CONSULTANT REPORT

Statewide Codes and Standards Program Appendices to Impact Evaluation Report

For Program Years 2010-2012

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DNV GL

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LIST OF ACRONYMS AND ABBREVIATIONS

A/C (AC)	Air Conditioning
ACCA	Air Conditioning Contractors of America
ACM	Alternative Calculation Method
ACP	Air Care Plus
ADM	ADM Associates
AEC	Architectural Energy Cooperation
AERS	Automated Energy Review for Schools
AHP	Analytic Hierarchy Process
ARI	Air Conditioning and Refrigeration Institute
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
BEA	Building Efficiency Analysis
Bldg	Building
C&I	Commercial
C&S	Codes and Standards
CASE	Codes and Standards Enhancement Initiative
CATI	Computer Assisted Telephone Interviewing
CBEE	California Board of Energy Efficiency
CEC	California Energy Commission
CEP	Compliance Enhancement Program
CFL	Compact Fluorescent Lamp
CF1-R	Title 24 Residential Compliance Form
CfR	Composite for Remainder
CG	Contract Group
CHEERS	California Home Energy Efficiency Rating Services
CIEE	California Institute for Energy Efficiency

CMFNH	California Multifamily New Homes Program
CMMHP	Comprehensive Manufactured-Mobile Home Program
CPUC	California Public Utilities Commission
CRCA	Computerized Refrigerant Charge and Airflow
CTZ	Climate Thermal Zone
CV	Coefficient of Variation
CZ	Climate Zone
DEER	Database for Energy Efficiency Resources
DfC	Designed for Comfort
DHW	Domestic Hot Water
DRET	Demand Response Emerging Technologies
DSA	Division of the State Architect
ECM	Energy Conservation Measure
ED	Energy Division
EE	Energy Efficiency
EEGA	Energy Efficiency Groupware Application
EM&V	Evaluation, Measurement, and Verification
EER	Energy Efficiency Rating
EUL	Economic Useful Life
FLA	Full Load Amps
GWh	Gigawatt Hours
HERS	Home Energy Rating System
HIM	High Impact Measure
HMG	Heschong-Mahone Group, acquired by TRC in 2013
HUD	Housing & Urban Development
HVAC	Heating, Ventilation and Air Conditioning
ICF	ICF International

IDEEA	Innovative Designs for Energy Efficiency Applications
InDEE	Innovative Design for Energy Efficiency
IOU	Investor Owned Utility
IPMVP	International Performance Measurement and Verification Protocol
ISSM	Integrated Standards Savings Model
ITD	Installed To Date
kBtu	Thousand Btu
kW	Kilowatt
kWh	Kilowatt Hour
LADWP	Los Angeles Department of Water & Power
LBNL	Lawrence Berkeley National Laboratory
LEED	Leadership in Energy and Environmental Design
LGP	Local Government Programs
LPD	Lighting Power Density
M&V	Measurement and Verification
MECT	Master Evaluation Contractor Team
MF	Multifamily
MHRA	Manufactured Housing Research Alliance
Mil	Million
MS	Microsoft
Mtherms	Million therms; also MTherms
n	Sample Size
NAC	Normalized Annual Consumption
NC	New Construction
NCCS	New Construction/Codes and Standards
NOMAD	Naturally Occurring Market Adoption
NOSAD	Normally Occurring Standards Adoption

NP	Non Participant
NRNC	Non Residential New Construction
NTG	Net to Gross
NTGR	Net to Gross Ratio
NTP	Notice to Proceed
P	Participant
PG&E	Pacific Gas & Electric
PIER	Public Interest Energy Research
PTAC	Packaged Terminal Air Conditioner
PY	Project Year
Q2	Second Quarter
Q3	Third Quarter
Q4	Fourth Quarter
QA	Quality Assurance
QC	Quality Control
QII	Quality Insulation Installation
RCA	Refrigerant Charge and Airflow
Res	Residential
RFP	Request for Proposal
RH	Relative Humidity
RLA	Rated Load Amps
RMSE	Root Mean Square Error
RNC	Residential New Construction
ROB	Replace on Burnout
RP	Relative Precision
SAS	Statistical Analysis Software
SBD	Savings By Design

SCE	Southern California Edison
SCG	Southern California Gas
SCP	Sustainable Communities Program
SDG&E	San Diego Gas & Electric
SDGE	San Diego Gas & Electric
SEER	Seasonal Energy Efficiency Rating
SES	Savings Estimate Spreadsheet
SF	Single Family
sf	Square Foot
SFA	Single Family Attached
SHGC	Solar Heat Gain Coefficient
SoCalGas	Southern California Gas
SOW	Statement of Work
sqft	Square Foot
T20	Title 20 Appliance Efficiency Standards
T24	Title 24 Building Energy Efficiency Standards
TBD	To Be Determined
TDV	Time-Dependent Valuation
TXV	Thermostatic Expansion Valve
UES	Unit Energy Savings
VFD	Variable Frequency Drive
VSD	Variable Speed Drive
VSP	Verification Service Providers
W/SF	Watts per square foot
WH	Water Heater

TABLE OF CONTENTS

Appendix A. Analysis of Savings from Superseded Standards

In the discussion of Objectives in Section 3.2 of the report, the evaluators had another unique situation to resolve when some of the new California standards superseded efficiency levels set by earlier California standards. In these cases, the IOU estimate typically shows savings for each standard in each year. In this model, the first standard produces the first "layer" of savings and each later standard adds an additional layer of savings. For the current project then, the evaluators were directed by Commission staff to determine evaluated savings in two scenarios.

- Scenario One: Layered savings are included. Evaluation results reported in the main report include layered savings unless otherwise noted.
- Scenario Two: Layered savings are not included. Only savings from the most recent standard are included. Scenario Two results are provided in this appendix.

The potential savings shown for Scenario Two in Table 1 also reflect the impact of federal pre-emption. In this scenario, savings for the standards superseded by later CA standards—Standard 18a and Standard 11b—have been adjusted to reflect the effective dates of the new standards. The shaded cells indicate superseded standards for which potential savings in California are reduced.

Table 1. Evaluation Scenario Two: Potential Savings Adjusted for Superseded Standards

Potential Savings (GWh) for Title 20 Standards										
	General Purpose Lighting						Televisions			
	Includes savings from superseded stds			Excludes savings from superseded stds			Includes savings from superseded stds		Excludes savings from superseded stds	
	Std 11b	Std 25	Std 26	Std 11b	Std 25	Std 26	Std 18a	Std 28a	Std 18a	Std 28a
2010	224.0	0.0	0.0	224.0	0.0	0.0	64.6	0.0	64.6	0.0
2011	183.9	194.2	0.0	134.5	194.2	0.0	64.6	385.5	0.0	385.5
2012	88.4	0.0	134.0	57.1	0.0	134.0	64.6	385.5	0.0	385.5

In ISSM, both pre-emption and layering are accounted for by adjusting the measure unit quantity in the years when a pre-empting or superseding standard takes effect. For mid-year effective dates, units are prorated.

In the case of Standard 11b, because this standard covers a range of products (bulbs in various lumen ranges), the pre-empting standards (EISA and, later, Standards 25 and 26) cover only a portion of the bulbs covered by Standard 11b in the first years. Cadmus' evaluation is based on analysis of sales and compliance data for bulbs sold in 2011 and 2012 in each regulated lumen range. Therefore, we were able to calculate unit energy and demand savings, compliance rates, and units sold for the years 2011 and 2012 using the appropriate product mix to account for the superseding standards. In order to incorporate these values into ISSM, we created records for Standard 11b with the appropriate product mix specific parameters for each year.

Table 2. Electric Energy Savings for Title 20 Standards for Two Evaluation Scenarios

Electric Energy (GWh/Year)		2005 Title 20				2006-2009 Title 20			
		Potential Savings	Gross Savings	Net Savings	Net Program Savings	Potential Savings	Gross Savings	Net Savings	Net Program Savings
Evaluated Scenario One Savings	2010	627	580	317	233	706	585	545	395
	2011	622	578	292	214	1,245	1,004	789	549
	2012	583	554	260	191	1,083	928	678	473
	Total	1,832	1,712	870	637	3,033	2,517	2,012	1,417
Evaluated Scenario Two Savings	2010	627	580	317	233	706	585	545	395
	2011	558	516	283	207	1,196	968	755	524
	2012	518	492	252	183	1,052	900	652	454
	Total	1,703	1,588	852	623	2,953	2,453	1,952	1,373
Scenario One/ Scenario Two		108%	108%	102%	102%	103%	103%	103%	103%

Table 3. Electric Demand Savings for Title 20 Standards for Two Evaluation Scenarios

Electric Demand (MW/Year)		2005 Title 20				2006-2009 Title 20			
		Potential Savings	Gross Savings	Net Savings	Net Program Savings	Potential Savings	Gross Savings	Net Savings	Net Program Savings
Evaluated Scenario One Savings	2010	105.8	98.4	55.7	41.0	89.3	73.4	68.6	47.8
	2011	105.0	98.2	51.0	37.6	158.7	123.3	98.1	66.7
	2012	98.7	94.3	45.3	33.4	131.6	110.6	81.2	55.0
	Total	309.5	290.9	152.0	112.0	379.6	307.3	247.9	169.6
Evaluated Scenario Two Savings	2010	105.8	98.4	55.7	34	89.3	73.4	68.6	47.8
	2011	95.6	89.1	49.7	30	150.6	117.5	92.6	62.7
	2012	89.4	85.3	44.1	27	126.4	106.0	76.9	51.9
	Total	290.8	272.8	149.4	91	366.4	297.0	238.1	162.4
Scenario One/ Scenario Two		106%	107%	102%	102%	104%	103%	104%	104%

Table 4. Gas Savings for Title 20 Standards for Two Evaluation Scenarios

Gas (MTherms)		2005 Title 20				2006-2009 Title 20			
		Potential Savings	Gross Savings	Net Savings	Net Program Savings	Potential Savings	Gross Savings	Net Savings	Net Program Savings
Evaluated Scenario One Savings	2010	-6.9	-6.4	-2.6	-1.8	-4.7	-3.8	-3.6	-2.4
	2011	-6.9	-6.4	-2.2	-1.5	-14.1	-11.7	-8.1	-5.2
	2012	-6.2	-6.0	-1.7	-1.1	-12.1	-10.8	-6.5	-4.1
	Total	-20.0	-18.7	-6.5	-4.4	-30.9	-26.3	-18.2	-11.7
Evaluated Scenario Two Savings	2010	-6.9	-6.4	-2.6	-1.8	-4.7	-3.8	-3.6	-2.4
	2011	-5.6	-5.1	-2.0	-1.3	-13.5	-11.3	-7.7	-4.9
	2012	-5.0	-4.7	-1.5	-1.0	-11.8	-10.5	-6.2	-3.9
	Total	-17.5	-16.2	-6.1	-4.1	-30.0	-25.6	-17.5	-11.2
Scenario One/ Scenario Two		115%	115%	106%	107%	103%	103%	104%	104%

Appendix B. IOU Estimate of Savings

The evaluation of the statewide C&S program required documentation of the program's accomplishments. To obtain a summary of the estimated savings, Commission staff submitted a data request in April 2011. The IOU responses (identified as PGE EEGA 1465, SCE EEGA 1466, SCG EEGA 1467, SDGE EEGA 1468) included a memo that addressed the eight questions included in the data request. The IOUs also sent Excel files that provided the details behind the estimates of energy savings. As documented in the evaluation plan[1], the IOUs provided two separate and distinct savings models. After additional discussion with the IOUs, Commission staff directed the evaluators to base the evaluation on a single savings model delivered in an Excel file named: *EEGA 1465 et al_Attachment 2_Total CS Program Savings_PGE.4381.xlsm*.

As directed by Commission staff, the evaluators made several adjustments to the savings estimates included in the total savings file to produce an adjusted IOU estimate against which the evaluation results are compared. These adjustments are described below.

1. **Interactive effects**. The evaluation separates savings into primary effects such as the reduction in electricity consumption due to installation of more efficient lighting and secondary effects such as an increase in heating energy requirements due to the installation of more efficient lighting.

   The evaluation includes analysis of savings under two scenarios: with primary effects only (no interactive effects) and with primary and secondary interactive effects.

2. **Compliance improvement.** The IOU model included increases in compliance for 17 of the Title 20 standards and 10 of the Title 24 codes. In most cases, the increase was expected to be a 5% improvement over the compliance value found in the 2006-2008 PY evaluation. Since there was no data to support a change in compliance for any of these standards, Commission staff direction was to remove these increases from the IOU estimate.

3. **Savings from federal standards** were modified according to direction received from Commission staff.

   a. **Methodology.** In the savings model provided by the IOUs, potential savings from a specific C&S are estimated for the entire United States. These savings are then adjusted for noncompliance and NOMAD. Finally, this adjusted national value is adjusted for attribution.

[1] Lee, Allen, Dan Groshans (Cadmus). 2012. *Draft Evaluation Plan California Statewide Codes and Standards (C&S) Program.* California Public Utilities Commission.

For the adjusted IOU estimate, potential savings are calculated for the state of California. These savings are then adjusted for noncompliance, NOMAD, and attribution.

b. **Pre-emption.** In cases where a federal standard pre-empts an existing California standard, the IOU model continues to show the savings stream for the California standard. Instead, the evaluators modified the IOU estimate to reflect the effective date of the federal standard. Specifically, potential savings for pre-empted California standards go to zero and potential savings for the federal standard begin on the effective date.

4. **Net savings from previously evaluated 2005 standards.** The IOU savings model did not include net savings from these standards in their summary tables. Commission staff direction is to include net savings from previously evaluated 2005 standards. This adjustment has been made.

5. **Title 24 Potential Savings.** The original IOU savings model included Standard B33 described as the Composite for Remainder (CfR) with annual energy savings of 235.6 GWh and expected demand savings of 74.9 MW. The evaluators understood from the IOUs that the Standard B33 savings were derived from a study funded by the CEC[2]. However, the nonspecific nature of the claim prompted the evaluators and Commission staff to submit a data request for more specific information about the CfR.

   The IOU responses to this data request (identified as PGE EEGA 2576, SCE EEGA 2577, SCG EEGA 2578, SDGE EEGA 2579) provided a revised estimate of total annual savings expected from the 2008 Title 24 Codes (effective 1/1/2010) as well as the CfR portion.

2 Architectural Energy Corporation. 2007. Impact Analysis: 2008 Update to the California Energy Efficiency Standards for Residential and Nonresidential Buildings. California Energy Commission.

Table 5. Annual Potential Savings from 2008 Title 24 Codes

Original IOU Estimate	GWh	MW	MMT
Non Residential Subtotal	456.7	99.8	8.3
Residential Subtotal	158.8	68.2	7.4
Total Potential	615.5	168	15.7
CfR Total	*235.6*	*74.9*	*-1.8*
Revised IOU Estimate	GWh	MW	MMT
Non Residential Subtotal	550.0	116.4	12.7
Residential Subtotal	133.3	88.1	6.4
Total Potential	683.3	204.5	19.1
CfR Total	*325.1*	*92.3*	*-0.2*

In their response, the IOUs provided additional detail on the savings previously identified only as the CfR savings. This detailed breakdown is shown in Table 6.

Table 6. Annual Potential Savings for Composite for Remainder Codes

Segment	Reference	CfR Standard	GWh
Nonresidential	B33a	CfR IL Complete Building Method	149.6
	B33b	CfR IL Area Category Method	82.5
	B33c	CfR IL Egress Lighting Control	30.0
	B33d	CfR HVAC Efficiency	17.5
Residential	B33e	CfR Res Cool Roofs	11.9
	B33f	CfR Res Central Fan WL	33.6
		Total	325.1

Appendix C. Net Savings: NOMAD Detail

C.1 Bass Curve Parameters

The findings of the NOMAD analysis are presented in Table 7. The IOU estimated values are compared to the evaluated parameters obtained from the Delphi panels.

Table 7. Appliance Standards (Title 20 and Federal Standards) NOMAD Parameters

Standard		IOU Estimates			Evaluated Parameters		
		Max Saturation (s)	Leading Behavior (p)	Following Behavior (q)	Max Saturation (s)	Leading Behavior (p)	Following Behavior (q)
Std 22a	Residential Incandescent Reflector Lamps	9%	0.000	0.213	4%	0.023	0.145
Std 22b	Commercial Incandescent Reflector Lamps	9%	0.000	0.213	---	---	---
Std 23	Metal Halide Fixtures	9%	0.000	0.213	51%	0.003	0.366
Std 24	Portable Lighting Fixtures	9%	0.000	0.213	22%	0.002	0.498
Std 25	General-Purpose Lighting – 100 W	9%	0.000	0.213	17%	0.004	0.346
Std 26	General-Purpose Lighting – 75 W	9%	0.000	0.213	16%	0.007	0.294
Std 27	General-Purpose Lighting – 60 / 40W	9%	0.000	0.213	17%	0.011	0.255
Std 28a	Televisions, Tier 1	90%	0.000	0.600	82%	0.004	0.534
Std 28b	Televisions, Tier 2	75%	0.000	0.500	82%	0.008	0.380
Std 29	Battery Charger – Consumer, Tier 1	43%	0.012	0.386	54%	0.007	0.321
Std 31	Battery Charger – Large, Tier 1	43%	0.012	0.386	47%	0.004	0.263
Std 32	Battery Charger – Large, Tier 2	43%	0.012	0.386	---	---	---
Fed 1	Electric Motors 1-200 HP	11%	0.000	0.202	15%	0.030	0.030
Fed 2	Refrigerated Beverage Vending Machines	96%	0.014	0.584	96%	0.014	0.584
Fed 3	Commercial Refrigeration	79%	0.009	0.433	45%	0.008	0.360
Fed 4	ASHRAE Products (Commercial Boilers)	31%	0.007	0.097	---	---	---
Fed 5	Residential Gas Ranges	31%	0.007	0.097	---	---	---
Fed 6	Incandescent Reflector Lamps	9%	0.000	0.213	39%	0.008	0.292
Fed 7	General-Service Fluorescent Lamps	9%	0.000	0.213	56%	0.010	0.330

In the NOMAD parameter assumptions for the utility savings claim, we used a single set of parameters as the input for all lighting standards: Standards 22a through 27 and Federal Standards 6 and 7. Likewise, we used a single set of coefficients to calculate savings for all battery charger standards: Standards 29 through 32. For the evaluated parameters for these standards, Cadmus solicited separate panelist input for each standard.

As Cadmus conducted a NOMAD evaluation of refrigerated beverage vending machines during the 2006-2008 Codes and Standards evaluation, Cadmus applied the parameters calculated from the previous evaluation to the current federal standards for these appliances. Projected savings are small for federal standards for boilers and electric/gas ranges, so Cadmus used the parameter assumptions used in the utility savings claim as evaluated inputs to the ISSM model.

The findings of the NOMAD analysis are presented in Table 8. The IOU estimated values are compared to the evaluated parameters obtained from Cadmus' Delphi panels.

Table 8. 2008 Title 24 NOMAD Parameters

Standard		IOU Estimates			Evaluated Parameters		
		Max Saturation (s)	Leading Behavior (p)	Following Behavior (q)	Max Saturation (s)	Leading Behavior (p)	Following Behavior (q)
Std B17	Envelope insulation	30%	0.009	0.200	52%	0.013	0.265
Std B18	Overall Envelope Tradeoff	30%	0.009	0.200	---	---	---
Std B19	Skylighting	45%	0.000	0.296	21%	0.004	0.311
Std B20	Sidelighting	20%	0.002	0.500	26%	0.014	0.191
Std B21	Tailored Indoor lighting	50%	0.001	0.210	49%	0.026	0.258
Std B22a	TDV Lighting Controls	0%	0.000	0.000	---	---	---
Std B22b	DR Indoor Lighting	0%	0.000	0.000	1%	0.057	0.097
Std B23	Outdoor Lighting	70%	0.001	0.180	63%	0.046	0.151
Std B24	Outdoor Signs	40%	0.000	0.300	5%	0.008	0.273
Std B26	Refrigerated warehouses	30%	0.000	0.300	---	---	---
Std B27	DDC to Zone	50%	0.000	0.296	41%	0.013	0.258
Std B28	Residential Swimming pool	25%	0.000	0.300	23%	0.011	0.258
Std B29	Site Built Fenestration	30%	0.000	0.300	40%	0.009	0.366
Std B30	Residential Fenestration	30%	0.000	0.300	73%	0.032	0.270
Std B31	Cool Roof Expansion	30%	0.000	0.300	36%	0.022	0.315
Std B32	MF Water heating control	60%	0.000	0.296	19%	0.018	0.284
Std B33	Composite for Remainder	50%	0.001	0.210	---	---	---

C.1.1 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.[3] 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

3 On the Epistemology of the Inexact Sciences, Rand Corp, AD0224126.

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 Cadmus (then known as Quantec, LLC).[4] 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

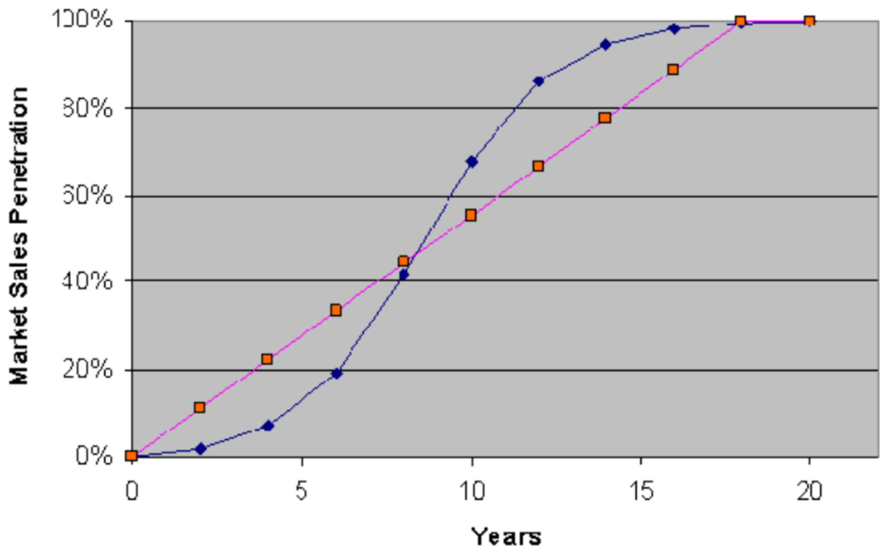
p captures the effect of consumers who are not influenced by the behavior of others and q captures the effect of consumers who are influenced by prior adopters.

For the purposes of this analysis, the most critical part of the curve to estimate accurately was the 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

4 Statewide Codes and Standards Market Adoption and Noncompliance Rates, Program No. 1134-04, 2007.

Figure 1 , which compares a Bass curve that produces 99% market penetration in 18 years to a linear curve.

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)

C.1.2 Panelist Selection Process Description

Selection Criteria

The Oxford English Dictionary defines an expert as "a person who has comprehensive and authoritative knowledge of or skill in a particular area." Cadmus compiled candidate lists for each standard using a combination of sources:

- Published CASE Reports
- Public documents regarding the California Energy Commission (CEC) building and appliance standards regulatory process (e.g., public comments, hearings, and workshops).
- NOMAD expert list compiled by Cadmus during the 2006-2008 Codes and Standards impact evaluation for the California Public Utilities Commission (CPUC).
- Web search of relevant industry associations, energy-related nonprofit organizations, government laboratory research groups, and professional societies

For the purpose of identifying expert candidates for participation in the modified Delphi panel approach, Cadmus used the criteria presented in Table 9, and required an expert panel candidate to meet two or more of these criteria for the specific technology or standard they were being asked to evaluate.

Table 9. NOMAD Expert Selection Criteria

Category	Requirement	Example
Credentials	Has been certified, or has received special training, in a capacity relevant to the technology or standard	• LEED AP • Professional Engineer (P.E.) • Certified Measurement and Verification Professional (CMVP) • Certified Energy Manager (CEM)
Education	Holds an advanced degree in a related field	• MS Mechanical Engineering – Product Design • MS Public Policy
Professional Experience	Has worked for ten or more years in a capacity that would provide knowledge of the technology and market	• 10+ years in product design for GE lighting • 20 years as head of Environmental Energy Technologies Division at LBNL
Publication	Has authored one or more papers or articles for conferences or industry journals on a topic related to the specific technology or standard	• "Reflector Lamp Market Trends and Implications for Regulation of Energy Efficiency"

Approach to Managing Bias

Cadmus recognized that all individuals considered for participation on the Delphi panels were likely to exhibit some degree of bias that could influence their input regarding the naturally occurring market adoption for a specific appliance standard. Cadmus' approach to managing bias followed the approach taken by ASHRAE in its disclosure form for potential project committee members.[5] In it, ASHRAE notes the importance of establishing a balance of interests among committee members and stresses that when all affected interests constructively participate in the consensus opinion, a fair standard will result. On the form, ASHRAE also states: "The question of potential sources of 'bias' ordinarily relates to views stated or positions taken that are largely intellectually motivated or that arise from the close identification or association of an individual with a particular point of view or the positions or perspectives of a particular group. Such potential sources of bias are not disqualifying for purposes of committee service. It is necessary, in order to ensure that a committee is fully competent, to appoint members in such a way as to represent a balance of potentially biasing backgrounds or professional or organizational perspectives."[6]

Consistent with this approach, Cadmus classified candidates by organization type using the following four categories:

- Government
- Manufacturer
- Industry Consultant
- Other (e.g., CEC, ACEEE, NRDC, Universities)

Cadmus reviewed the category mix for experts associated with each appliance standard to ensure that prospective panels were not dominated by a single category type (e.g., manufacturers, consultants). The team summarized the mix of expert candidates recruited for each standard and reviewed the membership mix with the project management team. Cadmus' objective was to assemble expert panels with representation from at least three of the defined categories. In this way, the team expected to achieve a balanced result where the biases of any one group were offset or at least tempered by members of the other groups on the panel.

Additionally, Cadmus reviewed all adoption curves and associated supporting comments. If input was substantially different from all other experts and/or the supporting comments indicated a distinct bias, then we removed that expert's input from the analysis. When this occurred, Cadmus documented the decision and the reasons for it.

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5 ASHRAE. *Potential Sources of Bias/Conflict of Interest*. https://www.ashrae.org/standards-research--technology/standards-forms--procedures. Rev 2/12.

6 Ibid

Approach to Identifying Conflict of Interest

In Appendix A of ASHRAE's disclosure form, ASHRAE notes that conflict of interest can occur when:

- Committees are not balanced and include individuals with strong personal, financial, or professional interests in seeing that the project produce a particular outcome
- An agency, sponsor, or private organization or company attempts to influence individual committee members or to skew the body of information reviewed by the committee.[7]

In *The Delphi Method: Techniques and Applications,* Chester G. Jones notes concerns are often raised about the credibility of Delphi results as "individual experts may bias their responses so that they are overly favorable toward areas of personal interest." In his examination of several Delphi processes, however, he finds individuals on the panels were able to "rise above the desire to protect personal interests." [8]

Cadmus mitigated potential conflict of interest in several ways. First, in concert with steps to minimize bias, Cadmus endeavored to create balanced panels by recruiting members representing the four interest groups identified above for each appliance standard.

Second, as part of the recruitment process, Cadmus asked all potential panelists whether a conflict of interest would impair their objectivity. We excluded from the panels individuals expressing a declared conflict of interest.

Finally, we provided information about the appliance standards to be evaluated in summaries in the online data collection tool; the information could be edited only by persons with the appropriate access level. Cadmus developed these summaries from publicly available documents, so it is unlikely that outside bodies would be able to skew the body of information reviewed by the panel members. We also assumed that it is unlikely that individuals or organizations would attempt to pressure individual panel members to provide input skewed in a specific direction; however, in the end, we reviewed each panelist's input in comparison with input from all other panelists and noted input that seemed out of the range of the consensus opinion. Cadmus reserved the option to disregard such input and documented any decisions to do so.

7 ASHRAE. *Potential Sources of Bias/Conflict of Interest*. https://www.ashrae.org/standards-research--technology/standards-forms--procedures. Rev 2/12.

8 Linstone, Harold A., and Murray Turoff. *The Delphi Method: Techniques and Applications*. Addison-Wesley. 2002. 155-161.

Process Used to Build Expert Panels

Cadmus prioritized recruitment efforts on those appliance standards that are projected to contribute at least 10% to the overall first-year gross electricity savings for the appliance standards under review during the 2010-2012 evaluation cycle. Doing so allowed development of evaluated NOMAD parameters for standards representing approximately 90% of first-year gross GWh savings.

For standards with first-year gross electricity savings of less than 10%, Cadmus did not set targets for the number of panelists submitting input, and recruitment for these standards was not as tenacious.

Cadmus took a similar approach with the federal standards under review and focused recruitment on incandescent reflector lamps, fluorescent lighting, and electric motors. Table 10 shows the list for Title 20 and federal appliance standards ranked by the IOU estimate of gross savings.

Table 10. Title 20 and Federal Appliance Standards Ranked by Relative Gross Savings

Appliance or Federal Standard	IOU Estimate First-Year Gross Savings (GWh)	Percent of Total First-Year Gross Electricity Savings
Std 27 – General-Purpose Lighting - 40 and 60 Watt Std 25 – General-Purpose Lighting - 100 Watt Std 26 – General-Purpose Lighting - 75 Watt	783.48	39%
Std 28a - Televisions, Tier 1 Std 28b - Televisions, Tier 2	730.65	37%
Std 29 - Battery Charger - Consumer, Tier 1 Std 32 - Battery Charger - Large, Tier 2 Incremental Std 31 - Battery Charger - Large, Tier 1	190.11	10%
Std 22b - BR, ER, and R20 Incandescent Reflector Lamps: Commercial	131.22	7%
Std 22a - BR, ER, and R20 Incandescent Reflector Lamps: Residential	67.27	3%
Std 24 - Portable Lighting Fixtures	43.30	2%
Std 23 - Metal Halide Fixtures	38.05	2%
Fed 6 - Incandescent Reflector	238.25	56%
Fed 7 - Fluorescent Lighting	171.91	40%
Fed 5 - Electric and Gas Ranges	7.56	2%
Fed 4 - ASHRAE - Boilers	5.95	1%
Fed 1 - Electric Motors	5.14	1%
Fed 2 - Vending Machines	0.00	0%
Fed 3 - Refrigeration	0.00	0%

Note: California standards ranked independently of federal standards

Prior to ranking, the evaluation team aggregated savings for similar standards, i.e., the standards for general-purpose lighting, televisions, and battery chargers, so that the rankings would reflect the aggregate percent contribution to overall first-year gross GWh savings, rather than the percent contribution of the individual standards. These aggregate percent contribution values guided the recruitment priorities. For example, where each individual lighting standard was expected to contribute only 10% to 20% to the total appliance standard savings, the group in aggregate constituted nearly 40% of overall savings, and we prioritized recruitment efforts accordingly.

Cadmus contacted approved candidates by e-mail, explained the Delphi process, and solicited input on specific codes or standards. Within a week of the initial contact, Cadmus followed up with each candidate by phone and asked a short series of questions. Cadmus used potential panelists' responses to these questions to confirm them as a member of an expert panel or to disqualify them from consideration. The questions were as follows:

- What are the main organizations in the [*name of appliance technology*] field with which you have been affiliated?
- How many years have you worked in the [*name of appliance technology*] industry?
  Are you currently active in the [*name of appliance technology*] industry?
  (If not currently active) When were you last active in this industry?
- How would you describe your role in the [name of appliance technology] industry?
- (To check for conflict of interest) Do you have any financial or other interest that will impair your objectivity in evaluating these standards?

The answers to these questions enabled Cadmus to verify candidates' expert status as well as identify any overt biases or conflicts of interest. In some situations, a candidate was not confirmed. These include:

- The candidate had not been active in the industry for more than four years.
- The candidate declared a conflict of interest.

When these situations arose, interviewers thanked the candidate for their time and explained the reason for their disqualification.

Table 11 presents the number of potential panelists Cadmus identified for each appliance or federal standard, the targets for submitted input, and the number of panelists who submitted input. Where standards have no submitted input target, this does not imply that the team did not attempt to recruit panelist input; rather, it means we did not pursue a specific minimum number of panelist submissions for these standards. The team focused recruiting efforts on the standards with the greatest first-year GWh savings; however, in general, we achieved submitted input from approximately 30 – 40% of the identified panelists for each standard.

Table 11. NOMAD Targets for Submitted Input

Appliance or Federal Standard		Number of Panelists Identified	Submitted Input Target	Submitted Input Achieved
Std 25	General-Purpose Lighting - 100 Watt	26	5	9
Std 26	General-Purpose Lighting - 75 Watt	27	5	8
Std 27	General-Purpose Lighting - 40 and 60 Watt	27	5	8
Std 28a	Televisions, Tier 1	25	5	8
Std 28b	Televisions, Tier 2	25	5	7
Std 29	Battery Charger - Consumer, Tier 1	16	5	6
Std 31	Battery Charger - Large, Tier 1	15	5	5
Std 22a	BR, ER, and R20 Incandescent Reflector Lamps	33	5	12
Std 23	Metal Halide Fixtures*	9	--	3
Std 24	Portable Lighting Fixtures*	8	--	3
Fed 6	Incandescent Reflector	31	5	12
Fed 7	Fluorescent Lighting	27	5	10
Fed 1	Electric Motors*	6	--	2
*These standards contributed less than 10% to the first-year gross GWh savings for appliance or federal standards.				

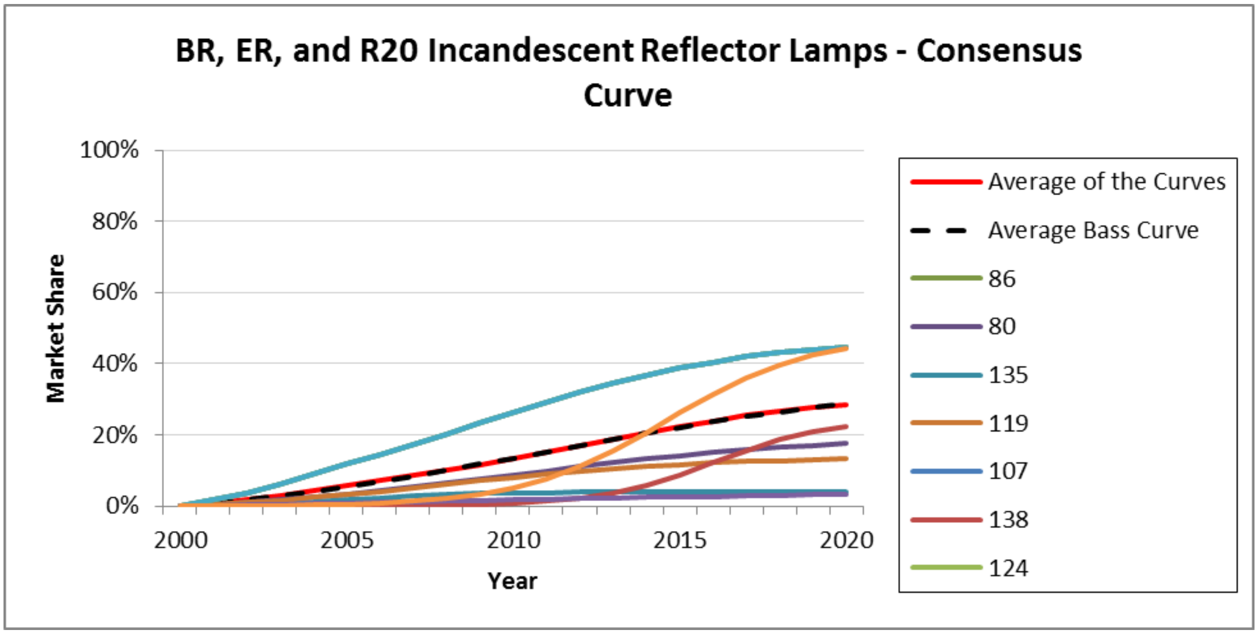
C.1.3 NOMAD Analysis Details for Appliance Standards

This section provides additional information on the NOMAD analysis conducted on the T20 appliance standards and presents the NOMAD curves that were created for each of the standards analyzed based on the expert inputs solicited for this evaluation.

C.1.4 Incandescent Reflector Lamps – Standards 22a and 22b

Figure 2 provides the consensus Bass curve for incandescent reflector lamps along with the panelist input used to develop it. Panelists agreed that without mandatory standards, manufacturers would have not developed more efficient incandescent reflector lamps and consumers would have had little incentive to adopt more efficient products for this specialty segment. Several panelists noted that these standards were developed to address a loophole in previous California and EISA regulation and that the products only gained market share because of the loophole. One panelist noted that "as a relatively inexpensive commodity product, and absent manufacturer intention to improve their efficacy, most of these products would likely have remained at the bottom of the efficiency scale for a very long time."

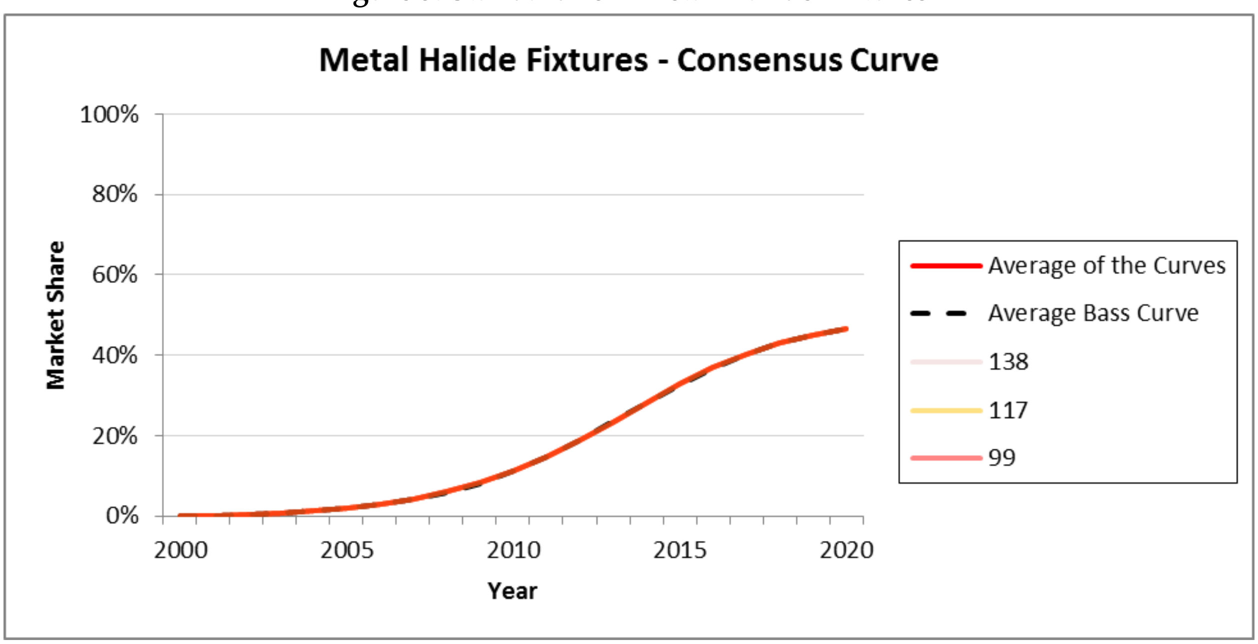
Figure 2. Standard 22a – Residential Incandescent Reflector Lamps



C.1.5 Metal Halide Fixtures – Standard 23

Figure 3 provides the consensus Bass curve for metal halide fixtures along with the panelist input used to develop it. All panelists elected to submit the average as their final input. Panelists noted that pulse start technology has advantages over probe start, but that metal halide is a dying technology. All three panelists noted that this technology is expected to be replaced with LED lighting fixtures after 2020, regardless of standards.

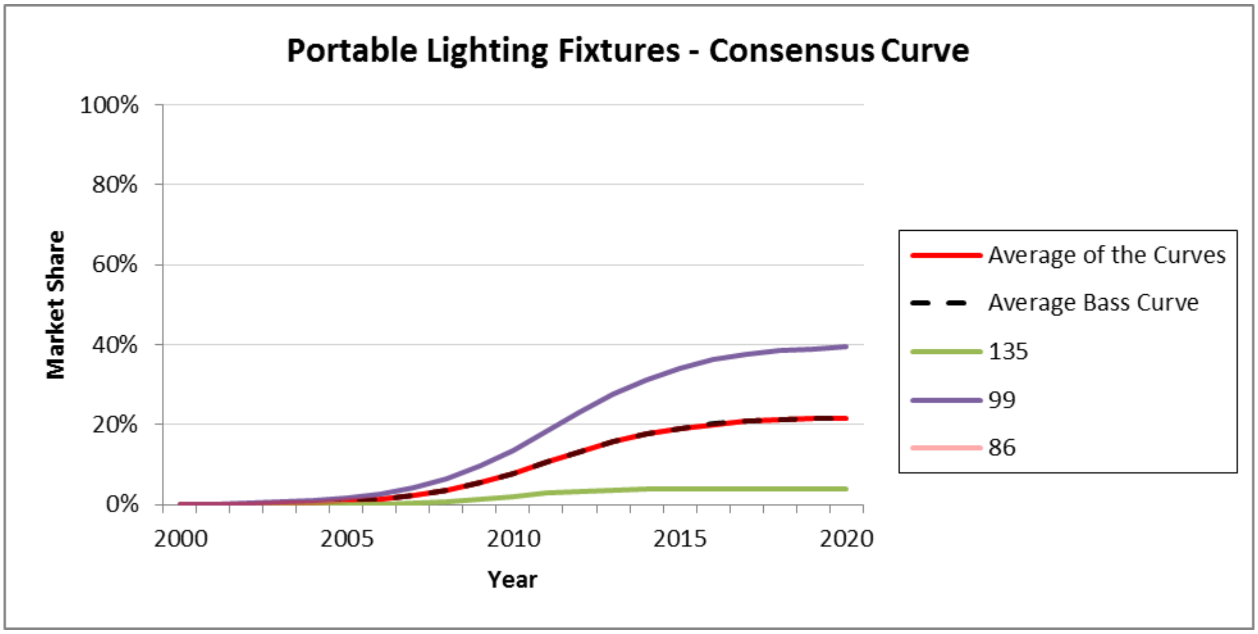
Figure 3. Standard 23 – Metal Halide Fixtures



C.1.6 Portable Lighting Fixtures – Standard 24

Figure 4 provides the consensus Bass curve for portable lighting fixtures along with the panelist input used to develop it. Final panelist input diverged in later years for panelists 135 and 99, while panelist 86 used the average as his/her final submission. Panelists agreed that the market for efficient products would be low in this market; but differed in how low. One panelist stated that there is little incentive for consumers to replace existing portable lighting products with new products and so the adoption rate would be quite small without standards. Another panelist remarked that there is a very diffuse market for portable lighting fixtures with many manufacturers and thousands of models, many of which are low cost, and noted it would be difficult to transform this market without standards.

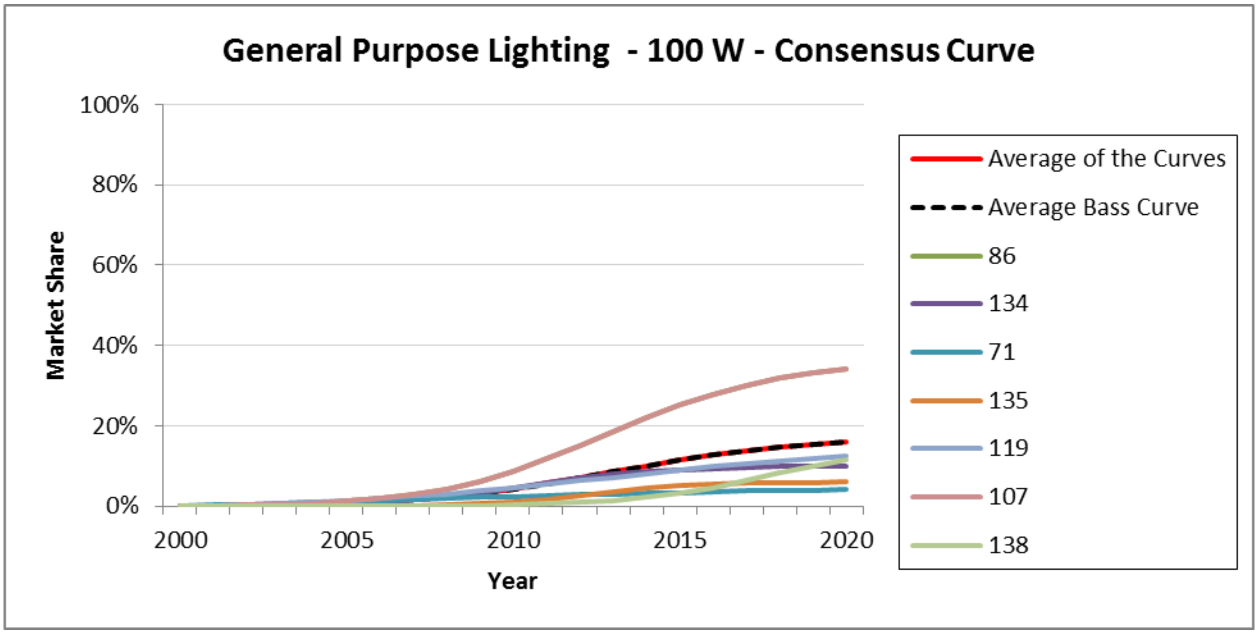
Figure 4. Standard 24 – Portable Lighting Fixtures



C.1.7 General Purpose Lighting 100 Watt – Standard 25

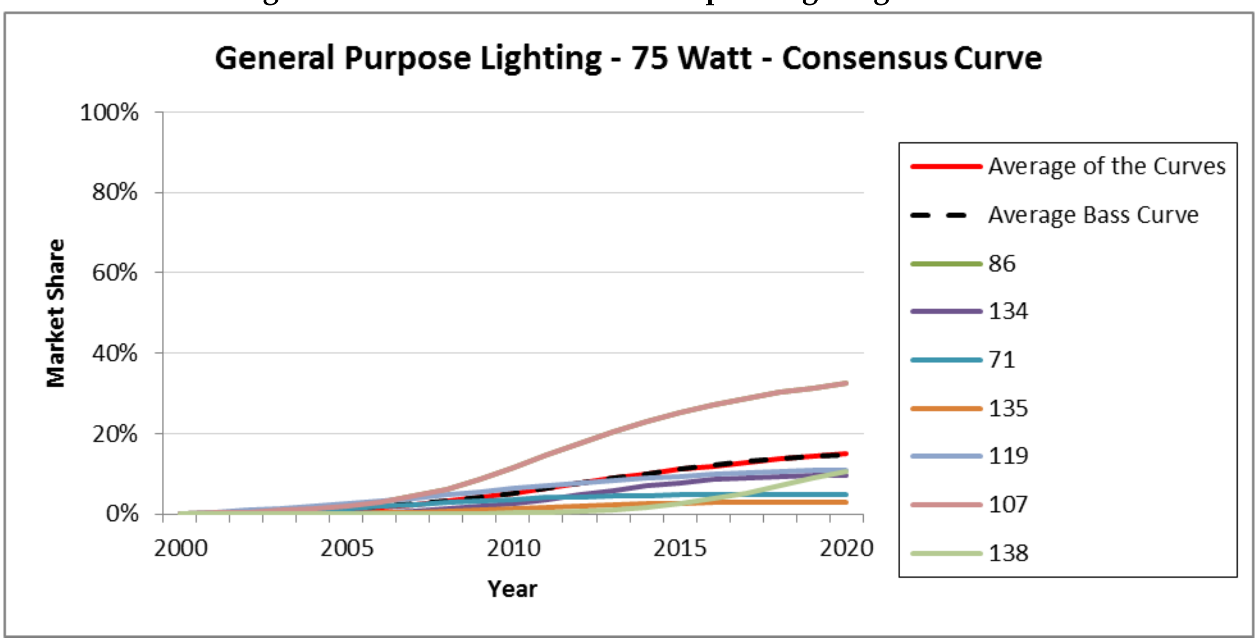
Figure 5 provides the consensus Bass curve for 100 Watt general purpose lighting along with the panelist input used to develop it. While the general purpose lighting standards 25 through 27 are technically lumen standards and stipulate the maximum Watts bulbs can use to produce specific lumen ranges, they are generally referred to using the former incandescent wattage values they are replacing. Panelists agreed that the market share for high efficacy general purpose lighting was very small and would not likely have increased much at all absent the California and subsequent EISA standards. Panelists noted consumer inertia and difficulty accessing information about efficiency and acting on it, and said that, in the absence of major educational efforts or mandates, consumers would be likely to remain with the standard familiar product. Additionally, most of the focus on replacement of 100 Watt lamps has been on alternative technologies, such as CFLs.

Figure 5. Standard 25 – General Purpose Lighting – 100 Watt



panelist noted that the 75 Watt lamp is not as widely used as the 100 or 60 Watt lamps and so both knowledge and interest are not as great. Any significant growth in the use of alternative products would require a substantial effort.

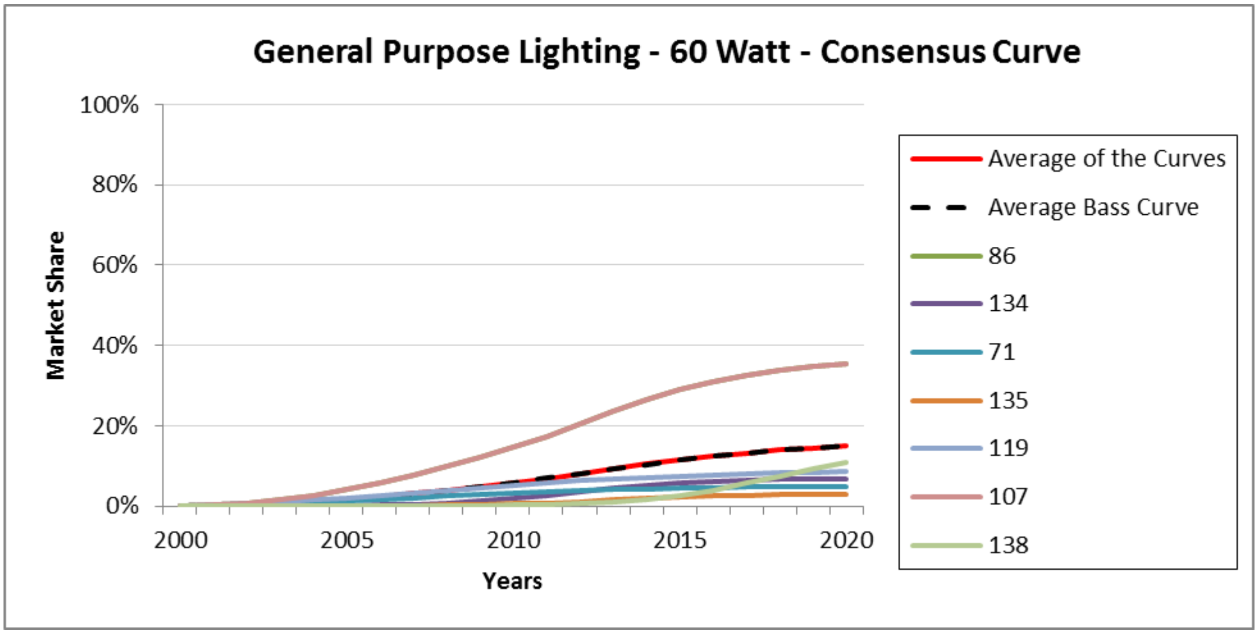
Figure 6. Standard 26 - General Purpose Lighting – 75 Watt



C.1.9 General Purpose Lighting 60 Watt and 40 Watt – Standard 27

Figure 7 provides the consensus Bass curve for 60 Watt and 40 Watt general purpose lighting along with the panelist input used to develop it. Panelists noted that without the California and EISA standards, manufacturers would not have brought to market the halogen-based incandescent lamps to satisfy this standard. One panelist remarked that 60 Watt bulbs are the most common bulb used in the home. Although adoption would still be relatively slow without a mandatory standard, alternative energy saving products would still have been adopted more frequently in this category since voluntary alternatives, such as CFLs, were more cost-effective and offered relatively good performance. Another panelist noted that, without legislation, this product has no particular purpose or market niche. The panelist commented that simply placing the product "on the shelf" will result in some sales, however, but the sales will be primarily the result of manufacturer and retailer promotion.

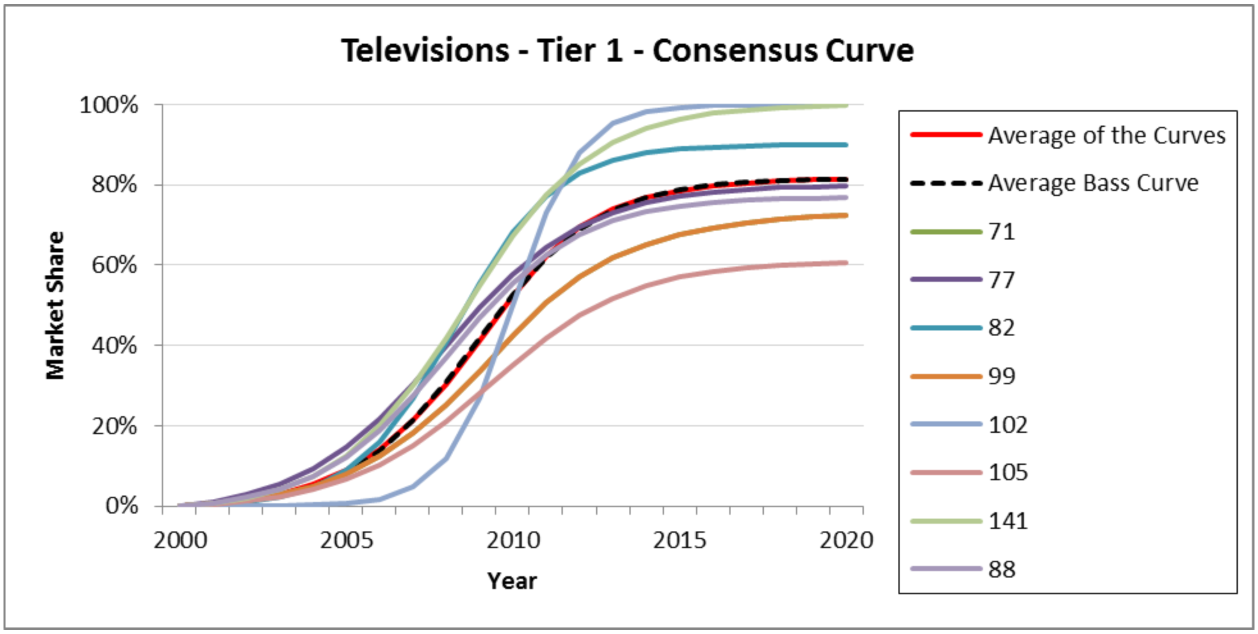
Figure 7. Standard 27 – General Purpose Lighting – 60 Watt and 40 Watt



C.1.10 Televisions – Tier 1 – Standard 28a

Figure 8 provides the consensus Bass curve for tier 1 televisions along with the panelist input used to develop it. Panelists felt the market for efficient televisions was influenced more by ENERGY STAR than by the California standards. Panelists noted that the majority of the televisions purchased have been ENERGY STAR for the past 5 to 10 years. An additional impetus to increased efficiency of televisions is the Federal Trade Commission's Energy Guide label. One panelist felt that as consumers are able to factor in annual energy costs when making their television purchase, manufacturers have been driven to produce televisions with increasing efficiency in order to get a good Energy Guide rating. competing for market share using efficiency.

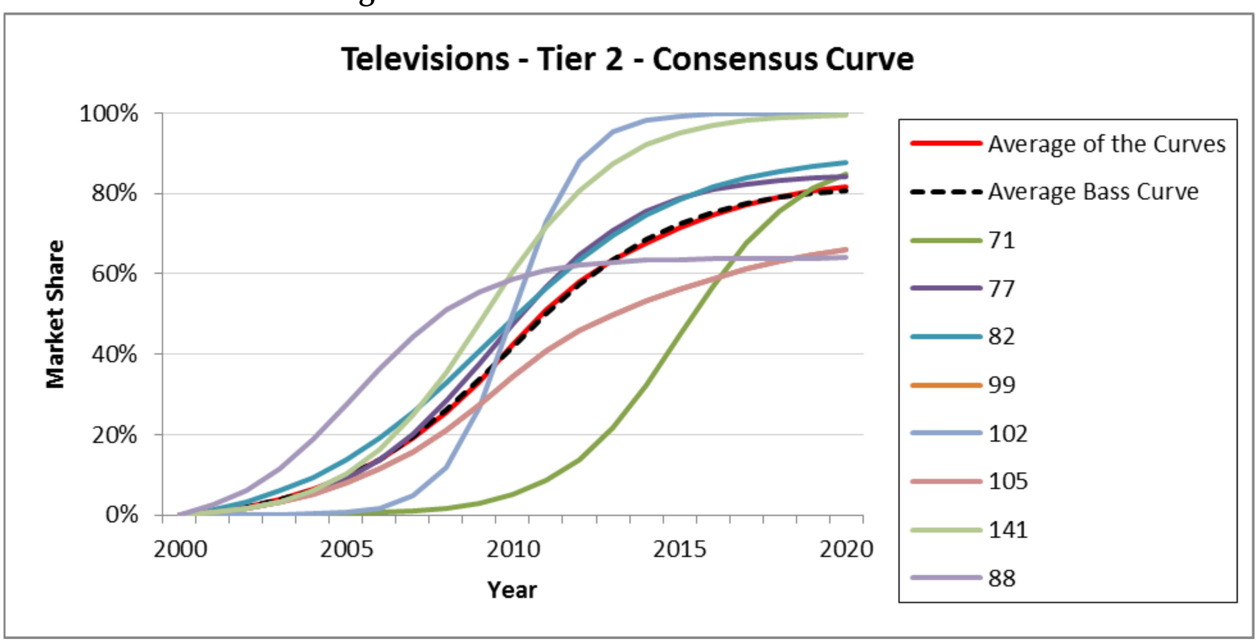
Figure 8. Standard 28a – Televisions – Tier 1



C.1.11 Televisions – Tier 2 – Standard 28b

Figure 9 provides the consensus Bass curve for tier 2 televisions along with the panelist input used to develop it. While panelists pointed out that ENERGY STAR standards also promoted manufacture of televisions that meet the Tier 2 efficiency levels, they noted that ENERGY STAR was able to develop more stringent standards than they were originally considering, due to the Tier 2 efficiency levels promoted by the California utilities and the CEC.

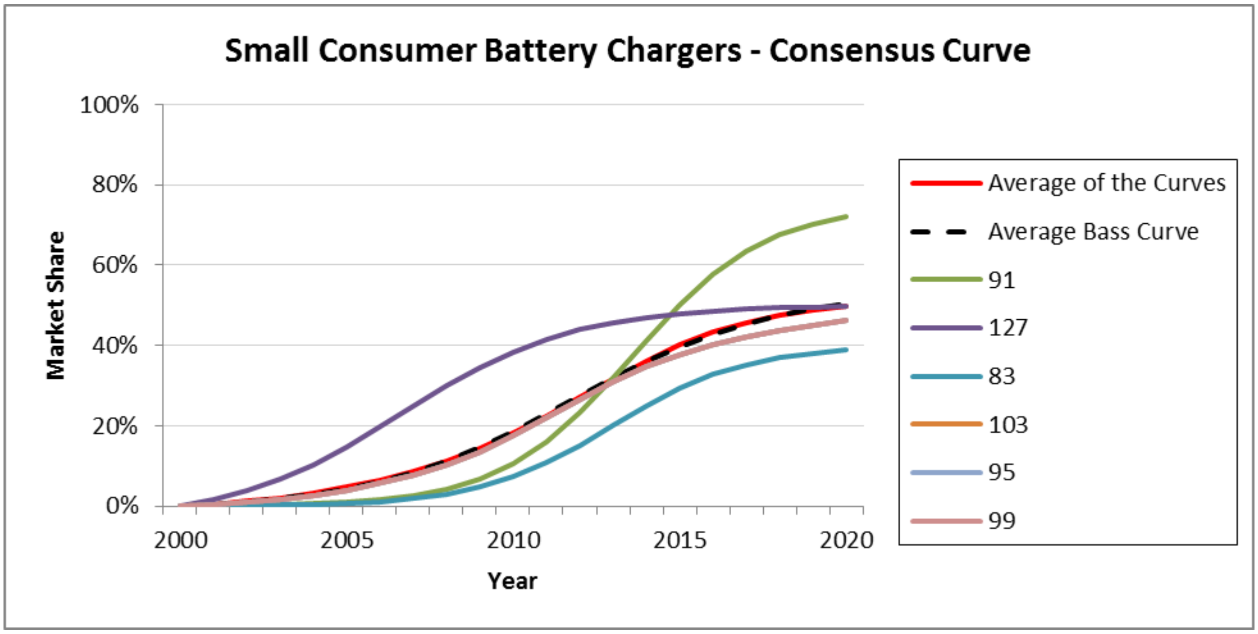
Figure 9. Standard 28b – Televisions – Tier 2



C.1.12 Small Consumer Battery Chargers – Tier 1 – Standard 29

Figure 10 provides the consensus Bass curve for small consumer battery chargers along with the panelist input used to develop it. Panelists agreed that there is little consumer incentive to adopt more efficient products as the savings are minimal per household. One panelist noted that most of the battery charger manufactures did not care about maintenance power and no-battery power before the standards.

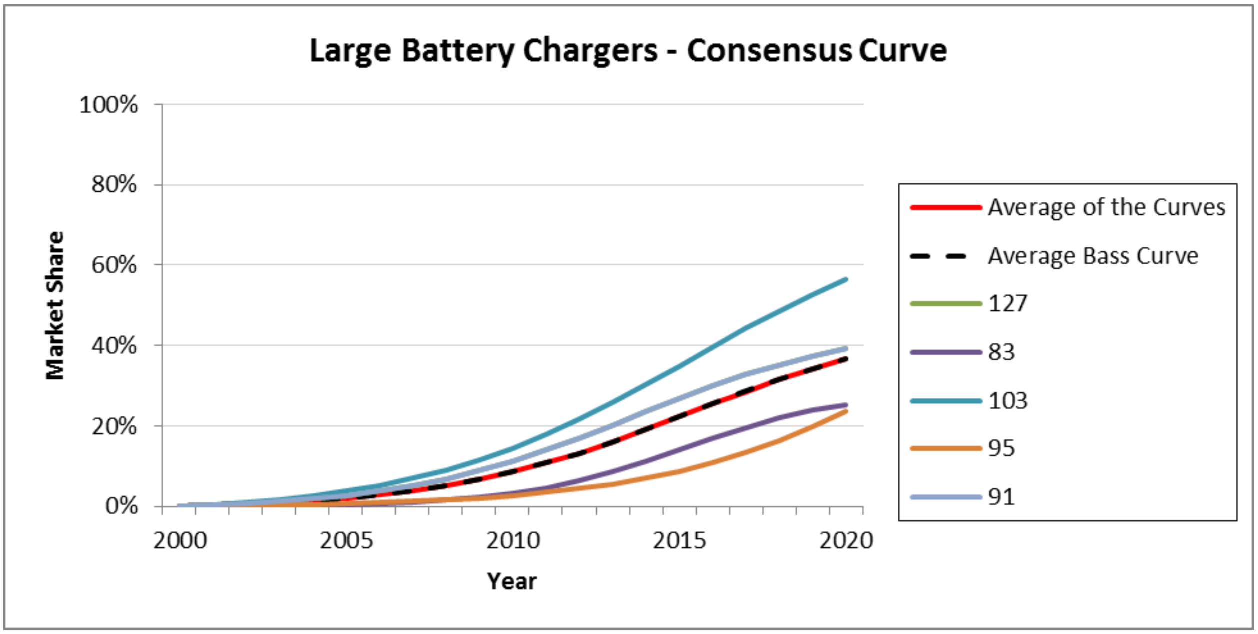
Figure 10. Standard 29 – Battery Chargers – Consumer – Tier 1



C.1.13 Large Battery Chargers – Tier 1 – Standard 31

Figure 11 provides the consensus Bass curve for large battery chargers along with the panelist input used to develop it. Panelists noted that the market for these chargers is driven by small business, who are very price-sensitive. While these businesses are reluctant to replace a still-functioning appliance (the charger), they are also sensitive to increases in their electric bill. Without the standard, electricity price increases would eventually help to drive the market for these chargers.

Figure 11. Standard 31 – Battery Chargers – Large – Tier 1



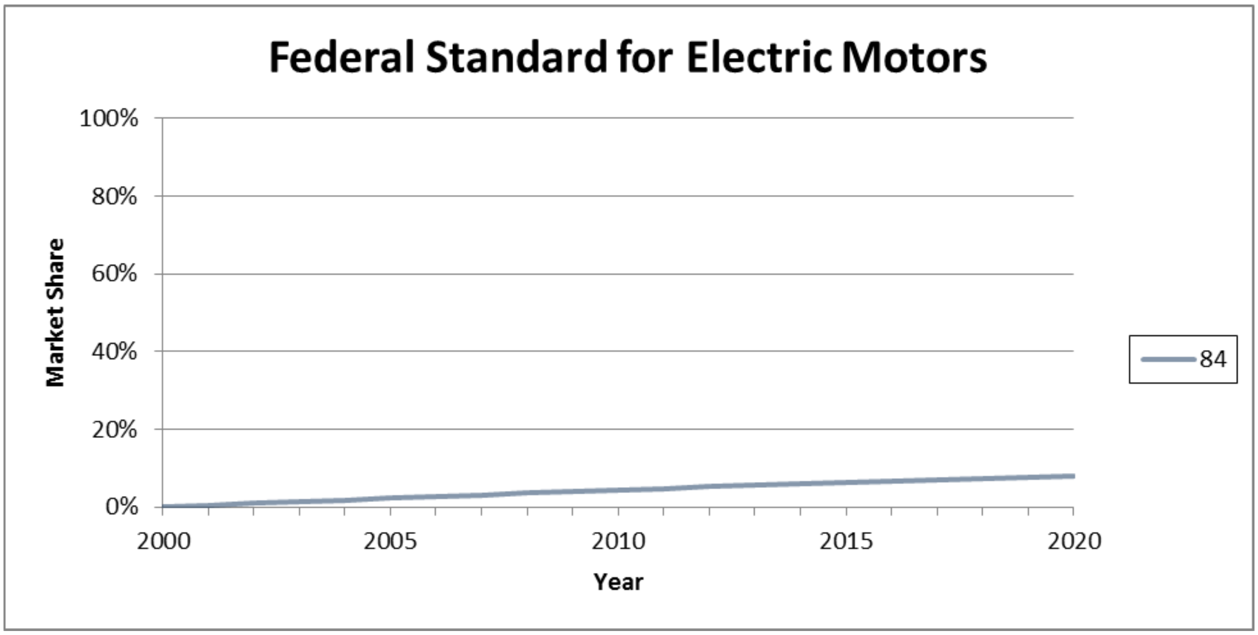
C.1.14 NOMAD Analysis Details for Federal Standards

This section provides additional information on the NOMAD analysis conducted on the Federal standards and presents the NOMAD curves that were created for each of the standards analyzed based on the expert inputs solicited for this evaluation.

C.1.15 Federal Standard for Electric Motors – Standard Fed 1

Figure 12 provides the Bass curve for the Federal standard for electric motors along with the panelist input used to develop it. Only two panelists provided input on the federal standard for motors; one panelist's comments submitted with the input indicated a lack of understanding of the NOMAD request. The evaluators used information from the remaining panelist rather than defaulting to the IOU input, as the source of the panelist input could be documented and came from an individual whose industry credentials had been vetted. This panelist noted that efficient motors have longer payback periods, *i.e.*, greater than three years, and there is no evidence to support the supposition that "they would ever achieve significant market share without standards." Moreover, the panelist observed that in recent years, customers were demanding far shorter payback periods, such as one quarter.

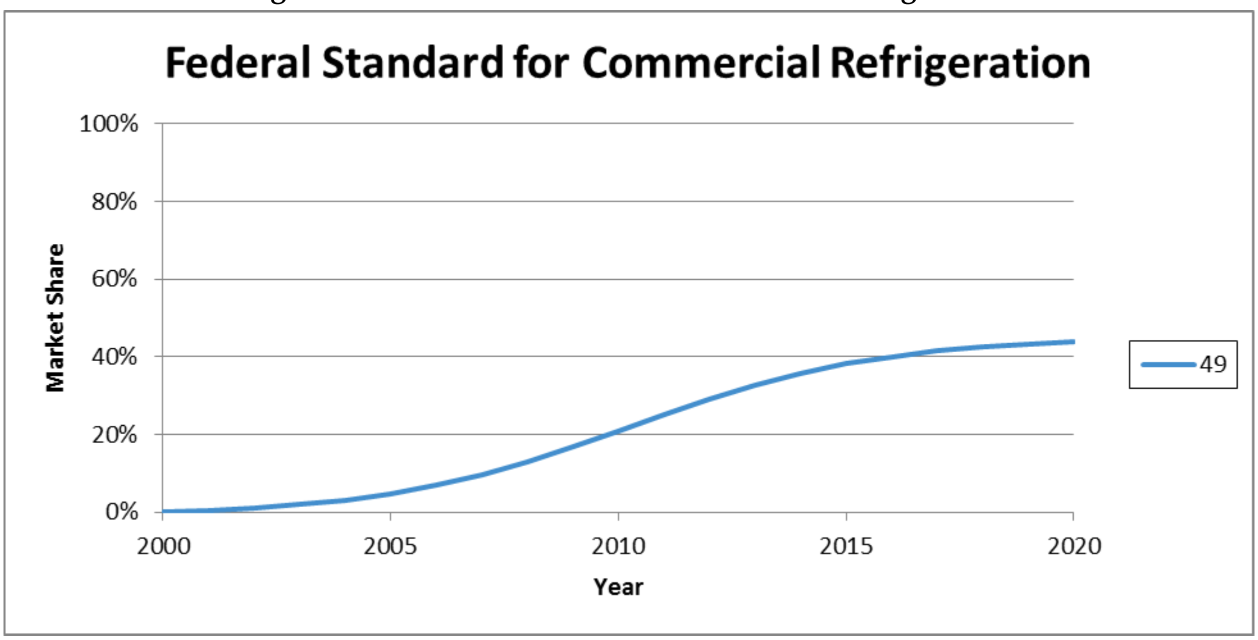
Figure 12. Standard Federal 1 – Electric Motors



C.1.16 Federal Standard for Commercial Refrigeration – Standard Fed 3

Figure 13 provides the consensus Bass curve for the Federal standard for commercial refrigeration along with the panelist input used to develop it. Only one panelists provided input on the federal standard for commercial refrigeration. The evaluators used information from this lone panelist rather than defaulting to the IOU input, as the source of the panelist input could be documented and came from an individual whose industry credentials had been vetted. Additionally, input provided by this panelist fell in the center of the range of the input provided in the previous evaluation for the three California commercial refrigeration measures. This panelist noted that some adoption of efficient commercial refrigeration would have occurred as a result of energy price sensitivity, but that many businesses, typically smaller entities, do not conduct a lifecycle cost analysis when making purchasing decisions, resulting in a leveling off of the market share, as seen in the later years in Figure 13.

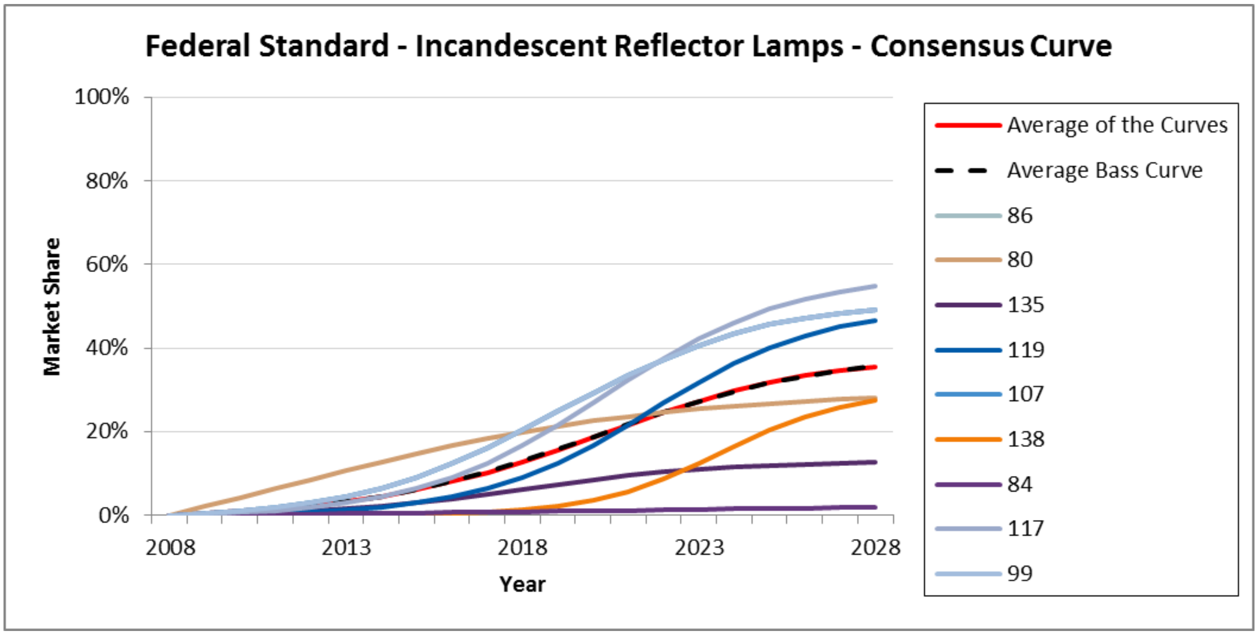
Figure 13. Standard Federal 3 – Commercial Refrigeration



C.1.17 Federal Standard for Incandescent Reflector Lamps – Standard Fed 6

Figure 14 provides the consensus Bass curve for the Federal standard for incandescent reflector lamps along with the panelist input used to develop it. Panelists agreed that without the federal standard, the adoption of more efficient incandescent reflector lamps would have been slow. One panelist pointed out that the increased efficiency is small given the cost of the improved reflective coating. Another panelist noted that there would have been little incentive for customers to pay more money for a more efficient product.

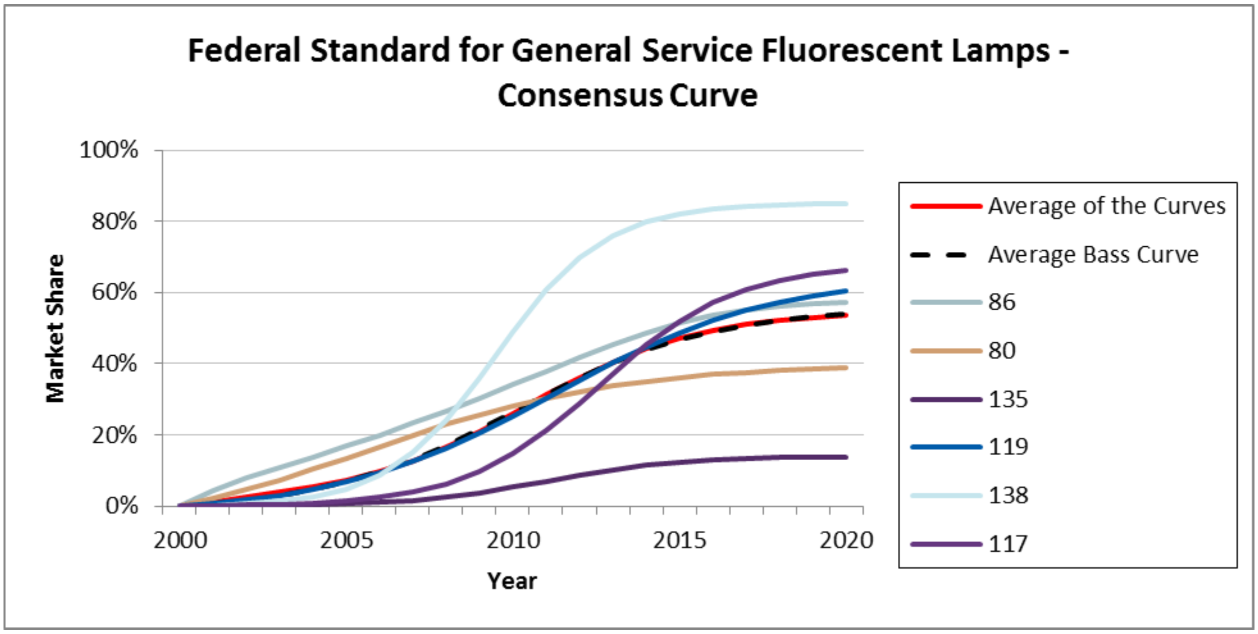
Figure 14. Standard Fed 6 – Federal Standard for Incandescent Reflector Lamps



C.1.18 Federal Standard for General Service Fluorescent Lamps – Standard Fed 7

Figure 15 provides the consensus Bass curve for the Federal standard for general service fluorescent lamps along with the panelist input used to develop it. Panelists held different opinions about the effect of federal standard on the adoption of general service reflector lamps. Several panelists noted that these products were already on their way to market dominance absent any federal or California standards. Other panelists noted that the savings from the lamp itself are small and that additional savings come from the ballast. Another critical factor influencing adoption of general service fluorescent lamps is the price and availability of rare earth phosphors, and the price of these phosphors has skyrocketed in recent years.

