CONSULTANT REPORT

California Statewide Codes and Standards Program Appendices to Impact Evaluation Report

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California Public Utilities Commission
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A.1 Standard 28b - Televisions Tier 2 Potential and Compliance

This section presents the results of Cadmus' evaluation of Standard 28b, which regulates TVs under 1,400 square inches (or 57 inches on the diagonal for a 9:16 aspect ratio screen). Table 1 summarizes the evaluation results.

Table 1. Evaluated Results of Standard 28b

	Evaluation Results
Description	Television Tier 2
Effective Date	1/1/2013
California Unit Sales/Year	3,744,138
Unit Energy Savings (kWh)	110
Unit Demand Reduction (watts)	9
Unit Natural Gas Savings (Therms)	0
First Year Potential Energy Savings (GWh)	413
First Year Potential Demand Reduction (MW)	35
First Year Potential Natural Gas Savings (Therms)	0
Compliance 2013	97.2%
Compliance 2014	98.5%

First Year Potential Savings

List of Data Sources

Cadmus used the following data sources to determine first year potential savings:

- Pacific Gas & Electric. *Work Paper PGECOAPP104: Energy Efficient Televisions, Revision #5.* August 24, 2012. (Reviewed workpaper according to 2013-2014 workpaper inventory http://www.deeresources.com/files/2013_14_exante/downloads/2013-2014_WorkpaperInventoryAndReview-October2013-v2.xlsx)

- The NPD Group, Inc. 2013-2014 Point of Sale Television Data for California.
- California Energy Commission. "Qualified Products List for TVs." Accessed April 15, 2015. https://cacertappliances.energy.ca.gov/Pages/ApplianceSearch.aspx
- Partnership for Resource Conservation. Personal communications with Paul Reeves, Database for Energy Efficient Resources Team. December 2015.

Market Size Analysis

Cadmus purchased point-of-sale data from The NPD Group, Inc., a leading market research company, on California TV sales in 2013 and 2014. Based on this unit sales data and NPD's estimate of the percentage of unit sales captured through their point-of-sale retail partners (74%), Cadmus estimated 3,744,138 annual TV sales in California (under 57 inches). Table 2 shows two-year TV sales by size category, as well as the weighted average screen size for each category and screen area based on a 9:16 aspect ratio.[1]

Table 2. 2013-2014 TV Sales by Screen Diagonal Size*

Diagonal Range	2-year Sales 2013-2014	Market Share	Representative Size	Area (square inches)
7-29 inches	1,263,420	17%	24 inches	238
30-39 inches	2,915,108	39%	33 inches	473
40-49 inches	1,841,295	25%	43 inches	780
50-57 inches	1,468,453	20%	52 inches	1,164
Total	**7,488,276**	**100%**	**--**	**--**

* Cadmus calculated values in this table using NPD data.

Unit Energy Savings and Demand Reduction

The baseline for Standard 28b (Tier 2) is Standard 28a (Tier 1). Using the standard's active mode maximum power consumption equations, below, we calculated the Tier 1 and Tier 2 power consumption for each size category, as shown in Table 3.

Tier 1 Maximum Active Mode Wattage = 0.20 * Area (in square inches) + 32

Tier 2 Maximum Active Mode Wattage = 0.12 * Area (in square inches) + 25

Next, we calculated the annual unit energy savings and demand reduction consistent with the methods documented in a PG&E workpaper on televisions. To calculate the annual energy consumption (AEC) of a television in active mode, we multiplied the active mode power (P_{active}) by the amount of time (T_{active}) the television is on (= 1,882 hours per the PG&E workpaper).

$$AEC\ (kWh/year) = (P_{active} * T_{active})$$

[1] Cadmus determined screen area using the Pythagorean theorem and basic geometry.

We calculated unit energy savings by subtracting the high-efficiency consumption from the baseline consumption.

$$\text{Annual Energy Savings (kWh/year)} = AEC_{baseline} - AEC_{high\ efficiency}$$

Table 3. Active Mode Power Consumption, Energy Savings, and Demand Reduction

Diagonal Range	Area (square inches)	Active Mode (W)		Unit Savings		Potential	
		Tier 1	Tier 2	Energy (kWh)	Demand (W)	Energy (GWh)	Demand (MW)
7-29 inches	238	80	54	49	4	31	3
30-39 inches	473	127	82	84	7	123	10
40-49 inches	780	188	119	131	11	120	10
50-57 inches	1,164	265	165	188	16	138	12
Weighted Average	**--**	**--**	**--**	**110**	**9**	**--**	**--**

We calculated the coincident peak demand reduction as:

$$\text{Peak Demand Reduction [W/Unit]} = \Delta\text{Watts/unit} * \text{Coincident Demand Factor}$$

We applied the coincident demand factor advised by the DEER Team of 0.158. To determine the potential energy savings and demand reduction, we multiplied the unit savings by the number of units sold in each size category.

Compliance

Cadmus estimated the compliance rate based on our analysis of a database purchased from NPD that provides unit sales in California for the 2013-2014 time period for TVs under 57 inches. The database includes brand, model, size, type, ENERGY STAR version, and power consumption (only for ENERGY STAR products). Over 60 brands are included in the database, which covers a total of 5,541,324 unit sales for the two-year period. As a quality control check, Cadmus compared the screen size, ENERGY STAR version, and power consumption between the NPD database and a list of qualified products obtained from the ENERGY STAR website[2] for a sample of 20 randomly selected ENERGY STAR designated models. There were discrepancies in the listed power consumption for five of the models; however, none of these discrepancies were large enough to affect the compliance status of the models in question.

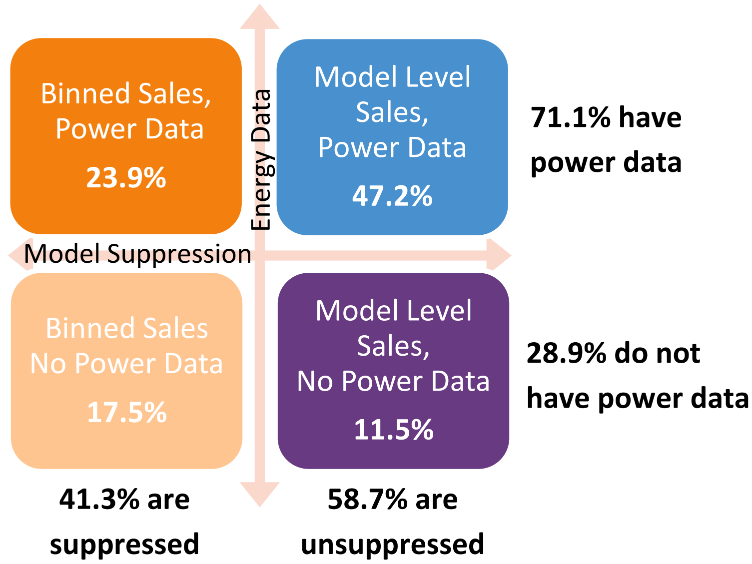
NPD Database Characteristics

The NPD dataset contains four categories of data, shown in Figure 1, with different levels of information available. Unit sales data at the model level are available for "unsuppressed" models (shown on the right side of figure). For suppressed models (shown on the left side of figure), unit sales across multiple models are binned to mask retailer-specific sales data, since some retailers carry exclusive models.

[2] https://www.energystar.gov/products/electronics/televisions

These bins are separated by time period, brand, display size and type, and ENERGY STAR disposition. For all TVs, NPD coded the ENERGY STAR version, status, and power consumption into its database at the time the model was introduced to their system.[3] Non-ENERGY STAR products do not include power consumption data in the database (shown on bottom half of figure). Cadmus' compliance analysis differed for each of the four categories of data.

Figure 1. Categories of NPD Data Analyzed



Listed Compliance

Cadmus calculated the listed compliance rate by summing the sales of all models in the NPD list that also appeared on the California Energy Commission (CEC) list and dividing by the total TV sales. Only unsuppressed models are included in the numerator since we require a model number in order to match against the CEC list.

Unlisted Compliance

Cadmus determined the compliance status of those units not on the CEC list using methods applicable to each of the categories shown in Figure 1, as described below. The unlisted compliance rate excludes the models already included in the listed compliance rate.

Models and Bins with Power Data

As long as sales data includes power consumption and screen size, we can determine compliance regardless if the model number is suppressed or unsuppressed. Using the maximum power consumption allowed by the standard for a particular screen size, Cadmus determined if a model or bin of models was compliant. Of the 71% of unit sales in the dataset with power consumption information available (and

3 Models that are later qualified as ENERGY STAR products may not be updated in NPD's database.

which we could therefore assess for compliance in this manner), we found compliance rates of 99.9% in 2013, 99.5% in 2014, and 99.7% across the two years.

Models without Power Data in NPD Database

For unsuppressed models that were listed as a non-ENERGY STAR product in the original NPD database (11.5% of the entire dataset), we cross-referenced ENERGY STAR product lists for models that may have become ENERGY STAR-qualified after NPD originally coded the disposition. These ENERGY STAR lists contain on-mode power consumption, enabling us to determine compliance.

Due to the large number of distinct model numbers, as well as formatting differences between the NPD dataset and ENERGY STAR lists, Cadmus standardized the model number formatting by stripping out non-alphanumeric characters (such as hyphens and asterisks) in order to maximize our success in matching model numbers. For models that did not result in an ENERGY STAR match, we researched their power consumption specifications on the internet, primarily via the brand websites.

We successfully matched power consumption information for 96% of the unit sales within this group, and determined that the compliance rates are 91.8% in 2013, 95.7% in 2014, and 92.8% between the two years. We assume the remaining 4% of unit sales within this group (0.5% of total sales) adhere to the same compliance rate.

Bins without Power Data in NPD Database

About 18% of unit sales in the NPD database were of suppressed models coded as non-ENERGY STAR and lacking the information required to compute compliance. To estimate the compliance rate of this remaining category, Cadmus considered multiple approaches.

1. The simplest method would be to assume that compliance among TVs with power data is identical to TVs without power data. However, this could lead to bias, as the models with power data provided by NPD were all originally coded as ENERGY STAR products, and are thus likely to be more efficient than those coded as non-ENERGY STAR.
2. Another method would be to obtain a list of suppressed models from NPD (without associated unit sales data) and determine compliance for each model, then use a straight average across all models. However, since the distribution of unit sales can vary tremendously among models, we decided against this approach.
3. The final method, and that which was eventually chosen, was to assume consistency between the suppressed and unsuppressed models at the brand level. About 70% of unit sales in this category were associated with a brand that had unsuppressed models in the database. To calculate compliance, we applied each brand's compliance rate to their sales in this data category. Using this approach and ignoring sales of unknown brands, we calculated annual compliance rates of 93.7% in both 2013 and 2014 for this data category.

Compliance Rates

Table 4 shows the annual listed, unlisted, and overall compliance rates. The listed and unlisted compliance rates are mutually exclusive; no unit sales are double counted.

Table 4. Compliant Sales

Category	Compliant Sales		Compliance Rate	
	2013	2014	2013	2014
Listed by CEC	148,457	553,941	5.4%	19.8%
Unlisted	2,522,144	2,196,915	91.8%	78.6%
Total*	**2,670,601**	**2,750,856**	**97.2%**	**98.5%**

* Total unit sales were 2,747,918 in 2013 and 2,793,406 in 2014.

The percentage of listed compliant sales is low because it requires model numbers to match between the NPD dataset and CEC list; about 42% of the NPD unit sales are suppressed (the model number is masked). If considering only unit sales with unsuppressed model numbers, the listed compliance rates are still just 9.1% in 2013, 34.6% in 2014, and 21.8% between the two years. Therefore, when ascertaining market compliance, we cannot rely on the CEC's compliance list alone.

A.2 Standards 29/30 – Small Battery Chargers Potential and Compliance

This section addresses an evaluation of Title 20 standards regulating consumer battery charger systems. The standards took effect between 2013 and 2014. Standards 29 and 30 regulate consumer battery charger systems with a rated input power of 2 kW or less, as well as consumer uninterruptible power supplies (UPS) and golf cart battery charger systems. Standard 29 covers consumer products that are not USB chargers and USB charger systems under 20 watt-hours (Wh),[4] while Standard 30 regulates USB charger systems with a battery capacity of 20 watt-hours or more, such as media tablets. Table 5 summarizes each standard's potential and compliance evaluation results.

Table 5. Evaluated Results

Standard	Standard 29	Standard 30
Description	Small Battery Chargers: Tier 1 (Consumer with no USB charger or USB charger <20 watt-hours)	Small Battery Chargers: Tier 2 (Consumer with USB charger ≥20 watt-hours)
Effective Date	2/1/2013	1/1/2014
California Unit Sales/Yr	43,767,000	5,197,800
Unit Savings kWh	9.9	0
Unit Demand Savings kW	0.00039	0
First Year Potential Savings GWh	433	0
First-Year Potential Demand Savings MW	17	0
2013–2015 Compliance Rate	90%	88%

[4] Standard 29 includes inductive charger systems and battery backup and uninterruptible power supplies.

In 2012, the U.S. Department of Energy (DOE) published a notice of proposed rulemaking regarding energy conservation standards for battery chargers. Title 20 standards for consumer products will be preempted once national standards take effect.[5]

First-Year Potential Savings

List of Sources

- NPD Group. Flat File for Cordless Phones, Notebook Computers, Tablets, Uninterruptible Power Supplies. Purchased September 2015.
- CASE Report: Analysis of Standards Options for Battery Charger Systems. Ecos Consulting. October 2010. 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
- California Energy Commission (CEC) Staff Report. "Staff Analysis of Battery Chargers and Self-Contained Lighting Controls." October 2011. Online at: http://www.energy.ca.gov/2011publications/CEC-400-2011-001/CEC-400-2011-001-SF.pdf
- CEC Qualified Products List- Battery chargers. Accessed June 15, 2015. Available at http://www.energy.ca.gov/appliances/.
- Technical Support Document (TSD): Battery Chargers for the Supplemental Notice of Proposed Rulemaking (SNOPR). U.S. DOE. July 2015. Available online at: http://www.regulations.gov/contentStreamer?documentId=EERE-2008-BT-STD-0005-0230&attachmentNumber=1&disposition=attachment&contentType=pdf
- TSD: Battery Chargers for the Notice of Proposed Rulemaking (NOPR). U.S. DOE. March 2012. http://www.regulations.gov/#!documentDetail;D=EERE-2008-BT-STD-0005-0075
- Battery Charger Systems Test Results. Pacific Gas and Electric (PG&E). June 22, 2009. Sent to Cadmus via email on 2/3/2016.

Market Size Analysis

As shown in Table 6, the CASE report provides 13 market segments where small consumer battery chargers are used. In 2010, when the CASE report was written,[6] tablets did not make up a large part of the market, but since they have gained market share and have a sizable battery (e.g., 38.5 watt-hour battery for the iPad Pro[7]), we added them to the list as a Standard 30 product. Table 6 shows 2013 sales, calculated using the CASE report's 2009 sales values and compound annual growth rate, and updated annual sales from the evaluation. For products based on the DOE TSD, we adjusted the market to California using 12% of the population.

