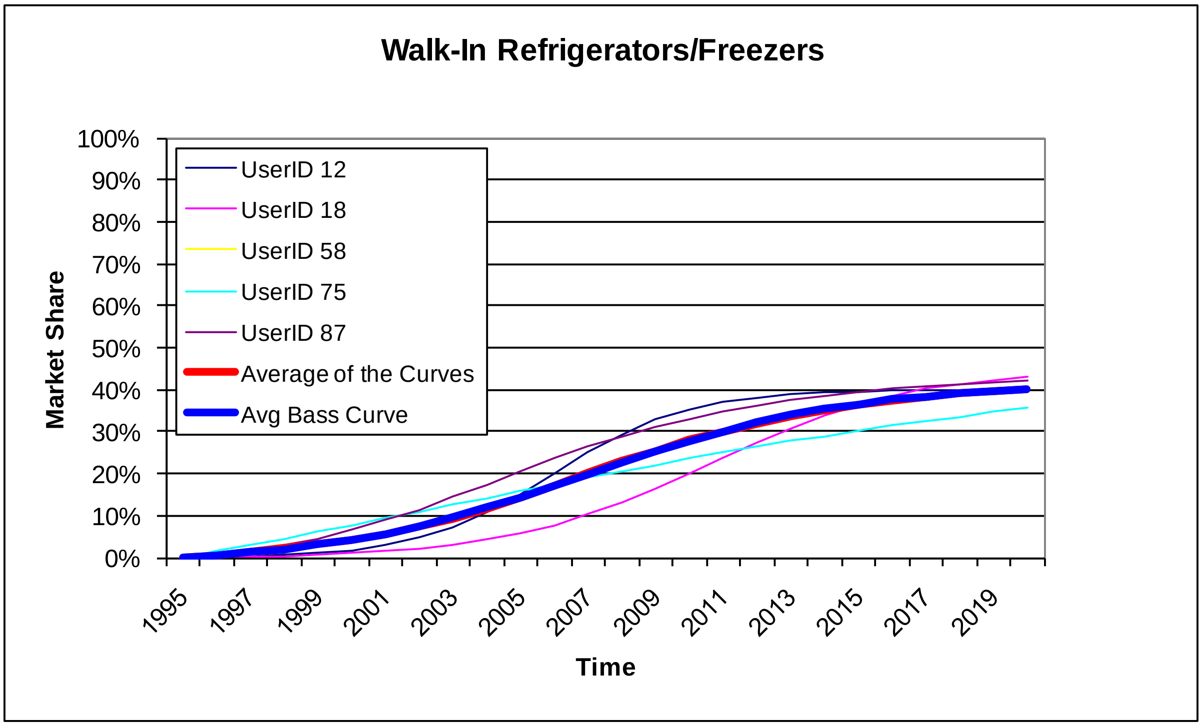


Figure 7: Refrigerated Beverage Vending Machines (Standard 5)

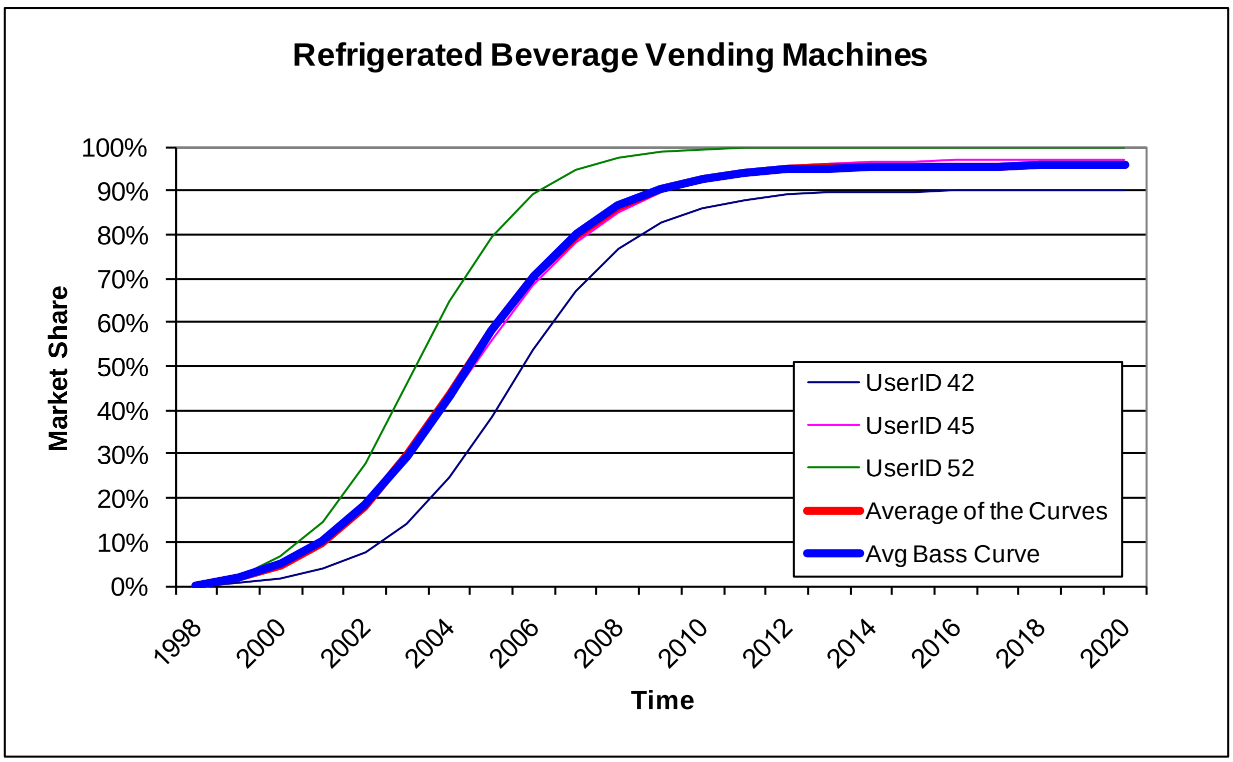


Figure 8: Large Packaged Commercial Air-Conditioners, Tier 1 (Standard 6)

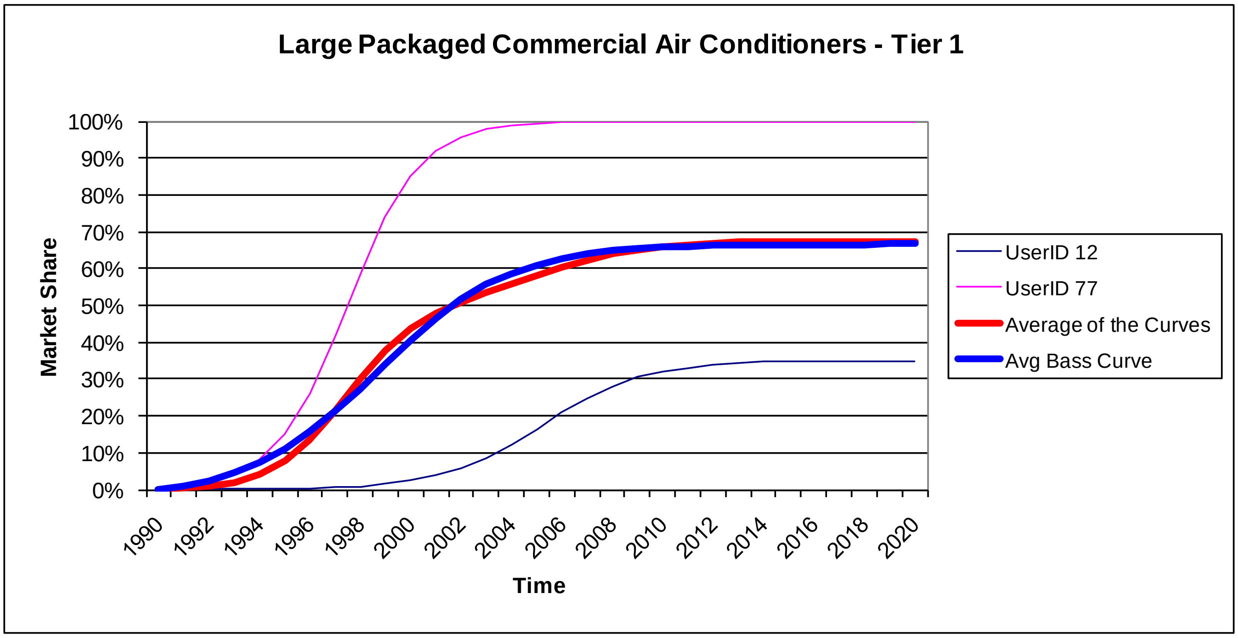


Figure 9: Large Packaged Commercial Air-Conditioners, Tier 2 (Standard 7)

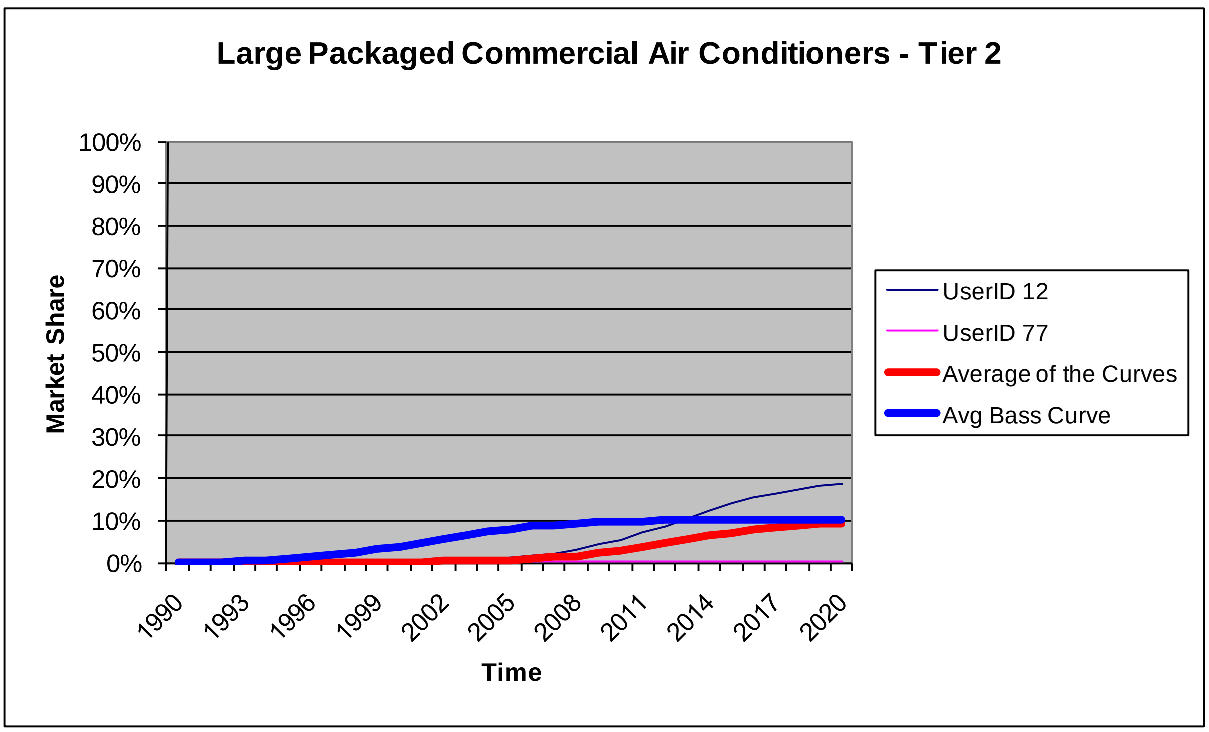


Figure 10: Residential Pool Pumps, High Eff Motor, Tier 1 (Standard 8)

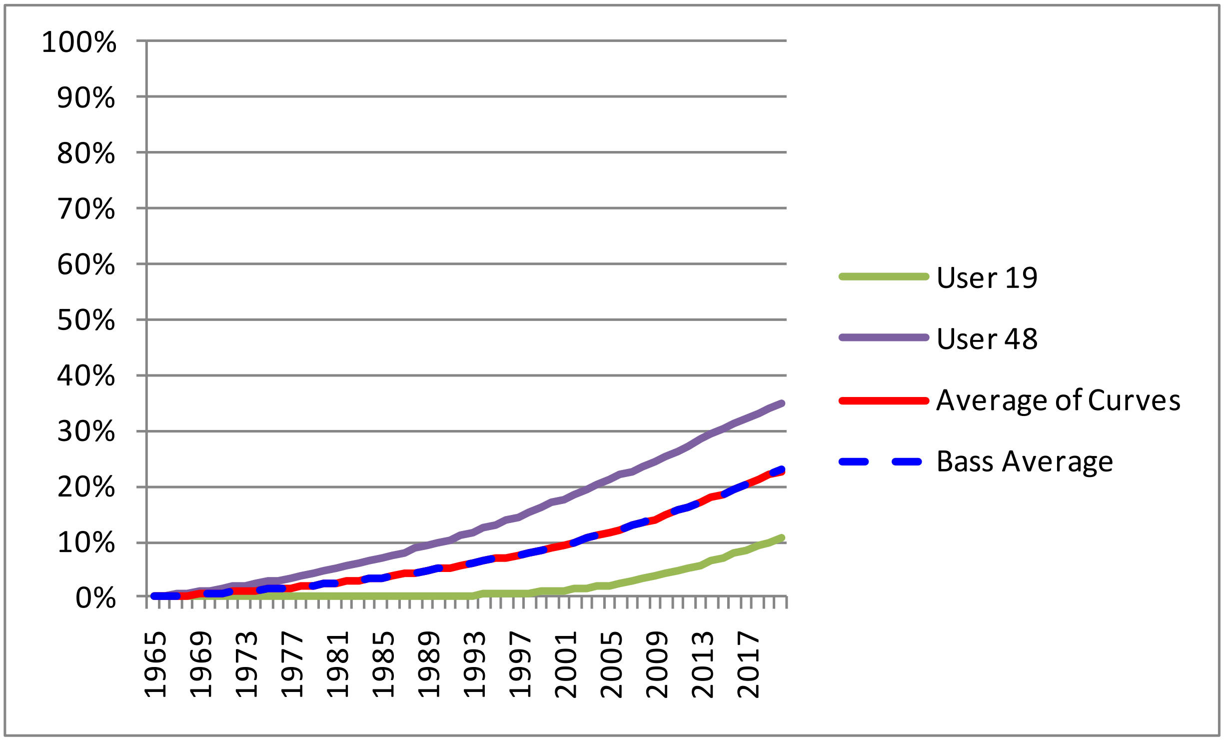


Figure 11: Residential Pool Pumps, 2-speed Motors, Tier 2 (Standard 9)