Figure 15. Standard Fed 7 – Federal Standard for General Service Fluorescent Lamps



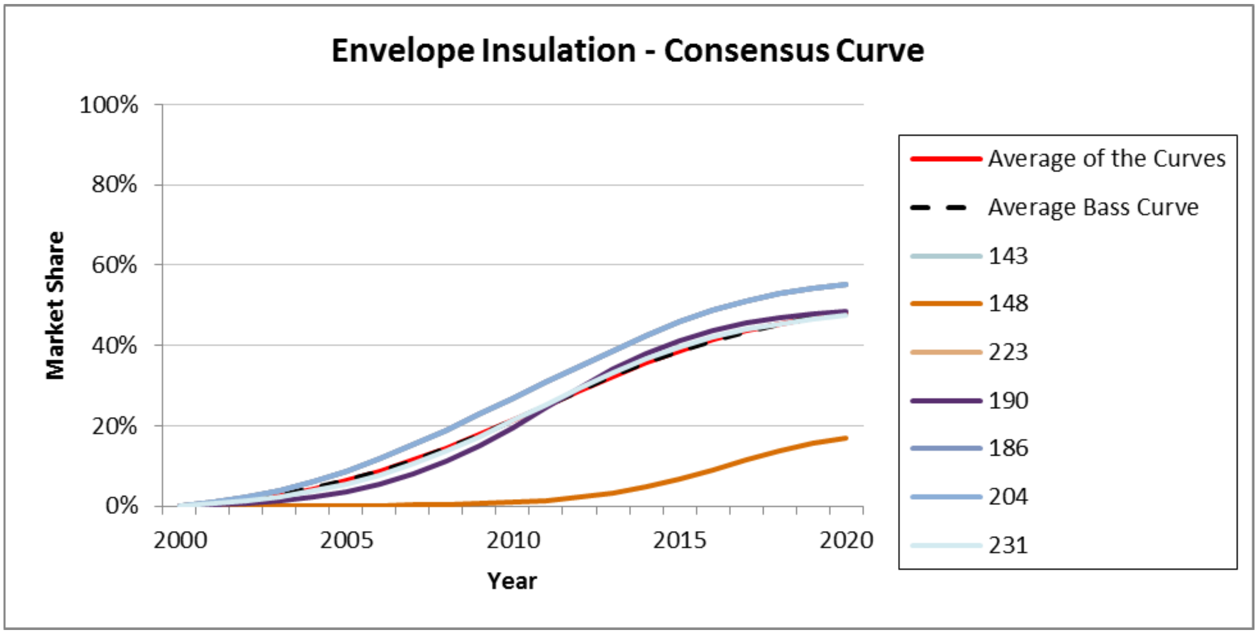
C.1.19 NOMAD Analysis Details for Building Codes

This section provides additional information on the NOMAD analysis conducted on the T24 building standards and presents the NOMAD curves that were created for each of the standards analyzed based on the expert inputs solicited for this evaluation.

C.1.20 Building Envelope Insulation – Standard B17

Figure 16 provides the consensus Bass curve for building envelope insulation along with the panelist input used to develop it. Panelists agreed that the building standards have been the main driver of increased insulation in buildings. Several panelists felt that, absent the building standards, the consensus curve would be the most that would have happened.

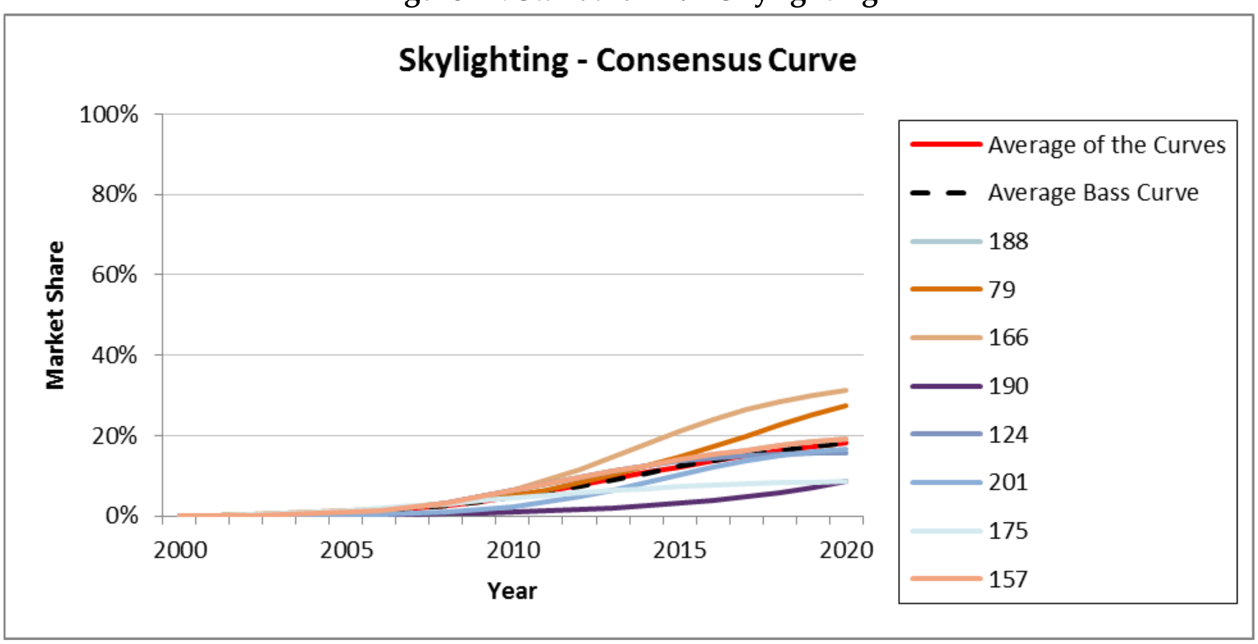
Figure 16. Standard B17 – Building Envelope Insulation



C.1.21 Skylighting – Standard B19

Figure 17 provides the consensus Bass curve for skylighting along with the panelist input used to develop it. Many panelists agreed that standards were either necessary for adoption of skylights in commercial buildings, or that adoption of skylights would have occurred eventually, but implementing the standards sped the adoption up. Other panelists felt that adoption of skylighting was well underway prior to code adoption and would have occurred anyway, with or without the code.

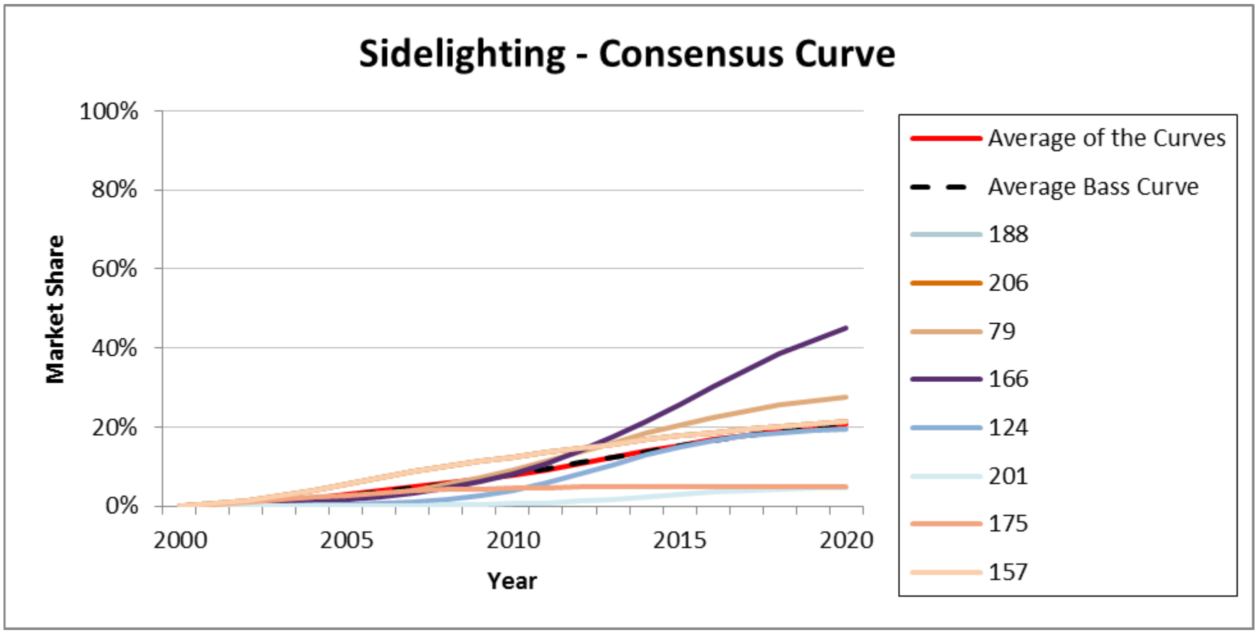
Figure 17. Standard B19 - Skylighting



C.1.22 Sidelighting – Standard B20

Figure 18 provides the consensus Bass curve for sidelighting along with the panelist input used to develop it. Most panelists felt that the standards were instrumental in accelerating the adoption rate of sidelighting; however, several panelists noted that development of an accurate daylighting sensor was also critical to implementation of sidelighting.

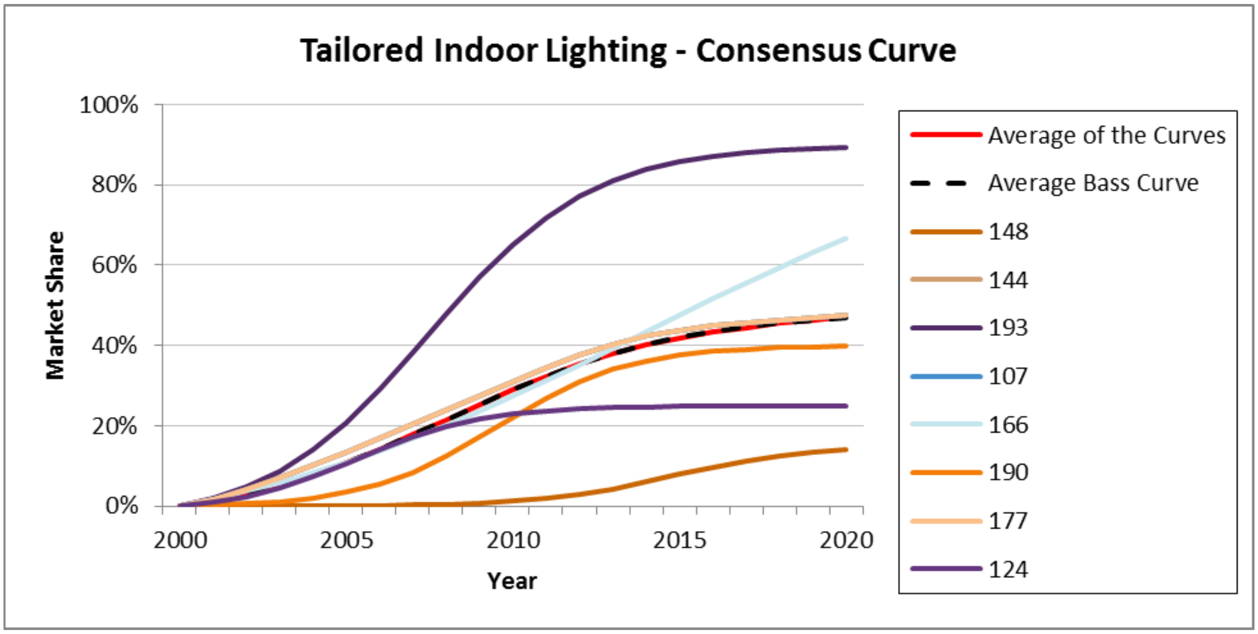
Figure 18. Standard B20 - Sidelighting



C.1.23 Tailored Indoor Lighting – Standard B21

Figure 19 provides the consensus Bass curve for tailored indoor lighting along with the panelist input used to develop it. There were differing opinions on the effects of codes on adoption of tailored indoor lighting. One panelist noted that in his or her experience, approximately half of larger retailers are interested in cost savings and will adopt new lighting technologies. The other half (such as retail and hospitality spaces) look primarily at first cost and are not motivated to adopt new lighting technologies by long range savings or energy use. Without the standards, most customers will choose the lowest initial cost solution. Another panelist noted that acceptance of tailored indoor lighting varies by market segment, with customers in the retail segment adopting faster than customers in other segments, such as schools.

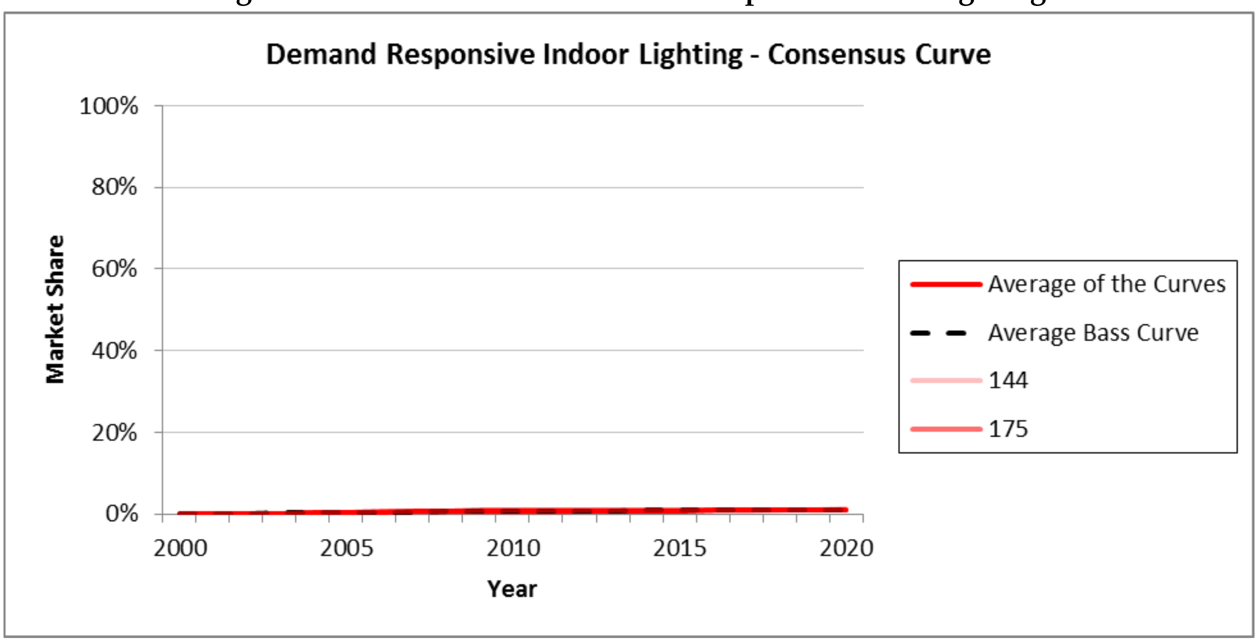
Figure 19. Standard B21 – Tailored Indoor Lighting



C.1.24 Demand Response Indoor Lighting – Standard B22b

Figure 20 provides the consensus Bass curve for demand response indoor lighting along with the panelist input used to develop it. The panelists agreed that, without the codes, there would be no market for demand responsive lighting controls.

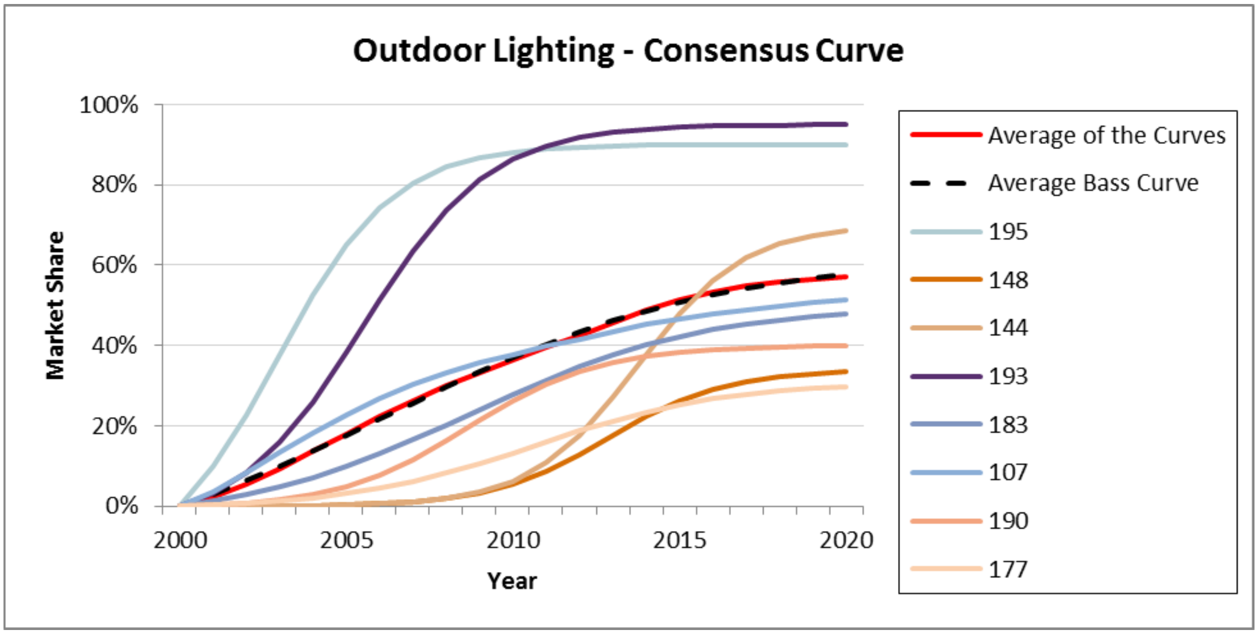
Figure 20. Standard B22b – Demand Response Indoor Lighting



C.1.25 Outdoor Lighting – Standard B23

Figure 21 provides the consensus Bass curve for outdoor lighting along with the panelist input used to develop it. Panelists noted that outdoor lighting adoption is influenced heavily by both concerns for safety and first cost. Competing code requirements for egress and emergency egress often take precedence over energy codes. Panelists expressed concern that at the same time we are protecting the environment, we are providing less protection to building users.

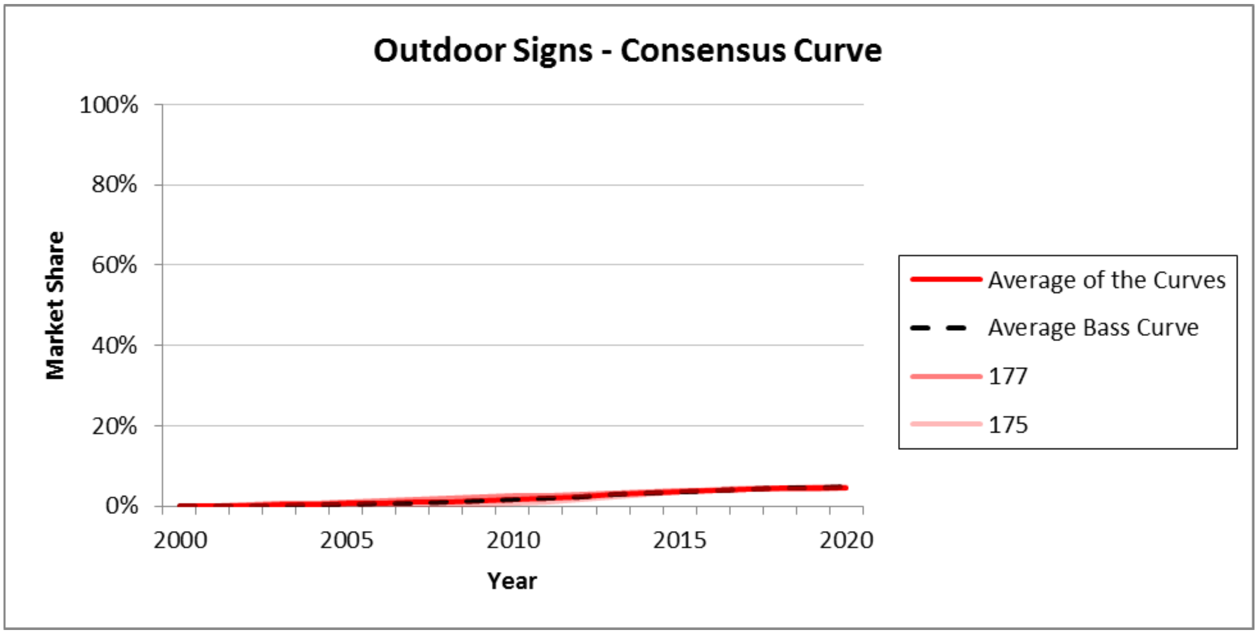
Figure 21. Standard B23 – Outdoor Lighting



C.1.26 Outdoor Signs – Standard B24

Figure 22 T provides the consensus Bass curve for outdoor signs along with the panelist input used to develop it. Panelists noted that it is difficult to change behavior regarding outdoor signage without standards as outdoor sign owners' first priority is potential customers' ability to see their signs.

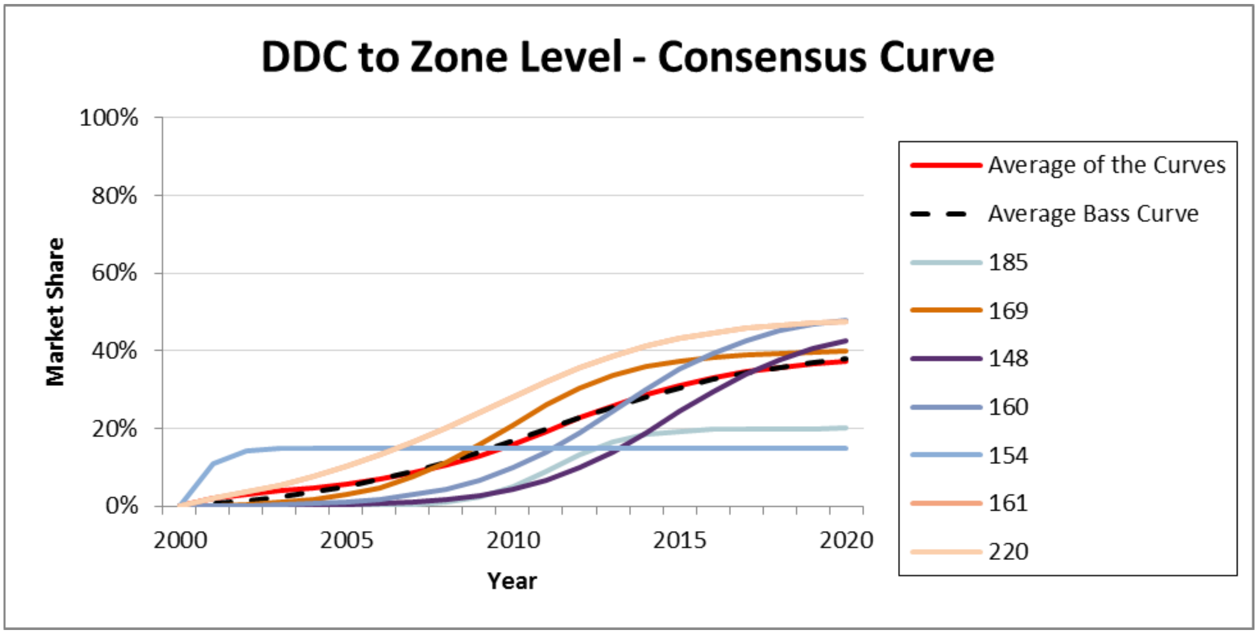
Figure 22. Standard B24 – Outdoor Signs



C.1.27 DDC to Zone Level – Standard B27

Figure 23 provides the consensus Bass curve for DDC to zone level control sequences along with the panelist input used to develop it. Panelists noted that adoption of DDC to zone level control sequences are often dependent on building size, with smaller buildings slow to adapt for cost reasons. Another panelist felt that the types of buildings that "voluntarily install DDC at the zone level are more advanced and are likely to have better engineers and contractors working on the jobs." Another panelist noted, "Most or all of these DDC features would not be implemented without guidance from code. Even though the added cost of implementing these features is negligible, there are few drivers in the marketplace (due to lack of understanding, lack of saliency or other reasons) that would cause owners, architects, or engineers to follow these best practices. These types of sequence of operation guidelines are perfect for codes because the cost is low once somebody figures out worthwhile system sequences and documents what should be done to save energy and increase comfort."

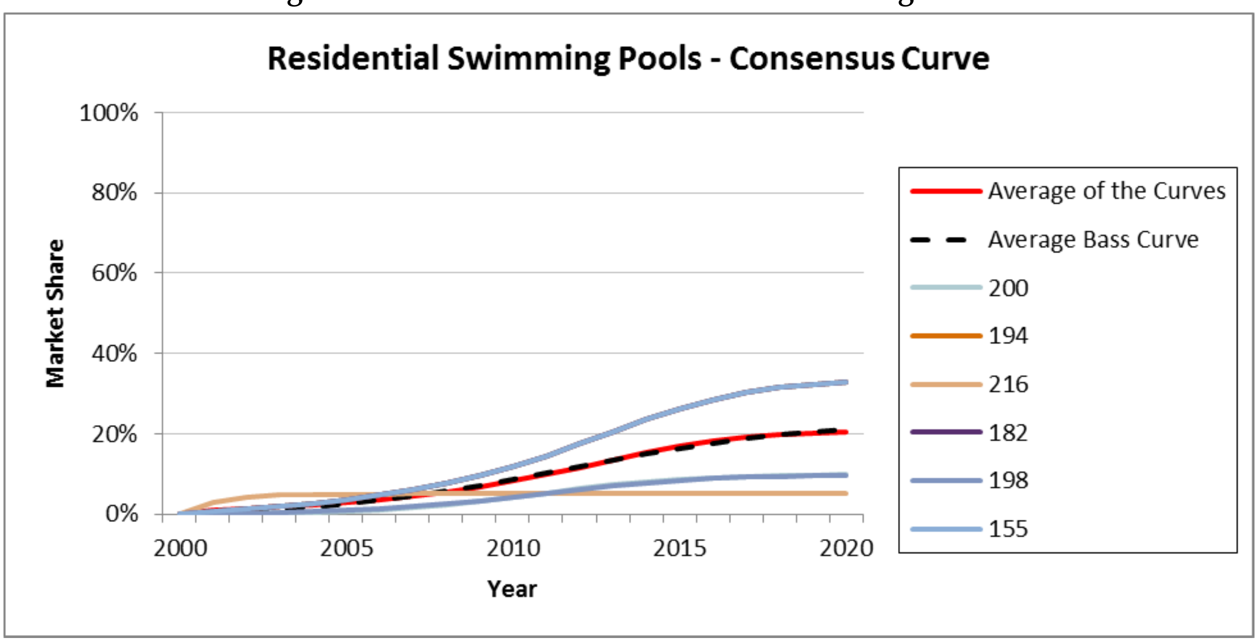
Figure 23. Standard B27 – DDC to Zone



C.1.28 Residential Swimming Pools – Standard B28

Figure 24 provides the consensus Bass curve for residential swimming pools along with the panelist input used to develop it. Panelists noted that pool owners are interested in the savings from more efficient pool pumps, but in the end, vote with their wallet. Without the standard, consumers would purchase less efficient pumps.

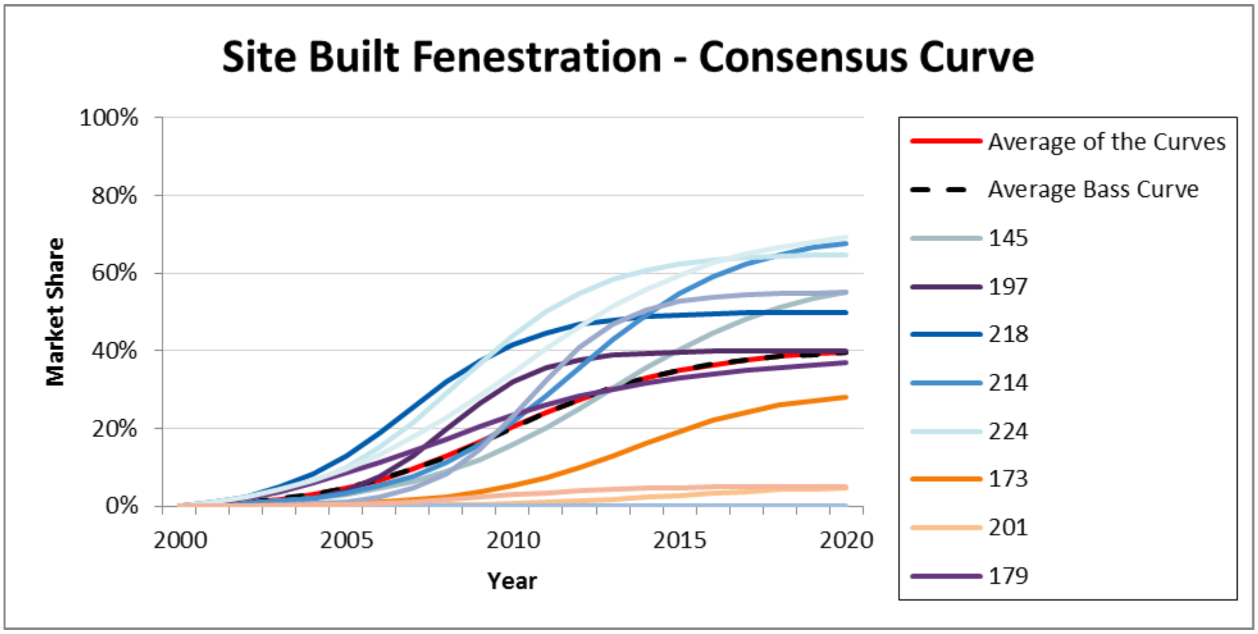
Figure 24. Standard B28 – Residential Swimming Pools



C.1.29 Site Built Fenestration – Standard B29

Figure 25 provides the consensus Bass curve for site built fenestration along with the panelist input used to develop it. Panelists provided a wide variety of opinions regarding adoption of site built fenestration, but agreed that standards were the driver for adoption of site built fenestration. One common theme was that code enforcement needed to improve.

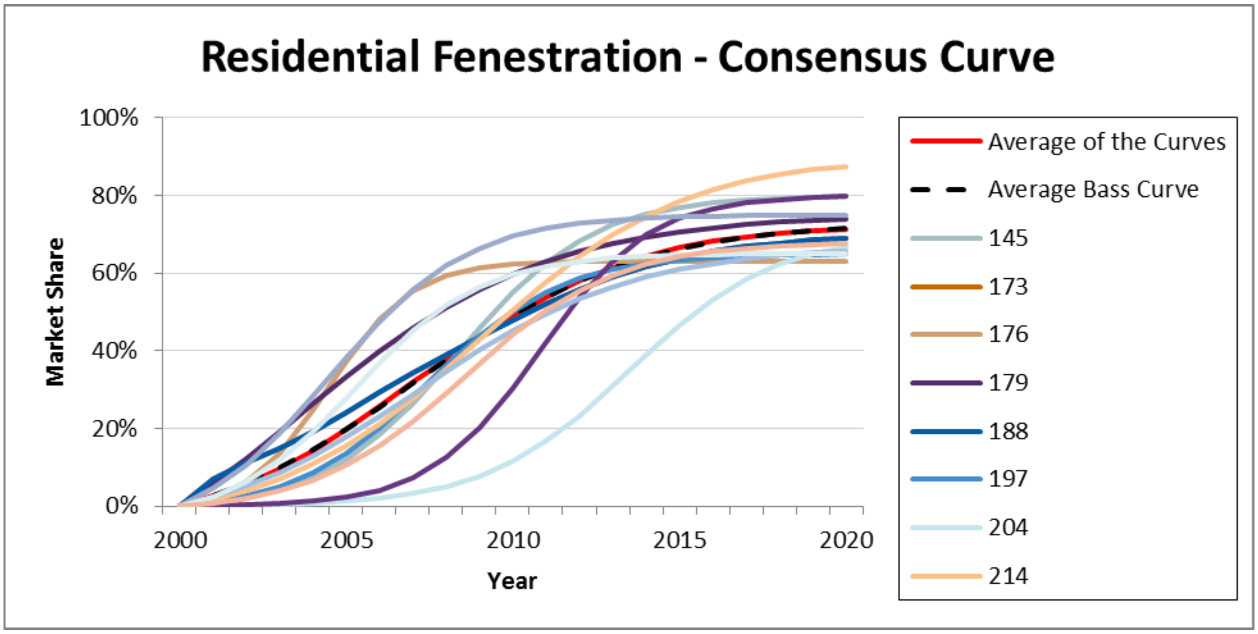
Figure 25. Standard B29 – Site Built Fenestration



C.1.30 Residential Fenestration – Standard B30

Figure 26 provides the consensus Bass curve for residential fenestration along with the panelist input used to develop it. Several panelists felt that Energy STAR would have pushed adoption of efficient residential fenestration with or without the codes. Other panelists noted that the California code provided economies of scale for the fenestration manufacturers, while other panelists felt that the codes were instrumental in the adoption of efficient residential fenestration. As in site built fenestration, code enforcement is an important consideration, although several panelists noted that windows meeting the standard are the stock windows in most "big box" homes.

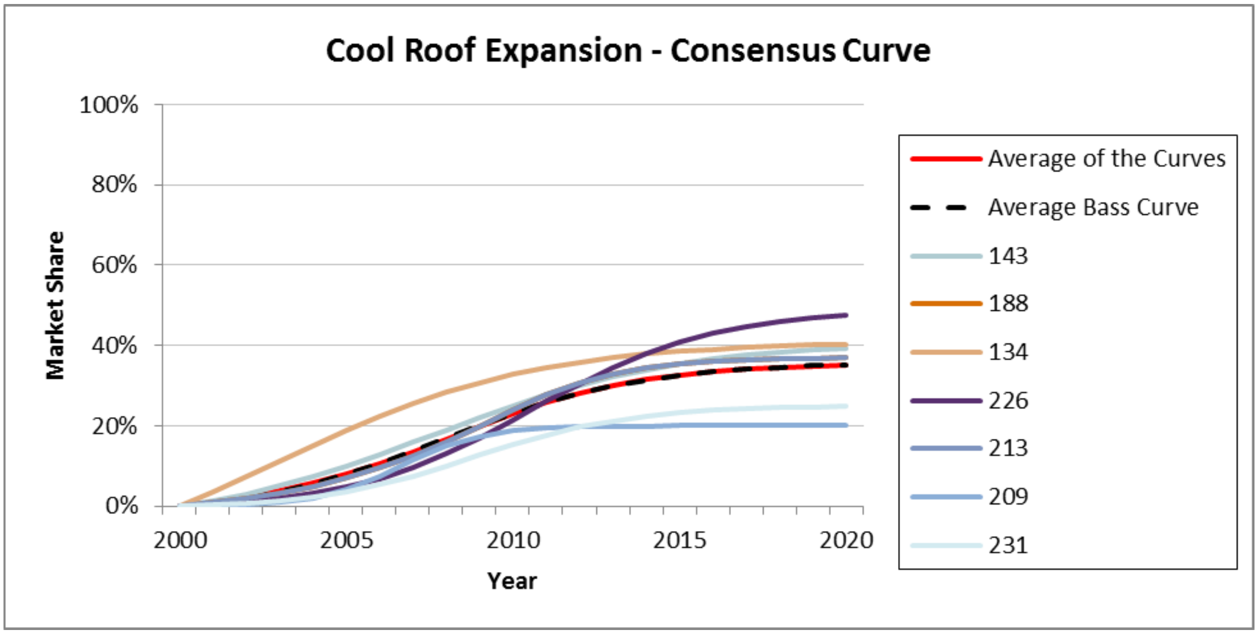
Figure 26. Standard 30 – Residential Fenestration



C.1.31 Cool Roof Expansion – Standard B31

Figure 27 provides the consensus Bass curve for cool roof expansion along with the panelist input used to develop it. Some panelists noted that steep slope cool roofing would not have been adopted without the standard. Other panelists pointed out that the standard introduced a weak requirement for minimum solar reflectance of steep roofs in non-residential buildings, and that only the darkest color roofing products, which are not often installed on non-residential buildings, fail to meet the requirements of the standard.

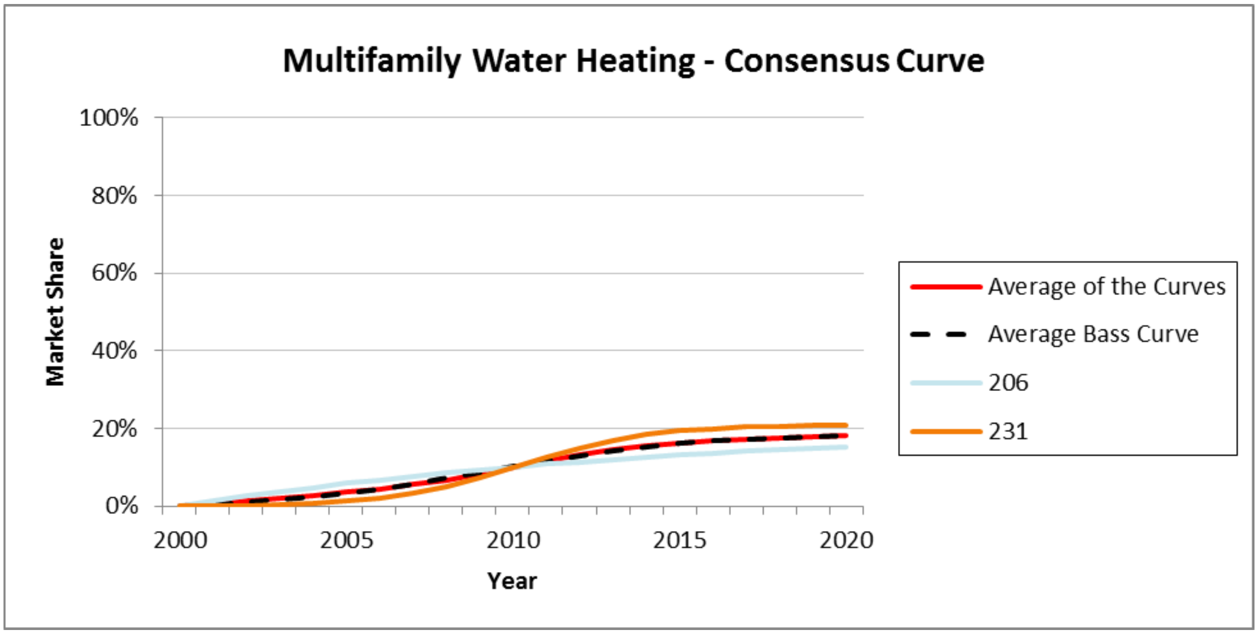
Figure 27. Standard B31 – Cool Roof Expansion



C.1.32 Multifamily Water Heating Controls – Standard B32

Figure 28 provides the consensus Bass curve for multifamily water heating controls along with the panelist input used to develop it. Panelists noted that it was difficult to disaggregate the effects of the standard on adoption of each of the different measures involved in the code requirements. Both panelists felt that adoption of the full suite of measures without the standard would be low, given the cost of measures and the need for knowledgeable plumbers working for "high-end clients prepared to spend additional money to save energy. "Hot water systems, in particular, require significant up-front investments.

Figure 28. Standard B32 – Multifamily Water Heating Controls



Appendix D. Attribution Methodology Memos

This appendix includes two memos that document the evaluation methodology.

The first memo was originally published on March 9, 2009. It documents methodology used in the 2006-2008 PY evaluation and also for the current 2010-2012 PY evaluation. It defines the attribution method used for California Title 20 and Title 24.

The second memo was originally published on September 24, 2013. It the attribution methods used for Federal appliance standards developed and used for the first time in the current 2010-2012 PY evaluation.

D.1 California Title 20 and Title 24 Attribution Methodology

D.1.1 Introduction

This document provides further explanation and clarification to the original document titled "The Proposed Cadmus Attribution Methodology" dated September 30, 2008. 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) 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.[9]

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.

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

D.1.2 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.

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.

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:

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%).

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.

D.1.3 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.

D.1.4 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.

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

(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. In other cases, it involves having an analysis tool that produces results indicating whether compliance is achieved.

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. 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 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.

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 yi, where:

yA1	=	Total effort required on factor A
yB1	=	Total effort required on factor B
yC1	=	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:

cA1	=	Proportion of credit C&S Program gets for addressing factor A
cB1	=	Proportion of credit C&S Program gets for addressing factor B
cC1	=	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:

$$C = (cA1*yA1 + cB1* yB1 + cC1* yC1) / (yA1 + yB1 + yC1)$$

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:

$$C = cA1*xA1 + cB1* xB1 + cC1* xC1$$

Where:

xA1	=	yA1/ (yA1 + yB1 + yC1)
xB1	=	yB1/ (yA1 + yB1 + yC1)
xC1	=	yC1/ (yA1 + yB1 + yC1)

xi 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.

A Numerical Example

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% on Factor A, 80% on factor B, and 25% 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:

$$
\begin{aligned}
C &= 0.4*0.1 + 0.8*0.6 + 0.25*.3 \\
&= 0.04 + 0.48 + 0.075 \\
&= 0.595
\end{aligned}
$$

Thus, energy savings attributable to the utility C&S Program would be approximately 60% 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:

1. [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?

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.

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.

(E) Application to Estimating Market Effects

A market effects study focused on the market effects of IOUs Residential New Construction programs (PY 2006-08) is underway as a separate study contracted by ED of the CPUC. One component of this market effects study is an estimate of the effects of utility DSM programs prior to 2005 on the current Title 24 residential standards. Past utility incentive programs may have influenced standards adoption by increasing market penetration and promoting acceptance of measures that were then adopted as standards.

In Appendix II, we present a refinement of the attribution model that we developed to estimate the market effects of utility DSM programs on Codes and Standards adoption. This refinement was developed for the market effects study, and the utilities will not receive credit for the DSM programs in the attribution analysis currently being conducted for the Codes and Standards Program evaluation.

D.1.5 Example I: Illustrative List of Activities for Which C&S Program Will Get Credit

Factor 1: Development of Compliance Determination Methods (Compliance)

- 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
- 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)

- 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
- 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
- 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)

- 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
- 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
- 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 effects 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.

D.1.6 Example II: Estimating Market Effects

The estimation approach is based on the assumption that prior non-C&S programs reduced the resources (effort) required to overcome one or more of the hurdles to standard adoption; in other words, without the prior programs, more resources would have been needed directly to develop and adopt the standard.

To account for utility incentive programs, let the effort for adoption that would have been required for each factor without non-C&S programs be yi where:

$yA2$ = Total effort required on factor A without non-C&S programs

$yB2$ = Total effort required on factor B without non-C&S programs

$yC2$ = Total effort required on factor C without non-C&S programs

It must be that $yA2 \geq yA1$, $yB2 \geq yB1$, $yC2 \geq yC1$, and equality would hold only in the event that utility non-C&S programs did not affect the market in a way that reduced the effort required to develop a standard.

Next, for each factor, define Pi to be the proportional increase in effort required to address each factor if the non-C&S programs had not been implemented:

$$PA = (yA2 - yA1)/yA1$$

$$PB = (yB2 - yB1)/yB1$$

$$PC = (yC2 - yC1)/yC1$$

Then the total (counterfactual) effort that the utilities would have had to expend overall on factor A would have been:

$$\text{IOU Effort A} = (yA1 * cA1) + (yA2 - yA1) = (yA1 * cA1) + PA * yA1 = yA1 * (cA1 + PA)$$

The total (counterfactual) effort all contributors would have had to expend to address factor A would have been:

$$\text{Total Effort A} = yA2 = yA1 + PA * yA1 = yA1 * (1 + PA)$$

Similarly:

$$\text{IOU Effort B} = yB1 * (cB1 + PB)$$

$$\text{Total Effort B} = yB1 * (1 + PB)$$

$$\text{IOU Effort C} = yC1 * (cC1 + PC)$$

$$\text{Total Effort C} = yC1 * (1 + PC)$$

Then the revised C&S Program credit, or attribution score is:

$$CME = (\text{IOU Effort A} + \text{IOU Effort B} + \text{IOU Effort C})/(\text{Total Effort A} + \text{Total Effort B} + \text{Total Effort C})$$

$$= [yA1 * (cA1 + PA) + yB1 * (cB1 + PB) + yC1 * (cC1 + PC)]/[yA1 * (1 + PA) + yB1 * (1 + PB) + yC1 * (1 + PC)]$$

Dividing top and bottom by (yA1 + yB1 + yC1), we get the market effects adjusted C&S Program credit for the standard, or the attribution score:

$$=[xA1 * (cA1 + PA) + xB1 * (cB1 + PB) + xC1 * (cC1 + PC)]/[xA1 * (1 + PA) + xB1 * (1 + PB) + xC1 * (1 + PC)]$$

Note that the market effects adjusted attribution score will be at least as large as the original attribution score (CME ≥ C). To see this in an informal way, suppose that cA1 = cB1 = cC1=0, but that utility non-C&S programs lowered the barriers to the adoption of the standard in at least one factor area (i.e., Pi > 0 for at least one of PA, PB¬¬, and PC). Then according to our attribution score definitions, C = 0, but the market effects adjusted attribution score, CME, would exceed zero.

The adjusted attribution score can then be used to calculate the change in net savings due to the utility DSM programs through market effects. The market effects of DSM programs on the savings attributed to the Codes and Standards Program would be calculated using the following equation:

$$MEC\&S = \text{Net standard energy savings} * (CME – C)$$

Because CME ≥ C, MEC&S will always be non-negative.

This method of estimating market effects requires a fairly straightforward extension of the data collection for the basic method. It only requires additional estimates of the percent increase in total effort that would have been required to address each factor if the utilities had not conducted relevant programs prior to adoption of the standards.

Numerical Example

Suppose, as before, the effort to overcome the three categories of hurdles are yA1 = 1000, yB1 =6000, and yC1 = 3000, where the units are some consistent measure of resources used. Then, as before xA1 = 0.1, xB1 =0.6, and xC1 = 0.3. Also as before, let cA1 = 0.4 , cB1 = 0.8, and cC1 = 0.25.

In this example, however, we are assuming development of the standard also depended on prior utility incentive programs. Suppose that in the absence of these programs the total resources required during the standard development would have been yA2 = 2000, yB2 =9000, and yC1 = 3000. Then PA = 1.0, PB =0.5, and PC = 0 (i.e., efforts would have had to be increased by 100% on factor A, 50% on factor B, and 0% on factor C). According to the model, the adjusted IOU attribution score is:

$$= [0.1 * (0.4 + 1.0) + 0.6 * (0.8 + 0.5) + 0.3 * (0.25 + 0)]/[0.1 * (1.0 + 1.0) + 0.6 * (1.0 + 0.5) + 0.3 * (1.0 + 0)]$$

$$= (0.14 + 0.78 + 0.075) /(0.2 + 0.9 +0.3)$$

$$= 0.995/1.4$$

$$=0.711$$

Accounting for IOU non-Codes and Standards program effects increases the IOU attribution score. The market effects, or energy savings, attributable to the utility DSM program would be approximately 12% (0.711-0.595) of the net energy savings from the standard.

D.2 Federal Attribution Methodology

The joint-utility Codes and Standards Program (C&S Program) of the California investor-owned utilities (IOUs) participates in the federal rulemaking process and claims savings in California from federal energy-efficiency appliance standards. The C&S Program is a rate-payer funded program dedicated to advancing state and federal energy efficiency appliance standards and building codes. This memo describes a methodology for evaluating the contributions of the C&S Program to federal energy efficiency appliance regulations ("federal attribution," for short.)

The federal rulemaking process begins when Congress passes a law to regulate an activity. The appropriate federal regulatory agency then creates regulations necessary to implement the law through a process known as administrative rulemaking. For example, the Department of Energy (DOE) creates energy-efficiency appliance standards under the authority of the Energy Policy and Conservation Act of 1975 (EPCA) and the Energy Independence and Security Act of 2007 (EISA) and several other acts created by Congress over the years. Acts such as these are known as "enabling legislation," because they enable the regulatory agencies to create the regulations required to administer enforce them.

Broadly speaking, there are two types of enabling legislation for federal energy-efficiency appliance standards. In the first type, Congress directs the DOE to develop and implement minimum energy conservation standards for categories of appliances and equipment. Since Congress gave the DOE responsibility for developing the regulation, we refer to these as standards developed through DOE rulemaking. In the second type of legislation, Congress sets the specific level of efficiency and, in some cases, also sets a timeline for the regulation to take effect. We refer to these as standards developed through the legislative process. This memo describes methods to evaluate federal attribution for both DOE and legislative rulemaking.

The first part of the memo briefly reviews the attribution of savings from California's Title 20 standards. The federal attribution methodology builds on the Title 20 methodology, so this section provides context for the next two sections. The second part of the memo addresses attribution for appliance standards developed through DOE rulemaking and is organized as follows: First we review the DOE energy-efficiency rulemaking process and compare it to California's. Second, we review the methodology for attributing energy savings from California energy efficiency standards to the IOUs. Third, we describe the methodology for evaluating the contributions of the C&S Program to DOE rulemaking.

The third part of the memo addresses attribution for federal energy-efficiency appliance standards established through the legislative process.

D.2.1 Part I: Review of California Title 20 Rulemaking Attribution Methodology

At the beginning of the 2006-2008 Codes and Standards Program evaluation, Cadmus proposed a methodology for attributing savings from Title 20 standards to the California IOUs. Cadmus developed the methodology with input from key stakeholders including the IOUs and the California Public Utilities (CPUC) Commission. CPUC accepted the methodology after stakeholders had the opportunity to review and comment on it and Cadmus revised it.

Under the methodology, the IOU C&S Program is evaluated for its contributions to state appliance efficiency rulemaking in three areas, known as "factors": (1) development of compliance tools and special analytic methods; (2) development of rule language and requirements, and technical research in support of the rulemaking; and (3) demonstration of the feasibility of complying with the proposed standard and performing stakeholder outreach and negotiation. Within each of these factors, there are sub-areas or "sub-factors" in which the C&S Program is evaluated. For example, the second factor includes (a) development of standard language and requirements; (b) estimating energy savings; and (c) demonstrating the cost-effectiveness of the standard. Table 12 lists the California evaluation attribution factors and sub-factors.

Table 12. California Title 20 and Title 24 Rulemaking Attribution Factors

Factor 1: Development of compliance determination and other special analytic methods (Compliance)
a. Development of a test method for verifying compliance
b. Development of a method for estimating energy savings (applies to building codes mostly)
Factor 2: Development of technical information (Technical)
a. Development of standard or code language
b. Demonstration of energy or peak demand savings
c. Demonstration of cost effectiveness
Factor 3: Stakeholder outreach and demonstrating feasibility of complying with code or standard (Feasibility)
a. Demonstration of market readiness (this includes general stakeholder outreach efforts)
b. Demonstration that proposed standard or code would not impose unreasonable and avoidable costs on end users
c. Demonstration that there are not significant negative human health or environmental externalities

Cadmus collected data about the contributions of the C&S Program and other stakeholders to each code or standard from the C&S Program Code Change Theory Reports (CCTRs), CASE Reports, the rulemaking docket, and interviews with stakeholders. The CASE Reports are code-change proposals written by the IOUs and submitted to the CEC. Each CASE Report describes the proposed changes to Title 20 or Title 24 and includes technical research about test methods, energy savings, and cost-effectiveness. The IOUs also wrote Code Change Theory Reports documenting their contributions to efficiency rulemaking from their perspective. The dockets typically included transcripts from CEC hearings, stakeholder letters submitted to the CEC, slide presentations at CEC hearings, and original and updated versions of the CASE Report.

An attribution analysis was performed for each code or standard. Using information gathered from the different sources, an independent panel of knowledgeable experts determined a percent score for the IOUs for each factor, indicating their relative contribution. The attribution score for a standard was the weighted average of the factor scores, where the weights summed to one and were based on the shares of stakeholder resources expended in the factor areas. The weights were derived from Cadmus surveys of participants in the rulemaking about resource allocation. The attribution score for a standard multiplied the net savings from the standard, the savings after adjusting for market compliance and naturally-occurring market adoption.

The IOUs received credit only for their contributions to the rulemaking. The factor scores did not reflect the contributions of the IOUs' voluntary programs that accelerated transformation of the market and code adoption. More generally, the methodology did not account for developments that preceded the rulemaking, though these developments may have been important, perhaps laying the groundwork for the code. For example, most standards required a test method. If the CEC adopted an existing test method, the development of a test method would not be a factor in the attribution of credit for the standard. The C&S Program, however, could receive attribution credit for identifying the test method.

D.2.2 Part II: Appliance Energy Efficiency Standards Developed Through DOE Rulemaking

Overview of DOE Rulemaking Process

DOE administers the federal energy-efficiency appliance standards process and requires consideration of issues similar to those considered in California. The Energy Policy and Conservation Act (EPCA) of 1975 and amending legislations establish that DOE is responsible for:

1. Developing test procedures for measuring energy efficiency, energy use, and estimated annual operating costs of regulated products (42 U.S.C. 6293);
2. Demonstrating that the proposed standard is designed to achieve maximum improvement in energy efficiency that is:
    a. Technologically feasible;[10]
    b. Significant in terms of energy savings; and
    c. Economically justified (42 U.S.C. 6295(o)(2)(A)).[11]

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10 "DOE considers a design option to be technologically feasible if it is currently in use by the relevant industry, or if a working prototype exists. See 10 CFR part 430, subpart C, appendix A, section 484(a)(4)(i) (providing that '[t]echnologies incorporated in commercially available products or in working prototypes will be considered technologically feasible.'"

11 There is also a product labeling requirement that is the responsibility of the Federal Trade Commission.

As part of the economic justification, EPCA directs DOE specifically to consider seven factors shown in Table 13.

Table 13. Federal Energy Efficiency Rulemaking Economic Considerations

Factor	Representative Analysis
2c.1. Economic impact on consumers and manufacturers	Life cycle cost analysis; manufacturer impact analysis
2c.2. Lifetime operating energy cost savings compared to any increase in product cost, maintenance, etc.	Life cycle cost analysis
2c.3. Total projected energy savings	
2c.4. Impact on utility or performance	Screening analysis; engineering analysis
2c.5. Impact of any lessening of competition	Manufacturer impact analysis
2c.6. Need for national energy conservation	National impact analysis
2c.7 Other factors the Energy Secretary considers relevant	Environmental assessment; utility impact analysis; employment impact analysis

Sources: Notice of Proposed Rulemaking for Refrigerators, Refrigerator-Freezers, and Freezers. Available at http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/refrig_nopr.pdf. DOE presentation at Advanced Notice of Proposed Rulemaking (ANOPR) Public Meeting. June 26, 2008.

DOE and its consultants conduct the engineering, economic, and policy analyses to demonstrate that the required conditions (1), (2a), (2b), and (2c.1-2c.7) for federal appliance standards adoption are satisfied. They may rely on data and analyses conducted by other researchers or state agencies. DOE research in support of the standard is made available on the Web as part of the rulemaking docket.

There are four steps in DOE rulemaking, which may take several years to complete:[12]

1. DOE publishes a framework document that proposes an approach for developing potential energy efficiency standards;
2. DOE publishes a preliminary analysis of the proposed standard with emphasis on the analytical methodology DOE is considering in setting potential standards;
3. DOE issues a notice of proposed rulemaking (NOPR);
4. DOE issues the final rule.

The framework document includes a description of the test method that will be used to verify compliance with the appliance standard. The DOE holds a separate rulemaking, which precedes or runs concurrently with the actual rulemaking, to determine federal test procedures.

The DOE rulemaking process is open and transparent. At each of the first three stages, there is opportunity for industry, consumer groups, environmental groups, and other interested stakeholders to comment on the proposed rules.

12 See https://www1.eere.energy.gov/buildings/appliance_standards/standards_dev_and_revision.html

DOE Energy-Efficiency Appliance Standards Attribution Methodology

The proposed methodology for federal energy-efficiency appliance standards attribution builds on the Title 20 attribution methodology. The California methodology is general enough that it can be adapted to the federal level and accommodate differences between California's Title 20 and DOE rulemaking processes.

Like the Title 20 methodology, the federal attribution methodology will have these key features:

A simple model of energy efficiency rulemaking. The model will be based on the DOE rulemaking process. The IOUs will get credit for their contributions to DOE rulemaking and satisfying the DOE's requirements for federal standards adoption.

Attribution will be determined on the basis of a careful and systematic review of the rulemaking docket, supplemented by interviews with key stakeholders and information from the utilities. and

An independent panel of experts will determine the C&S Program's contributions. The independent panel will lessen concerns about potential biases from having utility representatives or other interested parties directly involved in the determination of credit.

An important distinction between federal and California energy-efficiency rulemaking is that the IOUs play a leading role in California but only a supporting role at the federal level. In California, although the California Energy Commission is responsible for writing the final rules, the IOUs and their consultants are frequently responsible for leading their development.[13] The IOUs' possible activities in California include identifying appropriate test methods, determining the standard's requirements, calculating energy savings and cost-effectiveness, demonstrating market readiness, and negotiating with stakeholders. The IOUs summarize most of their research in a CASE Report that becomes the basis for adopting the rule. In contrast, at the federal level, no party other than the DOE and its consultants plays a leading role in the development of standards. The IOUs are an important stakeholder and provide input to federal rulemaking, but they may be only one of many participants.

The attribution methodology will capture the IOUs' more limited involvement in federal appliance standards rulemaking. By relying on information from a variety of sources including the federal rulemaking docket and stakeholder interviews, the DOE rulemaking attribution

13 According to Section 25402.7 of the California Public Resources Code, "in consultation with the [California Energy Electric Commission], electric and gas utilities shall provide support for building standards and other regulations… including appropriate research, development, and training to implement those standards and other regulations."

methodology will accurately assess the contributions of all stakeholders, not just those of the IOUs.[14] This will ensure that the IOU contributions are put into the proper perspective.

The attribution methodology for DOE appliance efficiency rulemaking has four main components:

- Attribution model: provides a framework for evaluating and scoring IOU contributions to federal rulemaking;
- Data collection: yields information about IOU and other stakeholder contributions to federal rulemaking and the allocation of stakeholder resources between factors;
- Evaluation of IOU contributions: Independent panel of knowledgeable experts determines contributions of IOUs and other stakeholders;
- Calculation and reporting of IOU attribution scores;

Attribution Model

The federal attribution model provides an analytical framework for determining the contributions of the C&S Program and other stakeholders to federal rulemaking. The model starts with the following basic assumptions:

- DOE must address the federal rulemaking requirements (1), (2a), (2b), and (2c.1-2c.7) to adopt a new rule or update an existing one.
- DOE does not have the flexibility to trade one factor off against another. Deficiencies in one area, say, lack of a test method, cannot be compensated for by superior outcomes in another area, such as comprehensive documentation of performance and cost. All requirements must be satisfied for DOE to adopt a standard.
- DOE relies on the expertise and support of outside stakeholders to address the rulemaking requirements.

Some rulemaking requirements may require DOE and stakeholders to expend more effort or resources to satisfy than others.

Stakeholders can support DOE and contribute to a rulemaking in a number of ways including, but not limited, to providing data, market research, and engineering or economic analysis or engaging in stakeholder outreach and negotiation.

When a federal standard preempts a California standard, the C&S Program can receive federal attribution credit for its past research and advocacy in California Title 20 rulemaking, if it can be demonstrated that the DOE rulemaking relied on or was influenced by these efforts.15

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14 Cadmus will not report attribution scores for other stakeholders, only a score for the IOU C&S Program.

Cadmus will evaluate the contributions of stakeholders to DOE rulemaking in the following areas referred to as factors:

- Development of federal compliance determination methods;
- Development of federal standard language and technical and cost analysis; and
- Demonstrating feasibility of complying with the federal standard (this includes stakeholder outreach and negotiation).

We now briefly describe each of the attribution factors as they concern DOE rulemaking:

Factor (1): Development of Compliance Determination Methods

Manufacturers must be able to determine that their products comply with federal standards. Similarly, the U.S. Department of Energy must have tools or methods to verify that products comply with the standards. Determining compliance requires having a reliable and readily-available test method.[16] The DOE must identify or develop a test method at the beginning of the rulemaking. DOE may identify an existing test method from a standards-setting organization like ASHRAE or ANSI or a government agency like EPA or the CEC. Establishing a test procedure is one of the first steps in a rulemaking. The DOE framework document, which describes the analytical methodologies applied in developing a standard, describes the test procedures that DOE will employ.[17]

Factor (2): Development of Standard Language and Technical and Cost Analysis

Significant scientific, policy, engineering, and economic research must be completed in support of DOE rulemaking. In addition, the requirements of the standard must be carefully defined in technical language. DOE conducts much of this research, but stakeholders contribute by submitting data and supporting analyses that enhance DOE's analysis.

DOE research focuses on three main areas. First, the requirements of the standard must be developed and the standard must be carefully defined in technical language, so compliance can

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15 For example, the 2011 federal refrigerated beverage vending machine relied extensively on the California standard and the research of the C&S Program. The C&S Program can get credit for these efforts.

16 For example, the Energy Independence and Security Act of 2007 requires that compliance of standard incandescent bulbs be determined according to the IESNA LM-45 test method.

17 Four steps in a rulemaking: (1) the publication of a framework document in which DOE describes the overall approach it is considering in developing potential energy conservation standards for a particular product or equipment; (2) the publication of a preliminary analysis that focuses on the analytical methodology DOE is considering in setting potential standards; (3) the issuance of a notice of proposed rulemaking (NOPR); and (4) the issuance of a final rule.

be determined unambiguously by end users and enforcement entities.[18] Second, the energy and peak savings from the proposed standard must be demonstrated through credible analysis or other reliable methods. The expected energy savings from the standard must be significant. It may be costly for manufacturers to comply with efficiency standards and for the federal government to develop and enforce new rules, so savings must justify the costs of a new rule. The DOE performs an "Energy Use Determination" to estimate the unit energy use of candidate regulated products and the energy savings from the proposed standard. In addition, DOE performs a National Energy Savings analysis for candidate products that is an input into the National Impact Analysis. Third, the costs of meeting the standard must be known, documented, and reasonable given the potential energy savings, and the standard should be cost-effective from an individual user's and a societal cost perspective. DOE performs life cycle costs analysis and considers any impacts on the performance and usefulness of products.

Factor (3): Demonstrating Feasibility of Complying with the Standard

Manufacturers must be able to produce appliances that meet the standards, and the costs of producing compliant products must be reasonable. "DOE considers a design option to be technologically feasible if it is currently in use by the relevant industry, or if a working prototype exists." See 10 CFR part 430, subpart C, appendix A, section 484(a)(4)(i) providing that '[t]echnologies incorporated in commercially available products or in working prototypes will be considered technologically feasible.'" DOE determines the feasibility of a design options in the market and technology assessment and technology screening analysis. DOE also considers effects on cash flows, profits, employment, plant closings, and lessening of competition. Finally, DOE also considers ancillary environmental and market benefits and costs such as the lessening of pollution and impacts on the reliability of the nation's electricity system.

A Comparison of Federal Attribution Factors and DOE Rulemaking Requirements

Cadmus will evaluate stakeholder contributions to federal energy-efficiency appliance standards in the three factor areas described above instead of the ten factors ((1), (2a), (2b), (2c.1-2c.7)) that DOE explicitly considers for the following reasons. First, the three attribution factors are a simple and logical categorization of rulemaking activities. The factors cover the important rulemaking issues and the range of possible stakeholder contributions. Also, the boundaries of the attribution factors are well-defined, with little overlap in rulemaking activities. In contrast, the boundaries between the ten factors DOE considers are somewhat ambiguous. For example, energy savings and cost-effectiveness analysis could apply to the factors (2b), (2c.2), and (2c.3). It would be complicated to allocate credit for the same analysis across the factors.

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18 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."

Second, it is simpler to assess C&S Programs in three factors instead of 10, and the DOE rulemaking requirements map neatly into the federal attribution factors. Table 14 shows the correspondence between the federal attribution factors and rulemaking requirements.

Table 14. Correspondence between Federal and California Attribution Factors

Attribution Factor	DOE Energy Efficiency Rulemaking Factors Requirements
Factor 1 (Compliance): Development of compliance determination and other special analytic methods	(1) Developing test procedures for measuring energy efficiency, energy use, and estimated annual operating cost of regulated products
Factor 2 (Technical): Development of Technical information (Standard language and requirements, energy savings, cost-effectiveness)	(2b) Demonstrating that the proposed standard is designed to achieve maximum improvement in energy efficiency that is significant in terms of energy savings (2c) Demonstrating that the proposed standard is designed to achieve maximum improvement in energy efficiency that is economically justified (2c.2) Demonstrating that lifetime operating energy cost savings of the proposed standard exceed any increase in product cost, maintenance, etc. (2c.3) Demonstrating that total projected energy savings of the proposed standard are significant
Factor 3 (Feasibility): Stakeholder outreach, feasibility of complying with code or standard, and effects on environmental, human health, and market or industry	(2a) Demonstrating that the proposed standard is designed to achieve maximum improvement in energy efficiency that technologically feasible; (2c.1) Demonstrating that economic impact on consumers and manufacturers of the proposed standard is reasonable given the expected energy savings; (2c.4) Demonstrating that the proposed standard does not significantly negatively impact utility or performance of the product (2c.5) Demonstrating that the proposed standard does not significantly lessen competition in the marketplace (2c.6) Demonstrating that there is a need for national energy conservation and that the proposed standard will reduce energy use (2c.7) Other factors the Energy Secretary considers relevant

As the DOE rulemaking requirements fit into the attribution framework in a straightforward way; it was not necessary to "shoehorn" the federal requirement into the attribution factors. Federal requirement (1) pertains to the development of a test method and corresponds to the first attribution factor. Requirements (2b), (2c), (2c.2), and (2c.3) concern energy savings and cost effectiveness, issues covered under attribution factor 2. The remaining requirements are about market readiness and externalities, which are issues related to attribution factor 3.

Attribution Score

Based on evidence about C&S Program and other stakeholder contributions, Cadmus will estimate an attribution score for each federal energy-efficiency appliance standard. The attribution score will measure the percent contribution of the C&S Program to the development and adoption of the standard and multiply the net energy savings (the energy savings from the federal standard after accounting for compliance and the natural market adoption of efficient measures). Here we define the attribution score and describe how it will be calculated.

The federal attribution score is a weighted average of the factor scores. The factor score indicates the relative (percent) contribution of the C&S Program to the factor and equals a percentage between 0 and 100. The factor scores are weighted to give the C&S Program more credit for contributions to factors that required relatively more effort. The factor weights measure the relative effort required in each factor area. The factor weight is a number between 0 and 1, and the sum of the factor weights equals one.

Calculations

For ease of exposition, denote the three factors (Compliance, Technical, and Feasibility) by C, T, and F, and let the absolute amount of effort required by stakeholders to address each be y, where:

yC	=	Total effort required on factor C
yT	=	Total effort required on factor T
yF	=	Total effort required on factor F

Thus, y captures the effort required by DOE and other stakeholders in a factor area to adopt the federal efficiency rule. Conceptually, effort can be thought of in terms of the market value of resources, such as labor, used. Our model does not require measurement of the actual resources.

Also, let credit attributed to the C&S Program for addressing each factor (i.e., the factor score) be c, where:

cC	=	Proportion of credit C&S Program gets for the work in factor C
cT	=	Proportion of credit C&S Program gets for the work in factor T
cF	=	Proportion of credit C&S Program gets for the work in factor F

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

$$C = (cC*yC + cT* yT + cF* yF) / (yC + yT + yF)$$

In weighting c by the amount of effort required to address the factor, the model gives the C & S Program more credit for contributions to factors where more resources were required. Hence, for a particular standard, a contribution of 5% to a factor requiring considerable effort will count for more than a 5% contribution to a factor requiring little effort.

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

$$C = xC*cC + xT*cT + xF*cF$$

Where:

$$xC = yC/(yC + yT + yF)$$

$$xT = yT/(yC + yT + yF)$$

$$xF = yF/(yC + yT + yF)$$

xi 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 directly. It is unnecessary to collect information on actual resource expenditures and unlikely such information would be available. Below, we describe how the c's and x's will be estimated.

A Numerical Example

Suppose effort to adopt the standard was yC = 1000, yT =6000, and yF = 3000, where the units are some consistent measure of resources used. Note that the absolute values of the y's are not needed, so for this example the units used to assess effort are not critical. Then xC = 0.1, xT =0.6, and xF = 0.3. In this example, most of the effort in developing the federal standard was expended in developing the standard language and requirements and in technical analysis.

Also, suppose the contribution of the C&S Program was 10% on Factor C, 5% on factor T, and 20% on factor F. Then cC = 0.1 , cT = 0.05, and cF = 0.05. Applying the definition of the attribution score above:

$$C = 0.1*0.1 + 0.6*0.05 + 0.3*0.05$$

$$= 0.01 + 0.03 + 0.015$$

$$= 0.055$$

Thus, the C&S Program would receive about 6% of the credit for the development of the federal standard. Other stakeholders and DOE would have received the remaining 94% of the credit. The energy savings attributable to the C&S Program would be approximately 6% of the net energy savings in California from the federal standard.

Data Collection

For each federal energy-efficiency appliance standard for which the IOUs claim savings, Cadmus will collect information about stakeholder contributions to the rulemaking. This information will be gathered from multiple sources and provide a variety of perspectives about stakeholder contributions.

Cadmus will use this information for two major purposes:

- To identify stakeholder contributions to each attribution factor; and
- To determine the factor weights or allocation of stakeholder resources among attribution factors.

Information about stakeholder contributions will be summarized and presented to an independent panel, which will determine an IOU C&S Program score (c) for each factor. Cadmus will also survey stakeholders about the allocation of resources between factor areas. Information from the surveys will be used to determine the factor weights (w).

Data Sources

Cadmus will collect information about stakeholder contributions to federal rulemaking from the following sources:

- Federal rulemaking docket. DOE carefully documents the rulemaking and makes the documentation including meeting notices, public comments, meeting transcripts, proposed rules, final rules, and supporting technical analysis available on its Website.[19] For example, the docket for the federal refrigerated beverage vending machine efficiency standard that became law in 2012 includes 36 comments from stakeholders including those from efficiency advocates, universities, machine manufacturers, soft drink producers, and government agencies. The docket also includes 39 meeting notices, meeting agendas, attendee lists, slide presentations, or meeting transcripts. There are also 18 technical support documents with 11 appendices used in determining the final rule. Each technical support document contains a detailed list of references.
- Code Change Theory Reports (CCTRs). The C&S Program submits a CCTR to CPUC for each federal energy-efficiency appliance standard for which it claims savings. The CCTRs provide the IOUs' perspective about their contributions to federal energy efficiency rulemaking. The CCTRs contain a description of the federal rules, a Codes & Standards Program logic model, a list of key stakeholders, a rulemaking timeline, a description of the specific contributions of the IOUs to the rulemaking, and supporting documentation such as communication logs and excerpts of communications between stakeholders.
- Stakeholder interviews. Cadmus will interview stakeholders in the federal rulemaking. Cadmus will interview stakeholders representing a variety of interests and perspectives including DOE staff and consultants, the IOUs and their consultants, industry, other utilities, efficiency advocates (e.g., the Natural Resources Defense Council, the Appliance Standards Awareness Project, Northwest Energy Efficiency Alliance), and state energy regulatory agencies. The interviews will help us to identify the most important issues in the rulemaking and stakeholder contributions that helped to resolve these issues. The interviews will also help us to fill in any gaps in our understanding of the development of the standard.

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19 The docket for the federal refrigerated beverage vending machine efficiency standard can be found here: http://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/24.

For each federal energy-efficiency appliance standard, Cadmus will complete interviews with at least three stakeholders. We will put the highest priority on interviews with DOE staff and its consultants, as these participants will have the most knowledge of the rulemaking. Finally, Cadmus will interview an industry representative or an efficiency advocate who was very involved in the rulemaking to obtain the perspective of a stakeholder who does not have a direct stake in the outcome of this evaluation.

California Title 20 rulemaking docket. In instances when a California appliance efficiency rule preceded the federal rule, Cadmus will review the California Title 20 docket to identify and verify any linkages claimed between the C&S Program's past research and advocacy efforts in California and the federal rulemaking.

Cadmus will carefully review information in the federal docket, findings from stakeholder interviews, and the claims of the IOUs in the CCTR to identify C&S Program and other stakeholder contributions to rulemaking. Cadmus will enter information about the contributions into an Excel spreadsheet, which will contain a short description of the contribution; who was responsible; the factor to which the contribution pertains; the data source; and a short explanation of how the contribution furthered development of the standard. The spreadsheet can be filtered to identify the contributions of particular stakeholders or particular to different factors.

Cadmus will summarize the information in the spreadsheets about stakeholder contributions in slide presentations, which will then be delivered to the independent panel of experts. The presentations will focus on identifying the major issues in each factor and the contributions of stakeholders in resolving the issues.

Surveys

To develop factor weights for each federal energy-efficiency appliance standard, we will survey DOE staff and their consultants and other knowledgeable stakeholders about the allocation of stakeholder resources between factors. Specifically, for each federal standard we will ask the following question:

For the [standard name] federal standard, what was the relative amount of resources needed to address each factor before the standard could be adopted? In other words, what was the percent allocation of total stakeholder resources across the factors in the development of the standard?

To ensure respondents are interpreting the question consistently, Cadmus will carefully define resources. The most unambiguous definition would be in terms of the approximate combined budgets of DOE and other stakeholders for the rulemaking. Defining resources in this way is easy to understand and, in comparison to defining resources in other units such as labor hours, has the advantage of accounting for the market value of all labor and non-labor resources used in the development of the standard. Note that to answer this question it is not necessary to know the actual allocation of dollars. The respondent must only be able to estimate the percent allocations. This should make it easier for stakeholders to answer this question.

Cadmus will field the survey through email in an Excel workbook that respondent will complete and return. The Excel workbook will include instructions including a high-level explanation of the federal attribution model, a list of DOE and stakeholder activities for each of the factors, and questions about the respondents' involvement in the development of the standard. Respondents will be asked to indicate the resource allocations and briefly explain their answers.

Cadmus will review the resource allocation estimates of stakeholders. If there are large discrepancies in responses between stakeholders or if the responses are inconsistent with our knowledge of how resources were allocated, we will follow up with the respondents to understand the differences.

Cadmus will use the stakeholder allocations to estimate the factor weights. Cadmus may give more weight to the allocations of stakeholders that are more knowledgeable about the rulemaking.

Evaluation of IOU Contributions to Federal Energy-Efficiency Appliance Standards by Independent Panel

Cadmus will convene a panel of federal appliance standards experts to determine the factor scores for each standard. The panel members will be independent and impartial; they will not have any other involvement in the C&S Program evaluation and will not have a stake in its outcome.

The panel will consider the IOUs' contributions to each federal energy-efficiency rulemaking separately. The panel will make an unbiased assessment of the contributions based on evidence collected from the data sources described above.

When the panel convenes, Cadmus will have already reviewed and analyzed the attribution data and summarized its findings in presentation slides. Cadmus will begin the scoring by explaining the attribution methodology and the factors the panel is to consider. Cadmus will then make a 15-minute presentation to the panel providing relevant background and summarizing stakeholder contributions to the rulemaking. The presentation for each standard will cover the following topics:

- Background about the federal standard
- Timeline for the rulemaking
- Stakeholders
- IOU and other stakeholder contributions

During and after the Cadmus presentation, the panel will discuss the evidence and findings. The panel then has three options:

- The panel can decide on a factor score by mutual agreement.
- Each panel member can submit his/her own score, and the final factor score will be a simple average of member scores.
- The panel can ask Cadmus for more information and the opportunity to determine the factor score at a later time in light of the new information.

Cadmus will record the factor scores and document the deliberations of the panel, including any issues that made determination of the factor scores difficult.

Calculation and Reporting of Attribution Score

The last step in the federal attribution task will be to calculate the attribution score for each federal energy-efficiency appliance standard using estimates of the factor scores and weights. The attribution score for a standard will indicate the percent contribution of the C&S Program to the development of the standard. It will be entered into the evaluation's Integrated Standard Savings Model and multiply the standard's net savings.

D.2.3 Part III: Energy-Efficiency Appliance Standards Established by the U.S. Congress

Cadmus will use a similar methodology to evaluate the contributions of the California IOUs to the development and establishment of energy-efficiency appliance standards passed by Congress. In legislative rulemaking, Congress sets the efficiency standards, leaving only the implementation and enforcement of the rules to DOE.

Legislation establishing federal energy-efficiency appliance standards starts with the introduction of a bill to the floor of the U.S. House of Representatives or Senate. Congressional leaders then refer the bill to the appropriate committee. There, the bill is debated, hearings may be held, and the bill may be amended before the committee holds a vote. Bills that pass out of the committee are sent to the floor for consideration by the full chamber. A bill must pass both the House and the Senate (and be signed by the President) before becoming law. Often, a committee of representatives of both chambers of Congress is necessary to work out differences between House and Senate versions of the bill.

There are obvious procedural differences between administrative and legislative energy-efficiency appliance rulemaking. In addition, there are subtle but important differences in how efficiency standards are set. One is that unlike in CEC and DOE energy efficiency rulemaking, there are not specific and explicit requirements that legislation must satisfy. For example, efficiency standards enacted by Congress do not have to satisfy specific cost-effectiveness criteria, as they do in California. In addition, the legislative process is not as transparent or open as administrative rulemaking. There are not mandatory comment periods; lawmakers are not required to solicit public participation in hearings; and documents that lawmakers rely on to write the bill are not always cited or made available.

These differences notwithstanding, the issues that Congress and DOE consider in setting appliance energy efficiency standards are very similar. When considering a new appliance efficiency standard, Congress often addresses issues of compliance and enforcement, including the availability of test methods for determining compliance with the standard. In addition, Congress usually weighs the expected energy savings against the expected incremental costs; thus, the cost-effectiveness of the standard becomes a fundamental issue. Finally, it frequently addresses issues regarding the feasibility of complying with the standard as well as the costs and benefits to different stakeholders. Even before a bill reaches the chamber floor and committee, there may be negotiations between stakeholders and legislators about the efficiency requirements. While the bill is in committee and before the full House or Senate chamber, there may be additional negotiations, culminating in amendments to the legislation.

As Congress does not have technical expertise in energy efficiency, it must rely on information and advice about these issues from stakeholders such as manufacturers, utilities, consumer advocates, and efficiency professionals. This means there is opportunity for stakeholders such as the California IOUs to influence the legislative process.[20] Stakeholders can submit letters and reports to Congress, testify at hearings, or lobby members of Congress. Stakeholders may also negotiate about the requirements of the standards.

Attribution Approach for Legislative Appliance Efficiency Standards

Cadmus will evaluate the contributions of the IOUs to federal legislative energy-efficiency appliance rulemaking using the basic approach for attribution of savings from DOE rulemaking. Rather than repeat many of the details of that methodology, this section presents a high level summary of the federal legislative attribution evaluation steps. We point out differences between the two approaches, in particular with respect to data sources.