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5 http://www.appliance-standards.org/product/battery-chargers

6 In 2010, the Apple iPad first launched: http://www.apple.com/pr/library/2010/01/27Apple-Launches-iPad.html

7 http://www.apple.com/ipad-pro/specs/

Table 6. Small Consumer Battery Charger Market Size

Product	Standard	CASE Report 2013 Sales*	Evaluated Annual CA Sales	Evaluation Data Source
Auto/Marine/RV	29	200,000	60,891	TSD SNOPRx12%
Cell phones (including smart phones)	29	41,650,000	20,985,140	TSD SNOPRx12%
Cordless phones	29	2,150,000	1,553,200	NPD
Personal audio electronics	29	13,730,000	4,883,603	TSD SNOPRx12%
Emergency systems (e.g., Uninterruptible Power Supplies [UPS])	29	1,300,000	153,200	NPD
Laptops	29	9,540,000	3,232,700	NPD
Personal care	29	2,110,000	1,812,000	TSD SNOPRx12%
Personal electric vehicles	29	90,000	977,981	TSD SNOPRx12%
Portable electronics	29	3,310,000	6,330,999	TSD SNOPRx12%
Portable lighting	29	10,000	10,406	CASE Report plus CAGR**
Power tools	29	3,490,000	3,615,537	TSD SNOPRx12%
Universal battery charger	29	120,000	123,806	CASE Report plus CAGR**
Golf cart/ electric carts	29	30,000	27,442	TSD SNOPRx12%
Tablets	30	N/A	5,197,800	NPD

*CASE Report Table 11 and Table 12.

**Values for these product categories were unavailable from data sources we examined.

Unit Energy and Demand Savings

Cadmus considered multiple approaches to assess energy and demand savings. Since the DOE is pursuing regulations for battery chargers, we initially attempted to utilize data from the DOE TSD as an additional data source on battery charger performance. However, we encountered a number of issues in attempting the comparison:

1. DOE indicates its standard is not comparable to the CEC standard. Indeed, Cadmus found the CEC standard covers battery charger *systems*, which include batteries, while DOE only regulates battery chargers. The energy consumption calculations reflect this difference.
2. In response to comments received during the rulemaking, DOE provided mapping[8] of its candidate standard levels to the CEC standard for each DOE product class. When Cadmus attempted to recreate the mapping based on product class typical energy performance, the results did not agree with DOE's mapping.
3. DOE's battery charger rulemaking does not include uninterruptible power supplies, which is covered in a separate rulemaking.

8 TSD NOPR 2012

Ultimately, Cadmus used an approach employed in previous evaluations of codes and standards: examining the CASE report for reasonableness. We recognize the CEC staff report is more recent than the CASE report, but because it was largely based on the CASE report and because it incorporates CEC staff adjustments to CASE report values, we decided to focus on the CASE report for the majority of our analysis.

Standard 29

CASE report calculations for baseline and compliant energy consumption are segmented into the 13 product categories previously discussed. A key calculation input is the duty cycle, which is the amount of time spent in active charging mode, maintenance mode, no battery mode, and unplugged. Table 7 shows the CASE report's duty cycles for each product category. Cadmus verified that each profile totals to 100% (allowing for rounding errors). We also examined profiles for reasonableness and found all to be feasible. For example, we would expect UPS charger systems (an emergency systems product category) to be in maintenance mode nearly all of the time, and we see that reflected in the table below. One can reasonably assume personal electric vehicle chargers would not be unplugged very often due to inconvenience, but cell phones and portable electronic chargers are often unplugged and carried around.

Table 7. Duty Cycle from CASE Report Table 6

Product	Duty Cycle				
	Charge %	Maintenance %	No Battery %	Unplugged %	Total
Auto/Marine/RV	1%	42%	46%	10%	99%
Cell Phones	3%	30%	19%	48%	100%
Cordless Phones	35%	56%	9%	0%	100%
Personal Audio Electronics	2%	25%	35%	38%	100%
Emergency Systems	0%	100%	0%	0%	100%
Laptops	4%	56%	30%	10%	100%
Personal Care	3%	86%	3%	9%	101%
Personal Electric Vehicles	36%	28%	35%	1%	100%
Portable Electronics	1%	11%	1%	87%	100%
Portable Lighting	0%	99%	0%	1%	100%
Power Tools	2%	48%	13%	37%	100%
Universal Battery Charger	0%	66%	17%	17%	100%
Golf Cart/Electric Carts	20%	47%	13%	19%	99%

Cadmus next examined the reasonableness of baseline and compliant wattages from the CASE report. Table 8 shows the baseline wattage in each operating mode, accompanied by Cadmus' assessment of reasonableness.

In two instances (highlighted in red), maintenance and no battery mode wattage appeared high. Products shown in green were considered reasonable (including, where available, a reference to support the assessment). Cadmus also obtained battery charger test results from PG&E—one of multiple inputs to the CASE report (shown in the rightmost column). The PG&E tests, conducted in 2007–2008, also suggested the CASE report contained unrealistically high maintenance mode wattages for auto/marine/RV and for personal electric vehicles. For most other products, PG&E's data agreed with the CASE report's maintenance mode power.

Table 8. Baseline Wattage from CASE Report Table 7 and PG&E 2009

Product	Baseline Wattage				Cadmus Judgement/Reference	PG&E 2009 Data
	Charge	Maintenance	No Battery	% at Peak	Reasonable?	Average Maintenance Wattage
Auto/Marine/RV	200.0	41.9	49.3	21%	Maintenance and no battery wattage is high	9.7
Cell Phones	5.8	0.5	0.3	28%	http://www.lodielectric.com/pdf/residential/Appliance%20usage-cost%20chart.pdf	0.4
Cordless Phones	2.7	2.2	1.7	95%		1.6
Personal Audio Electronics	6.1	0.5	0.1	16%		0.32
Emergency Systems	1.8	2.9	2.5	100%		13.4*
Laptops	49.4	3.0	1.9	32%	http://www.lodielectric.com/pdf/residential/Appliance%20usage-cost%20chart.pdf	N/A
Personal Care	4.3	1.0	0.9	80%	http://www.lodielectric.com/pdf/residential/Appliance%20usage-cost%20chart.pdf	1.1
Personal Electric Vehicles	261.4	34.1	33.9	31%	Maintenance and no battery wattage is high	3.6
Portable Electronics	20.0	2.5	0.9	6%	http://www.lodielectric.com/pdf/residential/Appliance%20usage-cost%20chart.pdf	N/A
Portable Lighting	5.0	1.6	0.4	70%		3.4
Power Tools	20.0	3.5	1.8	30%	http://www.treehugger.com/gadgets/is-it-greener-to-use-a-roomba-or-an-upright.html	2.4
Universal Battery Charger	10.0	1.1	0.9	26%		1.0

Product	Baseline Wattage				Cadmus Judgement/Reference	PG&E 2009 Data
	Charge	Maintenance	No Battery	% at Peak	Reasonable?	Average Maintenance Wattage
Golf Cart/Electric Carts	581.0	103.0	1.6	14%	http://www.ziparoundcarts.com/Energy-Savings.html	N/A
* Average wattage across 4 products tested. Two of the UPS systems had maintenance wattages under 3 W, while the other two had maintenance wattages over 20 W.						

When Cadmus examined compliant wattages from the CASE report (Table 9), we found two products where the maintenance/no battery mode power appeared unrealistic, based on the battery system's large size: golf carts and auto/marine/RV. For the universal battery charger product, we found the compliant wattage in the charge mode greater than the baseline, which appeared erroneous. For emergency systems (namely UPS), the 0.5 watts maintenance power appeared more stringent than the standard required.

Table 9. Compliant Wattage from CASE Report Table 8

Product	Compliant Wattage				Reasonable?
	Charge	Maintenance	No Battery	% at Peak	
Auto/Marine/RV	142.9	0.5	0.3	21%	Maint/No Battery Mode is not realistic given the battery energy capacity (Eb)
Cell Phones	3.9	0.5	0.3	28%	
Cordless Phones	0.9	0.5	0.3	95%	
Personal Audio Electronics	2.7	0.5	0.1	16%	
Emergency Systems	1.8	0.5	0.3	100%	Appears low
Laptops	47	0.5	0.3	32%	
Personal Care	1.6	0.5	0.3	80%	
Personal Electric Vehicles	186.8	0.5	0.3	31%	
Portable Electronics	14.3	0.5	0.3	6%	
Portable Lighting	3.6	0.5	0.3	70%	
Power Tools	14.3	0.5	0.3	30%	
Universal Battery Charger	47.7	0.5	0.3	26%	Active mode consumption greater than baseline
Golf Cart/Electric Carts	523	0.5	0.3	14%	Maint/No Battery Mode is not realistic given Eb

Cadmus also examined the CASE report calculations of annual energy consumption (AEC) and, using the following calculation, could not reproduce baseline and compliant AEC values for certain product categories:

$$E_{annual} = [(P_{charge} \times D_{charge}) + (P_{maint} \times D_{maint}) + (P_{no\ bat} \times D_{no\ bat})] \times \frac{8760\ hours/yr}{1000\ W/kWh}$$

Where:

P = power consumption in watts

D = duty cycle

The battery charger system is not consuming any energy while unplugged, so that mode does not appear in the calculation of AEC. Given Cadmus could not, in certain cases, reconcile the results with the CASE report AEC values, we calculated energy savings using the duty cycle shown in Table 7 and with updated wattages (in instances where we found concerns with the original CASE report values), which we highlighted in green in Table 10.

Table 10. Cadmus Unit Savings Calculation Inputs

Product	Baseline Wattage			Compliant Wattage			Unit Savings	
	Charge	Maint.	No Battery	Charge	Maint.	No Battery	kWh	kW
Auto/Marine/RV	200	10[a]	5.4[a]	142.9	5.8[b]	0.3[b]	40.9	0.0010
Cell Phones	5.8	0.5	0.3	3.9	0.5	0.3	0.5	0.0000
Cordless Phones	2.7	2.2	1.7	0.9	0.5	0.3	15.0	0.0016
Personal Audio Electronics	6.1	0.5	0.1	2.7	0.5	0.1	0.6	0.0000
Emergency Systems	1.8	2.9	2.5	1.8	0.95[b]	0.3	17.1	0.0020
Laptops	49.4	3	1.9	47	0.5	0.3	17.3	0.0006
Personal Care	4.3	1	0.9	1.6	0.5	0.3	4.6	0.0004
Personal Electric Vehicles	261.4	4[a]	2[a]	186.8	0.5	0.3	249.1	0.0088
Portable Electronics	20	2.5	0.9	14.3	0.5	0.3	2.5	0.0000
Portable Lighting	5	1.6	0.4	3.6	0.5	0.3	9.5	0.0008
Power Tools	20	3.5	1.8	14.3	0.5	0.3	15.3	0.0005
Universal Battery Charger	10	1.1	0.9	3.9[c]	0.5	0.3	4.4	0.0001
Golf Cart/Electric Carts	581	103	1.6	523	23.2[b]	0.6[b]	431.3	0.0069

[a] Value from PG&E test data averages.

[b] Calculated based on Eb of CEC database products.

[c] From CEC staff report Table A-6.

Baseline wattage updates were derived from PG&E test data, while updates to the compliant maintenance and no battery wattages were calculated based on the battery energy (Eb), in watt hours, of products listed in the CEC database, and then assigned a share to the maintenance mode and no battery modes based on actual product performance.

The standard requires the sum of maintenance mode power and no battery mode power to be equal to or less than:

$$(1 \times N + 0.0021 \times Eb)$$

N equals the number of charger ports.

Cadmus also examined the CEC database for product categories that we did not ultimately update. We found the CASE report compliant wattages generally agreed with the minimum compliant performance for products such as cell phones, power tools, and laptops.

From these values, Cadmus calculated sales-weighted unit energy and demand savings of 9.9 kWh and 0.00039 kW, respectively.

Standard 30

Cadmus could identify only one product class meeting this standard's definition (consumer products with USB charger greater or equal to 20 watt-hours): media tablets. This product was not a large part of the market when the CASE report was developed, and as such, no savings were attributed to tablets in the CASE report. In fact, the CASE report does not differentiate between USB and non-USB chargers. In our professional judgement, as the market did not exist when the standard was being developed, there are no savings.

Compliance

Cadmus determined sales-weighted compliance rates for battery charger products using California sales data purchased from the NPD Group and from checking whether product models appeared on the CEC qualified-products list. Products not found in the CEC list were categorized as noncompliant unless we could find performance specifications that indicated the model met the minimum standard requirements.

For most products, Cadmus could not find the required information (e.g., 24-hour charge and maintenance energy) to assess compliance solely using published product specifications (excepting UPS, where product specifications sometimes included the maintenance mode power). Even basic battery specifications, such as the energy capacity in watt-hours, proved unavailable for many tablets and notebook computers examined.[9] To increase the rigor of the compliance analysis, we recommend conducting additional independent testing of a sample of high-impact products, such as personal electric vehicles.

[9] One exception to note is that Apple provides battery energy in watt-hours for products such as the iPad and Macbook. Other manufacturers often provide battery capacity in terms of mAh or play time, which are not comparable units of energy.

Data Sources and Sampling Plan

- NPD Flat File (provided September 2015). Cadmus obtained California point-of-sale (POS) data for products using consumer battery charger systems (e.g., cordless phones, notebook computers, tablets, uninterruptible power supplies). This file provided Cadmus with 2013 and 2014 unit sales, manufacturers, product model numbers, product descriptions, and dollar sales. For some unit sales, the model number is suppressed to protect retailer confidentiality, as some retailers carry exclusive models. Table 11 shows the proportion of suppressed units for each product type.

Table 11. NPD Suppressed Unit Summary

	Total CA Units in NPD POS Database	Total Suppressed Units	Proportion of Suppressed Units
Cordless Phones	896,255	6,996	1%
Cordless Phones w/Answering Device	1,402,537	1,660	0%
Notebook Computers	4,784,433	526	0%
Uninterruptible Power Supply	226,791	2,471	1%
Tablets	7,692,769	362,609	5%
Total	**15,002,785**	**374,262**	**2%**

- CEC Qualified Products List: Battery chargers. June 15, 2015. Available at http://www.appliances.energy.ca.gov/ Cadmus largely relied on the CEC's compliant product list to determine compliance. This list provides Manufacturer, Model number and Consumer product number, Product descriptions, Product type, and Battery type. The model numbers are reported by manufacturers; some manufacturers provide consumer end-use product models while others report the battery charger component model information.

The following section describes the sampling approach Cadmus used to determine compliance for each standard. We assumed most tablets met the definition for Standard 30 (USB chargers over 20 watt-hours); so that product category was assigned to Standard 30 while other categories (e.g., cordless phone, cordless phone with answering machine, notebook computer, UPS) counted towards Standard 29.

Determine Sample Size

For Standard 29 and Standard 30, Cadmus developed a sample to achieve at least 90% confidence and 10% precision for the overall compliance rate. For Standard 29, Cadmus sampled in a manner ensuring a minimum of 80% confidence and 15% precision were achieved for each product category. Additionally, as laptop computers make up a majority of products and expected savings for battery chargers, we chose to sample more data points to achieve higher confidence and precision levels. Cadmus determined sample size at the product level using the following equation:

$$n_0 = \left(\frac{Z}{e}\right)^2 \hat{p}(1-\hat{p})$$

Cadmus used $\hat{p}$ to represent the proportion of compliant batteries. For the proposed sample design, we assumed $\hat{p} = 0.5$, maximizing variance and providing a conservative estimate of the sample size required to meet the confidence and precision targets. We determine the *z* value according to the desired level of confidence (e.g., for 80%, z=1.282) and *e* according to the desired level of precision (e.g., *e*=15%).

Table 12 presents sample size targets for each Standard 29 product as well as an estimate of overall confidence and precision. Table 13 shows the target sample size for Standard 30.

Table 12. Sample Size and Confidence/Precision for Standard 29 Products

Product Type	Target Sample Size	Confidence Level	Relative Precision
UPS	19	80%	± 14.7%
Notebook Computers	64	90%	± 10.3%
Cordless Phones	19	80%	± 14.7%
Cordless Phones with Answering Machines	19	80%	± 14.7%
Total	**121**	**90%**	**± 7.5%**

Table 13. Sample Size and Confidence/Precision for Standard 30

Product Type	Target Sample Size	Confidence Level	Relative Precision
Tablets	64	90%	± 10.3%
Total	**64**	**90%**	**± 10.3%**

Standard 29 Compliance Results

Table 14 shows sales-weighted compliance results for each product category, with the overall compliance rate for Standard 29 weighted by the relative sales in each product category.