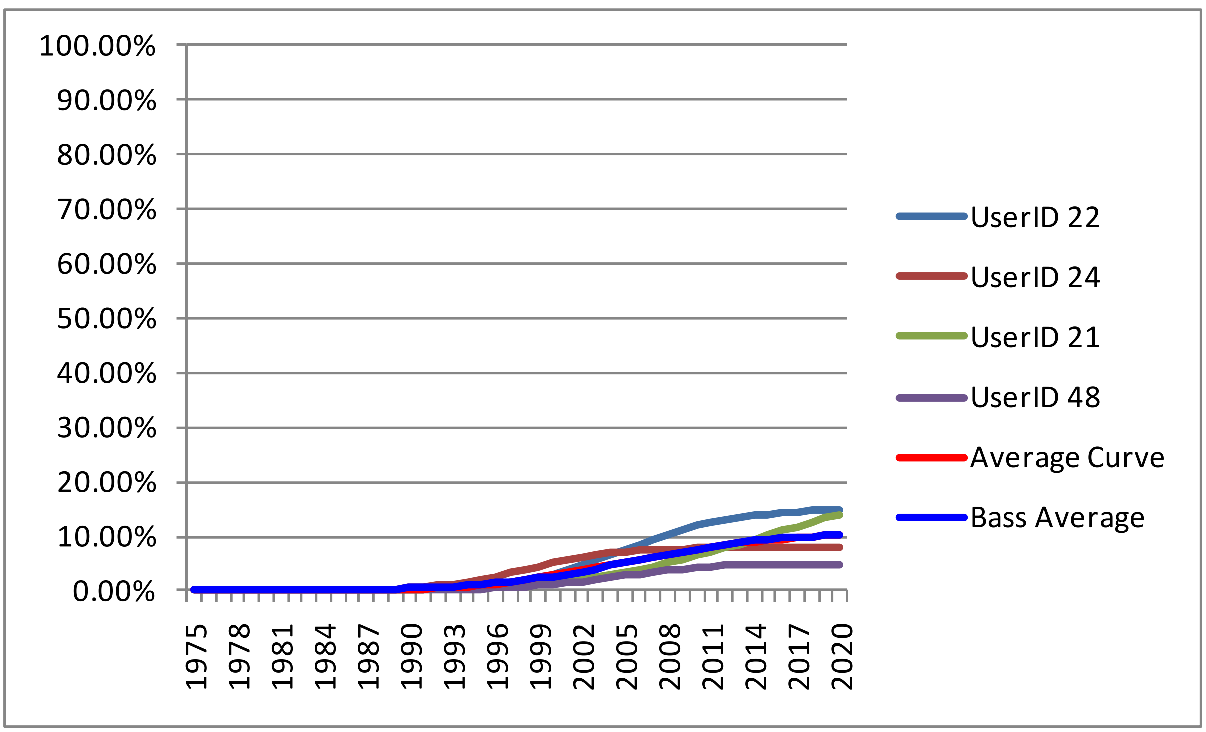


Figure 12: General Service Incandescent Lamps, Tier 2 (Standard 11)

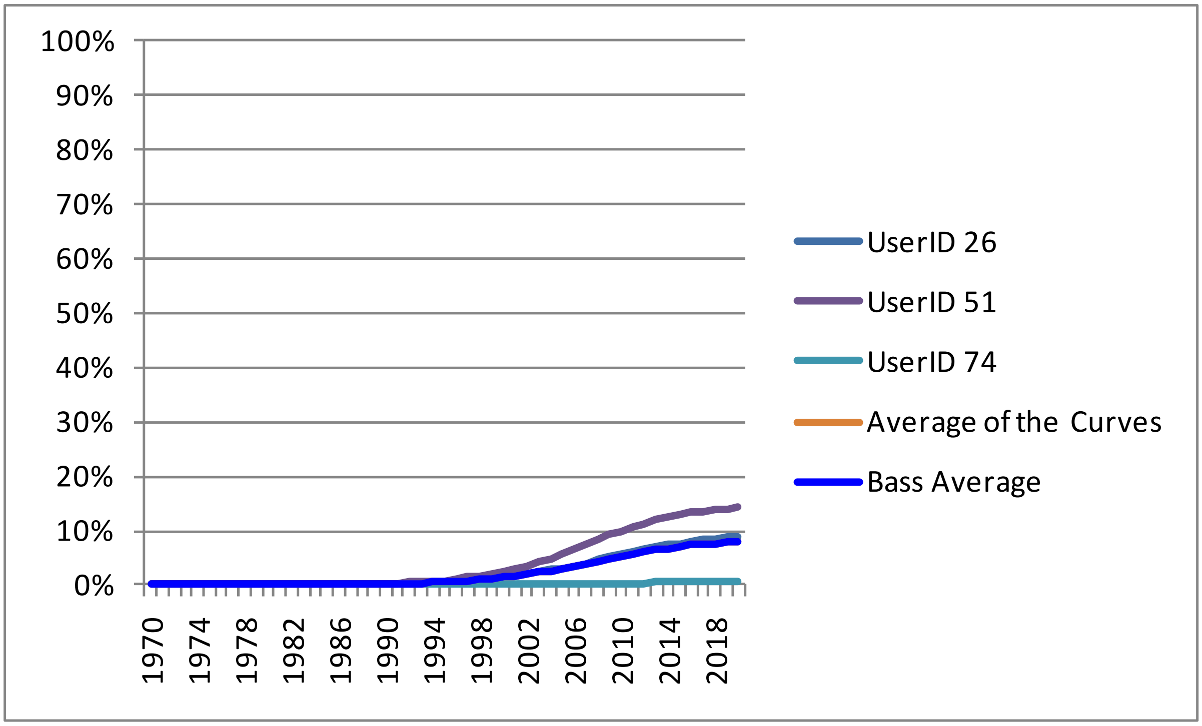


Figure 13: Pulse Start Metal Halide HID Luminaires, Tier 1 (Standard 12)

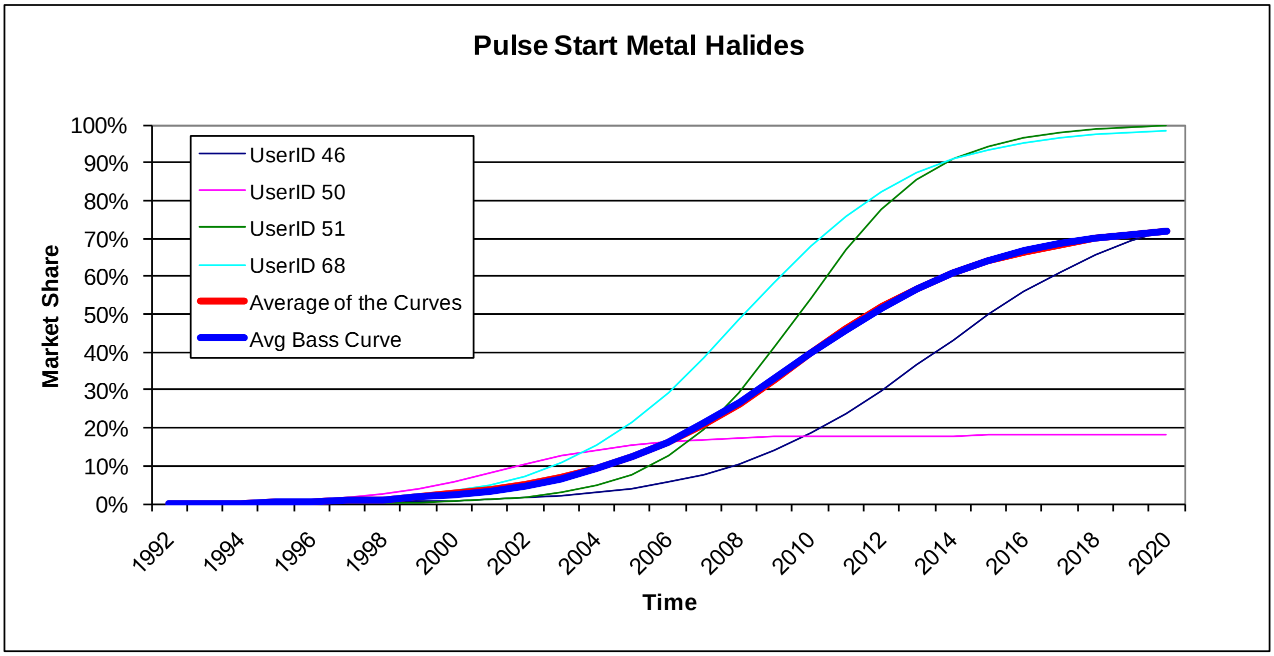


Figure 14: Modular Furniture Task Lighting Fixtures (Standard 13)

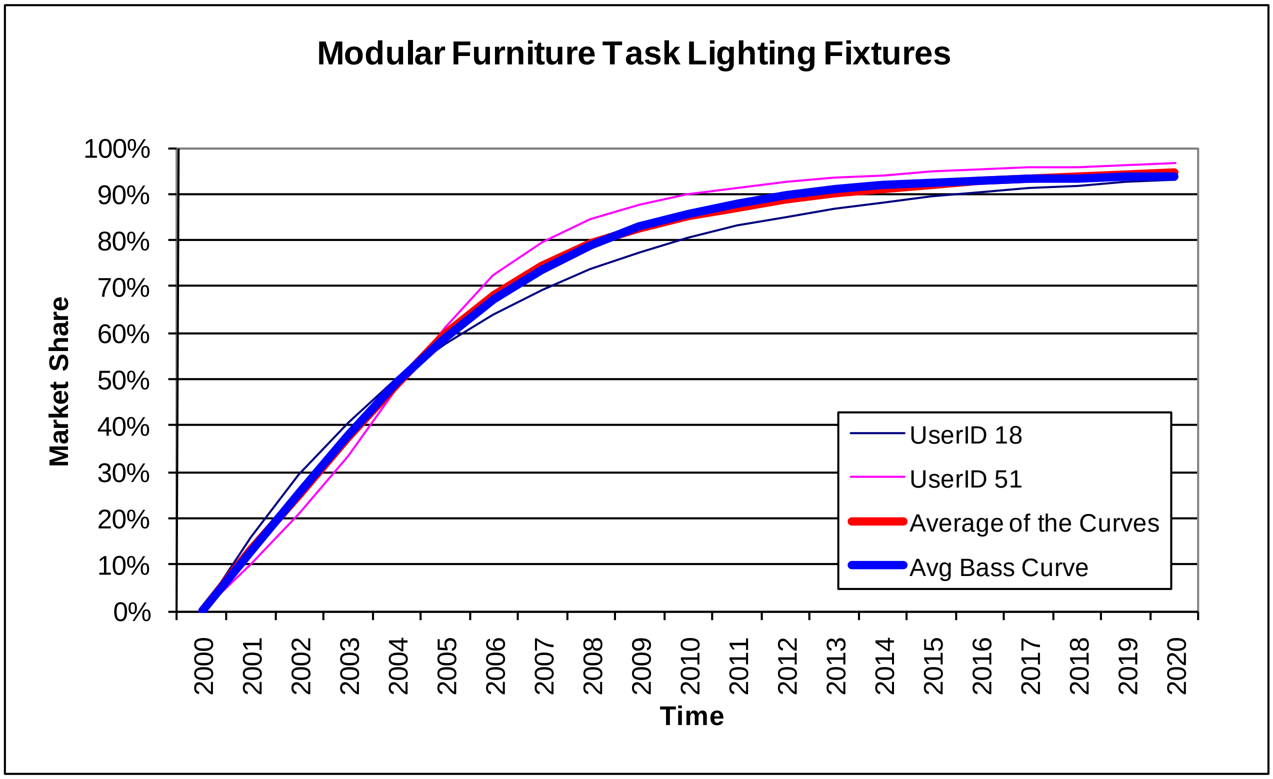


Figure 15: Hot Food Holding Cabinets (Standard 14)

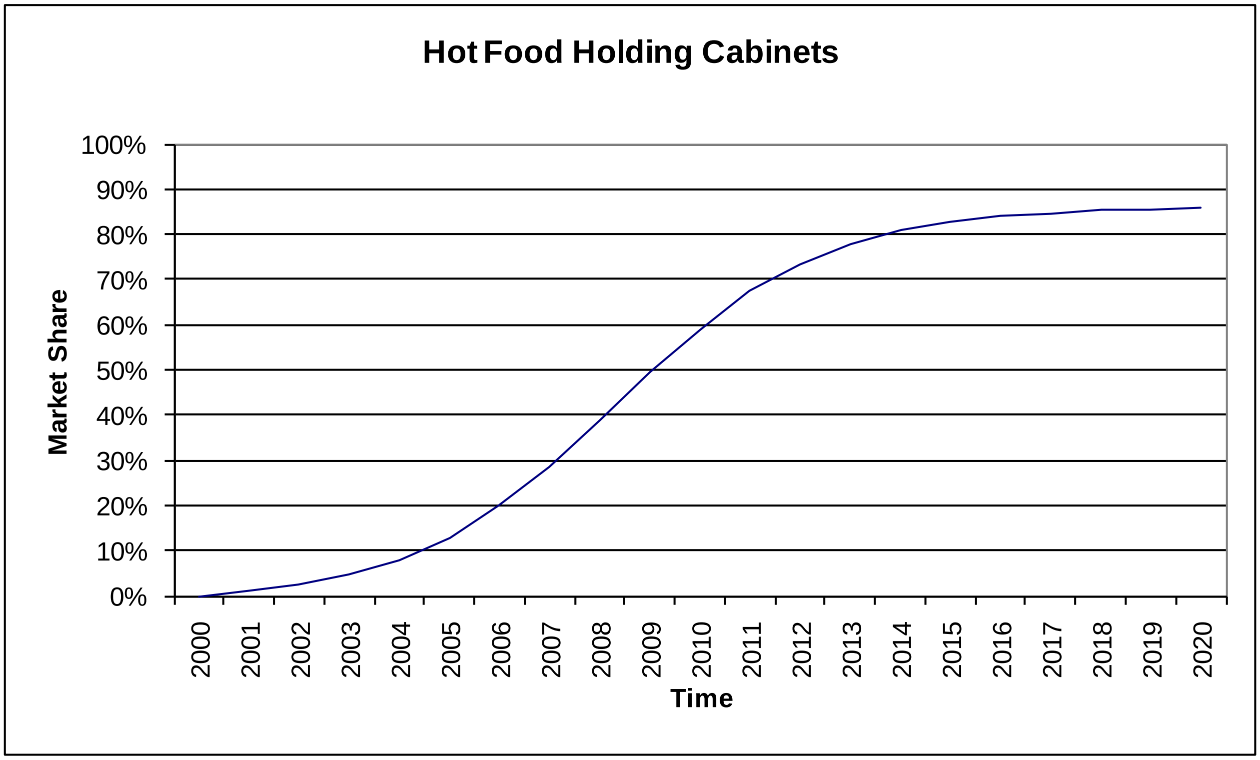


Figure 16: External Power Supplies, Tier 1 (Standard 15)