The C&S Program will be evaluated for its contributions to federal legislative energy-efficiency appliance standards in the three factor areas:

1. Compliance
2. Technical research
3. Stakeholder outreach and feasibility of standards adoption

In each area, Cadmus will identify the critical issues in achieving passage of the legislation and the specific contributions of the IOUs. The third factor would include IOU lobbying, testimony before Congressional committees, and reaching out to other stakeholders to secure their support. As with attribution for DOE rulemaking, Cadmus will collect information about IOU contributions to federal legislation standards in each of the areas and present the information to

20 Stakeholders can also influence the legislative process with campaign contributions or through personal ties to legislators.

a panel of independent experts. The attribution panel will determine a factor score indicating the percent contribution of the IOUs to each factor.

In addition, Cadmus will develop factor weights, indicating the relative importance of the factor in the legislative process. The factor weights will sum to one and indicate the share of stakeholder and legislative resources (principally, labor) expended on the factors. Cadmus will develop factor weights based on feedback from legislative participants and stakeholders about the importance of different issues in the rulemaking.

The CA IOUs' attribution score for a federal legislated efficiency standard will be the weighted average of the factor scores. The attribution score will reflect both the factor weights and attribution panel scoring.

Data Collection

Cadmus will collect data for attribution of savings from Congressional standards from a variety of sources. As parts of the legislative process may not be as well documented as the administrative rulemaking process, we expect to rely to a greater extent on interviews with participants and stakeholders.

- Cadmus will collect data from the following sources:
- California IOU Code Change Theory Reports (CCTRs)
- The Congressional Record of the Government Printing Office[21]
- Full text and summaries of original, amended, and final bills
- Timeline of legislation in Congress
- Transcripts of Congressional hearings[22]
- Congressional Committee Reports[23]
- Transcripts of floor speeches
- Interviews with legislation participants and stakeholders

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21 The Congressional Record is vast. The evaluation budget may not support review of every record relevant to the legislative rulemaking. Cadmus will focus its efforts on the most important records.

22 Congress makes available transcripts of public committee hearings. For example, transcripts for the U.S. Senate Committee on Energy and the Environment may be found here: http://www.gpo.gov/fdsys/browse/committeecong.action?collection=CHRG&committee=energy&chamber=senate&congressplus=112&ycord=0

23 Congressional Committee reports are searchable by key word and available here: http://thomas.loc.gov/home/abt_thom.html#committee

Cadmus will interview persons knowledgeable about the legislation representing a variety of viewpoints. These may include Congressional staff, lobbyists, efficiency advocates, efficiency experts, utilities, and manufacturers.

Evaluation of IOU Contributions to Congressional Rulemaking

Cadmus will convene an independent panel of appliance standards experts familiar with Congressional energy-efficiency appliance standards to determine the C&S Program contributions. For each legislated standard, the independent panel will review the evidence about the IOUs' contributions and determine a score for each factor through careful deliberation. Cadmus will guide the scoring process using the same procedures as those used in the panel scoring of the DOE standards.

Appendix E. Federal Attribution Workshop: Response to Comments

This appendix presents the Commission staff responses to public comments on the Federal Attribution Methods staff workshop. Commission staff held a workshop on October 18, 2013 to present and seek input on proposed Federal Appliance Standards Attribution methods and policy approach. Below are extracts of the comments and responses.

Author	Subject (comments below are extracts from original comments)
IOU Codes and Standards Team	Baseline for preempted federal standards
Comment	The savings from the previous standard continue as each new generation of standards are adopted. Incremental savings from new standards are layered on top of the previously existing standards. This approach is referred to as the "layered approach." The layered approach has been used in California C&S measures in all past C&S savings calculations performed by the IOUs for program planning and compliance filing and by the CPUC for impact evaluation and potential assessment. The IOU C&S programs designs, which [have] been approved by the CPUC, are based on the layered approach. We consider the layered approach to be the appropriate approach for calculating energy savings from succeeding standards. The proposed Preemption Treatment stops the energy savings for a Title 20 standard after a corresponding federal standard takes effect, even though the federal standard is in many instances modeled on the California standard or support for the federal standard by California parties is predicated on the existence of the California standard.
Commission staff response	Preemption of a Title 20 by a federal standard results in the Title 20 ceasing to apply to the regulated measure after effective date of the federal standard. Even if layering was accepted by Commission policy, it would not apply in this case. Staff disagrees with the broad assertion of precedent for layering. While IOUs may have included layered savings in their projections for 2010-12, there was no basis for doing so: (1) Prior to the 2006-08 cycle there were no savings credited for C&S. (2) In orders since the 2006-2008 cycle, there is no PUC decision recognizing layering of savings. (3) The only previous C&S Impact evaluation (2006-2008) did not present layered savings. The issue of the baseline for C&S savings, under debate since D. 05-09-043 (Appendix 10) was resolved in D.10-04-029: 'The baseline for gross savings should be the previous standard or the prevailing market practice' (p. 46). Following this order and finding no precedent for layering, Commission staff has advised the evaluation contractors to avoid layering for CA codes and standards. Any contribution by the California parties, including the existence of a Title 20 standard, is expected be captured by the proposed methodology.
	Adjustment of potential savings to reflect California savings
Comment	IOU C&S standard program should be allowed to receive 100% of the California potential savings by contributing to 12% of the federal standard development and advocacy efforts. Attribution to California share of savings = Maximum {100%, attribution at the federal level / 12% X100%} Net Program Savings = CA Potential Savings x Compliance Rate x (1---NOMAD) x CA Savings Share Attribution

Author	Subject (comments below are extracts from original comments)
Commission staff response	D.10-4-29 OP16 'Verified Codes and Standards savings pre and post 2006 shall count only for savings within the utility's service territory' Not correcting potential savings to the CA potential prior to evaluation protocols adjustments will inflate IOU savings credits as it would count savings realized in other states, which are not to the benefit of CA ratepayers and against Commission direction. While it is commendable that IOUs contribute to increasing EE savings in other states, it is already recognized in the fact that IOUs are able to operate in that space and claim savings, but limited to their savings territories. Moreover, consistent with the EE evaluation protocols - attribution should reflect the contribution of all stakeholders in the process[24]. It is not acceptable that IOUs would claim 100% credit for a process that they were not the sole contributors.
Appliance Standards Awareness Project (ASAP)	IOU incentives to pursue federal standards
Comment	If the CPUC attribution model eliminates or reduces IOU credit for (…) standards once an existing CA standard becomes national, then the CPUC would be incenting the IOUS to oppose national standards. We strongly urge you to avoid any scenario that would result in such an outcome.
Commission staff response	The methodology proposed will attempt to capture all IOU contribution and reflect this effort in the scores. The proposed policy ensures that savings streams continue after preemption, motivating the IOUs to operate in that space. Still, the attribution process should not ignore the fact a federal standard is put in place following a process not equal to the CEC process.
	Impact of proposed attribution on future T20 savings streams
Comment	Our understanding of the current state attribution calculation is that the utilities receive credit for a given timeframe for accelerating state codes and standards. At some point, it is assumed the state would have reached the same level of efficiency on its own and therefore at that assumed time, credit ceases to be attributed to the IOUs. For example, credit may no longer be given once the entire fleet of installed products is replaced and turned over. Assuming this is correct, have the CPUC and its consultants run scenarios to show the impact of this proposed policy recommendation?
Commission staff response	Once preempted, the Title 20 standard no longer exists. The IOUs will be credited with future savings streams adjusted to federal attribution.
Natural Resources Defense Council	Savings credit
Comment	The CPUC and their consultants have gone to great lengths to quantify the impacts of the IOUs participation in state standards setting processes and to assign a savings number. If there is no federal standard then the utilities are credited with these savings. If however the federal government goes ahead

24 'The evaluation contractor will conduct interviews with a representative sample of the key stakeholders identified (...) and use the results of these interviews, along with program materials and documents(...) to assign causation percentages for the change to various change agents identified by the stakeholders, including direct or indirect efforts of the program.' (See page 91 http://www.calmac.org/events/EvaluatorsProtocols_Final_AdoptedviaRuling_06-19-2006.pdf)

Author	Subject (comments below are extracts from original comments)
	and copies the California standard, per the CPUC consultant's proposal these savings would go to zero or would be significantly degraded once the federal standard takes effect. [S]trongly believe these savings should continue to accrue for the utilities for a reasonable time frame whether or not federal standards get set. The reality is the federal standards were set in large part due to existence of the California standard and the DOE and their consultants heavily relied on their initial analysis and research contained in their CASE report that was prepared for the CEC. We fail to see why these savings are no longer relevant if they are adopted by the federal government, either by regulatory or legislative processes.
Commission staff response	The methodology proposed will attempt to capture all IOU contribution and reflect the effort in the scores.
	Adjustment to California potential
Comment	CPUC should (…) retain the flexibility to develop alternate percent savings from the default 12% in the rare cases where California's market share might be significantly different than the national average due to unique market conditions.
Commission staff response	Agreed.

Appendix F. Potential and Gross Savings: Title 20 and Federal Standards

This appendix contains descriptions of the work completed to determine the potential savings and gross savings for all of the appliance standards evaluated. This work was previously summarized in a series of memos that were reviewed by the CPUC and the project management team and the memos are compiled here as this appendix. The order of the topics in this appendix is shown in Table 15. Topics are ordered by California standard number and by federal standard number when there is no corresponding state regulation. The discussion and analysis of similar appliances are often grouped together, as indicated by the reference fields in the table, when more than one standard is included.

Note: The potential energy savings in this appendix do not include interactive effects.

Table 15. Order of Appendix Contents

Reference	Description
Standard 4	Walk-In Refrigerators / Freezers
Standard 9	Residential Pool Pumps, 2-speed Motors, Tier 2
Standard 11b Standard 25 Standard 26 Standard 27	General Service Incandescent Lamps, Tier 2
	General Purpose Lighting -- 100 watt
	General Purpose Lighting -- 75 watt
	General Purpose Lighting -- 60 and 40 watt
Standard 22a / b / Federal 6	BR, ER and R20 Incandescent Reflector Lamps
Standard 23	Metal Halide Fixtures
Standard 24	Portable Lighting Fixtures
Standard 28a Standard 28b	Televisions - Tier 1
	Televisions - Tier 2
Standard 29	Battery charger - consumer - Tier 1
Standard 31 Standard 32	Battery charger - large - Tier 1
	Battery charger - large - Tier 2 incremental
Federal 1	Electric Motors 1-200HP
Federal 5	Residential Ranges
Federal 7	General Service Fluorescent Lamps

F.1 Standard 4 – Compliance for Walk-in Refrigeration

F.1.1 Introduction and Summary of Findings

This memorandum describes the results of Cadmus' evaluation of California Code of Regulations, Title 20 compliance for walk-in coolers and freezer for the 2010-2012 program cycle. Title 20 states that walk-in coolers and freezer manufactured on or after January 1, 2009, shall:

- Have automatic door closers that firmly close all walk-in doors within 1-inch of full closure (exceptions: doors wider than 3-foot 9-inches or taller than 7-feet)
- Have strip doors, spring-hinged doors, or another method of minimizing infiltration when doors are open
- Contain wall, ceiling, and door insulation of at least R-25 for coolers and R-32 for freezers (except the glazed portions of doors or structural members)
- Contain floor insulation of at least R-28 for freezers
- Use electronically commuted (EC) or 3-phase motors for evaporator fan motors under 1 horsepower (HP) and less than 460 volts
- Use EC, 3-phase, or permanent split capacitor motors for condenser fan motors under 1 HP
- Use interior light sources with an efficacy of 40 lumens per watt (LPW) or more, including ballast losses if any, or use light sources with an efficacy of less than 40 LPW with timers to switch off lights 15 minutes after walk-ins are not occupied

Walk-ins with transparent reach-in doors or windows shall:

- Have doors and door windows built out of double/triple pane glass with either heat reflective glass or gas fill (double pane glass is only allowed for coolers)
- If the appliance has an antisweat heater (ASH)
    - Walk-ins without ASH controls must have a total door rail, glass, and frame heater power draw of no more than 7.1 watts/square foot of door opening (for freezers) and no more than 3.0 watts/square foot of door opening (for coolers)
    - Walk-ins with ASH control must have a total door rail, glass, and frame heater power draw of no more than 7.1 watts/square foot of door opening (for freezers) and 3.0 watts/square foot of door opening (for coolers); the ASH controls shall reduce the energy use of the ASH in a quantity corresponding to the relative humidity in the air outside the door or to the condensation on the inner glass pane

Table 16 summarizes the results of our compliance rate (CR) evaluation for walk-in coolers and freezers, along with the original IOU CR estimate. Cadmus conducted a similar compliance evaluation for walk-ins during the 2006-2008 C&S evaluation, and that study yielded a CR of 88%.[25] Note during the last evaluation a slightly different standard was in effect.

Table 16. Evaluation Results: Title 20 Compliance Rate for Walk-ins

Value	Evaluation Result	Original IOU Estimate
Statewide CR for walk-ins	91%	93%

The following sections describe our approach and the findings listed in Table 16.

F.1.2 Appliance Compliance

Cadmus assessed the market CR through phone and e-mail surveys with walk-in cooler and freezer manufacturers that serve the California market. The survey questions are provided at the end of this section.

Cadmus contacted 25 manufacturers/service companies up to three times; only four responded to the survey questions. Others either declined or were not available to answer the survey. If survey participants were not available over the phone, Cadmus sent them an e-mail with the survey questions attached.

Table 17 summarizes the number of units (freezers and coolers) sold in 2011 by each of the four surveyed manufacturers in California. Manufacturers A and B are major suppliers in the state, while manufacturers C and D serve a smaller number of customers. This variation in the size of their operations increased the representativeness of the sample.

Table 17. Number of Units Sold by Each Surveyed Manufacturer in California, 2011

Manufacturer	Number of Units Sold in 2011	
	Coolers	Freezers
A	214	214
B*	199	246
C	~ 30	~ 50
D	Did not know	Did not know

* This manufacturer also participated in Cadmus' 2006-2008 codes and standards evaluation.

Based on the manufacturer survey responses, energy efficiency continues to be a critical parameter for customers in California, and two of the manufacturers showed strong awareness and knowledge of Title 20 regulations. In addition to mentioning the Title 20 efficiency measures, these two manufacturers said they also offer other energy-efficiency improvement measures, such as evaporator flow controls, load managers, refrigerant catalysts, occupancy

25 The Cadmus Group, Inc. "2006-2008 California IOU Codes and Standard Program Evaluation." April 9, 2010.

sensors, and upgrading or customizing system control strategies that improve the overall performance of the cooling/freezing process.

Cadmus used the Codes and Standards Enhancement Initiative Report (CASE Report) for walk-ins, authored by Davis Energy Group,[26] as a reference for estimating the approximate savings potential of each measure implemented. During our literature survey, we found the CASE Report referenced in several articles; it provides the most detailed analysis of all the studies we reviewed. The report outlines the expected energy savings for a typically sized walk-in cooler and freezer sold in the California market. Cadmus did not consider interactions between the measures in our analysis because it was outside our scope of work.

Table 18 lists the measures Cadmus considered for calculating the CR and their associated savings, from the CASE Report. We used the energy savings by measure to weight the manufacturer responses in calculating the CR.

Table 18. Measures and Corresponding kWh Savings

Measure	Walk-in Cooler Savings (kWh)	Walk-in Freezer Savings (kWh)
Automatic Door Closers	2,651	4,849
Strip Doors, Spring-hinged Doors	2,798	5,117
EC Motor Evaporator Fan	1,366	3,029
EC Motor Condenser Fan	353	1,464
Insulation	73	776
Energy-efficient Lighting	168	168
Transparent Reach-ins		
Anti-Sweat Heater Controls	384	1,383
Energy-efficient Doors (gas filled)	3,130	4,294

F.1.3 Algorithm and Results

Cadmus first calculated the CR for freezers and coolers separately, and then combined the results to obtain the overall CR.

To calculate the CR, Cadmus conducted the following steps as shown in Figure 29:

We calculated the savings weighted CR_{manf} for each manufacturer we interviewed using the *measure level* savings in Table 18 and the *measure level* CR_i obtained from interviewing manufacturers.

$$CR_{manf} = \frac{\sum_i kWh_i CR_i}{\sum_i kWh_i}$$, where *i* indicates each unique measure

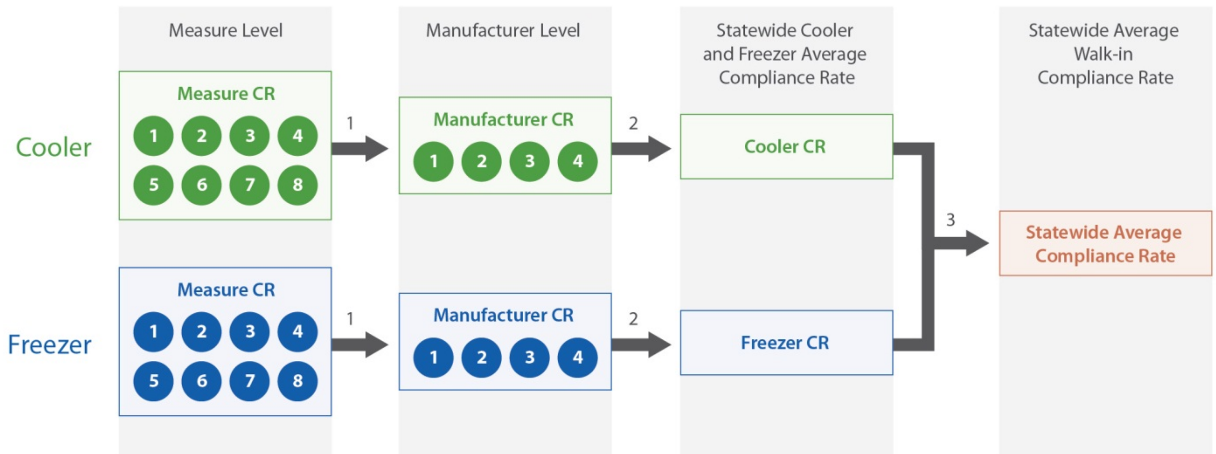
26 Davis Energy Group. "*Analysis of Standards Options for Walk-in Coolers and Freezers*." Prepared for Pacific Gas and Electric. 2004.

We calculated the $CR_{product}$ for each product type (cooler or freezer) by weighting the CR_{manf} by each manufacture's annual sales.

$$CR_{prod} = \frac{\sum_j Sales_j CR_{manf,j}}{\sum_j Sales_j}$$

Finally, we determined the overall walk-in CR by averaging the walk-in cooler and freezer results.

Figure 29. Compliance Rate Calculation Methodology



Following these steps, Cadmus determined that the average Title 20 CR for walk-ins sold in California is 91% for the 2010-2012 program cycle. At the measure level, automatic door closers have the lowest CR at 71%, while evaporator and condenser fan motors have the highest CR at 100%.

F.1.4 Walk-in Survey Cooler and Freezer Questions

1. How many walk-in freezers did you sell in 2011? To customers in California?
2. How many walk-in coolers did you sell in 2011? To customers in California?
3. What percent of the freezers sold in 2011 included an automatic door closer? (Note, do not include units with doors wider than 3-foot 9-inches or taller than 7-feet).
4. What percent of the coolers sold in 2011 included an automatic door closer? (Note, do not include units with doors wider than 3-foot 9-inches or taller than 7-feet).
5. What percent of units (freezers and coolers) sold in 2011 included strip doors, spring-hinged doors, or other devices to reduce infiltration when doors are open?
6. What type of evaporator fan motors less than 1 HP do you install (3-phase, EC, or other)?

7. What type of condenser fan motors under 1 HP do you install (3-phase, permanent split capacitor-type, EC, or other)?
8. What was the most common insulation R-value (wall, ceiling, door, and floor) in the freezers and coolers you sold in 2011?
    a. Wall insulation: Freezer ______ Cooler______
    b. Ceiling insulation: Freezer ______ Cooler______
    c. Door insulation: Freezer ______ Cooler______
    d. Floor insulation: Freezer ______ Cooler______
9. Did the systems you sold in 2011 include efficient interior lighting? Do you know how many lumens per watt? (Efficient lighting systems are light sources with an efficacy of more than 40 LPW.)
10. Did the systems you sold in 2011 include a timer or device to turn off lights within 15 minutes when the cooler or freezer is unoccupied?
11. In 2011, did you sell products with transparent reach-in doors?
    a. What percent of your walk-in freezers have transparent reach-in doors and windows made of triple-pane glass with either heat reflective glass or gas fill?
    b. What percent of your walk-in coolers have transparent reach-in doors and windows made of double/triple-pane heat reflective glass or gas fill?
    c. For both coolers and freezers, what percent have anti-sweat heat controls installed?
    d. What is the typical power draw of the heater in watts/square foot of door opening for freezers?
    e. What is the typical power draw of the heater in watts/square foot of door opening for coolers?
    f. What percentage of products with reach-in doors have door heater controls that manage energy draw with changes in humidity?
12. Do you offer any additional energy saving features to those mentioned above?
13. How often do customers ask about energy saving features? Is energy savings a big concern for your customers?

F.2 Standard 9 – Residential Pool Pump Motors – Tier 2

F.2.1 Introduction and Summary of Findings

This memo describes Cadmus' evaluation of potential energy savings and compliance for Standard 9: Residential Pool Pumps – Two-Speed Motors (Tier 2).[27] The standard states that residential pool pump motors with a capacity of one horsepower (HP) or greater and manufactured on or after January 1, 2010, must meet the following specifications:

- Motors must be able to operate at two or more speeds.
- Motors must be operated with a pump control capable of operating at two or more speeds.
- Pump controls manufactured after January 1, 2008, and sold for use with pumps capable of operating at two or more speeds, must be able to operate the pump at two or more speeds. The default speed shall be no more than half the motor's maximum rotation rate. High-speed override is allowed for up to 24 hours before it reverts to default settings.

Table 19 summarizes the results of our evaluation of Standard 9 (Std9) and the original IOU estimates.

Table 19. Evaluation Results for Std9

Value	Evaluation Result	Original IOU Estimate*
Units per Year	163,000	142,700
Unit Energy Savings (kWh/year)	2,065	725
Unit Demand Savings (kW)	0.15	0.17
First Year Potential Energy Savings (GWh)	337	104
First Year Potential Demand Savings (MW)	24.2	24
Compliance Rate	86%	99%

* Estimates provided by the California IOUs on May 13, 2011, in response to EEGA data request 1465, 1466, 1467, and 1468.

The following sections describe our approach and findings for each value listed in Table 19.

F.2.2 Potential Energy Savings

The ISSM model requires two values: the size of the California market, in units sold per year, and unit energy savings, as shown in Equation 1.

Equation 1. Annual Energy Savings

$$Annual\ Potential\ Savings = \#\ Units\ Purchased\ Annually \times Unit\ Energy\ Savings$$

27 The Tier 1 standard took effect in 2006 and requires pool pump motors manufactured on or after January 1, 2006, to not be split-phase or capacitor start-induction run type.

For every standard, the potential energy savings analysis begins with a review of the market size.

Market Size

We used several sources of information to estimate the market size for residential pool pump motors regulated under Std9:

- U.S. Swimming Pool and Hot Tub Market 2012, P.K. Data, Inc. for Association of Pool and Spa Professionals (APSP). 2012.
- Process Evaluation of 2006-2008 PG&E Mass Markets Program Portfolio and CFL, Swimming Pool Market Characterizations. KEMA. 2009.[28]
- CASE Report: Analysis of Standards Options for Residential Pool Pumps, Motors, and Controls. Davis Energy Group. 2004.[29]
- Performance and Energy Efficiency Evaluation of Residential Variable-Speed Pool Pumps (ET 04.12 Report). Design and Engineering Services, Southern California Edison. 2007.

Cadmus assumes that each residential swimming pool requires one pool pump, and each pool pump has one motor. Some homes may have a separate pool pump to operate pool-cleaning equipment; due to lack of available information, we are not including these additional pumps in our analysis. Both above-ground and in-ground swimming pools require filtration and thus are included in the scope of our market sizing analysis.

Table 20 lists the inputs and calculations in our market size analysis for Std9. First, we estimated the annual sales of pool pump motors in California (D) by adding together the number of new and replacement pool pumps installed in 2012. We approximated the number of new pool pump motor installations using the number of new pools installed (A). To obtain the number of replacement units, we divided the installed base (B) by the measure life (C).

28 http://www.calmac.org/publications/PGE_Mass_Market_Report_FINAL.pdf

29 http://www.energy.ca.gov/appliances/2003rulemaking/documents/case_studies/CASE_Pool_Pump.pdf

Table 20. Calculation of Swimming Pool Motor Market Size

Input/Calculation	Variable	Value	Source
California 2012 In-Ground and Above-Ground Swimming Pools: New units	A	29,527	P.K. Data (2012)
California 2012 In-Ground and Above-Ground Swimming Pools: Existing Installed Base	B	1,848,484	P.K. Data (2012)
Pool Pump Effective Useful Life	C	10 years	SCE (2007), CASE Report
New and Replacement Pool Pump Motors: Annual Sales (all capacities)	D = A+B/C	214,375	Cadmus Calculation
Percent of Pool Pumps under 1HP	E	24%	Cadmus Calculation (Table 21)
New and Replacement Pool Pump Motors 1HP and greater: Annual Sales (Std 9 – Tier 2)	F = D × (1 − E)	163,000	Cadmus Calculation

*In-ground pools in California only

Std9 regulates pool pump motors of 1 HP or greater, so Cadmus used data from a KEMA market characterization report to calculate the fraction of pool pumps under 1 HP (E). This calculation is described in Table 21, which also summarizes the results Cadmus extracted from the KEMA pool pump characterization survey conducted in 2008. Referring back to Table 20, we used the fraction of pool pumps under 1HP (E) to determine the number of annual sales volume of motors 1 HP and greater (F), which corresponds to the Std9 market size.

The first part of Table 21 shows the fraction of single-speed and multispeed pumps installed according to different populations surveyed by KEMA. The fraction of pumps less than 1 HP provided by each survey population is shown in the table for single and multispeed pumps. We multiplied the percent of pool pumps under 1 HP for each speed by its market share (e.g., 86% single speed) and summed to determine the fraction of all pumps under 1HP.

Table 21. Market Share of Pool Pumps under 1HP for Single and Multispeed Pumps

	PG&E Participating Contractors/Retailers		PG&E General Population Contractors		PG&E Pool Owners		Weighted Average	All Pumps <1HP
	Value	N	Value	N	Value	N*		
Percent Single Speed	76%	19	76%	27	89%	117	86%	24%
Percent Multispeed	11%		10%		9%		14%	
Single-Speed Pool Pumps								
Percent of Pumps <1 HP	25%	18	43%	27	21%	86	26%	
Multispeed Pool Pumps								
Percent of Pumps <1 HP	3%	16	15%	27	13%	8	11%	

*Included only respondents providing an answer

Comparison with CASE Report

The CASE Report also provides an estimate for annual pool pump sales (all motor sizes) by determining replacement and new sales. The author combined data from the CEC (2000) on residential swimming pool saturation in California, the annual growth rate of pool pump sales, and data on measure life from DOE (2001), to determine annual sales and an annual growth rate. Since the CASE Report value was specific to 2006, Cadmus escalated the number using the growth rate provided in the CASE Report (H) to obtain a figure for 2012 (Variable I in Table 22). The CASE Report sales number is similar to the final value Cadmus calculated in Variable F (Table 20), although the CASE Report analysis does not include above-ground pools nor does it make adjustments for pump motors under 1 HP that are exempt from the standard.

Table 22. Calculation of Swimming Pool Motor Market Size using CASE Report Data

Input/Calculation	Variable	Value	Source
CASE Report Annual Sales in 2006*	G	142,700	CASE Report
CASE Report Growth Rate	H	1.7%	CASE Report
CASE Report Calculated Annual Sales in 2012 (all capacities)	I = G × (1 + H)6	157,888	Cadmus Calculation

Unit Energy Savings

The energy savings for Std9 arise from the use of pump motor controls. We used the following data sources:

- Pool Pump CASE Report, described previously
- 2009 California Statewide Residential Appliance Saturation Survey. KEMA. 2010.
- California Statewide Residential Appliance Saturation Survey. KEMA-Xenergy, Itron, and RopwerASW. June 2004.
- Performance and Energy Efficiency Evaluation of Residential Variable-Speed Pool Pumps, ET 04.12 Report, Southern California Edison, March 7, 2007.
- Process Evaluation of 2006-2008 PG&E Mass Markets Program Portfolio and CFL, Swimming Pool Market Characterizations. KEMA. 2009
- PG&E, Work Paper PGECOPUM102 Variable Speed Pool Pump Revision #1. 4/27/2009
- ENERGY STAR, Savings Calculator for ENERGY STAR Certified Inground Pool Pumps Version 1. December 2013. Accessed April 21, 2014 at: http://www.energystar.gov/buildings/sites/default/uploads/files/Pool%20Pump%20Calculator121113.xlsx?39cb-4448&39cb-4448

- Consortium for Energy Efficiency. CEE Efficient Residential Swimming Pool Initiative. Draft. June 2012.[30]
- Southern California E3 Calculator Data[31]
- Pentair Pool Pump Calculator: http://www.pentairpool.com/pool-pro/dealer-resources/calculators/commercial-pump-calc/standard.html (accessed October 2012)
- Hayward Pool Pump Calculator: http://www.haywardnet.com/inground/products/energysolutions/calculator.cfm (accessed October 2012)
- Personal communications with Pool Equipment Representatives: Cadmus wishes to acknowledge the helpful discussions and reference documents provided by Jeff Farlow of Pentair Pools, and an informative conversation with Scott Petty of Hayward Pools.
- InDEE DEER Analysis 2007. Pentair for SCE.
- Hunt, A., and S. Easley. "Measure Guideline: Replacing Single-Speed Pool Pumps with Variable Speed Pumps for Energy Savings."[32] Building America Retrofit Alliance for U.S. Department of Energy. May 2012.

Calculation of unit energy savings for the Tier 2 case requires determining the energy savings for both a two-speed pump and a variable-speed pump relative to the base case of a single-speed pump that meets the 2006 Tier 1 requirements.

The Hayward pool pump calculator enables the determination of pump kWh for a specified number of turnovers per day. The calculator data are based on System Curve C per California Title 20 Appliance Energy Regulations (T20).

The following input data were used based on common pool system characteristics mentioned in the SCE ET 04.12 or KEMA market characterization report, and confirmed with the Pentair representative:

- 1.5 HP pump
- 20,000-gallon pool
- Approximately one turnover per day

30 http://www.poolspamarketing.com/newsletter/20120712/CEE_Efficient_Residential_Swimming_Pool_Initiative_DRAFT.pdf

31 http://asset.sce.com/Regulatory/Energy%20Efficiency%20Filings/A0807021EE_PP_Core_Programs_RollUp.xls

32 http://www.nrel.gov/docs/fy12osti/54242.pdf

The ENERGY STAR calculator and PG&E pool pump work paper indicate pumps are operated year-round. The output data resulting from the online calculator (number of turnovers per day and run time per day) and subsequent analysis described below are shown in Table 23.

Table 23. Results from Pool Pump Calculators and Analysis

Pump Type	Number Turnovers per Day	Run Time per Day (hours)	Energy Consumption (kWh/yr)	Peak Demand (Calculated; kW)
One-Speed (Tier 1)	1.3	5	3,522*	1.93× 0.15=0.29**
Two-Speed (Tier 2)	1	5.8	1,836	Full Speed 1.93×0.15=0.29 Half Speed 0.29×1/7=0.058 Overall 0.226
Variable Speed (Tier 2)	1	12.5	954	0.206×0.15=0.03**

* One speed energy consumption has been adjusted downward by 7.5% to approximate a T20 Tier 1 compliant pool pump

** Calculated: kW = kWh/(annual run hours) × 0.15 (peak coincidence); see discussion below.

Cadmus communicated with representatives from Hayward and Pentair, who both said that the one-speed results from the calculators are for a standard pump, not one meeting the California T20 Tier 1 requirement. The consensus was the difference in performance between the standard pump and a Tier 1 compliant pump is in the range of 5% to 10%; therefore, Cadmus adjusted the Hayward one-speed pump energy consumption by 7.5%. This is reflected in the kWh value in Table 23. The pool pump unit energy consumption (UEC) listed in the RASS 2009 is 3,502 kWh for the installed base, which indicates that the consumption for the Tier 1 one-speed pool pump from the calculator is within a reasonable range, although slightly high. The CEE 2012 report estimates that a high-efficiency single-speed pump consumes 3,300 kWh/year. In contrast, the CASE Report, published in 2004, indicates a baseline pool pump UEC estimate of 2,600 kWh, consistent with the RASS 2004 value.

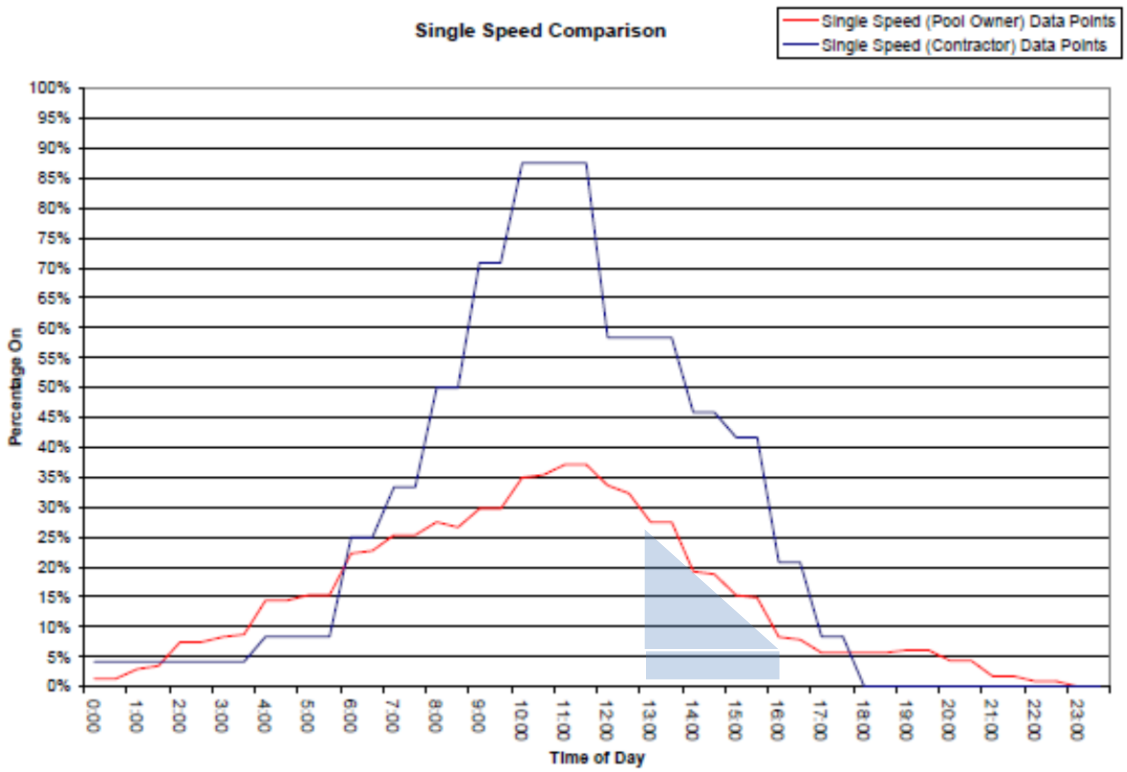
Peak Demand Savings

The DEER 2013 Codes and Standards Update states the peak demand occurs between 2:00pm and 5:00pm. Using the results from the pool owners survey[33] in Figure 30, we calculate the fraction of pool pumps that are on during the 2pm-5pm time period to be 15% if we average the endpoints (shaded area between 2PM and 5PM).

$$Peak\ Coincidence = \frac{1}{2}(25\% + 5\%) = 15\%$$

[33] Cadmus chose to use the pool owner data because the owners have direct knowledge of pool pump operation and because the average is based on a larger, statistically significant sample.

Figure 30. Percent of Single-Speed Pool Pumps Operating by Hours as Estimated by Pool Contractors and Pool Owners*



Note: 229 pool owners and 23 contractors provided hours of operation estimates.

*KEMA Market Characterization Report

To obtain the peak demand savings, we assumed that pool pumps have a 15% average peak coincidence factor, which is multiplied by the energy consumption divided by the annual run time. For the two-speed pump, we assumed the full-speed demand is the same as that for the single-speed pump. We calculated the low-speed demand based on information from the SCE report, which outlines pump affinity laws. The affinity laws state that the change in pump demand (kW) as a function of rpm (or flow rate) is proportional to the cube of the ratio of the new motor rpm and the old motor rpm. Thus, the theoretical demand at half-speed in a two-speed pump would be 1/8 the full-speed demand. However, the SCE report quotes from the 2004-2005 Database for Energy Efficiency Resources (DEER) report that "in practice the demand is actually 1/5 of the full speed power." In contrast, the Pentair representative said that, for a well-designed pool operating on or near Curve C, a ratio of 1/7 would provide a good estimate of the demand. Using data from Cadmus' work on the ENERGY STAR pool pump calculator, we find that the ratio varies for different pump sizes, but for the most common pump sizes (1-2 HP), the ENERGY STAR calculator uses a ratio of 1/5. Cadmus estimated the demand at half-speed as 0.058 kW. The kW for full-speed and half-speed are shown in Table 23.

To determine a weighted average peak kW for the two-speed pump, the operating hours at each speed must be found. We assume the flow rate, at full speed, is equal to the flow rate of a one speed pump with a turnover time of five hours. The Pentair calculator shows this figure to be 66.7 gallons per minute (gpm). At half speed, the flow rate would roughly be 33.4 gpm. The operating hours at each speed can now be obtained from the following two equations, with H1 the operating hours at full speed and H2 the operating hours at half speed:

H1*66.7 gpm*60 min/hr + H2*33.4 gpm*60 min/hr = 20,000 gal

H1 + H2 = 5.8 hours (total run time for two speed pump per Table 23)

Solving these two equations yields:

H1 = 4.2 hr at full speed

H2 = 1.6 hr at half speed

The weighted average peak kW is then:

(4.2 hours *0.29 kW + 1.6 hours *0.058 kW) / 5.8 hours = 0.226 kW, shown in Table 23.

Estimating the performance of a variable-speed pump requires making assumptions about its operation. A discussion with the Pentair pool representative led to the following analysis:

Assume two hours of operation per day at 60 gpm; then a flow rate of 20 gpm until one turnover is achieved. This results in 10.67 hours per day at low speed and two hours at high speed. The Pentair calculator determines the demand at 60 gpm is 0.67 kW and the demand at 20 gpm is 0.120 kW. This results in an energy use of 954 kWh per year. The weighted average peak kW, as shown in Table 23, is:

(0.67 kWhigh*2 hourshigh + 0.12 kWlow*10.67 hourslow)/12.67 hourstotal × 0.15 (average coincidence) = 0.03 kW/unit

The unit energy and demand savings obtained by using a two-speed pump or variable speed pump rather than a high-efficiency single-speed pump are shown in Table 24.

Cadmus estimated the weighted average unit energy and demand savings using estimates of the number of two-speed and variable speed pumps purchased. Cadmus interviewed retailers, discussed further in the appliance compliance section, and found 43% of multispeed pumps sold were variable speed while 57% were two-speed. Accordingly, the weighted average unit energy and demand savings are 2,065 kWh per year and 0.15 kW. The comparison of two-speed and variable-speed pump savings with other values in the literature show that the results, obtained using data from the Hayward online calculator, are within the expected range for energy savings. Demand savings, however, are much lower than that indicated in the literature since it appears the general literature assumes pumps are all operated during the peak period.

Table 24. Unit Savings Relative to Single-Speed Tier 1 Pool Pump

Pump Type	Energy Savings (kWh/yr)*	Peak Demand Savings (kW)*	Percent Energy Savings Over 1-Speed Pump	Literature Comparison Value(s)	Source
Two-Speed	1,686	0.29 – 0.226 = 0.064	48%	2,037 kWh	CEE 2012
				1,699 kWh; 0.52 kW	SCE E3 calculator
				1,040 kWh 71-73% demand savings	CASE Report
				1,400 kWh; 0.54 kW	InDEE DEER Analysis
Variable Speed	2,568	0.29 – 0.03 = 0.26	73%	34% to 50% energy savings	SCE ET Report
				3,796 kWh	DOE 2012
				3,086 kWh	CEE 2012
				1,950 kWh; 1.61 kW	InDEE DEER Analysis
Weighted Average	2,065	0.148	59%		

* Determined from energy consumption values in Table 23

Potential Energy Savings

Table 25 summarizes the evaluated potential energy and demand savings for Std9 compared to results from the CASE Report and original IOU estimated values.

Table 25. California Annual Energy Savings

Value	Evaluated	CASE Report (Two-Speed Pump)	Original IOU Estimate
Units per Year	163,000	142,700	142,700
Unit Energy Savings (kWh)	2,065	1,040	725.16
Unit Demand Savings (kW)	0.15	Not available	0.1675
First Year Potential Energy Savings (GWh)	337	1,000*	103.5
First Year Potential Demand Savings (MW)	24.2	Not available	23.9

*Value listed in CASE Report for compliance via two speed pumps, no calculation provided; the calculated value from multiplying units per year by unit energy savings is 148 GWh.

F.2.3 Appliance Compliance – Tier 2

We assessed the market compliance rate of Standard 9 through surveys with pool supply retailers during the third quarter of 2012. The survey questions are provided at the end of this section. We obtained 15 completed survey responses across the three main regions of California, as shown in Table 26.

Table 26. Completed Surveys of Pool Supply Retailers

Region	Number
North	6
Central	5
South	4
Total	15

The retailers surveyed each sold an average of 100 pool pumps or motors in 2011. Approximately half (seven) of the retailers mentioned California regulations, unprompted, during the course of the survey regarding restrictions on sales of single-speed pumps. Of retailers providing a response, they estimate the majority of their inventory (over 50%) was manufactured within the past two years, and nearly all was manufactured within the past four years.

A number of retailers estimated that customers ask for energy-efficient products between 10% and 75% of the time, and two of these retailers said this was becoming a more frequent customer concern. Three retailers say they usually initiate the discussion about energy efficiency with all their pool pump customers.

Table 27 shows the values used in calculating the compliance rate. All responses were weighted based on each retailer's sales.

Table 27. Pool Pump Compliance Calculation

Property		Sales Weighted Value
Fraction of Single Speed Pumps/Motors	A	10%
Fraction of Two Speed Pumps		51%
Fraction of Variable Speed Pumps		38%
Fraction of Multiple Speed Pumps Sold with Controls	B	96%
Compliance Rate	(1-A)*B	86%

First, we determined what fraction of units sold by the retailers interviewed were single-speed pumps or motors. Seven retailers did not sell any single-speed pumps or motors; eight said they only sold single-speed motors for replacement applications. More sold two-speed pumps than variable-speed pumps sold because the two-speed pumps are lower cost. However, many retailers said they encouraged customers to purchase a variable-speed pump because of higher quality.

Next, we calculated the sales weighted fraction of multispeed pumps sold with controls. Putting together these two factors, we calculated the compliance rate to be approximately 86%.

F.2.4 Pool Pump Retailer Questions

1. Do you sell pumps with motors that are 1 HP or greater?
2. What percent of the pool pumps you sell have single-speed motors?

   Specify percent

3. What percent of the pool pumps you sell are capable of operating at two speeds? What about variable speeds?

   Specify percent

4. What percent of the multispeed pool pumps you sell come with motor speed controls?

   Specify percent

5. If greater than 0%, ask: Do the controls have a high-speed override capability?
6. Do you install the pool pumps that you sell?

   If yes: Do you set the pool pump speed and control settings for the customer?

   Probe: At what setting do you most commonly put it?

7. How often do customers ask for an energy-efficient pool pump?
8. How many pool pumps did you sell to customers in 2011?
9. What are you best-selling pool pump models?
10. When was most of your inventory manufactured?

F.3 Standards 11b/25/26/27 – General Service Incandescent Lamps

F.3.1 Introduction and Summary of Findings

This memo describes Cadmus' evaluation of the appliance compliance rate and potential energy savings for California Title 20 standards regulating general service incandescent lamps: Standard 11b (Std 11b), Std 25, Std 26, and Std 27. General Service Incandescent Lamps are regulated under section 1605.3(k) parts (1) and (3) of California's December 2010 Appliance Efficiency Regulations.[34] Each of the standards listed above corresponds to a different part of these regulations.

Table 28 summarizes the scope of work covered in this document, which includes assessing compliance and potential savings for all standards except for Std 27, which takes effect in January 2013 and results in no savings for the 2010-2012 evaluation period. For Std 27, we assess

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[34] December 2010 Appliance Efficiency Regulations. CEC-400-2010-012,.Sec 1602(v), Pg. 149. Available at http://www.energy.ca.gov/appliances/2010regulations/index.html

the market compliance rate at a point in time prior to the standard taking effect, which is an alternative measurement of naturally occurring market adoption. We also forecast potential savings for Std 27.

Table 28. 2010-2012 C&S Evaluation Scope for Compliance and Potential Savings

Standard	Effective Date	Compliance	Potential Savings
11b	January 1, 2008	✓	✓
25	January 1, 2011	✓	✓
26	January 1, 2012	✓	✓
27	January 1, 2013	Pre-Standard Compliance Only	Preliminary

Although Section 1605.3(k)(3)(A) of the appliance regulations indicates Standards 25 through 27 also apply to any general service lamp, "whether incandescent or not," a discussion with CEC staff regarding the scope of Std 25–Std 27 resulted in the following findings:

- An issue with the LED test procedures means general purpose LED lamps cannot be regulated until it is resolved
- Most CFLs are regulated by federal standards and would not be considered state-regulated (Table K-3 in the 2010 appliance efficiency regulations)
- For the purposes of the evaluation, we should focus on incandescent lamps (normal and modified spectrum)

In general, state regulated general service incandescent lamps have a medium screw base and are intended for general service applications.[35] The appliance standards vary in effective dates, efficiency requirements, regulated lumen ranges, and spectrum type. Table 29 summarizes the requirements and effective dates for Std 11b, and Std 25 through Std 27 applying to standard spectrum general service incandescent lamps.

Table 30 summarizes the requirements for modified spectrum incandescent lamps. Rows containing information about Std 27 are in grey to denote that it is not officially a part of the scope of this evaluation.

[35] Refer to the 2010 Appliance Efficiency Regulations for official definitions.

Table 29. Standards for Standard Spectrum General Service Incandescent Lamps

Standard	Effective Date	Rated Lumen Range	Maximum Rated Wattage	Minimum Rated Lifetime (Hours)
11b	January 1, 2008	All	See Table 31	N/A
25	January 1, 2011	1490-2600	72	1,000
26	January 1, 2012	1050-1489	53	1,000
27	January 1, 2013	750-1049	43	1,000
		310-749	29	1,000

Table 30. Standards for Modified Spectrum General Service Incandescent Lamps

Standard	Effective Date	Rated Lumen Range	Maximum Rated Wattage	Minimum Rated Lifetime (Hours)
11b	January 1, 2008	All	See Table 31	N/A
25	January 1, 2011	1118-1950	72	1,000
26	January 1, 2012	788-1117	53	1,000
27	January 1, 2013	563-787	43	1,000
		232-562	29	1,000

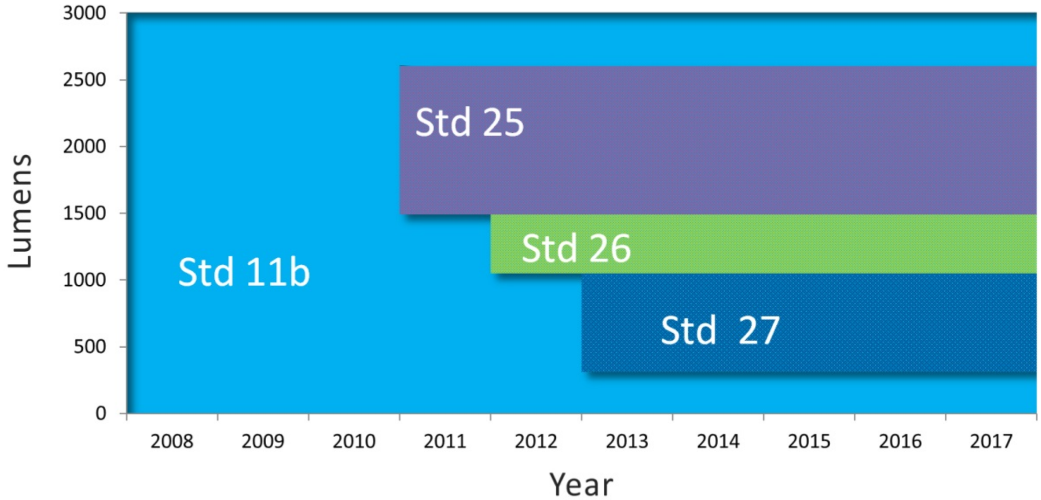
Table 31 shows the requirements that took effect in 2008 under Std 11b.

Table 31. Standards for State-Regulated General Service Incandescent Lamps

Frost or Clear		Soft White	
Lumens (L)	Maximum Power Use (watts)	Lumens (L)	Maximum Power Use (watts)
L < 340	(0.05 * Lumens) + 21	L < 310	(0.05 * Lumens) + 22.5
340 ≤ L < 562	38	310 ≤ L < 514	38
562 ≤ L < 610	(0.24 * Lumens) – 97	514 ≤ L < 562	(0.22 * Lumens) – 75
610 ≤ L < 760	(0.05 * Lumens) + 19	562 ≤ L < 730	(0.05 * Lumens) + 20.5
760 ≤ L < 950	57	730 ≤ L < 909	57
950 ≤ L < 1013	(0.20 * Lumens) – 133	909 ≤ L < 963	(0.22 * Lumens) – 143
1013 ≤ L < 1040	(0.05 * Lumens) + 19	963 ≤ L < 1010	(0.05 * Lumens) + 20.5
1040 ≤ L < 1300	71	1010 ≤ L < 1250	71
1300 ≤ L < 1359	(0.27 * Lumens) – 280	1250 ≤ L < 1310	(0.25 * Lumens) – 241.5
1359 ≤ L < 1520	(0.05 * Lumens) + 19	1310 ≤ L < 1490	(0.05 * Lumens) + 20.5
1520 ≤ L < 1850	95	1490 ≤ L < 1800	95
1850 ≤ L < 1900	(0.42 * Lumens) - 682	1800 ≤ L < 1850	(0.40 * Lumens) – 625
L ≥ 1900	(0.05 * Lumens) + 21	L ≥ 1850	(0.05 * Lumens) + 22.5

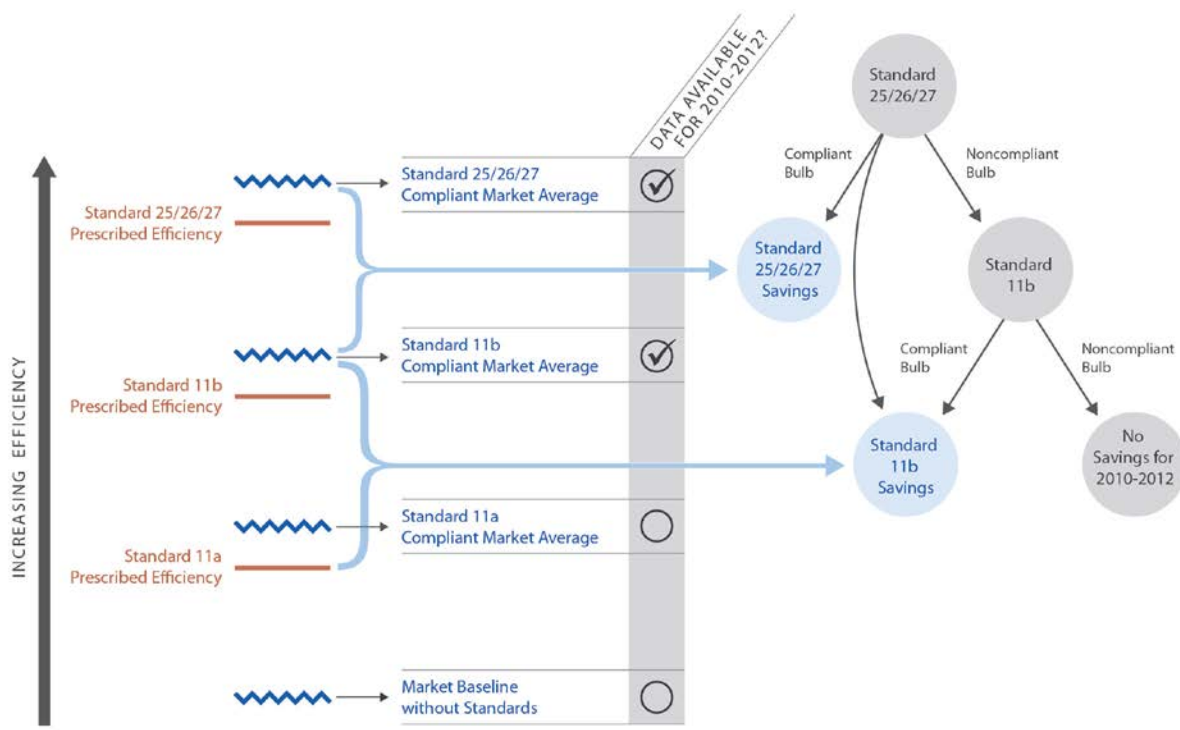
Figure 31 shows which standard applies to a given lumen range and time period for standard spectrum lamps, and also indicates where overlaps in the standards occur. Modified spectrum lamps follow a similar pattern with slight differences to the regulated lumen range.

Figure 31. Timing and Lumen Ranges of Standards Regulating General Service Incandescent Lamps (Standard Spectrum)



The integrated standards savings model (ISSM) calculates net savings on a per standard basis, thus we developed an approach to allocate savings to each standard. Figure 32 illustrates how we define the savings for each standard.

Figure 32. General Service Incandescent Lamp Standards Savings Allocation Model



The left part of the figure shows the relative efficiency of each standard from Standard 11a through Standards 25/26/27. The baseline for Standards 25/26/27 is Std 11b, while the baseline for Std 11b is Std 11a. The prescribed efficiency level is marked using red text and a red bar. If we assume it is possible for some products in the market to be more efficient than required, then the market average efficiency level of compliant products could be slightly higher than that prescribed by the standard. Thus, we use the market average efficiency level to calculate energy savings, when data are available, rather than the prescribed efficiency level. The right side of the figure shows how savings are allocated in our approach. Bulbs that comply with Standards 25/26/27 contribute to savings for those standards, as well as savings for Std 11b. Bulbs not compliant with Standards 25/26/27 are assessed for compliance with Std 11b. If it is found to be compliant, it contributes to savings for Std 11b.

Table 32, Table 33, and Table 34 summarize the evaluation results for Std 11b, Std 25 and Std 26, and Std 27. As shown in Figure 31, Std 11b was in effect during the entire 2010-2012 program cycle, and we present results for each year since the market size decreased during this time period. Std 25 was in effect during 2011 and 2012, and Std 26 was only in effect during 2012. Std 27 was not in effect at all during 2010-2012. The original IOU estimates are included in these tables for comparison.

Table 32. Evaluation Results for Std 11b

Item	Evaluation Result 2010	Evaluation Result 2011	Evaluation Result 2012	Original IOU Estimate*
Units per Year (millions)	80.22	65.85	54.39	74.3
Unit Energy Savings (kWh/yr)	2.61	2.61	2.57	3.42
Unit Demand Savings (W)	0.36	0.36	0.36	0.42
First Year Potential Energy Savings (GWh)	209.65	172.11	139.83	254.5
First Year Potential Demand Savings (MW)	28.98	23.79	19.33	31.4
Compliance Rate	72%	72%	87%	49%

* Estimates provided by the California IOUs on May 13, 2011, in response to EEGA data request 1465, 1466, 1467, and 1468.

Table 33. Evaluation Results for Std 25 and Std 26

Item	Evaluation Result Std 25 2011	Evaluation Result Std 25 2012	Original IOU Estimate Std 25*	Evaluation Result Std 26 2012	Original IOU Estimate Std 26*
Units per Year (millions)	12.22	10.07	0.2545	11.61	0.2301
Unit Energy Savings (kWh/yr)	14.85	12.60	1000	10.79	1000
Unit Demand Savings (W)	2.05	1.74	70	1.49	70
First Year Potential Energy Savings (GWh)	181.49	126.87	255	125.25	230
First Year Potential Demand Savings (MW)	25.09	17.54	18	17.32	16
Compliance Rate	36%	88%	85%	40%	85%

* Estimates provided by the California IOUs on May 13, 2011 in response to EEGA data request 1465, 1466, 1467, and 1468. The IOU response and subsequent discussions indicated the unit savings submitted were arbitrarily set to 1,000 kWh and the number of units were back calculated based on the IOUs' estimate of total savings. No further documentation was provided.

Table 34. Evaluation Results for Std 27 (Pre-Effective Date)

Item	Evaluation Result 2012	Original IOU Estimate*
Units per Year (millions)	32.24	0.442
Unit Energy Savings (kWh)	9.08	1000
Unit Demand Savings (W)	1.25	70
First Year Potential Energy Savings (GWh)	283.56	441.83
First Year Potential Demand Savings (MW)	39.07	30.93
Compliance Rate	11%	85%

* Estimates provided by the California IOUs on May 13, 2011 in response to EEGA data request 1465, 1466, 1467, and 1468. The IOU response and subsequent discussions indicated the unit savings submitted were arbitrarily set to 1,000 kWh and the number of units were back calculated based on the IOUs' estimate of total savings. No further documentation was provided.

The following sections describe our approach and findings for each component listed in Table 32 through Table 34.

F.3.2 Market Size

Data Sources

Cadmus used the following sources of information to estimate the annual sales of general purpose incandescent lamps by spectrum type, lumen range, and year:

- 2008 CASE Report: Energy Solutions and Ecos Consulting. Analysis of Standards Options for General Service Incandescent Lamps. Prepared for Pacific Gas & Electric. May 2008.
- Cadmus obtained custom queries from DNV KEMA from their WO13 and WO28 shelf study databases.

- Swope, Toby (2010). —The Present and Possible Future CFL Market. Accessed August 21, 2013: https://neep.org/Assets/uploads/files/events/Residential-Lighting-Workshop/2010-NEEP-Lighting-Swope.pdf
- U.S. Energy Information Administration (EIA), Annual Energy Outlook 2011. http://www.eia.gov/todayinenergy/detail.cfm?id=630 Accessed August 21, 2013
- Freedonia. Industry Study #2771 Lamps to 2015. August 2011.[36] (Purchased; report is not available publicly).

California Lamp Purchases/Sales in 2010

Cadmus obtained the 2010 sales/purchases of incandescent bulbs through three sources: the EIA, Freedonia, and Swope. These sources provide data at the national level and two of these sources also provide projections of sales into the future, in five-year increments.

To derive California's share of these sales, Cadmus considered two different approaches. The first approach was to use the ratio of California's population to the nation's population as a scaling factor. These proportions typically range from 10.8% to 12.1%, depending on whether household or population proportions are used. The second approach is to use actual sales proportions, which we thought would be better, but such data are hard to find in the available literature. We did find one report, the California Lamp Report from 2001,[37] which provided actual California bulb sales proportions to national sales. This proportion was slightly under 7%. Considering California's long history of efforts to transform the lighting market towards more efficient lights, which happen to have longer lifetimes than incandescents, we believe the value of ~7% is reasonable. We have applied the California sales proportion to all of the national sales/purchase estimates we found through Freedonia, Swope, and EIA. Results are shown in Table 35.

Table 35. 2010 California Sales of Incandescent Light Bulbs

Source	2010 National Sales (millions)	2010 California Sales (millions)
EIA	1,070	72.7
Freedonia	1,090	74.1
Swope	1,380	93.8

Purchases for 2011 and 2012

Information from the three data sources covered in Table 35 suggests the market for incandescent lamps is shrinking over time. In addition, Standards 25 through 27 take effect in different years, so the change in the market size will affect the first year savings. Thus we

36 http://www.freedoniagroup.com/DocumentDetails.aspx?DocumentId=554974

37 California Lamp Report, Fields et. al, Regional Economic Research, 2001

derived sales for 2011 and 2012. We substituted the Swope sales data, which covered up to 2010, with information from the CASE Report, which projected the annual unit sales for the 2011-2013 period in California.

Cadmus used a constant annual growth rate (CAGR) calculation to determine the 2011 and 2012 values from the EIA and Freedonia sources, interpolating between 2010 (start year) and 2015 (end year). The equation for the CAGR is ((End Year Sales/Start Year Sales)^(1/(Periods-1))-1). Table 36 shows the results by year.

Table 36. 2011-2012 California Sales of Incandescent Light Bulbs

Source	2011California Sales (millions)	2012 California Sales (millions)
EIA	57.4	44.6
Freedonia	83.9	59.1
CASE Report	56.2	56.2

Sales by Spectrum Type and Lumen Range

The 2008 CASE Report used a 75%-25% split between Normal (or Standard) Spectrum and Modified Spectrum lamp sales. The same CASE Report provided the distribution of sales by lumen bin, as shown in Table 37, based on the authors' analysis of various data sources. We applied the same lumen and spectrum distributions to the data from our other sources to derive the final market size values.

Table 37. Distribution of Sales by Lumen Range

Standard Spectrum Lumen Ranges	Modified Spectrum Lumen Ranges	Percentage Distribution by Lumen Range from CASE Report
310 to 749	232-562	13%
750 to 1049	563-787	46%
1050 to 1489	788-1117	22%
1490 to 2600	1118-1950	19%

Results and Comparison with CASE Report Values

Combining all the information above, we obtain the final results of the market size analysis. The values used in our potential energy savings estimate are an average of the first three sources.

Table 38 shows results for 2010. Since we only consider Standard 11b in 2010, results are not provided by lumen range or spectrum type. The projected values in the CASE Report for 2011-2013 are much lower than those Cadmus derived from other sources.

Table 38. 2010 Annual Sales to California (Millions)

Lumen Range	Swope* [1]	US EIA [2]	Freedonia [3]	Average of 1 to 3	CASE Report (2011-2013 Sales Projection)
All	93.8	72.7	74.1	80.2	55.1

* Swope value only for 2010

Table 39 summarizes results by spectrum type and lumen range for 2011 sales in California. The values from the CASE Report agree reasonably well with the EIA values, and the difference between the CASE Report values and values from other sources is smaller in 2011 than it was in 2010.

Table 39. 2011 Annual Sales to California (Millions)

Lumen Range	CASE Report [1]	US EIA [2]	Freedonia [3]	Average of [1] to [3]
Standard Spectrum Lamps				
1490-2600	7.9	8.0	12.4	9.4
1050-1489	9	9.3	14.3	10.9
750-1049	19	19.4	30.0	22.8
310-749	5.4	5.5	8.5	6.5
Above 2600*	0.4	0.4	0.8	0.5
Below 310*	0.8	0.8	1.6	1.1
Total	42.5	43.4	67.6	51.2
Modified Spectrum Lamps				
1118-1950	2.6	2.7	3.1	2.8
788-1117	3.0	3.1	3.6	3.2
563-787	6.3	6.5	7.5	6.8
232-562	1.8	1.8	2.1	1.9
Above 1950*	0.0*	0.0	0.0	0.0
Below 232*	0.0*	0.0	0.0	0.0
Total	13.7	14.0	16.3	14.7
Grand Total	56	57	84	66

*Allocation derived from DNV KEMA shelf survey data

Table 40 summarizes results by spectrum type and lumen range for 2012 sales in California.

Table 40. 2012 Annual Sales to California (Millions)

Lumen Range	CASE Report [1]	US EIA [2]	Freedonia [3]	Average of [1] to [3]
Standard Spectrum Lamps				
1490-2600	7.9	6.4	8.4	7.6
1050-1489	9	7.4	9.8	8.7
750-1049	19	15.4	20.4	18.3
310-749	5.4	4.4	5.8	5.2
Above 2600*	0.4	0.3	0.7	0.5
Below 310*	0.8	0.7	1.5	1.0
Total	42.5	33.5	44.3	41.2
Modified Spectrum Lamps				
1118-1950	2.6	2.1	2.8	2.5
788-1117	3.0	2.5	3.3	2.9
563-787	6.3	5.1	6.8	6.1
232-562	1.8	1.5	1.9	1.7
Above 1950*	0.0*	0.0	0.0	0.0
Below 232*	0.0*	0.0	0.0	0.0
Total	13.7	11.2	14.8	13.2
Grand Total	56	45	59	54

*Allocation derived from DNV KEMA shelf survey data

F.3.3 Potential Energy Savings and Compliance

Data Sources and Methodology

Cadmus used the following data sources to calculate unit energy and demand savings, and compliance rates for Standards 11b, 25, and 26. We also calculated the pre-effective date market compliance rate and projected savings for Std 27 as a baseline for future evaluation studies.

Cadmus obtained custom queries from DNV KEMA from their WO13 and WO28 shelf study databases. WO13 was a retail store shelf survey conducted by DNV KEMA staff between September and November 2011. WO28 was a shelf survey conducted by DNV KEMA staff in August and September 2012.

- Hours of use (HOU) – 2.2 hours per day, obtained from DEER 2008 update page 15
- Coincidence factor (CF) – 0.11, derived from DEER 2008 data

Compliance

During the shelf surveys, DNV KEMA staff visited retailers across California and gathered information about the number of light bulbs stocked on shelves, their wattages, color, spectrum, lumens, and bulb shapes. These surveys were conducted in two waves, about one year apart, and provided snapshots of the market at different points in time as different standards went into effect. In response to a data request from Cadmus, DNV KEMA summarized their shelf survey data by work order (or year) and spectrum type. They provided the number of bulbs observed, the number of lamps compliant with Standards 25-27, number of non-compliant bulbs, bulbs with insufficient information to determine compliance, and the average wattage of compliant and non-compliant bulbs.

In order to attribute potential savings appropriately where overlap between standards occurs, Cadmus instructed DNV KEMA to provide separate summary tables based on the compliance criteria for Standard 11b. Tables summarizing WO13 (2011) excluded bulbs compliant with Standard 25 so that the market average wattages for bulbs compliant with just Std 11b could be determined (refer to Figure 32). Bulbs compliant with Standards 25 or 26 were excluded from the WO 28 (2012) data tables for the same reason.

Cadmus calculated compliance rates for each standard and year by lumen range and spectrum type directly from the DNV KEMA shelf survey summary tables. We then computed an average compliance rate, weighted by potential savings, for each standard and year the standard was in effect.

Unit Energy Savings

Cadmus calculated the unit energy and demand savings for bulbs in each lumen range and spectrum type using the following equations:

$$kWh/yr = (Watts_{baseline} - Watts_{compliant}) * HOU * (365\ days/yr)/(1000\ watt \cdot hr/kWh)$$

$$kW = (Watts_{baseline} - Watts_{compliant}) * CF /(1000\ W/kW)$$

Standard 11b

Cadmus used the market average wattages of bulbs compliant with Standard 11b, excluding those compliant with Standards 25 through 27, to compute the unit energy savings attributable to Standard 11b relative to Standard 11a. In this way, the incremental savings of standards effective after Standard 11b can be attributed directly to those more stringent standards. We assumed Standard 11b compliant bulbs used 5% less energy than those that complied with Standard 11a.[38]

Note, in contrast to the approach used to derive average unit energy savings, bulbs compliant with Standards 25-27 were included in the calculation of compliance rates for Standard 11b since compliance with the more stringent standards would automatically mean the bulbs comply with Standard 11b and contribute savings to Standard 11b, as per Figure 31.

Standard 25/26/27

We used the average wattage of bulbs compliant with Standard 11b as the baseline for determining energy savings for Standards 25, 26, and 27.

38 2010 Appliance Efficiency Regulations, Table K-7

Potential Energy and Demand Savings

Cadmus calculated potential energy savings for bulbs in each lumen range and spectrum type by multiplying the unit savings by the market size (in millions) to obtain GWh and GW savings. Table 41 shows the detailed results of the analysis for Standard 11b in 2011.

Table 41. Standard 11b –Potential Savings by Lumen Range and Spectrum for 2011

Lumen Range	Avg. Wattage of Compliant Bulbs	Avg. Baseline Wattage	Unit Energy (kWh/yr)	Unit Demand (kW)	Market Size (millions)	Potential Energy Savings (GWh)	Potential Demand Savings, (GW)
Standard Spectrum							
1490-2600	95.27	100.28	3.99	0.0006	9.43	37.63	0.005
1050-1489	71.53	75.29	3.00	0.0004	10.87	32.56	0.005
750-1049	57.43	60.45	2.41	0.0003	22.79	54.81	0.008
310-749	45.18	47.56	1.89	0.0003	6.45	12.21	0.002
Above 2600	150.00	157.89	6.28	0.0009	0.54	3.42	0.000
Below 310	25.00	26.32	1.05	0.0001	1.09	1.14	0.000
Modified Spectrum							
1118-1950	75.00	78.95	3.14	0.0004	2.79	8.76	0.001
788-1117	53.00	55.79	2.22	0.0003	3.22	7.16	0.001
563-787	42.81	45.06	1.79	0.0002	6.75	12.11	0.002
232-562	29.00	30.53	1.21	0.0002	1.91	2.33	0.000
Above 1950	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Below 232	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Table 42 shows the results of the analysis for Standards 25/26/27 in 2011.

Table 42. Standard 25/26/27 –Potential Savings by Lumen Range and Spectrum for 2011

Standard	Lumen Range	Avg. Wattage of Compliant Bulbs	Avg. Baseline Wattage	Unit Energy (kWh/yr)	Unit Demand (kW)	Market Size (millions)	Potential Energy Savings (GWh)	Potential Demand Savings (GW)
Standard Spectrum								
25	1490-2600	71.97	95.27	18.54	0.0026	9.43	174.84	0.024
26	1050-1489	52.82	71.53	14.89	0.0021	10.87	161.83	0.022
27	750-1049	42.95	57.43	11.52	0.0016	22.79	262.57	0.036
27	310-749	28.57	45.18	13.22	0.0018	6.45	85.25	0.012
Modified Spectrum								
25	1118-1950	72.00	75.00	2.39	0.0003	2.79	6.66	0.001
26	788-1117	53.00	53.00	-	-	3.22	-	-
27	563-787	43.00	42.81	-	-	6.75	-	-
27	232-562	29.00	29.00	-	-	1.91	-	-

* Cells in grey indicate standard is not in effect in 2011

Cadmus summed the total annual potential energy and demand savings across both spectrum types to get the total potential savings. We then divided the total savings by the number of bulbs (market size) to compute the sales weighted average unit energy and demand savings across all lumen ranges and spectrum types.

Evaluation Results

Table 43 presents the annual results for Standard 11b for 2010 through 2012.

Table 44 and Table 45 show the results for Standards 25, 26, and 27 for 2011 and 2012.

While compliance rates show an upward trend over time, the market size over the three-year period decreases.

Table 43. Standard 11b Potential Savings by Year

Year	Total Market Size (millions)	Total Potential Energy Savings (GWh)	Total Potential Demand Savings (MW)	Unit Energy Savings (kWh/yr)	2011 Unit Demand Savings (kW)	Compliance Rate
2010	80.22	209.65*	28.98*	2.61	0.00036	72%
2011	65.85	172.11	23.79	2.61	0.00036	72%
2012	54.39	139.83	19.33	2.57	0.00036	87%

* Because Cadmus did not have data other than market size for 2010, we used the compliance rate computed for 2011 as our result for 2010. We also estimated the 2010 potential by multiplying the 2011 unit energy savings times the 2010 market size.

Table 44. Standard 25/26/27 Potential Savings for 2011

Standard	Total Market Size (millions)	Total Potential Energy Savings (GWh)	Total Potential Demand Savings (MW)	Unit Energy Savings (kWh/yr)	Unit Demand Savings (kW)	Compliance Rate
Std25	12.22	181.49	25.09	14.85	0.00205	36%
Std26	14.10	161.83	22.37	11.48	0.00159	11%
Std27	37.91	347.83	47.94	9.18	0.00126	17%

* Cells in grey indicate standard is not in effect in 2011

Table 45. Standard 25/26/27 Potential Savings for 2012

Standard	Total Market Size (millions)	Total Potential Energy Savings (GWh)	Total Potential Demand Savings (MW)	Unit Energy Savings (kWh/yr)	Unit Demand Savings (kW)	Compliance Rate
Std25	10.07	126.87	17.54	12.60	0.00174	88%
Std26	11.61	125.25	17.32	10.79	0.00149	40%
Std27	31.24	283.56	39.07	9.08	0.00125	11%

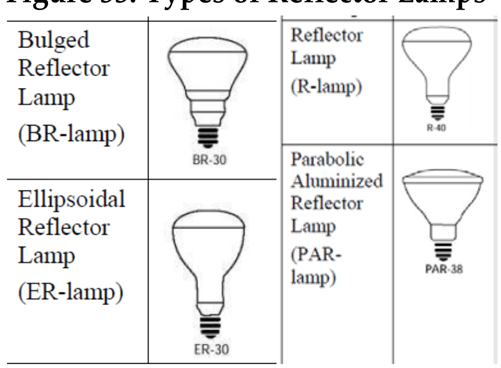
* Cells in grey indicate standard is not in effect in 2012

F.4 Standards 22a/22b/Federal 6 – Incandescent Reflector Lamps

This memo describes the Cadmus team's evaluation of the standards regulating incandescent reflector lamps (IRL): Standard 22a (Std 22a) residential, Standard 22b (Std 22b) commercial, and Fed6.

Section 1602 of the 2010 California Appliance Efficiency Regulations defines a state-regulated incandescent reflector lamp as "a lamp that is not colored or designed for rough or vibration service applications, that contains an inner reflective coating on the outer bulb to direct the light, a E26 medium screw base, that has a rated voltage or voltage range that lies at least partially within 115 to 130 volts, and that is either (1) BR or ER bulb shape with a diameter 2.25 inches or more; or (2) R, PAR, BR or similar bulb shape and which has a diameter of 2.25 to 2.75 inches." Figure 33 shows an illustration of each type of lamp.

Figure 33. Types of Reflector Lamps*



*From the Reflector Lamp CASE Report 2004

This standard, however, does not apply to these IRL lamps:

- IRLs rated at 50 watts or less that are ER30, BR30, BR40, or ER40 lamps
- IRLs rated at 65 watts that are BR30, BR40, or ER40 lamps
- R20 IRLs rated 45 watts or less

California Standards Std 22a and Std 22b require state-regulated IRLs that were manufactured on or after January 1, 2008, to meet the lumens-per-watt requirements in Table 46.[39]

Table 46. Standards for State-Regulated Incandescent Reflector Lamps

Rated Lamp Wattage	Minimum Average Lamp Efficacy (Lumens per Watt)
40-50	10.5
51-66	11.0
67-85	12.5
86-115	14.0
116-155	14.5
156-205	15.0

IRLs have been the subject of various federal and state energy efficiency standards since 1992.[40] In 2007, Congress passed the Energy Independence and Security Act (EISA), which expanded the types of bulbs subject to regulation starting in 2008, mirroring much of California's Title 20 regulations. From January 1, 2008 through June 16, 2008, Title 20 (T20) regulated many types of IRLs between 2.25 and 2.75 inches in diameter. EISA preempted Std 22a and Std 22b starting in June 2008. In 2009, the Department of Energy increased efficiency requirements for regulated bulbs, effective in 2012. Further information about the various IRL appliance standards can be found below.

The standards effective in 2012 were created through DOE rulemaking as opposed to Congressional action—and its requirements (shown in Table 47) apply to IRLs manufactured for sale in the United States or imported into the United States on or after July 14, 2012. In this report, we reference this standard as the Fed 6.

39 December 2010 Appliance Efficiency Regulations. CEC-400-2010-012,.Sec 1605.3(k)(2) Pg. 150. Available at http://www.energy.ca.gov/appliances/2010regulations/index.html

40 http://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/58

Table 47. Federal Energy Conservation Standards for Incandescent Reflector Lamps (Fed 6)

Lamp Wattage	Lamp Type	Diameter	Voltage	Minimum Lumens per Watt*
40W – 205 W	Standard Spectrum	>2.5	≥125	6.8×P0.27
			<125	5.9×P0.27
		≤2.5	≥125	5.7×P0.27
			<125	5.0×P0.27
40W – 205 W	Modified Spectrum	>2.5	≥125	5.8×P0.27
			<125	5.0×P0.27
		≤2.5	≥125	4.9×P0.27
			<125	4.2×P0.27

*P = rated lamp wattage, in watts

According to the Department of Energy's (DOE) Web page, "DOE has not exempted any states from this energy conservation standard." This indicates the Fed 6 standard preempts California's Title 20 for regulated IRLs starting in July 2012.

The federal standard regulates IRLs that are R, PAR, ER, BR, BPAR, or similar shape with an E26 medium screw base. Regulated bulbs have diameters that exceed 2.25 inches and have rated wattages of 40 watts or more. The same exceptions as those noted for California apply.[41]

F.4.1 Overview of Evaluation Results

Table 48 summarizes the results of our evaluation for Std 22a and Std 22b, comparing evaluated savings from state IRL standards to original IOU estimates. Evaluated compliance[42] for Std 22 was 81.7% with an unlisted compliance rate of 70.5% and a listed compliance rate of 11.2%. The majority of compliant bulbs were not listed in the CEC's list of approved products nearly four years after the standard took effect.

41 http://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/58

42 Our definition of compliance includes those products listed in the CEC's appliance database (listed compliance), as well as those that are not listed, but meet T20 energy consumption requirements based on the product's description (unlisted compliance).

Table 48. Evaluation Results for Std 22a and Std 22b

Item	Evaluation Result Std 22a	Original IOU Estimate Std 22a*	Evaluation Result Std 22b	Original IOU Estimate Std 22b*
Units per Year	1,688,793	81,100	113,902	158,200
Unit Energy Savings (kWh)	5.8	1,000	33.6	1,000
Unit Demand Savings (W)	1	124	7.8	134
First Year Potential Energy Savings (GWh)	9.9	81.10	3.8	158.2
First Year Potential Demand Savings (MW)	1.7	10.06	0.9	21.21
Compliance Rate	81.7%	85%	81.7%	85%

*Estimates provided by the California IOUs on May 13, 2011 in response to EEGA data request 1465, 1466, 1467, and 1468. Note that the IOUs indicated their unit energy savings were set to 1,000 kWh and units per year were back-calculated to produce first year energy savings corresponding to their claimed savings.