Table 14. Compliance Rates for Small Battery Chargers Standard 29

Product Type	Achieved Sample Size	Listed Compliance Rate	Unlisted Compliance Rate	Total Compliance Rate
UPS	19	22%	9%	31%
Notebook Computers	64	88%	NA	88%
Cordless Phones	19	100%	NA	100%
Cordless Phones with Answering Machines	19	100%	NA	100%
Overall	**121**	**89%**		**90%**

Table 15 presents the weights applied to each product category to determine the total compliance rate.

Table 15. Proportion of Standard 29 Sales by Product Category

Battery Type	Proportion of Sales
UPS	3%
Notebook Computers	65%
Cordless Phones	12%
Cordless Phones with Answering Machines	19%

Cadmus found cordless phones and cordless phones with answering machines exhibited the highest compliance rates for battery charger products, and uninterruptible power supplies exhibited the lowest compliance rates of all product categories. This primarily resulted from a relatively small CEC product list for UPS, making compliance verification difficult.

Verifying compliance for notebook computers proved difficult because some models in the CEC database were that of the battery charger component and not the consumer-facing model of the notebook computer, while the NPD database only provided consumer-facing product model numbers.

The CEC database manager told Cadmus that vendors supplied the model numbers. The model numbers in the CEC database were not reported consistently among manufacturers; in some cases, the model number did not align with consumer-facing product model numbers as some brands reported the component (battery charger) model information, which may apply to multiple notebook computer models.

From a compliance measurement standpoint, this proves problematic as some products cannot be verified using laptop computer model numbers and there is no known database tracking battery charger sales volume by component number. Additionally, to assess and enforce compliance for these brands, evaluators would need to verify that the battery charger supplied for a particular laptop actually was the component listed by manufacturers.

Standard 30 Compliance Results

Cadmus analyzed media tablets to assess compliance with Standard 30. If the CEC database did not list the product, Cadmus considered the product noncompliant with Title 20 regulations. We could not find the required product performance specifications online and subsequently could not assess unlisted compliance. Table 16 lists sales-weighted compliance rates for Standard 30 battery chargers.

Table 16. Compliance Rates for Standard 30

Product Type	Sample Size	Listed Compliance Rate
Tablets	64	88%
Total	**64**	**88%**

Cadmus found 88% of tablets sold in California complied with Standard 30, though many low-volume manufactures did not comply with the standard. The NPD database included over 76 unique tablet manufacturers, but only eight brands had sales greater than 1% of the CA tablet market.

As shown in Table 17, Apple, Inc., accounted for 57% of the CA tablet market, and all but one iPad model was found to be compliant (i.e., not listed in the CEC database). Additionally, Cadmus found that the CEC product database did not list a single product for some of the smaller manufacturers. For example, the CEC database did not contain Mach Speed or Visual Land products.

Table 17. Tablet Manufacturers with CA Market Share >1%

Manufacturer/Brand	CA Market Share
Apple, Inc.	57%
Samsung	18%
RCA	3%
Microsoft	3%
Google Nexus	3%
Nextbook	2%
Mach Speed	1%
ASUS	1%

A.3 Standard 32 – Large Battery Chargers

This section covers the evaluation of the Title 20 standards regulating large battery charger systems, which have a rated input power of more than 2 kW, such as for lift trucks.[10] Table 18 summarizes the potential and compliance evaluation results for Standard 32.

Table 18. Evaluated Results

Standard	Standard 32
Description	Large Battery Chargers
Effective Date	January 1, 2014
California Unit Sales/Yr	7,334
Unit Savings kWh	1,782
Unit Demand Savings kW	0.08
First Year Potential Savings GWh	13
First Year Potential Demand Savings MW	0.58
2013-2015 Cycle Compliance Rate	78%

First-Year Potential Savings

List of Sources

- Industrial Truck Association Market Intelligence: U.S. Factory Shipments 2014. Accessed July 1, 2015: http://www.indtrk.org/download/1407/

[10] Electric vehicles are not covered by this standard; golf carts are covered under the consumer battery charger standard; standards regulating non-consumer UPS chargers do not take effect until 2017.

- Michel, Roberto. "Elevating the fuel cell lift truck market." Modern Materials Handling, 2014. Accessed July 1, 2015: http://www.mmh.com/article/elevating_the_fuel_cell_lift_truck_market
- U.S. Energy Information Administration (EIA) 2013 Table C.10. Accessed July 1, 2015: http://www.eia.gov/state/seds/data.cfm?incfile=/state/seds/sep_sum/html/rank_use.html&sid=US
- Ecos Consulting. *CASE Report: Analysis of Standards Options for Battery Charger Systems*. October 2010.
- California Energy Commission. "Staff Report: Staff Analysis of Battery Chargers and Self-Contained Lighting Controls." October 2011. Available online: http://www.energy.ca.gov/2011publications/CEC-400-2011-001/CEC-400-2011-001-SF.pdf
- Interviews with battery charger manufacturers/vendors.
- California Energy Commission. 2014 Regulations. Available online: http://www.energy.ca.gov/2014publications/CEC-400-2014-009/CEC-400-2014-009-CMF.pdfMarket Size Analysis

Large battery charger systems are those with a rated input power of more than 2 kW. According to the Battery Charger CASE Report, lift trucks are the primary application of large battery charger systems. Therefore, we based our estimate of annual units per year of large battery chargers on the lift truck market.

According to personal communication with staff at the Industrial Truck Association (ITA), lift trucks are often sold without batteries; but batteries and their charger systems are also sold by lift truck equipment dealers. In our analysis of the market size (Table 19), we assumed that one battery charger system is sold for each lift truck. From ITA-reported shipments of lift trucks in 2014, we determined the number of battery-powered trucks at the national level. Then, we estimated California's share of shipments based on the percentage of commercial and industrial electricity sales in California versus the nation. By applying this share (6.7%) to the national sales estimate of electric lift trucks, we estimated that 7,334 lift truck battery charger systems were sold in California in 2014. This is comparable to the estimate in Table 11 of Ecos Consulting's CASE report, which shows 7,000 (2,000 single-phase and 5,000 three-phase) lift truck chargers were sold in California during 2009.

Table 19. Large Battery Charger Market Size Analysis

Market Parameter	Value [Source]
U.S. Factory Shipments in 2014 of Lift Trucks (All Classes)	184,979 [ITA]
Electric Lift Trucks (Electric Rider and Hand Trucks, Classes 1-3)*	109,939 [ITA]
Percentage of California C&I Electricity Sales to National C&I Sales	6.7% [EIA]
California Shipments	7,334 [Calculated]

* Fuel cell lift trucks are a small fraction (~1%) of the market and ignored in this analysis. (Source: Modern Materials Handling)

Unit Energy and Demand Savings

The evaluation team reviewed the unit energy savings estimates in the California Energy Commission (CEC) staff report, which drew heavily from the CASE report. The analysis in the CEC staff report is based on the promulgated standard, which we summarized in Table 20.

Table 20. Large Battery Charger Performance Standards

Performance Parameter		Standard
Charge Return Factor (CRF)	100%, 80%, depth of discharge	CRF≤ 1.10
	40%, depth of discharge	CRF ≤ 1.15
Power Conversion Efficiency		Greater than or equal to: 89%
Power Factor		Greater than or equal to: 0.90
Maintenance Mode Power (E_b = battery capacity of tested battery)		Less than or equal to: 10 + 0.0012Eb W
No Battery Mode Power		Less than or equal to: 10 W

The CEC staff report describes user behavior for battery chargers in terms of duty cycle and percentage on at peak (Tables A-4 and A-5 of the CEC report). During charge mode, a battery at less than full capacity is actively being charged. During maintenance, the battery is fully charged and plugged into the charger to maintain the full charge. During no battery/unplugged mode, the battery charger is disconnected from the battery or unplugged. This information is used to calculate energy and demand savings. We attempted to independently verify the duty cycles for single- and three-phase lift truck battery chargers through interviews with vendors (described in next section). However, we received only two responses for three-phase lift trucks and one for single-phase lift trucks. Furthermore, the information obtained from the vendors did not match the duty cycles from the CEC/CASE reports.

The CEC report (Table A-5, A-6, and A-7) also provides unit power consumption in each mode based on product testing by Ecos Consulting. Table 21 shows the duty cycles and wattages Cadmus used to calculate savings. Cadmus staff set the three-phase lift truck duty cycle equal to the single-phase lift truck cycle because the original values (98% charge mode, 2% no battery mode) appeared to be unreasonable (2% translates to half an hour out of a 24 hour day). Cadmus did not alter the wattages.

Table 21. Battery Charger Duty Cycle and Watts

	Charge	Maintenance %	No Battery/ Unplugged	% at Peak
Single-Phase Lift Trucks Duty Cycle	45%	32%	24%	19%
Single-Phase Lift Trucks Baseline Wattage	2,000 W	50 W	50 W	
Single-Phase Lift Trucks Compliant Wattage	1,770 W	36 W	10 W	
Three-Phase Lift Trucks Duty Cycle	45%	32%	24%	19%
Three -Phase Lift Trucks Baseline Wattage	5,600 W	88.5 W	33.5 W	
Three -Phase Lift Trucks Compliant Wattage	5,111 W	51 W	W 10	

Using these data, Cadmus calculated the annual baseline and efficient energy consumption (AEC) for single- and three-phase lift truck chargers as shown in Table 22.

Table 22. Baseline and Compliant Unit Energy Use

	Baseline AEC (kWh)	Efficient AEC (kWh)	Unit Energy Savings (calculated)	Unit Demand Savings (calculated)*
Single Phase Lift Trucks	8,129	7,100	1,029 kWh	0.044 kW
Three Phase Lift Trucks	22,394	20,311	2,083 kWh	0.093 kW

* Calculated by multiplying the wattage difference in active charge mode by percentage of time at peak.

To verify the reasonableness of these values, we back-calculated the power conversion efficiency of the CEC and CASE report baseline case (Table 23), assuming the charge mode wattage of the compliant case corresponded to a conversion efficiency of 0.89, the minimum required by the standard. We found that the implied baseline conversion efficiency is approximately 80%. This is consistent with interview results (next section) on the historic efficiency of charger systems, where one vendor said the typical efficiency was 80%, and another said the efficiency was 88%. We acknowledge that the interview results are not statistically significant due to the small sample size, but it does support the reasonableness of the unit AEC values.

Table 23. Calculation of Baseline Conversion Efficiency

	Efficient		Baseline	
	Charge Wattage [A]	Conversion Efficiency (standard minimum) [B]	Charge Wattage [C]	Conversion Efficiency ([A]*[B]/[C])
Single-Phase Lift Trucks	1,770*	89%	2,000*	78.8%
Three-Phase Lift Trucks	5,111*	89%	5,600*	81.2%

* Table B-6 of CEC Report

Applying the relative market shares of each type of charger results in a weighted average unit energy savings of 1,782 kWh and a demand savings 0.08 kW.

Vendor and Manufacturer Interviews

Cadmus asked equipment vendors how customers typically operate lift truck battery chargers. We initially contacted eight large Californian lift truck dealers but did not receive a response. Therefore, we compiled a list of seven lift truck battery charger manufacturers from a review of the ITA member directory.[11]

Of the seven charger manufacturers we contacted, one said the firm did not sell battery chargers, and four did not respond to messages. We interviewed representatives from the remaining two manufacturers, and our questions and their responses are presented in Table 24. Both vendors were familiar with CEC standards for lift truck battery chargers.

Table 24. Standard 32 Manufacturer Interview Results

Question Number	Question	Response 1	Response 2*
1. Deployment of Single-Phase Lift Truck Chargers			
1a	In a typical 24-hour day, how many hours and during what time of the day is the battery charger in *active charge mode*?	Approximately four hours on average, sometime between 12 and 6 p.m.	N/A
1b	In a typical 24-hour day, how many hours and during what time of the day is the battery charger in *maintenance charge mode*?	None	N/A
1c	In a typical 24-hour day, how many hours and during what time of the day is the battery charger not connected to a battery (e.g., lift truck off doing work)?	Approximately five hours on average, between 8 a.m. and 1 p.m.	N/A
2. Deployment of Three-Phase Lift Truck Chargers			
2a	In a typical 24-hour day, how many hours and during what time of the day is the battery charger in *active charge mode*?	Approximately six hours in aggregate; expected to charge for many shorter periods throughout the day	Approximately 10 hours in aggregate; expected to charge for many shorter periods throughout two shifts (two hours total), and for the entirety of an eight-hour shift from 10 p.m. to 6 a.m.
2b	In a typical 24-hour day, how many hours and during what time of the day is the battery charger in *maintenance charge mode*?	None	Six hours in “trickle charge” mode expected between 12 and 6 a.m., bringing battery from 80% to 100% of charge
2c	In a typical 24-hour day, how many hours and during what time of the day is the battery charger not connected to a battery (e.g., lift truck off doing work)?	Approximately 18 hours in aggregate throughout the day	Approximately 14 hours in aggregate between 6 a.m. and 10 p.m.

[11] ITA Associate Member Directory. http://www.indtrk.org/associate-members?products=chargers. Accessed September 4, 2015.

Question Number	Question	Response 1	Response 2*
3. Power Conversion Efficiency			
3a	What is the typical power conversion efficiency of these chargers?	91%	92%
3b	What was the conversion efficiency five years ago?	80%	88.5%
4. Awareness of Standards			
4a	Are you aware of any energy efficiency regulations in California that are specific to large battery chargers?	Yes	Yes
4b	What is the regulation? Do you know when those regulations took effect?	CEC regulations effective at the end of January 2014	CEC regulations effective starting in January 2014

* This manufacturer produces only three-phase fast chargers for lift trucks.

Compliance

To evaluate compliance with Standard 32, the evaluation team conducted a website review of 20 lift truck dealers across California. We researched the battery charger models sold by each vendor and compared these models against the CEC database of approved, compliant models to determine the proportion of models sold that met Title 20 standards. We considered evaluating compliance based on product technical specifications, but we found the technical specifications lacked the level of detail required to do this.

Model Compliance Review

We examined the websites of 20 lift truck retailers in the Northern, Central, and Southern California regions. We chose retailers that had the highest-rated matches through an Internet search of vendors across California. Upon reviewing the websites of each retailer, we found that battery charger model information was available online for just four companies.

We called each of the remaining 16 dealers, but received a response from only three. Of these, two did not maintain an inventory of new battery chargers but instead either ordered equipment at customer request or sold used chargers through a third-party vendor.

Table 25. Standard 32 Compliance Research Sample Size

	Number of Vendors
Initial Sample (CA retailers with websites)	20
Sample with Model Data on Website [A]	4
Sample with Model Data Offered over Phone [B]	1
Total Sample [A+B]	**5**

As shown in Table 25, for the five vendors for which battery charger model data were available, we compared the available models against the CEC database.[12] Our findings, presented in Table 26, indicate that 78% of the models were compliant with Standard 32 based on being listed on the CEC's approved list.

Table 26. Standard 32 Rate of Compliance

Vendor #	Number of Models Sold	Number of Models Sold on CEC List	Percent Compliance
1	2	1	50%
2	7	4	57%
3	14	8	57%
4	3	1	33%
5	28	28	100%
	54	**42**	**78%**

A.4 Federal 8/18/24/25 –Clothes Washers and Dryers Potential

This section covers the evaluation of the federal standards that regulate clothes washers and dryers, taking effect between 2013 and 2015: Fed 8, Commercial Clothes Washers; Fed 18, Residential Clothes Dryers; Fed 24, Residential Clothes Washers (Front Load); and Fed 25, Residential Clothes Washers (Top Load).