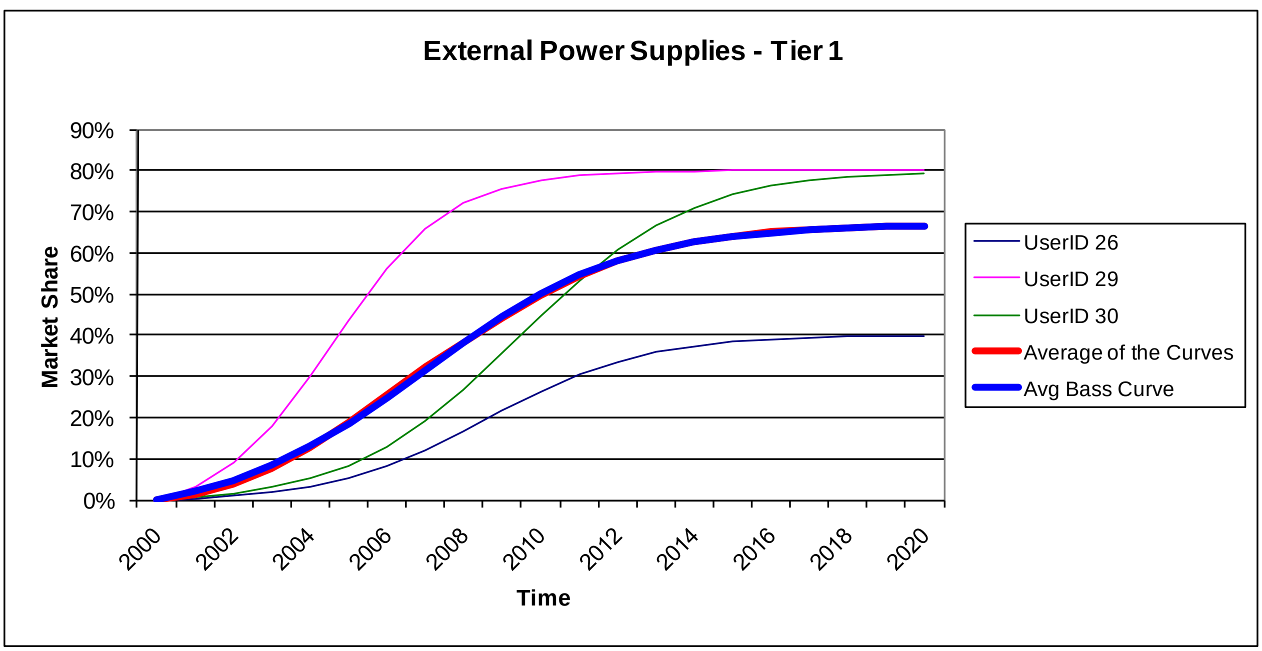


Figure 17: External Power Supplies, Tier 2 (Standard 16)

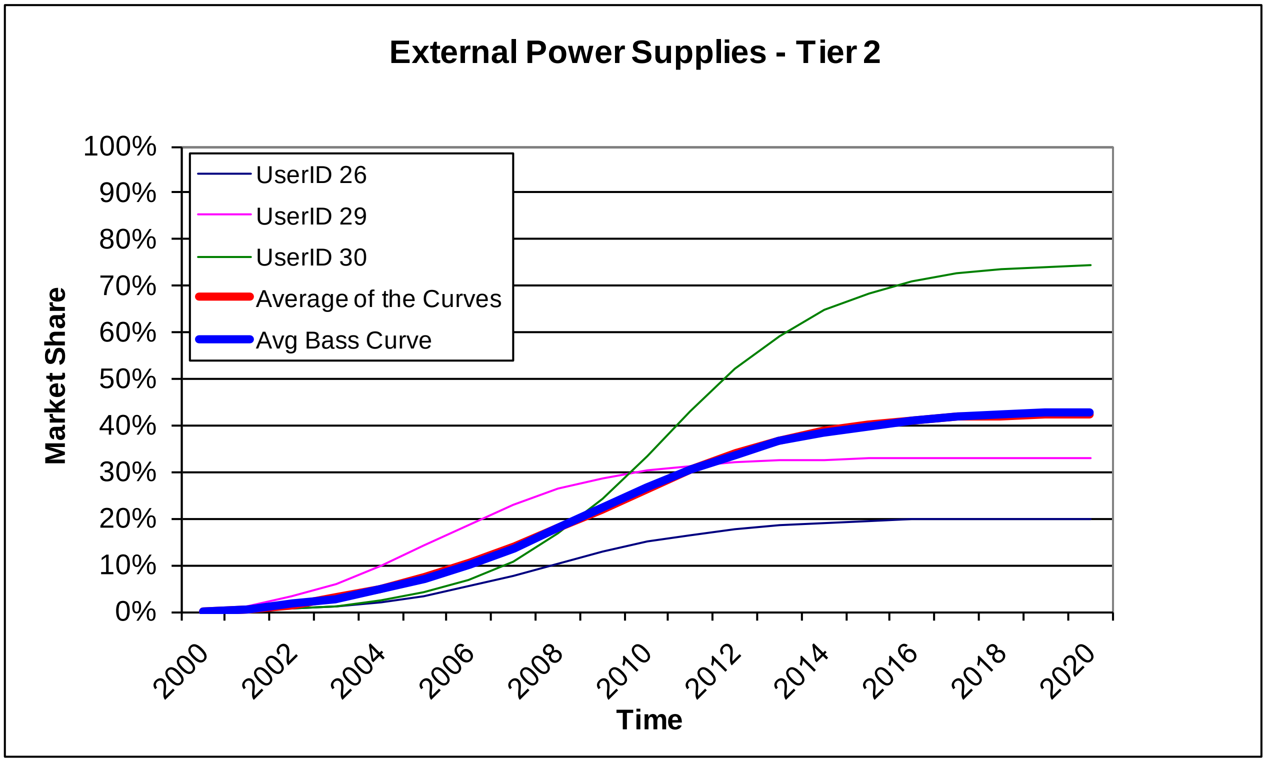


Figure 18: Consumer Electronics - Audio Players (Standard 17)

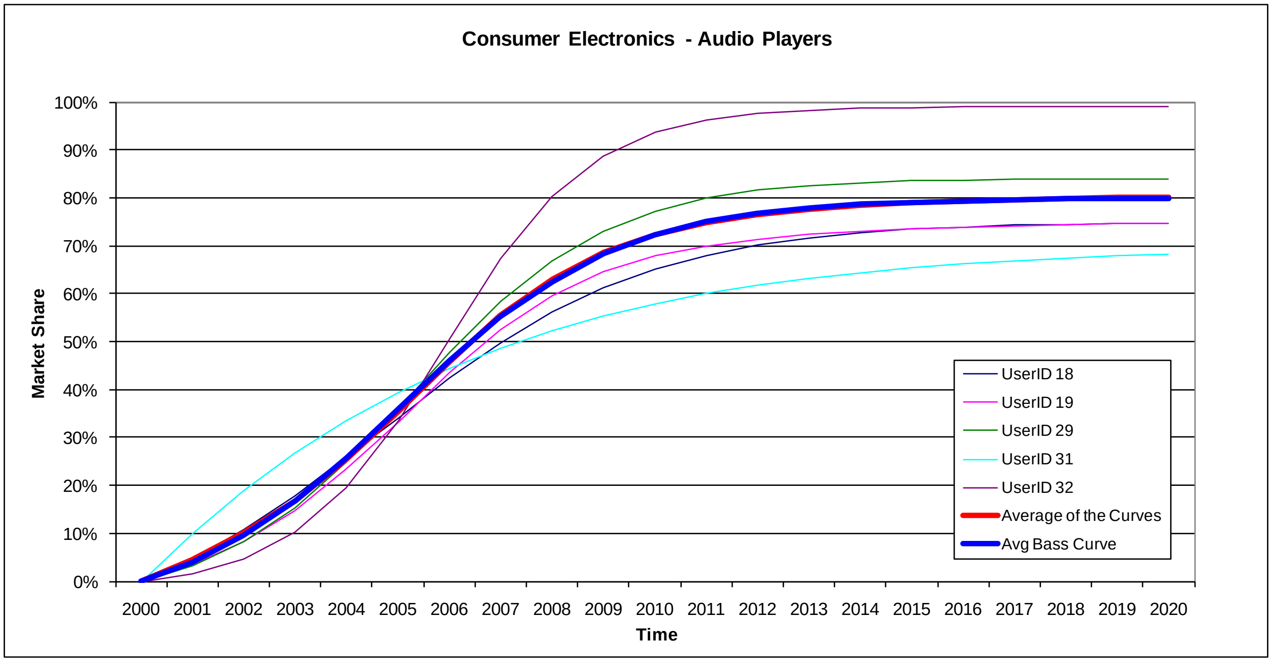


Figure 19: Consumer Electronics - TVs (Standard 18a)

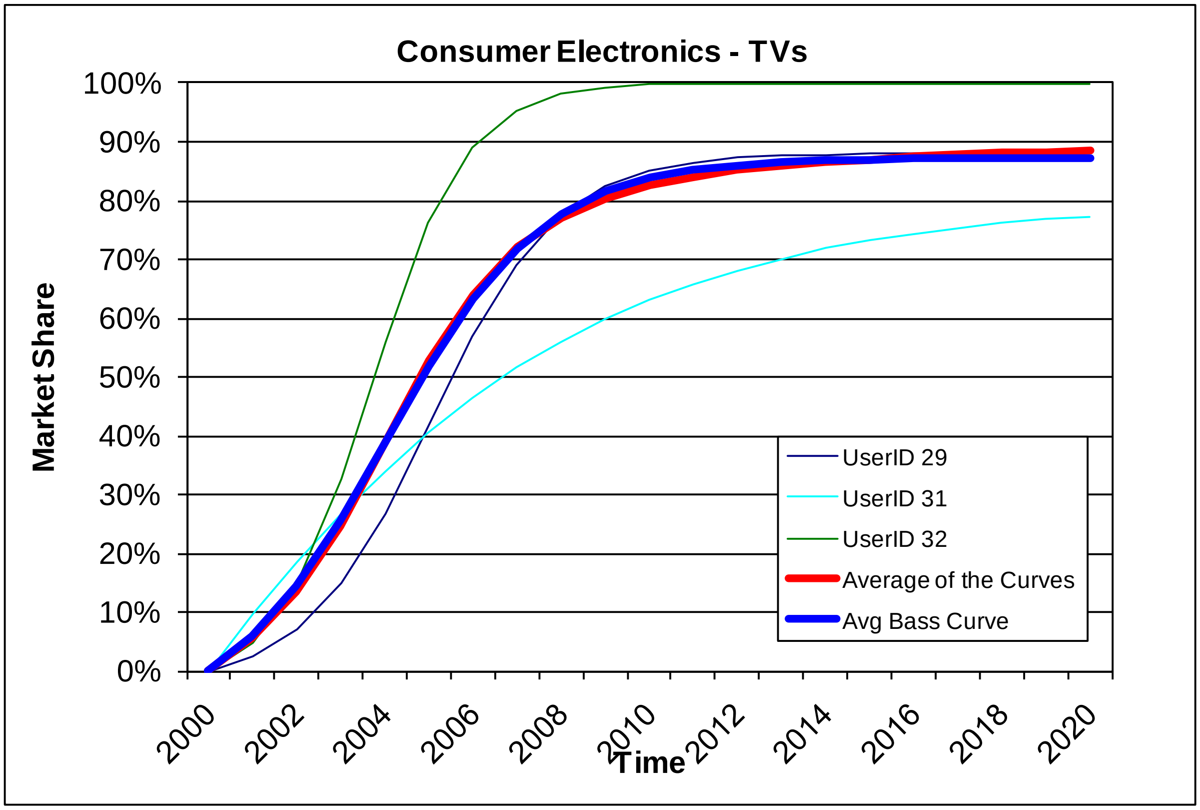


Figure 20: Consumer Electronics - DVDs (Standard 18b)

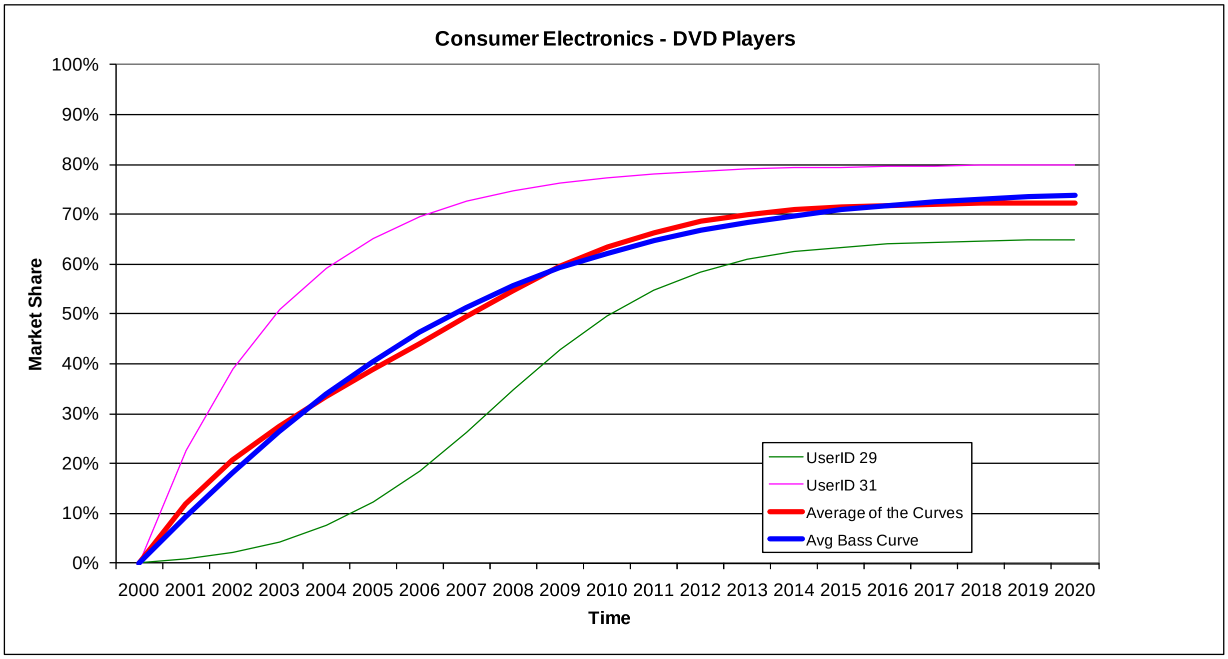


Figure 21: Water Dispensers (Standard 19)

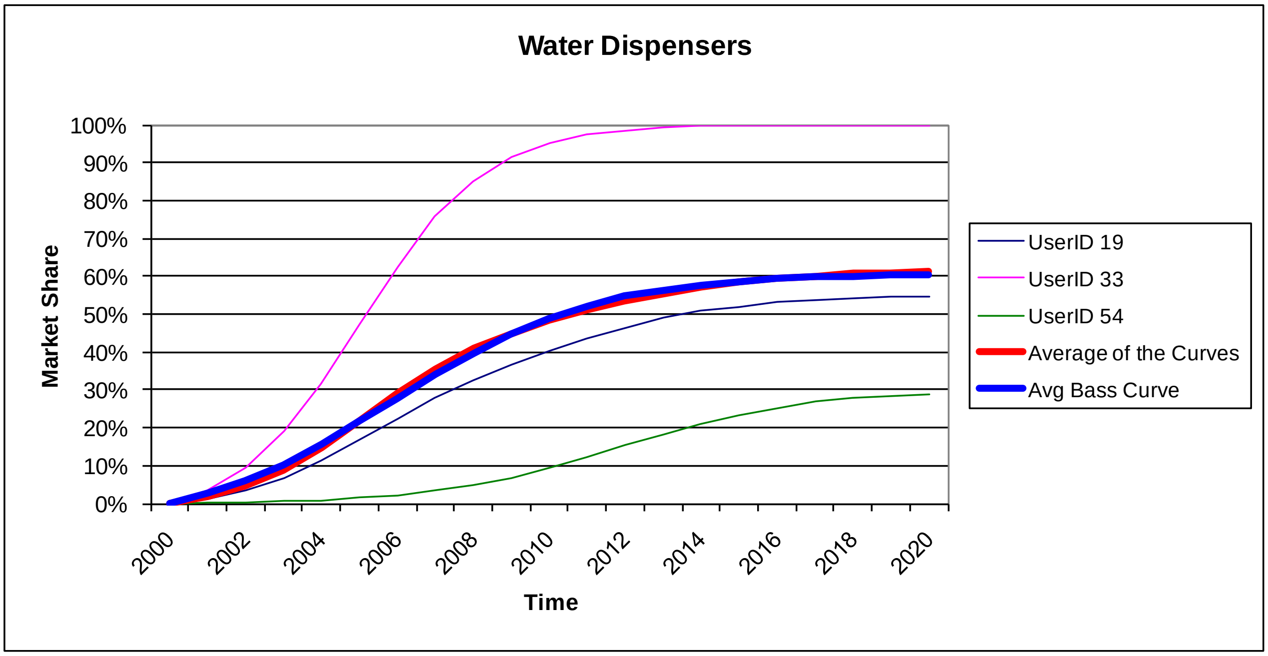


Figure 22: Unit Heaters and Duct Furnaces (Standard 20)