Table 49 summarizes the results of our evaluation for Fed 6, comparing evaluated savings from federal IRL standards to original IOU estimates.

Table 49. Evaluation Results for Fed 6 (2012)

Item	Evaluation Result	Original IOU Estimate
Units per Year	7,239,700	4,450,020
Unit Energy Savings (kWh)	7.1	1,000
Unit Demand Savings (W)	1.4	178
First Year Potential Energy Savings (GWh)	51.1	4,450
First Year Potential Demand Savings (MW)	10.4	794
Compliance Rate	6.9%	95%

F.4.2 Potential Energy Savings

As shown in the next equation, the ISSM model requires these two values to calculate annual potential energy savings: the number of IRLs purchased annually in California and the unit energy savings. Our analysis includes a discussion of each component.

$$\textit{Annual Potential Savings} = \#\,\textit{Units Purchased Annually} \times \textit{Unit Energy Savings}$$

Market Size

Cadmus used the following sources of information to estimate the size of the IRL market:

- Navigant Consulting for Department of Energy. U.S. Lighting Market Characterization. September 2002.[43]
- Itron Consulting. Reflector Results – U.S. and CA 2000 and 2002. 2003.[44]

43 http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/lmc_vol1_final.pdf

- American Council for an Energy-Efficient Economy, Energy Solutions. Analysis of Standards Options for BR, ER, and R20 Incandescent Lamps. April 28, 2004.[45] (Referred to as the CASE Report.)
- U.S. Department of Energy Building Technologies Program. Energy Conservation Standards for General Service Fluorescent Lamps and Incandescent Reflector Lamps ANOPR Public Meeting: National Impact Analysis. March 2008.[46]
- Navigant Consulting and Lighting Research Center for Department of Energy. Final Rule Technical Support Document: Energy Conservation Standards for General Service Fluorescent Lamps and Incandescent Reflector Lamps. July 2009.[47]
- Navigant Consulting for Department of Energy. 2010 U.S. Lighting Market Characterization. January 2012.[48]
- Freedonia. Industry Study #2771 Lamps to 2015. August 2011.[49] (Purchased; report is not available publicly).
- Census population data,[50], [51],[52],[53] shown in Table 50.

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44 As cited in American Council for an Energy-Efficient Economy, Energy Solutions. Analysis of Standards Options for BR, ER, and R20 Incandescent Lamps. April 28, 2004.

45 http://www.energy.ca.gov/appliances/2004rulemaking/documents/case_studies/CASE_BR_Lamps.pdf

46 http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/lamps_ecs_anopr_nia.pdf

47 http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/ch_3_lamps_standards_final_tsd.pdf

48 http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/2010-lmc-final-jan-2012.pdf

49 http://www.freedoniagroup.com/DocumentDetails.aspx?DocumentId=554974

50 http://www.census.gov/geo/www/guidestloc/guide_main.html

51 http://www.census.gov/popest/data/state/totals/2002/tables/ST-EST2002-01.xls

52 http://www.census.gov/popest/data/state/totals/2001/tables/ST-2001EST-04.xls

53 http://www.census.gov/popest/data/state/totals/2001/tables/ST-2001EST-04.xls

Table 50. Census Population

Year	California	United States	California as a % of United States
2000	33,871,648	281,421,906	12.04%
2001	34,501,130	284,796,887	12.11%
2002	35,116,033	288,368,698	12.18%
2010	37,253,956	308,745,538	12.07%

Cadmus calculated market size using the following steps:

- Determining the annual IRL sales volume for the nation.
- Verifying that data sources are acceptably accurate using two methods.
- Estimating the California IRL sales volume from national figures.
- Adjusting the California sales volume to exclude bulbs exempted from the standards.
- Comparing the evaluated California sales volume with the estimate provided in the CASE Report.
- Discussing changes to the IRL market over time to explain observed trends.

Total U.S. Market Size (Including Exempted Bulbs)

As shown in Table 51, the Freedonia report estimated the total unit sales of IRLs and halogen reflector lamps[54] (HRLs) in the United States for 2010 to be 150,000,000 units. The Freedonia report based this on data from the U.S. Bureau of Census and from the U.S. Department of Energy's 2010 U.S. Lighting Market Characterization report.

Table 51. Total U.S. Sales of IRLs in 2010*

Lamp Type	Units
Non-Halogen IRLs	100,000,000
Halogen Reflector Lamps	50,000,000
Total	150,000,000

*Data from Fredonia report

54 An HRL, which is tracked separately in industry reports, is a type of IRL that uses halogen gas to extend bulb life. Halogen infrared lamps (HIRs) are a subset of HRLs that utilize a bulb coating to reflect heat onto the filament to produce more light for the amount of energy consumed.

Verifying the Accuracy of the Freedonia Market Report

Cadmus used two methods to verify that the Freedonia market report figures presented in Table 51 are acceptably accurate.

Method 1. Estimating EUL and Inventory Turnover

We confirmed that the national values were reasonable by comparing the Freedonia U.S. unit sales to an estimate of annual bulb turnover. According to the DOE Lighting Market Characterization, there were a total of 641,803,000 lamps installed in the United States in 2010: 453,365,000 IRLs and 188,438,000 HRLs. The annual bulbs sold account for slightly less than a quarter of inventoried sales, as shown in Table 52.

Table 52. IRL Sales vs. Inventory in the U.S. for 2010*

Bulb Type	2010 Lamp Sales (Freedonia Report)	2010 Bulb Inventory (DOE Market Characterization)
Non-Halogen IRLs	100,000,000	453,365,000
Halogen Reflector Lamps	50,000,000	188,438,000
Total	150,000,000	641,803,000

*Data from Freedonia report and DOE's 2010 Market Characterization Report

We then estimated bulb turnover. This entailed using the following equation to determine the effective useful lifetime (EUL) of an average bulb in each sector:

EUL = Lifetime bulb hours / Daily hours of use / 365 days per year

We calculated a range for EUL (weighted by sector) using two lifetime bulb hours listed in the 2010 DOE technical support document[55] and hours of use from the DOE lighting market characterization.[56] Table 53 shows the results with a 2,500-hour bulb life.

55 Navigant Consulting and Lighting Research Center for Department of Energy. 2009. http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/ch_5_lamps_standards_final_tsd.pdf P. 71 (5-66).

56 Navigant Consulting for Department of Energy. 2012. P. 32.

Table 53. Weighted Calendar Life of Bulbs at 2,500 Hour Bulb Life

Sector	Daily HOU*	Bulb Life (Hours)**	Share of Lamps*	Effective Useful Lifetime (Years)
Residential	1.7	2,500	96%	4.03
Commercial	9.8	2,500	4%	0.70
Industrial	11.9	2,500	0%	0.58
Avg. EUL weighted by sector				3.9

*From the DOE 2010 Market Characterization
**From the 2010 DOE technical support document

Table 54 shows the results with a 3,000-hour bulb life.

Table 54. Weighted Calendar Life of Bulbs at 3,000 Hour Bulb Life

Sector	Daily HOU*	Bulb Life (Hours)**	Share of Lamps*	Effective Useful Lifetime (Years)
Residential	1.7	3,000	96%	4.83
Commercial	9.8	3,000	4%	0.84
Industrial	11.9	3,000	0%	0.69
Avg. EUL weighted by sector				4.7

*From the DOE 2010 Market Characterization
**From the 2010 DOE technical support document

The average effective useful lifetime of a bulb ranges from 3.9 to 4.7 years, suggesting that bulbs are replaced every four to five years. Based on this estimate, the Cadmus team anticipated that bulb sales should account for approximately a quarter of inventoried bulbs, which confirms the consistency of DOE and Freedonia numbers.[57]

Method 2. Comparing Freedonia Estimates to NEMA Shipments for 2005

The Cadmus team also compared the Freedonia market estimates for 2005 to shipments data from the National Electrical Manufacturers Association (NEMA), which is a large trade association for IRL manufacturers. For 2005, Freedonia estimated that 224 million IRL units were sold, while NEMA reported 300 million IRL units were sold.[58] (NEMA provided shipment data for the years from 2001 through 2005 to the DOE, as described in the Fluorescent and Incandescent Lamps Energy Conservation Standard Final Rule Technical Support Document [2009].)

Based on these two approaches, we conclude that the Freedonia report is acceptably accurate.

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57 This assumes the installed stock did not change significantly.

58 The DOE estimates that NEMA covers 85% of the industry, so after adjusting for this, the Cadmus team estimated the IRL sales for 2005 to be 301 million units.

Total California Market Size Estimate (Including Exempted Bulbs)

Table 55 shows the Cadmus team's estimate of the number of IRLs and HRLs sold annually in California. We calculated this by multiplying total IRL consumption across the United States (as reported by Freedonia) by the proportion of the U.S. population residing in California.

Table 55. IRL Sales in the U.S. and CA in 2010*

Region	Population Size	IRL units sold	HRL units sold	Total RLs sold
United States	308,745,538	100,000,000	50,000,000	150,000,000
California	37,253,956	12,066,233	6,033,117	18,099,350

*Estimated from Freedonia sales data and 2010 Census data

To estimate the California sales of IRLs and HRLs by sector, we assumed that the purchasing patterns in the state matched the national distribution of inventoried lamps by sector. Using national inventory data from the DOE's 2010 Market Characterization, we calculated the proportion of usage by sector and then multiplied it by the total California sales. As shown in Table 56, approximately 17 million IRLs were sold annually to California households and 1.1 million sold to the nonresidential sector.

Table 56. IRL and HRL Sales in California by Sector in 2010*

Sector	% of Non-Halogen IRL Sales in U.S.	Non-Halogen Units Sold in CA	% of HRL Sales in U.S.	HRL Units Sold in CA	Total Units Sold in CA
Residential	95.713%	11,548,947	89.619%	5,406,819	16,955,772
Commercial	4.284%	516,887	10.348%	624,289	1,141,224
Industrial	0.003%	399	0.033%	2,017	2,353
Total	100%	12,066,233	100%	6,033,117	18,099,350

*Estimated from Freedonia sales data, 2010 Census data, and the DOE's 2010 Market Characterization

Size Adjustment for Exempted Bulbs for Fed 6

The DOE's National Impact Analysis (NIA) estimates that EISA 2007 regulates approximately 40% of non-halogen IRLs.[59] To corroborate this estimate, the Cadmus team used the results from two shelf surveys conducted by DNV KEMA in the fall of 2011 and 2012 to calculate the percentage of reflector lamps regulated by the federal standards. Our results indicate that the percentage of IRLs regulated under federal standards observed on store shelves ranged from 39% to 44%. We discuss these data sources in more depth in the Unit Energy Savings section of this memo.

Using the NIA estimate, we calculated the sales of IRLs regulated by the standard in California. Table 57 shows the annual number of bulbs subject to Fed 6, effective in 2012, to be 6.8 million

[59] http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/lamps_ecs_anopr_nia.pdf

units in the residential sector and 460,000 in the nonresidential sector. Because data for 2012 sales were not available, we continue to use data from 2010 as a proxy.

Table 57. Sales of IRLs in California Subject to Fed 6 Standards

Sector	Non-Halogen IRLs	HRLs	Total Eligible Units Sold in CA
Residential	4,619,582	2,162,728	6,782,309
Commercial	206,767	249,723	456,490
Industrial	145	796	941
Total	4,826,493	2,413,247	7,239,740

California Size Adjustment for Exempted Bulbs Std 22a and Std 22b

Since Std 22 regulates a subset of bulbs covered under the Fed 6, the Cadmus team scaled the Fed 6 market size to estimate the Std 22 market size. To determine the subset of IRLs covered by state regulations, we again used data from the DNV KEMA shelf surveys and applied a scaling factor of 24.9% to the values listed in Table 57. (Utilizing the DNV KEMA database, we calculated this scaling factor by taking the ratio of bulbs meeting the state definition to those meeting the federal definition.) Table 58 lists the market size for bulbs covered under Std 22a and Std 22b.

Table 58. Market Size for Std 22

Standard	Market Size	Fraction of Market
Std 22a (Residential)	1,688,793	94%
Std 22b (Non-residential)	113,900	6%
Total	1,802,693	100%

Market Size Comparison with CASE Report

Using NEMA national shipment data[60] and an Itron residential retail study,[61] the CASE Report estimated that IRL sales in 2002 for California totaled 18.9 million IRLs: 10.1 million (53%) in the residential sector and 8.8 million (47%) in the commercial sector. Note that the CASE Report analysis did not adjust for exempted lamps; however, the results are comparable to our findings of 18.1 million total IRLs sold in California (Table 56).

Figure 34, which includes exempted bulbs, shows a comparison of the CASE results for 2002 to the Cadmus results for 2010. Our results show that the distribution of IRLs across sectors differs from that described in the CASE Report. Our analysis indicates that 94% of IRLs (Table 58) were

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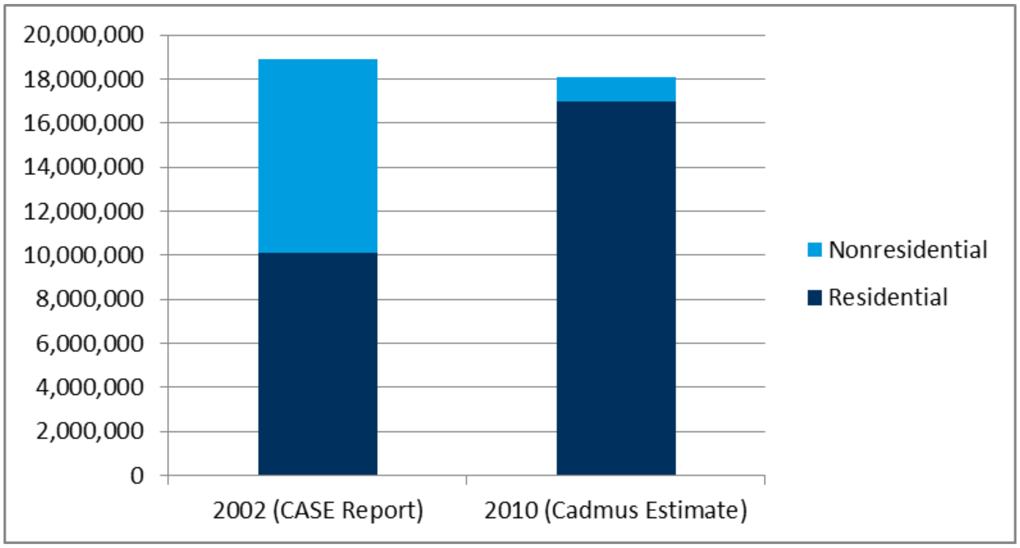
60 NEMA. 2003. "Number of PAR/R Lamps Survey for DOE." Arlington, VA: National Electrical Manufacturers Association.

61 Harcharik, Rachel. 2003. "Reflector Results—US and CA 2000 and 2002." San Diego, CA: Itron, Inc.

sold to the residential sector in 2010, an increase over the CASE Report estimate, and we offer an explanation for these differences in the next section.

Figure 34. Annual IRL Sales in California



Overall IRL Market Changes: 2001-2010

Based on our review of the data, our findings suggest that the market changed in two ways between 2001 and 2010: (1) Nonresidential sales of IRLs decreased while residential sales increased; and (2) the annual sales of IRLs decreased over time. As the 2001 characterization report did not track large HRLs, we cannot comment on changes in that product over time.

In comparing DOE market characterization reports for 2001 and 2010 (Table 59), we observed the following:

- IRL inventory increased by 65% in the residential sector.
- IRL inventory dropped by 76% in the commercial sector.

In the smaller industrial and outdoor sectors, IRL inventory virtually disappeared.

Table 59. Change in IRL Inventory in the United States from 2001 to 2010

Sector	2001 IRL Inventory	2010 IRL Inventory	% Change
Residential	262,471,000 (76%)	433,929,000 (96%)	65%
Commercial	81,229,000 (23%)	19,421,000 (4%)	-76%
Industrial	1,251,000 (<1%)	15,000 (<1%)	-99%
Outdoor	1,500,000 (<1%)	0 (<1%)	-100%
Total	346,451,000	453,365,000	31%

Source: DOE Lighting Market Characterization Studies for 2001 and 2010

Although the inventory of IRLs went up over time, Freedonia reported that annual sales of non-halogen IRLs dropped from 210 million in 2000 to 100 million in 2010. However, HRL sales increased from 32 million to 50 million between 2000 and 2010.

Market Forecast

The Freedonia report forecasts these market changes:

- A large decrease in IRL sales as a result of Fed 6 taking effect on July 14, 2012.[62]
- An increase in HRL sales as a result of growing consumer awareness.
- Sales tapering off by 2015 because of increased competition from other technologies (such as CFLs, LEDs, and metal halide lamps) in the reflector lamp market.

Unit Energy Savings

Cadmus used the following data sources to calculate per-unit energy savings for Std 22 and Fed 6.

- DNV KEMA WO13: a shelf survey conducted by DNV KEMA staff between September and November 2011—before Fed 6 took effect.[63]
- DNV KEMA WO28: a shelf survey conducted by DNV KEMA staff in August and September 2012—shortly after Fed 6 took effect.
- Navigant Consulting for Department of Energy. 2010 U.S. Lighting Market Characterization. January 2012.[64]

For the shelf surveys, DNV KEMA staff visited retailers across California and gathered information about numbers of bulbs, wattages, lumens, and bulb shapes. As part of two data requests from Cadmus, DNV KEMA staff summarized shelf survey data by the number of compliant bulbs, the number of non-compliant bulbs, and the number of bulbs without sufficient information to determine compliance. DNV KEMA staff also provided the average wattage of compliant and non-compliant bulbs.

For Fed 6, Cadmus determined the baseline wattage using data from WO13, which was collected in fall 2011. This baseline of 72.7 watts represents the average wattage of IRLs on the market before Fed 6 took effect. To calculate the wattage of bulbs compliant with the standard,

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62 U.S. Department of Energy. Energy Conservation Program: Energy Conservation Standards and Test Procedures for General Service Fluorescent Lamps and Incandescent Reflector Lamps; Final Rule. July 2009. http://www1.eere.energy.gov/buildings/appliance_standards/pdfs/74fr34080.pdf

63 http://www.calmac.org/publications/2011_California_Lighting_Retial_Store_Shelf_Survey_Final_Report_CALMAC.pdf

64 http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/2010-lmc-final-jan-2012.pdf p. 32

we used data from WO28, which were collected shortly after Fed 6 took effect. The average of bulbs that meet the minimum lumens-per-watt requirements of the Fed 6 standards is 63.5 watts.

For Std 22a and Std 22b, we used the non-compliant wattage from WO13 as the baseline, which represents the average wattage of bulbs that do not meet Std 22 efficiency requirements. For the efficient option wattage, we used the compliant wattage from WO13.

Table 60 summarizes the baseline and efficient option wattages.

Table 60. Baseline vs. Efficient Option Wattages

Standard	Baseline Wattage (W)	Compliant Wattage (W)	Wattage Difference (W)
Fed 6	72.7	63.5	9.2
Std 22a	66.0	56.6	9.4
Std 22b	66.0	56.6	9.4

Cadmus determined unit demand savings by multiplying the wattage difference by the percentage of bulbs that were on during peak demand hours. The results are shown in Table 61.

Table 61. Unit Demand Savings

Standard	Wattage Difference (W)	Percent On at Peak	Unit Demand Savings (W)
Fed 6	9.2	15.59%	1.4
Std 22a	9.4	11.02%	1.0
Std 22b	9.4	83.33%	7.8

For residential recessed ceiling fixtures—which contain IRL bulbs—we used the Lighting Efficiency Technology Report (1999) to estimate the percentage of bulbs that were on at peak hours for each lamp type listed in Percent of Lamps on at Peak

For the commercial sector, we assumed that most buildings sustained a constant lighting load from 9 a.m. to 5 p.m. Since these hours overlap with the peak period of 2 p.m. to 5 p.m.,[65] we estimate 83.33% as the commercial sector value for the percentage of bulbs on at peak.

For Fed 6, we used an average of the residential and commercial percentages weighted by the units sold by sector.

65 DEER 2013 Codes and Standards Update for the 2013-2014 Cycle.

Using average daily hours of use from the DOE's 2010 Lighting Market Characterization, we calculated annual unit energy savings for each standard with the equation below and the parameters listed in Table 62.

$$Annual\ Unit\ Energy\ Savings\ (kWh)$$
$$= Unit\ Demand\ Savings\ (W) \times Annual\ Hours\ of\ Use\ (h) \times \frac{1\ kW}{1{,}000\ W}$$
$$= (Baseline\ wattage - Efficient\ wattage) \times (Daily\ HOU \times 365\ days \times \frac{1\ kW}{1{,}000\ W})$$

Table 62. Daily Hours of Use by Sector

Standard	Sector	Wattage	Daily Hours of Use	Annual Unit Energy
Fed 6	All Sectors	9.2	2.1	7.1
Std 22a	Residential	9.4	1.7	5.8
Std 22b	Commercial	9.4	9.8	33.6

Potential Energy Savings

We calculated the first year potential savings using the equation below and parameters listed in Table 55.

$$Potential\ Savings\ (GWh)$$
$$= \#\ Units\ Purchased\ Annually \times Annual\ Unit\ Energy\ Savings\ (kWh) \times \frac{1\ GWh}{1{,}000{,}000\ kWh}$$

Table 63. Potential Energy Savings

Standard	Sector	Number of Eligible Units Purchased Annually	Annual Unit Energy Savings (kWh)	Potential Energy Savings (GWh)
Fed 6	All Sectors	7,239,740	7.1	51.1
Std 22a	Residential	1,688,795	5.8	9.9
Std 22b	Commercial	113,900	33.6	3.8

We calculated potential demand savings using the following equation:

$$Potential\ demand\ savings\ (MW)$$
$$= \#\ Units\ Purchased\ Annually \times Unit\ Demand\ Savings\ (W) \times \%\ on\ at\ peak \times \frac{1\ MW}{1{,}000{,}000\ W}$$

Table 64 lists the parameters we used to calculate potential demand savings.

Table 64. Potential Demand Savings

Standard	Sector	Number of Eligible Units Purchased Annually	Unit Demand Savings (W)	Potential Demand Savings (MW)
Fed 6	All	7,239,740	1.4	10.4
Std 22a	Residential	1,688,793	1.0	1.7
Std 22b	Commercial	113,902	7.8	0.9

Table 65 compares evaluated potential savings with the CASE Report estimates. The CASE Report assumed a higher number of units per year and, generally, greater unit energy and demand savings.

Table 65. IRL Savings Comparison

Item	Fed 6 Evaluation	Std 22a Evaluation	Std 22b Evaluation	CASE Report
Units per Year	7,239,700	1,688,800	113,900	18,900,000
Unit Energy Savings (kWh)	7.1	5.8	33.6	12.7*
Unit Demand Savings (W)	1.4	1.0	7.8	2.17*
First Year Potential Energy Savings (GWh)	51.1	9.9	3.8	240
First Year Potential Demand Savings (MW)	10.4	1.7	0.9	41

*Back calculated from total savings and units per year

Compliance Rate

Cadmus used the following data sources to estimate the compliance rate for IRLs:

- DNV KEMA WO 13 shelf survey
- DNV KEMA WO 28 shelf survey

We assumed that the description on the product packaging accurately reflects the products' actual performance.

Fed 6 Compliance

DNV KEMA WO 13, a shelf survey conducted in fall 2011, provides a snapshot of the IRL market before the federal IRL standards went into effect in July 2012. Using wattage information collected during the survey, we found that 2.0% of IRLs (424 bulbs out of 21,697 bulbs) qualified under the more rigorous 2012 federal efficiency standards before the standard took effect.

We used data from DNV KEMA WO 28, a shelf survey conducted in August and September 2012, to determine the compliance rate several months after the 2012 standards went into effect. From this survey, we determined that 6.9% of IRLs (1,419 out of 20,511 bulbs) met the efficiency standards. The change in the fraction of bulbs meeting the new efficiency standards suggests that more efficient bulbs are being stocked after the standard took effect than before.

The compliance rate is low for two reasons.

First, the 2012 standard applies only to bulbs manufactured after July 14, 2012. The manufacture date of the bulbs was not collected as part of WO28, so we could not exclude bulbs manufactured before the standard took effect in our compliance analysis.

Second, WO28 data collection was conducted only a couple months after the standard took effect, which means the market may not have had enough time to fully respond to the new standard.

Std 22 Compliance

To determine compliance with Std 22, we used WO13 data. Assuming that bulbs found on store shelves would be used for both residential and commercial applications, we calculated the compliance rate using this approach.

We compared bulb model numbers to a CEC list of compliant bulbs to determine the listed compliance.

For the bulbs that could not be matched, we compared their advertised lumens-per-watt to the efficiency standards listed in Std 22.

As of fall 2011, 81.7% of bulbs complied with the standard. This total compliance includes a listed compliance rate of 11.2% and an unlisted compliance rate of 70.5%. Nearly four years after Std 22 took effect, the majority of bulbs that are compliant with the standard, based on their product description, are not listed in the CEC database.

F.4.3 History of IRL Standards

On October 31, 1995, the first standards for incandescent reflector lamps (IRLs) became effective under the Energy Policy Act of 1992 (EPACT). These standards defined what products are considered to be IRLs, specified the types of IRLs covered by the standards, and described the minimum required efficiency level in lumens per watt.

The basic definition of an incandescent reflector lamp has not changed since it was initially specified in the EPACT. Thus, an incandescent reflector lamp:

- Contains an inner reflective coating on the outer bulb to direct the light;
- Has a rated voltage or voltage range that lies at least partially within 115 and 130 volts;
- Has an E26 medium screw base; and
- Is not colored or designed for rough or vibration service applications.

The bulb shapes covered by the EPACT standard included R and PAR shapes and applied to all bulbs over 2.75 inches in diameter.

The lumens per watt efficiency standard are listed in Table 66.

Table 66. EPACT Efficiency Standards

Nominal Lamp Wattage	Minimum Average Lamp Efficacy (LPW)
40-50	10.5
51-66	11.0
67-85	12.5
86-115	14.0
116-155	14.5
156-205	15.0

In 2005, California proposed to extend the scope of the federal standards to cover ER and BR bulb shapes, as well as R and PAR bulbs with diameters ranging from 2.25 and 2.75 inches. In short, California wanted to the following: (1) Close a loophole in the federal standard that exempted ER and BR bulb shapes from regulation; and (2) extend the standard to include smaller bulbs, such as the R-20. Although the 2005 standards introduced this set of bulbs as state-regulated IRLs, it was not until 2006 that the minimum lumens-per-watt for these bulbs were defined.

The 2006 California appliance efficiency standards extended the federal lumens-per-watt requirements to the previously exempted bulbs and specified an effective date of January 1, 2008. These standards also introduced exceptions for the following shapes:

- ≤45W R-20
- ≤50W ER-30, ER-40, BR-30, BR-40
- 65W ER-40, BR-30, BR-40

In 2007, Congress passed the Energy Security and Independence Act of 2007 (EISA), which generally adopted the language of the California extensions. This act extended the efficiency standards to BR/ER/BPAR bulb types starting January 1, 2008. It also extended the efficiency standards—as of June 17, 2008—to bulbs ranging in size from 2.25 to 2.75 inches. For a period of five and a half months, the California standard regulated bulbs in the 2.25-2.75 range before the second EISA effective data in June 2008. (Note that the California standards are a subset of bulbs within the EISA standards as EISA extends regulation to cover BPAR bulbs, while the California standards did not.)

In 2009, the Department of Energy finished a new rule, which became effective on July 14, 2012. The rule specified more stringent efficiency standards (as shown in Table 47). The new standards also set an upper limit of 205 watts for bulbs subject to the standard. In practice, this limit had already existed, because the former efficiency standards only listed wattages between 40 and 205 watts. The 2009 ruling concluded that bulbs above 205 watts represented an insignificant part of the market and savings and formalized their exclusion.

F.4.4 Percent of Lamps on at Peak

Cadmus used the Lighting Efficiency Technology Report (1999) to calculate the percentage of recessed ceiling fixtures on at peak. We used "Figure 2 - 33 Percent of Lights On, by Hour, by Room[66]" to obtain the percentage of residential lights on during peak hours between 2-5PM.

We used data from the table "Residential Lighting Applications, Sorted by Room Type"[67] to determine the number of IRLs per room and calculated the number of recessed ceiling fixtures on at peak. Table 67 shows the inputs and results of the calculations. We estimate that 11% of recessed ceiling fixtures are on at peak.

Table 67. Percentage of Recessed Lighting Fixtures on at Peak

Room Type	% of Lights on at Peak per Room	IRLs per Room	Number of IRLs on at Peak
Living Room	14%	3,106	435
Bedroom	8%	1,979	158
Den	15%	1,083	162
Kitchen/Dining	16%	22,102	3,536
Utility	0%	2,254	0
Garage	0%	1,440	0
Yard-Porch	0%	0	0
Hall/Entry	6%	6,304	378
Bathroom	7%	11,240	787
Total	N/A	49,508	5,457
% of IRLs on at peak		11%	

F.5 Standard 23 – Metal Halide Fixtures

F.5.1 Introduction and Summary of Findings

The 2010-2012 Codes and Standards Evaluation Plan specifies that Cadmus will evaluate compliance for Standard 12a: Pulse Start Metal Halide HID Luminaires (Std 12a) and Standard 23: Metal Halide Fixtures (Std 23). The plan also indicates we will evaluate the potential energy savings for Std 23.

Because Std 12a applies only to luminaires manufactured after January 2006 and before January 2009, we were unable to assess the market compliance rate with this standard during the evaluation in 2012. Std 23 expands on the requirements of Std 12a; Std 12a states luminaires shall not contain a probe-start metal halide ballast. The federal standard regulating metal halide

66 Lighting Efficiency Technology Report. 1999. P. 44

67 Lighting Efficiency Technology Report. 1999. P. 60-61

lamps (EISA 2007), which took effect in 2009, includes a provision exempting California's metal halide standard from preemption.[68]

This memo describes the findings from Cadmus' evaluation of potential energy savings and compliance for Std 23. Std 23 is a Title 20 standard that applies to metal halide luminaires that are at least partially rated within the 150 to 500 watt range and were manufactured after January 1, 2010. Indoor and outdoor products must not have probe-start ballasts and must meet at least one of the following compliance conditions:

- A minimum ballast efficiency of
  - 90% for 150 to 250 watt lamps
  - 92% for 251 to 500 watt lamps
  - A minimum ballast efficiency of 88% and an occupant sensor that automatically reduces lamp power through dimming
  - A minimum ballast efficiency of 88% and an automatic daylight control that automatically reduces lamp power through dimming
  - A minimum ballast efficiency of 88% and a relamping rated wattage within only one of the four wattage bins specified below. The luminaire must have a label that states the relamping rated wattage.
  - 150 to 160 watts
  - 200 to 215 watts
  - 290 to 335 watts
  - 336 to 500 watts, provided that the luminaire is able to operate 336 to 500 watt lamps, the luminaire shall be prepackaged and sold together with at least one lamp per socket, and has a minimum lamp mean efficacy of 80 lumens per watt based on published mean lumens and rated lamp power (watts).

Table 68 summarizes Cadmus' evaluation results for Std 23 along with the original IOU estimates.

[68] American Council for an Energy-Efficient Economy. "Codes and Standards (CASE) Initiative for PY2008: Title 20 Standards Development." Last modified April 3, 2008. Accessed December 27, 2012.

Table 68. Evaluation Results for Std 23

Component	Evaluation Result	Original IOU Estimate*
Units per Year	234,000	45,000
Unit Energy Savings (kWh/year)	173.4	1,000
Unit Demand Savings (W)	30.2	178
First Year Potential Energy Savings (GWh)	40.6	45
First Year Potential Demand Savings (MW)	7.1	8
Compliance Rate	95%	85%

* Estimates provided by the California IOUs on May 13, 2011, in response to EEGA data request 1465, 1466, 1467, and 1468.

The following sections outline our approach and findings for each component listed in Table 68.

F.5.2 Potential Energy Savings

The Integrated Standards Savings Model (ISSM) requires two values to determine potential savings: the number of units sold per year in California and the per-unit energy savings, as shown in Equation 2.

Equation 2. Annual Energy Savings

$$\textbf{Annual Savings} = \textbf{\# Units Purchased Annually} \times \textbf{Unit Energy Savings}$$

Cadmus began the potential energy-savings analysis by reviewing the market size.

Market Size

Cadmus used several sources of information to estimate the market size for metal halide fixtures. 2003 Commercial Building Energy Consumption Survey (CBECS) data are shown in Table 69.

Table 69. Commercial Buildings by Region in 2003

Census Region and Division	Number of Buildings
Northeast	710,000
New England	228,000
Middle Atlantic	482,000
Midwest	1,190,000
East North Central	659,000
West North Central	531,000
South	1,654,000
South Atlantic	835,000
East South Central	312,000
West South Central	507,000
West	850,000
Mountain	285,000
Pacific	565,000

Source: U.S. Energy Information Administration. 2003 Commercial Building Energy Consumption Survey. Table C13. Available online: http://www.eia.gov/emeu/cbecs/cbecs2003/detailed_tables_2003/detailed_tables_2003.html#consumexpen03.

According to the 2003 CBECS study, approximately 12.83% of commercial buildings are located in the Pacific census region (the region of interest for this analysis). A more recent survey was implemented in 2012, but the results were not publicly available at the time the analysis was conducted.

2010 Census population data are shown below in Table 70.

Table 70. 2010 Census Population

Region	2010 Census Population	% of U.S.
California	37,253,956	12 %
Pacific Census Region*	49,880,102	16%
United States	308,745,538	100%

Source: 2010 U.S. Census Data.

* This region includes Alaska, California, Hawaii, Oregon, and Washington.

According to the 2010 U.S. Census, California accounts for 75 % of the Pacific region's total population. When applying this figure to the percentage of commercial buildings in the Pacific region, California represents 9.6% of all commercial buildings in the U.S.

Estimated shipments data from 2011 U.S. Department of Energy (DOE) Preliminary Technical Support Document for metal halide lamp fixtures (MHLFs) are shown below in Table 71.

Table 71. Annual U.S. MHLF Shipments from 2008 to 2012

MHLF by Wattage	2008	2009	2010	2011	2012
70 Watts	582,000	596,000	612,000	628,000	645,000
250 Watts	1,227,000	1,258,000	1,292,000	1,326,000	1,361,000
400 Watts	1,227,000	1,258,000	1,292,000	1,326,000	1,361,000
1,000 Watts	680,000	697,000	716,000	734,000	754,000

Source: U.S. Department of Energy. Technical Support Document for the Preliminary Analysis for Metal Halide Lamp Fixtures. Chapter 9: Shipment Analysis, Tables 9.3.3 – 9.3.6. 2011. Available online: http://www1.eere.energy.gov/buildings/appliance_standards/commercial/pdfs/mhlf_pa_tsd_ch9_shipments.pdf.

The number of shipments for MHLFs encompasses both pulse-start and probe-start technology. The figures in Table 71 are the estimates developed by the U.S. DOE in an attempt to help with prescribing mandatory minimum efficiency levels for pulse-start metal halide ballasts, magnetic probe-start ballasts, and non-pulse-start electronic ballasts that operate lamps rated greater than or equal to 150 watts but less than or equal to 500 watts. Table 72 below outlines the average annual MHLF shipments in the U.S. (calculated from Table 71) and California from 2010-2012.

Table 72. 2010-2012 Average Annual MHLF Shipments in the U.S. and in California*

MHLF by Wattage	Average Annual U.S. MHLF Shipments from 2010-2012	Average Annual California MHLF Shipments*
70 Watts**	628,000	60,000
250 Watts	1,326,000	127,000
400 Watts	1,326,000	127,000
1,000 Watts**	735,000	70,000
Total	4,016,000	385,000

* Cadmus used an adjustment factor of 9.6% (the percentage of U.S. commercial buildings that are in California) to determine share of California MHLF shipments.
** Not regulated by Title 20

The number of MHLFs shipped annually into California regulated by Std 23 (150-500 watts) is approximately 254,000 units or 66% of total MHLF California shipments. To convert total shipments into total sales, we assumed that 8% of the total annual MHLFs shipped do not get sold during the year.[69] The total number of MHLFs sold annually in California is 234,000 when factoring in distributor inventory turns.

[69] Cadmus staff estimated these values from correspondence with manufactures

Comparison with the CASE Report

Table 73 shows the values cited in the 2008 CASE Report compared with Cadmus' findings. The figure cited in the 2008 CASE Report, 363,000 units sold in 2001, include MHLFs of all wattages. This is comparable to the number of total shipments we report in Table 72; there is a difference of approximately 6%.[70] The CASE Report assumes 70% of MHLFs are 150W to 1000W, or 254,000 units per year, but does not calculate the number between 150W and 500W.

Table 73. Annual Sales/Shipments of MHLFs in California

	CASE Initiative (2001) Annual Sales	Evaluated Shipments (2010-2012)	% Difference
All Wattages	363,000	385,000	6%
150W to 1,000W	254,000	325,000	28%
150W to 500W	N/A	Shipments: 254,000 Sales: 234,000	N/A

Unit Energy Savings

The energy savings for Std 23 MHLFs occurs from either retrofitting the complete MHLF or upgrading its ballast from magnetic to electronic. Cadmus used the following data sources to determine per-unit potential energy savings:

The Efficiency Boom: Cashing in on the Savings from Appliance Standards. This report was written by the American Council for an Energy Efficient Economy and the Appliance Standards Awareness Project (ASAP), and highlights the energy savings that can be realized through appliance standards. The federal standard for MHLFs, mirrors Std 23 in terms of ballast efficiency for various MHLF wattages; however, there is no exception for MHLFs that have lower ballast efficiency but contain control technology—which is a requirement in Std 23. Findings from this report include a projected national total energy savings of 4.3 TWh and $2.2 billion net present value savings to be achieved by the year 2035.

State Level Benefits from Potential National Appliance Standards - Residential.[71] This table is included in a report outlining ASAPs' analysis of projected energy savings for all of the federal standards. For MHLFs, they project a per-unit annual savings of 54 kWh, an incremental cost of $17.36, and payback period of 2.3 years.

70 American Council for an Energy-Efficient Economy. "Codes and Standards (CASE) Initiative for PY2008: Title 20 Standards Development." Last modified April 3, 2008. Accessed December 27, 2012.

71 Appliance Standards Awareness Project. "State Benefits of Federal Appliance Standards – California." Table titled "State-Level Benefits from Potential National Appliance Standards – Residential." 2011. Available online: http://www.appliance-standards.org/sites/default/files/fedappl_ca.pdf.

U.S. DOE Technical Support Document (TSD).[72] During the rulemaking period for MHLFs, the U.S. DOE completed an extensive engineering analysis that included testing several candidate standard levels (CSLs) to understand energy-saving implications in addition to manufacturer production costs and other economic measurements. The CSLs' ballast efficiency and annual energy consumption closely correspond to the Std 23 levels.

Relamping and Reduced MHLF Wattage Data from IOUs: The IOUs provided data that indicated reduced wattage MHLFs are installed with a typical energy savings of 20% for 250W and 400W MHLFs. When cross-referenced with available MHLFs within the CEC Compliance Database, we deemed that 60% of 250W MHLFs sold comply with Std23 with the remaining 40% being a reduced wattage MHLF. For 400W MHLFs, the Std23 compliance rate is 40.5% with the remaining 59.5% coming from reduced wattage MHLF. Our analysis of annual energy consumption based on the data provided by the IOUs is listed below in Table 74.

Table 74. MHLF Annual Energy Consumption

MHLF Wattage	CSL	Ballast Efficiency	Normalized Input Power (W)	Annual Energy Consumption (kWh)
250 Watt	Baseline	88%	284.1	1,160.8
	CA Ballast Efficiency Option	90.0%	277.8	1,135.0
	Reduced Wattage	NA	227.3	928.6
	Compliant MHLF	NA	257.4	1,051.8
400 Watt	Baseline	88%	454.5	1,857.2
	CA Ballast Efficiency Option	92.0%	444.4	1815.9
	Reduced Wattage	NA	363.6	1,485.8
	Compliant MHLF	NA	396.3	1,619.5

Source: U.S. Department of Energy. Technical Support Document for the Preliminary Analysis for Metal Halide Lamp Fixtures. Chapter 6: Energy Use Characterization. Tables 5.14, 5.18, 6.3.2 – 6.3.3. Available online: http://www1.eere.energy.gov/buildings/appliance_standards/commercial/pdfs/mhlf_preanalysis_chapter6.pdf.

In the TSD, DOE classified fixtures into four different bins based on wattage: 50 W to 149W, 150W to 250W, 251 to 500W, and over 500W. DOE chose 250W and 400W as the representative wattages for the 150 to 250W and 250 to 500W bins, respectively, and calculated the annual energy consumption using the weighted average annual hours of use of 4,086 for the baseline and CSLs. We utilized the same methodology in binning according to the TSD.

72 U.S. Department of Energy. "Building and Technologies Program: Metal Halide Lamp Fixtures Preliminary Technical Support Document." Last modified May 17, 2012. Accessed December 3, 2012. http://www1.eere.energy.gov/buildings/appliance_standards/commercial/metal_halide_fixtures_prelim_tsd.html.

The per-unit energy savings from retrofitting 250 watt and 400 watt MHLF from baseline to the Compliant MHLF listed in Table 74 are 109 kWh and 237.7 kWh, respectively. Since the same numbers of 250 watt and 400 watt MHLFs are shipped, we assume average per-unit savings of 173.4 kWh for either wattage of MHLF sold.

Cadmus completed a weighted-average analysis of the MHLF's that met the ballast efficiency option and those that were sold with reduced wattage based on the data provided by the IOUs.

Cadmus calculated the annual savings values from the CASE Report's annual operating hours[73] (4,380) and watts saved per fixture (18 to 56 W). The CASE Report provides a range for annual per-unit energy savings from 79 kWh to 245 kWh, which Cadmus recommended 173.4 kWh is within.

Demand Savings

The CASE initiative describes the percent of MHLFs on at peak as 78%. This is reasonable considering MHLFs are commonly used in commercial and industrial applications that operate during daytime hours. Using the wattage differences from Table 74, we estimate the per unit peak demand savings to be 30.2W. This value is roughly the median of the calculated values provided in the CASE Report, which results in per-unit demand savings of approximately 14 to 44W.[74]

Potential Energy Savings

The potential energy and demand savings for MHLFs are summarized in Table 75, along with estimates from the CASE Report.

Table 75. California Annual Potential Energy Savings from MHLFs

MHLF Savings	Evaluation Result	CASE Report
Units per Year	234,000	254,100
Unit Energy Savings (kWh)	173.4	79 to 245
Unit Demand Savings (W)	30.2	14 to 44*
First Year Potential Energy Savings (GWh)	40.6	19 to 59
First Year Potential Demand Savings (MW)	7.1	3 to 11

* Calculated from watt savings and percent on at peak

F.5.3 Compliance

Cadmus evaluated the market compliance rate with Std 23 by conducting surveys with distributors throughout California. We asked distributors questions to test their awareness of

73 The CASE Report cites DOE 2002 as the source of the annual operating hours.

74 The CASE Report indicates per fixture watt savings ranges from 18 to 56 W. Combined with the percent on at peak, 78%, Cadmus obtained 14 to 44W per unit.

Title 20 regulations covering MHLF (Std 23). We also asked what wattage fixtures they sold and the corresponding ballast efficiencies, and whether or not they sold any MHLFs with automatic daylight controls or occupancy sensors. Using a scoring rubric, Cadmus assigned a compliance rate to each distributor. For more information on how Cadmus determined the compliance rate, refer to the following sections, Distributor Compliance Practices and Distributor Survey Questions. The results are summarized in Table 76.

Table 76. Distributor Responses

Distributor Location	Result	Compliance
Fresno	They understood the Title 20 Std 23 restriction on probe-start MHLF, evidenced by the comment that: "all of our customers are requesting pulse-start MHLF." As a result, they no longer sell probe-start MHLFs. They did not provide any information about whether they carry automatic daylight control or occupancy sensing MHLFs.	100%
Monterey	They mentioned the Title 20 Std 23 regulation unaided when we asked about probe-start MHLFs. They carry a few MHLFs that are non-compliant, but only for replacement purposes (and sales of these units are extremely rare). They mentioned that only new products need to comply with Title 20 Std 23, and that they are still carrying existing inventory from before Std 23 went into effect.	90%
Truckee	They mentioned Title 20 at the start of discussing MHLFs. They only carry pulse-start fixtures and do not sell probe-start fixtures. Customers still request probe-start MHLFs because they are familiar with those products and unfamiliar with Title 20. Staff inform customers who inquire about probe-start that they need to retrofit to pulse-start MHLF in order to comply. They have also been primarily selling pulse-start for years, and Std 23 had little impact on their MHLF product mix.	100%
Brea	They referred to Title 20 unaided when we inquired about probe-start MHLFs. The ballast efficiency of MHLFs they carry is: "typically at 92% of efficiency." They still have probe-start MHLFs in stock and sell them as replacements. When we asked why they do this, they said that existing probe-start MHLFs purchased before the Std 23 went into effect could be sold as replacements, and that only new MHLF purchases need to comply with Std 23.	90%

Cadmus contacted 20 distributors during November 2012. In addition to Cadmus' own research, we obtained distributor contacts from lighting program staff at each of the IOUs. We left messages with 12 distributors, then called them a second, and sometimes third time to conduct the survey, but were unable to survey them. Three of the distributors' contact information that we had on file was incorrect and we were unable to reach them. One of the surveyed distributors provided information on the compliance of other lighting technologies, but not MHLFs.

The information provided by the four distributors outlined in Table 76 indicates an average compliance rate of 95%.

In addition to surveying distributors, Cadmus contacted several manufacturers in order to understand production trends and distribution patterns. We interviewed two of the top five metal halide manufacturers. The results from these interviews are summarized below in Table 77.

Table 77. Metal Halide Manufacturer Responses

Manufacturer	Findings
Manufacturer A	This manufacturer produces a diverse array of lighting products for the global market, including MHLFs. They are within the top 5 manufacturers of MHLF sales globally. They noted that pulse-start MHLFs are increasing in demand due to the upfront cost of probe-start MHLFs and the upcoming federal standard. They stated that a future production trend is an expected increase in ceramic MHLFs among large production manufacturers. This particular technology is more efficient than comparable MHLF technology currently in market. It represents an opportunity for manufacturers to improve the efficiency of their products. When asked about ballast efficiency, they responded that they produce 250 and 400 watt MHLFs that have a ballast efficiency of 90%. Any non-compliant MHLFs they produce will be sold overseas when the federal standard takes effect. Non-compliant Std 23 MHLFs are being sold to states where there are no specific MHLF standards. This manufacturer delineated between the federal standard and Title 20 Std 23: "Title 20 requirements for indoor and outdoor dimming applications differentiates them (California) from other markets. California is more willing to try dimming products." When asked whether Title 20 Std 23 changed their production practices, they indicated that they are developing more MHLFs with daylight controls and occupancy sensors than they were three years ago.
Manufacturer B	This manufacturer also produces a diverse array of lighting products for the global market, including MHLFs. They are also within the top 5 manufacturers of MHLF sales globally. They divulged that their average ballast efficiency for 250 and 400 watt MHLFs distributed in the U.S. market is 90%. They also discussed pulse-start technology and its efficiency in comparison to probe-start. Their comments on future trends for pulse-start technology and ceramic MHLFs validated several of the claims made by Manufacturer A.

The insights from manufacturers validate our interactions with distributors, as a greater percentage of pulse-start MHLFs continue to replace probe-start MHLFs in production and in the market.

F.5.4 Distributor Compliance Practices

Cadmus developed a scoring rubric to evaluate distributor's compliance with Std 23, outlined below in Table 78.

Table 78. Distributor Compliance Rubric

Criteria	Category	Weighted Value
Exhibits understanding of Title 20 Std 23 MHLFs	A	30%
Sells non-compliant MHLFs	B	60%
Sells non-compliant MHLFs that are grandfathered into Title 20 Std 23	C	10%

Within the rubric, values are assigned for specific categories:

- "A" – This category ranks the distributor's understanding of Title Std 23. If the distributor understands that there is a California law that prohibits the sale of Std 23 non-compliant MHLF, the distributor would be scored 100. Partial understanding of the Std 23, for example the distributor does not know whether or not Std 23 prohibits pulse-start or probe-start, would result in a score of 50. No understanding of Std 23 would result in a score of 0.

- "B" – This category covers the distributors buying patterns for MHLFs. A score between 0 and 100 is assigned based on the percentage of non-compliant products sold out of their total inventory. This information is obtained through survey questioning.
- "C" – This category is meant to determine if distributors are selling products that are non-compliant, but still eligible for sale due to the grace period for Std 23. Although these sales are legal, distributors who sell these non-compliant products may have a bias toward continued non-compliant MHLF sales. Scoring is based on "Yes" (0 points) and "No" (100 points) questioning.

Cadmus determined the distributor's compliance rate with Std 23 using Equation 3.

Equation 3. Distributor Compliance Rate

$$\text{Distributor Compliance Rate} = A + B\ (\%\ \text{of non} - \text{compliant products sold}) + C$$

We determined the percentage of non-compliant MHLFs sold using distributors' responses to our survey questions. Those survey questions are outlined in Appendix B.

F.5.5 Distributor Survey Questions

1. Do you sell metal halide fixtures rated for operating between 150 to 500 watts to customers in California?
2. Do you sell indoor fixtures, outdoor fixtures, or both in this range of wattages?
3. [If outdoor fixtures]: What percent of the outdoor fixtures you sell have automatic daylight controls?
4. What percent of the fixtures you sell have probe-start ballasts? Probe-start is not to be confused with the more recent pulse-start technology used in metal halides.
5. What is the typical ballast efficiency (in percentage format) for a lamp between 150 and 250 watts? Between 251 and 500 watts?
6. What regulations or requirements affect the types of metal halide fixtures you sell? [Record whether they mention Title 20.]
7. As you may know, metal halide lamps need to meet the efficiency levels prescribed by California regulations. Do customers ask for models that do not meet the California regulations?
8. How often does this happen?
9. What do you tell them?

10. Do you still sell products that do not conform with the regulations?
11. [If they still sell noncompliant products]: Was this inventory stocked prior to the standard's effective date, or is it new? Do you plan to stop selling the noncompliant products? When? Why or why not?

F.6 Standard 24 – Portable Lighting

F.6.1 Introduction and Summary of Findings

This memo describes Cadmus' evaluation of potential energy savings and compliance for Standard 24 (Std 24) : Portable Lighting Fixtures. Std 24 is a California Title 20 (T20) standard that applies to portable luminaires, such as table or floor lamps, manufactured on or after January 1, 2010. These products must meet one or more of the following requirements:

- Be equipped with a dedicated fluorescent lamp socket connected to a high-frequency electronic ballast contained within the portable luminaire.
- Be equipped with one or more GU-24 line-voltage sockets and not rated for use with incandescent lamps of any type, including line voltage or low voltage.
- Be an LED luminaire or a portable luminaire with an LED light engine with integral heat sink, and comply with the minimum requirements shown in Table 79 below.

Table 79. Minimum Requirements for Portable LED Luminaires and Portable Luminaires with LED Light Engines with Integral Heat Sink*

Criterion	Requirement
Light Output	≥ 200 lumens (initial)
Minimum LED Luminaire Efficacy	29 lumens/W
Minimum LED Light Engine Efficacy	40 lumens/W
Color Correlated Temperature (CCT)	2700 K through 5000 K
Minimum Color Rendering Index (CRI)	75
Power Factor (for luminaires labeled or sold for residential use)	≥ 0.70

* December 2010 Appliance Efficiency Regulations. CEC-400-2010-012,Sec 1605.3(k)(2) Pg. 155-157. Available at http://www.energy.ca.gov/2010publications/CEC-400-2010-012/CEC-400-2010-012.PDF

- Be equipped with an E12, E17, or E26 screw-based socket and be prepackaged and sold together with one screw-based compact fluorescent lamp (CFL) or screw-based LED lamp for each screw-based socket on the portable luminaire. The CFL or LED lamps that are prepackaged with the portable luminaire shall be fully compatible with the luminaire controls, meaning that portable luminaires having a dimmer control shall be prepackaged with dimmable CFL or LED lamps, and portable luminaires having three-way controls shall be prepackaged with three-way CFL or LED lamps. The CFLs that are prepackaged with the luminaires shall also meet the minimum energy-efficiency levels established by ENERGY STAR® for CFLs in effect on December 31, 2008. The LED lamps required to be packaged with the luminaire shall comply with the minimum requirements shown in Table 79.

- Be equipped with one or more single-ended, non-screw-based halogen lamp sockets (line or low voltage) and a dimmer control or a high-low control, and be rated for a maximum of 100W.

In addition to the above, portable luminaires that have internal power supplies shall have zero standby power when the luminaire is turned off.

Table 80 summarizes the results of our evaluation of Std 24 and the original IOU estimates.

Table 80. Potential Savings Evaluation Results for Std 24

Value	Evaluation Result	Original IOU Estimate*
Units per Year	3,156,743	3,700,000
Unit Energy Savings (kWh/year)	Table: 17.2 Floor: 32.7	14.0
Unit Demand Savings (W)	Table: 2.5 Floor: 4.8	18.7
First Year Potential Energy Savings (GWh)	80.7	45
First Year Potential Demand Savings (MW)	11.8	4.2
Compliance Rate	93%	85%

* Estimates provided by the California IOUs on May 13, 2011 in response to EEGA data request 1465, 1466, 1467, and 1468.

The following sections describe our approach and findings for each value listed in Table 80.

F.6.2 Potential Energy Savings

The evaluation requires two values to calculate potential energy savings: the size of the California market in annual unit sales and unit energy savings, as shown in the following equation.

$$Annual\ Savings = \#\ Units\ Purchased\ Annually \times Unit\ Energy\ Savings$$

Cadmus began the potential energy savings analysis with a review of the market size.

Market Size

We used the following sources of information to estimate the market size for table and floor lamps.

- Transparency Market Research report: "U.S. Lighting Products (Chandeliers, Table Lamps, Floor Lamps, Wall Sconce, Vanity Lights, Flush Mounts, Pendants and Outdoor Lanterns) and Ceiling Fan Market Analysis and Forecast by Retailers," 2011 - 2016. June 2012.[75] This report was purchased and is not available publicly.

- 2011 Census population estimates,[76] shown in Table 81.

Table 81. 2011 Census Population

Region	2011 Census Population	Percent of U.S.	Percent of Pacific Region
California	37,691,912	12%	75%
Pacific Census Region*	50,491,337	16%	100%
U.S.	311,591,917	100%	N/A

* Alaska, California, Hawaii, Washington, Oregon

U.S. Market Size

Using a mix of secondary research and primary interviews, the Transparency Market Research report estimated portable lighting (floor and table lamps) sales in the U.S. for 2011 to be 26 million lamps as shown in Table 82.

Table 82. Portable Lighting Sales in the U.S. for 2011*

Lamp Type	Units
Table Lamps	12,093,000
Floor Lamps	14,003,200
Total Lamps	26,096,200

*Data from Transparency Market Research report

California Market Size Estimate

Cadmus estimated the number of table and floor lamps sold annually in California by multiplying total sales across the U.S. as reported by Transparency Market Research, by the proportion of the U.S. population that California represents, using the following equation. Results are shown in Table 83.

$$\text{California sales} = \text{Total U.S. sales} \times \text{Fraction of U.S. population in California}$$

75 http://www.transparencymarketresearch.com/us-lighting-products-market.html

76 http://www.census.gov/popest/data/state/totals/2011/tables/NST-EST2011-01.xls

Table 83. Portable Lighting Sales in 2010

Region	Population Size	Table Lamps Sold	Floor Lamps Sold	Total Portable Lamps Sold
U.S.	311,591,917	12,093,000	14,003,200	26,096,200
California*	37,691,912	1,462,837	1,693,906	3,156,743

*Lamps scaled down using proportion of U.S. population in Calif., which is approximately 12%.

CASE Report Comparison

Using 2006 Census population estimates, average household portable fixture stock, and an ACEEE estimate of fixture lifetime, the CASE Report published in 2008 estimated that 3.7 million portable lamps will be sold annually in California between 2006 and 2030.[77] Cadmus' estimate of 3.2 million portable lamps is relatively close to the CASE Report estimate.

Unit Energy Savings

Cadmus used the following data sources to calculate unit energy savings for Std 24.

- KEMA Socket Inventory 08-09: An unpublished dataset from KEMA, collected before Std 24 took effect, used to determine baseline wattage.
- Heschong Mahone Group. 1999. Lighting Efficiency Technology Report, Volume 1, California Baseline.[78]
- DNV KEMA/Cadmus Shelf Survey 2012: A 2012 shelf survey used to derive the wattage of compliant lamps, or the "efficient option."

DNV KEMA/Cadmus Shelf Survey 2012

Cadmus coordinated with DNV KEMA staff managing work order 28 (WO28) shelf surveys in California to augment WO28 data collection activities to include portable lighting fixtures. During August and September 2012, DNV KEMA staff members conducted the shelf survey in retail stores across California to gather data needed to assess compliance and energy consumption. DNV KEMA staff members visited four stores in each region of California, as shown in Table 84. They visited both chain and non-chain stores.

77 http://www.energy.ca.gov/appliances/2008rulemaking/documents/2008-04-01_workshop/2008-04-04_Pacific_Gas_&_Electric_Portable_Lighting_Fixtures_CASE_Study.pdf

78 http://www.energy.ca.gov/efficiency/lighting/VOLUME01.PDF p.34

Table 84. Portable Lighting Shelf Survey Sample

	Region	Chain / Non-Chain	Store Name	City
1	North	Chain	Sears	Oakland
2	North	Chain	Fry's Electronics	Concord
3	North	Chain	Office Depot	Emeryville
4	North	Non-Chain	Berkeley Lighting Company	Berkeley
5	Central	Chain	Lowe's	Visalia
6	Central	Chain	Pier 1 Imports	Fresno
7	Central	Chain	Target	Merced
8	Central	Non-Chain	James & Co Lighting	Fresno
9	South	Chain	Walmart	Long Beach
10	South	Chain	Home Depot	City of Industry
11	South	Chain	IKEA	Costa Mesa
12	South	Non-Chain	Uni-Lite Lighting	Anaheim

DNV KEMA staff members recorded information by hand for each unique portable lamp model encountered. They noted the brand, model number, quantity in stock, lamp type, and other data specified in the data collection form. After visiting the store, the same staff entered the information gathered into an Excel worksheet. Staff sent scans of the completed data collection forms to Cadmus. After obtaining the shelf survey results in an Excel workbook, Cadmus checked a sample of the Excel entries against the scanned data collection forms for consistency.

Cadmus calculated the unit energy savings for floor and table lamps separately. First, we determined the baseline wattage using the KEMA Socket Inventory from 2008-2009, an unpublished dataset composed of socket information for more than 1,000 California homes. This baseline represents the average wattage of installed portable lighting fixtures before Std 24 came into effect. The average table lamp wattage was 36.2W (n=5,267). The average floor lamp wattage was 55.1W (n=129,892).

To calculate the efficient option wattage, we used the DNV KEMA/Cadmus 2012 shelf survey data, which examined a sample of portable lighting fixtures on retail store shelves across California after Std 24 took effect. The average wattage for compliant table lamps was 12.1W (n=3,892). The average wattage for compliant floor lamps was 16.1W (n=1,323). Compliance calculations using the shelf survey are discussed later in this memo.

Table 85 summarizes the baseline and efficient option wattages.

Table 85. Baseline vs. Efficient Option Wattages

Lamp Type	Baseline Wattage (W)	Efficient Option Wattage (W)
Table	36.2	12.1
Floor	55.1	16.1

We calculated unit energy savings for table and floor lamps with the following equation:

$$\begin{aligned}&Annual\ Unit\ Energy\ Savings\ (kWh)\\&= Unit\ Demand\ Savings\ (W) \times\ Annual\ Hours\ of\ Use\ (h) \times \frac{1\ kW}{1{,}000\ W}\\&= (Baseline\ wattage - Efficient\ wattage) \times (Daily\ HOU\ \times 365\ days \times \frac{1\ kW}{1{,}000\ W})\end{aligned}$$

We obtained hours of use (HOU) from the Lighting Efficiency Technology Report (1999)—the same source from which the CASE Report gathered HOU information. We used a daily HOU of 1.96 for table lamps and a daily HOU of 2.30 for floor lamps.

The annual unit energy savings for table lamps is 17.2 kWh and 32.7 kWh for floor lamps.

$$\begin{aligned}&Annual\ Unit\ Energy\ Savings\ for\ table\ lamps\ (kWh)\\&= (36.2\ watts - 12.1\ watts) \times \left(1.96 \frac{hours}{day} \times 365\ days\right) \times \frac{1\ kW}{1{,}000\ W} = 17.2\ kWh\end{aligned}$$

$$\begin{aligned}&Annual\ Unit\ Energy\ Savings\ for\ floor\ lamps\ (kWh)\\&= (55.1\ watts - 16.1\ watts) \times \left(2.30 \frac{hours}{day} \times 365\ days\right) \times \frac{1\ kW}{1{,}000\ W} = 32.7\ kWh\end{aligned}$$

Potential Energy Savings

Potential Annual Energy Savings

We calculated the annual savings using the following equation and the parameters listed below in Table 86.

$$\begin{aligned}&Annual\ Savings\ (GWh)\\&= \#\ Units\ Purchased\ Annually\ \times Annual\ Unit\ Energy\ Savings\ (kWh) \times \frac{1\ GWh}{1{,}000{,}000\ kWh}\end{aligned}$$

Table 86. Potential Energy Savings Parameters

Lamp Type	Number of Units Purchased Annually	Annual Unit Energy Savings (kWh)
Table	1,462,837	17.2
Floor	1,693,906	32.7

$$Annual\ Savings\ (GWh) for\ table\ lamps = 1{,}462{,}837 \times 17.2k\ Wh \times \frac{1\ GWh}{1{,}000{,}000\ kWh} = 25.2\ GWh$$

$$Annual\ Savings\ (GWh) for\ floor\ lamps = 1{,}693{,}906\ \times 32.7\ kWh \times \frac{1\ GWh}{1{,}000{,}000\ kWh} = 55.4\ GWh$$

Summing the annual savings for table and floor lamps, the total potential energy savings from portable lighting is 80.6 GWh.

Potential Demand Savings

We calculated potential demand savings using the following equation:

$$\text{Potential demand savings } (MW)$$
$$= \#\,\text{Units Purchased Annually} \times \text{Unit Demand Savings } (W) \times \%\text{ on at peak} \times \frac{1\,MW}{1{,}000{,}000\,W}$$
$$= \#\,\text{Units Purchased Annually} \times (\text{Baseline wattage} - \text{Efficient wattage}) \times \%\text{ on at peak} \times \frac{1\,MW}{1{,}000{,}000\,W}$$

The CASE Report used the Lighting Efficiency Technology Report (1999)[79] to estimate that 7% of portable lamps were on at peak. We used lighting statistics about household lamp distribution and load shapes from the Lighting Efficiency Technology Report to independently estimate this value. By scaling the percentage of lights on during peak by the proportion of portable lighting, we estimated that 11% of table and 12% of floor lamps (11% of portable lamps total) were on at peak.[80] We calculated the percent "on" at peak for each lamp type as described later in this section.

Table 87 lists the parameters we used to calculate potential demand savings.

Table 87. Potential Demand Savings Parameters

Lamp Type	Number of Units Purchased Annually	Delta Watts (W)	Percent On at Peak
Table	1,462,837	24.1	11%
Floor	1,693,906	39.0	12%

$$\text{Potential demand savings for table lamps}$$
$$= \#\,\text{Units Purchased Annually} \times \text{Delta Watts } (W) \times \%\text{ on at peak} \times \frac{1\,MW}{1{,}000{,}000\,W}$$
$$= 1{,}462{,}837 \times 24.1\,W \times .11 \times \frac{1\,MW}{1{,}000{,}000\,W} = 3.72\,MW$$

$$\text{Potential demand savings for floor lamps}$$
$$= \#\,\text{Units Purchased Annually} \times \text{Delta Watts } (W) \times \%\text{ on at peak} \times \frac{1\,MW}{1{,}000{,}000\,W}$$
$$= 1{,}693{,}906 \times 39\,W \times .12 \times \frac{1\,MW}{1{,}000{,}000\,W} = 8.13\,MW$$

79 http://www.energy.ca.gov/efficiency/lighting/VOLUME01.PDF

80 We used a peak of 7PM when lighting usage in the Lighting Efficiency Technology Report (1999) reached a daily maximum.

Summing the potential demand savings for table and floor lamps, we calculated a total potential demand savings of 11.8 MW.

Table 88 compares evaluated potential savings with the CASE Report estimates. The evaluated units per year were lower than the CASE Report estimate, but the evaluated energy savings exceeded CASE estimates by nearly a factor of two. The evaluated potential demand savings were slightly lower than the CASE Report projected.

Table 88. Annual Portable Lighting Energy and Demand Savings

Item	Cadmus Evaluation	CASE Report
Units per Year	3,156,743	3,700,000
Unit Energy Savings (kWh)	Table: 17.2 Floor: 32.7	14.0
Unit Demand Savings (W)	Table: 2.5 Floor: 4.8	18.7*
First Year Potential Energy Savings (GWh)	80.7	45
First Year Potential Demand Savings (MW)	11.8	4.2

*The CASE Report divides up portable lighting into three categories: screw-based lamps, ENERGY STAR compliant fixtures, and non-screw-based halogen lamps. The number presented here is a weighted average of screw-based lamps and ENERGY-STAR compliant fixtures based on lamp distribution assumptions on page 13 of the CASE Report: 90% of sales are screw-based lamps, which have unit demand savings of 19 W. Five percent (5%) of sales are ENERGY STAR compliant fixtures, which have unit demand savings of 32 W. Five percent (5%) of sales are non-screw-based halogen lamps, which have no unit demand savings.

F.6.3 Appliance Compliance

Compliance Analysis

Cadmus used information gathered during the portable lighting shelf survey to determine the compliance rate for portable lighting. To calculate listed compliance, Cadmus matched product information from the shelf survey with the CEC's compliant lighting product list. To calculate unlisted compliance, Cadmus checked product information from the shelf survey against the five requirements listed in Std 24. The next section describes the methodology in detail.

Exempted Products

Before calculating the compliance rate, we prepared the shelf-survey results spreadsheet by dropping exempted product categories. Std 24 indicates wall-mounted and artwork lamps may be exempted. In addition to dropping the exempted lamps, we also dropped lamps categorized as "strip," "spotlight," and "other" (78 lamps) because they did not fit the definition of portable luminaire. We dropped lamps that were not packaged with enough information for us to determine compliance (2,115) lamps. Finally, we removed products manufactured before the Std 24 effective date of January 1, 2010 (2,019 lamps). In total, we dropped 4,212 lamps out of 11,161 lamps (37.7%) from the shelf survey.

Compliance

To determine listed compliance, Cadmus matched the brand and model number listed in DNV KEMA's shelf study to their counterparts in the CEC's compliant product list. For products whose model numbers appeared on the CEC list, but did not match based on brand, we manually verified that the brands were indeed different and not alternate brand names (e.g., Mainstays is a Walmart brand).

To determine unlisted compliance, we examined lamps not found in the CEC list for a match with one of the five criteria listed in Std 24.

For compliance option 1, we checked that fixtures had a fluorescent socket with an electronic ballast. Thirty-five lamps met this criterion.

For compliance option 2, we checked that fixtures had a GU-24 line-voltage socket that was not rated for use with incandescents. One lamp met this criterion.

For compliance option 3, we checked that LED fixtures met standard requirements for light output, efficacy, CCT, CRI, and power factor. Only a few LED lamps had the requisite information to determine compliance under this option, and none of them qualified for compliance.

For compliance option 4, we checked whether fixtures had Edison screw sockets compatible with LEDs or CFLs and that they included lamps compatible with controls. This option was the largest compliance category, with 6,033 lamps.

For compliance option 5, we checked whether fixtures had a halogen socket that was 100W or less and had a light level control. Under this option, 109 lamps qualified.

We checked for double counting and made sure that each bulb qualified for only one type of unlisted compliance. Finally, we manually checked the noncompliant bulbs to ensure they were actually noncompliant.

Compliance Results

Table 89 shows the total compliance rate is 92.9%. However, the majority of compliant units were not listed in the CEC appliance database.

Table 89. Compliance Results

Category	Number in Database	% of Bulbs
Noncompliant	490	7.1%
Total Compliant	6,459	92.9%
Listed Compliant	281	4.0%
Unlisted Compliant 1	35	.5%
Unlisted Compliant 2	1	0%
Unlisted Compliant 3	0	0%
Unlisted Compliant 4	6,033	86.8%
Unlisted Compliant 5	109	1.6%
Total	6,949	100%

F.6.4 Percent of Lamps On at Peak

To check the CASE Report's estimate of percentage of lamps on at peak, we derived an independent estimate from the same source, the Lighting Efficiency Technology Report (1999). We used "Figure 2 - 33 Percent of Lights On, by Hour, by Room[81]" to obtain the percentage of residential lights on during peak hours between 2 and 5PM on weekdays.

Next, we obtained the number of portable lamps in each room from the table "Residential Lighting Applications, Sorted by Room Type."[82] Combining the two data sources, we obtained the number of portable lamps on at peak. Table 90 and Table 91 show the inputs and results of the calculations. Aggregating across rooms, we estimate that 11% of table lamps and 12% of floor lamps are on at peak.

81 Lighting Efficiency Technology Report. 1999. P. 44.

82 Lighting Efficiency Technology Report. 1999. P. 60-61.

Table 90. Percentage of Table Lamps on at Peak

Room Type	Percent of Lights on at Peak per Room	Table Lamp Fixtures per Room	Number of table lamp fixtures on at peak per room
Living Room	14%	17,322	36,003
Bedroom	8%	25,631	51,162
Den	15%	3,061	8,056
Kitchen/Dining	16%	1,075	40,070
Utility	0%	693	14,772
Garage	0%	273	13,519
Yard-Porch	0%	166	29,626
Hall/Entry	6%	250	18,581
Bathroom	7%	370	31,649
Total	N/A	48,841	243,438
Percentage of tables lamps on at peak		11%	

Table 91. Percentage of Floor Lamps on at Peak

Room Type	Percent of Lights on at Peak per Room	Floor Lamp Fixtures per Room	Number of floor lamp fixtures on at peak per room
Living Room	14%	6,118	857
Bedroom	8%	2,747	220
Den	15%	840	126
Kitchen/Dining	16%	251	40
Utility	0%	0	0
Garage	0%	0	0
Yard-Porch	0%	136	0
Hall/Entry	6%	0	0
Bathroom	7%	0	0
Total	N/A	10,092	1,242
Percentage of tables lamps on at peak		12%	

F.7 Standards 28a/28b – Televisions: Tier 1 and Tier 2

F.7.1 Introduction and Summary of Findings

This memo describes Cadmus' evaluation of potential energy savings and compliance for California Title 20 (T20) Standard 28a: Televisions, Tier 1. Since Standard 28b: Televisions, Tier

2, did not take effect until after the 2010-2012 program cycle, we provide a projection of the potential energy savings, which may feed into the next program evaluation cycle.

Standard 28a (Std 28a) is a California standard applying to televisions with a screen size under 1,400 square inches, and manufactured after January 1, 2011. Standard 28b (Std 28b) applies to televisions with a screen size under 1,400 square inches, manufactured after January 1, 2013. Televisions must meet the criteria shown in Table 92 and be CEC certified to officially comply with the standard.

Table 92. TV Qualifying Criteria

Standard	Effective Date	Screen Size (Area A in Square Inches)	Maximum TV Standby-Passive Mode Power Usage (Watts)	Maximum On Mode Power Usage (P in Watts)	Minimum Power Factor for **(P ≥ 100W)**
Standard 18a	January 1, 2006	All	3 W	No standard	No standard
Std 28a – Tier 1	January 1, 2011	A < 1,400	1 W	P ≤ 0.20 * A + 32	0.9
Std 28b – Tier 2	January 1, 2013	A < 1,400	1 W	P ≤ 0.12 * A + 25	0.9

Table 93 summarizes evaluation results for Std 28a and forecast for Std 28b and the original IOU estimates.

Table 93. 2010-2012 Evaluation Results for Std 28a and Std 28b

Value	Std 28a: Tier 1		Std 28b: Tier 2	
	Evaluated	Original IOU Estimate*	Projected	Original IOU Estimate*
Units Per Year	3,338,000	4,000,000	3,338,000	4,000,000
Unit Energy Savings (kWh/year)	110	132	102	84
Unit Demand Savings (W)	10	12.48	9	7.55
First Year Potential Energy Savings (GWh)	367	349	342	256
First Year Potential Demand Savings (MW)	33	33	29	23
Compliance Rate	98%	85%	N/A**	85%

* Estimates provided by the California IOUs on May 13, 2011, in response to EEGA data request 1465, 1466, 1467, and 1468.

**We were not able to determine compliance for standards not in effect during the 2010-2012 program cycle.

The following sections describe Cadmus' approach and findings for each value listed in Table 93.

F.7.2 Potential Energy Savings – Tier 1 and 2

The ISSM model requires two values: the size of the California market, in units sold per year, and unit energy savings, as shown in Equation 4.

Equation 4. Annual Energy Savings

$$\textit{Annual Potential Savings} = \#\,\textit{Units Purchased Annually} \times \textit{Unit Energy Savings}$$

We begin our potential energy savings analysis with a review of the market size.

Market Size

We used several information sources to estimate the television market size:

- NPD Group: Point of Sale (POS) Tracking Data for California. These data encompass an estimated 60% of television market transactions, and track and report actual sales share from over 60 NPD channel partners with brick and mortar stores across the United States. They do not currently include: e-commerce/catalog sales, Wal-Mart, Costco, or "mom and pop" shops. Data are recorded at the product category, brand/manufacturer, and model level. At the model level, models unique to a particular retailer are aggregated into an "all other" model level category due to retailer confidentiality limitations preventing finer granularity. Data from the entire POS database, including information from retailer specific models, are also aggregated (for unit share) by: display size; ENERGY STAR® Version;[83] LCD vs. plasma; and other factors. This provides a more complete picture of the attributes of the POS dataset. The blank database, provided below, offers an example of the types of information available.
- NPD Group: Consumer Panel Data for the Pacific Census Region.[84] NPD collects this data through an online consumer panel, consisting of more than 1.8 million registered adults and teens who agree to participate in the surveys. NPD has applied sampling and weighting techniques to ensure online representation of all demographic groups. This approach offers an advantage in measuring a product's total market size, regardless of distribution channels. Data collected include: brand purchased; channel purchased; retailer; price; reason for purchase; product attributes; sale vs. full price; and demographics. All data from NPD are proprietary; Cadmus purchased both NPD datasets for Cadmus internal use only. Both datasets contain quarterly information from Q3 2010 through Q2 2012.
- 2010 Census population data, shown in Table 94.

Table 94. 2010 Census Population

Region	2010 Census Population	Percent of U.S.
California	37,253,956	12.07% of U.S. 74.69% of Pacific Region
Pacific Census Region*	49,880,102	16.16%
U.S.	308,745,538	100%

* Alaska, California, Hawaii, Washington, Oregon.

83 NPD determines if a unit is ENERGY STAR by matching the model number with the list of qualified models on the energystar.gov Website.

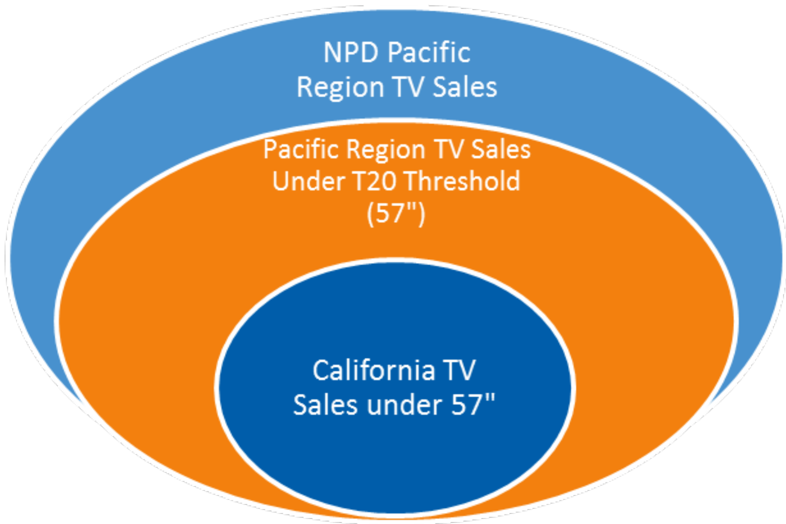
84 Alaska, California, Hawaii, Washington, and Oregon.

- The 2008 Television CASE Report and supporting data.[85]

Standards 28a and 28b regulate televisions under 1,400 square inches. Assuming a 16:9 aspect ratio, and using the Pythagorean theorem, Cadmus determined the corresponding diagonal display size to be 57 inches. Models over this display size are not subject to T20 regulations and are left out of our market size estimate.

Cadmus refined the NPD Consumer Panel Pacific region sales volume data through the process in Figure 35 to determine the size of the California television market subject to the standard.

Figure 35. Defining the California Market Size for Tier 1 Televisions



In the first step, we calculated the number of sales attributable to units under 57 inches. Using NPD POS data, which provided data at the quarterly level, we calculated the fraction of 57-inch or smaller units sold between the first quarter in 2011 through the second quarter of 2012. We then multiplied this fraction (96%) by the quarterly Pacific region unit sales, and summed each quarter to determine total Pacific region sales for 2011 and for the first half of 2012 (for 57-inch or smaller units).