Table 27 summarizes the evaluation results for each standard.

Table 27. Evaluated Results

Standard	Fed 8	Fed 18	Fed 24	Fed 25
Description	**Commercial Clothes Washers**	**Res. Clothes Dryer (Electric and Gas)**	**Res. Clothes Washer (Front Load)**	**Res. Clothes Washer (Top Load)**
Effective Date	**1/8/2013**	**1/1/2015**	**3/7/2015**	**3/7/2015**
California Unit Sales/Yr	40,779	Electric 394,326 Gas 354,695 Total 749,021	442,549	746,761
Unit Savings (kWh)	90	10.3	(-16)	70
Unit Demand Savings (watts)	12	1.3	(-2)	9.1
Unit Gas Savings (Therms)	20	0.35	4.3	10.2
First Year Potential Savings (GWh)	3.7	7.7	(-7)	52
First Year	0.48	1	(-1)	7

[12] Accessed August 26, 2015. https://cacertappliances.energy.ca.gov/Pages/ApplianceSearch.aspx.

Potential Demand Savings (MW)				
First Year Potential Gas Savings (Therms)	829,042	259,000	1,911,631	7,613,270
Water Savings (1,000 gal/year)	337,448	N/A	1,150,627	440,589

Fed 8—Commercial Clothes Washers

List of Data Sources

- U.S. Department of Energy (DOE) Technical Support Document (TSD): Commercial Clothes Washers, March 2011 (Accessed 8/7/2015). http://www.regulations.gov/#!documentDetail;D=EERE-2006-STD-0127-0118
- Work Paper PGECOAPP115: High Efficiency Clothes Washers Nonresidential Revision 3. PG&E. August 24, 2012
- ENERGY STAR Shipment Data (Accessed 8/7/2015). http://www.energystar.gov/ia/partners/downloads/unit_shipment_data/2013_USD_Summary_Report.pdf?4b19-a0b8
- U.S. Census: Statistics of U.S. Businesses 2012 States and NAICS sectors (Accessed 8/7/2015). http://www2.census.gov/econ/susb/data/2012/state_naicssector_2012.xls
- Coin Laundry Association: About the Industry (Accessed 8/7/2015). http://www.coinlaundry.org/about/about-industry
- Coin-Operated Clothes Washers in Laundromats and Multifamily Buildings: Assessment of Water Conservation Potential. https://cuwcc.org/Portals/0/PBMP%20Coin_Operated%20Clothes%20Washers%20final%20report%20(21August2012).pdf.pdf
- Partnership for Resource Conservation. Personal communications with Paul Reeves, Database for Energy Efficient Resources Team. December 2015.

Market Size Analysis

DOE's TSD estimates there are four major commercial clothes washer manufacturers and five other manufacturers. ENERGY STAR collects data from its partners to understand shipments and penetration of ENERGY STAR products. For the 2013 survey, 19 clothes washer manufacturers responded to the survey (residential and commercial), suggesting the ENERGY STAR data represent all major manufacturers. ENERGY STAR data indicate 60,000 commercial use washers were shipped in 2013.

To determine the share of commercial washers in California, we used U.S. Census data. The 2012 U.S. Business statistics allowed us to determine that for NAICS code 81 (other services except public administration)—the two-digit code for laundry services industry, 11% of the 2012 business receipts went to California. Thus, using this source, we estimate sales of 6,600 commercial washers in California in 2013.

In another study, published in 2012, that analyzed the water conservation potential for coin-operated clothes washers, the authors determined there were roughly 480,000 coin-operated washers in California across multifamily buildings and laundromats. Table 28 shows the distribution of units, based on top or front access from the study. In the right columns of the table, we estimate the number of units that must be replaced each year, based on an 11-year equipment life,[13] is 40,779 washers across all market categories. This estimate is much higher than the value obtained using ENERGY STAR shipment data. We prefer to use this value as we believe it provides a more comprehensive measure of the market. This data indicate the majority (82%) of commercial clothes washers go to multifamily applications.

Table 28. Market Size of Coin-Operated Clothes Washers

	Number of Units in California*			Annual Turnover (Calculated with 11-Year Equipment Life)	
	Top Loading	Front Loading	Total	Top Loading	Front Loading
Laundromat	39,158	42,903**	82,061	3,560	3,900
Multifamily	74% of stock is top loading	26% of stock is front loading	366,508	24,656	8,663

*Data sourced from Coin-Operated Clothes Washers in Laundromats and Multifamily Buildings: Assessment of Water Conservation Potential. Data for multifamily are given in percentages in the report.

**Front loading units with capacity under 25 lbs; larger capacity models are not subject to the regulation

Unit Energy and Demand Savings

Table 29 summarizes the 2013 federal standard and baseline efficiencies. The current standard has different requirements for top-loading and front-loading washers, while the previous standard made no distinction between the categories. As such, DOE in its TSD (Chapter 5) determined the baseline for front-loading machines should be adjusted.

Table 29. Commercial Clothes Washer Standards (Current and Previous)

	Current Standard	Baseline
Effective Date	January 8, 2013	January 1, 2007

[13] PG&E workpaper PGECOAPP115

Top-Loading	Modified Energy Factor (minimum)	1.60 ft^3/kWh/cycle	1.26 (previous standard)
	Water Factor (maximum)	8.5 gal/ft^3/cycle	9.5 (previous standard)
Front-Loading	Modified Energy Factor (minimum)	2.00 ft^3/kWh/cycle	1.72
	Water Factor (maximum)	5.5 gal/ft^3/cycle	8.0

Chapter Six of the TSD contains data on annual energy and water use at various efficiency levels for multifamily and laundromat applications.[14] Table 30 provides a summary of this information for the baseline and standard efficiency levels shown in Table 29; we use these data to derive unit savings for two fuel scenarios: gas water heating and electric dryers, and gas water heating and gas dryers in Table 31.

[14] http://www.regulations.gov/contentStreamer?documentId=EERE-2006-STD-0127-0118&attachmentNumber=8&disposition=attachment&contentType=pdf

Table 30. Commercial Clothes Washer Annual Energy and Water Use*

Laundromat								
			Annual Energy Use for Laundromat					
			Water Heating		Drying			
	MEF	WF	Electric	Gas	Electric	Gas	Machine	Water Use
Efficiency Level	cu.ft/kWh/cyc	gal/cu.ft	kWh/yr	MMBtu/yr	kWh/yr	MMBtu/yr	kWh/yr	1000 gal/yr
Top Load Baseline	1.26	9.5	1793	8.16	2782	10.63	291	58.3
Top Load Standard	1.6	8.5	1098	4.99	2485	9.5	250	25.1
Front Load Baseline	1.72	8	935	4.25	2380	9.1	250	49.1
Front Load Standard	2	5.5	680	3.1	2136	8.16	250	33.7
Multifamily								
			Annual Energy Use for Multifamily					
			Water Heating		Drying			
	MEF	WF	Electric	Gas	Electric	Gas	Machine	Water Use
Efficiency Level	cu.ft/kWh/cyc	gal/cu.ft	kWh/yr	MMBtu/yr	kWh/yr	MMBtu/yr	kWh/yr	1000 gal/yr
Top Load Baseline	1.26	9.5	1020	4.64	1583	6.05	166	33.1
Top Load Standard	1.6	8.5	625	2.84	1414	5.4	142	29.7
Front Load Baseline	1.72	8	532	2.42	1354	5.18	142	27.9
Front Load Standard	2	5.5	387	1.76	1215	4.64	142	19.2

*Source: *Commercial Clothes Washer TSD*, Chapter 6.

In the rightmost columns of Table 31, we provide fuel-weighted unit savings for top-load and front-load access in laundromats and multifamily applications. Based on the PG&E workpaper, 60% of California residences have a gas water heater and gas dryer, and nearly 40% have a gas water heater and electric dryer. The DEER support team provided Cadmus with a peak watts/kwh factor of 0.13, which we used to calculate demand savings.[15] Although the value is specific to residential washers and dryers, we felt it was appropriate to use because (1) the majority of commercial washers are used in multifamily applications and (2) we did not have a separate commercial sector specific value to apply.

[15] The DEER support team indicates the peak watts/kwh factor is applicable to the 2013-2014 time period

Table 31. Unit Energy and Water Savings by Fuel Type

Laundromat	Gas Water Heat And Electric Dryer			Gas Water Heat And Gas Dryer			Fuel Weighted			
	Unit Savings	Unit Demand Savings	Unit Savings	Unit Savings	Unit Demand Savings	Unit Savings	Unit Savings	Unit Demand Savings	Unit Savings	Water Savings
	Kwh/Yr	Watts	Mmbtu/Yr	Kwh/Yr	Watts	Mmbtu/Yr	Kwh/Yr	Watts	Mmbtu/Yr	1000 Gal/Yr
Top Load	338	141	3.17	41	17	4	160	21	3.85	33
Front Load	244	102	1.15	-	-	2	98	13	1.71	15
Multifamily	Gas Water Heat And Electric Dryer			Gas Water Heat And Gas Dryer			Fuel Weighted			
	Unit Savings	Unit Demand Savings	Unit Savings	Unit Savings	Unit Demand Savings	Unit Savings	Unit Savings	Unit Demand Savings	Unit Savings	Water Savings
	Kwh/Yr	Watts	Mmbtu/Yr	Kwh/Yr	Watts	Mmbtu/Yr	Kwh/Yr	Watts	Mmbtu/Yr	1000 Gal/Yr
Top Load	193	80	1.8	24	10	2	92	12	2.19	3
Front Load	139	58	0.66	-	-	1	56	7	0.98	9

Next, we estimate the unit and potential savings across all applications and the axis of access by applying fuel-weighted unit savings to the number of annual California units shown in Table 28. Table 32 provides the results.

Table 32. Commercial Clothes Washer Results Across All Applications and Axis of Access

California Unit Sales/Yr	40,779
Unit Savings (kWh)	90
Unit Demand Savings Watts	12
Unit Gas Savings (Therms)	20
First Year Potential Savings (GWh)	3.69
Potential Demand Savings (MW)	0.48
First Year Potential Gas Savings (Therms)	829,042
Water Savings (1,000 gal/year)	337,448

Fed 18—Residential Clothes Dryer

List of Data Sources

- AHAM 2014 Distributor Sales by State (Purchased). https://www.aham.org/index.php?ht=d/Store/name/INDRES/pid/
- ENERGY STAR Market and Industry Scoping Report, November 2011. https://www.energystar.gov/ia/products/downloads/ENERGY_STAR_Scoping_Report_Residential_Clothes_Dryers.pdf
- TSD: Residential Clothes Dryers April, 2011. http://www.regulations.gov/#!documentDetail;D=EERE-2007-BT-STD-0010-0053
- Email and phone correspondence with DEER Support Team. December 2015.

Market Size Analysis

A report from the Association of Home Appliance Manufacturers (AHAM) containing unit sales of major appliances sold through distributors in each U.S. State indicates nearly 750,000 dryers were sold in California during 2014, as shown in Table 33.

Table 33. 2014 U.S. and California Clothes Dryer Sales*

Region	Electric Dryer	Gas Dryer	Total
California	394,326	354,695	749,021
U.S. Total	5,489,543	1,277,545	6,767,088

*Source: AHAM.

California distributors sold approximately 11% of all dryers in the United States. In California, 53% of dryers sold were electric. By contrast, 81% of dryers in the United States were electric. Values in Table

33 appear reasonable, given 6.5 million clothes dryers were sold in the United States during 2010 and California's population represents 12% of the United States[16,17]

Unit Energy and Demand Savings

Fed 18 applies to products manufactured on or after January 1, 2015. Table 34 shows the current and previous standards for standard electric and gas residential clothes dryers. The Energy Policy and Conservation Act requires that test procedures for clothes dryers be amended to include measurement of standby-mode/off-mode power, and DOE amended the test procedure concerning the active mode. As a result, the baseline will be based on energy factors determined by the amended test procedure rather than the original dryer test procedure.[18]

Table 34. Energy Conservation Standards for Residential Clothes Dryers

Appliance	Minimum Energy Factor (lbs/kWh)		
Effective Date	1/1/2015	5/14/1994 – 12/31/2014 (original test procedure)	5/14/1994-12/31/2014 (amended test procedure)
Electric, standard clothes dryer ($4.4\ ft^3$ or greater capacity)	3.73	3.01	3.62
Gas clothes dryers	3.30	2.67	3.20

Table 35 shows unit energy savings for standard electric and gas dryers. The U.S. DOE test procedure uses 283 cycles per year and 8.45 pounds per load.[19] The peak watt/kwh factor of 0.13 was provided by the DEER support team for residential dryers. For gas dryers, we allocated the energy consumed into two categories: mechanical tumbling (5%) and heating (95%).

Table 35. Unit Energy Savings for Clothes Dryers

	Base Energy Consumption	EE Energy Consumption	Unit Energy Savings	Coincidence Factor	Unit Demand Savings (Watts)

16 Appliance Magazine. "2010 U.S. Appliance Shipment Statistics." April 2010.

17 U.S. Census American FactFinder; Population for 2014: 318,857,056 (US) and 38,802,500 (CA).

18 U.S. DOE Technical Support Document. *Residential Clothes Dryers and Room Air Conditioners*.

19 Ibid

	Base Energy Consumption	EE Energy Consumption	Unit Energy Savings	Coincidence Factor	Unit Demand Savings (Watts)
Electric Dryer	$\frac{8.45 \times 283}{3.62} = 661\ kWh/yr$	$\frac{8.45 \times 283}{3.73} = 641\ kWh/yr$	19.5 kWh	0.130	$19.5 \times 0.130 = 2.5\ watts$
Gas Dryer*	$\frac{8.45 \times 283}{3.2} \times 0.95 \times 0.03412 = 24.2\ therms$	$\frac{8.45 \times 283}{3.3} \times 0.95 \times 0.03412 = 23.5\ therms$	0.73 therms	N/A	N/A

*Conversion factor: 0.03412 therms per kWh

Table 36 shows the fuel-weighted unit savings and the statewide potential savings (e.g., electricity, demand, and gas).

Table 36. Fuel Weighted Unit and Potential Savings

	Unit Savings (kWh)	Unit Demand Savings (Watts)	Unit Gas Savings (therms)	Units/Year	Potential Savings (GWh)	Potential Demand Savings (MW)	Potential Gas Savings (Therms)
Electric Dryer	19.5	2.5		394,326	7.68	1	
Gas Dryer			0.73	354,695			285,927
Fuel Weighted	**10.3**	**1.3**	**0.35**	**749,021**	**7.68**	**1**	**285,927**

Fed 24 and Fed 25—Residential Clothes Washer

List of Data Sources

- AHAM 2014 Distributor Sales by State (Purchased). https://www.aham.org/index.php?ht=d/Store/name/INDRES/pid/
- TSD: Residential Clothes Washers. April 2012. http://www.regulations.gov/#!documentDetail;D=EERE-2008-BT-STD-0019-0047
- Work Paper PGECOAPP114: High Efficiency Clothes Washers Residential Revision 3. PG&E. August 24, 2012
- Email and phone correspondence with DEER Support Team. December 2015.

Market Size Analysis

A report from the AHAM, containing unit sales of major appliances sold through distributors in each U.S. state, indicates nearly 1.2 million clothes washers were sold in California during 2014, as shown in Table 37.

Table 37. 2014 California Clothes Washer Sales*

Region	Front Load	Top Load	Total
California	442,549	746,761	1,189,310
U.S. Total	2,116,269	6,582,440	8,698,709

*Source: AHAM.

In California, 63% of washers sold in 2014 were top load, while 75% of clothes washers sold nationwide were top load. Sales in California represented 14% of national sales.