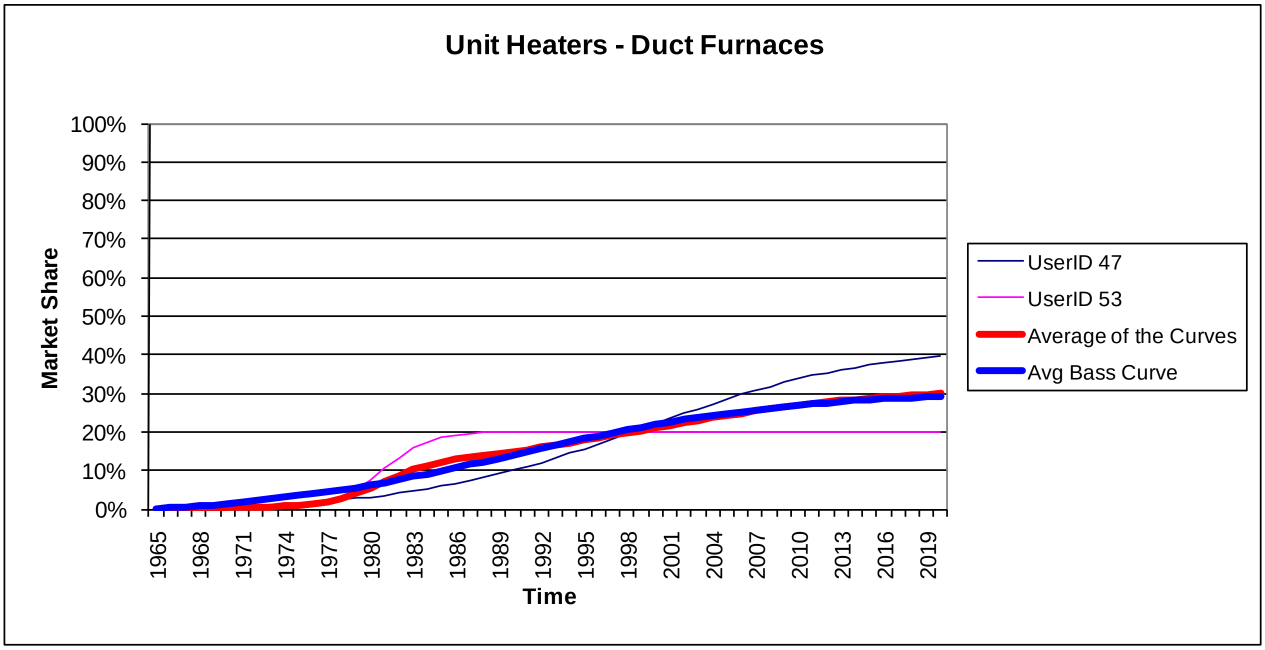


Figure 23: Commercial Dishwasher Pre-Rinse Spray Valves (Standard 21)

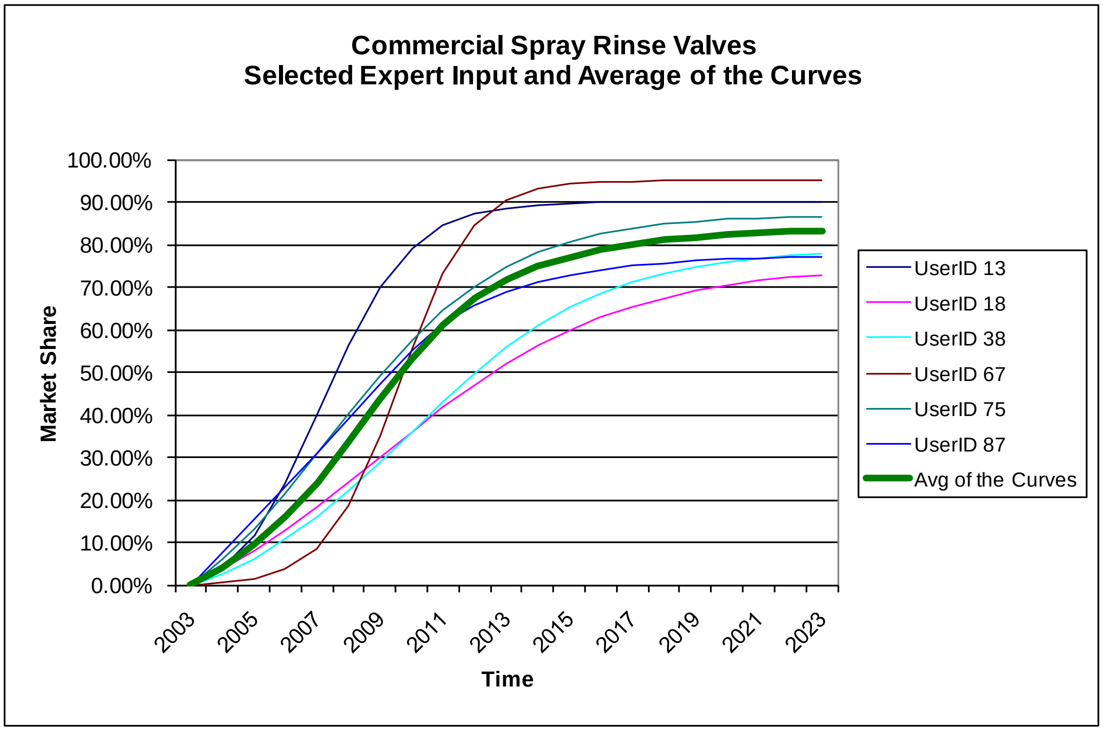


Figure 24: Residential Hardwired lighting (Standard B3)

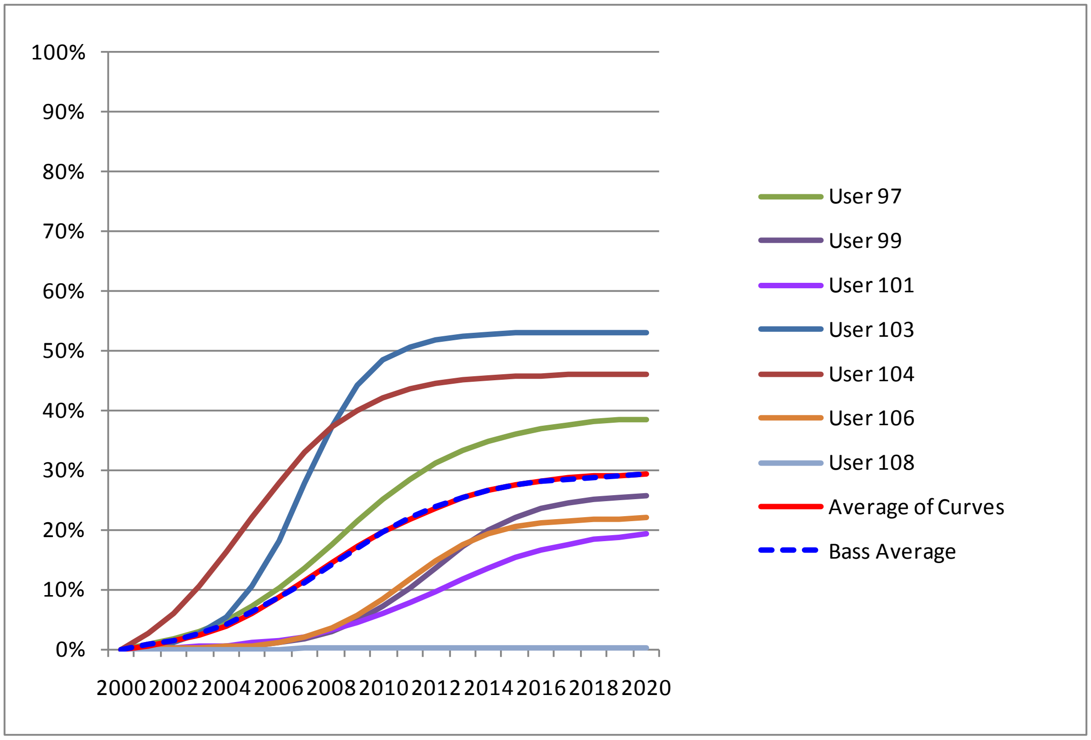


Figure 25: Duct improvement (Standard B4)

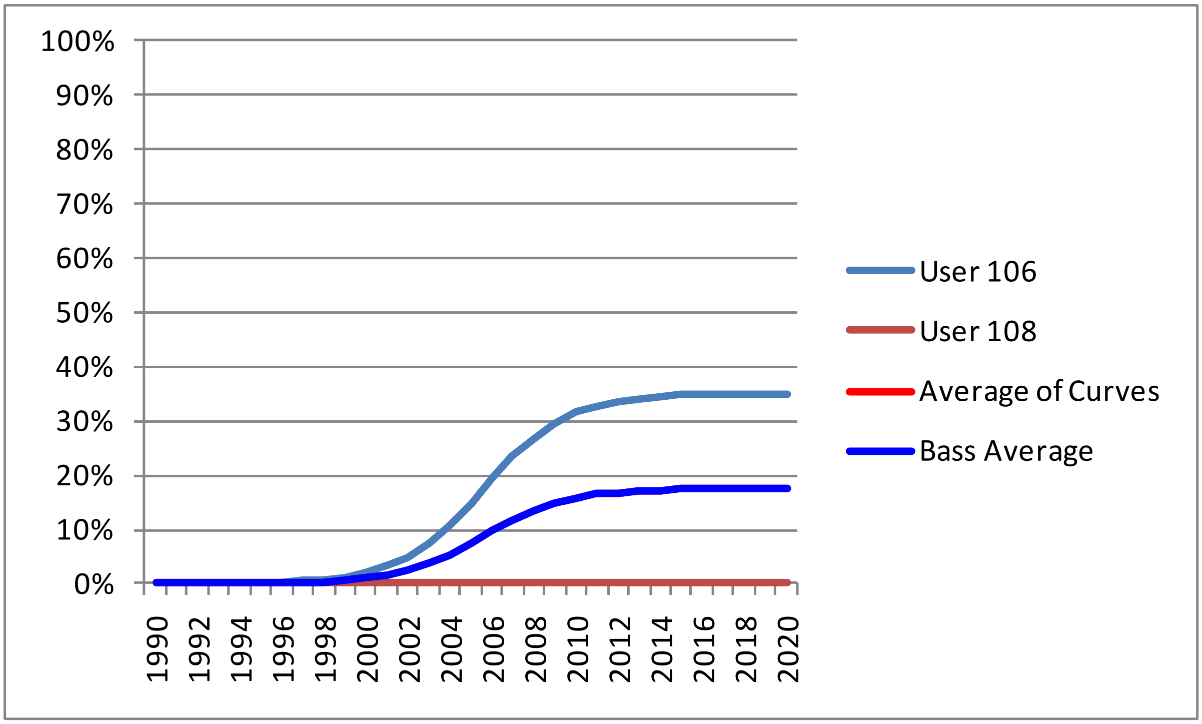


Figure 26: Window replacement (Standard B5)

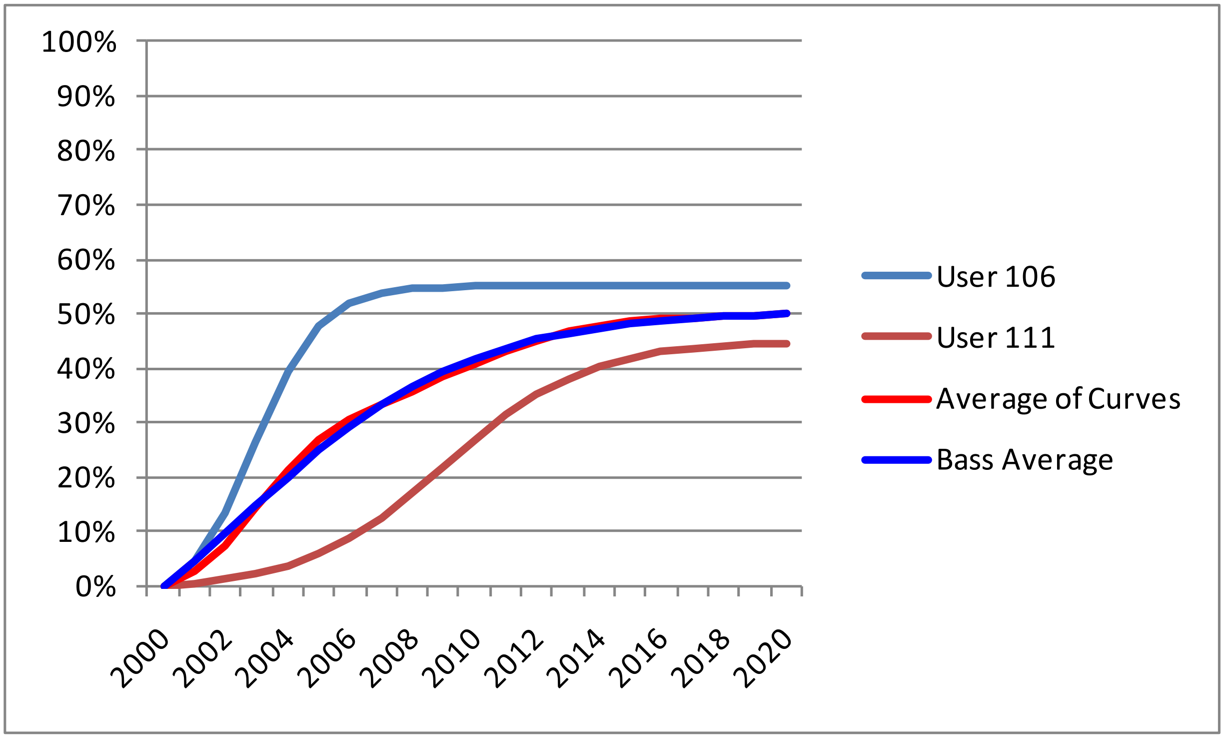


Figure 27: Lighting controls under skylights (Standard B6)