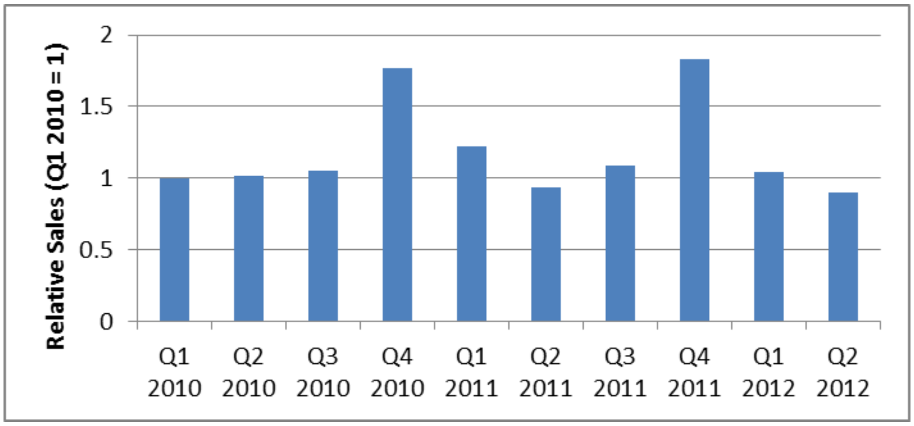
To project annual sales for 2012, we used the following equation.

$$2012\ Projected\ Annual\ Sales = \frac{2012\ Q1\ and\ Q2\ Sales}{2011\ Q1\ and\ Q2\ Sales} \times 2011\ Annual\ Sales$$

We chose not to double the 2012 sales through the first half of the year to determine annual sales because of strong seasonal sales trends (shown in Figure 36).

85 Chase, Alex. July 3, 2008. Analysis of Standards Options for Televisions Revised Proposal. Energy Solutions.

Figure 36. Pacific Region Normalized TV Sales Volume by Quarter



Next, using U.S. Census population data, we determined the fraction of Pacific region sales under 57 inches to be allocated to California. Table 95 summarizes the results for 2011, 2012, and an average of the two years.

Table 95. Tier 1 and 2 Television Annual Market Size

Source	CA 2011 TV Sales Under 57"	CA 2012 TV Sales Under 57"*	Average CA TV Sales
Cadmus Evaluation (2012)	3,484,000	3,191,000	3,338,000
CASE Report (2008)	4,200,000	4,300,000	4,300,000

* Projected from sales through the first half of the year.

Compared to values in the 2008 CASE Report, average evaluated unit sales for 2011 and 2012 were lower by nearly a million units. The revised CASE Report was published in 2008, right at the start of the financial crisis, thus the analysis would not have factored in the impact of the poor economy in ensuing years. The CASE Report approach was to combine estimated television shipments to North America from DisplaySearch[86] (2007) with the fraction of the North American population represented by the United States and California to estimate total units shipped to each region.

Tier 1: Unit Energy Savings

Energy savings for Std 28a occur primarily due to restrictions on the active and passive mode power draw. Analysis of energy savings utilized the following data sources:

- NPD POS (2012).
- Revised Television CASE Report (2008).

86 DisplaySearch is an NPD Group Company.

- Wazzan, C., and D. Eash. 2011. "A Review of the 2011 and 2012 Digital Television Energy Efficiency Regulations Developed and Adopted by the California Energy Commission." The California Journal of Politics and Policy. Vol 3, Issue 1.
- Nielsen Company A2/M2 Three Screen Report, 4th Quarter 2008.[87]
- Nielsen Company Three Screen A2M2 Presentation 2010.[88]
- King, Darrell, and R. Ponoum. February 2011. Power Consumption Trends in Digital Televisions Produced Since 2003. TIAX LLC.
- Roth, Kurt, and K. McKenney. December 2007. Energy Consumption by Consumer Electronics in U.S. Residences. TIAX LLC.

Cadmus calculated annual kWh consumption using the following equation, where T equals annual hours of use and P equals power. Subscripts refer to the mode (active or passive).

$$kWh = T_{active} \times P_{active} + T_{passive} \times P_{passive}$$

Energy savings could then be calculated based on the consumption difference between a typical baseline and a compliant unit. This memo presents our savings analysis, after the following background sections:

- Hours of use in each mode, per television;
- Average screen size;
- Market share by display technology type; and
- Mapping of ENERGY STAR to Title 20 (the NPD POS data contain information on: the ENERGY STAR version, the ENERGY STAR active mode power, and ENERGY STAR standby power).

Active and Passive Mode Hours of Use

Cadmus reviewed various data sources regarding hours of use in active and passive modes (shown in Table 96). Assuming users normally leave televisions plugged into outlets and the penetration of smart strips is negligible, the calculation for number of passive hours per year is as follows.

$$T_{passive} = 8{,}760 - T_{active}$$

87 http://blog.nielsen.com/nielsenwire/wp-content/uploads/2009/02/3_screens_4q08_final.pdf

88 http://blog.nielsen.com/nielsenwire/wp-content/uploads/2010/01/Nielsen-3screen-CES-2010.pdf

Table 96. Comparison of Annual Active Mode Hours for TVs

Report/Original	Active Hours per Year	Hours per Day
Nielsen (2008)	1,899	5.2
Wazzan and Eash (2011) using Nielsen (2008)	3,134	8.6
CASE Report (2008) using TIAX (2007)	1,882*	5.2
Cadmus Evaluation (2012) using TIAX (2007)	2,120	5.8

*This value represents only the residential sector; the final CASE Report value shows 1,907 hours, and is weighted between residential and commercial sectors (commercial sector assumptions: 12 hours per day and 1% end-use saturation).

The first two sources, derived directly from Nielsen or a Nielsen report, represent minimum and maximum bounds for active hours of use. The Nielsen (2008) report's hours per year represents average television viewing per individual, and only includes live television and playback. It does not include hours of use coupled with DVDs or game consoles, nor does it account for time left on without being viewed. This is the lower bound on active hours of use. Wazzan and Eash use total daily viewing times by all household members. As some family members may watch the same television together, using total household viewing time may overstate active mode usage.

In reality, households include multiple people and televisions. The TIAX 2007 report indicated larger units were more likely to be primary televisions in homes, and, as such, operated in active mode more hours per day than smaller units. This report summarized results from a 2006 consumer survey, developed by the Consumer Electronics Association, which asked consumers about active mode usage for primary, secondary, and other televisions.

The CASE Report uses analog television annual active usage from the TIAX 2007 report. Cadmus used the same data source, but chose the value specified for digital televisions, as analog televisions have been phased out of the market. Both TIAX 2007 values fell within the expected range bracketed by Nielsen data.

Average Screen Size and Display Type

Table 97 lists market shares by display types contained in the CASE Report, and calculated from NPD POS data. Technologies other than liquid crystal display (LCD) or plasma should be considered negligible. The CASE Report cites DisplaySearch 2007 data; the 2011-2012 NPD POS data for California indicate the market composition by display type has not changed significantly. For our analysis, we used NPD data from 2011-2012.

Table 97. TV Market Share by Display Type

	LCD	Plasma
CASE Report	88%	11%
NPD POS	86%	14%

Table 98 shows average screen size referenced in the CASE Report and as Cadmus calculated from NPD data. The CASE Report screen size is inclusive of all screen sizes while ours is for only models that are less than 1,400 square inches.

Table 98. Average Size (Square Inches) by Display Type

	LCD	Plasma	Weighted Average
CASE Report*	604	1,068	Not Used
Cadmus Calculation**	N/A	N/A	516***

* Referenced screen size based on projections for 2011 from DisplaySearch (2007), which is over all screen sizes.

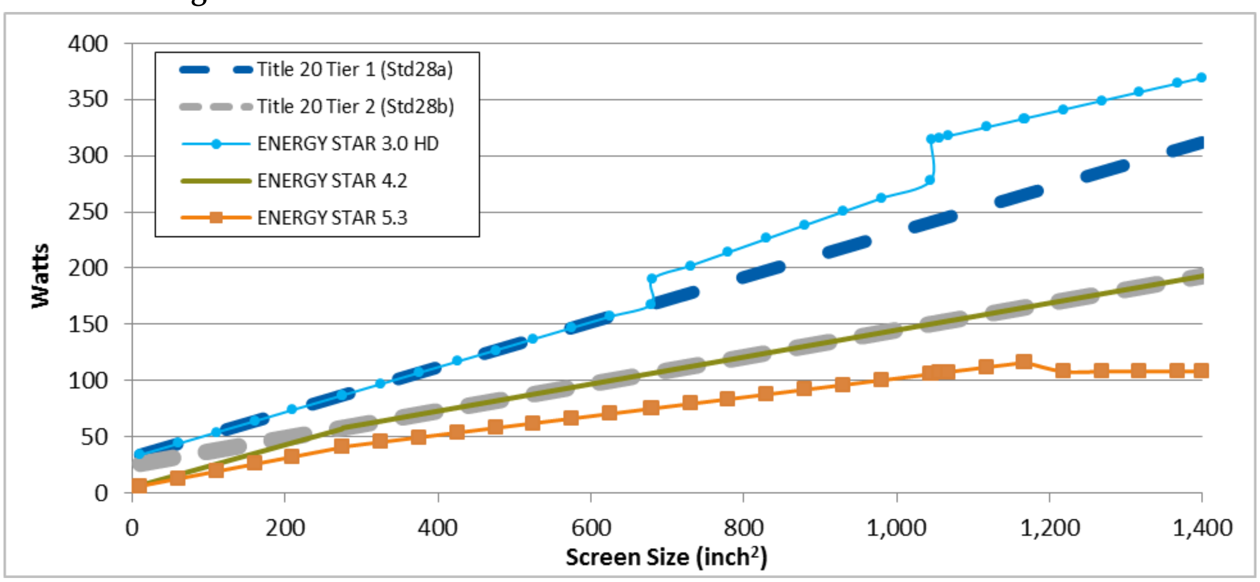
** Calculated using NPD POS data from 2011-2012

*** Only includes units under 1,400 square inches.

ENERGY STAR to Title 20 Active Mode Power Mapping

The NPD data provide aggregated active mode power consumption statistics for all ENERGY STAR models. To determine whether ENERGY STAR 3.0 and above can serve as a proxy for determining active power mode consumption for Tier 1 compliant models in the NPD data, Cadmus plotted the T20 and ENERGY STAR maximum allowable power (in watts) as a function of screen size (Figure 37). The figure shows ENERGY STAR 3.0 is less stringent than the Tier 1 standard for models with screen size above 680 square inches.

Figure 37. Maximum Active Mode Power as a Function of Screen Size



CASE Report Unit Energy Savings

The CASE Report author analyzed a PG&E-provided television dataset (2008) to determine the unit energy consumption and unit energy savings for LCD and plasma TVs. These values are reproduced in Table 99. Cadmus used the distribution from Table 97 to find the weighted average energy consumption and savings for all display types, per the NPD market shares. Note the CASE Report does not include passive mode power in the unit savings calculation.

Table 99. CASE Report Average Television Active Mode Energy Consumption and Savings

Display Type	Unit Energy Consumption (kWh/yr)			Unit Energy Savings (kWh/yr)	
	Base Case**	Tier 1	Tier 2	Tier 1 (Base minus Tier 1)	Tier 2 Incremental (Tier 1 minus Tier 2)
LCD	335.2	238.0	196.9	97.2	41.3
Plasma	719.7	468.4	292.1	251.3	176.3
Weighted Average*	389	270	210	119	60

*Cadmus used weighting values of 86% for LCD and 14% for Plasma

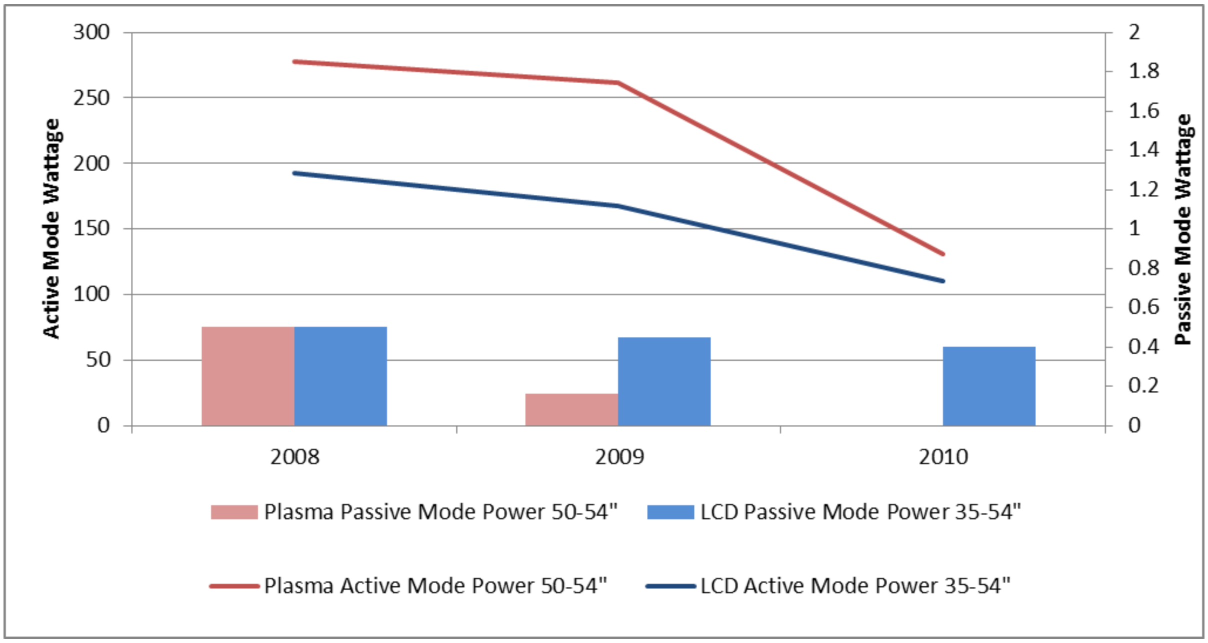
** The Case Report base case is derived from TVs in the PG&E TV dataset that do not qualify for the tier 1 standard

Cadmus Derived Unit Energy Savings

Per a Commission decision regarding the baseline to use for gross savings calculations, Cadmus used data representing the market average efficiency before the standard became effective as the baseline for calculating unit energy savings (Figure 38).[89]

[89] D.10-04-029 p. 46, which defines the baseline for gross savings as the "previous standard or the prevailing market practice," and D.12-05-015 p. 351, which defines the baseline in absence of an existing code or standard as "[i]n the cases when there is no regulation, code, or standard that applies, which would normally set the baseline equipment requirements, the baseline must be established using a 'standard practice' choice. For purposes of establishing a baseline for energy savings, we interpret the standard practice case as a choice that represents the typical equipment or commonly-used practice, not necessarily predominantly used practice" should be used to define unit savings as the difference between prevailing market practice energy use of televisions and the energy use of televisions just meeting the standard.

Figure 38. Active and Passive Mode Power Draw*



*Data from TIAX 2011 report.

This figure, recreated from data from the TIAX (2011) report,[90] shows active and passive mode power draws for plasma and LCD displays decreased[91] before Std 28a took effect in January 2011. Because the active mode decrease between 2009/2010 is more significant than that from 2008/2009, this suggests manufacturers could have begun shipping Std 28a compliant models in 2010.[92] Therefore, Cadmus determined the baseline active mode power draw should correspond to 2009 values. We calculated the weighted average 2009 active mode power draw over all LCD and plasma units, which resulted in a baseline of 181 watts. Unlike the CASE Report approach, the TIAX (2011) data do not separate models meeting and not meeting the Tier 1 requirement; the data represent the entire market average prior to the standard taking effect, which factors in naturally occurring market adoption of models with lower power usage. For the passive mode

[90] Data from the Consumer Electronics Association (CEA) survey of various digital television manufacturers.

[91] It is unknown whether this decrease occurred naturally, or if manufacturers responded in anticipation of Std 28a taking effect.

[92] Our compliance analysis also indicates the models on the market in late 2010 were largely compliant with Std 28a.

power draw, we used the prior standard's requirement of 3 watts as the maximum power consumption.[93]

Cadmus calculated the Tier 1 active mode power consumption based on the maximum power allowed by the standard for the average size television (listed in Table 98).

$$P_{active} = 0.2 \times 516 + 32 = 135 \text{ W}$$

Summarizing the savings analysis to this point, Table 100 shows active and passive power draws of the base case and Tier 1 case.

Table 100. Evaluated Power and Hours by Mode; Unit Energy Savings: Tier 1

Mode	Base Case (W)	Tier 1 (W)	Hours/Year	kWh Savings/Year
	(A)	(B)	(C)	(A-B)*C/1,000
Active	181 (market average*)	135 (tier 1 maximum allowed)	2,120	96.5
Passive	3 (prior standard)	1 (tier 1 maximum allowed)	6,640	13.3
Total			8,760	110

*Data from the TIAX (2011) report for the year 2009

The unit average energy savings is 110 kWh per Tier 1 compliant television. Both base case and Tier 1 average power draws in our evaluated savings analysis were lower than values used in the CASE Report (refer to Table 99).

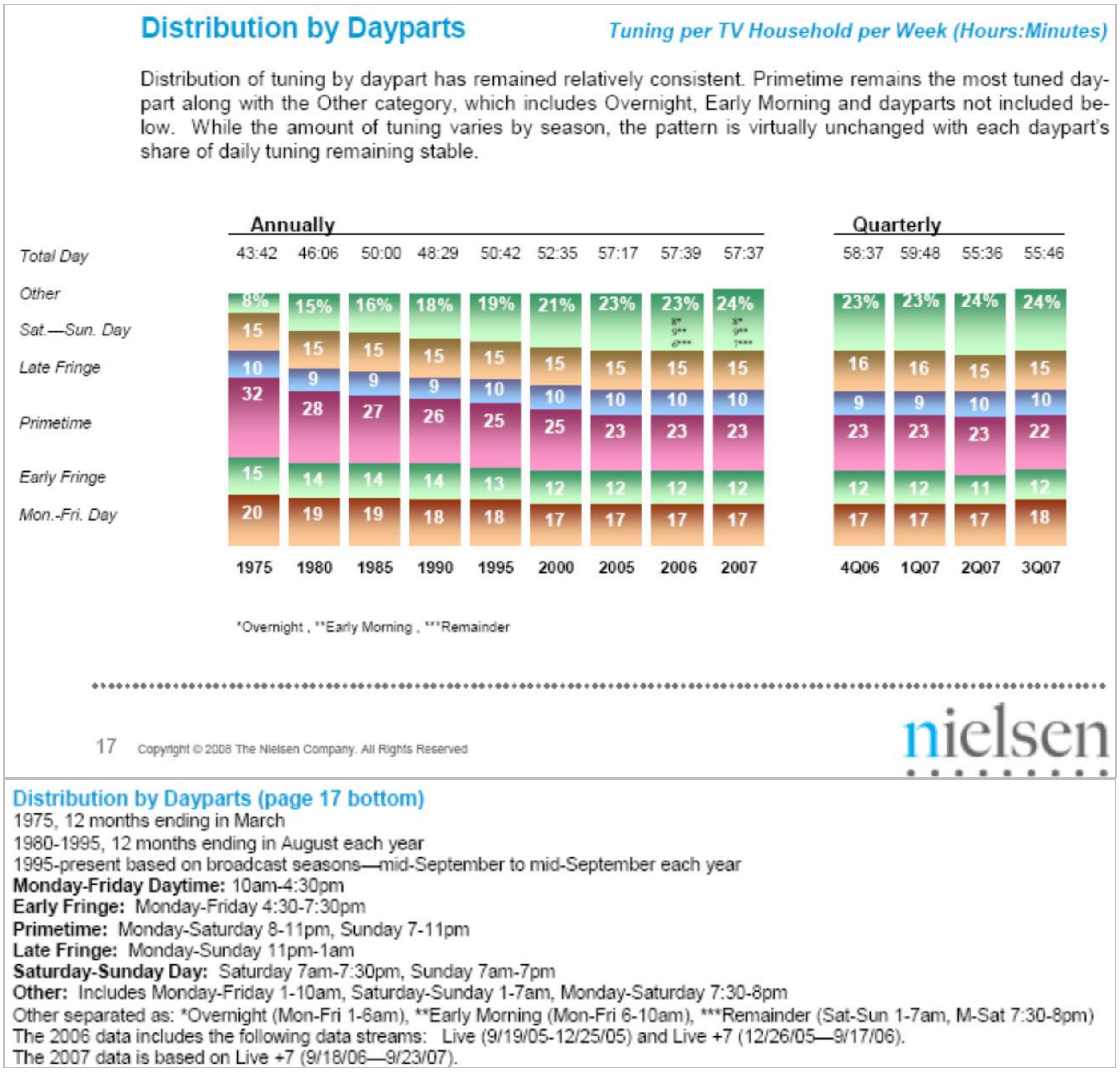
Cadmus Derived Demand Savings

The CASE Report's supporting information includes estimates for active mode demand savings. The peak, according to the 2013 DEER Update for Codes and Standards, the peak occurs between 2pm and 5pm. Figure 39 shows distributions of television tuning by dayparts, which remain relatively consistent over time. The Monday through Friday daytime and early fringe viewing corresponds to peak demand periods; in the third quarter of 2007, 18% of hours spent viewing television were coincident with the peak. The CASE Report also uses a coincidence factor[94] of 18%.

[93] The 2009 weighted average passive mode power draw is 0.41 watts, according to the TIAX data. This value of 0.41 watts is lower than that required by the Tier 1 standard. Using the 0.41 value as the baseline would lead to a negative savings when using the Tier 1 standard level as the efficient case.

[94] The CASE Report uses the term: "Peak Hour Load Share."

Figure 39. Distribution of TV Tuning per Household by Dayparts*



* Copied from the CASE Report supporting data;
source: Nielsen Media Research 2008. Television Audience 2007.

Using 18% as the coincidence factor for the active mode and 82% as the coincidence factor for the passive mode, we calculated demand savings, as shown in Table 101.

Table 101. TV Unit Demand Savings: Tier 1

Mode	Base Watts	Tier 1 Watts	Wattage Difference	Coincidence Factor	Demand Savings (W)
Active	181	135	46	0.18	8.3
Passive	3	1	2	0.82	1.6
Total					9.8

Tier 2: (Projected) Unit Energy and Demand Savings

Table 102 shows analysis results for TV Tier 2 unit energy and demand savings. Cadmus used the same active mode hours and coincidence factors used in the Tier 1 analysis. No passive mode savings were calculated as the standard does not prescribe a change in the maximum passive mode power. Cadmus calculated the Tier 2 power draw using the average screen size. Results are incremental to the Tier 1 findings.

Table 102. Tier 2 Unit Energy and Demand Savings and Inputs

Tier 1 (Baseline) Power Draw (W)	Tier 2 Power Draw (W)	Active Mode Hours	Energy Savings (kWh/year)	Coincidence Factor	Demand Savings (W)
135	87	2,120	102.4	0.18	8.7

The CASE Report, which was based on older data, estimates the unit energy savings is 56 kWh/year, which is lower than Cadmus' findings.

Potential Energy Savings

Table 103 summarizes annual energy and demand savings from Cadmus' evaluation of Std 28a: Tier 1 and Std 28b: Tier 2. The table includes values from the CASE Report for comparison. The CASE Report had higher potential energy savings overall because it used higher estimate of units sold per year and higher unit energy/demand savings. Tier 2 evaluated potential energy savings were higher than those in the CASE Report due to significantly higher unit savings.

Table 103. Annual TV Energy and Demand Savings

	Tier 1			Tier 2		
	Cadmus Evaluation	CASE Report	Original IOU Estimate	Cadmus Evaluation	CASE Report	Original IOU Estimate
Units per Year	3,338,000	4,360,000	4,000,000	3,338,000	4,360,000	4,000,000
Unit Energy Savings (kWh/year)	110	113*	132	102	56*	84
Unit Demand Savings (W)	10	11**	12.48	9	5**	7.55
First Year Potential Energy Savings (GWh)	367	482	349	342	243	256
First Year Potential Demand Savings (MW)	33	46	33	29	23	23

*Cadmus weighted between LCD and plasma.

** CASE Report uses a coincidence of 18%; Cadmus weighted between LCD and plasma.

Appliance Compliance: Std. 28a – Tier 1

Cadmus used NPD POS data at the model level to estimate compliance for products regulated by T20 (televisions under 1,400 square inches). The analysis included the following two compliance definitions (with models failing to meet either definition considered noncompliant):

- Listed Compliance: A model could be considered listed compliant if the model number in the NPD POS data was included in the CEC's current list of compliant models. We did not check the CEC list's accuracy; the CEC has retained another contractor to conduct a compliance study.
- Unlisted Compliant, ENERGY STAR: This category applied to models not on the CEC list, but still meeting power consumption requirements for Std 28a. ENERGY STAR 3.0 or higher models in the dataset are considered to be unlisted compliant, as ENERGY STAR 3.0 meets the requirements of Tier 1, up to 680 square inches. For models meeting ENERGY STAR 3.0 over 680 square inches, we checked if the model's power draw met Tier 1 requirements to determine whether it could be considered unlisted compliant. Models meeting ENERGY STAR 4.2 or 5.3 were automatically considered unlisted compliant.
- Unlisted Compliant, Non-ENERGY STAR Products: The NPD dataset did not contain information on power draw for non-ENERGY STAR labeled products. Cadmus attempted to obtain power-draw data for models with market share data by conducting a web search for model specifications. For those found, a product was considered unlisted compliant if it met the active mode energy consumption requirements. Models for which there was no data were excluded from the analysis. The total market share of these excluded models did not exceed 2% in any quarter.

Cadmus calculated quarterly compliance rates using the following equations:

$$\text{Listed Compliance Rate} = \frac{\sum_{known\ models} Market\ Share \times \begin{cases} 1\ if\ \mathbf{listed}\ compliant \\ 0\ if\ non-compliant \end{cases}}{\sum_{known\ models} Market\ Share}$$

$$\text{Unlisted Compliance Rate} = \frac{\sum_{known\ models} Market\ Share \times \begin{cases} 1\ if\ \mathbf{unlisted}\ compliant \\ 0\ if\ non-compliant \end{cases}}{\sum_{known\ models} Market\ Share}$$

$$Overall\ Compliance\ Rate = Listed\ Compliance\ Rate + Unlisted\ Compliance\ Rate$$

The NPD POS data did not show all televisions scanned at the model level. Models sold through only one retailer were aggregated into a line item called "all other" to represent the market share of those models. Thus, we normalized our calculation based on the number of models that we could evaluate individually for compliance.

Table 104 summarizes Std 28a's quarterly compliance rate, with the overall 2011–2012 compliance estimate (98%) based on compliance by quarter weighted by quarterly sales.

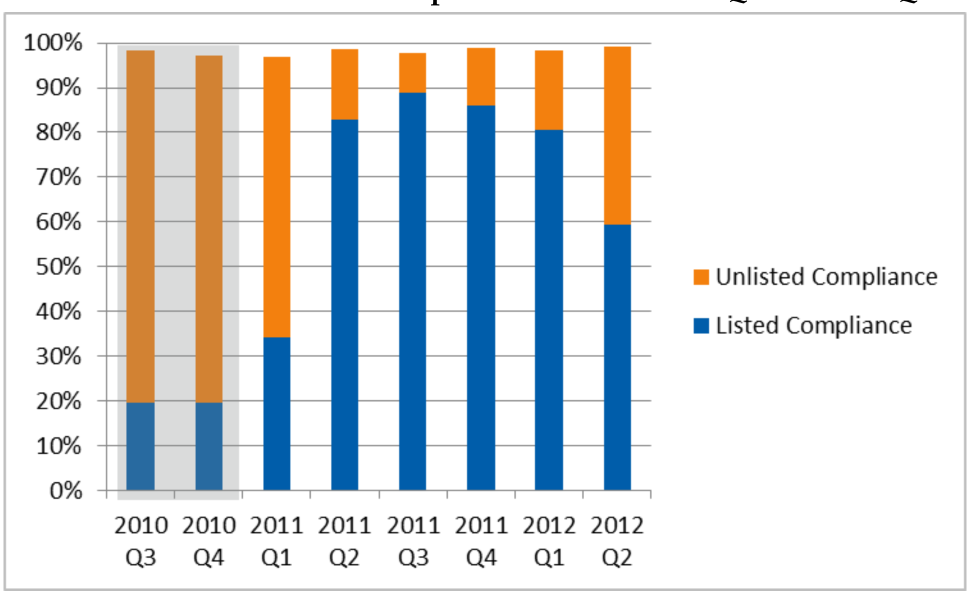
Table 104 also shows the "compliance rate" during the two quarters prior to the standard taking effect.

Table 104. Compliance with Standard 28a (Listed and Unlisted)

Compliance	2010 Q3	2010 Q4	2011 Q1	2011 Q2	2011 Q3	2011 Q4	2012 Q1	2012 Q2	2011–2012 Weighted Value
Listed Compliance	20%	19%	34%	83%	89%	86%	81%	60%	73%
Unlisted Compliance	79%	78%	63%	16%	9%	13%	18%	40%	26%
Overall Compliance	98%	97%	97%	99%	98%	99%	98%	99%	98%

As shown in Figure 40, the overall compliance rate started high, prior to the standard taking effect (shaded grey background), and remained high. A large proportion of models sold during the last two quarters of 2010 and the first quarter of 2011 were unlisted compliant. Listed compliance increased rapidly after the standard took effect. Lags in updating the CEC list could explain why listed compliance fell in the second quarter of 2012.

Figure 40. Listed and Unlisted Compliance Rate between Q3 2010 and Q2 2012*



*Calculated from NPD Data

Pre-2011 Standard Compliance Rate in 2010

Cadmus also examined the historical compliance rate with the pre-2011 standard, using the CEC's list of models compliant with the pre-2011 standard and the NPD POS dataset. Table 105 shows, during the last two quarters of 2010 when the pre-2011 standard was in effect, 100% compliance with the prior standard.

Table 105. Compliance with Pre-2011 Standard

	2010 Q3	2010 Q4	Pre-2011 Weighted Compliance Rate
Listed Compliance	44%	43%	44%
Unlisted Compliance	55%	57%	56%
Overall Compliance Rate	100%	100%	100%

F.8 Standards 31/32 – Battery Chargers: Updated Shipment Numbers and Sources

The amendments proposed originally to California's appliance efficiency regulations would regulate three types of battery charger systems, with effective dates between 2012 and 2013. Subsequently, the California Energy Commission's 15-day language, issued in December 2011, changed the effective dates to those listed below.[95]

- Consumer products (non-universal serial bus [USB] with a battery capacity of 20 watt-hours or more) manufactured on or after February 1, 2013.
- Large battery charger systems and consumer products (USB with a capacity of 20 watt-hours or more) manufactured on or after January 1, 2014.
- Small battery charger systems that are not consumer products manufactured on or after January 1, 2017.

When the California IOUs provided energy savings estimates to the evaluators (in May 2011) it was expected that the standards for the first two categories described above would take effect in 2012. For this reason, work to evaluate the IOU estimates began. After the effective dates for these standards changed, Cadmus responded by reallocating evaluation resources to other standards, since battery charger standards were not expected to save any energy during the 2010-2012 evaluation period.

The following sections provide a summary of the research that Cadmus had conducted to evaluate potential savings prior to the change in effective dates. This includes preliminary research on the size of the market for a variety of product categories that would be affected by battery charger standards. This memo provides updates to the sales numbers reported in the battery charger Codes and Standards Enhancement (CASE) Initiative report (2010),[96] including sales numbers from 2011, and summarizes data sources that could be used in the next program cycle impact evaluation.

95 http://www.energy.ca.gov/2011publications/CEC-400-2011-005/CEC-400-2011-005-15-DAY.pdf

96 http://www.energy.ca.gov/appliances/battery_chargers/documents/2010-10-11_workshop/2010-10-11_Battery_Charger_Title_20_CASE_Report_v2-2-2.pdf

F.8.1 Sales Figures for 2011

The CASE Report (2010) estimates potential energy savings for battery chargers based on 2009 stock and sales figures for various end-use product classes across three primary segments: small consumer products, small non-consumer products, and large non-consumer products.

Cadmus researched annual battery charger sales for 2011. Many of the market research reports we found provide sales figures at the national level. To estimate California sales, we scaled national sales estimates by population as shown in Table 106.

Table 106. 2011 Population Estimates

Region	2011 Population	% of U.S.
California	37,691,912	12%
U.S.	311,591,917	100%

Source: http://www.census.gov/popest/data/state/totals/2011/tables/NST-EST2011-01.xls

Table 107 shows 2009 sales figures from the CASE Report[97] along with sales figures for 2011 for selected products from Cadmus' preliminary market research.[98] In our data collection, we prioritized products that accounted for a higher percentage of total savings in the CASE Report. Though we found information sources for most product categories, we did not obtain all of the relevant reports we found as some were only available for purchase.[99] For these categories, the 2011 California sales numbers are listed as "not purchased." For other categories, we secured preliminary information that needs further processing in order to estimate unit sales, and these categories sales are listed as "N/A." We did not investigate categories with low potential savings as part of this preliminary research.

97 Derived from a variety of sources; the majority of data is U.S. national sales or stock.

98 A key to the data sources is provided at the end of Table 106, and links to sources are provided at the end of this memo.

99 To conserve limited resources, Cadmus did not purchase these reports for the 2010-2012 evaluation

Table 107. 2009-2011 Product Sales

Segment	Product Class	Details	CASE Report		Cadmus Research	
			% of Potential Savings	2009 CA Sales	2011 CA Sales	Data Source
Small Consumer	Auto/Marine/RV	Marine Chargers	30%	180,000	N/A	N/A
		Auto/RV Chargers			701,601	GIA
	Cell Phones	Cell phones	1%	28,270,000	20,132,430	CEA
		Cell phone accessories (Bluetooth headset)			N/A	CEA
	Cordless Phones	Cordless Phones	7%	3,210,000	1,253,688	CEA
	Emergency Systems	Power (uninterruptible power supply)	7%	2,600,000	Not purchased	NPD
		Security (security system)			N/A	CEA
	Golf Carts/ Electric Carts	Golf carts	5%	17,000	N/A	N/A
		Neighborhood electric vehicles (NEV)			1,783	EDTA
	Laptops	Laptops	16%	4,570,000	7,171,205	CEA
	Lighting	Lanterns	0%	10,000	N/A	N/A
		Flashlights			N/A	N/A
	Personal Care	Oral Care (rechargeable toothbrush)	1%	1,840,000	N/A	N/A
		Hair Trimmers/ Clippers (beard trimmer)			1,475,781	HWB
		Shavers (men's and women's shavers)			222,577	HWB
	Personal Electric Vehicles	Electric wheelchairs	4%	40,000	Not purchased	N/A
		Electric scooters			N/A	N/A
	Portable Audio Electronics	iPods, MP3 players	1%	10,520,000	4,386,577	CEA
		Portable CD players			351,163	CEA
	Portable Electronics	Toys (remote controlled car)	1%	2,000,000	4,672,297	CEA
		Video (digital camera)			4,560,041	CEA
		Video (video camera)			660,351	CEA
		Consumer two-way radios			697,004	CEA
	Power Tools	Electric House Wares (fan)	11%	2,870,000	4,366,859	HWB
		Electric House Wares (cordless vacuum)			2,395,119	HWB
		Outdoor Appliances (lawn and garden tools, lawn mower)			N/A	N/A
		Power Tools (cordless drills, saws, screwdrivers)			Not purchased	Freedonia
	Universal Battery Chargers	Universal Battery Chargers	0%	110,000	Not purchased	NPD

Segment	Product Class	Details	CASE Report		Cadmus Research	
			% of Potential Savings	2009 CA Sales	2011 CA Sales	Data Source
Small Non-Consumer	Emergency Backup Lighting	Emergency Backup Lighting	2%	75,000	N/A	N/A
	Handheld Barcode Scanners	Handheld Barcode Scanners	2%	780,000	N/A	N/A
	Commercial Two-Way Radios	Commercial Two-Way Radios	0%	300,000	N/A	N/A
Large Non-Consumer	Lift-Trucks	Lift-Trucks	11%	7,000	11,903	MMH
Total			100%	57,000,000	N/A	N/A

Sources:
CEA: Consumer Electronics Association
EDTA: Electric Drive Transportation Association
Freedonia: The Freedonia Group
GIA: Global Industry Analysts, Inc.
HWB: HomeWorld Business
MMH: Modern Materials Handling
NPD: NPD Group

In addition to the market research sources presented in Table 107, Cadmus reviewed the U.S. Department of Energy's (DOE) battery charger technical support document and supporting workbook.[100] The DOE's workbook contains information on its sources and methods for estimating product shipments. The DOE estimated 436,597,500 consumer products with battery charger systems were sold nationally in 2009.[101]

Our research shows changes in sales trends for several product categories between 2009 and 2011.

- Cordless phones sales had been declining since 2005 and continued to decline between 2009 and 2011.[102]
- Laptop sales had been increasing since 2003 and increased significantly between 2009 and 2011.[103]
- Portable audio player sales peaked in 2007 and have been dropping since, as reflected by 2009 and 2011 sales.[104]

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100 http://www1.eere.energy.gov/buildings/appliance_standards/pdfs/bceps_nopr_tsd.pdf

101 http://www1.eere.energy.gov/buildings/appliance_standards/residential/docs/bceps_preanalysis_market.xlsx

102 http://store.ce.org/FastFacts-Historical-Sales-Data--January-2013_p_485.html. We purchased the July 2012 edition of this data, which is no longer available.

103 http://store.ce.org/FastFacts-Historical-Sales-Data--January-2013_p_485.html.

- Lift truck sales have increased since 2009, as a result of increased economic activity after the recession.[105]

Sales for two categories differed significantly between the CASE Report and our findings, indicating additional research should be conducted in the future to understand the reason for discrepancies.

- Auto/marine battery charger sales for 2011, as reported by Global Industry Analysts, Inc. (GIA), are over three times higher than the value in the 2009 CASE Report.[106]
- The Consumer Electronics Association (CEA) reports sales of over ten million portable electronic devices for 2011—more than five times higher than the CASE estimate.[107]
- The CEA's data for portable electronic sales are similar in 2009 and 2011. The difference in magnitude between the values in the CASE Report and CEA data may be due, in small part, to the CEA's wider definition of an e-toy.[108]

F.8.2 Sources and Contacts

Below are the sources and contacts for the market research reports in Table 107.

- CEA: Fast Facts at http://store.ce.org/FastFacts-Historical-Sales-Data--January-2013_p_485.html. Cadmus purchased the July 2012 version, which is no longer available in the CEA store.
- HomeWorld Business: Annual Housewares Census: http://www.homeworldbusiness.com/links/research/research_01.php
- Electric Drive Transportation Association (EDTA): http://www.electricdrive.org/index.php?ht=d/Items/cat_id/27087/pid/27089/sortby/date/direction//paginateItems/5/paginateItemsPage/1/
- Freedonia: Power & Hand Tools to 2016: http://www.freedoniagroup.com/DocumentDetails.aspx?DocumentId=592481

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104 http://store.ce.org/FastFacts-Historical-Sales-Data--January-2013_p_485.html.

105 http://www.mmh.com/article/60_seconds_with_jim_moran_chairman_of_ita/

106 http://www.strategyr.com/Battery_Chargers_Market_Report.asp

107 http://store.ce.org/FastFacts-Historical-Sales-Data--January-2013_p_485.html

108 The CEA's definition includes "any electronic educational devices, handheld electronic games, radio controlled vehicles, other battery operated vehicles, robots and electronically controlled action figures, musical instruments and karaoke machines and any toys with WiFi and/or USB connectivity."

- Global Industry Analysts: Battery Chargers at http://www.strategyr.com/Battery_Chargers_Market_Report.asp
- Modern Materials Handling (MMH): http://www.mmh.com/article/60_seconds_with_jim_moran_chairman_of_ita/ and http://mmh.com/images/site/MMH1108_EquipRpt_LiftTruckBasics.pdf
- NPD Group: Communications with a Public Sector and Government Client Specialist.

F.9 Federal 1 – Electric Motors 1-200 HP

This memo describes Cadmus' evaluation of potential energy savings and compliance for the Federal appliance standard, Fed 1, covering electric motors. The standard applies to electric motors manufactured on or after December 19, 2010, and is summarized in Table 108.

Table 108. Electric Motor Standard (Fed 1)

Appliance	Horsepower (HP)	Minimum Nominal Full-Load Efficiency (as referenced in NEMA MG-1 [2006] Table)
General purpose electric motors (subtype I)	1 to 200 HP	Table 12-12; NEMA Premium
NEMA Design B, general purpose electric motors	201 to 500 HP	Table 12-11; ; NEMA Energy Efficient
General purpose electric motors (subtype II)	1 to 200 HP	Table 12-11; NEMA Energy Efficient
Fire Pump Motors	All	Table 12-11; NEMA Energy Efficient

EPACT 1992 set the prior motor standard, which regulated certain commercial and industrial electric motors (primarily subtype I under 200 HP). EISA 2007 set the standard (Fed 1) that took effect in 2010, which:

1. Raised the subtype I motor requirements to NEMA premium levels
2. Expanded the EPACT scope of coverage to include subtype II motors up to 200 HP and NEMA design B motors from 200 HP to 500 HP.

Definitions of subtype I, subtype II, and NEMA Design B motors from the U.S. Department of Energy's Preliminary Technical Support Document: Energy Conservation Standards for Electric Motors (July 23, 2012) follow:

> *"General Purpose Electric Motors (Subtype I) Definition*
>
> As a result of the recent electric motors test procedure final rule, 10 CFR 431.12 now defines a general purpose electric motor (subtype I) as a general purpose electric motor that:
>
> (1) Is a single-speed, induction motor;
>
> (2) Is rated for continuous duty (MG1) operation or for duty type S1 (IEC);
>
> (3) Contains a squirrel-cage (MG1) or cage (IEC) rotor;
>
> (4) Has foot-mounting that may include foot-mounting with flanges or detachable feet;

(5) Is built in accordance with NEMA T-frame dimensions or their IEC metric equivalents, including a frame size that is between two consecutive NEMA frame sizes or their IEC metric equivalents;

(6) Has performance in accordance with NEMA Design A (MG1) or B (MG1) characteristics or equivalent designs such as IEC Design N (IEC);

(7) Operates on polyphase alternating current 60-hertz sinusoidal power, and:

(i) Is rated at 230 or 460 volts (or both) including motors rated at multiple voltages that include 230 or 460 volts (or both), or

(ii) Can be operated on 230 or 460 volts (or both); and

(8) Includes, but is not limited to, explosion-proof construction.

General Purpose Electric Motors (Subtype II) Definition

Further, the recent electric motors test procedure final rule amended 10 CFR 431.12 and defined a general purpose electric motor (subtype II) as any general purpose electric motor that incorporates design elements of a general purpose electric motor (subtype I). Unlike a general purpose electric motor (subtype I), a subtype II motor is configured in one or more of the following ways:

(1) Is built in accordance with NEMA U-frame dimensions as described in NEMA MG1–1967 (incorporated by reference, see § 431.15) or in accordance with the IEC metric equivalents, including a frame size that is between two consecutive NEMA frame sizes or their IEC metric equivalents;

(2) Has performance in accordance with NEMA Design C characteristics as described in MG1 or an equivalent IEC design(s) such as IEC Design H;

(3) Is a close-coupled pump motor;

(4) Is a footless motor;

(5) Is a vertical solid shaft normal thrust motor (as tested in a horizontal configuration) built and designed in a manner consistent with MG1;

(6) Is an eight-pole motor (900 rpm); or

(7) Is a polyphase motor with a voltage rating of not more than 600 volts, is not rated at 230 or 460 volts (or both), and cannot be operated on 230 or 460 volts (or both).

NEMA Design B Electric Motor Definition

Also, as a result of the electric motors test procedure final rule, 10 CFR 431.12 defines a NEMA Design B electric motor as a squirrel-cage motor that is:

(1) Designed to withstand full-voltage starting;

(2) Develops locked-rotor, breakdown, and pull-up torques adequate for general application as specified in sections 12.38, 12.39 and 12.40 of NEMA MG1– 2009 (incorporated by reference, see § 431.15);

(3) Draws locked-rotor current not to exceed the values shown in section 12.35.1 for 60 hertz and 12.35.2 for 50 hertz of NEMA MG1–2009; and

(4) Has a slip at rated load of less than 5 percent for motors with fewer than 10 poles.

NEMA MG1-2009 establishes the same torque requirements for both NEMA Design A and NEMA Design B electric motors. However, NEMA Design B electric motors must be designed such that their locked-rotor (or starting) current is less than that established for NEMA Design A electric motors. Unless the application specifically requires a NEMA Design Ad electric motor design, NEMA Design B electric motors are often used instead of Design A electric motors because of the smaller spike in startup current. NEMA Design B electric motors are designed for continuous-duty operation and are commonly used in pumps, fans, blowers, and compressors."

Our evaluation focused on subtype I and II motors under 200 HP, and design B motors over 200 HP. Fire pump motors constitute a negligible part of the motor market and were not studied.

Table 109 summarizes the results of our evaluation of the potential energy savings (California) and compliance rate for Fed 1.

Table 109. Evaluation Results for Fed 1

Item	Evaluation Result	Original IOU Estimate*
Units per Year (California)	254,280	526,670
Unit Energy Savings (kWh)	575	1,000
Unit Demand Savings (W)	79	137
First Year Potential Energy Savings (GWh)**	146.2	527
First Year Potential Demand Savings (MW)**	20.1	72
Compliance Rate	91%	95%

*The IOUs provided these values in response to a data request (EEGA 1465, 1466, 1467, and 1468)

** First year potential is for the United States in the IOU Estimate and for California only in the Evaluation Result.

The following sections describe our approach and findings for each component listed in Table 109.

Potential Energy Savings

Cadmus' analysis of the Fed 1 potential energy savings used Tables 5 and 6 of the CASE Report as the starting point in our analysis. The key difference between our analysis approach and that from the CASE Report was that the CASE Report analyzed both EPACT and non-EPACT regulated motors going to NEMA Premium efficiency levels, while our analysis does not include non-EPACT regulated motors going to NEMA Premium efficiency levels (NEMA table 12-12) since the standard only requires they reach NEMA efficiency levels (NEMA table 12-11).

Market Size

Cadmus used several sources of information to estimate the market size for motors regulated under Federal Standard 1:

- U.S. Department of Energy. Preliminary Technical Support Document (PTSD) Energy Efficiency Program for Commercial Equipment: Energy Conservation Standards for Electric Motors; July 23, 2012
- ACEEE. Analysis of Standards Options for Integral Horsepower Electric Motors; December 29, 2006 (This is the document we will be referring to as the CASE Report.)
- Energy Solutions. Codes and Standards Program Change Theory for Federal Electric Motors; Prepared; May 2012
- NEMA News. "Motor Shipments Fell Sharply in Third Quarter of 2012;" December 2012
- EIA. Electricity Sales by end-use sector, state, and utility; 2011

First, Cadmus calculated the average annual number of national motor shipments from 2010 to 2011 using data from NEMA and the DOE national impact analysis for motors. Cadmus relied on the DOE's PTSD market estimate[109] for the following reasons: 1) the PTSD analysis provided an estimate of motor sales during the evaluation period, 2) the PTSD analysis included input from NEMA (which represents most North American manufacturers), and 3) the PTSD analysis estimated market volume for manufacturers that are not NEMA members. Our next step was to calculate the number of motors shipped to California (using the same approach as the CASE Report) by multiplying national shipments by a factor accounting for California's share of national electricity use in the commercial and industrial sectors and the relative electricity use of motors in these two sectors. These calculations resulted in an estimate of slightly more than 6.5% of national sales of motors in each size range going to California. Table 110 shows the estimated shipments by HP range for the U.S. and California. An estimated 282,500 motors were shipped to California each year during the 2010-2012 evaluation period, with most motors under 20 HP in size.

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[109] The evaluators use market estimates for product categories such as motors where data from manufacturers are not available.

Table 110. Average Annual Shipments from 2010 – 2012

HP Range	U.S.	California
1 – 5	2,528,409	165,269
6 – 20	1,296,426	84,741
21 – 50	324,106	21,185
51 – 100	108,035	7,062
101 – 200	43,593	2,849
201 – 500	21,797	1,425
Total	4,321,419	282,468

Adjustments for Regulated Motors

Not all motors sold are regulated by the federal standard. According to the CASE Report, 25% of motors from 1-200 HP and 90% of motors from 201-500 HP are regulated by the expanded coverage. Approximately 65% of all motors from 1-200 HP are impacted by the requirement that subtype I motors meet NEMA Premium efficiency levels. Table 111 shows the number of units regulated in California from each component of the standard after applying the above percentages to the total annual California shipments.

Table 111. California Motors Shipments Regulated by Fed 1

HP Range	Expanded Coverage to EPACT92 Levels (Subtype II and Design B over 200HP)	Subtype I Going to Premium Efficiency Levels	California Total Annual Shipments
1 – 5	41,317	107,425	148,742
6 – 20	21,185	55,081	76,266
21 – 50	5,296	13,770	19,067
51 – 100	1,765	4,590	6,356
101 – 200	712	1,852	2,565
201 – 500	1,282	-	1,282
Total	71,559	182,719	254,277

Unit Energy Savings

Cadmus used the following equation to calculate per unit energy savings for each motor HP range:

$$\text{kWh Savings} = \text{average HP} \times 0.746 \text{ kW/HP} \times \text{Load Factor} \times \text{Hours} \times (1/N_{Base} - 1/N_{EE})$$

N_{Base} and N_{EE} represent the motor efficiency for the base and efficient cases. To calculate demand savings, we divided the kWh savings by the operating hours and multiplied by the percent on at peak.

Table 112 summarizes the assumptions we used for average HP, operating hours, fraction of motors on at peak, and the load factor. We used the load factor from DEER instead of the 60%

assumed by the CASE Report and calculated the average HP using data from U.S. DOE; other values are the same as those used in the CASE Report.

Table 112. Savings Assumptions

HP Range	Average HP	Operating Hours	Pct. on at Peak	Load Factor
1 – 5	3.2	2,567	35%	75%
6 – 20	12.1	3,113	43%	75%
21 – 50	34.9	3,653	50%	75%
51 – 100	78.2	4,663	64%	75%
101 – 200	154.5	4,735	65%	75%
201 – 500	310.2	5,444	75%	75%
Data Source	Calculated from U.S. DOE Shipment Data	CASE Report	CASE Report	DEER 2005

Baseline and efficient levels depend on the type of motor. For subtype I motors going to NEMA premium levels, the weighted average EPACT efficiency levels were used as the baseline, while motors going to EPACT levels used values cited in the CASE Report and DOE for the baseline values.

Table 113 shows the values used to calculated annual unit savings for motors that were previously unregulated by EPACT.

Table 113. Unit Savings for Non-EPACT Regulated Motors Going to EPACT Levels

HP Range	Baseline Efficiency	Fed 1 Efficiency	Annual Savings (kWh)
1 – 5	79.80%	86.03%	420
6 – 20	86.30%	90.13%	1,038
21 – 50	89.90%	92.67%	2,371
51 – 100	92%	94.07%	4,875
101 – 200	94%	94.82%	5,744
201 – 500	95%	95.40%	4,170
Data Source	Nadel 2002, CASE Report, DOE Technical Support Document, Calculation	Weighted average of EPACT Efficiency Levels	Calculation

Table 114 shows the values used to estimate unit savings for subtype I motors going to NEMA Premium Efficiency Levels.

Table 114. Unit Savings for Subtype I Motors Going to NEMA Premium Efficiency Levels

HP Range	Baseline Efficiency	Fed 1 Efficiency	Annual Savings (kWh)
1 – 5	86.03%	88.27%	137
6 – 20	90.13%	92.09%	496
21 – 50	92.67%	93.90%	1,002
51 – 100	94.068%	95.272%	2,741
101 – 200	94.818%	95.764%	4,263
201 – 500	N/A	N/A	N/A
Data Source	Weighted average of EPACT Efficiency Levels	Weighted average of EISA Efficiency Levels	Calculation

Table 115 summarizes the first year energy and demand savings from multiplying the unit energy savings by the applicable sales.

Table 115. Potential Energy and Demand Savings

HP Range	Annual Applicable Sales	Annual Savings kWh/Motor	First Year Energy Savings (GWh)	First Year Demand Savings (MW)
Non-EPACT Motors going to EPACT				
1 – 5	41,317	420	17.4	2.4
6 – 20	21,185	1,038	22.0	3.0
21 – 50	5,296	2,371	12.6	1.7
51 – 100	1,765	4,875	8.6	1.2
101 – 200	712	5,744	4.1	0.6
201 – 500	1,282	4,170	5.3	0.7
EPACT Motors going to NEMA Premium Efficiency				
1 – 5	107,425	137	14.7	2.0
6 – 20	55,081	496	27.3	3.8
21 – 50	13,770	1,002	13.8	1.9
51 – 100	4,590	2,741	12.6	1.7
101 – 200	1,852	4,263	7.9	1.1
201 – 500	0	N/A	N/A	N/A
Total	254,277		146.2	20.1

Table 116 shows the results of the evaluation compared to the values in the CASE Report. The unit energy and demand savings are very similar; however, the evaluation results indicate the number of units per year affected is much greater than the CASE Report indicates. This is because the CASE Report used older data from U.S. Census Bureau 2003.

Table 116. Fed 1 and CASE Report Potential Energy Savings

Item	Evaluation Result	CASE Report
Units per Year	254,277	86,855
Unit Energy Savings (kWh)	575*	366*
Unit Demand Savings (W)	79*	51*
First Year Potential Energy Savings (GWh)	146.2	31.8
First Year Potential Demand Savings (MW)	20.1	4.4

* Calculated by dividing first year potential energy and demand savings by units per year

Appliance Compliance

Cadmus assessed the market compliance rate of motors through telephone surveys with motor distributors during the first quarter of 2013. The survey questions, provided later in this section, cover a range of topics from the respondents' 2012 sales volume to their awareness of the federal standard to estimates of the fraction of motors that meet NEMA Premium efficiency levels. We obtained nine completed survey responses and one partially completed response from distributors in both Northern and Southern California.

The distributors that we surveyed had sold, on average, approximately 487 motors per year to customers in California, with individual sales ranging from 60 to 2,750 motors in 2012. Of the distributors that responded, all nine[110] said that they were aware of the federal standard for electric motors ranging from 1 to 200 HP. When asked if they sold motors that were more efficient than premium efficiency, five out of nine said they did sell motors above NEMA's premium efficiency level. Three of these affirmative respondents noted that no customers had asked for such efficient motors.

We also asked distributors about their interactions with customers. The nine respondents estimated that, on average, customers mention energy efficiency 75% of the time when placing a motor order. Six out of eight[111] distributors reported discussing the standard with their customers. Most distributors thought that customers were generally aware of the standard. Two said that customers had no choice but to deal with the price increase, while two others reported that customers understood the benefits of using efficient motors.

We also asked distributors about barriers in the marketplace for efficient motors. Half of our respondents (three out of six[112]) did not think there were any barriers. Two reported that price was an issue; as one respondent noted, "Some people… just want the cheapest motor out

[110] One respondent did not answer this question.

[111] One respondent did not answer this question.

[112] The remaining respondents did not answer the question.

there." Another respondent noted that it is still possible to purchase certain products—56 frame motors, for example—that do not comply with the Fed 1 standard.

Cadmus calculated compliance based on self-reported results from distributors who estimated the proportion of their motors that met NEMA's premium efficiency levels. In Table 117 we list the 2012 sales weighted compliance rate for various motor horsepower ranges.

Table 117. Compliance Rates by Motor Horsepower

HP Range	Compliance Rate
1 – 5	90.5%
6 – 20	91.3%
21 – 50	90.4%
51 – 100	89.7%
101 – 200	89.2%

To calculate an overall compliance rate, we weighted the compliance rate from each horsepower range by the potential energy savings from Table 115 (excluding 201-500 HP motors) and obtained a savings weighted compliance rate of 91.4%.

F.9.1 Motor Distributor Survey Questionnaire

E1. First I want to confirm that you sell general-purpose (NEMA design A or B) motors that are 1HP or greater, is this correct?

1. Yes
2. No [thank and terminate]
98. Don't Know
99. Refused

E2. Do you market or promote the NEMA premium-efficiency electrical motors to your customers?

1. Yes
2. Yes [if mention required by federal law]
3. No
98. Don't Know
99. Refused

E3. How often do customers mention energy-efficiency when placing an order for motors? [0% - 100% of the time]

Record Response

E4. In general, what seems to be the most significant barrier to providing efficient motors to customers? [Probe: For example leftover inventory, lack of demand, higher cost, EPACT required levels]

Record Response

E5. I'm going to ask a few questions regarding general-purpose motors that your company sold in the past year meeting NEMA's premium efficiency levels. Please estimate as best you can what percentage of motors sold achieve this level of efficiency for various HP ranges. [Alternative: I'm now going to ask about the percent of motors your firm sold in the past year that met NEMA's premium efficiency levels. We'll cover five HP ranges.]

For…

HP Range	% Efficient (NEMA Premium Efficiency)
1-5	
6-20	
21-50	
51-100	
101-200	

E6. Do you sell motors that are more efficient than NEMA's premium efficiency?

1. Yes
2. No
98. Don't Know
99. Refused

E7. When was most of your inventory manufactured? Would you say they are fairly new, as in manufactured within the past three years?

Newer [Specify]
Older [Specify]
98. Don't Know
99. Refused

E8. Are you aware of current federal standards that require all general-purpose motors between 1 and 200 HP to meet NEMA's premium efficiency standard?

1. Yes
2. No
98. Don't Know
99. Refused

E9. [IF E8 = Yes] Have you spoken with your customers about these standards? What is their general disposition toward the standard?

Record Response

E10. How many motors (>1HP) did you sell to California customers in 2012? [Ballpark is all right; I just want a sense for order of magnitude]

Record Response

F.10 Federal 5 – Residential Ranges

F.10.1 Introduction and Summary of Findings

This memo describes Cadmus' evaluation of potential energy savings and compliance for standard Federal 5: Residential Electric and Gas Ranges, a federal standard applying to appliances manufactured after April 9, 2012 (Fed 5). Fed 5 states residential gas kitchen ranges, cooktops, and ovens without an electrical supply cord must not be equipped with a constant burning pilot light.[113] The federal standard that took effect in 1990 banned standing pilot lights in gas ranges and over that have an electrical supply cord.

Note: Gas cooking products use three basic ignition systems:[114] pilot, hot surface ignition, and spark ignition. The latter two can be considered "electronic ignition." Cordless models use pilot ignition or battery spark ignition.

Table 118 summarizes our evaluation results for the Fed 5 standard and the original IOU estimates.

Table 118. Evaluation Results for Fed 5

Value	Evaluation Result	Original IOU Estimate*
Units per Year	4,448	308,000
Unit Energy Savings (Therms/year)	30.5	10
First Year Potential Energy Savings (Therms)	135,664	3,080,000
Compliance Rate	100%	95%

* Estimates provided by the California IOUs on May 13, 2011 in response to EEGA data request 1465, 1466, 1467, and 1468.

The following sections describe Cadmus' approach and findings for each value listed in Table 118.

Potential Energy Savings

The Integrated Standards Savings Model (ISSM) model requires two values: the size of the California market, in units sold per year, and unit energy savings, as shown in Equation 5.

Equation 5. Annual Energy Savings

$$\textit{Annual Savings} = \#\ \textit{Units Purchased Annually} \times \textit{Unit Energy Savings}$$

The potential energy savings analysis began with a review of the market size.

113 http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/74fr16040.pdf

114 http://www.appliance411.com/faq/gas_range_ignition_systems.shtml

Market Size

Estimating cordless gas ranges' market size drew upon several information sources:

- Annual shipment data (national) from the Association of Home Appliance Manufacturers (AHAM) from 2000 to 2010. These data show ranges make up the majority of gas range types shipped (87%) shipped.
- Appliance Magazine Market Insights, June 2012 Edition (purchased), contained United States unit shipments of major kitchen appliances, through May of each year, from 2008 to 2012.
- 2010 Census population data, shown in Table 119.

Table 119. 2010 Census Population

Region	2010 Census Population	Percent of U.S.
California	37,253,956	12% of U.S. 75% of Pacific Region
Pacific Census Region*	49,880,102	16%
U.S.	308,745,538	100%

* Alaska, California, Hawaii, Washington, Oregon.

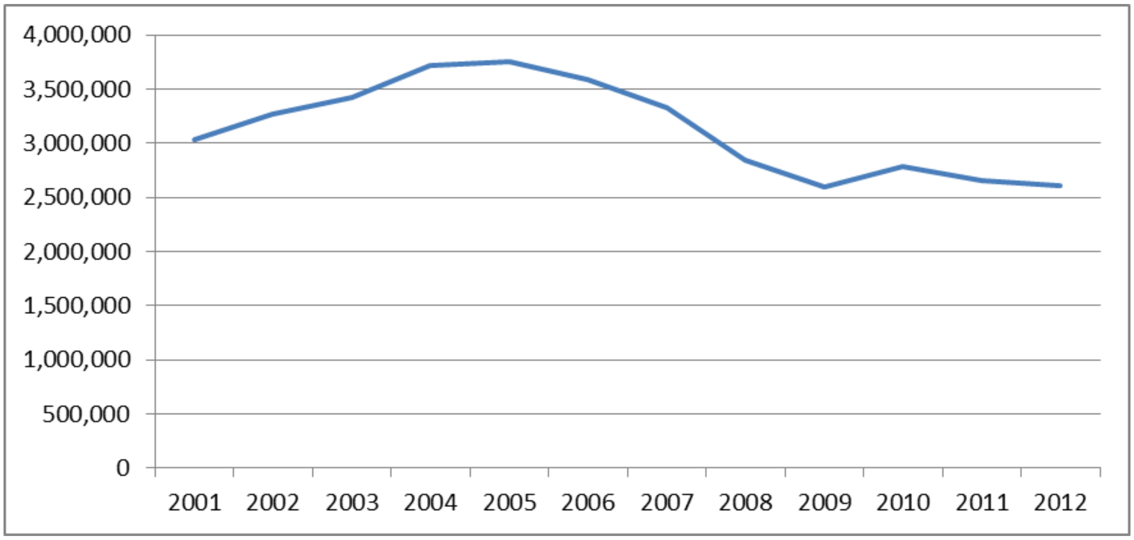
- Websites for Sears, Lowes, and Home Depot.[115]
- Websites for GE, Electrolux/Frigidaire, Maytag, Whirlpool, and Peerless Premier.[116]
- According to e-mail correspondence with the DOE and information contained in the Cooking Products Technical Support Document, 100% of cordless gas ranges on the market at the time of the standard development had pilot ignition systems.

Using AHAM data and Appliance Magazine Data, we estimated the number of gas range shipments (cordless and corded) within the United States, as shown in Figure 41.

115 Per *Appliance Magazine*, these outlets serve as the top appliance retailers.

116 According to the DOE technical support document, Chapter 3, these companies represent the top manufacturers in 2007, by market share.

Figure 41. U.S. Gas Range Shipments



We determined the number of California Gas Range Shipments (shown in Table 120) by multiplying the U.S. Gas Range Shipments by the percentage of the U.S. population represented by California residents (shown in Table 120). These numbers include both corded and cordless models.

Table 120. California Gas Range Shipments

	2010	2011	2012
Total California Gas Range Shipments	336,769	320,903	314,559

Next, we estimated the fraction of gas ranges without electrical supply cords on the market by reviewing major retailer and appliance manufacturer Websites for gas ranges, ovens, and cooktops. As noted above, gas cooking products use three basic ignition systems: pilot, hot surface ignition, and spark ignition. The latter two can be considered “electronic ignition.” Cordless models use pilot ignition or battery spark ignition.

Table 121 presents results from the manufacturer Website review. Cordless models tend to be lower-end products, and do not feature lights, exhaust fans, or clock features. Therefore, we reviewed the lowest-cost gas products in each category (range, cooktop, and oven), and also searched each Website for “cordless gas” models. When cord status could not be determined on the product specifications page, we reviewed product installation guides for electrical connection requirements. From the top five manufacturers, cordless models appeared to constitute 0.75% of total units.

Table 121. Manufacturer Website Review

Manufacturer	Market Share*	Number of Corded Models	Number of Cordless Models
GE	38%	116	1
Electrolux/Frigidaire	25%	97	0
Maytag	14%	48	0
Whirlpool	11%	57	0
Peerless Premier	7%	17	3
Others	5%	N/A	N/A
Fraction of cordless models, weighted by market share			0.75%

* From the U.S. Department of Energy's (DOE) Technical Support Document: Cooking Products

Table 122 shows the retailer Website review results. To find the number of cordless gas models, we searched for the term "cordless range" and filtered the results for appliances on each retailer Webpage.

Table 122. Retailer Website Review

	Number of Gas Ranges Online	Number of Cordless Gas Ranges
Sears	304	1
Lowes	343	1
Home Depot	174	18
Percentage of Models without Cords		2%

Results from the manufacturer and retailer reviews indicate the availability of cordless models is low. The top four manufacturers by market share did not produce the majority of cordless models identified. This suggests the result from the manufacturer websites is the lower bound, while the result from the retailer websites, which is not weighted by market share, could be an upper bound. Therefore, we chose to use the average (1.4%) as a proxy for the market fraction of cordless units, which we applied to total California shipments to determine the number of cordless gas ranges sold in California. Based on an average of California sales for 2011 and 2012 (317,731 units annually), we estimate cordless gas ranges have a 4,448-unit annual market size in California. The original IOU estimated number of installations is 308,000 units.

As the study examines a federal standard, a CASE Report was unavailable for review and comparison.

$$\begin{aligned}&\textit{California Market Size}\\&= 1.4\%\ \textit{Cordless Range Market Share} \times 317{,}731\ \textit{California Gas Ranges}\\&= 4{,}448\ \textit{Cordless Gas Range Units}\end{aligned}$$

Unit Energy Savings

Fed 5 energy savings result from elimination of a constantly burning pilot light. Our analysis assumed a natural gas-fed pilot, and utilized the following data sources:

- DOE Technical Support Document (TSD), Appendix 6A. Cooktops and Ovens: Determination of Energy-Using Components Table 6A.3.1 (reproduced in Figure 42). http://www1.eere.energy.gov/buildings/appliance_standards/residential/cooking_products_final_rule_tsd.html

Figure 42. Excerpt from DOE Cooking Products Technical Support Document

Table 6A.3.1 Gas Cooking Products: Energy-Using Components

Energy-Using Components	Cooktop		Standard Oven		Self-Cleaning Oven
	With pilot	Without pilot	With pilot	Without pilot	
Cooking Efficiency	39.9%	39.9%	5.92%	5.92%	7.13%
Cooking Energy (MMBtu/yr)	0.72	0.72	0.82	0.82	0.68
Self-Cleaning Energy					
Gas (MMBtu/yr)					0.17
Electric (kWh/yr)					0.7
Ignition					
Gas (MMBtu/yr)	2.02		1.01		
Electric (kWh/yr)				21.1	21.1
Clock (kWh/yr)*					31.5
Total					
Gas (MMBtu/yr)	2.74	0.72	1.83	0.82	0.85
Electric (kWh/yr)				21.1	55.1
Annual Useful Cooking Energy Output (O_{CT} for cooktops; O_O for ovens)					
Current DOE test procedure (kBtu)	527.6		88.8		88.8
Revised values (kBtu)	288.9		48.7		48.7

* Clock energy based on clock power of 3.6 W for self-cleaning ovens.

- Wisconsin Public Service (WPS) Gas Calculator: www.wisconsinpublicservice.com/home/gas_calculator.aspx
- Michael Bluejay Gas vs. Electric Cooking Calculator: http://michaelbluejay.com/electricity/gas.html

Table 123 shows results from three sources. Given these very similar values, we recommend using the average: 30.5 therms.

Table 123. Summary of Annual Pilot Light Energy Consumption Values

Source	With Pilot Light (Therms)	Without Pilot Light (Therms)	Pilot Light Consumption (Therms)
DOE TSD (Cooktop plus oven)	45.7	15.4	30.3
WPS	N/A	N/A	30.7*
Michael Bluejay (Default Values)	45.6	15.2	30.4

*From help file on Website.

Potential Energy Savings

Table 124 presents Fed 5 evaluated and original potential energy savings for California.

Table 124. California Annual Energy Savings

Value	Evaluated	Original IOU Estimated
Units per Year	4,448	308,000
Unit Energy Savings (Therms)	30.5	10
Potential Energy Savings (Therms)	135,664	3,080,000

The evaluated savings are significantly lower than the original estimate because of the large difference in number of installations.

F.10.2 Appliance Compliance

Cadmus evaluated the market compliance rate with Fed 5 by searching for gas ranges, ovens, and cooktops with pilot ignition systems. We reviewed Websites for Sears, Lowes, and Home Depot, and spoke with customer representatives via the Websites' live chat functions, asking representatives if their companies sold cordless gas ranges, and whether their units had pilot ignition systems. Table 125 summarizes the results. When customer representatives asked for location information from the Cadmus researcher, we referenced the 94539 ZIP code, located in Alameda County, CA.

Table 125. Retailer Web Chat Results

Retailer	Result	Retailer Compliance
Sears	Sears does not sell cordless units with piloted ignition; the representative did not know where else to find units with pilot ignition.	100%
Lowes	Lowes does not sell cordless units with piloted ignition; they sell only electric ignition units. When asked where we could find a cordless model, the representative sent the request to the local store in Fremont, CA, for follow up. The local store representative could not refer us to another store selling cordless ranges.	100%
Home Depot	The customer representative pointed us to a number of cordless models using interrupted spark ignition that used a battery. These models do not use a pilot light and are only available online.	100%

No retailer we spoke with sold cordless gas ranges with pilot ignition systems, nor could they successfully refer us to another California retailer selling cordless ranges with pilot ignition systems. This indicates the compliance rate is 100%.

F.11 Federal 7 – General Service Fluorescent Lamps

F.11.1 Introduction and Summary of Findings

This memo describes the findings from Cadmus' evaluation of potential energy savings and compliance for Federal Standard 7, General Service Fluorescent Lamps (Fed 7). A subcomponent of EISA 2007, Fed 7 took effect on July 14, 2012 and regulates general service fluorescent lamps (GSFLs). The 2010-2012 Codes and Standards Evaluation Plan specifies that Cadmus will evaluate compliance as well as potential energy savings for Fed 7. The performance requirements for GSFLs are provided in Table 126.

Table 126. Performance Requirements of GSFLs from EISA 2007 Regulation

Lamp Type	Correlated Color Temperature	New Standards (Lumens per Watt)
4' (T8 and T12) Medium Bi-Pin	<4500K >4500K and <7000K	89 88
2' (T8 and T12) U-Shaped	<4500K >4500K and <7000K	84 81
8' (T8 and T12) Slimline	<4500K >4500K and <7000K	97 93
8' (T8 and T12) High Output	<4500K >4500K and <7000K	92 88
4' (T5) Miniature Bi-Pin Standard Output	<4500K >4500K and <7000K	86 81
4' (T5) Miniature Bi-Pin High Output	<4500K >4500K and <7000K	76 72

Specifically, GSFLs that must meet these new standards include:

- 2′ medium bi-pin U-shaped lamps with rated wattage >25W and <28W
- 4′ medium bi-pin with wattage >25W and <28W
- 4′ T5 miniature bi-pin straight shaped with wattage >26W
- 4′ T5 miniature bi-pin straight shaped with wattage >49W
- 8′ recessed, double contact rapid start high output lamps
- 8′ single pin instant start slimline lamps >52W

The U.S. Department of Energy (DOE) has granted exceptions to allow manufacturers to continue selling GSFLs that do not meet the new performance criteria for upwards of two years and beyond.[117] These exceptions are primarily for 700 series lamps that are covered within the regulation. These 700 series lamps are typically 32 watt T8 GSFLs, which are one of the most popular products in the market due to their energy efficiency in comparison to 40 watt T12 GSFLs and their cost in comparison to the more energy-efficient 800 series which is typically a 28 watt T8 GSFL.

An updated federal standard for GSFLs is due in 2014, which is scheduled to take effect in 2017.

117 U.S. Department of Energy. "Building Technologies Program: General Service Fluorescent Lamps." Accessed January 28, 2013. http://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/70.

Table 127 summarizes Cadmus' evaluation results for Fed 7, along with the original IOU estimates.

Table 127. California Annual Energy Savings from GSFLs

Factor	Evaluation Results	Original IOU Estimate*
Units per Year	20 million	3.2 million
Unit Energy Savings (kWh/year)	32.4	1,000
Unit Demand Savings (W)	8	178
First Year Potential Energy Savings (GWh)	648	3,211
First Year Potential Demand Savings (MW)	160	573
Compliance Rate	94%	95%

*Estimates provided by the California IOUs on May 13, 2011 in response to EEGA data request 1465, 1466, 1467, and 1468.

The following sections outline our approach and findings for each component listed in Table 127.

Potential Energy Savings

To evaluate the potential energy savings, Cadmus determined the number of units sold per year in California and the per-unit energy savings, as shown in Equation 6.

Equation 6. Annual Energy Savings Calculation

$$\text{Annual Savings} = \#\,\text{Units Purchased Annually} \times \text{Unit Energy Savings}$$

The next section discusses the unit energy savings.

Unit Energy Savings

The energy savings for Fed 7 occurs from retrofitting a luminaire with a more energy-efficient luminaire. Cadmus used the following data sources to determine per-unit potential energy savings:

- The Efficiency Boom: Cashing in on the Savings from Appliance Standards. This report was written by the American Council for an Energy Efficient Economy and the Appliance Standards Awareness Project (ASAP), and highlights the energy savings that can be realized through appliance standards. Key energy analysis includes a projected national total energy savings of 6.9 TWh and $2.3 billion net present value savings projected through 2035, in addition to a per unit incremental cost of $0.75 and a 2.5-year payback period.

- State Level Benefits from Potential National Appliance Standards - Residential.[118] This table is included in a report outlining ASAP's analysis of projected energy savings for all of the federal standards. For GSFLs, they project a per-unit annual savings of 3 kWh, an incremental cost of $0.76, and payback period of 1.8 years.
- U.S. DOE's 2010 Lighting Market Characterization. This report provides annual hours of use for commercial buildings by lamp type. Linear Fluorescents were used for 11.1 hours per day.

After further examination, the first two of these reports are based on the upcoming revised federal standard that takes effect in July 2014, when the two-year grace period for the 700 series GSFLs will no longer be in effect. The majority of the savings will result from the eventual conversion to 32W and 28W 4' GSFLs when the 700 series exception expires. Cadmus does not have data to indicate what percent of the market is affected by the exceptions in the 2010-2012 program cycle.

According to our research through a literature review and conversations with industry representatives, the primary energy saving impact of Fed 7 is the retrofit of 4' linear and 2' U-shaped T12 lamps to T8 lamps. The most common retrofit required by Fed 7 is from T12 (40 watts) to T8 (32 watts), thereby resulting in a per unit savings of 8 watts for both 4' linear and U-shaped GSFLs. Reliable data on the energy savings potential of the other types of GSFLs are unavailable, so we did not include them in our analysis. Combined with a daily usage of 11.1 hours, we estimate the annual per unit energy savings to be 32.4 kWh.

Market Size

Cadmus used several sources of information to estimate the market size for GSFLs. First we determined the distribution of GSFLs products, and then the total number of T12 products sold per year at the national level. Then we scale the national values to California. Relevant tables are shown below.

2003 Commercial Building Energy Consumption Survey (CBECS), shown below in Table 128.

[118] Appliance Standards Awareness Project. "State Benefits of Federal Appliance Standards – California." Table titled "State-Level Benefits from Potential National Appliance Standards – Residential." 2011. Available online: http://www.appliance-standards.org/sites/default/files/fedappl_ca.pdf.

Table 128. Commercial Buildings by Region in 2003

Census Region and Division	Number of Buildings
Northeast	710,000
New England	228,000
Middle Atlantic	482,000
Midwest	1,190,000
East North Central	659,000
West North Central	531,000
South	1,654,000
South Atlantic	835,000
East South Central	312,000
West South Central	507,000
West	850,000
Mountain	285,000
Pacific	565,000

Source: U.S. Energy Information Administration. 2003 Commercial Building Energy Consumption Survey. Table C13. March 8, 2013. Available online: http://www.eia.gov/emeu/cbecs/cbecs2003/detailed_tables_2003/detailed_tables_2003.html#consumexpen03.

According to the 2003 CBECS study, approximately 12.83% of commercial buildings are located in the Pacific census region (the region of interest for this analysis). A more recent survey was implemented in 2007, but the results are not publicly available.

2010 Census population data, shown below in Table 129.

Table 129. 2010 Census Population

Region	2010 Census Population	% of U.S.
California	37,253,956	12.07%
Pacific Census Region*	49,880,102	16.16%
United States	308,745,538	100%

Source: 2010 U.S. Census Data

* This region includes Alaska, California, Hawaii, Oregon, and Washington.

According to the 2010 U.S. Census, California accounts for 74.69% of the Pacific region's total population. When applying this figure to the percentage of commercial buildings in the Pacific region, California represents 9.58% of all commercial buildings in the U.S.

The inventory of installed GSFLs, from the U.S. DOE's 2010 Lighting Market Characterization report is shown in Table 130.

Table 130. Inventory of Installed GSFLs

Lamp Segment	Diameter	Total Installed	Percentage
Miniature Bi-Pin	T5	120,947,000	5.07%
Less than 4'	T8 & T12	32,151,000	1.35%
	T8	17,818,000	0.75%
	T12	14,333,000	0.60%
4'	T8 & T12	1,816,430,000	76.15%
	T8	1,050,174,000	44.03%
	T12	766,256,000	32.12%
Greater than 4'	T8 & T12	181,213,000	7.60%
	T8	32,632,000	1.37%
	T12	148,581,000	6.23%
U-Shaped	T8 & T12	59,763,000	2.51%
	T8	47,598,000	2.00%
	T12	12,165,000	0.51%
Miscellaneous		174,895,000	7.33%
Total		2,385,399,000	100%

Source: U.S. Department of Energy. 2010 U.S. Lighting Market Characterization. Table 4.1 Estimated Inventory of Lamps in the U.S. by End-Use Sector in 2010. January 2012. Available online: http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/2010-lmc-final-jan-2012.pdf

Using GSFL installed stock data we approximate the distribution of sales by lamp segment, assuming that all of the installed lamps are subject to the same lifetime and degradation factors and that there is equal distribution throughout the U.S.