Unit Energy and Demand Savings

Standard Efficiency Requirements

Fed 24 and Fed 25 apply to products manufactured after March 7, 2015, and before January 1, 2018. Table 38 shows standards for standard-sized residential clothes washers. After January 1, 2018, the standards become more stringent.

Table 38. Energy Conservation Standards for Residential Clothes Washers

Product Class	Integrated Modified Energy Factor (ft^3/kWh/cycle) (minimum values)	Integrated Water Factor (gal/cycle/ft^3) (maximum values)
Top-loading, Standard (1.6 ft^3 or greater capacity)	1.29	8.4
Front-loading, Standard (1.6 ft^3 or greater capacity)	1.84	4.7

Clothes washers manufactured before March 7, 2015, are regulated by a different set of standards, as shown in Table 39 for standard-sized washers. These standards use the modified energy factor (MEF) and water factor (WF). Fed 24 and Fed 25 use new metrics, called the integrated modified energy factor (IMEF) and the integrated water factor (IWF). The IMEF includes standby and off-mode consumption; IWF incorporates water usage from all cycles included in the energy test cycle rather than just the cold wash cycle. The new metrics can be correlated to the previously used MEF and WF.[20, 21]

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20 http://www.appliance-standards.org/product/clothes-washers

21 TSD. *Clothes Washers.*

Table 39. Previous Standards for Standard-Sized Residential Clothes Washers

Appliance	Minimum Modified Energy Factor (Effective January 1, 2007)	Maximum Water Factor (Effective January 1, 2011)
Top-loading standard clothes washer	1.26	9.5
Front-loading clothes washers	1.26	-

*Source: CEC 2014 Regulations.

Baseline

For the top-loading standard clothes washer, DOE defined the baseline efficiency level as the previous standard. For front-loading standard models, DOE applied the previous ENERGY STAR level, effective prior to July 2009, as all models on the market exceeded the previous standard and the former ENERGY STAR level of 1.72 MEF and 8.0 WF.[22]

Table 40. Standard Sized Clothes Washer Baseline Unit Efficiency Level*

Product Class	Baseline Efficiency Level Reference Source	Modified Energy Factor (ft^3/kWh/cycle) (minimum values)	Water Factor (gal/ft^3) (maximum values)	Integrated Modified Energy Factor (ft^3/kWh/cycle) (minimum values)	Integrated Water Factor (gal/cycle/ft^3) (maximum values)
Top-loading, Standard	DOE Standard (effective 2011)	1.26	9.5	0.84	9.9
Front-loading, Standard	Former ENERGY STAR	1.72	8.0	1.37	8.3

*Source: *TSD Clothes Washers*.

22 Ibid

Calculation

Chapter Seven of the residential clothes washer TSD[23] contains data on annual energy and water use at various efficiency levels for top- and front-loading, standard-size clothes washers. Table 41 shows usage for the baseline and standard efficiency levels for top- and front-loading washers. The TSD and PG&E workpaper savings are based on 295 wash cycles per year. The TSD assumes 100% efficiency for electric water heaters and on 75% efficiency for gas water heaters. We used these data to derive savings for two fuel configurations: gas water heating and electric dryers; and gas water heating and gas dryers, as shown in Table 42.

Table 41. Residential Clothes Washer Annual Energy and Water Use*

	IMEF cu.ft/kWh/cyc	Energy Use (kWh/year)				
		IWF gal/cyc/cu.ft	Machine kWh/yr	Dryer kWh/yr	Water Heat kWh/yr	Water Use 1000 gal/yr
Top Load Base	0.84	9.9	82	637	366	9
Top Load EE	1.29	8.4	67	499	204	8.41
Front Load Base	1.37	8.3	33	386	205	7.36
Front Load EE	1.84	4.7	45	395	106	4.76

*Source: *Residential Clothes Washer TSD, Chapter 7.*

Table 42. Unit Energy and Water Savings by Fuel Type

Axis Of Access	Gas Water Heat And Electric Dryer			Gas Water Heat And Dryer			Fuel Weighted			
	Unit Savings Kwh/Yr	Unit Demand Savings Watts	Unit Savings Therms	Unit Savings Kwh/Yr	Unit Demand Savings Watts	Unit Savings Therms	Unit Savings Kwh/Yr	Unit Demand Savings Watts	Unit Savings Therms	Water Savings 1000 Gal/Yr
Top	153	20	7	15	2	12	70	9	10	0.59
Front	-21	-3	5	-12	-2	4	-16	-2	4	2.6

According to the PG&E Clothes Washer Workpaper, for PG&E and SCE customers, 60% have gas water heating and gas dryers and 38% have gas water heating and electric dryers. As a simplification, we weighted the unit savings using 60% for gas water heating and drying and 40% for gas water heating and electric drying.

The DEER support team provided the 2013-2014 applicable peak watt/kwh factor for residential clothes washers of 0.13 peak watts/kWh, which we applied to derive demand savings. Electric savings for front loading washers are negative due to the higher machine energy consumption by the efficient model.

23 http://www.regulations.gov/contentStreamer?documentId=EERE-2008-BT-STD-0019-0047&attachmentNumber=8&disposition=attachment&contentType=pdf

A.5 Federal 9/10/19/20/21 – Residential Water Heating, Direct Heating, and Pool Heater Potential

This section covers the evaluation of potential savings for federal standards regulating residential water heaters, pool heaters, and direct heating equipment (DHE) (e.g., space heaters, wall heaters, floor heaters, room heaters). These standards took effect in 2013 and 2015. Table 43 summarizes the evaluation results for each standard.

Table 43. Evaluated Potential Savings Results

Standard	Fed 19	Fed 20	Fed 21	Fed 9	Fed 10
Description	Res. Gas-Fired Storage Water Heater	Res. Electric Storage Water Heater	Res. Gas-Fired Inst. Water Heater	Pool Heater	Direct Heating Equipment
Effective Date	4/16/2015	4/16/2015	4/16/2015	4/16/2013	4/16/2013
California Unit Sales/Yr.	1,042,067	87,628	54,846	16,246	60,610
Unit Savings (kWh)	0	173	-29	0	0
Unit Demand Savings (watts)	0	17	-3	0	0
Unit Gas Savings (Therms)	9	0	58	18	13
First Year Potential Savings (GWh)	0	15	-2	0	0
First Year Potential Demand Savings (MW)	0	2	0	0	0
First Year Potential Gas Savings (Therms)	9,378,603	0	3,181,047	292,428	791,194

Fed 19-21—Residential Water Heaters

List of Sources

- U.S. Department of Energy (DOE) Technical Support Document (TSD) for Consumer Products—Residential Water Heaters, Direct-Heating Equipment, and Pool Heaters: http://www.regulations.gov/#!documentDetail;D=EERE-2006-STD-0129-0170
- Air-Conditioning, Heating, & Refrigeration Institute (AHRI) Monthly Shipment Statistics July 2015 and December 2014 (Accessed 9/23/2015): http://www.ahrinet.org/App_Content/ahri/files/Statistics/Monthly%20Shipments/2015/July_2015.pdf

- U.S. Census Bureau Quickfacts for California (Accessed 9/23/2015): http://quickfacts.census.gov/qfd/states/06000.html
- 2012 Residential Heater, Water Heating, and Cooling Equipment Evaluation, Volume 1. Cadmus. June 2013 (Page 28) http://www.rieermc.ri.gov/documents/2013%20Evaluation%20Studies/CADMUS_2013_HEHE_Cool%20Smart_NTG_Evaluation_Report.pdf
- Partnership for Resource Conservation. Personal communications with Paul Reeves, Database for Energy Efficient Resources Team. December 2015.
- CLASS Web Tool Search Results for Water Heater Fuel Type. DNV GL. Accessed 11/12/2015

  https://webtools.dnvgl.com/susc/CPUC_CLASS_2012/SUSc_CPUC_CLASS_2012.aspx

Market Size Analysis

Table 44 shows the number of U.S. storage water heater shipments reported by AHRI for January through July 2015. The last four columns present Cadmus' calculations to project sales for 2015 for California. First we projected the number of 2015 shipments for the United States by applying the percent change in year-to-date (YTD) shipments in July 2015 over July 2014 to the total number of shipments in 2014. We then used California's population share to determine California's 2015 projected shipments. Using the water heater fuel shares from the most recent California Lighting and Appliance Saturation Study (88% Gas, 7.4% Electric), we estimated the number of each type of water heater.

Table 44. AHRI U.S. Shipments of Storage Water Heaters, January to July 2015

<table>
<tr><th></th><th colspan="4">U.S.</th><th colspan="3">California</th></tr>
<tr><th>Res. Storage Water Heater</th><th>July 2015 YTD</th><th>July YTD % Change from 2014</th><th>2014 Shipments</th><th>U.S. 2015 Projected (Calculated)</th><th>California Population % of Nation (Calculated)</th><th>California 2015 Projected (Calculated)</th><th>California 2015 Projected (Calculated)</th></tr>
<tr><td>Gas</td><td>2,783,727</td><td>7.4%</td><td>4,471,903</td><td rowspan="2">9,259,799</td><td rowspan="2">38,802,500 ÷ 318,857,056 = 12.2%</td><td rowspan="2">1,129,695</td><td>1,042,067</td></tr>
<tr><td>Electric</td><td>2,579,986</td><td>4.2%</td><td>4,277,329</td><td>87,628</td></tr>
</table>

As the AHRI shipment report did not include tankless water heaters, we estimated the 2015 shipments based on a Cadmus evaluation report, which indicated tankless water heaters made up 5% of the gas water heater market. Assuming there are a total of 1,042,067 storage type gas water heaters that make up 95% of the market, then the annual gas water heater market (tankless plus storage) is 1,096,913 units. This results in 54,846 tankless water heater shipments to California for 2015.

Unit Energy and Demand Savings

Table 45 shows current and previous (baseline) water heater standard requirements for minimum energy factor (EF) by product class. Using the EF equations provided in the table, Cadmus calculated the baseline and standard efficiency levels using the most common rated volumes (provided by the DOE TSD in Table 7.2.2.

Table 45. Current and Previous Water Heater Standards

Product Class	Storage Volume (V)	EF as of January 20, 2004	EF as of April 16, 2015
Gas-fired Storage Water Heater	≧ 20 gallons and ≦ 100 gallons	0.67-(0.0019 × V)	Rated Storage Volume at or below 55 gallons: EF = 0.675-(0.0015 × V) Rated Storage Volume above 55 gallons: EF = 0.8012-(0.00078 × V)
Electric Storage Water Heater	≧ 20 gallons and ≦ 120 gallons	0.97-(0.00132 × V)	Rated Storage Volume at or below 55 gallons: EF = 0.960-(0.0003 × V) Rated Storage Volume above 55 gallons: EF = 2.057-(0.00113 × V)
Instantaneous Gas-fired Water Heater	< 2 gallons	0.62-(0.0019 × V)	EF = 0.82-(0.0019 × V).

Based on the representative EF for each product class, Cadmus looked up annual energy consumption, as calculated by DOE in its TSD, Chapter 7. The middle columns of Table 46 show annual consumption for the base and standard compliant units. From these values, we calculated unit energy savings. We then derived unit demand savings by applying the DEER energy/peak factor of 0.10 watts/kWh (provided by the DEER support team) to unit energy savings. DOE notes in its TSD that tankless ("instantaneous") gas-fired units at 0.78 EF and above use more electricity than less-efficient units, thus explaining the negative electric savings.

Table 46. Water Heater Unit Energy Consumption and Savings

Product Class	Most Common Rated Volume*	EF Base	EF Standard	Base Consumption*	Standard Consumption*	Unit Energy Savings	Unit Demand Savings (Watts)
Gas-fired Storage Water Heater	40	0.594	0.615	16.6 MMBtu	15.7 MMBtu	0.9 MMBtu	0
Electric Storage Water Heater	50	0.904	0.945	2,618 kWh	2,445 kWh	173 kWh	17
Instantaneous Gas-fired Water Heater	N/A	0.62	0.82	16.8 MMBtu	11MMBtu 29 kWh	5.8 MMBtu -29 kWh	-3

*Source: DOE TSD Chapter 7, tables 7.2.2 and 7.2.14

Fed 9—Residential Pool Heater

List of Sources

- TSD for Consumer Products—Residential Water Heaters, Direct Heating Equipment, and Pool Heaters: http://www.regulations.gov/#!documentDetail;D=EERE-2006-STD-0129-0170
- Association of Pool and Spa Professional Industry Statistics. P.K. Data, Inc., 2013. Accessed 9/25/2015: http://apsp.org/portals/0/images/APSP%20statistics%202013.jpg
- Codes and Standards Enhancement Initiative: Analysis of Standards Proposal for Residential Gas Fired Pool Heaters. Davis Energy Group. July 29, 2013. Accessed 9/25/2015: http://www.energy.ca.gov/appliances/2013rulemaking/documents/proposals/12-AAER-2F_Residential_Pool_Pumps_and_Replacement_Motors/California_IOUs_Response_to_the_Invitation_for_Standards_Proposals_for_Pool_Heaters_2013-07-29_TN-71754.pdf
- Custom Analysis for Cadmus from Pkdata. October 2015.

Market Size Analysis

Cadmus commissioned a custom report from Pkdata (a market research firm specializing in the pool and spa industry; they are also cited in the TSD), estimating 2014 sales of gas-fired pool heaters for California. PKdata started with national aggregated sales figures for gas heaters (based on 2014 shipments including all major pool heater manufacturers) and used California pool permitting and construction data to provide a state-level sales estimate. Its report indicates 16,246 heaters were sold in California.

Unit Energy and Demand Savings

The previous standard (baseline) requires pool heaters to have a 78% or greater thermal efficiency. The current standard requires an 82% minimum efficiency. Based on Table 7.4.2 of Chapter 7 of the TSD, a standard-compliant gas-fired pool heater achieves average energy savings of 1.8 MMBtu/year.

Multiplying unit energy savings and annual sales, Cadmus estimated first-year potential savings of 290,000 therms.

Fed 10—Residential Direct-Heating Equipment

List of Sources

- TSD for Consumer Products: Residential Water Heaters, Direct Heating Equipment, and Pool Heaters: http://www.regulations.gov/#!documentDetail;D=EERE-2006-STD-0129-0170
- Hearth Industry Unit Shipments 1998-2013. Hearth, Patio & Barbecue Association (HPBA). Accessed 10-7-2015: http://www.hpba.org/statistics/2012-statistics/HearthShipmentsUS982013official.pdf

Market Size Analysis

Residential DHE equipment includes vented gas space heaters, wall and floor heaters, and room heaters. Chapter 9 of the TSD forecasts residential DHE shipments for the United States through 2040, estimating nearly 1 million DHE shipments nationally in 2015. Cadmus applied the 12.2% proportion (by population) to national shipments to determine California estimates for 2015. As shown in Table 47, we estimate 116,510 DHE shipments to California in 2015.

Table 47. 2015 DHE Shipments for Nation and California

	Gas Room	Gas Wall Gravity	Gas Wall Fan	Gas Floor	Gas Hearth/ Gas Appliances	Total
National Forecast*	20,000	105,000	40,000	negligible	790,000**	955,000
California Forecast	2,440	12,810	4,880	negligible	96,380**	116,510
Adjusted CA Forecast	2,440	12,810	4,880	0	40,480	60,610

*Values from Chapter 9 of TSD.

**Includes appliances not regulated by the standard.

The HPBA'S website provides industry shipment statistics through 2013. In 2013, 784,633 gas hearth/gas appliances shipped. This suggests DOE's forecast for 2015 of 790,000 units is the right order of magnitude. Notably, Chapter 9 of the DOE TSD indicates 42% of gas appliance shipments provided by HPBA are regulated DHE. Applying this number to California's forecast produced final adjusted DHE shipments of 60,610 units for California.