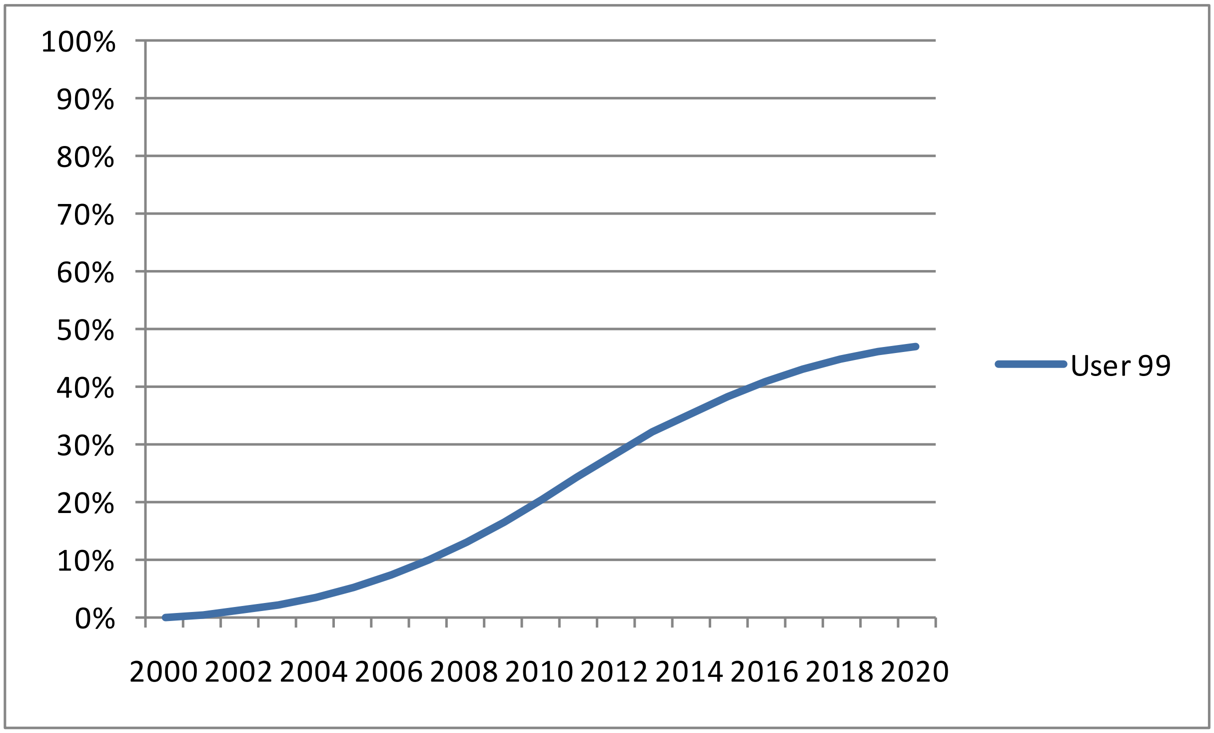


Figure 28: Ducts in existing commercial buildings (Standard B7)

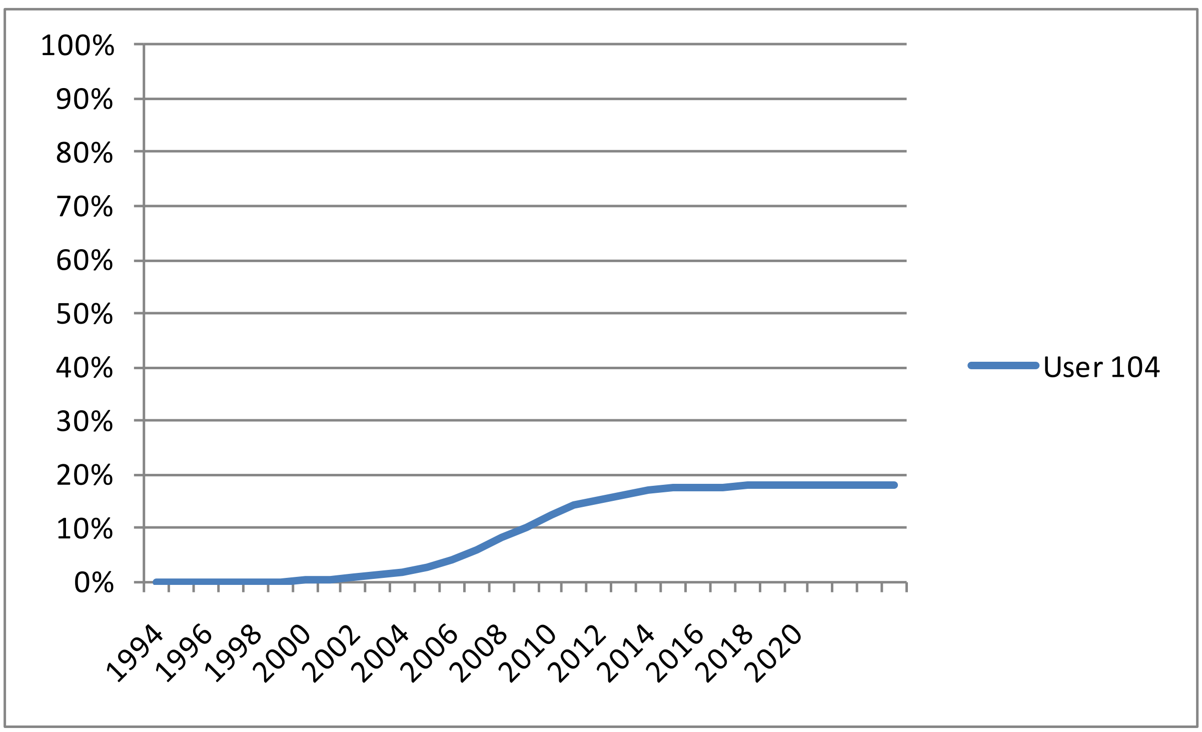


Figure 29: Cool roofs (Standard B8)

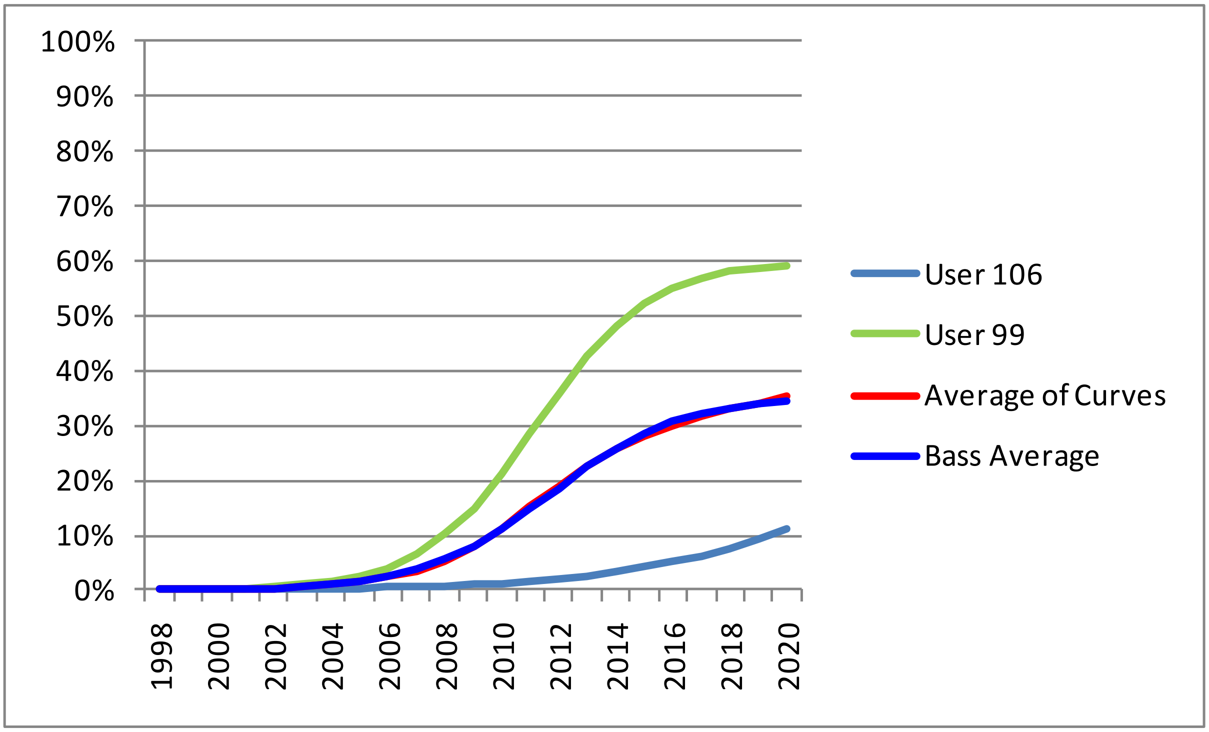


Figure 30: Bi-level lighting control credits (Standard B10)

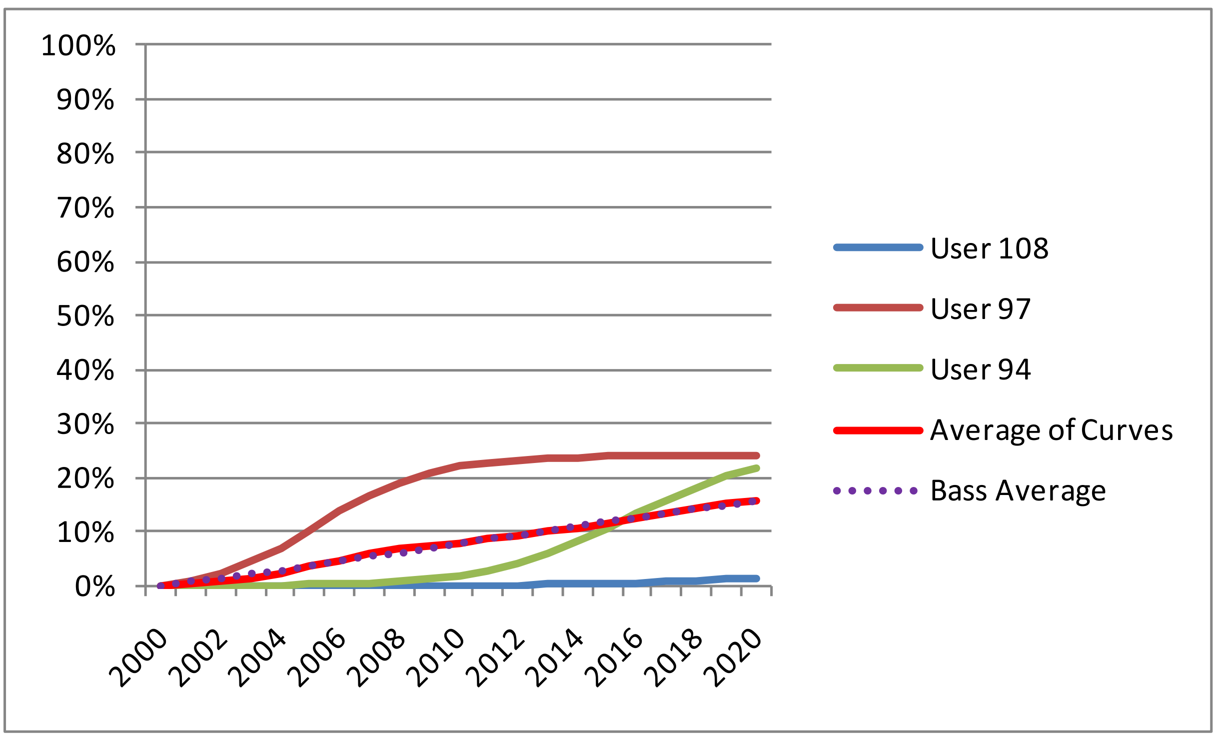
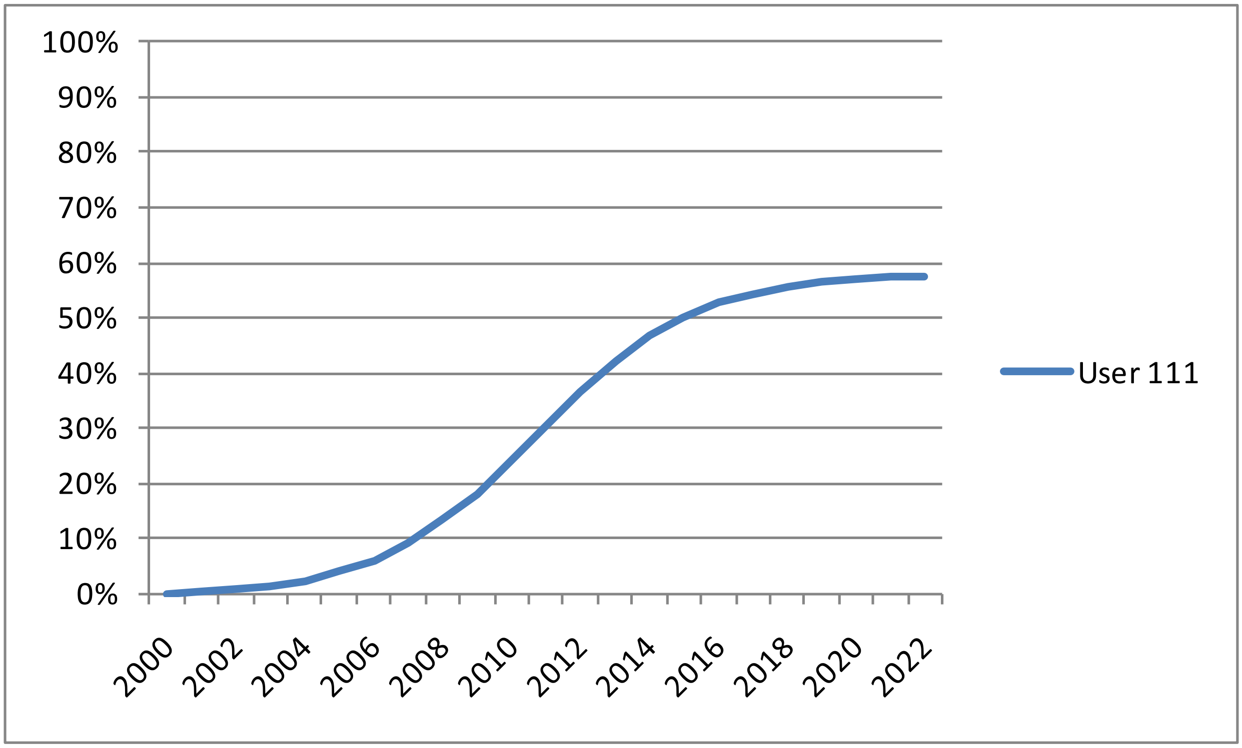


Figure 31: Duct testing/sealing in new commercial buildings (Standard B11)



Appendix P: Responses to Public Comments

This appendix presents the written comments on the draft Volume III final evaluation report that were submitted by the public and the formal responses to these comments. These comments have been taken into account in the preparation of this final evaluation report.