An ACEEE report prepared by the Appliance Standards Awareness Project indicated 640 million GSFL lamps are sold each year.[119] To determine the allocation by T12 lamp segment, we applied the percentages from Table 130 to the total U.S. sales to obtain the results shown in Table 131. Then we used an adjustment factor of 9.58% (the percentage of U.S. commercial buildings that are in California) to determine the share of California T12 sales.

119 Appliance Standards Awareness Project and the American Council for an Energy-Efficient Economy. *The Efficiency Boom: Cashing in on the Savings from Appliance Standards.* March 2012. http://www.aceee.org/sites/default/files/publications/researchreports/a123.pdf

Table 131. Annual T12 Sales

Lamp Segment	Table 130 T12 Saturation	National T12 Sales	California T12 Sales*
4'	32.12%	640 million x 32.12% = 205.6 million	19.7 million
U-Shaped	0.51%	640 million x 0.51% = 3.3 million	0.3 million
Total	32.63%	209 million	20 million

* Cadmus used an adjustment factor of 9.58% (the percentage of U.S. commercial buildings that are in California) to determine the share of California GSFL shipments.

Using the values from Table 131, we estimated that there are approximately 20 million T12s sold in California annually.

Potential Savings

The potential energy and demand savings for GSFLs are summarized in Table 132.

Table 132. California Annual Energy Savings from GSFLs

GSFL Savings	Evaluated Value
Units per Year	20 million
Unit Energy Savings (kWh)	32.4
Unit Demand Savings (W)	8
First Year Potential Energy Savings (GWh)	648
First Year Potential Demand Savings (MW)	160

F.11.2 Compliance

Cadmus evaluated the market compliance rate with Fed 7 by conducting surveys with distributors throughout California. We asked distributors questions to test their awareness of the federal regulation on GSFLs from EISA 2007, and then we asked what wattage luminaires they sell.

Cadmus contacted 20 distributors during November 2012 and five responded. In addition to Cadmus' generated contact list, we obtained distributor contacts from lighting program staff at each of the IOUs. We left messages with 12 distributors, and called them up to three times to conduct the survey, but were unable to connect with them. Three of the distributors' contact information that we had on file was incorrect and we were unable to reach them.

The survey results are summarized in Table 133.

Table 133. Distributor Responses

Distributor Location	Result	Compliance
San Diego	This distributor sells only T5 and T8 GSFLs. Energy-efficiency is a high priority for their stocking and sales strategy. They mentioned that their commercial customers have a great opportunity to save money on their energy bill. When asked about Fed 7, they knew of and understood the standard, as well as several of the exemptions for the 700 series (based on their conversations with manufacturer sales reps). They recommend replacement products to their customers, so they are always proactively selling energy-efficient, Fed 7 compliant GSFLs. They have not sold T-12 GSFLs for over 15 years. Fed 7 has had no impact on their business because they were already focused on selling energy-efficient GSFLs as part of their business. They reported that the utilities are ending the T8 rebates too soon. There is more incentive for major commercial entities to upgrade their lighting systems with these rebates.	100%
Fresno	They sell T5 and T8 fixtures, as well as some T12 basic strip lights. Energy efficiency is a medium-to-high business priority for them. They have many customers asking for LED fixture replacements. They are aware of the regulations that went into effect in July 2012 through the State of California, but are not aware of the regulations through Fed 7. We believe the distributor may have confused the specification. They reported that California is enforcing the legislation, and did not know it was a federal mandate. Fed 7 has had no major impact on their business since they were already selling compliant products. They noted seeing an increase in LED products entering the market. Their customers are moving away from fluorescent and other standard products to LEDs.	90%
Monterey	They sell T5, T8, and T12 fixtures. Energy efficiency is a major business priority due to their customers' high utility costs and operations expenses. They were very aware of Fed 7, referred to it as "EPAC," and discussed the progression that is occurring from T12 to T8 and T5 GSFLs. It is rare that their customers ask for T12s and other non-compliant Fed 7 fixtures; however, it is not rare for their customers to ask for incandescent light bulbs. They are still selling T12s as replacements, which is allowed by Fed 7. Fed 7 has forced them to sell more energy-efficient technology. They've progressed from T12 to T8 and T5. They've experienced a natural decline in T12 sales over the past decade.	90%
Truckee	They sell T5, T8, and T12 fixtures. Energy efficiency is a high priority for their business since their customers demand these products from them. They were aware of Fed 7. Since its introduction, they've received at most two to three requests for non-compliant product. They used the opportunity to upsell these customers to more energy-efficient fixtures after explaining the mandate to them. They sell very few T12s as replacements, which is still allowed under Fed 7. Fed 7 has had no effect on their business since they've been selling primarily T8's for a while. They commented that their T12 stock is less than 5% now.	90%
Brea	They sell T5 and T8 fixtures. Energy efficiency is a major priority for their business due to demand from their customers. They are aware of Fed 7 and have ceased carrying T12 fixtures. There was no impact on their business from Fed 7, since they've been selling T8 fixtures for a while.	100%

The information provided by the five distributors outlined in Table 133 indicates an average compliance rate of 94%. Our research has uncovered that the compliance rate for Fed 7 could be considered 100% due to the exceptions provided by the U.S. DOE. We determined that a more accurate projection of code compliance includes degrading the compliance rate for distributors who are carrying products impacted by the two-year grace period, which is why our stated compliance rate is 94%. For more information on how Cadmus determined the compliance rate, refer to discussion later in this section.

In addition to surveying distributors, Cadmus contacted several manufacturers in order to understand production trends and distribution patterns. We interviewed two of the top three GSFL manufacturers. The results from these interviews are summarized in Table 134.

Table 134. Manufacturer Responses

Manufacturer	Findings
Manufacturer A	This manufacturer produces a diverse array of lighting products for the global market, including GSFLs. They are within the top five manufacturers of GSFLs sales globally. Energy efficiency is a high priority for them. They noted that they produced more T8s than T12s in 2011. When asked about remaining stock, they noted that they currently have 3,000 non-compliant GSFLs in warehouses in the U.S. They were quick to point out the Fed 7 standard and noted that they've played a major role in educating their customers through sales reps and educational tools that explain the legislation and its impact on their product line. They also discussed at length how several of their products have been exempted from the current specification. They still sell T12s that are compliant through the exemptions. There is still a lot of national demand for T12s. They noted that not everyone has seen the benefit in switching to energy-efficient T8s and T5s just yet. All of their customers, which are mainly distributors, are buying T12s, but the percentage has decreased significantly. The current distribution of their GSFL product is 30% T12s, 60% T8s, and 10% T5s. They noted that compared to the U.S. market overall, the California market is an outlier. Their reasoning is that California has an advantage over many other states due to their progressive incentives and rebates for energy-efficient products. It is challenging for them to track what they shipped and sold in California, but did report that they shipped a higher percentage of T5s and T8s into California as a result of rebate and incentive programs.
Manufacturer B	This manufacturer also produces a diverse array of lighting products for the global market, including GSFLs. They are also within the top five manufacturers of GSFL sales globally. Energy efficiency is a medium priority for this manufacturer due to average customer demand. Different customers have different lighting needs. For example, retail customers want high quality lighting, so they sell more specialized LED products to them. Overall, 90% of their customers ask about energy-efficient lighting. This figure has grown over the past few years with the emergence of LEDs. They are aware of the new federal standard and have taken measures to educate their customers about it. In their opinion, Fed 7 has done more to push energy-efficient lighting than any other singular regulation. Their customers still ask for T12s and non-compliant lamps. About 15% to 25% of their customers still use T12s. Their sales pitch is based on energy-efficiency savings and the availability of utility rebates. They are trying to minimize their customers' use of T12s by pushing them to retrofit to T5s and T8s while there are utility incentives available to help defray the cost. Fed 7 has impacted them to shift their focus toward increasing production of 25W and 28W T8 products.

F.11.3 Distributor Compliance Practices

Cadmus developed a rubric to estimate distributors' compliance with Fed 7, outlined in Table 135.

Table 135. Distributor Compliance Rubric

Compliance Indicator	Points Available	Weighted Value*
(A) Exhibits understanding of Fed 7	0 – 100%	50%
(B) Sells non-compliant GSFLs	0 – 100%	40%
(C) Sells non-compliant GSFLs that are covered by exemptions until 2014	0 – 100%	10%

* Cadmus' method of determining the weighted values are outlined in the text below this table.

We assessed distributors' interview responses along three indicators:

- A rates the distributors' understanding of Fed 7. If the distributor understands that there is a federal law that prohibits the sale of non-compliant GSFLs, we scored that distributor as 100% compliant in this category. Partial understanding of the Fed 7 resulted in a score of 50%. No understanding of Fed 7 resulted in a score of 0%.
- B describes the distributors' buying patterns as related to Fed 7. We scored each distributor based on the percentage of non-compliant products sold out of their total inventory.
- C determines whether distributors are still selling products that received exceptions for Fed 7. Although these sales are legal, distributors who sell these products may have a bias toward continuing their GSFL sales practices past the exception period. We based the scoring on a whether they are (0%) or are not (100%) selling excepted products.

Cadmus determined each distributor's compliance rate with Fed 7 using the following equation.

$$\text{Distributor Compliance Rate} = (A * 50\%) + (B * 40\%) + (C * 10\%)$$

The distributor interview questions are provided below.

F.11.4 Distributor Interview Questions

1. Do you distribute any of the following GSFL products in California: 2-foot U-shaped; 4-foot medium bipin; 4-foot miniature bipin standard output; 4-foot miniature bipin high output; 8-foot slimline; and 8-foot high output?
2. Is energy-efficient lighting a low, medium, or high priority for your customers? Why do you say that?
3. What percentage of your customers ask for energy-efficient lighting? Has this number increased?
4. What regulations or requirements affect the types of fluorescent lamps that you sell?
5. Do your customers still ask for T12s or other models that do not meet the new federal standard?
6. How often does this happen? What do you tell them?
7. How has the new federal standard affected the overall mix of fluorescent products you have sold to customers to date?
8. What is the percentage of T12s you sold before the standards took effect in comparison to now?
9. How many general service fluorescent lamps do you sell each year? Has this number fluctuated from previous years?

Appendix G. Potential Savings: Title 24 Detail

Table 136. Order of Appendix Contents

Reference	Description	Evaluation Disposition
Standard B17	Envelope insulation	Evaluated
Standard B18	Overall Envelope Tradeoff	Not evaluated: No savings in IOU Estimate
Standard B19	Skylighting	Evaluated
Standard B20	Sidelighting	Evaluated
Standard B21	Tailored Indoor lighting	Evaluated
Standard B22a	TDV Lighting Controls	Not evaluated: No savings in IOU Estimate
Standard B22b	DR Indoor Lighting	Not evaluated: accepted IOU Estimate
Standard B23	Outdoor Lighting	Not evaluated: accepted IOU Estimate
Standard B24	Outdoor Signs	Evaluated
Standard B26	Refrigerated warehouses	Evaluated
Standard B27	DDC to Zone	Evaluated
Standard B28	Residential Swimming pool	Evaluated
Standard B29	Site Built Fenestration	Evaluated
Standard B30	Residential Fenestration	Evaluated
Standard B31	Cool Roof Expansion	Evaluated
Standard B32	MF Water heating control	Not evaluated: accepted IOU Estimate
Standard B33a	CfR IL Complete Building Method	Evaluated
Standard B33b	CfR IL Area Category Method	Evaluated
Standard B33c	CfR IL Egress Control	Evaluated
Standard B33d	CfR HVAC Efficiency	Evaluated
Standard B33e	CfR Res Cool Roofs	Evaluated
Standard B33f	CfR Res Central Fan WL	Evaluated

Unit Savings and Unit / Measure Quantities

In response to data requests from the CPUC on behalf of the evaluators, the IOUs provided a considerable body of documentation regarding the total potential savings for the Title 20, Title 24, and Federal codes and standards within the scope of this evaluation. The evaluators faced several challenges in attempting to use this information

- IOU Estimate spreadsheet uses 1000 kWh/unit as savings quantity for most of the standards being evaluated. Unit quantities are then calculated based on an expected total number of GWh savings for that standard. As a result, neither the unit savings value or quantities retain any connection to the underlying change that is expected to produce savings.
- CASE Reports estimates differ from later potential estimates. The unit savings and measure quantities in the CASE reports are often inconsistent with later estimates.

Cadmus has spent considerable effort to develop a consistent set of unit savings values and measure quantities that can be associated with the revised IOU Estimate of potential savings. Even with this effort, some gaps remain. Most of the tables in this section use 1000 kWh/unit as a savings estimate since that figure was received from the IOUs. The supporting discussion will identify the probable value used to calculate total potential but there is some small uncertainty regarding these calculations since we are trying to piece them together from the available data.

G.1 Standard B17 – Envelope Insulation

Table 137 provides a summary of the findings Cadmus used to estimate potential energy savings for envelope insulation.

Table 137. Nonresidential Insulation Energy Savings Estimate

Description	IOU Estimate		Evaluated	
	New Construction	Re-roofing	New Construction	Re-roofing
Unit Energy Savings (kWh)	1000	1000	0.16	0.15
Unit Demand Savings (kW)	0.1984	0.1984	N/A	N/A
Unit Gas Savings (therms)	87.55	87.55	0.0072	0.018
Total Electric Energy Savings (GWh/yr)	73.1		7.0	48.9
Total Demand Reduction (MW)	14.5		3.31	--
Total Gas Energy Savings (Mtherms)	6.4		0.3	5.6
Total applicable units (sq. ft.)	73,100		41,400,000	325,980,000

G.1.1 Description

This standard imposes a set of prescriptive insulation requirements for Nonresidential Buildings, High-Rise Residential Buildings, and Hotels/Motels. The proposed updates to Title 24 affect the pre-calculated U-factors for all common construction assemblies based on time dependent valued (TDV) energy which are contained in Tables 143-A, 143-B, and 143-C.

The regulations in Section 143 of the California building code read as follows:[120]

> **"(a) Envelope Component Approach.**
>
> **1. Exterior roofs and ceilings.** Exterior roofs and ceilings shall:
>
> A. Roofs. All roofing products shall meet the requirements of Section 118 and the applicable requirements of Subsections i through iii:

[120] 2008 Building Energy Efficiency Standards for Residential and Nonresidential Buildings, CEC-400-2008-001-CMF, December 2008

i. Nonresidential buildings with low-sloped roofs in climate zones 2-15 shall have a minimum 3-year aged solar reflectance of 0.55 and a minimum thermal emittance of 0.75, or a minimum aged SRI of 64.

EXCEPTION 1 TO SECTION 143(a)1Ai: Wood-framed roofs in climate zones 3 and 5 are exempt from the minimum requirements for solar reflectance and thermal emittance or SRI if the roof assembly has a U-factor of 0.039 or lower.

EXCEPTION 2 TO SECTION 143(a)1Ai: Metal building roofs in climate zones 3 and 5 are exempt from the minimum requirements for solar reflectance and thermal emittance or SRI if the roof assembly has a U-factor of 0.048 or lower.

EXCEPTION 3 TO SECTION 143(a)1Ai: Roof area covered by building integrated photovoltaic panels and building integrated solar thermal panels are not required to meet the minimum requirements for solar reflectance and thermal emittance or SRI.

EXCEPTION 4 TO SECTION 143(a)1Ai: Roof constructions that have thermal mass over the roof membrane with a weight of at least 25 lb/sf.

ii. Nonresidential steep-sloped roofs with roofing products that have a roof weight of less than 5 pounds per square foot in climate zones 2-16 shall have a minimum 3-year aged solar reflectance of 0.20 and a minimum thermal emittance of 0.75, or a minimum SRI of 16. Steep-sloped roofing products that have a roof weight of 5 pounds per square foot or more in climate zones 1 through 16 shall have a minimum 3-year aged reflectance of 0.15 and a minimum emittance of 0.75, or a minimum SRI of 10.

iii. High-rise residential buildings and hotels and motels with low-sloped roofs in climate zones 10, 11, 13, 14, and 15 shall have a minimum 3-year aged solar reflectance of 0.55 and a minimum thermal emittance of 0.75, or a minimum SRI of 64.

B. Have insulation placed in direct contact with a continuous roof or drywall ceiling where required by Section 118(e); and

C. Have an overall assembly U-factor no greater than the applicable value in TABLE 143-A, TABLE 143-B, or TABLE 143-C.

2. Exterior walls. Exterior walls shall have an overall assembly U-factor no greater than the applicable value in TABLE 143-A, TABLE 143-B, or TABLE 143-C.

3. Demising walls. Demising walls shall meet the requirements of Section 118(f).

4. External floors and soffits. External floors and soffits shall have an overall assembly U-factor no greater than the applicable value in TABLE 143-A, TABLE 143-B, or TABLE 143-C.

5. Windows. Windows shall:

A. Have (1) a west-facing area no greater than 40 percent of the gross west-facing exterior wall area, or 6 feet times the west-facing display perimeter, whichever is greater; and (2) a total area no greater than 40 percent of the gross exterior wall area, or 6 feet times the display perimeter, whichever is greater; and

EXCEPTION to Section 143(a)5A: Window area in demising walls is not counted as part of the window area for this requirement. Demising wall area is not counted as part of the gross exterior wall area or display perimeter.

B. Have a U-factor no greater than the applicable value in TABLE 143-A, TABLE 143-B, or TABLE 143-C; and

C. Have a relative solar heat gain, excluding the effects of interior shading, no greater than the applicable value in TABLE 143-A, TABLE 143-B, or TABLE 143-C. The relative solar heat gain of windows is:

i. The solar heat gain coefficient of the windows; or

ii. Relative solar heat gain as calculated by EQUATION 143-A, if an overhang extends beyond both sides of the window jamb a distance equal to the overhang projection.

EXCEPTION to Section 143(a)5C: The applicable "north" value for relative solar heat gain in TABLE 143-A, TABLE 143-B, or TABLE 143-C or 0.56, whichever is greater, shall be used for windows:

a. That are in the first story of exterior walls that form a display perimeter; and

b. For which codes restrict the use of overhangs to shade the windows.

EQUATION 143-A RELATIVE SOLAR HEAT GAIN

$$RSHG = SHGC_{win} \times \left[1 + \frac{aH}{V} + b\left(\frac{H}{V}\right)^2\right]$$

Where:

RSHG	= Relative solar heat gain.
SHGCwin	= Solar heat gain coefficient of the window.
H	= Horizontal projection of the overhang from the surface of the window in feet, but no greater than V.

V	*= Vertical distance from the window sill to the bottom of the overhang in feet.*
a	*= -0.41 for north-facing windows, -1.22 for south-facing windows, and -0.92 for east and west-facing windows.*
b	*= 0.20 for north-facing windows, 0.66 for south-facing windows, and 0.35* for east and west-facing windows.

6. Skylights. Skylights shall:

A. Have an area no greater than 5 percent of the gross exterior roof area; and

EXCEPTION to Section 143(a)6A: Atria over 55 feet high shall have a skylight area no greater than 10 percent of the gross exterior roof area.

B. Have a U-factor no greater than the applicable value in TABLE 143-A, TABLE 143-B, or TABLE 143-C; and

C. Have a solar heat gain coefficient no greater than the applicable value in TABLE 143-A, TABLE 143-B, or TABLE 143-C.

7. Exterior doors. All exterior doors for conditioned spaces shall have a U-factor not greater than the applicable value in TABLE 143-A, TABLE 143-B or TABLE 143-C.

8. Relocatable Public School Buildings. In complying with Sections 143(a)1 to 7, relocatable public school buildings shall comply either with TABLE 143-A, including the non-north window RSHG and skylight SHGC requirements, when the manufacturer/builder certifies that the relocatable building is manufactured only for use in a specific climate zone(s) and that the relocatable building cannot be lawfully used in other climate zones or with TABLE 143-C when the manufacturer/builder certifies that the relocatable building is manufactured for use in any climate zone. When the relocatable building complies with TABLE 143-C for use in more than one climate zone, the relocatable building shall meet the most stringent requirements for each building component in all of the climate zones for which the relocatable building is certified.

The manufacturer/builder shall place 2 metal identification labels on each relocatable building module, one mechanically fastened and visible from the exterior and the other mechanically fastened to the interior frame above the ceiling, at the end of the module. In addition to information required by the Division of the State Architect (DSA), the labels shall state either "Complies with Title 24, Part 6 for all Climate Zones" or "Complies with Title 24, Part 6 for Climate Zones" and then list all of the climate zones for which the manufacturer has manufactured the relocatable building to comply. The location of the identification labels shall be shown on the building plans.”

G.1.2 Potential Energy Savings Estimates

Unit Energy Savings Estimates

The CASE study utilized DOE-2.1E software simulations for a prototypical building model to establish the relationship between changes in U factor and TDV energy for each construction type. A simple five-zone model represents all cases in the simulation. Since the evaluator does not have the actual energy model for review, we reviewed the assumptions (used by the CASE report authors) to create the energy model and the results tables in the CASE report. Overall, the assumptions in the energy model seem reasonable; however, the CASE report indicates that only one model represents all cases for the entire nonresidential building stock. Cadmus advises that creating alternative energy models for different building types would allow to identify the impacts of the modifications to the prescriptive insulation requirements for nonresidential and high-rise residential buildings more precisely.

Applicable Square Footage

New Construction

The CASE report estimates the annual nonresidential new construction floor space as 157.8 million ft^2 based on the Dodge nonresidential new construction survey for program years 2000 through 2003. Cadmus used McGraw-Hill Construction (MHC) data to determine the average square footage for new construction and additions for the years 2010 through 2012. In MHC data, there is a significant drop in the applicable square footage of new construction and additions after 2008. MHC data estimates the average annual nonresidential new construction floor space including high-rise residential buildings (4 stories and higher) for the years 2010 through 2012 as 41.4 million ft^2, which is considerably lower than the estimate in CASE report.

Re-Roofing

The estimations for re-roofing square footage are based on the existing building stock floor area. The CASE report indicates that the total existing building stock floor area is 6.96 billion ft^2 and the square footage of roof replaced is calculated as 278.54 million ft^2 assuming that total roof area represents 80% of the total floor area and the total area of roof replaced represents 5% of the total roof area. Although the CASE report indicates high-rise residential buildings (4 stories and higher) as applicable building types, estimated existing building stock of 6.96 billion ft^2 in the CASE report does not include the high-rise residential buildings, which are covered by the code, and high-rise residential buildings (4 stories and higher) represent about 1.8 billion ft^2. Cadmus estimates the existing building stock floor area as 8.15 billion ft^2 and the square footage of roof replaced as 325.98 million ft^2 per year based on the other factors used in the CASE report.

Statewide Potential Energy Savings Estimates

The statewide impact of code changes for insulation requirements for new nonresidential construction would provide 27.42 Gigawatt-hours per year of electric energy savings and

1.2 million therms of gas energy savings according to the analysis in CASE report[121]. This analysis does not estimate electrical demand savings for new construction. The CASE report also indicates that updated insulation requirements would save 41.7 Gigawatt-hours per year electric energy and 5 million therms of gas energy due to annual re-roofing activities.

In December 2012, Cadmus asked the CA IOU's to provide additional data to clarify Title 24 potential savings. Revised estimates from EEGA data request 2576-2579 provided revised estimates for potential savings for nonresidential insulation illustrated in Table 138.

Table 138. Revised Nonresidential Insulation Energy Savings Estimate

	Total Electric Energy Savings (GWh/yr)	Total Demand Reduction (MW/yr)	Total Gas Energy Savings (Mtherms)
New Construction	31.4	14.50	1.4
Re-roofing	41.7	--	5
Total	73.1	14.50	6.4

G.1.3 Findings

However, it was observed that in the unit energy savings analysis, for metal building walls, it was assumed that 40% of new construction that is Storage based on the Dodge data. Recent square footage numbers show that currently, storage buildings (warehouses) represent about 12% of new construction.

Due to the significant changes in new construction and re-roofing square footages in recent years, we revised statewide potential energy savings as summarized in Table 137.

G.2 Standard B18 – Overall Envelope Tradeoff

In the initial IOU Estimate, savings were given as 0.1 GWh/year. In the revised IOU Estimate, zero savings were expected. Cadmus used the unit savings value from the CASE report and applied it to the appropriate new construction square footage to produce the estimate shown in Table 139.

[121] *Final Report Insulation Requirements,* Codes and Standards Enhancement Initiative (Case), December 31, 2008

Table 139. Nonresidential Overall Envelope Tradeoff Energy Savings Estimate

Description	Evaluated New Construction
Unit Energy Savings (kWh)	0.19
Unit Demand Savings (kW)	N/A
Unit Gas Savings (therms)	N/A
Total Electric Energy Savings (GWh/yr)	0.22
Total Demand Reduction (MW)	N/A
Total Gas Energy Savings (Mtherms)	N/A
Total applicable units (sq. ft.)	1,159,200

G.3 Standard B19 – Skylighting

Table 140 provides a summary of the finding Cadmus used to estimate potential energy savings for the skylighting code.

Table 140. Evaluated Skylighting Estimates

Description	New Construction	
	IOU Estimate	Evaluated
Unit Energy Savings (kWh)	1000	1.8
Unit Demand Savings (kW)	0.0541	N/A
Unit Gas Savings (therms)	--	0.0072
Total Electric Energy Savings (GWh/yr)	3.7	3.30
Total Demand Reduction (MW)	0.2	0.18
Total Gas Energy Savings (Mtherms)	--	--
Total applicable units (sq. ft.)	3,700	1,832,940

G.3.1 Description

Skylighting requirements are listed in the Sections 116 and 143 of the California building code. The proposed changes for skylighting requirements in the CASE report[122] target increased use and control of skylights for daylighting to reduce interior lighting energy use. The changes to the skylighting requirements include:

- Minimum space size criteria for requiring skylights dropped from 25,000 square feet (sf) to 8,000 sf
- Definition of skylit area has changed
- Required use of photocontrols in large skylit zones under skylights

122 *Final Report Updates to Skylighting Requirements*, Codes and Standards Enhancement Initiative (Case), December 31, 2008

- Lighting control credits allowed only when total daylit area in an enclosed space is less than 2,500 sf
- Updated lighting control credits
- Exemption of multi-level requirement for daylighting controls when LPD is lower than 0.5 W/sf
- Single level controls for skylight retrofits
- Requirement for a deadband adjustment
- Clarify area controls and multi-level switching requirements
- Updated allowable minimum performance requirements (U-factor and SHGC) for skylights

The current requirements for skylighting in the Section 143 of the California building code[123] read as follows:

"(a) Envelope Component Approach

6. Skylights. Skylights shall:

A. Have an area no greater than 5 percent of the gross exterior roof area; and **EXCEPTION to Section 143(a)6A:** Atria over 55 feet high shall have a skylight area no greater than 10 percent of the gross exterior roof area.

B. Have a U-factor no greater than the applicable value in TABLE 143-A, TABLE 143-B, or TABLE 143-C; and

C. Have a solar heat gain coefficient no greater than the applicable value in TABLE 143-A, TABLE 143-B, or TABLE 143-C.

(c) Minimum Skylight Area for Large Enclosed Spaces in Buildings with Three or Fewer Stories. In climate zones 2 through 15, low rise conditioned or unconditioned enclosed spaces that are greater than 8,000 ft2 directly under a roof with ceiling heights greater than 15 feet shall meet Sections 143(c)1-4 below.

1. **Daylit Area.** At least one half of the floor area shall be in the skylit daylight area, the primary sidelit daylight area, or a combination of the skylit and primary sidelit daylight areas. The skylit and primary sidelit daylight areas shall be shown on the building plans. Skylit and primary sidelit daylight areas are defined in Section 131(c)1.

2. **Minimum Skylight Area or Effective Aperture.** Areas that are skylit shall have a minimum skylight area to skylit area ratio of at least 3.3 percent or minimum skylight effective aperture of at least 1.1 percent. Skylight effective aperture shall be determined as specified in Equation 146-C. If primary sidelit area is used to comply with Section

[123] 2008 Building Energy Efficiency Standards for Residential and Nonresidential Buildings, CEC-400-2008-001-CMF, December 2008

143(c)1, the primary sidelit daylight areas shall have an effective aperture greater than 10 percent. The effective aperture for primary sidelit daylight areas is specified in Section 146(a)2E.

3. **Skylight Characteristics.** Skylights shall:

A. Have a glazing material or diffuser that has a measured haze value greater than 90 percent, tested according to ASTM D1003 (notwithstanding its scope) or other test method approved by the Commission; and

B. If the space is conditioned, meet the requirements in Section 143(a)6 or 143(b).

4. **Controls.** Electric lighting in the daylit area shall be controlled as described in Section 131(c)2.

EXCEPTION 1to Section 143(c): Auditoriums, churches, movie theaters, museums, and refrigerated warehouses.

EXCEPTION 2 to Section 143(c): In buildings with unfinished interiors, future enclosed spaces where it is planned to have less than or equal to 8,000 sf of floor area, or ceiling heights less than or equal to 15 feet, based on proposed future interior wall and ceiling locations as delineated in the plans. This exception shall not apply to these future enclosed spaces when interior walls and ceilings are installed for the first time, the enclosed space floor area is greater than 8,000 sf, and the ceiling height is greater than 15 feet (see Section 149(b)1M). This exception shall not be used for S-1 or S-2 (storage), or for F-1 or F-2 (factory) occupancies.

EXCEPTION 3 to Section 143(c): Enclosed spaces having a designed general lighting system with a lighting power density less than 0.5 watts per square foot.

In addition, TABLE 116-A Default Fenestration Product U-Factors and TABLE 116-B Default Solar Heat Gain Coefficient (SHGC) in the California building code, lists the required U-factor and SHGC values for fenestration products including skylights."

G.3.2 Potential Energy Savings Estimates

Per-Unit Savings Estimates

The CASE report claims that the addition of skylights and photocontrols save on average approximately 1.8 kWh/sf of building stock and more energy savings would be expected in big box retail, whereas less energy savings would occur in warehouses. The CASE report refers to the SkyCalc skylighting design tool for the calculations; however, the derivations of these estimates are not shown. The electricity savings for warehouses (in the CASE report) are estimated as 1.51 kWh/sf and for retail buildings the savings are estimated as 2.2/kWh/sf (and 0.16 therms/sf heating fuel increase) that will be applied to the building stock that are between 8,000 and 25,000 sf.

Statewide Potential Energy Savings Estimates

According to the CASE report, proposed changes for increased use and control of skylights for daylighting would reduce interior lighting energy use. The initial IOU Estimate gave first-year savings of new nonresidential construction with skylighting and photocontrols of 4.48 GWh/yr energy savings and 0.25 MW demand savings. CASE report analysis also estimate that proposed changes would cause additional natural gas consumption of 0.10 Mtherms.

In December 2012, Cadmus asked the CA IOUs to provide additional data to clarify Title 24 potential savings. Revised estimates using applicable square footage of 9% of non-refrigerated warehouses (23,078,756 sf) from EEGA data request 2576-2579 are illustrated in Table 141.

Table 141. Revised Skylighting Energy Savings Estimates

Total Electric Energy Savings (GWh/yr)	Total Demand Reduction (MW)	Total Gas Energy Savings (Mtherms)
3.70	0.20	--

G.3.3 Findings

Cadmus accepted the per-unit savings estimates from the CASE report for electric energy (kWh) and demand (kW). Cadmus applied a negative gas interactive factor to determine gas impact (instead of the value given in the CASE report).

Cadmus updated the applicable square footage based on actual construction data from MHC.

The unit estimates and square footage are combined to determine evaluated potential energy savings shown in Table 139..

G.4 Standard B20 – Sidelighting

Table 142 provides a summary of the findings Cadmus used to estimate potential energy savings for the sidelighting code.

Table 142. Evaluated Estimates for Sidelighting

Description	IOU Estimate		Evaluated	
	New Construction	Alterations	New Construction	Alterations
Unit Energy Savings (kWh)	1,000	--	0.92	--
Unit Demand Savings (kW)	0.4167	--	0.00038	--
Unit Gas Savings (therms)	8.33	--	0.008	--
Total Electric Energy Savings (GWh/yr)	1.2	--	1.33	--
Total Demand Reduction (MW)	0.5	--	0.55	--
Total Gas Energy Savings (Mtherms)	0.01	--	0.01	--
Total applicable units (sq. ft.)	1,200	--	1,447,050	--

G.4.1 Description

The CASE report[124] for sidelighting proposes changes for the definition of daylit and sidelit areas and requirements for Daylighting Controls and Multi-Level Controls to encourage better design practices and the use of photocontrols in sidelit spaces in new nonresidential construction. Key changes include redefinition of primary and secondary sidelit areas by windows and the effective aperture for the primary and secondary sidelit areas by windows.

These changes impact Section 119 – Mandatory Requirements for Lighting Control Devices, Ballasts, and Luminaires, Section 131 – Indoor Lighting Controls That Shall Be Installed, Section 143 (c) – Minimum Skylight Area for Large Enclosed Spaces in Buildings with Three or Fewer Stories, and Section 146 – Prescriptive Requirements for Indoor Lighting of 2008 Building Energy Efficiency Standards.[125]

G.4.2 Potential Energy Savings Estimates

Per-Unit Savings Estimates

The CASE report indicates that DOE2.2 (eQuest) simulations were utilized to model sample buildings to estimate per unit savings based on the proposed changes for sidelighting. The simulation models estimate an average savings of 0.7 to 1.5 kWh/sf for typical configurations. Descriptions provided for the sample building model in the CASE report list reasonable engineering parameters. However, since evaluators did not have the actual model, these parameters could not be confirmed.

A total of 32 building models were simulated in the analysis to identify the energy savings estimates between building models with Dimming Photocontrols and No Daylighting Controls in 16 California Climate Zones. Based on the simulation results, per-unit savings from daylighting controls were calculated as listed in Table 143.

Table 143. Per-Unit Savings Estimates for Sidelighting

Electric Savings (kWh/sf)	Electric Peak Savings (kW/sf)	Gas Savings (Thm/sf)
0.92	0.00038	0.008

Applicable Square Footage

The CASE report uses construction data from the Nonresidential New Construction (NRNC) database to estimate aggregate savings. According to the CASE report, a total of 1,708,327 sf of nonresidential floor area per year is eligible or applicable for this savings analysis. The average square footage estimate of about 1.7 million sf is based on the total applicable floor space from

124 Final Report Sidelighting – Daylighting Requirements for Sidelit Areas near Windows, Codes and Standards Enhancement Initiative (Case), December 31, 2008.

125 2008 Building Energy Efficiency Standards for Residential and Nonresidential Buildings, CEC-400-2008-001-CMF, December 2008.

2000 to 2005 in the NRNC data. Total applicable floor space is calculated based on the building types of:

- Assembly, Bio/Tech & Light Manufacturing
- Community College, Small & Large Schools, Large Universities
- Large Offices
- Hotels
- Groceries, Small & Large Retail
- Conditioned and Unconditioned Warehouses
- Other type of buildings (CASE report does not indicate what are the building types in this group; however, the square footage for this type of buildings are not that significant)

Small Offices and Hospitals are not used in the estimation. The evaluator assumed that these building types were not considered since hospitals are exempt from the code requirements and the sidelit area in small offices would not exceed the 2,500 sf primary sidelit area criteria.

Cadmus estimated that the total annual nonresidential floor area for the building types listed above for the years 2010 – 2012 is about 21.7 million sf. Considering the downturn in the economy and reduction in annual construction volume in recent years, the applicable square footage for this standard was expected to be lower than the CASE report estimate. However, since the CASE report does not provide details for how the applicable square footage was determined, the evaluator could not provide comparable square footage estimation.

Statewide Potential Energy Savings Estimates

Table 144 summarizes the first-year savings for new nonresidential construction with skylighting and photocontrols according to the CASE report.

Table 144. Sidelighting Energy Savings Estimate

Total Electric Energy Savings (GWh/yr)	Total Demand Reduction (MW)	Total Gas Energy Savings (Mtherms)
1.57	0.64	0.01

In December 2012, Cadmus asked the CA IOUs to provide additional data to clarify Title 24 potential savings. Revised estimates from EEGA data request 2576-2579 provided are illustrated in Table 145.

Table 145. Revised Sidelighting Energy Savings Estimate

Total Electric Energy Savings (GWh/yr)	Total Demand Reduction (MW)	Total Gas Energy Savings (Mtherms)
1.20	0.50	0.01

G.4.3 Findings

Unit energy savings assumptions for the sample building appear to be reasonable; however, the positive gas savings reported for all climate zones needs further clarification. Since the building simulations evaluate only the parametric conditions of Dimming Photocontrols and No Daylighting Controls in each climate zone and no skylights/windows added or shading coefficient is changed, no savings from heating (gas savings) would be expected. Even increased gas consumption (negative gas savings) might be expected since the heat produced by lighting is reduced with the help of Dimming Photocontrols. Moreover, the sample buildings modeled in building simulations to estimate per-unit savings typically represents offices, schools, colleges with high window-wall ratio and does not seem appropriate for manufacturing facilities, warehouses, groceries and retail stores which represent approximately 18% of the total applicable sf/year in the NRNC estimate of eligible spaces (Figure 3 in the CASE report). Therefore, per-unit savings for the Standard 20 - Sidelighting savings may be overestimated somewhat, but the evaluator did not have enough information or resources to fully reanalyze the savings.

G.5 Standard B21 – Tailored Indoor Lighting

Table 146 provides a summary of the findings Cadmus used to estimate potential energy savings for tailored indoor lighting.

Table 146. Nonresidential Tailored Indoor Lighting Energy Savings Estimate

Description	IOU estimate		Evaluated	
	New Construction	Alterations	New Construction	Alterations
Unit Energy Savings (kWh)	1000	1000	3.2	3.2
Unit Demand Savings (kW)	0.2201	0.2201	0.0007	0.0007
Unit Gas Savings (therms)	--	--	--	--
Total Electric Energy Savings (GWh/yr)	10.8	20.1	1.13	26.51
Total Demand Reduction (MW)	2.40	4.40	0.25	5.80
Total Gas Energy Savings (Mtherms)	--	--	--	-0.1
Total applicable units (sq. ft.)	10,800	20,100	353,000	8,284,000

G.5.1 Description

The prescriptive requirements for indoor lighting are listed in Section 146 of the California building code. The proposed changes for Title 24 for improvements to the indoor lighting requirements in the CASE report aim to reduce Lighting Power Density (LPD) and total lighting consumption in nonresidential buildings since advanced lighting technologies are now available in the market. The scope of these changes has a particular emphasis on the Tailored Method for Retail Lighting. The primary proposed changes include:

- Reduced allowed lighting power density for accent display and feature lighting under the Tailored Method.
- Reduced allowed lighting power density for wall display lighting under the Tailored Method.
- Adjustment in criteria used to differentiate between luminaires qualifying as wall display versus floor display.
- Re-alignment of mounting height adjustment factor (TABLE 146-E T24-2005) to compensate for the difference between the lamp wattage range and optics of CMH versus halogen.
- Mandate use of comprehensive lighting controls as a prerequisite to using the Tailored Lighting method of Title 24 compliance under the 2008 standards.
- Expand requirement for daylight harvesting to more space types and to smaller spaces when/where appropriate.

Statewide Potential Energy Savings Estimates

According to the CASE report, the statewide impact of the proposed changes for interior lighting would be 21.1 GWh/yr of energy savings and 4.7 MW of electrical demand savings. No gas energy savings are assumed based on the proposed changes.

Table 147. Tailored Indoor Lighting Energy Savings Estimate

Total Electric Energy Savings (GWh/yr)	Total Demand Reduction (MW/yr)	Total Gas Energy Savings (Mtherms)
21.1	4.7	-

Unit Energy Savings Estimates

Unit energy savings estimates given in the IOU response to Data Request 10 (EEGA 2576-2579) are 3.2 kWh/square foot and 0.0007 kW/square foot.

Applicable Square Footage

The response to the data request provided assumptions for applicable square footage in new construction and alterations that were not available in the CASE report or the initial IOU Estimate. The total savings under these revised assumptions are given in Table 146 above.

G.5.2 Findings

Cadmus applied the IOU Estimate for savings per square foot to an updated estimate of applicable floor space (based on actual construction data) and assumed alteration floor area. However, the square footage estimates show that there is a significant difference in new and retrofitted retail spaces. Following the same methodology on the CASE report, Cadmus estimates that currently 0.35 million/sf/yr new retail spaces are built and there is about 8.2 million sf of existing retail space in California. Therefore, Cadmus estimate shows that tailored method would have an impact on a total of 8.5 million sf/yr of new or remodeled lighting systems.

G.6 Standard B22a – TDV Lighting Controls

No energy savings were included in the revised IOU Estimate for TDV lighting controls.

G.7 Standard B22b – DR Indoor Lighting

Due to the relatively low amount of savings associated with Demand Response (DR) Indoor Lighting, Cadmus choose to agree with the IOU's assumptions regarding market size and potential energy savings.

Table 148. Nonresidential DR Indoor Lighting Energy Savings Estimate

Description	IOU Estimate New Construction
Unit Energy Savings (kWh)	4,000
Unit Demand Savings (kW)	1.00
Unit Gas Savings (therms)	--
Total Electric Energy Savings (GWh/yr)	0.040
Total Demand Reduction (MW)	0.01
Total Gas Energy Savings (Mtherms)	--
Total applicable units (sq. ft.)	10

G.8 Standard B23 – Outdoor Lighting

Due to the relatively low amount of savings associated with outdoor lighting, Cadmus chose to agree with the IOU's assumptions regarding market size, without adjustment for actual construction which may not be directly related tooutdoor lighting improvements, and potential energy savings.

Table 149. Nonresidential Outdoor Lighting Energy Savings Estimate

Description	IOU Estimate New Construction
Unit Energy Savings (kWh)	1,000
Unit Demand Savings (kW)	--
Unit Gas Savings (therms)	--
Total Electric Energy Savings (GWh/yr)	7.8
Total Demand Reduction (MW)	--
Total Gas Energy Savings (Mtherms)	--
Total applicable units (sq. ft.)	7,820

G.9 Standard B24 – Outdoor Signs

Table 150 provides a summary of the finding Cadmus used to estimate potential energy savings for the outdoor signs.

Table 150. Evaluated Estimates for Outdoor Signs

Description	IOU Estimate New Construction	Evaluated New Construction
Unit Energy Savings (kWh)	1,000	1,000
Unit Demand Savings (kW)	--	--
Unit Gas Savings (therms)	--	--
Total Electric Energy Savings (GWh/yr)	1.2	1.2
Total Demand Reduction (MW)	--	--
Total Gas Energy Savings (Mtherms)	--	--
Total applicable units (sq. ft.)	1,210	1,210

G.9.1 Description

The 2008 Title 24 requirements for outdoor signs impose a series of measures to reduce energy use in outdoor lighting. The measures include:

- Automatic time switch controls on signs;
- A dimmer on outdoor signs that are illuminated during nighttime and daytime hours;
- Demand responsive controls for Electronic Message Centers with a connected load greater than 15 kW.

The 2008 California Building Code[126] specifies these provisions in sections 132, 133, 148, and 149 as listed below:

Section 132 (c) **Controls for Outdoor Lighting**

"1. All permanently installed outdoor lighting shall be controlled by a photocontrol or astronomical time switch that automatically turns off the outdoor lighting when daylight is available.

EXCEPTION to Section 132(c)1: Lighting in tunnels and large covered areas that require illumination during daylight hours.

2. For lighting of building facades, parking lots, sales and non-sales canopies, all outdoor sales areas, and student pickup/ drop-off zones where two or more luminaires are used, an automatic time switch shall be installed that is capable of (1) turning off the lighting when not needed and (2) reducing the lighting power (in watts) by at least 50 percent but not exceeding 80 percent or providing continuous dimming through a range that includes 50 percent through 80 percent reduction. This control shall meet the requirements of Section 119(c).

Section 133 (a) **Controls for All Signs.** All signs with permanently connected lighting shall meet the requirements of Section 133 below:

1. **Automatic Time Switch Control**. All signs with permanently connected lighting shall be controlled with an automatic time switch control that complies with the applicable requirements of Section 119.

2. **Photocontrol or outdoor astronomical time switch control**. All outdoor signs shall be controlled with a photocontrol or outdoor astronomical time switch control.

EXCEPTION to Section 133(a)2: Outdoor signs in tunnels and large covered areas that require illumination during daylight hours.

3. **Dimming**. All outdoor signs shall be controlled with a dimmer that provides the ability to automatically reduce sign power by a minimum of 65 percent during nighttime hours.

EXCEPTION 1 to Section 133(a)3: Signs that are illuminated for less than 1 hour per day during daylight hours.

EXCEPTION 2 to Section 133(a)3: Outdoor signs in tunnels and large covered areas that require illumination during daylight hours.

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126 2008 Building Energy Efficiency Standards for Residential and Nonresidential Buildings, CEC-400-2008-001-CMF, December 2008.

EXCEPTION 3 to Section 133(a)3: Metal halide, high pressure sodium, cold cathode, and neon lamps used to illuminated signs or parts of signs.

EXCEPTION 4 to Section 133(a)3: Demand Responsive Electronic Message Center Control. An Electronic Message Center (EMC) having a new connected lighting power load greater than 15 kW shall have a control installed that is capable of reducing the lighting power by a minimum of 30 percent when receiving a demand response signal that is sent out by the local utility.

EXCEPTION 5 to Section 133(a)4: EMCs required by a health or life safety statute, ordinance, or regulation, including but not limited to exit signs and traffic signs.

Section 148 (a) **Maximum Allowed Lighting Power.**

1. For internally illuminated signs, the maximum allowed lighting power shall not exceed the product of the illuminated sign area and 12 watts per square foot. For double-faced signs, only the area of a single face shall be used to determine the allowed lighting power.

2. For externally illuminated signs, the maximum allowed lighting power shall not exceed the product of the illuminated sign area and 2.3 watts per square foot. Only areas of an externally lighted sign that are illuminated without obstruction or interference, by one or more luminaires, shall be used.

(b) **Alternate Lighting Sources.** The sign shall comply if it is equipped only with one or more of the following light sources:

1. High pressure sodium lamps; or

2. Metal halide lamps that are:

   A. Pulse start or ceramic served by a ballast that has a minimum efficiency of 88 percent or greater, or

   B. Pulse start that are 320 watts or smaller, are not 250 watt or 175 watt lamps, and are served by a ballast that has a minimum efficiency of 80 percent.

   Where ballast efficiency is the measured output wattage to the lamp divided by the measured operating input wattage when tested according to ANSI C82.6-2005; or

3. Neon or cold cathode lamps with transformer or power supply efficiency greater than or equal to following:

   A. A minimum efficiency of 75 percent when the transformer or power supply rated output current is less than 50 mA; or

   B. A minimum efficiency of 68 percent when the transformer or power supply rated output current is 50 mA or greater.

Where the ratio of the output wattage to the input wattage is at 100 percent tubing load; or

4. Fluorescent lamps with a minimum color rendering index (CRI) of 80; or

5. Light emitting diodes (LEDs) with a power supply having an efficiency of 80 percent or greater; or

EXCEPTION to Section 148(b)5. Single voltage external power supplies that are designed to convert 120 volt AC input into lower voltage DC or AC output, and have a nameplate output power less than or equal to 250 watts, shall comply with the applicable requirements of the Appliance Efficiency Regulations (Title 20).

6. Compact fluorescent lamps that do not contain a medium screw base sockets (E24/E26) ; or

7. Electronic ballasts with a fundamental output frequency not less than 20 kHz;

EXCEPTION 1 to Section 148: Unfiltered incandescent lamps that are not part of an electronic message center (EMC), an internally illuminated sign, or an externally illuminated sign.

EXCEPTION 2 to Section 148: Exit signs. Exit signs shall meet the requirements of the Appliance Efficiency Regulations.

EXCEPTION 3 to Section 148: Traffic Signs. Traffic signs shall meet the requirements of the Appliance Efficiency Regulations.

Section 149 (b) **Alterations.** Alterations to existing nonresidential, high-rise residential, or hotel/motel buildings or alterations in conjunction with a change in building occupancy to a nonresidential, high-rise residential, or hotel/motel occupancy not subject to Subsection (a) shall meet either Item 1 or 2 below.

1. **Prescriptive approach.** The altered envelope, space conditioning, lighting and water heating components, and any newly installed equipment serving the alteration, shall meet the applicable requirements of Sections 110 through 139; and

NOTE: Replacement of parts of an existing luminaire, including installing a new ballast or new lamps, without replacing the entire luminaire is not an alteration subject to the requirements of Section 149(b)1.

Section 149 (b) H. New internally and externally illuminated signs shall meet the requirements of Sections 119, 133 and 148.

I. Alterations to existing indoor lighting systems shall meet the following requirements:

1. Alterations that increase the connected lighting load, replace, or remove and re-install a total of 50 percent or more of the luminaires in an enclosed space, shall meet the requirements of Sections 130 and 146; and

2. The following wiring alterations shall meet the requirements of Sections 119, 131, and 134:

i. Where new or moved wiring is being installed to serve added or moved luminaires; or

ii. Where conductor wiring from the panel or from a light switch to the luminaires is being replaced, or

iii. Where a lighting panel is installed or relocated.

3. For an alteration where an existing enclosed space is subdivided into two or more spaces, the new enclosed spaces shall meet the requirements of Sections 131(a) and (d); and

4. Alterations that have less than 0.5 watts per square foot and increase the existing lighting power density to 0.5 watts per square foot or greater shall meet the requirements of Sections 119, 130, 131, 134, 143(c), and 146."

G.9.2 Potential Energy Savings Estimates

Per-Unit Savings Estimates

The 2008 CASE report based its estimate of statewide annual savings on the California Outdoor Lighting Baseline Assessment.[127] This differs from other standards, for the CASE report does not provide a unit savings estimate such as wattage per sign nor a quantity figure such as number of signs.

The IOUs' estimated savings reported for the adopted code is 1.21 GWh per year, or 3.7%, based on time dependent valuation (TDV) calculations, weighted and aggregated for the various sign measures. The measures simulated include time control switches, dimmers, and high efficiency LED power supplies. The estimate of savings included the use of applicability factors, which provide an estimate of the occurrence of the measure in new signs on a statewide basis.

Quantity

No relevant quantity figure was given for this standard in the CASE report and none can be provided here, for no update to the 2003 Baseline Assessment exists.

Statewide Potential Energy Savings Estimates

The statewide impact of this code expressed as first-year savings of new nonresidential illuminated sign construction is 1.21 GWh per year. The statewide estimate of new sign construction energy use is based on data reported in the Baseline Assessment. This assessment

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127 *California Outdoor Lighting Baseline Assessment Technical Report*, California Energy Commission Document Number P500-03-082-A-18, October 2003.

assumed that signs are replaced every 15 years and that a lower bound of statewide sign energy usage is 410 GWh per year.

Since Cadmus did not find an update to the 2003 Baseline Assessment report, the value of 1.21 GWh is the same as that given in the CASE report,[128] and provides an estimate of annual savings during the 2010-2012 period.

G.9.3 Findings

The 2003 Baseline Assessment did not include a mechanism for estimating growth in signage over time. However, the signs installed since 2003 would not yet be scheduled for replacement, given the 15 year assumption, leaving the 2003 estimate of energy savings as a reasonable figure, since it assumes a uniform distribution of sign installations and a lower bound of annual sign energy usage.

G.10 Standard B26 – Refrigerated Warehouses

Table 151 provides a summary of the finding Cadmus used to estimate potential energy savings for refrigerated warehouses.

Table 151. Evaluated Estimates for Refrigerated Warehouses

Description	IOU Estimate New Construction	Evaluated New Construction
Unit Energy Savings (kWh)	1000	7.9
Unit Demand Savings (kW)	0.1635	0.0013
Unit Gas Savings (therms)	--	--
Total Electric Energy Savings (GWh/yr)	10.4	0.86
Total Demand Reduction (MW)	1.7	0.14
Total Gas Energy Savings (Mtherms)	--	--
Total applicable units (sq. ft.)	10,400	109,053

G.10.1 Description

This standard imposes a set of mandatory requirements for refrigerated warehouses. The previous Title 24 standards had not addressed refrigerated warehouses or the processes around them, such as pre-coolers and food processing, which are extremely energy intensive. Specific measures, not previously captured by the energy standards, can provide energy savings and demand reductions.

The changes to Title 24 affected the building shell insulation levels, evaporator fan controls, condenser fan power and control strategies, compressor plant controls and interior lighting levels for refrigerated warehouses. The equipment-related changes deal only with the storage

[128] *Codes and Standards Enhancement Initiative (CASE), Final Report: Requirements for Signs*, PG&E, December 31, 2008.

part of the facility; standards for pre-coolers or other clearly process related equipment were still not addressed.

The regulations in Section 126 of the California building code[129] read as follows:

"A refrigerated warehouse with total cold storage and frozen storage area of 3,000 sf or larger shall meet the requirements of this section.

EXCEPTION 1 to Section 126: A refrigerated space less than 3,000 sf shall meet the Appliance Efficiency

Regulations for walk-in refrigerators or freezers.

EXCEPTION 2 to Section 126: Areas within refrigerated warehouses that are designed solely for the purpose of quick chilling or freezing of products with design cooling capacities of greater than 240 Btu/hr-ft2 (2 tons per 100 square foot).

(a) **Insulation Requirements.** Exterior surfaces of refrigerated warehouses shall be insulated at least to the R-values in Table 126-A.

TABLE 126-A REFRIGERATED WAREHOUSE INSULATION

Space	Surface	Minimum R-Value (°F-hr-sf/Btu)
Frozen Storage	Roof/Ceiling	R-36
	Wall	R-36
	Floor	R-36
Cold Storage	Roof/Ceiling	R-28
	Wall	R-28

(b) **Underslab heating.** Electric resistance heat shall not be used for the purposes of underslab heating.

EXCEPTION to Section 126(b): Underslab heating systems controlled such that the electric resistance heat is thermostatically controlled and disabled during the summer on-peak period defined by the local electric utility.

(c) **Evaporators.** Fan-powered evaporators used in coolers and freezers shall conform to the following:

1. Single phase fan motors less than 1 hp and less than 460 Volts shall be electronically commutated motors.

[129] 2008 Building Energy Efficiency Standards for Residential and Nonresidential Buildings, CEC-400-2008-001-CMF, December 2008.

2. Evaporator fans shall be variable speed and the speed shall be controlled in response to space conditions.

EXCEPTION to Section 126(c)2: Evaporators served by a single compressor without unloading capability.

(d) **Condensers.** Fan-powered condensers shall conform to the following:

1. Condensers for systems utilizing ammonia shall be evaporatively cooled.

2. Condensing temperatures for evaporative condensers under design conditions, including but not limited to condensers served by cooling towers shall be less than or equal to:

A. The design wetbulb temperature plus 20°F in locations where the design wetbulb temperature is less than or equal to 76°F,

B. The design wetbulb temperature plus 19°F in locations where the design wetbulb temperature is between 76°F and 78°F, or

C. The design wetbulb temperature plus 18°F in locations were the design wetbulb temperature is greater than or equal to 78°F.

3. Condensing temperatures for air-cooled condensers under design conditions shall be less than or equal to the design drybulb temperature plus 10°F for systems serving frozen storage and shall be less than or equal to the design drybulb temperature plus 15°F for systems serving cold storage.

Exception to Section 126(d)3. Unitary condensing units.

4. All condenser fans for evaporative condensers shall be continuously variable speed, and the condensing temperature control system shall control the speed of all condenser fans serving a common condenser loop in unison. The minimum condensing temperature setpoint shall be less than or equal to 70°F.

5. All condenser fans for air-cooled condensers shall be continuously variable speed and the condensing temperature or pressure control system shall control the speed of all condenser fans serving a common condenser loop in unison. The minimum condensing temperature setpoint shall be less than or equal to 70°F, or reset in response to ambient drybulb temperature or refrigeration system load.

6. All single phase condenser fan motors less than 1 hp and less than 460 V shall be either permanent split capacitor or electronically commutated motors.

(e) **Compressors**. Compressor systems utilized in refrigerated warehouses shall conform to the following:

1. Compressors shall be designed to operate at a minimum condensing temperature of 70°F or less.

2. The compressor speed of a screw compressor greater than 50 hp shall be controllable in response to the refrigeration load or the input power to the compressor shall be controlled to be less than or equal to 60 percent of full load input power when operated at 50 percent of full refrigeration capacity.

EXCEPTION to Section 126 (e) 2: Refrigeration plants with more than one dedicated compressor per suction group."

G.10.2 Potential Energy Savings Estimates

Per-Unit Savings Estimates

As documented in the CASE report for this standard, the IOUs estimated per-unit savings by simulating the effects of measures (shell measures, evaporator fan controls, and evaporative condensers) with DOE 2.2R for two prototypical warehouses (92,000 sf and 26,000 sf) in two CZs (3, mild coastal and 13, warm inland). Table 152 lists the per-unit savings estimates.

Table 152. Refrigerated Warehouse Unit Savings

Energy (kWh/sf)	Demand (kW/sf)	Heating (therms/sf)
7.9	0.0013	0

Quantity

MHC data on new construction of refrigerated warehouses shows construction of 109,053 square foot of new space per year. This is the figure Cadmus used to estimate annual savings.

Statewide Potential Energy Savings Estimates

Statewide savings per year during 2010-2012 are estimated from the unit savings given in Table 152 and the warehouse space figure of 109,053 sf.

Using the noted values of project square footage and the CASE report's value of per-square-foot energy and demand savings, we derived the savings estimates shown in Table 151.

G.11 Standard B27 – DDC to the Zone

Table 153 provides a summary of Cadmus' findings with regard to potential energy savings from the implementation of standard B27, Direct Digital Control (DDC) to the zone level, in newly constructed buildings.

Table 153. Evaluated Estimates for DDC to the Zone

Description	IOU Estimate New Construction	Evaluated New Construction
Unit Energy Savings (kWh)	1000	0.475
Unit Demand Savings (kW)	0.3971	0.00020
Unit Gas Savings (therms)	103.73	0.05548
Total Electric Energy Savings (GWh/yr)	61.7	30.76
Total Demand Reduction (MW)	24.5	13.07
Total Gas Energy Savings (Mtherms)	6.4	3.99
Total applicable units (sq. ft.)	61,700	64,812,000

G.11.1 Description

The five separate measures required by this standard are prescribed in order to deliver energy savings through the use of DDC at the zone level, to parts of a building's HVAC system. The CASE report provided statewide savings estimates based on F. W. Dodge[130] Nonresidential New Construction data (averaged from 2000 to 2003). The impacts of the standard were calculated assuming the proportion of systems that would be affected, i.e. Variable Air Volume (VAV) boxes would affect 41% of systems installed. Each measure's energy savings were based on modeling simulations of a prototype building in each climate zone to determine unit energy savings and statewide energy impact. Some of the five requirements are modifications of existing requirements, others are new. In all cases, the regulations apply to new construction as well as retrofit, if the relevant HVAC equipment has DDC to the zone level.

Cadmus summarized the potential energy and demand savings from all five measures and the total square footage affected in the table above. The unit energy savings values shown are the average for the different measures.

Part 1 – VAV Zone Minimums

This part requires new minimum levels of air flow for VAV boxes with DDC controls. This regulation is described in Section 144(d) of the 2008 California code[131] as follows:

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[130] The F.W. Dodge report is produced by McGraw Hill Construction (MHC). Their reports are referred to by either of these names.

[131] 2008 Building Energy Efficiency Standards for Residential and Nonresidential Buildings, CEC-400-2008-001-CMF, December 2008.

"**Space-conditioning Zone Controls**. Each space-conditioning zone shall have controls that prevent:

1. Reheating; and

2. Recooling; and

3. Simultaneous provisions of heating and cooling to the same zone, such as mixing or simultaneous supply of air that has been previously mechanically heated and air that has been previously cooled, either by cooling equipment or by economizer systems.

EXCEPTION 1 to Section 144(d): Zones served by variable air-volume systems that are designed and controlled to reduce, to a minimum, the volume of reheated, re-cooled, or mixed air supply are allowed only if the controls meet the following requirements:

A. For each zone with direct digital controls (DDC):

1. The volume of primary air that is reheated, re-cooled, or mixed air supply shall not exceed the larger of:

a. 50 percent of the peak primary airflow, or

b. The design zone outdoor airflow rate per Section 121.

2. The primary airflow in the deadband shall not exceed the larger of:

a. 20 percent of the peak primary airflow; or

b. The design zone outdoor airflow rate per Section 121.

3. Airflow between deadband and full heating or full cooling must be modulated.

B. For each zone without DDC, the volume of primary airflow that is reheated, re-cooled, or mixed air supply shall not exceed the larger of the following:

1. 30 percent of the peak primary airflow; or

2. The design zone outdoor airflow rate per Section 121.

Part 2 – Demand Shed Controls

This part requires the ability to centrally reset thermostat setpoints of all non-critical zones by up to 4°F on remote contact closure.

The regulation is described in Section 122(h) of the 2008 California code:

Automatic Demand Shed Controls. HVAC systems with DDC to the Zone level shall be programmed to allow centralized demand shed for non-critical zones as follows:

1. The controls shall have a capability to remotely setup the operating cooling temperature set points by 4 degrees or more in all non-critical zones on signal from a

centralized contact or software point within an Energy Management Control System (EMCS).

2. The controls shall remotely set down the operating heating temperature set points by 4 degrees or more in all non-critical zones on signal from a centralized contact or software point within an EMCS.

3. The controls shall have capabilities to remotely reset the temperatures in all non-critical zones to original operating levels on signal from a centralized contact or software point within an EMCS.

4. The controls shall be programmed to provide an adjustable rate of change for the temperature setup and reset.

Part 3 – Hydronic Pressure Reset

This part requires reset by valve demand for pump pressure setpoint on variable flow systems. The regulation is a modification of an existing prescriptive requirement in Section 144(j)6.

The regulation is described in the California code as follows:

Variable Flow Controls.

A. Variable Speed Drives. Individual pumps serving variable flow systems and having a motor horsepower exceeding 5 hp shall have controls and/or devices (such as variable speed control) that will result in pump motor demand of no more than 30 percent of design wattage at 50 percent of design water flow. The pumps shall be controlled as a function of required differential pressure.

B. Pressure Sensor Location and Setpoint.

i. For systems without direct digital control of individual coils reporting to the central control panel, differential pressure shall be measured at or near the most remote heat exchanger or the heat exchanger requiring the greatest differential pressure.

ii. For systems with direct digital control of individual coils with central control panel, the static pressure set point shall be reset based on the valve requiring the most pressure, and the setpoint shall be no less than 80 percent open. The pressure sensor(s) may be mounted anywhere.

EXCEPTION 1 to Section 144(j)6: Heating hot water systems.

EXCEPTION 2 to Section 144(j)6: Condenser water systems serving only water-cooled chillers.

Part 4 – Demand Control Ventilation

This regulation requires multiple zone systems with DDC to the zone level to have demand control ventilation complying with Section 121(c)4. The regulation is a modification of an existing mandatory requirement of Section 121(c)3.

The regulation is described in the California code as follows:

> 3. **Required Demand Control Ventilation**. HVAC systems with the following characteristics shall have demand ventilation controls complying with 121(c)4:
>
> A. They have an air economizer; and
>
> B. They serve a space with a design occupant density, or a maximum occupant load factor for egress purposes in the CBC, greater than or equal to 25 people per 1,000 sf (40 sf per person); and
>
> C. They are either:
>
> i. Single zone systems with any controls; or
>
> ii. Multiple zone systems with Direct Digital Controls (DDC) to the zone level.

Part 5 – Supply Air Temperature Reset

This regulation removes an exception to the supply air temperature reset requirements for VAV systems with variable speed drives.

The regulation as prescribed by Section 144(f) of the California code follows:

> **Supply Air Temperature Reset Controls**. Mechanical space-conditioning systems supplying heated or cooled air to multiple zones shall include controls that automatically reset supply-air temperatures:
>
> 1. In response to representative building loads or to outdoor air temperature; and
>
> 2. By at least 25 percent of the difference between the design supply-air temperature and the design room air temperature.
>
> Air distribution systems serving zones that are likely to have constant loads, such as interior zones, shall be designed for the air flows resulting from the fully reset supply air temperature."

G.11.2 Statewide Potential Energy Savings Estimates

The unit savings per measure are given in Table 154 and the estimated new construction square footage per measure is discussed below. Potential savings are based on new construction only.

Table 154. Unit Energy Savings per DDC Measure

Reference	Measure	Energy Savings Per Unit (kWh)	Demand Savings Per Unit (kW)	Gas Savings Per Unit (therms)
Part 1	VAV Zone Minimums	0.260	-	0.0230
Part 2	Demand Shed Controls	0.020	0.000420	-
Part 3	Hydronic Pressure Reset	0.110	-	-
Part 4	Demand Control Ventilation	1.000	0.000600	0.1600
Part 5	Supply Air Temperature Reset	0.500	-	0.0520

With regard to the unit energy savings values, the CASE report describes how results from eQUEST building simulations were weighted by the applicable new construction square footage in each of the state's sixteen climate zones to produce these values. Cadmus used these values to determine potential energy savings but we note the absence of data from actual buildings that substantiates the savings estimates. In the field research conducted for the PY 2010-2012 evaluation, Cadmus identified eight sites with DDC to zone systems but this number of sites is too low to provide statistically significant results that could be compared to the estimated UES values.

Background

The CASE report gives the average annual nonresidential new construction areas by CZ from F.W. Dodge data for 2000-2003.The total is 157,827,000 sf. The building types used to compile this total are:

Amusement	Office
Assembly	Retail
Education (college)	School (K-12)
Government	Service
Hotel	Storage
Medical	Other

For each of the five parts of this standard, the CASE report provides a narrative describing the percent of total square footage that has DDC to the zone level. Cadmus determined square footages based on those narratives and found that in each case the resulting square footage did not agree with the square footage found by dividing the statewide savings by the unit savings. Cadmus requested clarification of those narratives in Data Request 10, but was only directed back to the descriptions in the CASE report. The response to the data request provided UES values for each climate zone as well as overall new construction square footage values by building type. While the response to the data request included UES values for each climate zone, it did not include the weighting information needed to determine an average statewide UES value for each measure. For this reason, Cadmus chose to use the unit energy saving values documented in the CASE report. We checked that the UES values fell within the range of values presented for each climate zone in the response to the data request.

Table 154 shows the percent of total new construction square footage applicable to each measure as given in the CASE report. Data request 10 presented revisions to these figures but

Cadmus was unable to verify the source of the revisions and therefore chose to use the proportions presented in the CASE report instead.

Table 155. Square Footage Applicable to Each Part of the Standard

Description	Part 1	Part 2	Part 3	Part 4	Part 5
Share of New Construction	41%	16%	17%	41%	41%
Applicable Square Footage	16,960,000	6,900,000	7,032,000	16,960,000	16,960,000

Current Case

We obtained estimates of the average square footage during 2010-2012 for new construction from MHC data. Cadmus excluded hospitals, arenas and collisuems, manufacturing labs, plants, warehouses, parking garages and automotive services and found the average over the three years is 41,365,000 sf, and this is the value used to obtain statewide savings. When the percentages shown in

Table 155 are applied to the overall square footage value, we found that the standard applies to a total of 64,812,000 sf because more than one of the measures are sometimes applicable in the same building space.

G.11.3 Findings

Combining the UES values with the applicable square footage, Cadmus found the potential energy savings from each of the five parts of the standard. These values are shown in Table 156.

Table 156. Potential Savings for each Part of the Standard

Reference	Description	Annual Energy Savings (GWh)	Annual Demand Savings (MW)	Annual Gas Savings (Mtherms)
Part 1	VAV Zone Minimums	4.41	-	0.39
Part 2	Demand Shed Controls	0.14	2.90	-
Part 3	Hydronic Pressure Reset	0.77	-	-
Part 4	Demand Control Ventilation	16.96	10.18	2.71
Part 5	Supply Air Temperature Reset	8.48	-	0.88
Std B27	Total All Parts	30.76	13.07	3.99

G.12 Standard B28 – Residential Swimming Pool

Table 157 provides a summary of the findings Cadmus used to estimate potential energy savings for residential swimming pools.

Table 157. Evaluated Estimates for Residential Swimming Pools

Description	IOU Estimate New Construction	Evaluated New Construction
Unit Energy Savings (kWh)	1,000	1,623
Unit Demand Savings (kW)	0.5583	0.9070
Unit Gas Savings (therms)	--	--
Total Electric Energy Savings (GWh/yr)	56.6	17.85
Total Demand Reduction (MW)	31.6	9.98
Total Gas Energy Savings (Mtherms)	--	--
Total applicable units (pools)	56,000	10,999

G.12.1 Description[132]

This standard mandates various design and operational aspects of new California swimming pools. The measures established the minimum acceptable pool design for increased energy efficiency while maintaining safety standards.

Proposed mandates included pump motor selection, pipe design, filter size selection, and pool cover use. Energy savings are obtained by reducing the pool system total dynamic head, or TDH, through recommended pipe design and filter specifications, and by using a correctly sized pump and motor. Special purpose single-phase motors, such as those used in residential pool pumps, and two-speed motors, are not regulated by federal motors standards, but are included in the 2005 Title 20 appliance standards regulations.

> "Any pool or spa heating system or equipment may be installed only if the manufacturer has certified that the system or equipment has a thermal efficiency that complies with the Title 20 Appliance Efficiency Regulations. Title 20 standards for residential pool pump motors (Tier 2) stipulate that pump motors with a capacity of 1 HP or greater and manufactured on or after January 1, 2010, must meet the following requirements:
>
> - Must be able to operate at two or more speeds
> - Must be operated with a pump control capable of operating at least at two speeds

132 Portions of this section are taken from the California code: *2008 Building Energy Efficiency Standards for Residential and Nonresidential Buildings*, CEC-400-2008-001-CMF, December 2008, and from the CASE report: *Codes and Standards Enhancement Initiative (CASE), Residential Swimming Pools*, PG&E and SDG&E, January 8, 2009.

- Pump controls manufactured after January 1, 2008 sold for use with two or more speed pumps must be able to operate the pump at least at two speeds. The default speed shall be no more than half of the motor's maximum rotation rate. High speed override is allowed for up to 24 hours before it reverts back to default settings.

In addition, any pool or spa system or equipment shall be installed with all of the following:

1. **Piping**. At least 36 inches of pipe shall be installed between the filter and the heater or dedicated suction and return lines, or built-in or built-up connections shall be installed to allow for the future addition of solar heating equipment;

2. **Covers**. A cover for outdoor pools or outdoor spas that have a heat pump or gas heater.

3. **Directional inlets and time switches for pools**. If the system or equipment is for a pool:

i. The pool shall have directional inlets that adequately mix the pool water; and

ii. A time switch or similar control mechanism shall be installed as part of the pool water circulation control system that will allow all pumps to be set or programmed to run only during the off-peak electric demand period and for the minimum time necessary to maintain the water in the condition required by applicable public health standards."

G.12.2 Potential Energy Savings Estimates

Per-Unit Savings Estimates

Unit savings estimates are based upon differences in energy from model simulations of three base case pools and a desired pool with design measures applied. The values in Table 158 are found on p. 31 of the CASE report.

Table 158. Energy Savings per Pool

kWh/yr/pool	kW/yr/pool	Therms/yr/pool
1,623	0.907	0

Quantity

The CASE report provided an estimate of 34,848 new pools per year.

The average number of pools installed per year in the evaluation period was 10,999, according to the U.S. Swimming Pool and Hot Tub Market 2010 and 2011. (P.K. Data, Inc.).[133]

133 The numbers for new in-ground pool units in California were taken from the U.S. Swimming Pool and Hot Tub Market 2010 and 2011. (P.K. Data, Inc.)

G.12.3 Statewide Potential Energy Savings Estimates

Using the updated quantity of pools and the unit savings from the CASE report, we estimated the first year statewide savings shown in Table 157. The high demand savings shown result from the assumption that pool motors would be running concurrently with peak in the baseline; this follows from requirement 3.ii above that pumps must run "only during the off-peak electric demand period."

G.12.4 Findings

New pool construction dropped from about 35,000 pools per year in 2005 to about 11,000 in 2010-2012. Nevertheless, the statewide savings from this standard remain substantial.

G.13 Standard B29 – Site Built Fenestration

Due to the relatively low amount of savings associated with site-built fenestration, Cadmus simply adjusted the IOUs' estimates of the potential savings for the change in the level of new construction. The actual level of construction was found to be 21.7% of the level assumed in the IOU Estimate as detailed in Chapter 5 of the main report.

The unit savings and quantity of units shown by the IOUs were selected for convenience to produce the estimated total potentials and were not intended to be actual estimates of these quantities, as shown in Table 159. These values were not revised.

Table 159. Nonresidential Site Built Fenestration Energy Savings Estimate

Description	IOU Estimate New Construction	Evaluated New Construction
Unit Energy Savings (kWh)	1,000	1,000
Unit Demand Savings (kW)	--	--
Unit Gas Savings (therms)	25.68	25.68
Total Electric Energy Savings (GWh/yr)	7.4	1.9
Total Demand Reduction (MW)	--	--
Total Gas Energy Savings (Mtherms)	0.2	0.03
Total applicable units	7,400	7,400

G.14 Standard B30 – Low Rise Residential Fenestration

Table 160 provides a summary of the findings Cadmus used to estimate potential energy savings for residential fenestration. The unit savings and quantity of units shown by the IOUs were selected by the IOUs for convenience to produce the estimated total potentials and were not intended to be actual estimates of these quantities.

Table 160. Evaluated Estimates for Residential Fenestration

Description	IOU Estimate		Evaluated	
	New Construction	Alterations	New Construction	Alterations
Unit Energy Savings (kWh)	1,000	1,000	127	127
Unit Demand Savings	0.8206	0.8206	0.084	0.084
Unit Gas Savings	209.87	209.87	40	40
Total Electric Energy Savings (GWh/yr)	26.7	4.5	3.86	0.66
Total Demand Reduction (MW)	21.9	3.72	2.94	0.50
Total Gas Energy Savings (Mtherms)	5.6	0.95	1.10	0.15
Total applicable units (sq. ft.)	26,700	4,500	27,433	4,664

G.14.1 Description

The 2005 Title 24 code prescribed maximum U-factor, maximum SHGC, maximum total area, and maximum West facing area for fenestration in low-rise residential buildings. The 2008 T24[134] modified the maximum U-factor and the maximum SHGC values as shown in Table 161.

Table 161. Residential Fenestration Requirements

Climate Zone	Max. U, 2005	Max. U, 2008	Max. SHGC, 2005	Max. SHGC, 2008
1	0.57	0.40	NR	NR
2	0.57	0.40	0.40	0.40
3	0.67	0.40	NR	NR
4	0.67	0.40	0.40	0.40
5	0.67	0.40	NR	0.40
6	0.67	0.40	NR	0.40
7	0.67	0.40	0.40	0.40
8	0.67	0.40	0.40	0.40
9	0.67	0.40	0.40	0.40
10	0.57	0.40	0.40	0.40
11	0.57	0.40	0.40	0.40
12	0.57	0.40	0.40	0.40
13	0.57	0.40	0.40	0.40
14	0.57	0.40	0.40	0.40
15	0.57	0.40	0.40	0.35
16	0.55	0.40	NR	NR

The values in the 2008 columns constitute the current B30 fenestration standards.

G.14.2 Potential Energy Savings Estimates

Per-Unit Savings Estimates

Per-house IOU savings estimates from the 2008 fenestration standard come from simulations of a basecase 1,761 sf house in each of California's 16 CZs. For the simulation, the base case was a

[134] 2008 Building Energy Efficiency Standards for Residential and Nonresidential Buildings, CEC-400-2008-001-CMF, December 2008.

house meeting the 2005 T24 requirements, and the proposed house was one meeting those same requirements except that the windows met the 2008 fenestration values listed in Table 161 (called Package D values).

The energy savings results in each CZ were weighted by the percent of housing starts in that CZ. The weighted averages for energy, demand, and heating are shown in Table 162. The savings figures per house come from a CEC-provided spreadsheet[135] that served as the CASE report input.

Table 162. Weighted Averages of Energy Savings per House

kWh/yr/house	kW/yr/house	Therms/yr/house
127	0.084	40

Number of Housing Starts

The number of housing starts in 2010, 2011, and 2012 are 25,900, 21,600, and 34,800, respectively. The housing figures come from AAMA/WDMA U.S. Industry Regional Statistical Review and Forecast (May 2012). The average of these is 27,433, and that is the number used to estimate statewide potential energy savings from this standard.

The CASE report gave total housing construction of 154,834 combined single family and multifamily homes based on 2005 data.

The revised IOU estimate gave total housing construction of 108,021 single family homes and 37,505 multifamily homes. It also estimated additional savings of 17% for alterations to existing homes.

Cadmus used 27,433 based on the source cited above for new construction and 4,664 (or 17%) additional units for alterations.

Cadmus combined the energy savings per home and updated construction estimates to produce the savings shown in Table 160.

G.15 Standard B31 – Cool Roof Expansion

Table 163 provides a summary of the findings Cadmus used to estimate potential energy savings for the cool roof expansion standard. The unit savings and quantity of units shown by the IOUs were selected for convenience to produce the estimated total potentials and were not intended to be actual estimates of these quantities.

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135 Statewide Energy Savings Estimate – Res Windows.xls.

Table 163. Evaluated Estimates for Cool Roof Expansion

Description	IOU Estimate		Evaluated	
	New Construction	Alterations	New Construction	Alterations
Unit Energy Savings (kWh)	1,000	1,000	1.0	0.9440
Unit Demand Savings (kW)	0.0919	0.0919	0.0001	0.0001
Unit Gas Savings (therms)	(3.41)	(3.41)	(0.00278)	(0.00275)
Total Electric Energy Savings (GWh/yr)	21.9	51.0	5.10	17.56
Total Demand Reduction (MW)	2.0	4.70	0.47	1.62
Total Gas Energy Savings (Mtherms)	(0.1)	(0.15)	(0.01)	(0.05)
Total applicable units (sq. ft.)	21,900	51,000	5,096,000	18,599,000

G.15.1 Description[136]

The 2005 Title 24 standards prescribed minimum values of solar reflectance and thermal emittance for low-sloped roofs (i.e., roofs with a ratio of rise to run not exceeding 2:12) on nonresidential buildings. The 2008 standard adds prescriptive requirements for the solar reflectance and thermal emittance of roofs to California's Title 24 standards for nonresidential buildings with steep-sloped roofs (i.e., roofs with a ratio of rise to run exceeding 2:12). The code also adds the specification of three-year-aged, rather than initial, values of solar reflectance and thermal emittance for nonresidential buildings with steep-sloped roofs and nonresidential buildings with low-sloped roofs. The specific requirements of 2008 Title 24 include:[137]

> i. Nonresidential steep-sloped roofs with roofing products that have a roof weight of less than 5 pounds per square foot in climate zones 2-16 shall have a minimum 3-year aged solar reflectance of 0.20 and a minimum thermal emittance of 0.75, or a minimum SRI of 16. Steep-sloped roofing products that have a roof weight of 5 pounds per square foot or more in climate zones 1 through 16 shall have a minimum 3-year aged reflectance of 0.15 and a minimum emittance of 0.75, or a minimum SRI of 10.
>
> ii. High-rise residential buildings and hotels and motels with low-sloped roofs in climate zones 10, 11, 13, 14, and 15 shall have a minimum 3-year aged solar reflectance of 0.55 and a minimum thermal emittance of 0.75, or a minimum SRI of 64.