Unit Energy and Demand Savings

Table 48 shows the baseline and standard annual fuel utilization efficiency (AFUE) for each DHE product category. It also presents average unit energy savings, as provided in the TSD, along with Cadmus' estimate of first-year potential gas savings by product category. AFUE ratings are based on the most prevalent product capacity in kbtu/h, as provided in Table 7.3.2 of the DOE TSD.

Table 48. Baseline and Standard AFUE and Consumption by DHE Category

	Gas Room (35 kbtu/h*)	Gas Wall Gravity (34 kbtu/h*)	Gas Wall Fan (57 kbtu/h*)	Gas Hearth/ Gas Appliances (34 kbtu/h*)	Total
Baseline AFUE*	64	64	74	64	
Current minimum AFUE	67	66	76	67	
Average Unit Energy Savings* (MMBtu/yr.)	1.2	0.8	1.9	1.4	
First Year Potential Gas Savings (therms)	29,280	102,480	92,720	566,714	791,194

*Chapter 7 of the DOE TSD.

Cadmus' analysis indicates first-year potential savings of 791,194 therms, resulting in average unit energy savings of 13 therms for DHE.

A.6 Federal 11/12/17 – Residential Refrigerators, Room AC, and Dishwashers Potential

This section covers the evaluation of potential savings for federal standards that regulate: refrigerators and freezers, room air conditioners (AC), and dishwashers. These standards took effect in 2013 and 2014. Table 49 summarizes the evaluation results for each standard.

Table 49. Evaluated Potential Savings Results

Standard	Fed 11	Fed 12	Fed 17
Description	Residential Refrigerators and Freezers	Residential Room AC	Residential Dishwashers
Effective Date	9/15/2014	6/1/2014	5/30/2013
California Unit Sales/Year	1,328,654	290,397	787,790
Unit Savings (kWh)	58	73	-6.2
Unit Demand Savings (watts)	7	103	-0.7
Unit Gas Savings (Therms)	[redacted]	[redacted]	2.5
First Year Potential Savings (GWh)	77	21	-4.9
First Year Potential Demand Savings (MW)	9	30	-0.5
First Year Potential Gas Savings (Therms)	[redacted]	[redacted]	1,937,963
First Year Potential Water Savings (Gallons)	[redacted]	[redacted]	254,062,275

Fed 11—Residential Refrigerators & Freezers

List of Sources

- Association of Home Appliance Manufacturers (AHAM) 2014 Distributor Sales by State (Purchased). https://www.aham.org/index.php?ht=d/Store/name/INDRES/pid/
- U.S. Department of Energy (DOE) Appliance Standards Technical Support Document (TSD) (Accessed September 8, 2015). http://www.regulations.gov/#!documentDetail;D=EERE-2008-BT-STD-0012-0128
- Partnership for Resource Conservation. Personal communications with Paul Reeves, Database for Energy Efficient Resources Team. December 2015.

Market Size Analysis

Cadmus purchased a report from AHAM containing unit sales of major appliances sold through distributors in each U.S. state during 2014. The report indicated sales of 1,328,654 freezers and refrigerators in California. Table 50 shows the distribution of sales by appliance category.

Table 50. 2014 California Distributor Sales of Freezers and Refrigerators*

Freezers: Upright	Freezers: Chest	Refrigerators: Side by Side	Refrigerators: Bottom Mount Freezer	Refrigerators: All Other (6.5 & Over)	Total 2014 California Sales
43,434**	78,311	242,010	448,366	516,533	1,328,654

*Source: AHAM.
**Cadmus assumes one-half of upright freezers have manual defrost and one-half have automatic defrost.

Unit Energy and Demand Savings

The first two rows of Table 51 show the previous standard (baseline) and the amended (current) standard (efficient case) equations for maximum energy use in kWh per year, based on the adjusted volume (AV) in cubic feet.

Table 51. Energy Savings of Amended Federal Standards

	Freezers: Upright with Manual Defrost	Freezers: Upright with Automatic Defrost (Without Automatic Icemaker)	Freezers: Chest	Refrigerators: Side By Side (with Through-the-Door Ice Service)	Refrigerators: Bottom Mount Freezer (Without Through-the-Door Ice Service)	Refrigerators: Automatic defrost with top-mounted freezer without automatic icemaker
Previous Standard	7.55AV+258.3	12.43AV+326.1	9.88AV+143.7	10.10AV+406.0	4.60AV+459.0	9.80AV+276.0
Amended Standard	5.57AV + 193.7	8.62AV + 228.3	7.29AV + 107.8	8.54AV + 432.8	8.85AV + 317.0	8.07AV + 233.7
AV*	30	30	30	30	25	20
kWh savings	124	212	114	20	36	77
Watts	15	25	14	2	4	9

*Average AV from figures in TSD Chapter 3

Below the rows describing the standards, we provide the AV used to calculate energy savings for each product category and the associated energy and demand savings. Cadmus derived AVs from figures in DOE's TSD, Chapter 3, showing consumption as a function of AV. Cadmus selected what appeared to be the most common AV for each type of appliance. We used the demand/energy factor of 0.12W/kWh as provided by the DEER Resource Team for this application.

Based on the data in Table 50 and Table 51, we calculate first year potential energy and demand savings of 77 GWh and 9 MW. Back-calculating the unit savings results in an average refrigerator/freezer with savings of 58 kWh and 7 watts of demand.

Fed 12—Residential Room AC

List of Sources

- AHAM 2014 Distributor Sales by State (Purchased). https://www.aham.org/index.php?ht=d/Store/name/INDRES/pid/
- U.S. DOE Appliance Standards TSD (Accessed September 16, 2015). http://www.regulations.gov/#!documentDetail;D=EERE-2007-BT-STD-0010-0053

- Work Paper SCE13HC027, Revision 0: Portable Room Air Conditioners. SCE. March 29, 2012.

Market Size Analysis

Cadmus purchased a report from AHAM containing unit sales of major appliances sold through distributors in each U.S. state during 2014. The report indicated sales of 290,397 room ACs in California.

According to the TSD, there are 16 room AC product classes, based on capacity, reverse cycle, louvered sides, and casement options.[24] The TSD also indicated 12% of room ACs were used in commercial applications. Table 9.3.2 in Chapter 9 of the TSD indicated the first three classes (without reverse cycle, with louvered sides, between 1 to 13,999 btuh) represented over 80% of the market share, as shown in Table 52. As such, we limited our savings analysis to these three categories.

Table 52. TSD Chapter 9, Room AC Product Class Market Shares

Product Class	Market Share	Cumulative Share
1	30.7%	30.7%
2	18%	48.7%
3	33.4%	82.1%
4	4.8%	86.9%
5	2.8%	89.7%
6	0.1%	89.8%
7	0.4%	90.2%
8	8%	98.2%
9	0.3%	98.5%
10	0.0%	98.5%
11	0.8%	99.3%
12	0.1%	99.4%
13	0.3%	99.7%
14	0.0%	99.7%
15	0.1%	99.8%
16	0.3%	100.10% (error due to rounding)

Unit Energy and Demand Savings

The previous energy conservation standard for residential room ACs (effective from October 1, 2000, through May 31, 2014) set minimum energy efficiency requirements using the energy efficiency ratio (EER). In its 2011 test procedure final rule, DOE determined a more comprehensive measure of efficiency should be used, incorporating standby and off-mode energy consumption. Called the combined energy efficiency ratio (CEER), the new measure uses units of btu/hr/watt.

24 TSD. Chapter 3, Table 3.3.2.

Table 53 shows amended and previous (baseline) standards in CEER units. Below the efficiencies, we list other parameters used to derive unit energy savings by product class, such as the assumed capacity and hours of use, by sector. The following equation calculates energy consumption of a room AC unit:

$$kWh = \frac{capacity\ \left(\frac{Btu}{h}\right) \times hours\ of\ use}{CEER\ (\frac{Btu}{h \cdot W})} \times \frac{1\ kW}{1{,}000\ W}$$

Table 53. Room AC Standards and Unit Savings Calculation by Product Class

		Class 1: Without reverse cycle, with louvered sides, and less than 6 kBtu/h	Class 2: Without reverse cycle, with louvered sides, and 6 kBtu/h to 7.9 kBtu/h	Class 3: Without reverse cycle, with louvered sides, and 8 kBtu/h to 13.9 kBtu/h
	Previous Standard (CEER)	9.52	9.52	9.52
	Amended Standard (CEER)	11	11	10.9
	Representative Capacity (Btu/h)	5,000	7,000	12,000
Residential	Hours of use*	756	684**	611
Residential	Baseline consumption (kWh)	397	503	755
Residential	Amended standard consumption (kWh)	344	435	673
Residential	Annual savings (kWh)	53	68	83
Residential	Demand savings (watts)	71	99	136
Commercial	Hours of use*	1,142	1,098	1,054
Commercial	Baseline consumption (kWh)	600	807	1,303
Commercial	Amended standard consumption (kWh)	519	699	1,160
Commercial	Annual savings (kWh)	81	109	143
Commercial	Demand savings (watts)	71	99	136

* Hours of use from the TSD Chapter 7

**Hours of use average of Class 1 and Class 3 values

Based on the SCE workpaper, we believe the TSD hours of use values for the residential sector are reasonable for California. The workpaper support workbook provides hours of operation for various CA climate zones (CZ) ranging from 225 hours for CZ 6 up to 851 hours for CZ 14. The calculations in the workpaper are for 12,000 btu/h portable room AC systems, which would correspond to Class 3 in Table 53.

To remain consistent with the demand calculation used in the SCE Room AC workpaper, Cadmus used a 100% coincidence factor. From the results shown in Table 53, we calculated the product class weighted savings (using 37% for class 1, 22% for class 2, and 41% for class 3), and then weighted by sector (12% commercial) to determine average unit energy and demand savings of 73 kWh and 103 watts, respectively.

Fed 17—Residential Dishwashers

List of Sources

- AHAM 2014 Distributor Sales by State (Purchased). https://www.aham.org/index.php?ht=d/Store/name/INDRES/pid/
- 2009 Residential Appliance Saturation Survey (RASS). KEMA, Inc. October 2010.
- Partnership for Resource Conservation. Personal communications with Paul Reeves, Database for Energy Efficient Resources Team. December 2015.
- Technical Support Document: Residential Dishwashers. U.S. DOE. May 2012. http://www.regulations.gov/#!documentDetail;D=EERE-2011-BT-STD-0060-0007

Market Size Analysis

Cadmus purchased a report from AHAM that contained unit sales of major appliances sold through distributors in each U.S. state during 2014. This report indicated sales of 787,790 dishwashers in California. Of these, 784,687 (or over 99%) were built-in dishwashers; the remaining were portable dishwashers. The AHAM report did not differentiate between standard-sized and compact-sized dishwashers. Information from DOE's TSD Chapter 9 indicates 0.1% of dishwasher shipments are compact-sized.

Unit Energy and Demand Savings

As the majority of appliances shipped are standard-sized, built-in dishwashers, Cadmus derived savings only for this category. Shaded cells in Table 54 show previous and current standard requirements for total annual energy use and water consumption per cycle. Table 7.3.1 of the TSD provides additional breakdowns of annual energy use into water heating, machine/drying, and standby power consumption (also shown in Table 54) for 215 cycles per year. Further down, we provide unit energy savings for a dishwasher with a gas water heater. The 2009 RASS indicates the majority (>98%) of PG&E and SCE customers had gas water heating. To get the demand savings, we applied the peak watts/annual kWh factor (0.12) provided from the DEER support team.

Table 54. Standard Capacity Dishwasher Standards and Unit Savings

	Total Annual Energy Use (kWh/yr)	Water Consumption (gallons/cycle)	Annual Energy Use Components (DOE TSD Chapter 7)		
			Water Heating (MMBtu/yr)	Machine/ Drying (kWh/yr)	Standby (kWh/yr)
Previous Standard (Effective January 1, 2010)	355	6.5	1.068	120.2	0
Current Standard (Effective May 30, 2013)	307	5.0	0.822	111.9	14.5
Energy Savings (kWh)	(Machine + Standby) -6.2				
Demand Savings (W)	(Machine + Standby) -0.7				
Gas Savings (Therms)	(Water Heating) 2.5				
Water savings (gallons/yr)	(215 cycles/year) 323				

A.7 Federal 13 – Fluorescent Ballasts Potential and Compliance

This section describes the evaluation of Fed. 13, the federal standard that regulates fluorescent ballasts, which took effect on November 14, 2014. Table 55 summarizes the evaluation results for the Fed. 13 standard.

Table 55. Evaluated Results

Description	Fluorescent Ballasts
Effective Date	11/14/2014
California Unit Sales/Year	1,995,941
Unit Savings (kWh)	15.31
Unit Demand Savings (kW)	0.0029
First Year Potential Savings (GWh)	31
First Year Potential Demand Savings (MW)	5.7
Compliance Rate	80%

Potential

Data Sources

- Technical Support Document: Fluorescent Lamp Ballasts. U.S. DOE. November 2011.

  http://www.regulations.gov/contentStreamer?documentId=EERE-2007-BT-STD-0016-0067&disposition=attachment&contentType=pdf

- 2010 U.S. lighting Market Characterization. U.S. DOE. January 2012. http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/2010-lmc-final-jan-2012.pdf

Market Size Analysis

To determine the size of the market for fluorescent ballasts (FB) in California, we performed the following:

1. Estimated the total number of linear fluorescent (LF) lamps sold annually in all sectors (commercial and residential);
2. Calculated ballast sales as a fraction of linear fluorescent lamp sales using available market data combined with insights from ballast manufacturers;
3. Adjusted ballast sales to account for the dramatic increase in market share of LED technology; and
4. Calculated ballast sales for only the covered ballast types under the Fed. 13 standard.

This four-step process allowed us to determine the total number of annual fluorescent ballast unit sales in California, as expressed in the following formula:

$$Total\ FB = (Total\ LF\ lamp\ sales) \times (ratio\ of\ FB{:}LF\ sales) \times (ratio\ of\ LF{:}LED\ sales) - (noncovered\ FBs)$$

Linear Fluorescent Lamp Unit Sales: We assessed the number of linear fluorescent lamps installed in California by applying census data to the total number of linear fluorescent lamps installed in the U.S. across all sectors, as shown in Table 56. Using a measure life of 12.34 years for installed linear fluorescent fixtures in the commercial and industrial[25] (C&I) sector and 15 years for residential,[26] we calculate 22,794,928 linear fluorescent lamps will be sold annually in California.

[25] Measure life of 12.34 years for C&I determined using weighted average of 11% install for industrial and 88% install for commercial using data from DOE TSD (page 8.2.4).

[26] Measure life of 15 years for residential installations based on data from DOE TSD (page 8.2.4).

Table 56. Total Linear Fluorescent Lamps Installed in the US and California

Types of Linear Fluorescents	Total Linear Fluorescents installed U.S. base*	Total Linear Fluorescents in CA (C&I Sectors)**	Total Linear Fluorescents in CA (Residential)***
T5	120,947,000	14,618,800	455,576
T8 U-Shaped	47,598,000	5,787,530	144,717
T12 U-Shaped	12,165,000	1,476,572	39,594
T8 Less than 4ft	17,818,000	1,844,064	378,394
T12 Less than 4ft	14,333,000	910,692	880,204
T8 4ft	1,050,174,000	122,890,089	8,021,698
T12 4ft	766,256,000	54,141,314	41,571,949
T8 Greater than 4ft	32,632,000	3,895,863	171,530
T12 Greater than 4ft	148,581,000	14,940,932	3,594,115
Miscellaneous	145,771,000	1,731,162	16,523,907
Total	2,356,275,000	222,237,019	71,781,683

*U.S. Department of Energy, Office of Energy Efficiency & Renewable Energy. "2010 U.S. Lighting Market Characterization, Table 4-1." Published January 2012.