REF	Author	Subject
1	**Kathy Gumbleton**	**Please see attachment. (Comments that follows are extracts from the attachment)**
	Comment 1.1	TDV was designed to be transparent to the user, and that design choices that improve peak load performance simply make it easier to comply. Consequently, one would not expect most users to be aware that they were choosing peak reduction measures to "comply with TDV". Because TDV is not a requirement, "complying with TDV" is not applicable. The report authors themselves acknowledge this when they state that "it is a calculation procedure, rather than a performance or prescriptive requirement for a building component." As the authors correctly noted, "TDV was integrated into compliance software to assist designers in evaluating the energy cost performance of their buildings during peak times and in understanding the potential tradeoffs between measures." So the real question is not "were they aware of TDV," but rather, did consultants understand the potential tradeoffs between measures when they performed their peak modeling analysis, as a result of using the updated software, and did this result in more energy efficient design choices for any measure, not just HVAC.
	Response 1.1	As the C&S evaluation report points out, the reference building used to establish the Title 24 performance requirement does not require measures with large savings on peak. For example, the residential reference building assumes an air conditioner EER of 10. Consequently, when the compliance software is run for a proposed building the performance target that must be met does not reflect any special on-peak efficiency requirement. Thus, there is no clear reason the TDV approach would lead to designs that save more energy on peak than they would if the performance target were set without the TDV metric. This is clearest in the case of the analysis used to estimate the claimed savings for residential buildings. The analysis assumes that designers would opt for air conditioners with an EER of 11 instead of the assumed baseline EER of 10. However, the reference building that sets the performance requirements is modeled with an EER of 10 so there is no compelling reason to assume that designers would specify an 11 EER when a 10 EER would suffice. The Title 24 code compliance software is a required step in permitting a structure when the energy codes apply. A passing TDV score is required. The issue is the software as the tool for compliance is not stipulating action that addresses on-peak savings when tradeoffs are allowed which result in a passing TDV score that does not actually increase on-peak savings.
1	**Comment 1.2**	The analysis in Appendix J concludes that the evaluation team could not find sufficient evidence that would provide a sufficient basis for crediting TDV with any energy savings. Due to some conceptual misunderstandings noted above we feel that its premature to arrive at any definitive conclusion on this. We think it is important to revisit this in the next impact evaluation so that additional information and analysis can be carried out.

REF	Author	Subject
	Response 1.2	The interview and field data collected for this evaluation demonstrated that residential air conditioner EERs above 10 are relatively common; however, there was no clear evidence from our evaluation that this was due to TDV.
2	**Athena Besa**	**Attribution and Sampling Issues**
	Comment 2.1	Elimination of Savings Due to Federal Standards The study notes that "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." The elimination of these savings resulted in the study concluding that the evaluated natural gas savings were "a little less than half" the Savings Estimate Spreadsheet (SES, developed by HMG) estimate. The impact of eliminating the potential savings for these items implies that the utilities will not get credit for any savings related to the installation of Tier 2 Large Packaged Commercial Air Conditioners and Pre-rinse Spray Valves. One issue that arises here is whether the Federal standard was a direct consequence of the codes and standards adopted by California. If this is indeed the case then attribution to the IOUs needs to be re-examined. For example, the Federal Energy Program website, http://www1.eere.energy.gov/femp/technologies/eep_low-flow_valves.html, notes that in the case of pre-rinse spray valves, research and product testing was conducted by the Food Service Technology Center (FSTC) with funding by California utility customers. Specifically, the website notes, "The Food Services Technology Center (FSTC) has an online database of pre-rinse spray valves that have been tested in accordance with ASTM 2323-03. FSTC in San Ramon, California conducted research and product testing on pre-rinse spray valves. FSTC is funded by California utility customers and administered by the Pacific Gas and Electric Company under the auspices of the California Public Utilities Commission."The Joint Utilities believe that this is a major flaw in the findings of the study and therefore should be corrected in the final study. To not address the issue could result in the study being unreliable and not provide accurate estimates of program results and therefore should not be used in the ERT and VRT process or be used for DEER updates.
	Response 2.1	Establishing a quantifiable and rigorous estimate of indirect effects of the possible influence of IOU C&S Program activities on federal standards was argued by parties at the time of the adoption of the evaluation plan. ED determined at that time that reliable measurement of influences outside California was beyond the scope of the 2006-08 evaluation. The evaluation did not claim federal preemption of the pre-rinse spray valve standard but the result of the federal standard is a new and improved baseline. The federal Large Packaged Commercial Air Conditioner standard did preempt California's Tier 2 standard, but the basic effect is that it established an efficiency baseline equivalent to California's Tier 1 standard as of January 2010.
2	**Comment 2.2**	Elimination of Savings for Time Dependent Valuation Standards The report notes that, "no potential energy or demand savings were estimated for the two Time Dependent Valuation (TDV) 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." In Appendix J, the authors of the study discuss their rationale for eliminating the savings associated with TDV standards. First they note "the original (TDV) savings estimate was calculated by assuming that in residential buildings the standards

REF	Author	Subject
		would lead to installation of air conditioners with an EER of 11, rather than an assumed base level of 10." Based on field data used to determine compliance with the TDV standard the authors found that 54% of the air conditioners installed had an EER of 11 or higher. Furthermore, the authors found that higher EERs were being used to meet the TDV requirement, but in as little as 18% of the cases. It should be noted however, that the authors also found that just less than 50% of respondents said the approach used to meet the TDV standard varied or they did not know what approach was used. Thus, it is quite possible that EER's were being used in significantly more than 18% of the cases to meet the TDV standard. The joint utilities believe this is a major error. This needs to be corrected in the study.
	Response 2.2	The interview and field data collected for this evaluation demonstrated that residential air conditioner EERs above 10 are relatively common; however, there was no clear evidence from our evaluation that this was due to TDV. As the C&S evaluation report points out, the reference building used to establish the Title 24 performance requirement does not require measures with large savings on peak. For example, the residential reference building assumes an air conditioner EER of 10. Consequently, when the compliance software is run for a proposed building the performance target that must be met does not reflect any special on-peak efficiency requirement. Thus, there is no clear reason the TDV approach would lead to designs that save more energy on peak than they would if the performance target were set without the TDV metric. This is clearest in the case of the analysis used to estimate the claimed savings for residential buildings. The analysis assumes that designers would opt for air conditioners with an EER of 11 instead of the assumed baseline EER of 10. However, the reference building that sets the performance requirements is modeled with an EER of 10 so there is no compelling reason to assume that designers would specify an 11 EER when a 10 EER would suffice. The Title 24 code compliance software is a required step in permitting a structure when the energy codes apply. A passing TDV score is required. The issue is the software as the tool for compliance is not stipulating action that addresses on-peak savings when tradeoffs are allowed which result in a passing TDV score that does not actually increase on-peak savings.
2	**Comment 2.3**	General Service Incandescent Lamps, Tier 1 The authors of the study conclude there are no savings associated with the General Service Incandescent Lamps, Tier 1 standards. In Appendix I, the author's justify the no savings claim by noting the following, "The data from our appliance standard compliance research in 2008-09 (discussed later) provides supporting evidence for the observation that producers were likely to increase output without reducing wattage. We found, more than two years after the Tier 1 standard went into effect, that between 56% and 63% of bulbs sold had the same wattage as the traditional wattage category they were in; that is, 75 watt bulbs were still being sold and, to comply, their lumen output was increased. There are no unit savings associated with these bulbs. As noted above, the adopted Tier 1 standard was less stringent than the proposed Tier 1 standard. Based on our analysis, the result of the two outcomes—unchanged wattage with reduced lumens and a less stringent standard—was that there were essentially no energy savings from the adopted Tier

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		1 standard." If approximately 60% of bulbs provided no units savings, what about the other 40%? Even with the reduced standard, some savings should be attributable to at least the 40% of bulbs with unit savings. The fact that the authors of the study attributed no savings to General Service Incandescent Lamps, Tier 1 standards resulted in a loss of 20.7 GWh/year of claimed savings by the utilities (see Table 36). This should be corrected in the final report.
	Response 2.3	As stated in the study, the evaluation finding is that there are no savings associated with the adoption of the Tier 1 standard. The significance of the Tier 1 standard was that it established a regulatory framework in which the input (wattage) for the general service incandescent lamps was linked to the output (lumens). This set the stage for the Tier 2 standard which used the same framework to require a 5% decrease in wattage levels for these devices. So for example, what had been a 100 watt lamp would be reduced to a 95 watt lamp under Tier 2. This decrease in wattage is the basis for the savings associated with the Tier 2 standard.The reference in Appendix I to approximately 60% of the bulbs found in the market still in the traditional wattage categories provides evidence that the industry had responded to the standard by increasing output without reducing wattage, thus providing no energy savings, which is one argument made for estimating no energy savings from Tier 1. The report notes that about 44% of bulbs did comply with Tier 2 so savings resulted from Tier 2 as documented in the report. We note that the savings number suggested by the IOUs is based on the full compliance and the unit savings from the CASE report, when, in fact the adopted standard was not as rigorous as the CASE report analyzed.
2	**Comment 2.4**	Sampling Issues: In general, the study is based on very small sample sizes, ad hoc weighting, and ad hoc assignment of relevance to survey responses. Consider the following examples. • The first-round NOMAD analysis for commercial dishwasher pre-rinse spray valves is based on responses from eight individuals, two of which were characterized as outliers. However, the criteria utilized to determine outlier status (their responses seemed unreasonable) is ad hoc. How would the results differ if alternative criteria were used? Also, the Bass curve fit produces estimates of NOMAD that are significantly different from the prior study. Are these results robust to alternative functional forms?
	Response 2.4	This response focuses on the key issues in the comment. For the NOMAD estimate for pre-rinse spray valves, all inputs and associated comments were examined by the evaluators. The two that were identified as outliers were analyzed and, as noted in the report, it was found that their estimates were inconsistent with what was known about the spray valve market. A similar process was used across all standards to identify those inputs that were not credible or were inconsistent with market data. With regard to the comment that the NOMAD process was ad hoc or tailored too much to this analysis, we maintain that the process is based on general principles that are used to produce forecasts in many areas of business and economics. These general principles include the use of the Bass market adoption model and Delphi forecasting method. The application of these methods is described in Section 2.2.3 of the report. Each of the methods is then described in some detail in Appendix E

REF	Author	Subject
		along with references to additional documents on these topics. An internet search on these subjects will produce a great many additional examples of the academic and industry use and ongoing development of both the Bass model and the Delphi forecasting method. The Quantec 2005 study found that the compliant spray valves represented 25% of the natural market in 2006 while the current study estimates that this market penetration will be only 16% in 2006. In the longer term, the current study shows a higher natural market adoption rate than the prior study which is consistent with the joint utility / water company program to install these valves across the state. We believe that the current results presented in the C&S evaluation report are more accurate because the process used to obtain the inputs was more fully developed and implemented.
2	**Comment 2.5**	Allocation/attribution Issues:• (1) In the area of surveying experts about stakeholder allocation in attribution, most standards were analyzed with three to five responses from experts (small sample size issue), weighted by "involvement of the respondent in the development of the standard and his or her presumed knowledge of stakeholder activities." The determination of the weights seems completely ad hoc. In addition, strong agreement between experts about resource allocation is determined by a standard deviation less than 0.5. This value, as are the values that determine moderate and low agreement, is also completely ad hoc. (2) Attribution was determined by a panel of independent evaluators. The discussion began with a score proposed by the facilitator. There is a large potential for starting point bias in this type of protocol (i.e., the final score is essentially determined by the initial proposed score). Were alternative protocols considered? Was there an attempt to investigate starting point bias? How often and by how much did the final score deviate from the initial score? (3) The author's also note that in many cases, their final sample was based simply on who was willing to talk to them or provide them access to their files or inventories. Thus, the sample was not randomly chosen and potentially suffers from severe non-random sample selection bias. Once again this raises questions about the ability of the authors to draw any meaningful conclusions about the population. The Joint Utilities believe that this is a major flaw in the findings of the study and therefore should be corrected in the final study. To not address the issue could result in the study being unreliable and not provide accurate estimates of program results and therefore should not be used in the ERT and VRT process or be used for DEER updates.
	Response 2.5 **1 of 3**	(1) Cadmus asked the respondents to describe their involvement in the development of the standards. From their responses and our knowledge of their roles, we identified one respondent who was significantly less involved in the development of the standards than the others and whose responses were therefore thought to be less reliable. It was clear that this respondent's input should be weighted less than the others' but not how much less. We chose to weight the respondent's input by 1/2N, where N is the number of respondents for the standard. With this weighting scheme, the respondent's input would still matter but count for no more than one-half of the input of a more knowledgeable respondent (with large N). The weighting scheme has the desirable property that as N gets smaller, the less knowledgeable respondent's input counts for relatively

REF	Author	Subject
		less. This weighting scheme was developed in response to stakeholder comments during the review of the evaluation plan. According to the report, strong agreement between the experts is determined by a standard deviation of the responses of less than 0.05, not 0.5. The categories were arbitrary but sensible and are meant primarily to illustrate that there was substantial agreement between the respondents. For example, with N=2, responses of 0.4 and 0.3 would generate a standard deviation of 0.05. Given the passage of time between the development of the standards and the survey and the different information sets of the respondents, we believe such responses would constitute substantial agreement about the allocation of resources. Overall, there was high or moderate agreement about how resources were allocated between the factors for most standards.
2	**Response 2.5** **2 of 3**	(2) The attribution methodology was chosen after careful consideration of the objectives of the evaluation and alternative approaches. The chosen method enabled the evaluation panel to consider a large amount of information about attribution and to reach agreement about an attribution score reflecting the true C & S Program contribution in an efficient manner. First, the determination of attribution requires the collection and assimilation of a large amount of information. This was best done by a small team led by the facilitator. The facilitator collected and analyzed relevant information about C & S Program and other stakeholder contributions from a large number of sources including: CASE reports, code change theories, CEC transcripts, letters, and written comments, and interviews. The facilitator identified the contributions of the C & S Program and recommended factor scores for each standard based on the contributions to the panel of evaluators. The panelists read the CASE Report and the Code Change Theory and had access to other supporting documents. Second, the protocol resulted in attribution scores that reflected the actual contributions of the C & S Program. The recommendations of the facilitator were supported with specific pieces of evidence about C & S Program contributions. The panelists sometimes disagreed with the recommended scores proposed by the facilitator, and in such instances, the final score differed from the recommended scores. Also, to mitigate the potential for reference point bias, the facilitator did not have a say in the determination of the final score. Finally, the protocol allowed the panel to determine the attribution scores efficiently. The panel had to consider 114 contributions of the C & S Program (3 factor areas x 38 standards (including 3 Composite for Remainder groups of measures)). This was best done by having the facilitator create a starting point for discussion. The facilitator made recommendations of scores for contributions to 114 factors (38 standards x 3 factors per standard). In 20 instances (18%), the panel disagreed with the recommendation of the facilitator and adopted a different score. (In 17 standards, there was disagreement about at least one factor score.) In 13 instances of disagreement, the panel increased the recommended score. The average absolute disagreement was 16 percentage points. The absolute disagreement was less than or equal to 10 percentage points in 10 cases. The facilitator worked on the compilation and review of the information used to make his recommendations for more than one year and was extremely familiar with the materials. His recommendations were based on a thorough review of the record and extensive analysis of the information. Consistency, documentation, and repeatability were