For nonresidential buildings, high-rise residential buildings, and hotels/motels, where more than 50% of the roof or more than 2,000 sf of roof, whichever is less, is being replaced, recovered or recoated, this altered roof area shall meet the applicable requirements of sections i-ii above.

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136 Most of the following text has been excerpted from Code Change Proposal: Inclusion of Solar Reflectance and Thermal Emittance: Prescriptive Requirements for Steep-Sloped Nonresidential Roofs in Title 24, PG&E/LBNL, May 18, 2006.

137 2008 Building Energy Efficiency Standards for Residential and Nonresidential Buildings, CEC-400-2008-001-CMF, December 2008.

G.15.2 Potential Energy Savings Estimates

Per-Unit Savings Estimates

The IOUs used the MICROPAS building energy model to estimate the effects of cool roofs on space cooling and heating energy use by a prototypical Title 24-compliant non-residential building for each of California's 16 climate zones. The simulated savings (normalized per 1,000 sf of cool roof area) were combined with projections of annual new roof and re-roofing area additions to predict statewide savings.

The prototype building is a non-directional one-story office building with a conditioned floor area of 2,000 sf and a steep-sloped hip roof with a slope of 5:12. Building envelope, interior mass, thermostat setpoint, occupancy, internal gain, and water heating characteristics are consistent with the Title 24 Nonresidential Building Standards Alternative Calculation Method Approval Manual.

Space conditioning is provided by a SEER 13 split-system air-conditioner and a 78% AFUE natural gas furnace. This space conditioning system is attached to "sealed" supply and return air ducts that are located in the attic (4% leakage for each of the supply and return duct sections). The ducts have R-4.2 insulation as prescribed by the Standards. A setback thermostat is specified with cooling setpoints of 73°F for hours 6 through 18 and 77°F for hours 1 through 5 and 19 through 24, and heating setpoints of 70°F for hours 8 through 18, 65°F for hours 6, 7 and 19; and 60°F for hours 1 through 5 and 20 through 24.

Three different roofing materials were simulated: fiberglass asphalt shingles, concrete tiles, and standing-seam metal panels. The thermal performance of a building with a clay tile roof was assumed similar to that of a building with a concrete tile roof.

For each of the 192 variations of the prototypical building that were simulated (16 climate zones, three roofing materials, two solar reflectances, two roof insulation types), MICROPAS estimated annual source and 30-year TDV-weighted space cooling electricity use and space heating natural gas use, as well as peak power demand for space cooling.

Simulations were conducted for six scenarios (three roofing materials and two insulation types) in all 16 climate zones. Minimum and maximum unit savings were found, and Table 164 shows the average of electricity savings, peak demand savings, and heating savings (negative). These values do not appear to have been used for analyses reported in later sections of the CASE report. Please see discussion under Findings.

Table 164. Average Energy, Demand, and Gas Savings as a Function of Insulation Type

Average of Findings	Insulation Type	
	Unfaced	FSK-faced
TDV-weighted electricity savings (kWh/1000 sf)	1.688	1.497
Peak demand savings (kW/1000 sf)	0.16	0.14
TDV-weighted natural gas deficits (therms/1000 sf)	5.8	5.4

Roof Area Affected

Cadmus obtained MHC data on new construction and additions/alterations for the years 2010-2012 and used the building types shown in Table 165 for this standard in accordance with the CASE report.

Table 165. Building Types for Standard B31

Building Types	Building Types
Apartment, 4+ stories	Houses of worship
Amusement	Schools, libraries, & labs.
Arenas & coliseums	Food/beverage services
Dormitories	Shopping centers
Government buildings	Stores
Hotels & motels	Refrigerated warehouses
Misc. nonresidential buildings	Non-refrigerated warehouses
Office & bank buildings	

The MHC data provides floor area figures for each building type and year. The CASE report (pp. 12-13) indicates that the ratio of overall roofing area to floor area is 0.66. Furthermore, it stated that that California re-roofing area is estimated at 3.85 times the new construction roofing area. Last, the CASE report estimates that steep-sloped roofs account for 20% of the new and re-roofing area, and that 90% would ordinarily be built with a non-cool roof.

Cadmus used these estimates to find the total new construction and re-roofing area for each year, 2010-2012, and then averaged the annual results to find the new construction and re-roofing area to estimate annual savings. The results are 5,096,000 sf of new construction roof area and 18,599,000 sf of re-roofing area.

G.15.3 Statewide Potential Energy Savings Estimates

The product of the unit savings times the roofing areas yields the statewide savings estimates for the new construction and re-roof cases. Table 166 lists the results; the therm total is affected by rounding.

Table 166. Statewide Savings

Case	GWh	MW	Ktherm
New construction	5.1	0.47	-14.7
Re-roofing	17.6	1.62	-51.1
Total	22.7	2.09	-65.9

Findings

There are a number of places in which figures in one part of the CASE report do not agree with figures in another part.

Graphs on pp. 49-54 display simulation findings as a function of climate zone. The y-axis on the first graph on p. 49 is labeled Annual TDV Energy Savings (MBtu/1000 sf). A review of the figures (a)-(f) shows that the average cooling value is about 5 MBtu/1000 sf. This corresponds to about 1.46 MWh/1000 sf. However, the table on the top of p. 26 labels the electricity savings as kWh/1000 sf, not MWh. That table also has errors with the minimum values: 477 should likely be 0.477 and 421 should be 0.421. The designation M can be confirmed as million, not thousand, by the value that is derived for the heating savings in therms.

Table 7 (a, b) on p. 47 lists Annual TDV Energy Savings for electricity (GWh) and gas (ktherm), as well as peak demand savings. Dividing the annual savings for the unfaced insulation case by the new construction square footage (14 Msf of roof area) gives unit savings of:

- 1.07 MWh/1000 sf The table on p. 26 has 1.688
- -3.0 therms/1000 sf The table on p. 26 has -5.8
- 0.1 kW/1000 sf The table on p. 26 has 0.16.

For the re-roof case of 54 Msf in the CASE report, the unit savings are not consistent with the new construction case, above. This may be fine given that the figures resulted from different simulations. The corresponding re-roof unit savings are:

- 1.00 MWh/1000 sf, not 1.07
- -2.852 therms/1000 sf, not -3.0
- 0.093 kW/1000 sf, not 0.1.

The unit savings figures for the re-roof and new construction cases are reasonably close.

The FSK-faced insulation case unit savings figures also disagree with those on p. 26.

The MHC data does not indicate the type of insulation in each building, and therefore Cadmus averaged the unit savings for the two insulation cases using the data presented in Table 7 (a, b) of the CASE report. The MHC data does enable an estimation of new construction square footage and re-roofing square footage. Therefore, Cadmus determined average unit savings figures for both the new construction and re-roof cases. The values are shown in Table 167 and are the figures used to determine statewide savings.

Table 167. Unit Savings for Cool Roof Standard

Roof Case	Energy, MWh/ksf	Demand, kW/ksf	Heating, therm/ksf
New construction	1.0	0.093	-2.893
Re-roofing	0.944	0.087	-2.75

G.16 Standard B32 – Multifamily Water Heating Control

Table 168 provides a summary of the findings Cadmus used to estimate potential energy savings for the multifamily water heating controls standard.

Table 168. Energy Savings Estimates for Multifamily Water Heating Controls

Description	IOU Estimate	Evaluated
	New Construction	New Construction
Unit Energy Savings (kWh)	--	--
Unit Demand Savings (kW)	--	--
Unit Gas Savings (therms)	7.27	2.4
Total Electric Energy Savings (GWh/yr)	--	--
Total Demand Reduction (MW)	--	--
Total Gas Energy Savings (Mtherms)	0.04	0.02
Total applicable units (sq. ft.)	5,500	7,853

Description

A water heating recirculation loop is a type of hot water distribution system that reduces the time needed to deliver hot water to fixtures that are distant from the water heater, boiler or other water heating equipment.[1] The recirculation loop is comprised of a supply portion, connected to branches that serve multiple dwelling units, guest rooms, or fixtures and a return portion that completes the loop back to the water heating equipment. The standard applies to high-rise residential, hotel/motel, and other nonresidential occupancies, although the savings reported below only apply to multifamily buildings. A water heating recirculation loop shall include the following requirements, according to the California building code:[138]

A. **Air release valve or vertical pump installation**. An automatic air release valve shall be installed on the recirculation loop piping on the inlet side of the recirculation pump and no more than 4 feet from the pump. This valve shall be mounted on top of a vertical riser at least 12" in length and shall be accessible for replacement and repair. Alternatively, the pump shall be installed on a vertical section of the return line.

B. **Recirculation loop backflow prevention**. A check valve or similar device shall be located between the recirculation pump and the water heating equipment to prevent water from flowing backwards though the recirculation loop.

C. **Equipment for pump priming**. A hose bibb shall be installed between the pump and the water heating equipment. An isolation valve shall be installed between the hose bibb and the water heating equipment. This hose bibb is used for bleeding air out of the pump after pump replacement.

[138] 2008 Building Energy Efficiency Standards for Residential and Nonresidential Buildings, CEC-400-2008-001-CMF, December 2008.

D. **Pump isolation valves**. Isolation valves shall be installed on both sides of the pump. These valves may be part of the flange that attaches the pump to the pipe. One of the isolation valves may be the same isolation valve as in item C.

E. **Cold water supply and recirculation loop connection to hot water storage tank**. Storage water heaters and boilers shall be plumbed in accordance with the boiler manufacturer's specifications. The cold water piping and the recirculation loop piping shall not be connected to the hot water storage tank drain port.

F. **Cold water supply backflow prevention**. A check valve shall be installed on the cold water supply line between the hot water system and the next closest tee on the cold water supply line. The system shall comply with the expansion tank requirements as described in the California Plumbing Code Section 608.3.

Statewide Potential Energy Savings Estimates

The first-year statewide savings are calculated by multiplying estimated per-unit energy savings by the number of units (central hot water heating systems) installed per year. Data from HMG reported in the CASE report (p. 12) indicates that the statewide average for central systems is 40% of the number of units. Based on the per-unit savings of 2.4 therm/unit/year and the number of units,7,853, both discussed below, the statewide savings is estimated at 18,800 therms/yr.

Per-Unit Savings Estimates

Crossover is the term used to describe the flow of water between the hot and cold water pipes. It results in wasted energy and unpredictable temperatures.[139] The pressure differentials associated with recirculation pumps make crossover particularly serious in recirculation systems. Crossover can be reduced both by installing a check valve on the cold water supply line before it tees into the hot water return line, and by reducing the connection of hot and cold water lines at single-lever valves (shower mixing valves and single-lever faucets). These two measures together would likely cause a significant reduction in crossover, but may not completely eliminate it.[140]

Three buildings were monitored by HMG in the 2006 PIER DHW field study: one exhibited no measurable crossover, and two exhibited levels of 26 and 19 gallons per day per unit. HMG calculated these figures using a conservative algorithm that identified crossover as occurring only when there was reverse flow along the cold water pipe *and* when the temperature of the cold water pipe was high.[141]

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139 Design Brief on Central DHW Systems in Multifamily Buildings, Energy Design Resources.

140 CASE Report: Revised Report: Central Hot Water Distribution Systems in Multifamily Buildings, Southern California Gas Company, Nov. 16, 2007.

141 Ibid

These crossover flows created energy waste that HMG calculated as 83 and 1.6 Btu/hr/unit respectively. The average of those heat loss rates is 42 Btu/hr/unit. The building with the higher heat loss rate was an older (1992) building, while the other building was built in 2004, so the difference in heat loss rate is consistent with older, leakier valves.[142]

Multiplying this heat loss rate over an entire year (assuming that the recirculation pump is switched on for only 16 hours per day) yields an annual heat loss of 2.4 therms per year per unit. The CASE report states that this estimate is conservative and has a high degree of error, so actual savings may be significantly greater or less than this figure.

Number of Affected Units

The American Architectural Manufacturers Association (AAMA/WDMA) U.S. Statistical Review and Forecast-California (May 2012) published estimates of the number of apartments in 2010, 2011, and 2012 (estimate). The values for each year are 13,900, 21,200, and 23,800, respectively. Approximately 40% of these units are assumed to have central domestic hot water systems (CEC 2005, p.19).[143] Taking 40% of each value and then finding the average over the three years gives 7,853 units. This is the value used to estimate statewide savings.

Findings

As stated in the CASE report, a per unit savings estimate of 2.4 therms per year has a high degree of uncertainty, based as it is on the average of just two data points an order of magnitude apart (83 and 1.6 Btu/hr/unit).

[142] Ibid

[143] CEC 2005 estimates that 40% of multifamily homes in climate zones 6-10 will have central water heating, and 15% in other climate zones. However, data from HMG's implementation of multifamily incentive projects indicates that the statewide average for central systems is now 40%.

G.17 Standard B33 – Composite for Remainder

With their response to Data Request 10 in February, 2013, the IOUs identified six specific standards that produce the savings in the category referred to as the Composite for Remainder. Cadmus revised the potential savings associated with these six standards by using the unit energy savings values provided by the IOUs combined with revised construction volumes. The result of these updates are shown in the six tables below.

Table 169. Estimated Energy Savings for Complete Building Method

Description	IOU Estimate		Evaluated	
	New Construction	Alterations	New Construction	Alterations
Unit Energy Savings (kWh)	1000	1000	0.4714	0.9588
Unit Demand Savings (kW)	0.2226	0.2226	0.0001	0.0002
Unit Gas Savings (therms)	--	--	--	--
Total Electric Energy Savings (GWh/yr)	31.4	118.2	6.35	118.2
Total Demand Reduction (MW)	7.0	26.3	1.42	26.30
Total Gas Energy Savings (Mtherms)	--	--	--	--
Total applicable units (sq. ft.)	31,400	118,200	13,465,776	123,282,381

Table 170. Estimated Energy Savings for Area Category Method

Description	IOU Estimate		Evaluated	
	New Construction	Alterations	New Construction	Alterations
Unit Energy Savings (kWh)	1000	1000	0.18	0.34
Unit Demand Savings (kW)	0.22	0.22	0.0004	0.00007
Unit Gas Savings (therms)	--	--	--	--
Total Electric Energy Savings (GWh/yr)	18	64.5	4.1	64.5
Total Demand Reduction (MW)	4	14.5	0.91	14.5
Total Gas Energy Savings (Mtherms)	--	--	--	--
Total applicable units (sq. ft.)	18,000	64,500	22,720,394	184,539,420

Table 171. Estimated Energy Savings for Egress Control

Description	IOU Estimate New Construction	Evaluated New Construction
Unit Energy Savings (kWh)	1000	0.81
Unit Demand Savings (kW)	--	--
Unit Gas Savings (therms)	--	--
Total Electric Energy Savings (GWh/yr)	30	5.67
Total Demand Reduction (MW)	--	--
Total Gas Energy Savings (Mtherms)	--	--
Total applicable units (sq. ft.)	30,000	6,999,325

Table 172. Estimated Energy Savings for HVAC Efficiency

Description	IOU Estimate New Construction	Evaluated New Construction
Unit Energy Savings (kWh)	1000	1000
Unit Demand Savings (kW)	0.54	0.54
Unit Gas Savings (therms)	--	--
Total Electric Energy Savings (GWh/yr)	17.5	3.80
Total Demand Reduction (MW)	9.6	2.08
Total Gas Energy Savings (Mtherms)	--	--
Total applicable units (sq. ft.)	17,500	3,798

Table 173. Estimated Energy Savings for Residential Cool Roofs

Description	IOU Estimate		Evaluated	
	New Construction	Alterations	New Construction	Alterations
Unit Energy Savings (kWh)	1000	1000	1000	--
Unit Demand Savings (kW)	0.69	0.69	0.69	--
Unit Gas Savings (therms)	(17.23)	(17.23)	(17.23)	--
Total Electric Energy Savings (GWh/yr)	10.2	1.7	3.07	--
Total Demand Reduction (MW)	7.1	1.21	2.35	--
Total Gas Energy Savings (Mtherms)	(0.2)	(0.03)	-0.14	--
Total applicable units (sq. ft.)	10,200	1,700		--

Table 174. Estimated Energy Savings for HVAC Efficiency

Description	IOU estimate		Evaluated	
	New Construction	Alterations	New Construction	Alterations
Unit Energy Savings (kWh)	1,000	1,000	1,000	--
Unit Demand Savings (kW)	0.6726	0.6726	0.6241	--
Unit Gas Savings (therms)	--	--	--	--
Total Electric Energy Savings (GWh/yr)	28.7	4.9	8.36	--
Total Demand Reduction (MW)	19.3	3.28	6.62	--
Total Gas Energy Savings (Mtherms)	--	--	-0.17	--
Total applicable units (sq. ft.)	28,700	4,900	8,039	--

Appendix H. Gross Savings: Title 24 Compliance Detail

H.1 New Construction

H.1.1 New Construction Impact Findings

Through its evaluation efforts, Cadmus analyzed 91 newly-constructed sites in California to determine compliance with and savings relative to the 2005 and 2008 Title 24 commercial building codes, as shown in Figure 43.

Figure 43. Distribution of New Construction Sites Analyzed

Through the efforts described above, Cadmus found that 82 of the 91 newly-constructed sites analyzed met the 2008 Title 24 lighting code requirements. All of these sites complied with the

2005 Title 24 code, and an additional three sites were compliant with the 2005, but not the 2008, lighting code. The remaining six sites complied with neither the 2005 nor the 2008 lighting code.

Table 175. Percentage of Sites in Compliance with 2005 and 2008 Title 24 Interior Lighting Codes

Building Type	Count	Percent of Sites in Compliance with 2005 Code	Percent of Sites in Compliance with 2008 Code
Retail	18	100.0%	100.0%
Office Building	14	92.9%	92.9%
High-bay or Industrial	10	100.0%	80.0%
Restaurant	10	80.0%	70.0%
Religious Facilities	9	100.0%	100.0%
Assembly	7	100.0%	100.0%
Gas Station	5	60.0%	60.0%
Athletic Facilities	4	100.0%	100.0%
Auto Care/Maintenance	4	100.0%	100.0%
Classroom Building	2	100.0%	100.0%
Medical Building	2	100.0%	100.0%
Multifamily/Group Living	2	50.0%	50.0%
Museum	2	100.0%	100.0%
Research and Laboratories	2	100.0%	100.0%
Total	91	93.4%	90.1%

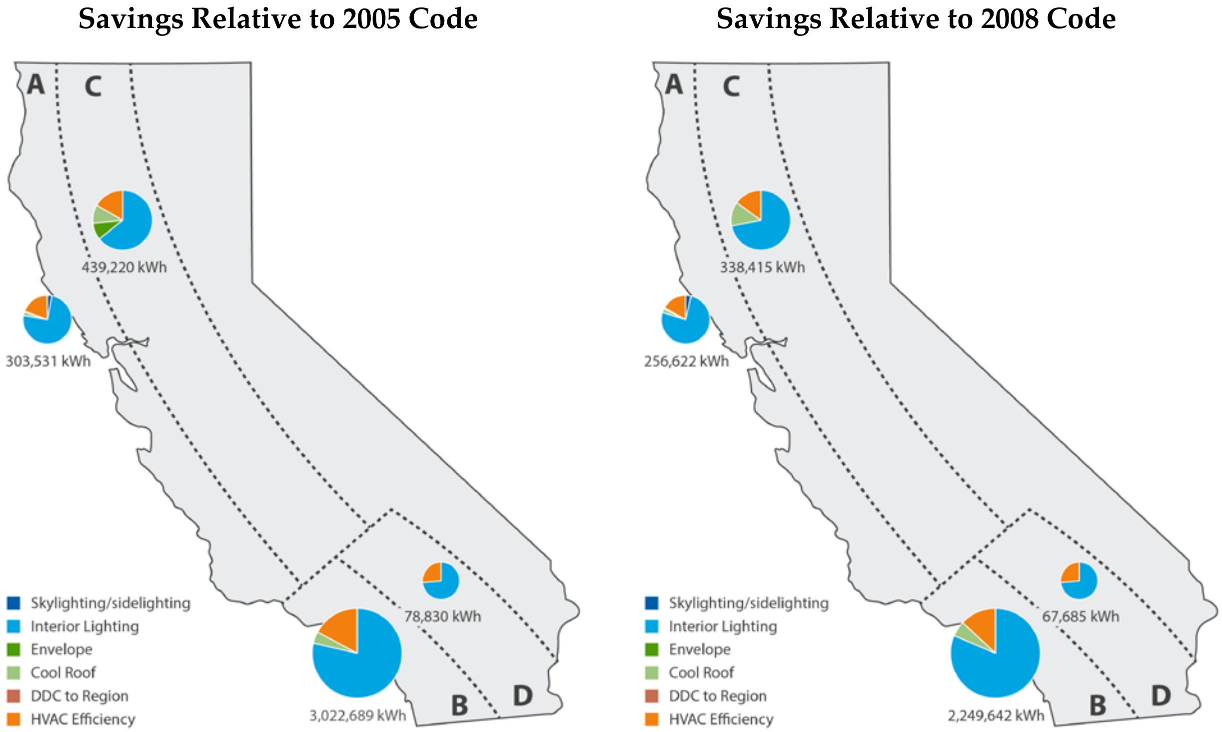
Interior lighting measures were the main driver of savings relative to both code years. On a measure level, the sampled new construction sites realized electric savings across all areas of building improvement except for envelope measures, as shown in Table 176.

Table 176. New Construction Electric Savings by Measure Type

Measure	kWh Savings Relative to 2005 Code	kWh Savings Relative to 2008 Code
Skylighting/Sidelighting	11,368	11,368
Interior Lighting	3,054,602	2,399,327
Envelope	-156	-35,945
Cool Roof	176,500	176,463
DDC to Region	977	832
HVAC Efficiency	673,369	408,762
Total	3,916,660	2,960,807

Measure-level savings are presented for each climate zone in Figure 44.

Figure 44. New Construction Savings by Measure, 2005 and 2008 Codes



For all measures at the 91 newly-constructed sites, Cadmus found that the sites analyzed saved 3,917 MWh relative to a baseline 2005 Title 24 code model, and 2,961 MWh relative to the 2008 Title 24 code, as shown in Table 177. While lighting improvements often result in an increase in gas consumption due to higher heating loads, other site improvements resulted in overall gas savings of 13,267 Therms relative to the 2005 code, and 2,050 relative to the 2008 code.

Table 177. Overall Savings for New Construction Sites

Savings Type	Overall Consumption			Savings	
	As-Built	Minimally Compliant with 2005 Title 24 Code	Minimally Compliant with 2008 Title 24 Code	Savings Relative to 2005 Title 24 Code	Savings Relative to 2008 Title 24 Code
Electric Energy (kWh)	19,886,535	23,803,195	22,847,342	3,916,660	2,960,807
Demand (kW)	5,865	7,265	6,838	1,399	972
Gas Energy (Therms)	191,551	204,817	193,601	13,267	2,050

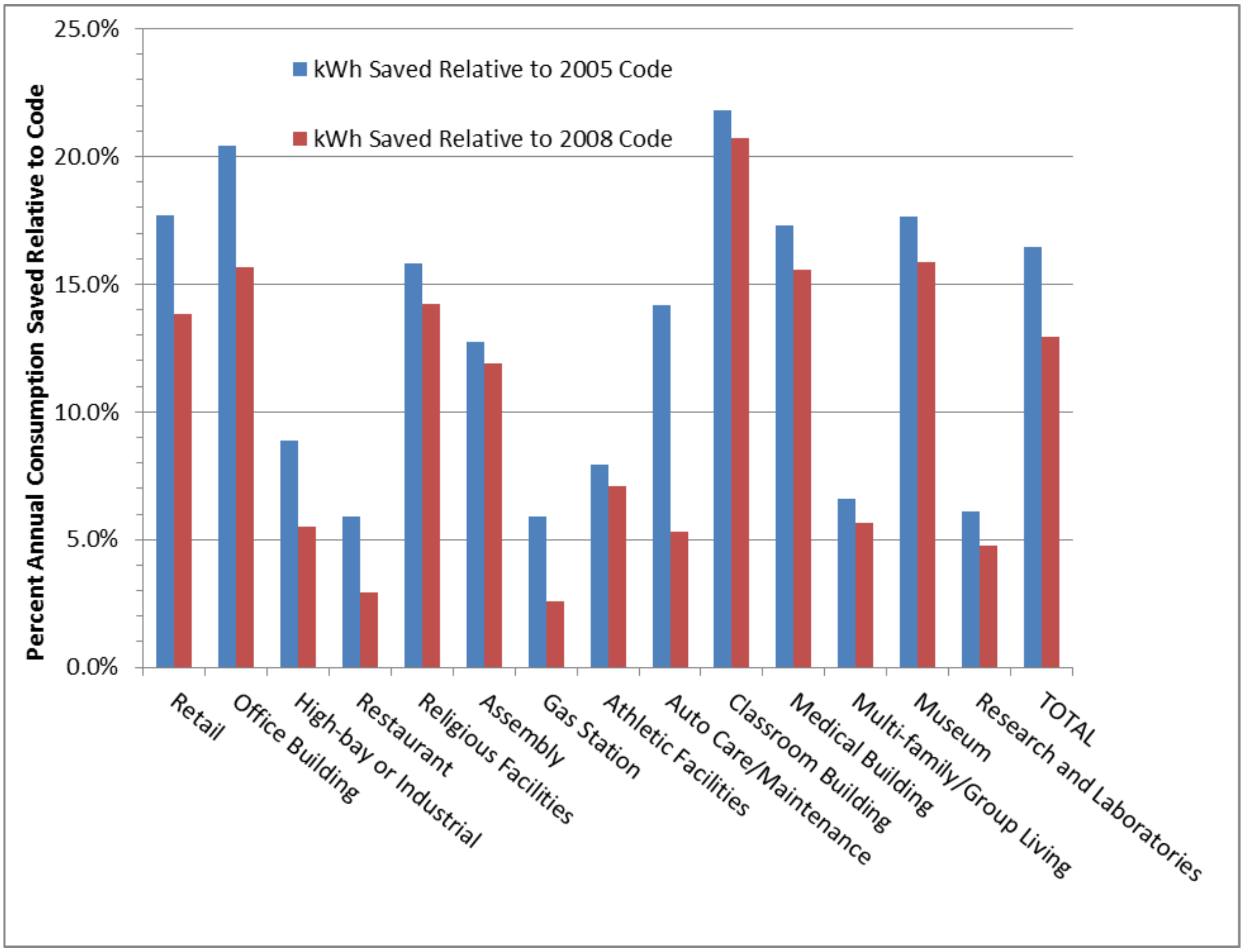
New construction sites saved approximately 16.5% of their electric consumption relative to the 2005 code, and 13.0% of their electric consumption relative to the 2008 code, as shown in Table 178. Gas usage decreased by 6.5% relative to the 2005 Title 24, but by 1.1% relative to the 2008 Title 24 code.

Table 178. New Construction Savings by Building Types, Sampled Projects

Building Type	Count	Percent of Electric Consumption Reduced Relative to 2005 Code	Percent of Electric Consumption Reduced Relative to 2008 Code	Percent of 2005 Gas Consumption Reduced Relative to 2005 Code	Percent of Gas Consumption Reduced Relative to 2008 Code
Retail	18	17.7%	13.9%	2.8%	-0.4%
Office Building	14	20.4%	15.7%	4.6%	1.4%
High-bay or Industrial	10	8.9%	5.5%	-1.2%	-27.5%
Restaurant	10	5.9%	2.9%	4.1%	1.3%
Religious Facilities	9	15.8%	14.2%	4.0%	3.4%
Assembly	7	12.8%	11.9%	5.8%	2.1%
Gas Station	5	5.9%	2.6%	3.4%	-1.6%
Athletic Facilities	4	7.9%	7.1%	22.0%	7.9%
Auto Care/Maintenance	4	14.2%	5.3%	3.5%	0.8%
Classroom Building	2	21.8%	20.7%	0.0%	0.0%
Medical Building	2	17.3%	15.6%	7.0%	-4.3%
Multifamily/Group Living	2	6.6%	5.7%	14.9%	14.2%
Museum	2	17.7%	15.9%	12.8%	-46.1%
Research and Laboratories	2	6.1%	4.8%	-4.5%	-16.0%
Total	91	16.5%	13.0%	6.5%	1.1%

Electric savings relative to each code are shown for all building types in Figure 45.

Figure 45. Sampled Projects New Construction Electric Reduced Consumption Relative to 2005, 2008 Codes



H.2 Lighting Alterations

H.2.1 Interior Lighting Modeling Approach and Process

For those sites for which Cadmus developed building simulations, we determined the compliance method from Title 24 compliance forms, wherever available. In the absence of these forms, the site surveyor's report was referenced, as Cadmus field staff were on occasion permitted to review, but not retain, compliance documentation. Lacking any source of documentation, the team assumed:

- **Complete Building:** One function type accounts for more than 90% of a space's floor area.
- **Area Category:** Surveyor has not noted large amounts of decorative or task lighting. Most undocumented sites were assumed to use this method of compliance.

- **Tailored:** Analysis using the Area Category method produces outlying results, or the surveyor records indicate a large amount of ornamental lighting.

The team referenced the surveyor's notes in determining the function type of each tenant space, and assigning appropriate load profiles and schedules.

Building Envelope

Drawing on information provided in building plans and Title 24 compliance forms, the team constructed an approximation of the building envelope using EnergyPro. Where no plans were available, the team referenced the surveyor's sketches and area estimates. We used satellite imaging information to confirm building orientation, and reviewed site photos for estimates of ceiling height and glazing area.

When surveyors collected limited information on building envelope characteristics, the team often relied on EnergyPro default values for building materials and insulation levels. The team assumed:

- **Exterior Walls:** Wood-framed with an insulation value of R-13
- **Shared Walls:** Unconditioned spaces were modeled as R-19 north-facing walls to eliminate any solar gain; walls shared with conditioned spaces were modeled as interior surfaces where permitted by EnergyPro (i.e., where more than one area type was modeled), or as an R-38 north-facing wall otherwise to prevent solar gain
- **Roofs:** Insulated to R-19, with material and tilt based on site photos and/or satellite views of the site
- **Windows:** Double-paned windows with metal frames, with a U-factor of 0.71 and an SHGC of 0.73

Building Systems and Equipment

In modeling the site HVAC system, the team looked first to the surveyor's notes and site photos for fuel and system type. Where permitted, the surveyor took photos of nameplates for heating and cooling equipment, allowing team member to research specifications and use them in the simulation. To supplement any information provided by the surveyor, the team reviewed site documentation including Title 24 compliance forms and building plans. These often listed HVAC equipment efficiencies and outputs. Absent any information about the installed HVAC equipment, we assumed a direct-expansion (DX) packaged system with an 11 SEER or 9.9 EER[144] central air conditioner and a 78 AFUE natural gas furnace. Where a heat pump was

[144] $EER \approx -0.02 \times SEER^2 + 1.12 \times SEER$. R. Hendron and C. Engebrecht. Building America House Simulation Protocols. Prepared by the National Renewable Energy Laboratory. U.S. Department of Energy Building Technologies Program. NREL/TP-550-49426. http://www.nrel.gov/docs/fy11osti/49246.pdf. October 2010.

known to be installed, we assumed an HSPF of 7.5. The team assumed that air conditioners were sized such that one ton of cooling was installed per 400 sf of conditioned area, with sensible cooling output equal to 75% of the installed capacity, and heating output equal to 85% of cooling output (these values were based on a survey of the EnergyPro HVAC catalogue). Fan flow was assumed to be one cubic foot per minute (CFM) per square foot of conditioned area, and fan power was also estimated based on similar units in the EnergyPro HVAC catalogue.

In order to estimate overall building consumption, the team used expert judgment to make a number of reasonable estimates and approximations when inputs were not available in provided documentation. While efforts were made to use the most accurate inputs possible in each building model, results must be viewed in light of model sensitivity to these components. Nevertheless, as these assumptions influence primarily HVAC consumption and interaction savings, the impact resulting from these uncertainty factors is expected to be small. Given the magnitude of the potential impact, we believe that this approach best optimizes usage of project resources.

While HVAC equipment was critical in determining the appropriate HCIF applicable to lighting savings, most other systems installed at a site were not influenced by lighting alterations and, therefore, the team used broad approximations for this equipment. We did not anticipate any need for an interactive factor between lighting and water heating. In the absence of concrete data from building plans, Title 24 compliance documentation, site photos, or surveyor notes, the team assumed that 50-gallon natural-gas-fueled water heaters were installed, with the number approximated based on the type and size of the tenant space.

Installed Lighting

The team characterized installed lighting fixtures based primarily on data collected on-site by the field staff. Surveyors noted lighting technology type (e.g., four-foot linear fluorescent), the nameplate wattage of the installed fixture, the number of fixtures of that type in each space, and any controls applied to that fixture. We supplemented recorded data by site photos, which were used to confirm lamp types where possible. We also referred to photos for qualitative support of any observations on lighting levels, e.g., notably bright or dimly lit spaces.

Bi-level switching controls and lighting timers could not be modeled through the EnergyPro software. Where present, the team modeled bi-level switches as manual dimmers. Lighting timers were modeled as either multi-level occupancy sensors or as non-controlled fixtures depending on the function of the space in which the fixture was installed. Where the fixture would be on throughout business hours, no control was applied as the lighting schedule supplied by EnergyPro would correspond with the lighting timer. In spaces with short-term occupancy, such as restrooms or storage, the team modeled timers as occupancy sensors, since these fixtures were expected to turn on only when the room was in use.

To supplement the records on installed lighting collected at each site, the team relied on Title 24 compliance forms, where available, to verify fixture type, wattage, and ballast factor. Where we found discrepancies between Title 24 forms and surveyor observations, we gave the team's on-site data precedence. Where near matches were found, the modeler reviewed site photos and worked with the site surveyor to confirm the accuracy of the recorded data.

Where lighting ballast factors could not be confirmed using Title 24 compliance forms, building plan lighting schedules, or lamp specification sheets, the team referenced standard ballast factors catalogued in the 2012 California Database for Energy Efficient Resources (DEER). This database provides common wattages for linear fluorescents (T5, T8, T10, T12), CFL fixtures, high-intensity discharge (HID) lamps (high-pressure sodium, metal halide, mercury vapor), and exit signs. The team restricted its search to fixtures of the same type, length, and lamp-count as the fixture recorded during the site audit; if the diameter for a linear fluorescent was unknown, 1-inch diameter (T8) was assumed. For linear fluorescents, the team assumed normal light output (NLO), rapid-start, and two lamps per ballast. We assumed electronic ballasts in the absence of other information. Where ambiguity still existed in terms of the final fixture wattage, the team averaged across all possible lamps.

In rare cases, the team was unable to extrapolate an appropriate ballast factor from DEER. In these situations, generally for circline and U-tube fluorescent lamps, the EnergyPro lighting catalogue was referenced.

All LEDs were also assumed to have a ballast factor of one. Ballast factors are not relevant to LED technology; however, LED drivers may influence the total power consumption of the fixture. Nevertheless, in the absence of any information on LED drivers, no adjustment was made to LED nameplate wattages.

Title 24 Commercial Interior Lighting Alterations Supporting Tables

Table 179. Area Category Method LPD Values and Comparison*

Area Category	Allowed LPD, 2005 Code Watts per Sq. Ft.	Allowed LPD, 2008 Code Watts per Sq. Ft.	Difference, 2008 – 2005 Watts per Sq. Ft.	Area Category	Allowed LPD, 2005 Code Watts per Sq. Ft.	Allowed LPD, 2008 Code Watts per Sq. Ft.	Difference, 2008 – 2005 Watts per Sq. Ft.
Auditorium	1.5	1.5	0.0	Housing, Public and Common Areas – Multifamily, Dormitory	N/A	1.0	Not in 2005 Code
Auto Repair	1.1	0.9	-0.2				
Beauty Salon	N/A	1.7	Not in 2005 Code	Housing, Public and Common Areas – Senior Housing	N/A	1.5	Not in 2005 Code
Civic Meeting Place	1.3	1.3	0.0				
Classrooms, Lecture, Training, Vocational Room	1.2	1.2	0.0	Kitchen, Food Preparation	1.6	1.6	0.0
				Laboratory, Scientific	N/A	1.4	Not in 2005 Code

Area Category	Allowed LPD, 2005 Code Watts per Sq. Ft.	Allowed LPD, 2008 Code Watts per Sq. Ft.	Difference, 2008 – 2005 Watts per Sq. Ft.
Commercial and Industrial Storage	0.6	N/A	Not in 2008 Code
Commercial and Industrial Storage (Conditioned & Unconditioned)	N/A	0.6	Not in 2005 Code
Commercial and Industrial Storage (Refrigerated)	N/A	0.7	Not in 2005 Code
Convention, Conference, Multipurpose and Meeting Centers	1.4	1.4	0.0
Corridors, Restrooms, Stairs, and Support Areas	0.6	0.6	0.0
Dining	1.1	1.1	0.0
Electrical, Mechanical, Telephone Rooms	0.7	0.7	Telephone rooms not in 2005 Code
Exercise Center, Gymnasium	1.0	1.0	0.0
Exhibit, Museum	2.0	2.0	0.0
Financial Transactions	1.2	1.2	0.0
General Commercial and Industrial Work - High bay	1.1	1.0	-0.1
General Commercial and Industrial Work - Low Bay	1.0	0.9	-0.1
General Commercial and Industrial Work - Precision	1.3	1.2	-0.1
Grocery Sales	1.6	1.6	0.0

Area Category	Allowed LPD, 2005 Code Watts per Sq. Ft.	Allowed LPD, 2008 Code Watts per Sq. Ft.	Difference, 2008 – 2005 Watts per Sq. Ft.
Laundry	0.9	0.9	0.0
Library – Reading Areas	1.2	1.2	0.0
Library – Stacks	1.5	1.5	0.0
Lobbies – Hotel Lobby	1.1	1.1	0.0
Lobbies – Main Entry Lobby	1.5	1.5	0.0
Locker/Dressing Room	0.8	0.8	0.0
Lounge/Recreation	1.1	1.1	0.0
Malls and Atria	1.2	1.2	0.0
Medical and Clinical Care	1.2	1.2	0.0
Office	1.2	N/A	Not in 2008 Code
Offices – > 250 Square Feet	N/A	0.9	Not in 2005 Code
Offices – ≤ 250 Square Feet	N/A	1.1	Not in 2005 Code
Parking Garage	0.4	N/A	Not in 2008 Code
Parking Garage – Parking Area	N/A	0.2	Not in 2005 Code
Parking Garage – Ramps and Entries	N/A	0.6	Not in 2005 Code
Religious Worship	1.5	1.5	0.0
Retail Merchandise Sales Wholesale Showrooms	1.7	1.6	-0.1
Tenant Lease Space	1.0	1.0	0.0
Theaters – Motion picture	0.9	0.9	0.0
Theaters –	1.4	1.4	0.0

Area Category	Allowed LPD, 2005 Code Watts per Sq. Ft.	Allowed LPD, 2008 Code Watts per Sq. Ft.	Difference, 2008 – 2005 Watts per Sq. Ft.	Area Category	Allowed LPD, 2005 Code Watts per Sq. Ft.	Allowed LPD, 2008 Code Watts per Sq. Ft.	Difference, 2008 – 2005 Watts per Sq. Ft.
				Performance			
Hotel Function Area	1.5	1.5	0.0	Transportation Function	1.2	1.2	0.0
Housing, Public and Common Areas – Dormitory, Senior Housing	1.5	N/A	Not in 2008 Code	Waiting Area	1.1	1.1	0.0
				All other	0.6	0.6	0.0
Housing, Public and Common Areas – Multifamily	1.0	N/A	Not in 2008 Code				

* Where an area category was not specifically provided an allowance in 2005, EnergyPro software assigned an appropriately-matched 2005 area category, such as industrial precision work in place of a scientific laboratory. For the beauty salon area category, however, Cadmus assumed that the retail area category would be the most similar activity type available under the 2005 Title 24 code, and adjusted the lighting calculations accordingly rather than using EnergyPro's assumption of 1.0 Watts per square foot.

Sources:

- 2005 Building Energy Efficiency Standards for Residential and Nonresidential Buildings. California Energy Commission. CEC-400-2006-015. Table 146-C. http://www.energy.ca.gov/2006publications/CEC-400-2006-015/CEC-400-2006-015.PDF. September 2004, revised September 2006. Effective October 1, 2005, revisions effective September 11, 2006.
- 2008 Building Energy Efficiency Standards for Residential and Nonresidential Buildings. California Energy Commission. CEC-400-2008-001-CMF. Table 146-F. http://www.energy.ca.gov/2008publications/CEC-400-2008-001/CEC-400-2008-001-CMF.PDF. December 2008. Effective January 1, 2010.

Table 180. Complete Building Method LPD Values and Comparison

Building Category	Allowed LPD, 2005 Code Watts per Sq. Ft.	Allowed LPD, 2008 Code Watts per Sq. Ft.	Difference, 2008 – 2005 Watts per Sq. Ft.
Auditoriums	1.5	1.5	0.0
Classroom Building	N/A	1.1	Not in 2005 Code
Commercial and Industrial Storage Buildings	0.7	0.6	-0.1
Convention Centers	1.3	1.2	-0.1
Financial Institutions	1.1	1.1	0.0
General Commercial and Industrial Work Buildings - High Bay	1.1	1.0	-0.1
General Commercial and Industrial Work Buildings - Low Bay	1.0	1.0	0.0
Grocery Stores	1.5	1.5	0.0
Hotel*	1.4	N/A	Not in 2008 Code
Library	N/A	1.3	Not in 2005 Code
Medical Buildings and Clinics	1.1	1.1	0.0
Office Buildings	1.1	0.85	-0.25
Parking Garages	0.4	0.3	-0.1
Religious Facilities	1.6	1.6	0.0
Restaurants	1.2	1.2	0.0
Retail and Wholesale Stores*	1.5	N/A	Not in 2008 Code
Schools	1.2	1.0	-0.2
Theaters	1.3	1.3	0.0
All Others	0.6	0.6	0.0
* Hotels, motels, and high-rise residential buildings are prohibited from using this compliance method. As of 2008, retail and wholesale stores are not permitted to use this method.			

Sources:

- 2005 Building Energy Efficiency Standards for Residential and Nonresidential Buildings. California Energy Commission. CEC-400-2006-015. Table 146-B. http://www.energy.ca.gov/2006publications/CEC-400-2006-015/CEC-400-2006-015.PDF. September 2004, revised September 2006. Effective October 1, 2005, revisions effective September 11, 2006.
- 2008 Building Energy Efficiency Standards for Residential and Nonresidential Buildings. California Energy Commission. CEC-400-2008-001-CMF. Table 146-E. http://www.energy.ca.gov/2008publications/CEC-400-2008-001/CEC-400-2008-001-CMF.PDF. December 2008. Effective January 1, 2010.

H.2.2 Tailored Method: Background and Methodology

Through a review of site-specific Title 24 compliance documentation, the evaluation team identified eight sites that used the Tailored method to comply with the interior commercial lighting codes. The Tailored method is used to determine the allowed indoor lighting power of a building or a particular activity area within a building. The Tailored method, as described in the 2008 Building and Energy Efficiency Standards report shall only be used “on projects with primary functions that do not use the Area Category Method."[145] Since any given building *area* may be eligible to use either, but not both, the Area Method or the Tailored method, the evaluation team deferred to the method used in the site's Title 24 documentation in determining which method to use for analysis. The evaluation team analyzed eight sites using the Tailored method.

The EnergyPro modelling software does not have the capability to estimate energy savings associated with areas designated as using the Tailored method; therefore, the evaluation team created a customized tool to assess energy savings. This external tool calculates the allowed indoor lighting power using the Tailored method as presented within California's 2005 and 2008 Building and Energy Efficiency Standards reports, which contain administrative regulations relating to energy building regulations in Title 24, Part 6.

The Tailored method calculation requires detailed data on both lighting and area characteristics. We collected the required inputs through on-site measurements by the evaluation team's surveyors. In conjunction with the site visits, the surveyors reviewed site permits, architectural drawings, and Title 24 compliance documents for comprehensiveness. To calculate the allowed LPD within a space, the following inputs are necessary.

- **Room Cavity Ratio:**[146] Computed using the perimeter of the space, the area of the space, and the lighting fixture height.[147] This value is required to determine the appropriate LPD for the space.
- **Tailored Task Primary Function Category:** Used to identify an illumination category that, in conjunction with the Room Cavity Ratio (see below), determines the allowed LPD.
- **Installed Lighting Fixtures, their Respective Wattages, and Display Purposes:** Dependent on a fixture's display purpose, additional allowances may be provided.
- **Lighting Controls:** Lowers effective wattages for controlled fixtures.

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145 2008 Building Energy Efficiency Standards for Residential and Nonresidential Buildings. *The California Energy Commission.* Section 146(c), Pg. 115. January, 2010.

146 $RCR = 2.5 * Height * Perimeter / Area$

147 Two variations on the height input are required. The vertical distance between the work-plane to the centerline of the lighting fixture is used with the area square footage and area perimeter to determine the Room Cavity Ratio. The second variation represents the mounting height of the fixtures above the floor. If the mounting height of a fixture is sufficiently high, the additional allowed lighting power density is increased by a multiplicative factor. The multiplicative factors are not the same in the 2005 and the 2008 codes.

The lighting allowance calculation methods presented within the 2005 and 2008 Title 24 code use these inputs in an identical fashion. The overall allowed LPD within the space is determined from lookup tables on the basis of Room Cavity Ratio and Tailored Task Primary Function category. In a few instances, the 2008 report would define the illumination category for a primary function area while the 2005 report instructed the reader to reference the Illuminating Engineering Society of North America handbook for the category. In these instances, the evaluation team applied the same category found in the 2008 report to the 2005 calculations. For a list of category areas in the 2005 code for which the 2008 illumination category was used, please refer to Table 181. For a complete listing of category areas, illumination categories, and additional allowances please refer to the 2008 and 2005 and Building and Energy Efficiency Standards reports.[148]

Table 181. Category Areas with Undefined Illumination Categories in 2005

2005 Category Area Name	2008 Category Area Name	2008 Illumination Category Used
Corridors, restrooms, stairs and support areas	Stairways and corridors; toilets and washrooms	B
Office	Private Office	E
Commercial and industrial storage	Commercial and industrial storage -Active: small items; small labels	D
Commercial and industrial storage	Commercial and industrial storage -Active: bulky items; large labels	C
All other not included above[149]	Scientific Laboratories	E

Additional lighting power allowances may be awarded based on the display purpose of the installed lighting fixtures, and are added to the general allowance. These additional allowances must either be used or lost. If the installed wattages of the lighting fixtures used for display purpose is less than the calculated allowance, the evaluation team set the additional allowance to the actual installed lighting wattage. Both 2005 and 2008 Title 24 codes specify four display purpose categories, each with maximum allowed lighting densities dependent upon the primary function area.

- **Wall Display:** Linear feet of wall display
- **Floor Display:** Area of floor display

148 2008 Building Energy Efficiency Standards for Residential and Nonresidential Buildings. *The California Energy Commission.* Section 146. January, 2010.

2005 Building Energy Efficiency Standards for Residential and Nonresidential Buildings. *The California Energy Commission.* Section 146. September, 2006.

149 The 2005 code does not include science labs as a possible primary function area.

- **Ornamental Display:** Area used for ornamental lighting
- **Very Valuable Display:** Area of very valuable display cases or similar contained display areas

Once the total lighting power allowance was calculated, the evaluation team took the difference between the lighting power allowance and the total installed wattage, multiplied by the estimated annual lighting hours use, to obtain annual lighting energy savings. An HCIF dependent on the facility's space heating-fuel type was then applied to calculate total annual energy savings for that site.

To remain consistent with the other evaluated lighting sites, the evaluation team relied on the EnergyPro modelling software to develop its estimates of the hours of use (HOU) and HCIF appropriate to each Tailored method site. For all eight sites, the team entered building and geographical information into the EnergyPro modelling software and extracted the resulting HOU from the model. The evaluation team developed the HCIF by taking the average HCIF, by fuel type, of all non-Tailored method interior lighting sites evaluated using EnergyPro.

Out of the eight sites evaluated, six sites primarily served retail function, one site was a restaurant, and one site was a museum. The restaurant did not represent the full building area; only the dining area component of the building was evaluated by the team using the Tailored method while the rest was modeled within EnergyPro.

While the 2008 code is relatively flexible, indicating that the Tailored method shall only be used "on projects with primary functions that do not use the Area Category Method," the 2005 code is more restricted in application. Within the 2005 code, the Tailored method shall only be used for spaces whose combined area does not exceed 30 percent of the building space. [150] There are two exceptions. A single function area exceeding 30 percent of the total building space may be modeled using the tailored method. Additionally, buildings with primary functions associated with retail merchandise sales or museums may use the Tailored method for 100% of the building.

Table 182 presents the annual lighting energy consumption and the saved energy in relation to the baseline energy usage. The 2008 and 2005 baseline consumption values are defined through the Tailored Method in the 2005 and 2008 Building and Energy Efficiency Standards reports, for the eight sites evaluated by the team. HVAC savings are calculated by multiplying the annual lighting savings by the HCIF factor for the site.

150 2005 Building Energy Efficiency Standards for Residential and Nonresidential Buildings. *The California Energy Commission.* Section 146(b), Pg. 104. September, 2006.

Table 182. Summary of Sampled Tailored Lighting Sites

Site Number	Building Function	Climate Region	As-Built Annual Lighting Energy Use (kWh)	2008 Baseline Annual Lighting Energy Use (kWh)	2005 Baseline Annual Lighting Energy Use (kWh)	2008 kWh Saved (Lighting)	2005 kWh Saved (Lighting)	2008 kWh Saved (HVAC)	2005 kWh Saved (HVAC)
30	Retail	B	38,143	38,277	43,605	134	5,462	45	1,850
35	Restaurant	C	41,632	44,861	44,861	3,229	3,229	1,093	1,094
32	Retail	C	137,771	149,321	154,804	11,550	17,034	3,054	4,857
62	Retail	B	36,295	36,556	38,363	261	2,067	106	2,239
71[151]	Restaurant	C	6,216	8,549	8,143	2,333	1,927	731	585
91	Retail	C	9,466	14,747	14,711	5,281	5,245	1,655	1,592
129	Retail	C	8,100	11,713	11,936	3,613	3,836	1,321	1,399
6	Museum	C	8,147	10,624	10,624	2,477	2,477	906	904

A review of the sampled tailored lighting sites indicates that all sites perform better than required by both the 2005 and 2008 codes. Several sites (Site 30, and Site 62) have annual consumption levels remarkably close to code levels, indicating that the codes have likely played a role in their current consumption levels. The differences between the 2005 and 2008 baseline consumption levels indicate the newer codes might be directly responsible for energy savings at Site 30. However, the 2005 versus 2008 code allowances remaining the same or very similar for a number of sites resulted in zero to very small consumption differences between the 2005 and 2008 code baselines.

H.2.3 Interior Lighting Alteration Impact Findings

The evaluation team compiled results for all models, and incorporated sites analyzed using external tools into the overall analysis as appropriate. The team investigated all outliers for quality-control purposes, and remarked on key drivers and reasons for any anomalies.

In total, the team analyzed 75 interior lighting sites, and four outdoor lighting sites. During the analysis process, the team removed two sites from consideration as they had received utility incentives for their alterations; these sites were removed to avoid double-counting the savings that had already been credited as a result of participation in a utility-sponsored program and not related to state codes and standards. Of the 75 sites analyzed, 35 did not have available Title 24 lighting documentation exhibiting their method of compliance. Two sites were assumed to use the Complete Building method, as more than 90 percent of their floor area was devoted to a single primary function. We assumed that the remaining 33 sites used the Area Category method, as the team did not have any evidence for using the Tailored method, and in many

151 The baseline consumption presented in the 2008 code for site number 71 is higher than the 2005 baseline consumption because of the new mounting height adjustment factors in the 2008 code.

cases did not have the detailed inputs required for the latter approach. Using these assumptions we determined that among those sites that performed interior lighting alterations, the Area Category method was the most widely used method of compliance, accounting for 84% of all sites; the Tailored method and the Complete Building method accounted for 9% and 7% of analyzed sites, respectively. Climate zone C, encompassing California's central valley and some parts of the Bay Area, contained the highest number of sites using methods of compliance other than the Area Category method. The distribution of interior lighting sites across jurisdictions and compliance methods are shown in Figure 46.

Figure 46. Interior Lighting Sites by Compliance Method

The evaluation team analyzed a diverse sample of sites, both geographically and with regard to their primary function. As shown in Table 183, retail spaces were the most common site the team visited. Together with office buildings and restaurants, these spaces constituted more than 61% of the sites reviewed for interior lighting upgrades. The reduced energy consumption is expressed in MMBtu unit (electricity and gas cumulatively) to account for the secondary impacts of the lighting upgrade that are related to increased heating load and hence the increased gas and electricity consumption to meet the load, as well as the reduced lighting end-use.

Table 183. Building Types, Interior Lighting Alterations

Building Type	Count	Percent of Interior Lighting Sites	Percent of Overall MMBtu Savings Relative to 2005 Code	Percent of Overall MMBtu Savings Relative to 2008 Code
Retail	23	30.7%	18.5%	15.4%
Office Building	13	17.3%	6.1%	4.6%
Restaurant	10	13.3%	3.2%	4.7%
Athletic Facilities	6	8.0%	5.4%	7.8%
Medical Building	6	8.0%	0.7%	0.9%
Hotel/Motel	4	5.3%	-0.1%	-0.1%
Salon	3	4.0%	1.2%	1.8%
High-bay or Industrial	3	4.0%	57.8%	54.8%
Gas Station	3	4.0%	2.1%	2.8%
Museum	2	2.7%	2.1%	3.0%
Religious Facilities	1	1.3%	2.9%	4.0%
Classroom Building	1	1.3%	0.2%	0.3%
Total	75	100%	100%	100%

Through the evaluation efforts described in the Lighting Alterations section, Cadmus found that 62 of the 75 sites analyzed that had performed interior lighting alterations met the 2008 Title 24 lighting code requirements. All of these 62 sites complied with the 2005 Title 24 code, and an additional two sites were compliant with the 2005, but not the 2008, lighting code. The remaining 11 sites complied with neither the 2005 nor the 2008 code.

The two noncompliant sites were office buildings, one of which included a large unconditioned warehouse in its scope. The office area category was divided into large (> 250 square feet) and small (≤ 250 square feet) categories in 2008, and maximum allowed LPDs declined for both area types. As a result, the lighting “cap” for buildings with large office spaces fell noticeably between 2005 and 2008, potentially leading to the decline in compliance shown in Table 184.

Table 184. Percentage of Sites in Compliance with 2005 and 2008 Title 24 Interior Lighting Codes

Building Type	Count	Percent of Sites in Compliance with 2005 Code	Percent of Sites in Compliance with 2008 Code
Retail	23	74%	74%
Office Building	13	100%	85%
Restaurant	10	90%	90%
Athletic Facilities	6	67%	67%
Medical Building	6	83%	83%
Hotel/Motel	4	75%	75%
Salon	3	100%	100%
High-bay or Industrial	3	100%	100%
Gas Station	3	100%	100%
Museum	2	100%	100%
Religious Facilities	1	100%	100%
Classroom Building	1	100%	100%
Total	75	85%	83%

The percentage of total sites complying with 2008 code is below 100% (83%). However, since the total positive electric savings are greater than the total negative electric savings resulting from non-compliance, the cumulative electric savings are positive. Overall, Cadmus found that the 75 sites analyzed saved 1,609 MWh relative to a baseline 2005 code site minimally compliant with the 2005 Title 24 code, and 1,079 MWh relative to the 2008 code, as shown in Table 185.

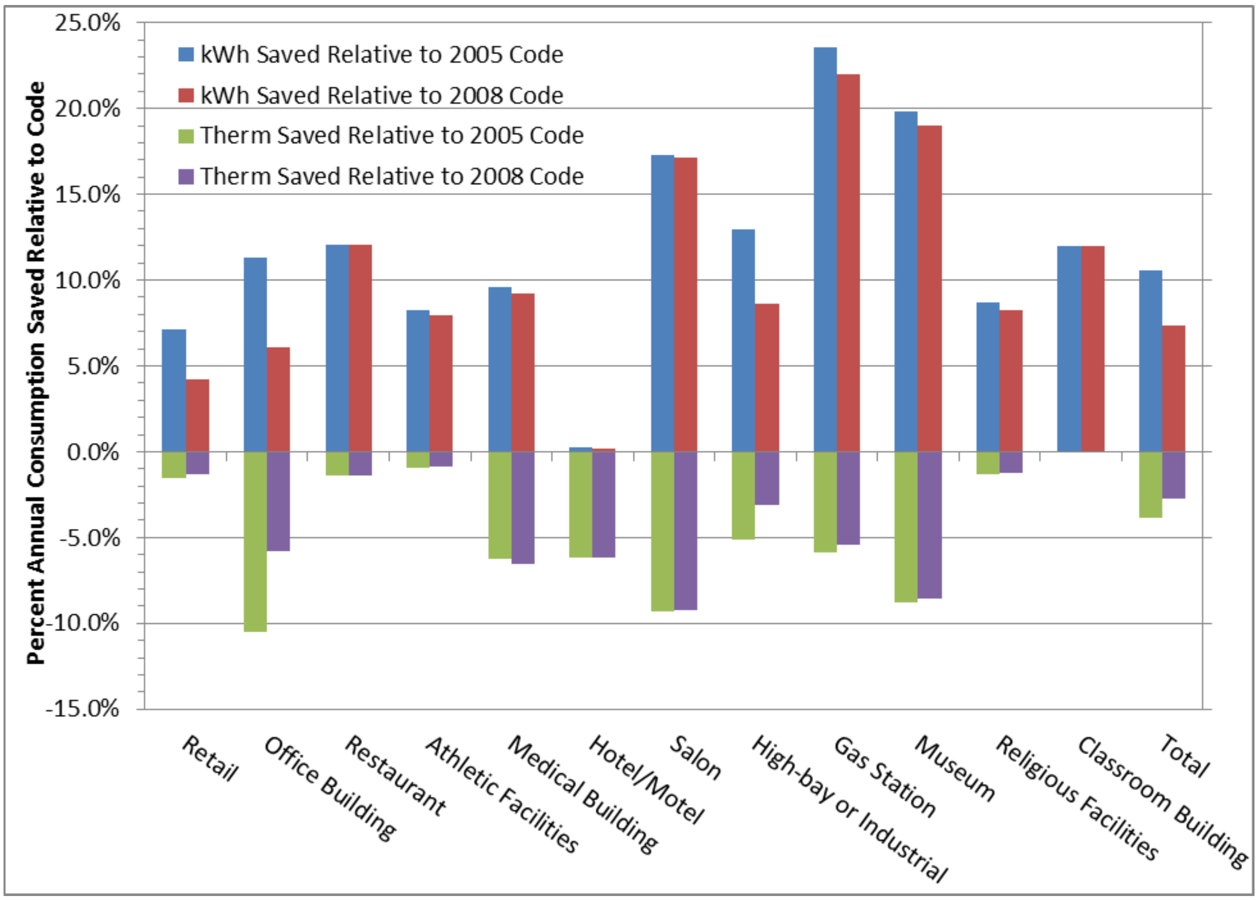
Table 185. Overall Savings for Interior Lighting Sites

Savings Type		Overall Consumption			Savings	
		As-Built	Minimally Compliant with 2005 Title 24 Code	Minimally Compliant with 2008 Title 24 Code	Savings relative to 2005 Title 24 Code	Savings relative to 2008 Title 24 Code
Area Category	Electric Energy (kWh)	7,013,531	7,646,315	7,467,202	632,784	453,671
	Demand (kW)	2,368	2,517	2,476	149	108
	Gas Energy (Therms)	86,885	83,733	84,636	-3,152	-2,248
Complete Building	Electric Energy (kWh)	6,155,136	7,079,377	6,746,145	924,240	591,009
	Demand (kW)	1,954	2,267	2,150	313	196
	Gas Energy (Therms)	43,329	41,618	42,109	-1,711	-1,220
Tailored	Electric Energy (kWh)	N/A	N/A	N/A	51,720	34,676
	Demand (kW)	N/A	N/A	N/A	N/A	N/A
	Gas Energy (Therms)	N/A	N/A	N/A	-246	-149
t	Electric Energy (kWh)	N/A	N/A	N/A	1,608,744	1,079,356

	Demand (kW)	N/A	N/A	N/A	N/A	N/A
	Gas Energy (Therms)	N/A	N/A	N/A	-5,108	-3,617

While the overall energy consumption of the site could not be calculated for those buildings using the Tailored method of compliance, sites using the Area Category and Complete Building methods saved approximately 10.6% of their annual electric consumption relative to the 2005 code, and 7.3% of their energy consumption relative to the 2008 code, as shown in Figure 47. Due to heating penalties, the team found that gas consumption increased with these lighting alterations; for sites complying using the Area Category and Complete Building methods, gas usage increased 3.9% relative to the 2005 code, and 2.7% relative to the 2008 code.

Figure 47. Annual Percentage of Savings by Building Types*



* Results are shown only for Area Category and Complete Building method sites, as overall building consumption could not be estimated using the external tool developed for Tailored method sites.

Outliers

During the course of our analysis, Cadmus analyzed several sites whose energy usage was distinctive and whose results may have had a large impact on the aggregation of savings:

- **Site 14:** The team analyzed one outlying site whose building design resulted in an energy use index (EUI) of 46.0 kWh/sf, nearly double the next-highest consumption per square foot. The scope of the lighting alteration was a large hotel lobby circumscribed by a high-ceilinged glass dome. The solar heat gain experienced within the space resulted in sizable cooling and fan loads. Moreover, extensive high-wattage track lighting was installed throughout the space, further driving up cooling and fan loads and incurring substantial lighting penalties.
- **Site 43:** Another notable site, a hospital and medical lab, provided building schedules that stipulated high ventilation requirements within the laboratory area. As a result, heating loads for this site were increased dramatically, constituting more than 60% of the building's energy consumption.
- **Site 36:** A final outlier was excluded from considerations of heating and cooling interactions, as it was the sole site containing substantial unconditioned area within the scope of analysis: a 10,000 square foot warehouse. As such, any interaction between lighting and HVAC loads would not pertain to other sites with fully conditioned interiors.

Heating-Cooling Interactions

For each of the analyzed sites, the team examined overall building consumption relative to the 2005 and 2008 codes (see Table 186). This process allowed cooling and fan savings associated with lighting power reductions, as well as heating penalties, to be assessed in conjunction with the team's review of code compliance.

As a result of having developed detailed building simulations for the majority of interior lighting alterations examined, the team was able to derive a relationship between heating, cooling, and fan savings (or penalties) and observed lighting savings relative to each code. The degree of variation in the results supports the team's choice to use site-specific modeling to obtain estimates of HVAC savings and penalties at the building level.

The team confirmed that climate regions B and D, the southern coastal and desert regions respectively, produced the highest cooling and fan savings for every kilowatt-hour of lighting savings, although the sample size for climate region D limited the conclusions that we were able to draw from this analysis. Climate region A, the cooler north/central coastal region, showed the highest heating penalty among sites with gas-fueled heating systems, while climate region D produced the highest electric heating penalty. Table 186 presents the average savings per square foot by load type for each of the four climate zones investigated, differentiating between heating fuel types.

Table 186. Savings per Square Foot by Load Type for Interior Lighting Alterations

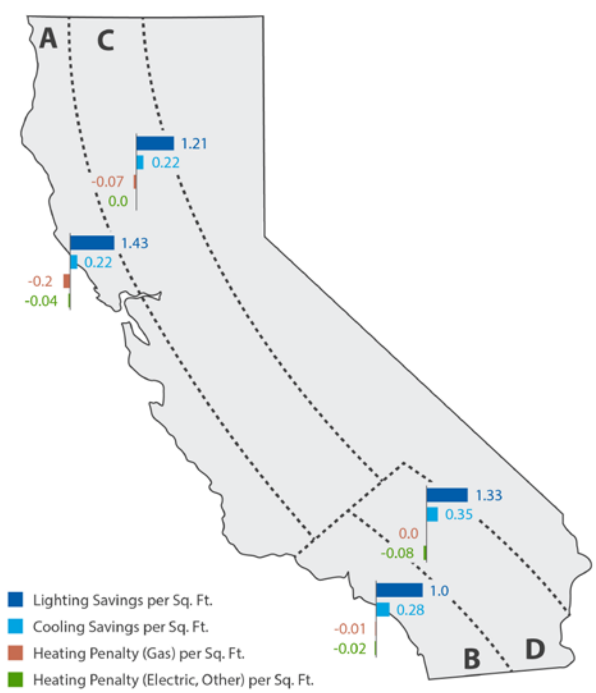
Characteristic	A		B		C		D	
	Savings Relative to 2005 Title 24 Code	Savings Relative to 2008 Title 24 Code	Savings Relative to 2005 Title 24 Code	Savings Relative to 2008 Title 24 Code	Savings Relative to 2005 Title 24 Code	Savings Relative to 2008 Title 24 Code	Savings Relative to 2005 Title 24 Code	Savings Relative to 2008 Title 24 Code
Average Lighting Savings (kWh) per sf	1.43	1.17	1.00	0.68	1.21	1.01	1.33	0.99
Average Fan Savings (kWh) per sf	0.22	0.18	0.28	0.22	0.22	0.15	0.35	0.26
Average Cooling Savings (kWh) per sf	0.07	0.06	0.03	0.02	0.04	0.03	0.10	0.07
Average Gas Heating Penalty (therms) per sf	-0.20	-0.14	-0.01	0.00	-0.07	-0.07	N/A	N/A
Average Electric Heating Penalty (kWh) per sf	-0.04	-0.03	-0.02	-0.02	0.00	0.00	-0.08	-0.07

* One site was excluded from this calculation, as it included a large unconditioned area. Furthermore, sites located in conditioned interiors were not considered for these calculations.

Savings and penalties per square foot, in kilowatt-hours and therms, are shown by climate zone in Figure 48.

Figure 48. Interior Lighting Savings per Square Foot by Load Type, 2005 and 2008 Codes

Savings Relative to 2005 Code | **Savings Relative to 2008 Code**



H.2.4 Outdoor Lighting Savings

The evaluation team analyzed the energy savings associated with four commercial sites where alterations to outdoor lighting were conducted. To assess energy savings, the team developed a tool to calculate the light power allowances for these sites, as presented within California's 2005 and 2008 Building and Energy Efficiency Standards report. The evaluation team determined the size of hardscaped areas for each site through a review of site construction documentation wherever possible. The evaluation team used the available satellite-imaging software to estimate areas in the absence of clearly-presented documentation. The evaluation team collected data on the installed lighting fixtures through on-site inspections, and estimated an appropriate HOU based on discussion with the site's operations manager regarding the lighting usage schedule.

To calculate the allowed LPD for each site, the team required several inputs.

- **Lighting Zone:** Defines the typical ambient illumination levels
- **Lighting Application:** Used in conjunction with the lighting zone to identify allowed LPD. [152]
- **Security requirements for the hardscape area**: If applicable, acts as a multiplicative factor on allowances. [153]

The methods to calculate power allowances presented within the 2005 and 2008 codes have a number of differences. In the 2005 code, allowances are calculated based upon the general lighting *application* and the hardscaped paved area, with an added 5 foot buffer on the paths of travel. General lighting applications included areas for automotive use, pedestrians use, outdoor sales lots, and building entrances. In addition the general allowance for areas designated for pedestrian use could also be by assuming a 25 foot wide pathway to calculate the allowed area. In the 2008 code, general power allowances are determined independent of lighting *application* and factors in both the hardscaped area and perimeter. All areas in the 2008 code are also provided an initial lighting power allowance that is independent of hardscaped area and perimeter.

Additional lighting power allowances can be provided for specific applications under both 2005 and 2008 codes. Since the 2005 codes already used broad application definitions to define the general allowances, the 2008 list of specific applications is larger. Additional allowances must either be used or lost. In the event that the hardscape area has special or security needs (such as at a police station or near a senior care facility), then the allowed lighting power under the 2005 code is multiplied by a factor of up to two. For a complete listing of application areas and

[152] The lighting applications are defined differently in the 2005 and the 2008 codes, described in following paragraphs.

[153] Only applicable in the 2005 report.

additional allowances please refer to the 2008 and Building and Energy Efficiency Standards reports.[154]

Table 187 presents the as-built and baseline outdoor lighting energy consumption, as defined through the methods presented within the 2005 and 2008 Building and Energy Efficiency Standards reports, for the four outdoor lighting sites evaluated by the team. Savings are calculated as the difference between the as-built consumption and the baseline consumption.

Table 187. Summary of the Savings (kWh) Related to the Sampled Outdoor Lighting Sites

Site Number	Site Function	Lighting Consumption			Savings	
		As-Built	Minimally Compliant with 2008 Title 24 Code	Minimally Compliant with 2005 Title 24 Code	Savings relative to 2008 Title 24 Code	Savings relative to 2005 Title 24 Code
29	Gas Station	6,541	13,584	14,529	7,044	7,988
65	Mall	98,112	495,678	1,119,350	397,566	1,021,238
161	Local Education Building	2,313	3,860	3,066	1,548	753
165	University Education Building	2,996	4,763	6,459	1,767	3,463
	Total	109,961	517,885	1,143,404	407,924	1,033,442

All sites were in compliance with both the 2008 and the 2005 codes. Savings for the outdoor lighting projects are driven by site 65, a mall within the climate region A. The hardscaped area includes the large parking area surrounding the buildings. Most of the lighting consumption comes from the placement of 25 1,000W lighting fixtures in the parking area. Prior to the lighting alteration, these fixtures were estimated to have 4,000W each. Thus, the lighting alteration resulted in a large reduction in energy consumption.

The large difference in 2005 and 2008 baseline consumption for site 65 is observed because of the different calculation methodologies in the codes. The 2008 code provides allowances through both the hardscape perimeter and area, while the 2005 code primarily considers the hardscaped area. As a site gets larger, the perimeter does not grow at the same rate as the hardscaped area, providing for diminishing returns in the allowed LPD within the 2008 code.

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154 2008 Building Energy Efficiency Standards for Residential and Nonresidential Buildings. *The California Energy Commission.* Section 147. January, 2010.

2005 Building Energy Efficiency Standards for Residential and Nonresidential Buildings. *The California Energy Commission.* Section 147. September, 2006.

Appendix I. Title 24 Compliance Evaluation, Pilot Study Summary Memo

The memo included in this appendix was written at the conclusion of Cadmus' investigation of methods to be used in the evaluation of Title 24 compliance. The work described by the memo was completed between February and August 2012 and the final memo was delivered in November 2012. Many of the recommendations included in the last section of the memo were followed by the evaluators in the full statewide Title 24 compliance evaluation.

I.1.1 Introduction

This memo summarizes work done to evaluate compliance of nonresidential construction projects to Title 24 (T24) requirements. As noted in the evaluation plan, determination of compliance in this area is a high priority since only limited analyses have been conducted in the past. A key objective is to collect primary data on a sample of appropriate construction projects. Data will be collected to support evaluation of whole building performance and also to allow for the determination of compliance for specific prescriptive measures.

Three categories of construction are referred to in this memo: new construction, additions, and alterations. New construction is used to indicate construction of new buildings. Additions are projects that add square footage to existing buildings. Alterations will mean all other projects that involve existing buildings.

Due to issues encountered in the execution of prior field compliance studies, the project was planned to have a pilot phase in order to test the methods used to identify and audit qualified sites. Initially, the pilot scope was defined to include all of the steps necessary to audit and analyze up to 20 construction projects in two jurisdictions. Although this effort was expanded to include four jurisdictions, the team was able to complete field audits of only ten construction projects. As a result, the team planned for new approaches to the task and a second pilot stage was defined to test these new methods.

This memo will refer to the stages of the project as follows:

- Pilot phase one refers to the pilot as initially planned.
- Pilot phase two refers to continuation of phase one in which new approaches were tested.
- Full statewide compliance evaluation refers to the post-pilot implementation of the full evaluation task.

Following the description of the pilot work, the memo includes a brief discussion of expected issues and strategies for work on this task going forward.

I.1.2 Title 24 Building Codes

As stated above, this project task is to determine compliance of nonresidential construction to Title 24 requirements. Specifically, the task is focused on the requirements of Title 24 codes that became effective on January 1, 2010 and for which the California IOUs have claimed energy savings. Since the defining document[155] was published in December 2008, this group of regulations is referred to throughout this document as the 2008 Title 24 (T24) codes. A list of the 2008 T24 codes is shown in Table 188.

Table 188. 2008 Title 24 Building Codes

Reference	Description	Effective Date
Std B17	Envelope Insulation	1/1/2010
Std B18	Overall Envelope Tradeoff	1/1/2010
Std B19	Skylighting	1/1/2010
Std B20	Sidelighting	1/1/2010
Std B21	Tailored Indoor Lighting	1/1/2010
Std B22	Time Dependent Valuation (TDV) Lighting Controls	1/1/2010
Std B22a	Demand Response Indoor Lighting	1/1/2010
Std B23	Outdoor Lighting	1/1/2010
Std B24	Outdoor Signs	1/1/2010
Std B26	Refrigerated Warehouses	1/1/2010
Std B27	Direct Digital Control to Zone (HVAC Control)	1/1/2010
Std B28	Residential Swimming Pool	1/1/2010
Std B29	Site Built Fenestration	1/1/2010
Std B30	Residential Fenestration	1/1/2010
Std B31	Cool Roof Expansion	1/1/2010
Std B32	Multifamily Water Heating Control	1/1/2010
Std B33	Composite For Remainder	1/1/2010

I.1.3 Pilot Process

The Cadmus evaluation team initiated phase one of the pilot by developing a sampling plan for the overall research so the pilot data would be useful in that context as well. We then selected the sample, recruited projects, conducted field audits, and completed the compliance analysis. The pilot also included a second phase in which Cadmus developed new data gathering and recruitment processes to be applied in the full evaluation. The following is a summary of each of these steps.

155 2008 Building Energy Efficiency Standards for Residential and Nonresidential Buildings, CEC-400-2008-CMF, http://www.energy.ca.gov/2008publications/CEC-400-2008-001/CEC-400-2008-001-CMF.PDF

Sampling Plan

For the Title 24 compliance study, Cadmus first divided the state into five climate regions, based on the CEC's 16 climate zones, and used aggregated construction data purchased from McGraw Hill Construction (MHC) to compare the regions' relative sizes in terms of T24-permitted construction square footage.[156] The Mountain Region accounted for less than 1% of statewide square footage, so this region was excluded from sampling. Cadmus used two-stage sampling to plan site visits within each of the remaining regions. In stage one, building departments were used as the primary sampling unit, and the stage-one sample was allocated among climate regions in approximate proportion to region size. Within each region, building departments were selected using probability-proportional-to-size (PPS) sampling.

In the full compliance evaluation, our initial plan was to select qualified buildings (permitted under 2008 Title 24) from each sampled building department jurisdiction. This process was also expected to use the probability proportional to size method within each jurisdiction. Cadmus planned to work with selected building departments to develop sampling frames. We also planned to explore the possibility of purchasing data on individual buildings from MHC for this purpose.

Sample Development and Recruitment

Representatives from the team contacted the building departments in the jurisdictions with the most construction activity (in terms of total square footage for all projects) in each climate region to determine the ease of accessing permit data for sample projects. Some jurisdictions were eliminated from the pilot due to challenges revealed in conversations with building department staff, such as departments being short staffed due to budget cuts or the apparent complexity of record retrieval due to limited digital archiving or accessibility of physical archives. Based on these building department interviews, the Cadmus team selected four jurisdictions for inclusion in the pilot: Fremont, Berkeley, Walnut Creek, and Davis.

The team purchased detailed project-specific data from MHC covering commercial construction starts for new buildings, additions, and alterations after January 1, 2010, in each of the four jurisdictions. One limitation of data from this source is that MHC does not track the permit date and associated T24 code for each project. As expected, we found projects for which construction started in 2010 that had been permitted in an earlier year and under the earlier code. Even with this limitation, we decided to use the MHC data as the basis for the pilot site visits since it included all three types of construction projects and contact information for each project.

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156 For the sampling analysis, size refers to total construction square footage from MHC for 2009, 2010, and most of 2011. The data purchased by Cadmus consisted of square footage aggregated by zip code for new construction and additions but not for other building alterations. MHC does offer information on alterations but that information was not included in the data purchased for the sampling analysis.

Using the MHC data, the evaluation team recruited buildings for the sample. Team members called the building owners (or managers) to confirm the applicability of projects for the evaluation and to obtain permission for site visits. The team attempted to contact 211 building owners, and ultimately recruited 18 potential buildings for the pilot audits. Disposition of the recruiting effort is shown in Table 2.

When we contacted building owners and asked about T24 code compliance, we learned that building staff had copies of the permit documents and construction documents on site in nearly every case although they sometimes did not know which version of the T24 code was required. For this reason, we visited the buildings to obtain these documents instead of obtaining permit documents from the building departments as originally planned.