** Adjusted to CA based on EIA data on 2012 Commercial Building Energy Consumption

***Adjusted to CA based on CA household population (39,144,818) divided by total U.S. household population (312,418,820) using 2015 census data; Table 1. Annual Estimates of the Resident Population for the United States, Regions, States, and Puerto Rico: April 1, 2010 to July 1, 2015.

Ratio of Ballast to Lamp Sales: Cadmus interviewed two lighting ballast manufacturers[27] and assessed available market data to understand the relationship between linear fluorescent lamp and fluorescent ballast sales. We concluded that based on the penetration,[28] and replacement rate,[29] of linear fluorescent lamps to ballasts, that for every 4.72 linear fluorescent lamps sold, 1 fluorescent ballast is sold. This figure includes the sales of new fixtures (lamp plus ballast) and replacement components.

Market Adjustment for LED Sales: The market for fluorescent ballasts and lamps consists of two primary sales channels: new construction and existing retrofit.

> **New construction** is serviced by original equipment manufacturers (OEM), such as Eaton Cooper or Acuity Brands, which produce and sell fluorescent ballasts that can be used in 1, 2, 3, and 4 lamp configurations. OEMs sell directly to developers in C&I market segments (e.g., hospitality, institutional).

[27] Cadmus arrived at this conclusion based on available data on ballast performance included in the TSD (page 8.2.4) and by interviewing two leading ballast manufacturers for purposes of collecting market data not readily available online or for purchase.

[28] Cadmus determined the penetration of linear fluorescent lamps to fluorescent ballasts is 2.5 to 1 based on data from the TSD.

[29] Cadmus determined the replacement rate of linear fluorescent lamps to fluorescent ballast is 1.88 to 1 that was determined by comparing the average lifetime of a linear fluorescent lamp (6.87 years) by the average lifetime of a fluorescent ballast (12.98 years).

The retrofit market is serviced by wholesalers, such as Grainger or Graybar, that source fluorescent ballasts from suppliers and sell directly on account to their customers (e.g., building owners and facility managers).

These two sales channels operate independently, but were similarly affected in 2015 by LED technology. Prior to 2015, linear LED lamps cast poor-quality light and were cost prohibitive compared to linear fluorescent lamps. In 2015, linear LED lamp technology improved while its cost decreased, which led to the first occurrence of a 1 to 1 ratio of sales between linear LED lamps and linear fluorescents. Thus, out of the total number of ballasts sold in 2015, fluorescent ballasts accounted for 50% of the market share.

Covered Ballasts: Fed. 13 does not cover dimmable ballasts, which we determined accounted for 12.58% of the market.[30] We reviewed available data on linear fluorescent lamp types and concluded that we should not account for the miscellaneous lamps (Table 56) in our calculation of total annual sales of fluorescent ballasts because it is uncertain whether or not the Fed. 13 standard affects them. The impact of removing dimmable ballasts and miscellaneous fluorescent lamps was a decrease of 418,776 fluorescent ballasts.

Using the analysis described above, we calculated the total annual fluorescent ballast sales for all sectors in California that the Fed. 13 standard could affect, as shown in the following equation:

$$Total\ FB = (22{,}794{,}928)\ X\ \left(\frac{1}{4.72}\right) X \left(\frac{1}{2}\right) - (418{,}776)$$

$$Total\ FB = 1{,}995{,}941$$

Unit Savings Analysis

Fed. 13 led to a change in the method of calculating the efficiency of fluorescent ballasts. The Department of Energy (DOE) developed a new metric, ballast luminous efficiency (BLE), which has replaced the commonly used ballast efficacy factor (BEF) that was the primary metric in calculating and comparing efficiency. The DOE developed the new metric because BEF relies on the full system of the ballast and the installed linear fluorescent lamp, and therefore cannot be used to calculate the efficiency of the ballast only, whereas BLE can be used for this purpose.

Although BLE is a better metric for assessing fluorescent ballast energy savings, a baseline did not exist, which makes it difficult to calculate per-unit fluorescent ballast savings using BLE because a comparison cannot be made to the previous standard. As a result, we determined that using data from DOE's Technical Support Document (TSD) and final ruling to assess potential energy savings was the best approach, and we used these data to determine the baseline and the energy saving level (ESL) that new

30 Cadmus analyzed the NEMA Premium Ballast list and determined that of the three predominant ballast types, the market consists of 69.08% rapid/instant start ballasts, 18.34% programmed start ballasts, and 12.58% dimmable ballasts.

ballasts must meet to be sold in the U.S. after Fed. 13 took effect. We then multiplied the savings by the market share to get the weighted average unit savings. Table 57 shows the results of our analysis.

Table 57. Fluorescent Ballast Unit Savings

Covered Linear Fluorescents	Ballast Type; Sector	Market Share	Ruling ESL (kWh)*	Baseline (kWh)**	Unit Savings (kWh)
4-foot medium bipin (T8)	IR; C&I	42.550%	206.4	218.8	12.4
4-foot medium bipin (T12)	IR; C&I	18.746%	206.4	236.0	29.6
8-foot slimline	IR; C&I + Res	7.440%	422	441.1	19.1
4-foot medium bipin (T8 & T12)	IR; Res	14.126%	44.8	49.4	4.6
4-foot medium bipin (T8 & T12)	P; C&I & + Res	17.1340%	149.1	163.1	14.0
8-foot RDC HO	IR; C&I	0.004%	1251.7	1516.8	256.1
Weighted Average					**15.31**

*Ruling ESL corresponds to TSL 3A; source: "Rules and Regulations 70621." Federal Register. Vol. 76, No. 219. Monday, November 14, 2011.

**Baseline kWh savings derived from U.S. DOE. "Final Rule: Technical Support Document for Fluorescent Lamp Ballasts." November 2011. Table 6-3.

Demand Savings Analysis

To calculate demand, we used the IOU-weighted average coincidence factor from DEER 2014's Lighting Summary Table (CDF: 0.689). We also used a weighted average hours of use for fluorescent ballasts with the understanding that commercial installations accounted for 80% of the market; residential and industrial accounted for 10% each.[31] Our calculation and inputs are shown in the following equation:

$$kW = \left(\frac{kWh}{HOU}\right) X\ Concidence\ Factor$$

$$kW = \left(\frac{15.31}{3662.4}\right) \times 0.689$$

$$kW = 0.0029$$

Our analysis determined annual peak demand savings of 0.0029 kWh and potential annual peak demand savings of 6.8 MW.

[31] Hours of use derived from U.S. DOE. "Final Rule: Technical Support Document for Fluorescent Lamp Ballasts." November 2011. Table 6-3. .

Compliance

Initially, we attempted to assess compliance through lighting distributor interviews. However, the four distributor representatives who agreed to participate were unable or unwilling to answer our questions about their company's product offerings, specifically what types of ballast models they were selling in California. As a result, we changed our approach to reviewing lighting distributors'/manufacturer's product catalogs for fluorescent ballasts. We acquired the catalogs from six distributor/manufacturer websites and reviewed all of the ballast models against the CEC product list to determine the compliance rate.

Sampling

To achieve 90% confidence at ±10% precision for the compliance research, we needed to verify the compliance of at least 72 fluorescent ballasts, assuming that fluorescent ballasts were 80% compliant in California. We ended up reviewing 200 fluorescent ballasts in six lighting distributor/manufacturer product catalogs. We were unable to vet the compliance of fluorescent ballasts using the DOE's BLE metric because those specifications were not available in product catalogs for fluorescent ballasts. Compliance was based on whether the ballast model was listed in the CEC database.

Fluorescent Ballast Compliance Results

After inspecting 200 fluorescent ballasts, Cadmus found 161 to be compliant. Table 58 shows the results of the compliance assessment.

Table 58. Fluorescent Ballast Compliance Rate

Standard	Number of Compliant Models	Number of Models Examined	Compliance Rate
Fluorescent Ballasts	161	200	80%

The compliance rate for fluorescent ballasts is at 80% based on the CEC list. The lack of BLE specification data makes it difficult to determine compliance for products not listed on the CEC list.

As previously mentioned, we interviewed two ballast manufacturers and learned customers still utilize the old metric, BEF, to purchase and specify projects, and that interest is limited for the BLE metric because it is new and unfamiliar to customers. Both manufacturers interviewed say they list the BEF in their product catalogs. One manufacturer said they plan to update their catalogs with the BLE in 2016, and the other said they were assessing whether adding the BLE to their product catalogs would be necessary or practical. Both manufacturers noted that BLE is a DOE created metric that currently has little meaning in the industry, which is why this information is not often disclosed in customer facing materials.

A.8 Federal 14/15/16 – Package AC and Computer Room AC Potential and Compliance

This section covers the evaluation of potential savings and compliance for the federal standards that regulate commercial package air conditioners (CPACs) and computer room air conditioners (CRACs) that came into effect in between 2013 and 2014. These include:

- Fed 14, Small CPACs (≥65 and <135 kBtu/h)
- Fed 15, Large and Very Large CPACs (≥135 kBtu/h)
- Fed 16, CRACs (>=65,000 Btu/h and < 760,000 Btu/h)

Table 159 summarizes the evaluation results for each standard.

Table 59. Evaluated Results

Standard	Fed 14	Fed 15	Fed 16
Description	Small Commercial Package Air-Conditioners	Large and Very Large Commercial Package Air-Conditioners	Computer Room ACs
Effective Date	6/1/2013	6/1/2014	10/29/2013
California Unit Sales/Yr (2015 forecast)	16	166	2,723
Unit Annual Savings (kWh)	23	688	76
Unit Demand Savings (kW)	0.006	0.273	0.009
First Year Potential Savings (kWh)	370	114,196	207,812
First Year Potential Demand Savings (kW)	0	45	24
Compliance	100%	100%	100%

Potential Savings

Fed 14, Small Commercial Package Air-Conditioners (≥65 and <135 kBtu/h)

List of Data Sources

- U.S. Department of Energy (DOE) Commercial Heating, Air Conditioning, and Water Heating Equipment (i.e., ASHRAE Equipment) Final Rule Rulemaking Technical Support Document (TSD), July 20, 2012 (Accessed 9/15/2015). http://www.regulations.gov/#!documentDetail;D=EERE-2011-BT-STD-0029-0039
- U.S. Department of Commerce (DOC) Bureau of Economic Analysis, "Broad Growth Across States in 2014: Advance 2014 and Revised 1997-2013 Statisitics on GDP by State". http://www.bea.gov/newsreleases/regional/gdp_state/gsp_newsrelease.htm
- U.S. Census Bureau: State and County Quick Facts (Accessed 9/15/2015). http://quickfacts.census.gov/qfd/states/06000.html

- Partnership for Resource Conservation. Personal communications with Paul Reeves, Database for Energy Efficient Resources Team. December 2015.

Market Size Analysis

The federal standard distinguishes four types of small CPACs:

- Water-cooled, ≥65 and <135 kBtu/h, Electric Resistance/No Heating
- Water-cooled, ≥65 and <135 kBtu/h, Other Heating
- Evaporatively-cooled, ≥65 and <135 kBtu/h, Electric Resistance/No Heating
- Evaporatively-cooled, ≥65 and <135 kBtu/h, Other Heating

Chapter 7 of DOE's TSD (Table 7.3.1) provides a forecast of 2015 unit sales on a national level, reproduced below in Table 28. Chapter 2 of the TSD indicated that evaporatively cooled CPAC units did not exist in this size category based on DOE's survey of the AHRI database and manufacturers' websites.[32] The estimate of California's share of those national estimates, roughly 12.1%, was based upon the average of California's share of private nonfarm employment, retail sales, and GDP in the United States.

Table 60. DOE TSD's 2015 Forecast of Market Size of Small CPACs

Type of Small CPAC	U.S. Unit Sales in 2015	CA Unit Sales in 2015
Water-cooled, ≥65 and <135 kBtu/h, Electric Resistance/No Heating	113	14
Water-cooled, ≥65 and <135 kBtu/h, Other Heating	13	2
Evaporatively-cooled, ≥65 and <135 kBtu/h	0	0
Total	126	16

Unit Energy and Demand Savings

Table 61 summarizes the unit kWh consumption and savings as reported in the DOE TSD and the unit demand savings Cadmus calculated using data from DEER.[33,34] The TSD examined the savings moving from a baseline unit to the ASHRAE 90.1-2010 standard for small CPACs. ASHRAE standards were eventually adapted as the federal standard. Data provided by the DEER Support Team indicates the statewide average measure kW/kWh ratio is 0.0025; we applied this value to the energy savings to calculate unit peak demand savings.

Table 61. Annual Unit Energy and Demand Savings for Small CPACs

Type of Small CPAC	Baseline Unit	ASHRAE Unit	Unit Energy	Unit Demand

[32] Section 2.4.3.2 of DOE TSD

[33] Table 8.3.6 of DOE TSD

[34] DEER version 2014, weighted across all four IOUs as provided by the DEER support team for measure Energy Impact ID: NE-HVAC-airAC-SpltPkg-65to109kBtuh-12p0eer

	Energy Use (kWh/year)	Energy Use (kWh/year)	Savings (kWh/year)	Savings (kW)
Water-cooled, ≥65 and <135 kBtu/h, Electric Resistance/ No Heating	8,088	8,065	23	0.006
Water-cooled, ≥65 and <135 kBtu/h, Other Heating	8,126	8,102	24	0.006

Table 62 shows the energy and demand savings potential based on 2015 unit sales of small CPACs. The average unit savings is 23 kWh and 0.006 kW.

Table 62: First Year Potential Energy and Demand Savings in California for Small CPACs

Type of Small CPAC	Energy Savings (kWh) in CA 2015	Demand Savings (kW) in CA 2015
Water-cooled, ≥65 and <135 kBtu/h, Electric Resistance/No Heating	322	0.081
Water-cooled, ≥65 and <135 kBtu/h, Other Heating	48	0.012
Total	**370**	**0.1**

Fed 15, Large and Very Large Commercial Package Air-Conditioners (≥135 kBtu/h)

List of Data Sources

- U.S. Department of Energy (DOE) Commercial Heating, Air Conditioning, and Water Heating Equipment (i.e., ASHRAE Equipment) Final Rule Rulemaking Technical Support Document, July 20, 2012 (Accessed 9/15/2015). http://www.regulations.gov/#!documentDetail;D=EERE-2011-BT-STD-0029-0039
- U.S. Department of Commerce (DOC) Bureau of Economic Analysis, "Broad Growth Across States in 2014: Advance 2014 and Revised 1997-2013 Statisitics on GDP by State". http://www.bea.gov/newsreleases/regional/gdp_state/gsp_newsrelease.htm
- U.S. Census Bureau: State and County Quick Facts (Accessed 9/15/2015). http://quickfacts.census.gov/qfd/states/06000.html
- Partnership for Resource Conservation. Personal communications with Paul Reeves, Database for Energy Efficient Resources Team. December 2015.

Market Size Analysis

The federal standard distinguishes six different types of large and very large CPACs:

- Water-cooled, ≥135 and <240 kBtu/h, Electric Resistance/No Heating
- Water-cooled, ≥135 and <240 kBtu/h, Other Heating
- Water-cooled, ≥240 and <760 kBtu/h, Electric Resistance/No Heating
- Water-cooled, ≥240 and <760 kBtu/h, Other Heating
- Evap-cooled, ≥240 and <760 kBtu/h, Electric Resistance/No Heating

- Evap-cooled, ≥240 and <760 kBtu/h, Other Heating

DOE's TSD[35] forecasts 2015 units sales on a national level shown in Table 63. The DOE TSD indicated that evaporatively cooled CPAC units did not exist in the ≥135 and <240 kBtu/h size category.[36] The estimate of California's share of those national estimates, roughly 12.1%, was based upon the average of California's share of private nonfarm employment, retail sales, and GDP in the United States.