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		stressed by the facilitator and evaluation panel in assigning scores across the standards. Before the scoring, neither the facilitator nor the panel reviewed the attribution scores that were used to derive the IOUs' claimed savings, but a review after the analysis showed the scores were usually similar and in many cases the evaluator's scores were higher. We are confident that the methodology was unbiased and the final score was not significantly influenced by the facilitator's recommendation.
2	**Response 2.5 3 of 3**	(3) Cadmus attempted to collect information from and interview a variety of stakeholders including the utilities and their consultants, the CEC and its consultants, industry, and other interest groups. We were not always successful in our efforts as some stakeholders could not or would not provide the information we requested. Regarding the attribution survey, we found that only utility staff, utility consultants, and CEC consultants had the knowledge to respond to the survey. We attempted to recruit as many such individuals as possible. We recognize that the final sample of respondents was not representative of all stakeholders, but we note that there were a small number of individuals, or groups, that were knowledgeable about the resource distribution related to development and adoption of the standards, and they were included among the experts participating for each standard. Because the survey concerned the allocation of resources and not the contributions of the C & S Program to standard development, Cadmus believes that there was not an opportunity for bias in the results. Regarding the contributions of the C & S Program, Cadmus spoke to and relied on the input of stakeholders representing a variety of viewpoints. Also, the interviews were just one source from which we collected information about utility contributions. Other sources included CEC transcripts of hearings, letters and other written comments to the CEC, the Code Change Theory, and the CASE reports. By using a large number of sources, the evaluation team obtained a complete and unbiased view of the contributions of the C & S Program.
2	**Comment 2.6**	Conclusion/Recommendation Tables 36 through 41 present the final evaluated savings estimates for the C&S Program statewide for the period 2006 through 2008. The tables present the evaluated savings in columns 1 through 3 for years 2006, 2007, and 2008, respectively and the SES for 2006 (which corresponds to the utilities claimed savings) in column 4. While the tables are illuminating, they are hard to interpret since no confidence intervals are provided for the evaluated savings. Specifically, consider the following methodology for determining whether utilities have met their claimed savings. Make the SES for 2006 the null hypothesis (i.e. the hypothesized level of savings). Next, calculate the evaluated savings and the standard deviation of evaluated savings. If a 95 percent confidence interval for evaluated savings includes the 2006 SES value then we fail to reject the null. In other words, we can not reject the null hypothesis that evaluated savings are the same as claimed savings. In that case, the utility should credit for its claimed savings. Given the methodology employed in the study and the issues identified above, it is our belief that the standard errors associated with evaluated savings will be large. Consequently, the joint utilities believe it is unlikely that the authors could reject that evaluated savings are statistically different from claimed savings. If this is not done, the Joint Utilities believe and would recommend that this study

REF	Author	Subject
		not be accepted as reliable or used for updating DEER or used to measure utility performance in the ERT and VRT process.
	Response 2.6	The intent of this evaluation is to calculate the verified savings not test the claimed savings as the null hypothesis. Chapter 5 presents 95% confidence intervals for savings estimates.
3	**PG&E Company**	
	Comment 3	The rationale for finding zero savings for TDV is based partially on these findings: "The first finding demonstrated that higher EERs were becoming fairly common in the California new home market, but provided no evidence this was because of the TDV requirement. The second finding suggested that higher EERs were being used to meet the TDV requirement, but in as little as 18% of the cases." We believe that the first finding could just as easily demonstrate the opposite, that TDV was helping builders to justify the higher EER, as intended. The second finding, which included evidence that builders were choosing a variety of relatively costly measures that provide TDV credits, is also a showing that TDV was working as intended. It should be noted that the authors also found that just less than 50% of respondents said the approach used to meet the TDV standard varied or that they did not know what approach was used. Thus, it is quite possible that EER's were being used in considerably more than 18% of the cases to meet the TDV standard.
	Response 3	The interview and field data collected for this evaluation demonstrated that residential air conditioner EERs above 10 are relatively common; however, there was no clear evidence from our evaluation that this was due to TDV. As the C&S evaluation report points out, the reference building used to establish the Title 24 performance requirement does not require measures with large savings on peak. For example, the residential reference building assumes an air conditioner EER of 10. Consequently, when the compliance software is run for a proposed building the performance target that must be met does not reflect any special on-peak efficiency requirement. Thus, there is no clear reason the TDV approach would lead to designs that save more energy on peak than they would if the performance target were set without the TDV metric. This is clearest in the case of the analysis used to estimate the claimed savings for residential buildings. The analysis assumes that designers would opt for air conditioners with an EER of 11 instead of the assumed baseline EER of 10. However, the reference building that sets the performance requirements is modeled with an EER of 10 so there is no compelling reason to assume that designers would specify an 11 EER when a 10 EER would suffice. The Title 24 code compliance software is a required step in permitting a structure when the energy codes apply. A passing TDV score is required. The issue is the software as the tool for compliance is not stipulating action that addresses on-peak savings when tradeoffs are allowed which result in a passing TDV score that does not actually increase on-peak savings.
4	**PG&E Company**	
	Comment 4	The reviewers state their primary reason for eliminating the savings from the TDV standard as follows: "the most significant concern was that the way the TDV methodology is implemented it does not appear to require significant peak

REF	Author	Subject
		savings for compliance, even though the underlying methodology provides more credit for on-peak energy savings." They do not appreciate that TDV was designed to be transparent to the user, and design choices that improve peak load performance simply make it easier to comply. Consequently, one would not expect most users to be aware that they were choosing peak reduction measures to "comply with TDV". In fact the notion of "complying with TDV", as the reviewers put it, is faulty because TDV is not a requirement. In helping to develop, and then adopting TDV, the CEC firmly believed that it would painlessly produce these kinds of changes to practice. The same principle applies to many of the demand response programs that the CPUC is encouraging. To conclude that TDV produces no benefit is not justifiable. The rationale provided for doing this is weak and largely subjective.
	Response 4	Please refer to Response 3.

5	PG&E Company	
	Comment 5	The IOUs' attempt to estimate statewide TDV savings was based on one illustrative TDV measure (higher EER adoptions). There will clearly be other kinds of savings. This study also found, for example, increased use of high performance windows. Because of the conservative and limited nature of the IOU estimate, we recommend that it be accepted by the evaluators as reasonable and illustrative, rather than thrown out in its entirety. The evaluators provide no alternative calculation of savings. Rather, they chose to award zero savings, which is clearly incorrect. When evaluators are unable to derive a better savings estimate than the program, the program estimate should be the default.
	Response 5	As the C&S evaluation report points out, the reference building used to establish the Title 24 performance requirement does not require measures with large savings on peak. For example, the residential reference building assumes an air conditioner EER of 10. Consequently, when the compliance software is run for a proposed building the performance target that must be met does not reflect any special on-peak efficiency requirement. Thus, there is no clear reason the TDV approach would lead to designs that save more energy on peak than they would if the performance target were set without the TDV metric. This is clearest in the case of the analysis used to estimate the claimed savings for residential buildings. The analysis assumes that designers would opt for air conditioners with an EER of 11 instead of the assumed baseline EER of 10. However, the reference building that sets the performance requirements is modeled with an EER of 10 so there is no compelling reason to assume that designers would specify an 11 EER when a 10 EER would suffice. The role of the evaluation was to verify the claimed savings by the IOUs and not depend on ex-ante estimates according to Commission Decision: "The codes and standards are to be *verified* (as opposed to *ex-ante* estimates used for planning purposes)".(D.07-09-043)

6	PG&E Company	
	Comment 6	The evaluators have incorrectly concluded that the Tier 2 lighting and appliance standards (Std 11b and Std 12b) should be treated the same as all of the other standards in this study, which were developed through pre-2006 advocacy efforts. CPUC policy makes it clear that pre-2006 advocacy results are discounted by 50% for purposes of the MEP, and do not count toward PEB. The Tier 2 standards, however, are mistakenly treated this way. Advocacy for the Tier 2 standards continued until their adoption in April 26, 2006 (with additional minor amendments made July 5, 2006), and their effective date was in 2008. Savings from advocacy work undertaken in 2006 and beyond are to be counted at 100% and applied toward PEB. An e-mail from Zenaida Tapawan-Conway (attached, dated June 9, 2008) confirms this and cites the pertinent decision (D.05-09-043, OP 14.(e)). We request that the correct credit be calculated and reported for the Tier 2 standards. "Subject: RE: Citations for C&S credits Folks – I happened to be reviewing past decisions' ordering paragraphs and came across this one, which indicates that savings associated with the utilities' post-2006 advocacy work will count towards the PEB. Please also refer to Attachment 10 of the decision which further elaborates on this issue. So, it appears that this issue is already resolved and if there's still ambiguity from the utilities' perspective, they should seek clarification in their 2009-2011 filing."
	Response 6	For the Pulse Start Metal Halide HID Luminaires Tier 2 (12b), our review of the process and the CASE report indicated that the main work in the Metal Halide Tier 1 as well as Tier 2 have been completed prior to 2006. Therefore, the analysis included savings from this standard for the 2006-2008 cycle. We removed the 50% credit toward the MPS for the 2006-08 cycle for General Service Incandescent Lighting Tier 2 (Std 11b). In accord with the cited email above from Zenaida Tapawan-Conway and according to Attachment 10, pg 5, in the decision D.05-09-043, OP 14.(e), we will refer the issue of verifying and counting savings that result from post- 2006 Codes and Standards program efforts to the EMV effort of the next program cycle. Savings related to post-2005 C&S support efforts are beyond the assigned scope of the current evaluation. D07-09-043 Section 10.3.2 established the scope of this evaluation effort to provide bonus savings for the 2006-08 cycle: "All parties commenting on this issue recommend that 50% of the savings attributed to pre-2006 C&S advocacy work count towards establishing whether the MPS has been met for the 2006-2008 cycle. They also recommend excluding these savings from the calculation of PEB. We find these recommendations to be fully consistent with our determinations in D.05-09-043, as discussed above, and will adopt them. As stated in that decision, for this purpose the C&S savings are to be verified (as opposed to ex ante estimates used for planning purposes). Energy Division's EM&V contractors are in the process of verifying those savings estimates, and Energy Division will be including the verified numbers in its Annual Verification Reports."

7	**PG&E Company**	
	Comment 7	The evaluators have incorrectly concluded that savings for pre-rinse spray valves (Std 21) are disallowed based on a claim that a federal standard governs their efficiency. The Energy Policy Act of 2005 amends the general preemption rule in the Energy Policy and Conservation Act to include a specific carve out for regulations "concerning standards for commercial pre rinse spray valves adopted by the California Energy Commission before January 1, 2005." The current California Title 20 standard was adopted December 2004. Therefore, the standard is not preempted. Cadmus should allow the calculated savings attribution to the IOUs.
	Response 7	The evaluation did not claim federal preemption of the pre-rinse spray valve standard but the result of the federal standard is a new and improved baseline. The impact on potential savings is still the same. The higher baseline means there are no incremental savings to be credited.
8	**PG&E Company**	
	Comment 8	There is an error in the electricity sales calculation, leading to incorrect IOU allocation factors, which should be corrected in the final evaluation report. The SES derived these allocation factors using the energy forecast data provided in the following CEC report: California Energy Demand 2006-2016 Staff Energy Demand Forecast, June 2005 CEC-400-2005-034-SD. Electricity sales data is provided in table Form 1.c - Statewide California Energy Demand 2006-2016 Staff Forecast Retail Sales by Utility (GWh). For each IOU, the allocation factors for were calculated by dividing their electricity sales by the total statewide electricity sales in 2006, which was 266,954GWh. (See the SES, row 3, worksheet ""Totals - by IOU""). This statewide value of 266,954GWh includes 8865 GWh for the California Department of Water Resources (DWR), associated with the state water project for pumping water from the Delta (see Chapter 9). This pumping energy in unrelated to energy consumption by buildings or appliances. The correct statewide electricity sales should be 266,954 - 8865 = 258,089 GWh. Therefore, the corrected allocation factors for electricity and demand savings for each IOU should be: PG&E: 32.7%, SCE: 33.7%, SDG&E: 7.6%.
	Response 8	There was no error. This was the original allocation method that the IOUs used for estimating their claimed savings (included in the IOUs' SES). The evaluators proposed using the same allocation method in the evaluation plan and in workshops and received no public comments on it. Since no objections were raised during the course of the plan development and stakeholder comments prior to this, ED believes that the current allocation method should be used for this evaluation period. Updating the allocation factors for electricity sales is much more complicated than presented in the comment, because it is necessary, at a minimum, to sort out all of the non-code/standard qualifying loads served by the IOUs as well as those of the non-IOU providers.
9	**PG&E Company**	
	Comment 9	**(Revised savings results)** Based on the preceding comments, which we believe point out errors in the evaluators' decisions to disallow savings, we have re-calculated the results, and present them in the document attached hereto. Comment states adjustment should be made for DWR pumping and other adjustments for spray valves, cooling towers, MF water heating savings should be corrected as described.

	Response 9	The potential savings for the pre-rinse spray valves are zero because the federal standard is a new and improved baseline equivalent to the T20 standard. Please refer to Response 2.1 for further clarifications. For the cooling towers, the evaluators have accepted the Eley estimates and credited the savings (refer to Appendix J, Table 124). For MF water heating, Appendix J notes that only 15% or 40% of units were expected to be affected by this standard, but these factors did not appear to be taken into account in the prior analyses by Eley/ADM. The evaluation included this factor and the final Appendix J includes Table 126 showing the calculations. Regarding the issue of SWR pumping and issue related to allocation please refer to Response 8.
10	**PG&E Company**	
	Comment 10	**Weighting of compliance data** In Table 28, Compliance Level for Specific Measures, data were weighted by "the number of observations". Is this the correct way to weight? One would think they should be weighted by an energy measure.
	Response 10	All observations were weighted equally. The reference to "number of observations" meant that the average for new construction and alterations were weighted by the number of observations in each group, thus giving each observation equal weight. We did investigate using square footage as a proxy for energy savings, but did not have enough observations with square footage to establish a consistent metric.
11	**PG&E Company**	
	Comment 11	**Std 13 MF Water Heating savings** The Appendix J of the evaluation report provides no explanation on why the potential energy savings were reduced from 1.54 MTherm/year to 0.31 MTherm/year, as shown in Table 126 of the report. As shown in the following statement quoted from the report, the evaluators determined that the savings estimate provided in the study conducted by the Eley Associates is reasonable, which is what was used in the SES for generating claimed savings. "Based on the information provided, we believe the Eley savings estimate is reasonable. This is the value used in the SES. The two prior savings estimates and our final evaluated estimate are presented in Table 126. The Eley/ADM value is included in the SES." This seems to be a simple mistake that should be corrected. Otherwise, the report should explain in detailed why savings are reduced even though results from Eley's study are deemed to be reasonable.
	Response 11	Appendix J notes that only 15% or 40% of units were expected to be affected by this standard, but this factor did not appear to be taken into account in the prior analyses by Eley/ADM. The evaluation included this factor and the final Appendix J includes Table 126 showing the calculations.

12	**PG&E Company**	
	Comment 12	**Std 12 Cooling Towers** The evaluators determined that this measure would not generate any energy savings based on the following reasons: "Estimates per unit vary from 22 percent to 65 percent in the different studies. The data relied on are based on small samples or unverified analyses. Further study involving the application of multiple building types across all California climate zones is needed to provide reliable savings estimates.