Table 189. Disposition of Recruiting Effort

Recruitment Results	Berkeley		Fremont		Walnut Creek		Davis		Total	
	Alts	New Bldgs	Alts	New Bldgs	Alts	New Bldgs	Alts	New Bldgs	Alts	New Bldgs
Total Raw	40	11	71	5	44	9	21	10	176	35
Too Small	5	0	1		11				17	0
Apartment/Townhome under 3 stories			2	2		2			2	4
Permitted before 2010	2	2	4		3	1	2		11	3
Federal Funding (T24 exempt)	4	1							4	1
Owner Refused		2	3		2	2	1		6	4
Poor contact information (McGraw Hill)	4	0	22		6		9	4	41	4
Conversation Pending	15	6							15	6
Exhausted outreach efforts	7		33	3	18	3	7	4	65	10
Circumstances do not permit site visit (construction, limited staff, etc.)			1		3	1	1		5	1
Building Demolished	1								1	0
Recruited/Visited	3		9		1	1	1	3	14	4
Qualified and Audited	3	0	4	0	1	0	0	2	8	2
Note: Alts indicates alterations										

Field Audits

Members of the evaluation team visited the 18 recruited projects in Fremont, Berkeley, Walnut Creek and Davis. Of those sites visited, 10 were found to be qualified for the evaluation, while the others were eliminated due to information, such as project scope or governing code, revealed during the visit. At each site, the team met with building managers, reviewed building plans, confirmed occupancy, and hours of operation, and walked through the buildings, recording data on energy related building components, including photographs of equipment nameplates.

Analysis

Following the site visits, the team analyzed the data to determine the compliance rate. For the two new buildings and one major alteration project that used the whole building performance approach for permitting, the team ran energy simulations, comparing the project as-built to the 2008 and 2005 standards. We used the special version of EnergyPro[157] software created by EnergySoft, LLC for this project. For new construction and alteration projects that used the prescriptive approach for permitting, the team conducted a comparative analysis of all affected standards applicable to the project.

Pilot Phase 2 Sample Development and Recruitment

During the first phase of the pilot, the evaluation team found that the MHC data, while useful as a source of a nearly complete[158] list of construction projects, had limitations (lacking permit date and current owner contact information) as a basis for sample development and recruitment. Based on these findings, representatives from the team, with assistance from a former building official, contacted the building departments for Berkeley and Walnut Creek since these two jurisdictions were included in the first phase. These jurisdictions provided a full list of commercial and multifamily residential projects with permit applications after January 1, 2010. This data included basic information about the project type and scope, and the name and address of the owner.

The team also contacted Energy Soft and obtained data on projects for which they had provided simulation models and code compliance forms. This data indicated the version of the Title 24 code and code compliance path, and also noted applicable measures (exterior envelope, roof replacement, and interior lighting) for alteration projects. The data also noted project participation in the Savings by Design program. These data are summarized in Table 190.

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157 EnergyPro is one of two software packages approved by the CEC for projects that choose to use the performance path to comply with the T24 energy code. EnergyPro provides an interface for the development of a building model which is then simulated using the DOE 2.2 engine. EnergyPro was selected by the evaluators since it is used for more projects than any other package and because the company was willing to support the evaluation project.

158 MH4C is the most complete list of nonresidential construction projects known to the evaluators. MHC estimates that their database includes over 90% of all new construction projects which and a high percentage of additions and alteration projects as well. The evaluators will compare information from building departments to MHC data when possible to better understand the extent of MHC coverage.

Table 190. Quantities of New and Alteration Projects

Jurisdiction	Project Type	Data Source		
		McGraw Hill	Building Dept.	Energy Soft
Berkeley	New Buildings	8	4	10
	Alterations	38	17	6
Walnut Creek	New Buildings	9	12	6
	Alterations	88	382	1

I.1.4 Pilot Results

The Cadmus evaluation team conducted analysis of all valid sites that were audited, using the approach outlined above. For sites that were permitted using a prescriptive path, compliance with the standards updated in the 2008 Title 24 is recorded in Table 191.

Table 191. Summary of Pilot Site Audits

Ref.	Description	New/ Alteration	Compliance Path	Compliance Level					
				B23	B27	B29	B30	B31	B32
1	Business - Office	Alteration	Prescriptive	0%	100%	N/A	N/A	N/A	N/A
2	Mercantile - Retail	Alteration	Prescriptive	100%	75%	UTA**	N/A	UTA**	N/A
3	Business - Municipal	Alteration	Prescriptive	N/A	N/A	0%	N/A	N/A	N/A
4	Business - Office	Alteration	Prescriptive	N/A	50%	N/A	N/A	N/A	N/A
5	Assembly - Library	Alteration	Prescriptive	100%	25%	100%	N/A	100%	N/A
6	Assembly - Library	Alteration	Performance	100%	50%	100%	N/A	0%	N/A
7	Business - Office	Alteration	Prescriptive	N/A	100%	N/A	N/A	N/A	N/A
8	Business - Office	New	Performance						
9	Assembly - Education	New	Performance						
10	Assembly - Education	Alteration	Performance						
* Compliance level assessment based on 2008 standard framework, even for projects permitted under 2005 standards.									
** Unable to assess relative to 2008 standard framework									

For sites that were permitted using a performance path, comparative energy savings for each site, looking at the as-built energy use relative to the 2005 and 2008 codes, is shown in Table 192. Based on our analysis, Project 8 did not comply with the 2008 code requirements. Since this is a prefabricated building, we are seeking additional information from the manufacturer to confirm this finding.

Table 192. Energy Analysis of Performance Path Projects

Description	Energy Consumption			Savings			
				As-Built - T24 2005		As-Built - T24 2008	
	As-Built	T24 2005	T24 2008	Energy	Percent	Energy	Percent
Project 10: School (Alteration)							
Electricity (kWh)	69,286	73,084	72,921	3,798	5.2%	3,635	5.0%
Total Energy (kBtu)	236,402	249,362	248,805	12,959	5.2%	12,403	5.0%
Project 9: University (New)							
Electricity (kWh)	346,757	480,220	453,145	133,462	27.8%	106,387	23.5%

Gas (therms)	9,991	10,396	8,073	406	3.9%	(1,917)	-23.7%
Total Energy (kBtu)	2,182,208	2,678,147	2,353,470	495,940	18.5%	171,262	7.3%
Project 8: Research Lab (New)				-			
Electricity (kWh)	23,273	23,772	20,757	499	2.1%	(2,515)	-12.1%
Total Energy (kBtu)	79,406	81,110	70,824	1,704	2.1%	(8,582)	-12.1%

Findings from Analysis

- Variability in compliance to Standard B27: This is the standard pertaining to HVAC. There are five subsections to the code requirements. In our assessment of the detailed requirements of these sections, we found wide variations in compliance.
- Mandatory measures for performance sites: It is our understanding that sites that choose the 'Performance' compliance path still have to comply with the mandatory measures listed in the standards. In some cases, it was found that the site complied based on meeting the performance model requirements, but did not comply with specific mandatory requirements.
- Larger projects exhibited better documentation: Title 24 compliance forms were more complete and readily available for the projects of larger scope.
- Domestic Hot Water standards and compliance need further investigation: As these instances were not affected by the 2008 T24 code, this was a secondary focus for this pilot. However, additional investigation is needed on this topic since T24 manufactured device requirements (Section 100h) were routinely overlooked in project submissions, and requisite forms (MECH-2C Part 3 of 3) were customarily blank or missing.
- Demand Response or Demand Shed Controls requirements were largely avoided: Most sites observed did not need to comply with demand-side management codes since they appeared to have found ways to circumvent or 'opt-out' of the measures.

I.1.5 Recommendations for Next Evaluation Stage

The following is a summary of the evaluation team's experience and findings from the pilot evaluation, with recommendations for changes to the process in the full statewide compliance evaluation.

Building Population Data

The evaluation team found that many of the projects identified in the McGraw Hill data were not applicable to the pilot for one or more of the following reasons:

- Project was permitted under the previous code
- Project scope did not trigger T24 compliance requirements
- Project was multifamily residential under four-stories and thus covered by the residential Title 24, not the nonresidential standard
- Project participated in Savings By Design

To more accurately define the full population of commercial buildings constructed or renovated under the 2008 Title 24 code from which to pull a viable sample, the evaluation team proposes to combine construction start data from a number of sources including some or all of the following:

- McGraw Hill construction starts database
- Permit application data from jurisdiction building departments (confirming current code)
- New connection data from IOUs[159]
- Project information and simulation models from Energy Soft (flagging Savings By Design)
- California Association of Building Energy Consultants (CABEC),
- Department of the State Architect
- University of California Office of the President.

As shown in Table 190 above, the identification of appropriate projects using building department permit data and Energy Soft project records was more effective than the use of McGraw Hill data alone. One issue with the McGraw Hill data (based on construction start date) is that projects are permitted before construction begins and many of the ones we attempted to use were permitted under the prior (2005) T24 code. A key finding was that these additional sources of information would improve our ability to find qualified projects.

Sample Recruitment

The evaluation team faced a number of challenges that slowed down the recruiting process including:

- Difficulty in finding contact information for owners/managers of potential projects
- Difficulty in obtaining information from jurisdiction building departments
- Difficulty in determining which code the project was permitted under due to:
    - Limitations of the McGraw Hill data (start date vs. permit date)
    - Lack of knowledge of the project contact person

159 The evaluation team obtained new connection data from PG&E to assist in the recruitment process. The data was of limited use because a contact phone number for the account representative was not included in the data. The evaluators are exploring the possibility of obtaining contact information from the IOUs.

- Conflicting information on code compliance documents (in at least one case, the code compliance report cover noted a different code version than the content of the report)

Cadmus enlisted a retired California building official to assist the team in communicating with building departments in targeted jurisdictions and to streamline the process of gathering data for potential projects to include in the sample. Using this approach in the second stage of the pilot, the evaluation team was able to more readily identify applicable projects permitted under the 2008 standards.

T24 Compliance

Entering the pilot, the evaluation team assumed that a new compliance model would have to be created for each site that was permitted using a performance-based compliance path. In the process of gathering data on sample projects in the pilot, the team learned that many T24 compliance models are produced by EnergySoft. For the next stage of the evaluation, EnergySoft may be a good source of information on sample projects to streamline the auditing and analysis process.

Expected Issues and Strategy

A few issues remain as potential obstacles to completion of the audit work going forward. Probably the one of greatest concern is the difficulty in obtaining permission to audit from the owners or operators of the buildings / construction projects. We are pursuing multiple approaches to overcome this issue. This includes contacting the Building Owners and Managers Association (BOMA) in California since this organization has assisted audit efforts in other states. A second approach is based on the finding that it is often easier to obtain the simulation model for projects than it is to obtain permission to audit. In this context, an evaluation could be structured to use the data from many compliance models and then physically audit a nested sample within the model pool. In this way, adjustment factors for different construction project types could be developed and then applied to statewide construction activity.

A second issue is the number and distribution of new construction projects and alteration projects throughout the California jurisdictions. The initial sampling plan for 272 site audits did not define targets for new and alteration projects although it did have two options for the number of jurisdictions. In one case, the evaluation would involve 34 jurisdictions and would need to audit an average of 8 projects per jurisdiction. In the alternative scenario, the evaluation would involve 18 jurisdictions with 15 project audits in each. Subsequent study of energy savings from alteration projects has led us to set a target of 50% new building projects and 50% alteration projects. We are in the process of revising the plan to reflect what we have learned from the pilot work. Specifically, we expect that it will require somewhat more than 18 jurisdictions to have a large enough pool of new buildings from which to recruit.

Appendix J. Interactive Effects Detail

Cadmus used the methods described in Chapter 3 of the main report to determine specific interactive effect values for each code and standard. The table shows all of the standards for which a value was assigned. If the standard is not listed then the IE values are zero.

Table 193. Interactive Effect Values: Evaluated and IOU Estimate

Standards		Electric IE kWh/kWh	Demand IE kW/kW	Gas IE Therms/kWh	Assumption Used to Calculate IE	Gas IE by IOUs
	2005 Title 20					
Std1	Comm. Refrig. Equip., Solid Door	1.0500	1.3200	-0.0207	AVG of res and nonres TVs similar to the IOU estimation	-0.0121
Std2	Comm. Refrig. Equip., Trans. Door	1.0500	1.3200	-0.0207	AVG of res and nonres TVs similar to the IOU estimation	-0.0121
Std3	Commercial Ice Maker Equipment	1.0250	1.1600	-0.0103	Half of res and nonres TVs similar to the IOU estimation	-0.0060
Std5	Refrig. Bev. Vending Machines	1.0250	1.1600	-0.0103	Half of res and nonres TVs similar to the IOU estimation	-0.0060
Std11a	Gen. Svc. Incand. Lamps, Tier 1	1.0700	1.2733	-0.0124	AVG of res and nonres CFL similar to the IOU estimation	-0.0177
Std12a	PSMH HID Luminaires, Tier 1	1.1000	1.3200	-0.0207	Commercial Non-CFL	-0.0119
Std12b	PSMH HID Luminaires, Tier 2	1.1000	1.3200	-0.0207	Commercial Non-CFL	-0.0119
Std13	Mod. Furniture Task Ltg. Fixtures	1.1000	1.2267	-0.0040	Commercial CFL	-0.0119
Std14	Hot Food Holding Cabinets	1.0500	1.3200	-0.0207	AVG of res and nonres TVs similar to the IOU estimation	-0.0121
Std15	External Power Supplies, Tier 1	1.0500	1.3200	-0.0207	AVG of res and nonres TVs similar to the IOU estimation	-0.0121
Std16	External Power Supplies, Tier 2	1.0500	1.3200	-0.0207	AVG of res and nonres TVs similar to the IOU estimation	-0.0121
Std17	Cons. Electronics - Audio Players	1.0400	1.3200	-0.0207	Residential TVs similar to the IOU estimation	-0.0158
Std18a	Cons. Electronics - TVs	1.0400	1.3200	-0.0207	Residential TVs similar to the IOU estimation	-0.0158
Std18b	Cons. Electronics - DVDs	1.0400	1.3200	-0.0207	Residential TVs similar to the IOU estimation	-0.0158
Std19	Water Dispensers	1.0250	1.1600	-0.0103	Half of res and nonres TVs similar to the IOU estimation	-0.0121
	2006-2009 Title 20					
Std11b	Gen. Svc. Incand. Lamps, Tier 2	1.0700	1.2733	-0.0124	AVG of res and nonres CFL similar to the IOU estimation	-0.0177
Std22a	BR, ER and R20 IRLs: Res.	1.0400	1.3200	-0.0207	Residential CFL similar to the IOU estimation	-0.0234
Std22b	BR, ER and R20 IRLs: Comm.	1.1000	1.3200	-0.0207	Commercial Non-CFL	-0.0119
Std23	Metal Halide Fixtures	1.1000	1.3200	-0.0207	Commercial Non-CFL	-0.0119
Std24	Portable Lighting Fixtures	1.0700	1.2733	-0.0124	AVG of res and nonres CFL similar to the IOU estimation	-0.0177
Std25	GPL -- 100 watt	1.0700	1.2733	-0.0124	AVG of res and nonres CFL similar to the IOU estimation	-0.0177
Std26	GPL -- 75 watt	1.0700	1.2733	-0.0124	AVG of res and nonres CFL similar to the IOU estimation	-0.0177
Std27	GPL -- 60 and 40 watt	1.0700	1.2733	-0.0124	AVG of res and nonres CFL similar to the IOU estimation	-0.0177
Std28a	Televisions - Tier 1	1.0500	1.3200	-0.0207	AVG of res and nonres TVs similar to the IOU estimation	-0.0121
Std28b	Televisions - Tier 2	1.0500	1.3200	-0.0207	AVG of res and nonres TVs similar to the IOU estimation	-0.0121
	Federal Appliance					0.0000
Fed 2	Refrig. Bev. Vending Machines	1.0250	1.1600	-0.0103	Half of res and nonres TVs similar to the IOU estimation	-0.0060
Fed 3	Commercial Refrigeration	1.0500	1.3200	-0.0207	AVG of res and nonres TVs similar to the IOU estimation	-0.0121
Fed 6	IRLs	1.0700	1.2733	-0.0124	AVG of res and nonres CFL similar to the IOU estimation	-0.0177
Fed 7	Gen. Svc. Fluorescent Lamps	1.1000	1.2267	-0.0040	Commercial CFL	-0.0119
	2005 Title 24					
Std B3	Res. Hardwired lighting	1.0400	1.3200	-0.0207	Residential CFL similar to the IOU estimation	-0.0234
Std B6	Lighting controls under skylights	1.0500	1.1133	-0.0020	Half of the Commercial CFL	-0.0060

Standards		Electric IE kWh/kWh	Demand IE kW/kW	Gas IE Therms/kWh	Assumption Used to Calculate IE	Gas IE by IOUs
Std B10	Bi-level lighting control credits	1.1000	1.3200	-0.0207	Commercial Non-CFL	-0.0119
	2008 Title 24					
Std B17	Envelope insulation	N/A	N/A	-0.0058	AVG "Comm. Glass type method dbl clear" for all CZs*	0.0000
Std B19	Skylighting	N/A	N/A	-0.0040	Interactive effect assumed to be that of Com CFL	-0.0119
Std B20	Sidelighting	N/A	N/A	-0.0040	Interactive effect assumed to be that of Com CFL	-0.0119
Std B21	Tailored Indoor lighting	N/A	N/A	-0.0040	Interactive effect assumed to be that of Com CFL	-0.0119
Std B22	DR Indoor Lighting	N/A	N/A	-0.0020	Interactive effect assumed to be half of the Com CFL	0.0000
Std B29	Site Built Fenestration	1.1700	1.2700	-0.0058	AVG "Comm. Glass type method - dbl clear" for all CZs*	0.0000
Std B30	Residential Fenestration	1.1100	1.2750	-0.0321	AVG "Res. Glass type method - dbl clear" for all CZs**	0.0000
Std B33a	CfR IL Complete Building Method	N/A	N/A	-0.0040	Commercial CFL	N/A
Std B33b	CfR IL Area Category Method	N/A	N/A	-0.0040	Commercial CFL	N/A
Std B33c	CfR IL Egress Control	N/A	N/A	-0.0040	Commercial CFL	N/A
Std B33d	CfR HVAC Efficiency	N/A	N/A	-0.0040	Commercial CFL	N/A
Std B33e	CfR Res Cool Roofs	1.1100	1.2750	-0.0321	AVG "Res. Glass type method - dbl clear" for all CZs**	N/A
Std B33f	CfR Res Central Fan WL	1.0400	1.3200	-0.0207	Residential CFL similar to the IOU estimation	N/A

MH	Metal Halide
IRL	Incandescent Reflector Lamp
GPL	General Purpose Lighting
IL	Interior Lighting

*IE Sensitivity Report Appendix H pg.109

**IE Sensitivity Report Appendix H pg.129

Appendix K. IOU Estimate and Evaluated Savings without Interactive Effects

Table 194. Summary of Savings with Interactive Effects

Interactive Effect On								
GWh	IOU Estimate				Evaluated			
	Potential	Gross	Net	Net Program	Potential	Gross	Net	Net Program
2005 T-20	1,743	1,620	820	601	1,832	1,712	870	637
2006-2009 T-20	3,405	2,637	2,026	1,510	3,033	2,517	2,012	1,417
Fed Appliance	610	580	508	254	533	452	371	161
2005 T-24	936	797	509	280	939	797	509	280
2008 T-24	1,588	1,320	965	498	902	3,656	2,512	583
2010-2012 Total	8,282	6,954	4,828	3,142	7,239	9,134	6,273	3,078

MW	IOU Estimate				Evaluated			
	Potential	Gross	Net	Net Program	Potential	Gross	Net	Net Program
2005 T-20	250	233	124	92	310	291	152	112
2006-2009 T-20	404	315	253	190	380	307	248	170
Fed Appliance	101	96	85	43	98	83	64	25
2005 T-24	270	221	140	72	270	221	140	72
2008 T-24	482	401	300	160	217	845	584	144
2010-2012 Total	1,508	1,266	902	556	1,275	1,747	1,187	523

Mtherms	IOU Estimate				Evaluated			
	Potential	Gross	Net	Net Program	Potential	Gross	Net	Net Program
2005 T-20	-10.18	-9.20	-1.77	-1.13	-20.02	-18.69	-6.46	-4.40
2006-2009 T-20	-46.84	-34.85	-27.35	-20.19	-30.89	-26.33	-18.20	-11.71
Fed Appliance	-6.60	-6.27	-5.62	-2.81	-1.32	-0.73	-0.38	-0.11
2005 T-24	12.94	13.08	11.24	8.29	13.04	13.06	11.22	8.27
2008 T-24	43.77	36.40	29.15	20.70	14.08	4.33	3.29	7.00
2010-2012 Total	(6.91)	(0.84)	5.65	4.85	(25.10)	(28.35)	(10.54)	(0.94)

Table 195. Summary of Savings without Interactive Effects

Interactive Effect Off								
GWh	IOU Estimate				Evaluated			
	Potential	Gross	Net	Net Program	Potential	Gross	Net	Net Program
2005 T-20	1,743	1,620	820	601	1,743	1,626	827	607
2006-2009 T-20	3,405	2,637	2,026	1,510	2,912	2,419	1,937	1,368
Fed Appliance	610	580	508	254	515	438	361	159
2005 T-24	936	797	509	280	936	797	509	280
2008 T-24	1,588	1,320	965	498	898	3,653	2,510	583
2010-2012 Total	8,282	6,954	4,828	3,142	7,005	8,934	6,144	2,995

MW	IOU Estimate				Evaluated			
	Potential	Gross	Net	Net Program	Potential	Gross	Net	Net Program
2005 T-20	250	233	124	92	250	234	125	93
2006-2009 T-20	404	315	253	190	310	252	205	142
Fed Appliance	101	96	85	43	87	75	59	24
2005 T-24	270	221	140	72	270	221	140	72
2008 T-24	482	401	300	160	211	839	580	143
2010-2012 Total	1,508	1,266	902	556	1,128	1,620	1,109	473

Mtherms	IOU Estimate				Evaluated			
	Potential	Gross	Net	Net Program	Potential	Gross	Net	Net Program
2005 T-20	7.42	7.42	5.38	3.91	7.42	7.42	5.38	3.91
2006-2009 T-20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fed Appliance	0.49	0.46	0.33	0.17	0.31	0.30	0.22	0.07
2005 T-24	13.22	13.14	11.30	8.33	13.22	13.14	11.30	8.33
2008 T-24	44.73	37.19	29.69	21.08	17.96	15.42	10.70	8.30
2010-2012 Total	65.86	58.22	46.70	33.50	38.91	36.28	27.59	20.61

Table 196. Summary of Savings: Difference due to Interactive Effects

Difference Due to Interactive Effect (IE On - IE Off)								
GWh	IOU Estimate				Evaluated			
	Potential	Gross	Net	Net Program	Potential	Gross	Net	Net Program
2005 T-20	-	-	-	-	89	86	43	31
2006-2009 T-20	-	-	-	-	122	97	75	49
Fed Appliance	-	-	-	-	17	14	9	2
2005 T-24	-	-	-	-	2	1	1	0
2008 T-24	-	-	-	-	3	3	2	1
2010-2012 Total	-	-	-	-	234	201	129	83

MW	IOU Estimate				Evaluated			
	Potential	Gross	Net	Net Program	Potential	Gross	Net	Net Program
2005 T-20	-	-	-	-	60	57	27	19
2006-2009 T-20	-	-	-	-	69	56	43	28
Fed Appliance	-	-	-	-	11	8	5	1
2005 T-24	-	-	-	-	-	-	-	-
2008 T-24	-	-	-	-	7	6	3	1
2010-2012 Total	-	-	-	-	146	127	79	49

Mtherms	IOU Estimate				Evaluated			
	Potential	Gross	Net	Net Program	Potential	Gross	Net	Net Program
2005 T-20	(18)	(17)	(7)	(5)	(27)	(26)	(12)	(8)
2006-2009 T-20	(47)	(35)	(27)	(20)	(31)	(26)	(18)	(12)
Fed Appliance	(7)	(7)	(6)	(3)	(2)	(1)	(1)	(0)
2005 T-24	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)
2008 T-24	(1)	(1)	(1)	(0)	(4)	(11)	(7)	(1)
2010-2012 Total	(73)	(59)	(41)	(29)	(64)	(65)	(38)	(22)

Appendix L. Comments and Responses

The following comments were received during the public comment period. These comments were posted on energydataweb.com by Mary Andersen of PG&E on 9/9/2014. Ms. Andersen posted a cover letter, dated August 29, 2014 with three overarching comments and an embedded excel spreadsheet that included fifty seven more detailed questions. We have included the cover letter comments here with designation "CL." Responses from the evaluation team are also included in the table along with references to changes in the report or appendices documents if applicable.

No.	Subject:	Section / Page	Comment or Question:	Response	Change to Documents
CL 1a)	1 a) Potential Code Compliance Overestimation		The C&S Evaluation potentially overestimates the compliance rates for the residential and nonresidential retrofit markets. The IOUs believe that the compliance rates merit further study to ensure that they accurately reflect the market conditions. The compliance rates should not be used in workpaper assumptions or other energy savings calculations until additional research has been completed.	Thank you for the comment.	No change
CL 1b)	1 b) Develop evaluation methodologies at the early stage and present them for discussion.		The IOUs have asked the CPUC evaluation team in past PCG meetings to provide specifics on compliance evaluation methods. The team was told that detailed method would be developed as the evaluation process proceeds. While this was true the final compliance evaluation method, including the definition of compliance rate and compliance adjustment factor and the approach of applying whole building compliance rate to individual measures, was provided to the IOUs after the draft report was developed. The IOUs had little opportunity to consider and comment on this method. The method and associated results can mislead people to think that all adopted measures have a compliance rate of larger than 100%. The implication of the compliance evaluation method used by the CPUC evaluators need to be carefully considered prior to using the results of the report for reporting and future policymaking.	Thank you for the comment.	No change
1	Background	1.3 / p. 16	The effective dates for 2008 Title 24 code measures in table 5 seem to include estimated construction delay period, instead of the official CEC effective date. The residential swimming pool and other retrofit measures should have a short construction delay. Did the evaluator consider this effect? If the assumed construction periods are for new construction buildings are they really applicable to res swimming pool, lighting retrofit, and roof retrofit measures, which should have much shorter construction periods than those for new construction?	The effective dates for 2008 Title 24 codes do include a construction delay period to allow for construction to be completed under the codes effective on January 1, 2014. Based on earlier research including the 2006-2008 PY evaluation, the evaluators assumed delays of six months for residential measures, eight months for the B33 CfR codes, and nine months for all other nonresidential codes. In the absence of more specific data about specific project categories, these delays were applied to both new construction and alteration projects. A footnote (text below) has been added to Table 16 of the report: "All 2008 Title 24 codes became effective on 1/1/2010. Adjusted Effective Date here reflects the assumed lag between the legal requirement and the completion of construction that produces savings. The assumed lags are 6 months for residential, 8 months for the B33 CfR codes, and 9 months for the nonresidential codes."	Section 2.2

<table>
<tr><th>No.</th><th>Subject:</th><th>Section / Page</th><th>Comment or Question:</th><th>Response</th><th>Change to Documents</th></tr>
<tr><td>2</td><td>Federal savings from Large Packaged Commercial Air-Conditioners</td><td>2.2.1 / p. 24</td><td>As noted in the paragraph under Table 17, Title 20 Standard 6 (Large Packaged Commercial Air-Conditioners) was preempted by a Federal standard that took effect 1/1/2010. The federal standard resulted from the EPACT 2005 Federal legislation and influenced by the existing Title 20 standard. This history is described in the IOU memo sent to the CPUC and Cadmus on January 24, 2014.

As it stands now, our understanding is that the IOUs will no longer receive any savings credit for the Title 20 measure or the Federal measure. Is this correct?

As outlined in the January 24, 2014 IOU memo, the IOUs would like to make a case for receiving some savings attribution for the Federal standard that became effective 1/1/2010. The IOUs didn't include savings for the federal measure in the original savings claims reported to the CPUC for this evaluation cycle. However, since those claims were submitted, IOUs learned that Title 20 savings will be eliminated once a Federal measure is effective. Thus, given the new/clarified policy, could the evaluation team make a note in the final report that this topic should be considered for re-assessment in the next evaluation?</td><td>As noted in the PY 2006-2008 evaluation report, the evaluated potential for Title 20 Standard 6 and Standard 7 was found to be zero as of January 1, 2010 due to to pre-emption by federal standards.

For documentation of expected savings, the evaluators relied on the information provided by the IOUs in response to CPUC data requests. In their responses to data requests, the IOUs did not claim any California Title 20 or Federal savings in this evaluation cycle from Large Packaged Air Conditioners. For this reason, Cadmus did not conduct an attribution analysis and the independent panel did not determine attribution scores for the state or federal Large Packaged Commercial Air-Conditioners standards.

Determinations for future evaluations cannot be made at this time.</td><td>No change</td></tr>
<tr><td>3</td><td>IE Evaluation</td><td>3.1.3 / p. 31</td><td>“For this calculation we used the DEER values for residential and non-residential CFLs for existing buildings. We assumed the existing building types are dominant for most of the standards.” New buildings are more efficient than existing buildings and, therefore, would have less heating and cooling loads and energy used. Wouldn’t the approach of using CHIF values for existing buildings overestimate the IE for new buildings?

<table>
<tr><th>Sector</th><th>Measure Type</th><th>Building Type</th><th>Average Energy</th><th>Average Demand</th><th>Average Gas</th></tr>
<tr><td colspan="6">New Buildings</td></tr>
<tr><td>Com</td><td>CFL</td><td>Com</td><td>1.100</td><td>1.227</td><td>-0.004</td></tr>
<tr><td>Res</td><td>CFL</td><td>Res</td><td>1.040</td><td>1.320</td><td>-0.021</td></tr>
<tr><td>Com</td><td>Non-CFL</td><td>Com</td><td>1.100</td><td>1.217</td><td>-0.004</td></tr>
<tr><td colspan="6">Existing Buildings</td></tr>
<tr><td>Com</td><td>CFL</td><td>Com</td><td>1.090</td><td>1.230</td><td>-0.004</td></tr>
<tr><td>Res</td><td>CFL</td><td>Res</td><td>1.077</td><td>1.320</td><td>-0.020</td></tr>
<tr><td>Com</td><td>Non-CFL</td><td>Com</td><td>1.060</td><td>1.177</td><td>-0.004</td></tr>
</table></td><td>The applicable square footage for existing buildings is significantly higher than the applicable square footage for new construction. For this reason Cadmus used the average IE factors for existing buildings.

We can assume that new buildings are more efficient than the existing buildings and they cause less heating and cooling load needs; however, IE factors are the ratio of whole building annual energy savings to direct measure annual savings. This ratio depends on the amount of savings generated by the measure and the amount of savings generated by the whole building. The table from the report and provided in the comment shows that the average IE factors for new buildings can be higher or lower than IE factors for existing buildings. For this reason we don't believe that the approach taken overestimates the IE energy.</td><td>No change</td></tr>
</table>

<table>
<tr><th>No.</th><th>Subject:</th><th>Section / Page</th><th>Comment or Question:</th><th>Response</th><th>Change to Documents</th></tr>
<tr><td>4</td><td>IE Evaluation</td><td>3.1.3 / p. 31</td><td>In Table 21, the Therm IE factor for Com Non-CFL lighting measures is -0.0207. Using the same DEER reference, we got a value of -0.0041 (see below). Nonresidential buildings in general have much smaller IE than residential buildings (as indicated by DEER data). Should the evaluator re-examine this assumption and make adjustment accordingly.
<table>
<tr><th colspan="5">Indepenent Values</th><th colspan="3">IE Factors</th></tr>
<tr><th>IE Meas Type</th><th>IOU</th><th>Building Vintage</th><th>Building SubSector</th><th>Climate Zone</th><th>Energy kWh/kWh</th><th>Demand kW/kW</th><th>Gas therm/kWh</th></tr>
<tr><td>Non-CFL</td><td>PGE</td><td>Ex</td><td>Com</td><td>IOU</td><td>1.06</td><td>1.20</td><td>-0.0061</td></tr>
<tr><td>Non-CFL</td><td>SCE</td><td>Ex</td><td>Com</td><td>IOU</td><td>1.12</td><td>1.23</td><td>-0.0033</td></tr>
<tr><td>Non-CFL</td><td>SDG</td><td>Ex</td><td>Com</td><td>IOU</td><td>1.12</td><td>1.22</td><td>-0.0029</td></tr>
<tr><td>Average</td><td></td><td></td><td></td><td></td><td>1.1000</td><td>1.2167</td><td>-0.0041</td></tr>
</table></td><td>There was an error in this paragraph. In the DRAFT 08192014 report, the text was revised to clarify that the evaluators used the IE factors for both the residential and nonresidential buildings. Commercial TV-HVAC IE factors (only electric energy IE factors are available) are listed in Table 21 in the report already.

IE factors depend on the measure; therefore, we cannot make an assumption that nonresidential buildings in general have much smaller IE than residential buildings. As it is listed in Table 21, TV Res Avg IOU IE factor (1.04 kWh/kWh) is lower than the TV Com Avg IOU IE factor (1.06 kWh/kWh).</td><td>Section 3.1.3</td></tr>
<tr><td>5</td><td>Title 24 compliance evaluation methodology</td><td>3.2.3 / p. 41</td><td>“New construction square footage was used as a proxy for the distribution of alteration activity since there isn’t a source for statewide alteration activity.” Areas with relatively large new buildings populations may have less alteration activities. Alteration activities may have stronger correlation with existing building stock. How would changing the alteration activity proxy to existing building stock have impacted the savings estimates?</td><td>Although the distribution of alteration activity was based on new construction square footage, the total quantity of alteration activity was based on total existing building stock. We don't know whether changing the distribution proxy to existing building stock would affect the savings estimates.</td><td>No change.</td></tr>
<tr><td>6</td><td>Title 24 compliance evaluation methodology</td><td>3.2.3 / p. 39</td><td>“In addition to these two categories, we conducted research into nonresidential re-roofing (envelope insulation and cool roof) and outdoor lighting since these categories accounted for another 100 GWh of potential savings.” What types of research were conducted? According to Table 12, the compliance rate for outdoor lighting was not evaluated. The evaluator suggested that 4 samples were analyzed for compliance assessment of the Title 24 outdoor lighting measure. Shouldn't the evaluator release the analysis results in the report and discuss the reason for not using the result to estimate savings?</td><td>"Roofing Alteration" under section 3.2.3 Title 24, p. 53, discusses the evaluation methodology behind estimating the compliance percentage using a binary approach (compliant or non-compliant) for roofing projects including a table of the simulated savings results. For outdoor lighting, Cadmus collected and analyzed data for 4 sites as case studies to identify potential extreme scenarios to be considered for a more indepth evaluation in future program years. All these four sites proved to be in compliance with the code. However, since the number of the sampled sites was not statistically significant, the evaluation team decided not to extrapolate the result values to the entire population. The analysis results for these sites are presented in Appendix H.2.4.</td><td>No change.</td></tr>
<tr><td>7</td><td>Title 24 compliance evaluation methodology</td><td>3.2.3 / p. 53</td><td>“The evaluation team used the 2011 DEER for default values when ballast factor data were not collected”. What is the DEER value based on? Does it reflect market baseline or minimum standard requirement?

“When an appropriate ballast factor was not found in DEER, the team used additional sources, such as manufacturer specifications and the EnergyPro lighting library which is based on market frequency of the product.” What is market frequency?</td><td>According to the DEER website, market frequency indicates that the value is based on the specification for the product that is the most commonly used equipment in market.</td><td>No change.</td></tr>
<tr><td>8</td><td>NOMAD initial market penetration</td><td>3.3.1 / p. 57</td><td>In the “Initial market penetration” section, the first sentence reads: “The initial market penetration represents the state of the market at the time the standard became effective ; in other words, it is the share of annual installations or purchases already meeting the requirements of the standard.” Given that market actors start adjusting to the standard when its adopted, shouldn’t the initial market penetration represent the state of the market at the time of adoption as opposed to effective date?</td><td>The term "initial market penetration" is not used in the report and therefore a definition is unnecessary. The definition has been removed from section 3.3.</td><td>Section 3.3</td></tr>
</table>

No.	Subject:	Section / Page	Comment or Question:	Response	Change to Documents
9	10% prior program adjustment	3.3.1 / p. 59	Can you clarify when the 10% adjustment starts? It seems to make sense that the adjustment would start the after the last year the program was active but it's not clear if this is the case.	The Utility Programs Effect adjustment starts the year the standard becomes effective, which is usually one year after resource programs could incent measures of the same efficiency. The utility programs effect adjustment is reduced by 10% of the original value every year (i.e., the effect is zero in the eleventh year).	No change.
10	Discrepancies between values in main report and Appendix	4.1 / p. 65	We noticed the following discrepancies (shown on separate worksheet) between potential savings in the main body and the Appendix: This is very likely due to the fact that interactive effects hadn't yet been incorporated into the Appendix, but please confirm.	Agreed. The potential values included in the Appendix do not include interactive effects. This has been noted in the document at the beginning of Appendix F.	Appendix F.
11	Table 34 gas savings	4.1 / p. 65	The sentence preceding Table 34 states: "The only standard for which there are first-year potential gas savings is federal standard 5, residential gas ranges." However, gas savings are shown for federal standard 5 too. Why don't the therm savings shown in Table 32 for Fed4 (0.3 Mtherms) and Fed 5 (0.1 Mtherms) match with the per topic Tables 78 and 79?	Agreed.The text has been revised in Section 4.1 of the final report to indicate that there are positive gas savings for Federal 4 and Federal 5. The text has also been revised to state that the values shown are for a full year and that potential is adjusted if the standard takes effect after January 1. Since Federal 4 and Federal 5 are in effect for 8-9 months of 2012, the 2012 potential is somewhat less than the full year potential.	Section 4.1
12	Savings from EISA lighting standards	4.1.1 / p. 66	Prior to Table 35, the document states: "In cases where the IOUs include a corresponding federal standard in their estimate, some or all of these potential savings will be evaluated with the federal standards group as shown in the lower section of Table 36. The EISA lighting standards are a notable exception—the IOUs did not include EISA with the federal standards in their estimate." As outlined in the January 24, 2014 IOU memo to the CPUC and Cadmus, the IOUs provided some history of IOU activities that contributed to the EISA lighting standards. We're not aware of a discussion to or reaction to that memo in the draft impact evaluation. Could the final report include a discussion of that memo and provide a recommendation that these federal standard be considered for evaluation in during the next cycle?	Cadmus reviewed the January 24, 2014 IOU memo as part of the current evaluation. However, the evaluation team was focused on determination of attribution for standards for which savings were included in the IOU responses to CPUC requests (primarily Data request #1 / EEGA 1465/1466/1467/1468 and Data request #10 / EEGA 2576/2577/2578/2579). There were no savings claims in the ISSM model or included in response to a data request for the EISA standards. Determinations for future evaluations cannot be made at this time.	No change.
13	Fed 6 Naturally Occurring Market Adoption	4.3.1 / p. 68 6.3.6 / p. 104	Cadmus found based on conversations with industry experts that Naturally Occurring Market Adoption was 19% by 2012. However, Cadmus' own shelf surveys in 2011 and 2012, even *with* the 2009 adoption of the standard, found the adoption rate to be far lower (2.0% and 6.97%, respectively). These findings support the notion that there was very little momentum in the market for these higher efficiency products, outside the standard itself. Why didn't Cadmus assume a naturally occurring market adoption in the range of 2%-7% (or lower) as that was the assessed market share a full 2 years after the adoption of the standard (but before the full roll out of the effective date)?	The IOU comment is referring to the DNV-KEMA shelf studies WO13 and WO28 (Described in Appendix F.4). Shelf study data were not available at the time we were collecting the NOMAD input from the panelists so we did not provide market data to respondents. Following the receipt of this comment, the evaluation team determined that an adjustment to the NOMAD curve was logical. We kept the NOMAD curve defined by the expert panel but moved the start year in ISSM to 2008 to have NOMAD value of 1.4% in 2011 be slightly less than the shelf study finding. This adjustment is also visible in the 2% evaluated NOMAD value for 2012 presented in Table 86 (Section 6.3.6) of the report.	Section 6.3.6

No.	Subject:	Section / Page	Comment or Question:	Response	Change to Documents
14	Attribution factor scores for portable lighting fixtures	4.4 / p. 71	Relative to other Title 20 measures, portable lighting fixtures received significantly lower factor scores. Can you provide some context for why? The report provides background on the methodology to assign attribution (Section 3.4) but doesn't provide details on a per measure basis.	Attribution was performed for only four Title 20 measures: IRLs, Metal halide fixtures, Portable lighting fixtures, and GPL. The attribution scores for Portable lighting fixtures were 40% for Compliance, 50% for Technical, and 50% for Feasibility. Of the T20 measures, Portable lighting fixtures received the lowest scores for compliance and technical and the second lowest score for feasibility. The compliance score for Portable lighting fixtures was less than half of that for IRLs and GPLs, but the technical and feasibility scores for Portable lighting fixtures, while lower, were similar in magnitude to those for the other measures. The independent panel determined the factor scores after carefully weighing the evidence about the contributions of the IOUs,CEC, and other stakeholders. The panel believed that the CEC, ALA, and other stakeholders deserved significant credit for their contributions to the portable lighting fixtures standard. The panel believed that the IOUs made proportionately larger contributions to the development of the other standards. Finally, as the weight on compliance for portable lighting fixtures, was relatively small (10%), even a substantially higher score for this factor would have relatively little impact on the overall attribution score. Note that the IOUs were surveyed for input on factor weights. Their input was for 10% weight on the compliance factor for portable lighting fixtures.	No change.
15	Attribution factor scores for Fed6, IRLs	4.4 / p. 71	Given that Federal IRL standards were based largely on previously adopted Title 20 standards (for which the IOUs played a significant role in developing the CASE report and through advocacy), we would have expected the "Technical" and "Feasibility" factor score to be higher (25% and 35% respectively). Can you provide some context for why? The report provides background on the methodology to assign attribution (Section 3.4) but doesn't provide details on a per measure basis.	As with CA portable lighting fixtures, the independent panel determined the factor scores after carefully weighing the evidence about the contributions of the IOUs, DOE, and other stakeholders. The panel recognized that the IOUs made significant contributions to the Federal IRL standard, but also determined that DOE deserved a large share of credit for authoring and conducting primary research in support of the standard. Other stakeholders also received small amounts of credit.	No change.

No.	Subject:	Section / Page	Comment or Question:	Response	Change to Documents
16	Title 20 Evaluation Results - NOMAD	5.4 / p. 68	Regarding prior program adjustments, did the evaluator not find any incentive program installation for Fed 7 General-Service Fluorescent Lamps? In reponse to CPUC evaluation team's request, the IOUs developed a detailed mapping between C&S measures and incentive program measures. The IOUs had a meeting with the evaluation team on Oct 29, 2012 to discuss this data request. The developed mapping covers Title 20 standards, Title 24 measures, and federal standards. For example, for Fed 7 GS fluorescence lamp standards, the IOUs' response listed more than one thousand program entries affected by this standard. Please explain how the mapping information was used and why incentive program data was not considered by other appliance and buildings standards.	We appreciate the IOUs support of the process used to obtain information on measures incented by utility programs (before a standard becomes effective). These data allowed us to make adjustments for utility incentive programs for Std. 9 (Pool Pumps), Std. 23 (Metal Halide Fixtures), and Std. 28 (Televisions). For Federal standards, the IOU's response had program data for Fed 1 (electric motors), Fed 2 (vending machines), and Fed 7 (General service fluourescent lamps). We found that Fed 1 and Fed 7 are responsible for 96% of the net savings from federal standards. When we analyzed the data associated with Federal 1 (electric motors) and Federal 7 (GS fluorescent lamps), we were unable to reconcile the units reported with the units used to define the markets for these products. For Fed 7, the utility program units reported totaled about 90 million units per year in 2010 and 2011. The IOUs and the evaluators agreed in earlier discussions that the California market consists of less than 10 million units per year. If we assume that the adjustment due to units incentivized by IOU programs were one third of the estimated NOMAD, the net effect would be about 3 GWh of additional savings in 2012. For Fed 1, the utility program units reported total about 15 million units per year in 2010. The IOUs and the evaluators found that the market for regulated motors was in the range of 234,000-254,000 motors per year. If we assume that the adjustment due to units incentivized by IOU programs were one third of the estimated NOMAD, the net attributable effect would be about 2 GWh of additional savings per year in 2011 and 2012. For these two standards together, the total effect of the assumed savings would be about 1/4 of 1% of the evaluated net program savings. Given the scale of the work required and the uncertainty in the overall analysis, the evaluators did not spend additional effort to reconcile the utility program units reported for federal standards. For Title 24 codes, the application of utility program units to adjust NOMAD for codes evaluated at the project level (nonresidential whole building and lighting alterations) is conceptually undefined. Utility program values were given for four codes evaluated at the measure level: B23 (Outdoor lighting), B24 (Outdoor signs), B26 (Refrigerated Warehouses), and B30 (Residential Fenestration). We found unit issues similar to the federal standard examples given above. Assuming that the adjustments due to utility programs were one third of the estimated NOMAD, net savings for these standards would increase by about 1 GWh per year. Given the scale of the work required and the uncertainty in the overall analysis, the evaluators did not spend additional effort to reconcile the utility program units reported for Title 24 codes."	No change.
17	Title 24 Evaluation Results - Potential Savings	5.1 / p. 73	"Table 42. Nonresidential Construction Activity" indicates that verified NRNC activity is 21% of the IOU estimate, which was based on a CEC forecast. According to the historic NRNC activity data (in dollar amount) provided by CBIA to the CEC in 2012, 2010 had the lowest NRNC activity, which is still about 30% of value in the peak year of 2006. Please explain how the evaluation results are not underestimating the NRNC activity during 2010 to 2012, given the CBIA data.	We reviewed the CBIA data and compared them to the MHC data we used. CBIA lists alterations and additions together, but our MHC data does not have alterations and only include new construction and additions. Therefore there is a significant difference between the numbers calculated based on these two sources. Since CBIA data include alterations and exclude some of the nonresidential building types (government buildings, heavy construction (nonbuilding)), we will not use these data. We believe MHC data reflects the most accurate data for the estimation of NRNC activity during 2010 to 2012.	No change.

No.	Subject:	Section / Page	Comment or Question:	Response	Change to Documents
18	Title 24 Evaluation Results - Compliance	5.2 / p. 75	Table 45 presents compliance evaluation results for B17 Envelope Insulation (Re-roof) (18 Sites) and B31 Cool Roof Expansion (Re-roof) (11 Sites). Can the evaluator provide detailed evaluation information in the appendix H, where detailed information is provided for NRNC and lighting alteration?	We provided a summary of the roofing analysis results in Section 3.2.3. We decided not to include the detailed site data in an appendix since it is not used in the evaluation. This site level data are included in the Title 24 Compliance Site Summary file that is available upon request from the CPUC.	No change.
19	Results for the Statewide Program	6.1 / p. 79	Did the evaluator apply the verified new construction data to 2005 Title 24 savings?	Notes that this adjustment was not done at this time were added to the executive summary and at the beginning of Chapter 6 of the CS Evaluation Report DRAFT 08192014.	Exec Summary, Ch 6 intro.
20	Results for the Statewide Program – Title 24	6.1 / p. 79	CEC's impact analysis for these two code updates show similar level of improvement: 2005 Title 24: 20% for RNC and 7.7% for NRNC 2008 Title 24: 23% for RNC and 4.9% for NRNC. The results in Table 49, however, shows very large 2008 Title 24 gross and net (not program net) savings: 3681 and 3359 GWh, respectively. They are substantially higher than those achieved by 2005 Title 24 (~ 4-5 times higher). Can the evaluator provide some explanation of this large difference? Net savings represent the actual impact to the demand on the grid. The annual California electricity consumption is in the order of 250,000 GWh. The evaluation results would suggest that 2008 Title 24 net savings would reduce CA annual electricity consumption by about 0.4%. This seems to be too high. These results include the effect of significantly low new construction rates. In coming years when new construction rates may recover significantly, net 2008 Title 24 savings would increase significantly accordingly, implying even larger contribution to the state electricity usage reduction. What is the confidence level for the 2008 Title 24 evaluation results?	Evaluated 2008 T24 nonres savings are based on as-built buildings / renovations compared with 2005 Title 24 requirements. We did not address the improvement of 2005 T-24 over the previous code. We found these projects saved about 4 times as much energy as predicted comparing 2008 with 2005 Title 24 requirements. The report includes analysis of the confidence and precision of the compliance analysis in Section 5.2 and an uncertainty analysis for the overall savings in Section 6.5.	No change.
21	Results for the Statewide Program – Title 24	6.1.5 / p. 91	"Cadmus found NOMAD to be about 9% across all of the 2008 Title 24 codes and so net savings are also much larger than the IOU Estimate." According to the data presented in Table 47, the simple average of NOMAD for all measures is 20%; the average weighted by potential savings is 12%. How was the 9% derived?	We estimated the "average" NOMAD by taking the ratio of total net savings to total gross savings.	No change.
22	Results for the Statewide Program – Title 24	6.1.5 / p. 91	"Net program savings are 130 GWh, or 26% larger than the IOU Estimate, although we found attribution overall to be under 20%." How was the 20% obtained? This value seems not to be consistent with data provided in Table 48.	We estimated the "average" attribution by taking the ratio of total net program savings to total net savings.	No change.
23	Portable lighting fixtures	6.2.5 / p. 99	The top of page 99 states: "Net program savings, however, were found to be about 10% higher than the IOU estimate as larger NOMAD and smaller attribution—49% versus the IOU estimate of 74%—resulted in a large discount of gross savings." The 10% value is incorrect for GWh, MW, and Mtherms. For GWh, savings were 14% to 20% *higher*, depending on the year. The MW net program savings were almost 90% *lower* and Therms were 17% *lower*.	Agreed. The evaluated total energy savings over the 3-year period is 17% higher than the IOU estimate. In Section 6.2.5 of the final report, the text has been revised to reflect the evaluation results.	Section 6.2.5

No.	Subject:	Section / Page	Comment or Question:	Response	Change to Documents
24	Fed 2 CAF	6.3.2 / p.102	For each year of the three year analysis period (2010-2012), Cadmus estimated a CAF of 37%. It appears the original source of this compliance value is based on a 2007 Quantec report (prepared for SCE: http://www.calmac.org/publications/Codes_and_Standards_Final_Report.pdf) where the field sampling occurred July 26 and September 11, 2006. This value was also used in the 2006-08 IOU C&S Impact evaluation (http://www.calmac.org/publications/Codes_Standards_Vol_III_FinalEvaluationReportUpdated_04122010.pdf). Can you confirm that this is correct? This compliance rate was based a Title 20 standard not the Federal standard that became effect in August 2011. It seems reasonable that compliance has improved since 2006, especially since it is now a Federal standard. Why shouldn't this be acknowledged in the report and potentially adjusted upward?	The CAF value is taken from the prior evaluation of the California beverage vending machine standard. We note in the report that the focus of this evaluation was on the standards adopted since 2006. For this reason, we did not evaluate most parameters for the earlier standards.	No change.
25	Fed 6 Market Size	6.3.6 / p. 104	Cadmus made the following statement on page 104: "*For potential savings, the IOU Estimate assumes that this regulation covers a large part of the IRL market. Cadmus found that a large part of this market was already regulated by EPACT 2007.*" Despite the typo (we believe this should read *EISA* 2007), we agree that a large portion of the IRL market was already regulated by previous legislation (originally EPCA and then amended in EISA 2007). However, the 2009 DOE rule, effective 2012, significantly strengthened the requirements for all of these covered lamps. So the fact that they were "already regulated" seems irrelevant. The savings being claimed here is the difference in performance between the previous legislated standards and the more stringent DOE standards. Why was this not accounted for?	We don't find the cited passage in the DRAFT 08192014 report. But, we did not remove any bulbs from the Fed6 calculation based on the cited passage.	No change.

No.	Subject:	Section / Page	Comment or Question:	Response	Change to Documents
26	Std 9 UES for pool pumps	Appendix F.2.2 Table 22 / p. 84	Cadmus uses a different baseline than the CA IOUs did, leading to a weighted unit energy savings of 2,065 kWh/ year whereas the IOUs only calculated 725 kWh/ year. The CA IOUs used a baseline of 2,600 kWh for single speed pool pumps in the 2004 CASE Report. This value was confirmed with other sources in the 2004 CASE report and calculated as well. Cadmus assumes a single speed pool pump uses 3,522 kWh/ year. It appears this result relies primarily on the Energy Star Calculator and online Hayward pool pump calculator. Based on interviews with Pentair and Hayward, Cadmus determined the average nameplate horsepower pump was 1.5HP and that the run time was 5 hours. When you insert this in to the Hayward calculator, it tells you that the annual energy use of your current pump is ~3,500 kWh therefore making their new efficient Variable Speed pump look all that much better. One potential issue with using the Hayward calculator is that they use CEC Curve C (efficient plumbing/ low head) and a relatively large pump and run hours which led to 1.3 water turnovers per day. Manufacturers recommend 1 turnover per day, and in reality PG&E has found that pool owners only actually run their pumps long enough to filter ~65% of the water (.65 turnovers). This reality of actually how much homeowners filter their water was incorporated into the PG&E Work Paper and the potential savings were adjusted accordingly. Cadmus verified their baseline value with what's in the RASS 2009 for pool pumps of 3,502 kWh/ year. However, we have always assumed this value to include all pool pumping energy (including booster/ auxiliary pumps), not just 1 pump. In summary, Cadmus essentially set the baseline very high and while not out of the realm of possible, it's certainly at the upper limit of baselines based on data the CA IOUs have obtained over the years.	We reviewed the analysis and see no reason to revise it.	No change.
27	Std 11b/25/26/27 UES	Appendix F.3.1 / p. 92	In Figure 32, why is the baseline for savings from Std 11b not the market average efficiency level (compliance market average) for Std 11a? The 2006-08 evaluation provided a compliance rate for Std 11a, which is 69%, indicating the market average efficiency level was below the prescribed efficiency level. Could you explain why the baseline should not be based on market average efficiency level, which includes consideration of actual compliance rate of the prior standard? The evaluator-adopted baseline biases the savings downward from what actually occurred.	As noted in the evaluation report of PY 2006-2008, potential savings for Standard 11a were found to be zero because the manufacturers kept the same lamp wattages and increased lighting lumens to comply with the standard. For this reason, noncompliance does not equate to a different level of energy consumption. We would have used the same baseline wattage values for the Standard 11b UES whether compliance to 11a were assumed to be 69% or 100%.	No change.
28	Std 11b/25/26/27 UES	Appendix F / p. 93,101	Compliance market average for Std 11b changes over time, as confirmed by the evaluation results shown in Tables 31 and 42. Wouldn't this imply that Standard 25, 26, and 27 would each have different baseline values for each year?	We did use different baselines for 2011 and 2012, based on the shelf-stocking data. However, since these standards only generate savings for the first year, this isn't applicable to the evaluation results.	No change.

No.	Subject:	Section / Page	Comment or Question:	Response	Change to Documents
29	Std 11b/25/26/27 Market Size	Appendix F / p. 93-96	The appendix states: "we present results for each year since the market size decreased during this time period" and data in Table 31 through 33 shows reducing market size for incandescent lamps over time. The section of "Purchases for 2011 and 2012" on pages 95 – 96 further discusses "the market for incandescent lamps is shrinking over time" and presents the approach of "constant annual growth rate (CAGR)". What is the value for CAGR and how it is used? Does the evaluation consider market size variation and the application of CAGR for other standards? Should growth rate be considered for all standards? If detailed historic sales data are not available, shouldn't major market factors, such as population growth, be considered to develop growth rate estimates?	Because 2 of the 3 sources used in the average estimate of market size were based on predicted change over a 5-year period, we used a CAGR to interpolate annual values between the start and end dates during this period. Thank you for the comments regarding general treatment of growth rate.	No change.
30	Std 11b/25/26/27 Market Size	Appendix F / p. 95	Pg. 95 states: "Considering California's long history of efforts to transform the lighting market towards more efficient lights, which happen to have longer lifetimes than incandescents, we believe the value of ~7% is reasonable." Thus, should the market transformation effect include utility lighting program efforts, which would be reflected as adjusted NOMAD results?	Assuming the utility programs incent only CFLs and LEDs (the supporting rationale for using % sales of incandescents smaller than the population proportion of 12%), the utility programs effect would not be relevant to the adoption of more efficient incandescents.	No change.
31	Std 11b/25/26/27 Compliance	Appendix F / p. 98	Compliance rates were determined based on shelf survey results. Since not all products on the shelf are sold at the same rate how much bias is caused by this approach?	In the absence of market sales data, shelf survey results have been used in many prior studies. We are not aware of studies that have compared sales and shelf data, so we are unable to comment about any potential uncertainty.	No change.
32	Std 11b/25/26/27 Compliance	Appendix F / p. 99	Are "bulbs with insufficient information to determine compliance" considered to be compliant with the standard, or not?	These were excluded from the analysis. We needed both lumens and wattage to determine which category bulbs fell into.	No change.
33	Std 11b/25/26/27 UES	Appendix F / p. 98	Hours of use (HOU) are based on DEER database information. There is no explanation why the CASE study assumption is not used. Does this mean that the evaluator would use DEER database assumptions to override savings calculation assumptions vetted through the CEC rulemaking process? Are you suggesting that the CEC rulemaking process employ DEER values whenever possible?	The evaluation team has generally used DEER information rather than CASE report assumptions when DEER information is based on more recent evaluations. We have no comment on the CEC rulemaking process.	No change.
34	Std 11b/25/26/27 UES	Appendix F / p. 99	Pg 99 states: "Cadmus used the market average wattages of bulbs compliant with Standard 11b, excluding those compliant with Standards 25 through 27, to compute the unit energy savings attributable to Standard 11b relative to Standard 11a." This does not appear to be consistent with the model presented in Figure 15. Before, Std 25/26/27 takes effect why should the UES calculation for Std 11b exclude 25/26/27 compliant bulbs, given that Std 25/26/27 is not relevant at that point? Figure 31 provides a very clear picture of the five lumen ranges covered by Std 11b. As Std 25/2/6/27 take effect in sequence, the corresponding lumen range should be excluded from the UES calculation for the Std 11b UES calculation. The Std 11b UES would change over time. Have you considered breaking Std 11d into five lumen range components and calculating the UES for each range? The UES of Std 11b would be calculated as the weighted average UES of remaining lumen range components after Std 25/26/27 takes effect.	Cadmus did break Std. 11 into lumen ranges and computed UES and potential for each range. In 2011, we excluded only bulbs in the lumen range covered by Std. 25 and compliant with Std. 25 from the average compliant wattage used to compute UES, as these savings are attributable to Std. 25 and the incremental increase in efficiency is reflected in the potential for Std. 25. In 2012, we did the same for lumen ranges covered by both Std. 25 and 26. The total potential for 2011 and 2012 is a weighted average of the potential computed for each lumen range. We did not have data specific to 2010 with regard to wattages of bulbs sold during this period, so we used the weighted average potential computed for 2011 and adjusted it proportionally by the larger market size in 2010.	No change.

No.	Subject:	Section / Page	Comment or Question:	Response	Change to Documents
35	Std 11b UES	Appendix F / p. 99, 100	Pg 99 states: "We assumed Standard 11b compliant bulbs used 5% less energy than those that complied with Standard 11a." This treatment is reflected in the results shown in Table 40. Why is this treatment not consistent with the model shown in Figure 32 that indicates the compliance market average of Std 11b is to be used for UES calculation? Our previous comments also suggest that the compliance market average of Std 11a should be used as the baseline following the approach in Figure 32. The 2006-08 evaluation provided compliance rate for Std 11a. Wattage data from DNV KEMA WO13 also provides compliance information.	This is consistent with the figure since the table and figure are based on bulbs just compliant with Std 11b.	No change.
36	Std 11b UES	Appendix F / p. 101	Table 42 shows different UES values for Std 11b in 2012. How is the 2012 UES calculated? Shouldn't 2011 UES be different from the one in 2010, since Std 25 took effect in 2011?	As explained above, the savings attributable to Std. 25 in 2011 are already excluded from UES for Std. 11b in 2011. We had data specific to 2011 and 2012 compliant wattages, and we needed to break Std. 11b into 3 years for the version of ISSM used to exclude savings from standards superseded by later CA standards (layering), so we were able to use the UES values specific to each year in the model.	No change.
37	Std 22a, 22b UES	Appendix F / p. 114	"For Std 22a and Std 22b, we used the non-compliant wattage from WO13 as the baseline, which represents the average wattage of bulbs that do not meet Std 22 efficiency requirements. For the efficient option wattage, we used the compliant wattage from WO13." Std 22a and 22b took effect in 2008. WO13 was done in 2011. The evaluation results have been showing rapid changes in lighting markets. Please explain how using 2011 market data to determine the 2008 baseline does not bias results given the rapid change in lighting markets.	We have found from market data that "non-compliant" energy use before and after a standard goes into effect is fairly constant.	No change.
38	Std 22a, 22b, Fed 6 UES	Appendix F / p. 114	DNV KEMA WO13 shelf survey is for incandescent general purpose A-lamps. Please explain how A-lamps accurately reflect the market for IRLs and, therefore, why the baseline wattage and compliant wattage should not be adjusted.	We used IRL shelf data.	No change.

No.	Subject:	Section / Page	Comment or Question:	Response	Change to Documents
39	Fed 6 Compliance	Appendix F / p. 116	Cadmus explained the following around its assessment of a 7% compliance rate for Federally covered incandescent reflector lamps: "We used data from DNV KEMA WO 28, a shelf survey conducted in August and September 2012, to determine the compliance rate several months after the 2012 standards went into effect. From this survey, we determined that 6.9% of IRLs (1,419 out of 20,511 bulbs) met the efficiency standards. The change in the fraction of bulbs meeting the new efficiency standards suggests that more efficient bulbs are being stocked after the standard took effect than before. The compliance rate is low for two reasons. First, the 2012 standard applies only to bulbs manufactured after July 14, 2012. The manufacture date of the bulbs was not collected as part of WO28, so we could not exclude bulbs manufactured before the standard took effect in our compliance analysis. Second, WO28 data collection was conducted only a couple months after the standard took effect, which means the market may not have had enough time to fully respond to the new standard. "We agree with Cadmus' conclusion that conducting a shelf survey less than 1 to 2 months after the July 14, 2012, effective date was not an adequate way to assess the compliance with the standard. Through our communication with manufacturers and observation of this market, compliance is quite high, and Cadmus should reassess survey results taken immediately following the effective date, as that was clearly not enough time for the stock of pre-standards product to run out. This is especially true for this product class where there was little momentum in the market for the higher efficiency products apart from the standard itself (see comment below). Can Cadmus re-assess compliance rates now to gain a better understanding of the true impact of the standard towards the latter half of 2012? In addition, how will increased compliance be adjusted for 2013 and beyond in the next impact evaluation?	We agree that the compliance rate in the last 2-3 months of 2012 might be higher than that assessed based on data from Aug-Sept, but it is beyond the scope of this evaluation to re-assess compliance at this time. Determinations for future evaluations cannot be made at this time.	No change.
40	IRLs – percent on at peak	Appendix F.4.4 / p. 119	With respect to Table 66, we have three comments: 1. The last column should say "Weighted % of Recessed Lighting Fixtures on at Peak" instead of ""Weighted % of Floor Lamps on at Peak". 2. The third column total may be incorrect. It could be 29,869 instead of 10,092. 3. Please check the methodology to calculate percent of recessed lighting on at peak as it may be incorrect and results in very low evaluated percentages. We think the percentage in the second column ("Percent lighting on at peak per room") should apply equally to both recessed lighting and non-recessed lighting (please let us know if this is evidence to the contrary). Thus, it seems like a more straightforward and accurate methodology would be to multiple the second column values ("Percent lighting on at peak per room") by the third column values ("Recessed Ceiling Fixtures per Room") to get the number of recessed lighting fixtures on at peak per room. This totals to 3,060, which is 10% of the total amount of recessed fixtures (instead of 1.26%).	We have updated the calculation and fixed typos based on CPUC feedback. The previous method was accidentally calculating the % of recessed fixtures on at peak out of total residential fixtures. The revised value is 11.0 %.	Section F.4.4
41	Std 23 Market Size appears underestimated	Appendix F.5 / p. 123	150 watt shipments appear to be omitted from historical shipments.	These data were not included the DOE Technical Support document that we used for our analysis.	No change.

No.	Subject:	Section / Page	Comment or Question:	Response	Change to Documents
42	Std 23 Shipments.	Appendix F.5 / p. 122	The estimate that "California represents 9.6% of all commercial buildings in the U.S." appears to be underestimated based on more recent data. The 9.6% value is based on EIA's 2003 2003 Commercial Building Energy Consumption Survey The preliminary results 2012 CBECS are available and they shows that the Pacific share of commercial buildings is 16.7% (compared to the 12.83% estimate from 2003), leading to a California share of national commercial buildings of 12.5% instead of 9.6%. Why shouldn't this information be used in the report?	When we completed the analysis in 2012, the 2012 CBECS data were not yet available.	No change.
43	Std 23 Market Size	Appendix F.5 / p. 123	Page 123 states: "To convert total shipments into total sales, we assumed that 8% of the total annual MHLFs shipped do not get sold during the year. The total number of MHLFs sold annually in California is 234,000 when factoring in distributor inventory turns". Will the 8% be sold in the following years? If so, how will this be accounted for in the impact assessment?	The manufacturer interviewed during our analysis indicated that the 8% of MHLF purchased, but not sold within the year, would be sold within the next quarter of the new year. This figure would carry over from year to year based on recent trends in supplier inventory.	No change.
44	Std 23 UES	Appendix F.5 p. 125-6	The draft evaluation likely under-estimates per unit savings from California MHLF standards by about two-thirds because the draft report uses DOE regulations as a proxy for California standards. The California standards are structured very differently, and allow for multiple compliance pathways including: improving ballast efficiency, using lower wattage lamps, and integral controls (the last option is infrequently used). We suggest that the corrected demand savings are 30.2 watts per fixture and energy savings are 171.6 kWh per fixture, as explained in the Appendix A titled "Per Unit MHLF Energy and Demand Savings Estimate".	We updated the unit savings based on feedback received from the IOUs provided in response to the impact of the CA ballast efficiency option and subsequent lower-wattage installation data they had accessible.	Section F.5.2
45	Portable Lamps peak calculation	Appendix F.6.4 / p. 139	The methodology to calculate percent of lamps on at peak appears to be incorrect and results in very low evaluated percentages. For Table lamps (Table 89), we think the percentage in the second column ("Percent lighting on at peak per room") should apply equally to both table lamps and non-table lamps (please let us know if this is evidence to the contrary). Thus, it seems like a more straightforward and accurate methodology would be to multiple the second column values ("Percent lighting on at peak per room") by the third column values ("Table Lamps per Room") to get the number of table lamps on at peak per room. This totals to 5,148, which is 11% of the total amount of table lamps (instead of 2.11%). A similar analysis for floor lamps results in 12% of floor lamps being on at peak (compared to 0.52%). An Excel spreadsheet showing the Cadmus methodology vs. the proposed methodology is available upon request. This would also help to explain the discrepancy between the IOU and Evaluated GWH and MW estimates in Table 71 of the main report. In that table, for GWh, savings were 14% to 20% higher, depending on the year, but the MW net program savings were almost *90% lower*.	We made changes based on the feedback received. Our previous method was accidentally calculating % of table or floor lamps on at peak out of all residential lamps. Thank you for letting us know about this inconsistency.	Section F.6.4

No.	Subject:	Section / Page	Comment or Question:	Response	Change to Documents
46	TVs / Cadmus Derived Unit Energy Savings	Appendix F.7.2 / p. 148	Footnote 89 states the following: "D.10-04-029 p. 46, which defines the baseline for gross savings as the "previous standard or the prevailing market practice," and D.12-05-015 p. 351, which defines the baseline in absence of an existing code or standard as "[i]n the cases when there is no regulation, code, or standard that applies, which would normally set the baseline equipment requirements, the baseline must be established using a 'standard practice' choice. For purposes of establishing a baseline for energy savings, we interpret the standard practice case as a choice that represents the typical equipment or commonly-used practice, not necessarily predominantly used practice" should be used to define unit savings as the difference between prevailing market practice energy use of televisions and the energy use of televisions just meeting the standard." Can you define the difference between the "typical equipment or commonly-used practice" as compared to the "predominantly used practice"? For TVs, can you give an example of each case?	When the evaluation team discussed this terminology, we concluded that they basically mean the same thing.	No change.
47	TV UES and NOMAD	Appendix F.7.2 / p.149	At the bottom of page 149, the report states: "Unlike the CASE Report approach, the TIAX (2011) data do not separate models meeting and not meeting the Tier 1 requirement; the data represent the entire market average prior to the standard taking effect, which factors in naturally occurring market adoption of models with lower power usage." While the IOUs recognize that using the entire market average to set the baseline is consistent with previous CPUC decisions (e.g., D.10-04-029), the IOUs note that this can sometimes cause complications when estimating savings for codes & standards. For instance, take the following hypothetical example. Assume that the market average kWh/y for a particular widget is 55 kWh/yr, with min/max ranging from 10 kWh/yr to 100 kWh/yr. Given that the unit savings for C&S evaluations are calculated by subtracting the maximum standard level from the market baseline, you could potentially get a negative UEC if the standard level was set at any value higher than 55 kWh/yr. For instance, assume the standard level was set at 80 kWh/y. All the products on the market between 80 kWh/yr and 100 kWh/yr would be eliminated (thus resulting in savings in the state), but the UEC would be calculated to be an illogical -25 kWh/y. In another scenario, assume the standard was set at 50 kWh/yr. This would eliminate over half of the market but the unit savings would be calculated (and under-represented) as only 5 kWh/yr. Thus, IOUs recommend that evaluators consider alternative approaches for calculating unit energy savings when appropriate. In CASE reprots, IOUs often compare the average UEC between the qualifying and non-qualifying subset of products, with the differerence being the unit energy savings. Then, to avoid overcounting statewide savings, the unit energy savings are multiplied by the product sales on the market that don't qualify for the proposed standard.	A baseline reflecting the market average efficiency should not be confused with NOMAD, an adjustment for natural market adoption that is applied after the standard becomes effective. The evaluators agree that the methods used to determine the baseline, unit energy savings, and the NOMAD adjustment need to be consistent to calculate savings correctly.	No change.
48	Fed 1 Potential Savings	Appendix F.9 / p. 165	Why don't the values in the Annual Savings (kWh) columns in Tables 112 and 113 not match with what are presented as Annual Savings (kWh) in Table 114?	Thank you for letting us know about this inconsistency. These tables have been revised and are now consistent in the FINAL appendices document.	Appendix F.9

No.	Subject:	Section / Page	Comment or Question:	Response	Change to Documents
49	Fed 1 Potential Savings	Appendix F.9 / p. 162	In Table 108, potential savings from the original IOU estimate are for US savings, while the evaluation results are for California. Please consider noting this in the report.	A table note regarding these potential savings values has been added in the Final report.	Appendix F.9
50	Title 24 Potential Savings Details: Envelope insulation measure	Appendix G 1.3	The evaluation report does not have any discussion on how the UES values presented in Table 136 were derived and if the CASE study results were used. In Table 136, are the UES values based on total NRNC floor area, instead of the floor area of applicable buildings? Also, please explain how is the following evaluation findings were used to determine UES: "However, it was observed that in the unit energy savings analysis, for metal building walls, it was assumed that 40% of new construction that is Storage based on the Dodge data. Recent square footage numbers show that currently, storage buildings (warehouses) represent about 12% of new construction." The IOU revised savings claim included peak kW savings. Why did the verified savings not include any kW savings?	The UES values are taken directly from the CASE report. The evaluated savings are based on the applicable square footage for NRNC and alterations. The new construction square footage includes apartment buildings of four or more stories among the applicable building types but the total is not simply equal to the total NRNC. Although the CASE report does not include any analysis or estimates of demand savings, we note that the revised savings did include demand savings for new construction. We have calculated the average UES from the revised savings and applied it to the applicable new construction square footage in the revised evaluation results. Our notes indicate the percentage of storage buildings just to indicate the change in recent years. New square footage numbers obtained from MHC data were only used to estimate the applicable square footage and not to determine UES.	No change.
51	Title 24 Potential Savings Details: Tailored Lighting	Appendix G.5.2 / p. 200	"Following the same methodology on the CASE report, Cadmus estimates that currently 0.35 million/sf/yr new retail spaces are built and there is about 8.2 million sf of existing retail space in California. Therefore, Cadmus estimate shows that the tailored method would have an impact on a total of 8.5 million sf/yr of new or remodeled lighting systems." The IOU C&S team estimated that 7% of the retail buildings and 3% of misc. buildings would use the tailored lighting design method. What percentage of sample buildings that evaluator investigated used the tailored lighting design method?	Two percent of new construction sites (2 out of 91 NC sites) and 10.6% of lighting alteration sites (8 out of 75 sites) used Tailored method. This percentage is based on all sampled building types. **Retail only:** 5.5% (one out of 18) of NC retail buildings used Tailored method and 26% (6 out of 23) of alteration sites.	No change.
52	Title 24 Potential Savings Details: DDC to Zone	Appendix G.11 / p. 216	The report provided details of the savings estimation and revised statewide energy savings. Savings provided in Table 156 are not consistent with the UES provided in Table 154: Part 1 should have Therm savings; the presented savings for Part 3 and 4 should be for Part 4 and 5, respectively; and the total Therm savings for the measure should be revised accordingly.	We agree with these observations. We have revised the appendix to be consistent. Thank you for alerting us to these issues.	Appendix G.11
53	Title 24 Potential Savings Details: CfR	Appendix G.17 / p. 224	"With their response to Data Request 10 in February, 2013, the IOUs identified six specific standards that produce the savings in the category referred to as the Composite for Remainder. " The IOU Estimate UES values presented in Table 167 – 172 are not consistent with those provided in IOUs' response to Data Request 10. The response provided UES by building types, not 1000kWh. How were the evaluated UES values were derived?	From the data provided in the response to Data Request #10, we were unable to determine the overall UES for each of the CFR standards. We calculated the aggregate UES for the three largest CfR standards and used the 1000 kWh provided previously for the other three standards.	No change
54	Title 24 Gross Energy Savings: lighting alteration	Appendix H.2.1 / p. 234	"When surveyors collected limited information on building envelope characteristics, the team often relied on EnergyPro default values for building materials and insulation levels. The team assumed:" How do assumed envelope parameters compared to 2008 Title 24 requirements? Are these assumptions for existing buildings consistent with those used by DEER or IOU incentive programs?	Since the lighting alterations were performed in existing buildings of varying vintages, the assumed characteristics and parameters did not necessarily align with the 2008 Title 24 building code for non-lighting measures. We did not include DEER or IOU incentive programs since the effect of the envelope specifications on the secondary impact (HVAC consumption) proved to be negligible, as determined by Cadmus through several sensitivity tests. Instead, for envelope characteristics	No change

No.	Subject:	Section / Page	Comment or Question:	Response	Change to Documents
				we assumed typical values based on professional judgment and default values from the modeling software.	
55	Title 24 Gross Energy Savings: lighting alteration	Appendix H.2.3 / p. 244	"Using these assumptions we determined that among those sites that performed interior lighting alterations, the Area Category method was the most widely used method of compliance, accounting for 84% of all sites; the Tailored method and the Complete Building method accounted for 9% and 7% of analyzed sites, respectively." Are the percentages based on floor area or number of buildings?	The percentages are based on number of buildings complying using each method (indicating the frequency of the various methods used).	No change.
56	Title 24 Gross Energy Savings: lighting alteration	Appendix H.2.3 / p. 252	Are the values in Table 1875 valves too large, compared to those presented in Appendix J? Are negative gas interactive factors not calculated?	The values presented in the table were calculated using a different method (and a much smaller set of source data) than the IE values used in the evaluation. For this reason, there is no way to reconcile the two sets of values. Since the values shown in Appendix H were not used elsewhere in the evaluation and to avoid further confusion, the table has been removed from Appendix H.	Appendix H.2.3
57	Interactive Effect Details	Appendix J / p. 264-5	Why were IE factors developed for the following HVAC standards? - Std B33d CfR HVAC Efficiency - Std B33f CfR Res Central Fan WL	IE factors were assigned to these standards under the assumption that they each affected loads in conditioned space. We agree that assignment of IE factors to these standards may have been an error and that the question warrants further investigation. However, the IOU share of net program savings associated with these standards is approximately 0.7 GWh per year (and the portion of savings impact due to the IE factors is much smaller). For this reason, we are not changing the IE factors for these standards at this time.	No change.
			Why were electric IE factors not applicable to the following indoor lighting standards? - Std B19 Skylighting - Std B20 Sidelighting - Std B21 Tailored Indoor lighting - Std B22 DR Indoor Lighting - Std B33a CfR IL Complete Building Method - Std B33b CfR IL Area Category Method	For each of these measures, Compliance Adjustment Factors (CAFs) were based on energy simulation of actual projects. When the simulation models produce energy consumption for each project, they include interactions within the building envelope. Therefore, the CAF values applied to electric energy (kWh) and demand (kW) for these standards already include the expected positive interactive effects. We believe that applying additional IE factors in these cases would overestimate electric energy and demand savings.	No change.
			For Std B33c CfR IL Egress Control, savings are achieved during the periods when the building is not occupied (night, weekend, and holidays). Buildings are not (or minimally) conditioned during those periods. Is it more appropriate to assume the IE factors to be zero?	We applied the IE factors in all cases where savings were expected within the building envelope. We are not aware of data that would allow us to quantify the difference in interactive effects for this specific measure type.	No change.
			For all Title 20 and Federal appliance standards related to applications in nonresidential buildings, shouldn't the CHIF values be based on those for nonresidential buildings? As discussed in a prior comment, the evaluator seems to have used CHIF for TVs in residential buildings for non-lighting appliances.	After discussion of the methods used to assign IE factors with the analyst at TRC, we decided to use the same approach as that used in the IOU Estimate. We used DEER and other research to develop revised statewide values (rather than the PG&E-specific values used in the IOU Estimate). As noted above, we don't assume that nonresidential buildings have lower (or different) IE factors than residential buildings.	No change.