		Consequently, we recommend attributing no savings to this measure." As explained in the following comment, we disagree with the assertion. We also object on principal to the conclusion that, lacking an alternative savings estimate, there should be a presumption of zero savings. The CPUC should either provide a more defensible estimate, or it should accept the default estimate provided by the program.
	Response 12	We are taking this comment into consideration. The main weakness noted in the evaluator's review of the original analysis was the lack of extensive field data, but we recognize that the costs of collecting these data would be prohibitive. The modeling that was done to produce the claimed savings appeared to be sound. Appendix J (Table 124) has been modified to reflect the decision to accept the claimed savings estimate.
13	**PG&E Company**	
	Comment 13	**Std 12 Cooling Towers** The evaluators incorrectly question the reliability of the savings estimates from two previous studies, the Cooling Tower CASE study and the ADM study, because sample numbers were small and the analysis was not verified. However, the CASE study followed the CEC CASE study template for analysis, based on a 100,000 sq ft office building in representative climate zones, which can be readily adjusted for other building types. Engineering analysis, rather than sampling, should be used to determine energy savings. Rather than being unverified, the CASE study was reviewed by leading industry experts. The analysis used the accepted building analysis tool, DOE-2. Performance characteristics for the cooling systems are well understood and reflected in the DOE-2 models. If the evaluators question the analysis, they should provide specific technical objections or evidence that the DOE-2 models are not reliable. The scope and applicability of this measure were based on CASE author's professional experience, on input from cooling tower manufacturers, and on validation from industry stakeholders. The evaluators should provide a more compelling justification for overruling all these estimates, which are at least as rigorous as CPUC HIM estimates.
	Response 13	The Eley estimates have been accepted refer to Appendix J, Table 124.
14	**PG&E Company**	
	Comment 14	**Std 12 Cooling Towers** For Std B12, Cooling Towers, the evaluation report didn't allocate any demand savings. As this standard addresses the energy efficiency of large air conditioning systems, which are operated mostly during peaking demand periods, there should be demand savings as well, as indicated in the CASE study report.
	Response 14	Demand savings are mentioned in the CASE report but no estimates or supporting information are provided. Also, the SES shows no demand savings for this measure. As noted in response to Comments 12 and 13, we accepted the claimed energy savings and have estimated no demand savings since the IOUs did not claim demand savings and presented no estimates in supporting documentation.
15	**PG&E**	
	Question 15	Given that the study has determined residential whole building compliance rates, shouldn't those compliance rates be applied to Composite for Remainder measures?
	Response 15	As the report notes, the Composite for Remainder compliance value was based on the ex ante energy savings estimates for the three components of the CfR that saved the most energy. The evaluation developed a whole building compliance estimate for only the residential Title 24 and most of the savings in the CfR category were from

		nonresidential measures. On that basis alone, it would not be appropriate to use the residential whole building compliance rate for the CfR. In addition to that, the whole building compliance rates by definition include the effects of all measures so applying the aggregate rate to individual measures or groups of measures would not be appropriate.
16	**PG&E**	
	Question 16	The report identifies two issues that represent departures from the CPUC's evaluation protocols for C&S programs: (1) the definitions of potential, gross and net savings; and (2) the abandonment of the NOSAD (normally-occurring standards adoption) adjustment to savings. Do these have the effect of permanently modifying the adopted protocols?
	Response 16	The evaluation contractor's recommendations were accepted by ED for this evaluation as permitted by the protocols.
17	**PG&E Company**	
	Question 17	The ISSM models are not limited to program years 2006-08, but rather generate yearly first savings estimates out into the future. Will those savings be credited to future utility program years, and if so will they be based on this version of the ISSM? Will any of the ISSM numbers be revisited in future years?
	Response 17	C&S savings will not be credited until they are verified.
18	**PG&E**	
	Question 18	**NOMAD methodology** The report mentions several difficulties with the NOMAD estimates, including the difficulty in estimating the precision of the results. Based on the evaluators' experience with implementing the NOMAD methodology, are there recommendations for how to improve the method in the next evaluation?
	Response 18	We have confidence in the method used to estimate the NOMAD curves. However, we did experience some challenges as we collected and tracked market data. One of these challenges was the identification of DSM programs that have a direct effect on the natural market for an efficient product. There is a recommendation in Section 6.2 to "implement a comprehensive strategy linking DSM programs and activities to the C&S Program and long-term goals for standard adoption." In addition to this specific recommendation, we discussed the possible benefits of a broader effort to monitor the markets for efficient products and specifically, those that are regulated by the C&S program. Such data would be valuable in establishing the natural market at the time of standard adoption (a.k.a. initial market penetration). In this discussion, periodic--perhaps annual--updates on key markets would provide additional context for the NOMAD estimate.

19	**PG&E**	
	Question 19	**Compliance rate methodology** The report mentions several major problems encountered estimating statewide compliance rates. Are there recommendations for how this methodology could be improved in the next evaluation?
	Response 19	This question does not clarify whether it refers to building or appliance standards so we cannot respond directly. The problems encountered were primarily difficulties obtaining the required data, not limitations of the methodologies. The report and appendices describe some issues and recommendations related to the compliance analysis data collection for future reference. For example, access to compliance documentation at the jurisdictions was an issue. Both res and non-res compliance analyses would benefit from instituting a common methodology for record keeping of the Title 24 documents across all California jurisdictions. Additionally, all jurisdictions should be working from the same set of rules regarding public access to compliance documentation and supporting building plans. This issue routinely came to the forefront when some jurisdictions would make requested documentation available, while others would refuse citing copyrighting as a reason to not share compliance documentation with our public inquiry.
20	**PG&E**	
	Question 20	Previous draft studies published by this team have included the NOMAD graphs showing how individual reviews drew the curves, and how this resulted in the average curves. Will those graphs for this study be included in this report or its appendices? They may be laboriously viewed, respondent-by-respondent, in the ISSM, but it is useful to see them compiled and printed in the report.
	Answer 20	We have prepared an MS Word file released with the report materials as Appendix O.
21	**PG&E**	
	Question 21	**Effective dates of standards** The report lists the effective date of each of the standards included in the study. Can it also list the adoption date for each?
	Response 21	The effective date is necessary for quantifying impacts, because that determines when the savings start accruing. The date of adoption is unnecessary for the evaluation.
22	**PG&E**	
	Question 22	This is the first study to ever show that residential non-participant whole building compliance rates are greater than one. Are you confident that the non-participant sample was not influenced by reach codes or other beyond code programs? Why are these findings, with compliance rates of 120% for electricity and 235% for therms, so different from previous studies?
	Response 22	Using data from the utilities, the evaluation excluded homes that were included in utility programs so we are confident that program homes were excluded. No information was provided on beyond code programs and addressing possible effects of such programs, including market effects and spillover of other programs, was not in the scope of this study. The analysis was based on extensive field data for nearly 200 homes distributed throughout California. Based on these data, the average natural gas energy savings of homes built under the 2005 Title 24 was a little over two times the amount estimated based on the difference between just meeting the 2001 Title 24 and just meeting the 2005 Title 24. Although this is a significant increase over the minimal

		savings, this way of expressing savings should not be confused with the compliance margin. The standard compliance margin is expressed as the difference in consumption of a home as-built and one just meeting the standard divided by the consumption of the home if it just met the standard. Using this measure, the average compliance margin (treating natural gas use alone) was a very plausible 8%. Although average performance was better than required by the standard, particularly for natural gas consumption, the projected natural gas savings from the 2005 Title 24 residential standards were relatively small (about 6%). As noted in the report, between 15% and 40% of new homes had instantaneous gas water heaters, which were not assumed in the 2005 Title 24 analysis. In addition to leading to the homes using less gas than anticipated in the original Title 24 savings predictions and possibly contributing to the observed savings, the tradeoffs possible through the performance compliance approach could have allowed the electricity use to be higher than predicted while permitting compliance, even within the TDV framework.

23	**PG&E**	
	Question 23	Final Verified and Claimed savings are related to each other. Would it also be useful to relate the Verified Savings to each utility's overall portfolio goals?
	Response 23	That will be addressed in the VRT process.
24	**PG&E**	
	Question 24	The report states that the residential simulation models were calibrated to end-use metered data. Does the report also explain what effect these calibrations had on the model predictions?
	Response 24	Refer to the Volume I of the NCCS Evaluation Report for a complete discussion of the end-use metered data.
25	**PG&E**	
	Comment 25	"Similarly to Lighting Tier 2, the Tier 2 Pool Pump standards are mistakenly treated as pre-2005 activities: in practical application they were defended and re-adopted in fall of 2008 and their effective date was in 2008 and 2010. We request that the correct credit/PEB be calculated and reported for the Tier 2 standards on two independent grounds: 1. Very significant post-2005 IOU activities were required to defend the adopted Pool Pump Tier 2 regulations culminating in a follow on rulemaking under docket # 08-AAER-1B and adoption in fall of 2008. In the absence of such IOU actions, it is probable that Tier 2 standards would have been eliminated or deferred for several years. Given the extraordinary efforts on the part of the IOUs to maintain support (prevent a rescission by CEC) with key industry groups for the standard in the post adoption period, the IOUs should receive treatment of Tier 2 as a post-2006 adoption. 2. A very significant aspect of the pool pump standard under both Tier 1 and Tier 2--coverage of pool pump motor only replacements--was found (post-adoption) by the CEC to not be covered by the adopted regulation, due to crafting errors in the section 1601 G scope section by CEC. CEC determined that it did not, therefore, have the ability to regulate pool pump-motor only replacements, based on this scope language. Only those situations where pump/motor combinations were sold together were technically covered. Thus, a large component of pool pump motor sales in 2008 were not really covered by the adopted standards. In docket # 08-AAER-1B adoption in fall of 2008, the CEC corrected the scope, added new definitions and clarified the

		regulations, such that motor-only replacements were to be covered effective January 1, 2010. This circumstance further justifies treatment of Tier 2 as a post-2006 standard."
	Response 25	We removed the 50% credit toward the MPS for the 2006-08 cycle for Pool Pump Tier 2. According to the decision D.05-09-043, OP 14.(e), we will refer the issue of verifying and counting savings that result from post- 2006 Codes and Standards program efforts to the EMV effort of the next program cycle. Savings related to post-2005 C&S support efforts are beyond the assigned scope of the current evaluation. D07-09-043 Section 10.3.2 established the scope of this evaluation effort to provide bonus savings for the 2006-08 cycle: "All parties commenting on this issue recommend that 50% of the savings attributed to pre-2006 C&S advocacy work count towards establishing whether the MPS has been met for the 2006-2008 cycle. They also recommend excluding these savings from the calculation of PEB. We find these recommendations to be fully consistent with our determinations in D.05-09-043, as discussed above, and will adopt them. As stated in that decision, for this purpose the C&S savings are to be verified (as opposed to ex ante estimates used for planning purposes). Energy Division's EM&V contractors are in the process of verifying those savings estimates, and Energy Division will be including the verified numbers in its Annual Verification Reports."

26	**Jonathan McHugh**	
	Comment 26	Please see attachment. This describes a methodology for evaluating the impact of TDV on peak demand savings for buildings using the performance method. Page 2 2005 T-24 C&S evaluation (energy efficiency ratio rated at 95°F outdoor air temperature). TDV required temperature dependent air conditioning models and air distribution models and gave credit to things such as EER. · TDV simplified life for the decision maker concerning the trade-offs between peak demand and energy savings not just in terms of code compliance but also in terms of efficiency and rating programs that are based on TDV. · TDV helped create the economic basis for demand response which was explicitly valued for cost-effectiveness in the 2008 standards. Much of the benefit of TDV is in how trade-offs are made in the performance method, so market and compliance information is required to accurately calculate the energy savings from TDV. TDV was also used in developing the cost-effectiveness analysis of various measures, thus for instance duct sealing would have a lower B/C ratio without TDV. This likely would have impacted the number of climate zones deemed cost-effective for duct sealing upon retrofit. Since the benefits of duct sealing are already attributed to the C&S program, perhaps it is not necessary to count this benefit again for TDV. However, it seems likely that TDV has had an impact on the performance method - if one installs a measure with little peak impact one has to install more of that measure to get enough TDV benefit and the TDV benefit for peak reduction measures is greater so that these peak reduction measures are used more frequently. To evaluate this one might consider the following design. · Collect a statistical sample of performance runs under the 2001 T-24 standards. Run the simulations using the 2005 software (including TDV) but with a 2001 reference home and reference building. Identify the compliance margin. Compare the results to the following. · Collect a statistical sample of performance runs under the 2005 T-24 standards.

		Run the simulations using the 2005 software and with a 2005 reference home and reference building. Identify the compliance margin. TDV also provided the basis for giving credit for EER (if you had a HERS rater verify the EER) for residential air conditioning. This may have transformed the market. For the 2008 standards the Heschong Mahone Group conducted a telephone survey with distributors responsible for the sales of approximately 100,000 residential air conditioners. These distributors reported that all of their SEER 13 equipment that they sold was EER 11 or higher. The report indicates that EERs were evaluated and 54% of air conditioners had EERs of 11 or higher – this may reflect the social desirability bias in self-reporting. However, the CEC equipment database has EER's as low as 10.5 for SEER 13 equipment. TDV valuation and credit for EER may have impacted the sales of higher EER air conditioners. To evaluate this one might consider the following design: · Compare the sales of higher EER equipment between California and other states. TDV not only affects the energy code but it also affects the whole building incentive programs that base incentives on the percentage that a given design exceeds code. Page 3 2005 T-24 C&S evaluation 2005 T-24 C&S evaluation In addition, the report indicates that 18% of the compliance analysts interviewed indicated that they specified higher EERs to meet the new TDV requirements. Note that to take this credit the EER has to be verified by a HERS rater, so the analysts have to convince their clients to participate in a HERS rating, something many builders don't want to do because of the perceived hassle factor related to scheduling HERS inspections. Nonetheless this one data point may indicate that the HMG estimate should be derated to 18% of its initial value not 0%. Since TDV occurs "under the hood" of the performance method simulation program, this may be the tip of the iceberg and other analysts are finding lowest cost methods of compliance without really thinking that their choices are being subtly nudged by TDV. I hypothesize that the performance method analysis described earlier would capture this effect of changing the performance evaluation rules. Thus I think the reported 18% of HERS raters using the EER path for addressing compliance under TDV is a conservative estimate of savings and the less apparent effects might be even larger.. TDV has also created the vehicle for evaluating the benefit of demand response. This allowed the following measures in the 2008 standards · demand response requirements for air conditioning systems with direct digital control to the zone · demand responsive lighting controls for stores greater than 50,000 sf. When the 2008 standards are evaluated, hopefully TDV will be credited for some of the peak savings associated with DR controls. In summary, to capture the impacts of TDV, one needs to conduct market surveys to evaluate the impact of TDV. Preliminary research in the report indicates at least an 18% impact on the choice of high EER air conditioners. There may be additional demand savings that perhaps can be better captured in the methodology I have described above by comparing 2001 and 2005 performance runs and evaluating them using the 2005 software. I can't see that one could justify giving TDV zero credit for peak demand reduction without conducting the types of analysis described above.
	Response 26	We appreciate your feedback. As the C&S evaluation report points out, the reference building used to establish the Title 24 performance requirement does not require measures with large savings on peak. For example, the residential reference building assumes an air

		conditioner EER of 10. Consequently, when the compliance software is run for a proposed building the performance target that must be met does not reflect any special on-peak efficiency requirement. Thus, there is no clear reason the TDV approach would lead to designs that save more energy on peak than they would if the performance target were set without the TDV metric. This is clearest in the case of the analysis used to estimate the claimed savings for residential buildings. The analysis assumes that designers would opt for air conditioners with an EER of 11 instead of the assumed baseline EER of 10. However, the reference building that sets the performance requirements is modeled with an EER of 10 so there is no compelling reason to assume that designers would specify an 11 EER when a 10 EER would suffice. The Title 24 code compliance software is a required step in permitting a structure when the energy codes apply. A passing TDV score is required. The issue is the software as the tool for compliance is not stipulating action that addresses on-peak savings when tradeoffs are allowed which result in a passing TDV score that does not actually increase on-peak savings.