Table 63. Market Size of Large/Very Large CPACs

Type of Large /Very Large CPAC	U.S. Unit Sales in 2015	CA Unit Sales in 2015
Water-cooled, ≥135 and <240 kBtu/h, Electric Resistance/No Heating	143	17
Water-cooled, ≥135 and <240 kBtu/h, Other Heating	16	2
Water-cooled, ≥240 and <760 kBtu/h, Electric Resistance/No Heating	97	12
Water-cooled, ≥240 and <760 kBtu/h, Other Heating	868	105
Evap-cooled, ≥240 and <760 kBtu/h, Electric Resistance/No Heating	25	3
Evap-cooled, ≥240 and <760 kBtu/h, Other Heating	223	27
Total	1,372	166

Unit Energy and Demand Savings

The first four columns of Table 64 summarizes unit energy savings as established by the DOE TSD.[37] The TSD examined the savings moving from a baseline units to the ASHRAE 90.1-2010 standard for large and very large CPACs. ASHRAE standards were eventually adapted as the federal standard. Cadmus staff calculated demand savings in the rightmost column of Table 64. Data provided by the DEER Support Team indicates the statewide average measure kW/kWh ratio is 0.0004; we applied this value to the energy savings to calculate unit peak demand savings.

Table 64. Annual Unit Energy Savings for Large/Very Large CPACs

Type of Large/Very Large CPAC	Baseline Unit Energy Use (kWh/year)	ASHRAE Unit Energy Use (kWh/year)	Unit Energy Savings (kWh/year)	Unit Demand Savings (kW/year)
Water-cooled, ≥135 and <240 kBtu/h, Electric Resistance/ No Heating	15,776	15,309	467	0.185
Water-cooled, ≥135 and <240 kBtu/h, Other Heating	15,818	15,407	411	0.163
Water-cooled, ≥240 and <760 kBtu/h,	36,893	36,279	614	0.244

35 Table 7.3.1 of DOE TSD
36 Section 2.4.3.2 of DOE TSD
37 Table 8.3.6 of DOE TSD

Electric Resistance/ No Heating				
Water-cooled, ≥240 and <760 kBtu/h, Other Heating	36,980	36,452	528	0.209
Evap-cooled, ≥240 and <760 kBtu/h, Electric Resistance/ No Heating	46,166	44,584	1,582	0.628
Evap-cooled, ≥240 and <760 kBtu/h, Other Heating	46,436	45,033	1,403	0.557

Table 65 shows the energy and demand savings potential based on 2015 unit sales of large and very large CPACs. The average unit energy savings is 688 kWh and 0.273 kW.

Table 65: Annual Energy and Demand Savings in California for Large/Very Large CPACs

Type of Large /Very Large CPAC	Energy Savings (kWh) in CA 2015	Demand Savings (kW) in CA 2015
Water-cooled, ≥135 and <240 kBtu/h, Electric Resistance/No Heating	7,939	3
Water-cooled, ≥135 and <240 kBtu/h, Other Heating	822	0
Water-cooled, ≥240 and <760 kBtu/h, Electric Resistance/No Heating	7,368	3
Water-cooled, ≥240 and <760 kBtu/h, Other Heating	55,440	22
Evap-cooled, ≥240 and <760 kBtu/h, Electric Resistance/No Heating	4,746	2
Evap-cooled, ≥240 and <760 kBtu/h, Other Heating	37,881	15
Total	**114,196**	**45**

Fed 16, Computer Room ACs (>=65,000 Btu/h and < 760,000 Btu/h.)

List of Data Sources

- U.S. Department of Energy (DOE) Commercial Heating, Air Conditioning, and Water Heating Equipment (i.e., ASHRAE Equipment) Final Rule Rulemaking Technical Support Document, July 20, 2012 (Accessed 9/15/2015). http://www.regulations.gov/#!documentDetail;D=EERE-2011-BT-STD-0029-0039
- Data Center Map website. Lists number of colocation data centers in U.S. by state. http://www.datacentermap.com/usa/

Market Size Analysis

The federal standard distinguishes fifteen types of computer room air conditioners (CRACs) based on cooling fluid and capacity as shown in Table 66.

Table 66. Types of CRACs regulated by Federal Standards

Cooling Fluid	<65 kBtu/h	≥65 and <240 kBtu/h	≥240 and <760 kBtu/h
Air	✓	✓	✓

Water	✓	✓	✓
Water with fluid economizer	✓	✓	✓
Glycol	✓	✓	✓
Glycol with fluid economizer	✓	✓	✓

Chapter 7 of DOE's TSD provides a forecast of the number of CRAC units sold nationwide.[38] However, the TSD used an annual growth rate of only two percent – a number that does not reflect growth of the data center industry in general. For example, an October 2015 Cisco report indicated that internet traffic will triple between 2014 and 2019.[39] A recent DCD Intelligence report forecasted a growth in colocation at 15% annually.[40] A Technavio's study predicts the compound annual growth rate (CAGR) for data center cooling at 13%.[41] To estimate sales of CRAC units in 2015, as shown in Table 67, we applied a 13% CAGR to the 2013 estimate in the DOE's TSD. The estimate of California's share of those national estimates, roughly 13% or 2,723 units, was based upon the number of data center colocation facilities located in California compared to the United States as determined using the datacentermap.com website.

Table 67. 2015 Forecast of CRAC Unit Sales

Type of CRAC	U.S. Unit Sales in 2015	CA Unit Sales in 2015	% of California Sales
Air-cooled <65 kBtu/h	879	114	4%
Air-cooled ≥65 and <240 kBtu/h	9537	1,242	46%
Air-cooled ≥240 and <760 kBtu/h	2133	278	10%
Water-cooled <65 kBtu/h	97	13	0%
Water-cooled ≥65 and <240 kBtu/h	1,568	204	8%
Water-cooled ≥240 and <760 kBtu/h	598	78	3%
Water- cooled with fluid economizer <65 kBtu/h	60	8	0%
Water-cooled with fluid economizer ≥65 and <240 kBtu/h	1,317	172	6%
Water-cooled with fluid economizer ≥240 and <760 kBtu/h	229	30	1%
Glycol-cooled <65 kBtu/h	90	12	0%
Glycol-cooled ≥65 and <240 kBtu/h	1,568	204	8%
Glycol-cooled ≥240 and <760 kBtu/h	492	64	2%

[38] Table 7.3.4 of TSD located at: http://www.regulations.gov/#!documentDetail;D=EERE-2011-BT-STD-0029-0039
[39] http://www.datacenterdynamics.com/app-cloud/cisco-total-data-center-traffic-will-triple-by-2019/95113.fullarticle
[40] http://www.datacenterdynamics.com/app-cloud/15-growth-forecast-for-north-america-colocation-market-2014/84554.fullarticle
[41] http://www.reportlinker.com/p0764716/Global-Precision-Air-Conditioning-Market.html

Type of CRAC	U.S. Unit Sales in 2015	CA Unit Sales in 2015	% of California Sales
Glycol-cooled with fluid economizer <65 kBtu/h	90	12	0%
Glycol-cooled with fluid economizer ≥65 and <240 kBtu/h	1,820	237	9%
Glycol-cooled with fluid economizer ≥240 and <760 kBtu/h	439	57	2%

The majority (60%) of CRAC unit sales are air-cooled.

Unit Energy and Demand Savings

Table 68 summarizes the unit energy savings as established by the DOE TSD and demand savings as calculated by Cadmus staff.[42] The TSD examined CRAC savings moving from a baseline unit to the ASHRAE 90.1-2010 standard. DOE eventually adopted the ASHRAE standard as the federal standard. Demand savings were determined by assuming data centers are on 24/7 and the percent time during peak load is 100%.

Table 68. DOE TSD Annual Unit Energy Consumption and Savings for CRACs

Type of CRAC	Baseline Unit Energy Use (kWh/year)	ASHRAE Unit Energy Use (kWh/year)	Unit Energy Savings (kWh/year)	Unit Demand Savings (kW/year)
Air-cooled <65 kBtu/h	23,968	23,910	58	0.0066
Air-cooled ≥65 and <240 kBtu/h	84,109	84,109	0	0.0000
Air-cooled ≥240 and <760 kBtu/h	197,405	197,405	0	0.0000
Water-cooled <65 kBtu/h	22,774	22,676	98	0.0112
Water-cooled ≥65 and <240 kBtu/h	84,342	84,195	147	0.0168
Water-cooled ≥240 and <760 kBtu/h	190,426	190,075	351	0.0401
Water- cooled with fluid economizer <65 kBtu/h	14,441	14,391	50	0.0057
Water-cooled with fluid economizer ≥65 and <240 kBtu/h	53,536	53,459	77	0.0088
Water-cooled with fluid economizer ≥240 and <760 kBtu/h	120,357	120,175	182	0.0208
Glycol-cooled <65 kBtu/h	22,672	22,571	101	0.0115
Glycol-cooled ≥65 and <240 kBtu/h	92,071	91,878	193	0.0220
Glycol-cooled ≥240 and <760 kBtu/h	204,842	204,399	443	0.0506
Glycol-cooled with fluid economizer <65 kBtu/h	18,324	18,249	75	0.0086
Glycol-cooled with fluid economizer ≥65 and <240 kBtu/h	74,341	74,195	146	0.0167
Glycol-cooled with fluid economizer	165,328	164,993	335	0.0382

[42] Table 8.3.8 of DOE TSD

Type of CRAC	Baseline Unit Energy Use (kWh/year)	ASHRAE Unit Energy Use (kWh/year)	Unit Energy Savings (kWh/year)	Unit Demand Savings (kW/year)
≥240 and <760 kBtu/h				

Table 69 shows the first year potential energy and demand savings based on 2015 unit sales of large and very large CPACs. Notice the savings for air-cooled CRACs between 65 and 760 kBtu/h is zero; these units account for over 50% of all CRAC shipments.

Table 69. First Year Potential Energy and Demand Savings in California for CRACs

Type of CRAC	Energy Savings (kWh)	Demand Savings (kW)
Air-cooled <65 kBtu/h	6,636	0.758
Air-cooled ≥65 and <240 kBtu/h	-	-
Air-cooled ≥240 and <760 kBtu/h	-	-
Water-cooled <65 kBtu/h	1,233	0.141
Water-cooled ≥65 and <240 kBtu/h	30,012	3.426
Water-cooled ≥240 and <760 kBtu/h	27,316	3.118
Water- cooled with fluid economizer <65 kBtu/h	389	0.044
Water-cooled with fluid economizer ≥65 and <240 kBtu/h	13,209	1.508
Water-cooled with fluid economizer ≥240 and <760 kBtu/h	5,424	0.619
Glycol-cooled <65 kBtu/h	1,187	0.136
Glycol-cooled ≥65 and <240 kBtu/h	39,404	4.498
Glycol-cooled ≥240 and <760 kBtu/h	28,388	3.241
Glycol-cooled with fluid economizer <65 kBtu/h	882	0.101
Glycol-cooled with fluid economizer ≥65 and <240 kBtu/h	34,594	3.949
Glycol-cooled with fluid economizer ≥240 and <760 kBtu/h	19,137	2.185
Total	**207,812**	**24**

The average unit energy and demand savings is 76 kWh and 0.009 kW.

Compliance

Fed 14, Small Commercial Package Air-Conditioners (≥65 and <135 kBtu/h) and Fed 15, Large and Very Large Commercial Package Air-Conditioners (≥135 kBtu/h)

To assess compliance, Cadmus first reviewed the CEC Appliance database, which contains a list of appliances certified with the CEC as compliant with Title 20 and federal standards.[43] We found the

[43] Online at: https://cacertappliances.energy.ca.gov/Pages/ApplianceSearch.aspx

"Large and Very Large Air Conditioners" product category had only air cooled units in it (not applicable to Fed 14 and 15, which only includes water-cooled and evaporatively cooled units). The "Evaporatively Cooled Air Conditioners" product list only had split systems less than 5 tons (60 kbtuh). Our standards evaluated regulate CPACs larger than 5 tons. However, the "Water Cooled Air Conditioner" database had over 100 models listed of water cooled small, large and very large CPACs.

Online Research Results

Cadmus conducted online searches of small, large and very large water-cooled commercial package air conditioners and found that all the units met the minimum EER specification. However, most of the water-cooled units reviewed were not listed in the CEC "Water Cooled Air Conditioner" database. For example:

- Of the 10 Carrier water cooled commercial package units reviewed, only one model was found in the CEC database.[44]
- Trane's SCWF and SIWF water cooled self-contained units from 20 to 58 tons were not on the CEC list.[45]
- Johnson Control's York CSV line of water cooled units were on the CEC list[46] but their LSWU series was not.[47]

For very large evaporatively-cooled CPACs, Cadmus conducted online searches and found that both Daiken units [48] and Trane units[49] complied with the ASHRAE 90.1 Efficiency Standard, which were used as the minimum EER levels in the federal standard.

Given the results of this analysis, Cadmus estimated a 100% compliance rate with the federal standard for small, large and very large water-cooled CPAC and very large evaporative-cooled CPAC. However, we note that the CEC "Water Cooled Air Conditioner" database should be updated with more information from manufacturers.

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[44] http://www.carrier.com/building-solutions/en/us/products/packaged-indoor/packaged-indoor-self-contained/. All 10 water cooled units make EER requirement (have to click on each model) but only 50XCW models are on CEC list

[45] http://www.trane.com/content/dam/Trane/Commercial/global/products-systems/equipment/unitary/self-contained-systems/signature-20-to-110-tons/PKG-PRC002V-EN_06262015.pdf

[46] http://www.johnsoncontrols.com/content/dam/WWW/jci/be/integrated_hvac_systems/hvac_equipment/indoor_packaged_equipment/watercooled10/145.00-EG3_710%29_Water-Cooled_Self_Contained.pdf

[47] http://cgproducts.johnsoncontrols.com/yorkdoc/145.05-EG2.pdf

[48] http://lit.daikinapplied.com/bizlit/DocumentStorage/RooftopSystems/Brochures/ASP_31-791_Evap_Condenser_Rooftops.pdf

[49] https://www.trane.com/content/dam/Trane/Commercial/lar/es/product-systems/comercial/Rooftops/IntelliPakl/catalogo/IntelliPak%201%20Cat%C3%A1logo%20%28Ingl%C3%A9s%29.pdf

Fed 16, Computer Room ACs (>=65,000 Btu/h and < 760,000 Btu/h.)

Cadmus reviewed the CEC's "Computer Room Air Conditioner" database.[50] The companies with the most entries in that database were Liebert, Schneider Electric, and DataAire. For each of these manufacturers, we went to their websites and selected CRAC models prominently displayed on their website and checked to see if the models were on the CEC database. The following was observed:

- For Liebert, we examined two model families. The Liebert CRV (self-contained row-based cooling) and Liebert DSE (precision cooling for large server rooms) were both on the CEC "Computer Room Air Conditioner" database.
- For Schneider Electric, a long list of air cooled CRACs was examined and only 40% (108 of 270 models) were on the CEC database.
- For DataAire, we found that 7 out of the 10 model families were on the CEC database.

We attempted to examine CRAC models and model families not found in the CEC database to check compliance with the federal standard. However, data on sensible coefficient of performance (SCOP) was not listed with CRAC literature we examined and inquiries to the manufacturers were not successful. At this point in time, we have no evidence to suggest that CRAC units not on the CEC database do not meet the federal standard (based on SCOP requirement) and estimate compliance at 100%. However, the CEC "Computer Room Air Conditioner" database should be updated with more information from manufacturers.

A.9 Federal 9/10/11/12/17 – Appliance Compliance

Introduction

As a part of the 2013-2015 Codes and Standards Program evaluation, Cadmus determined the compliance of certain federally and state-regulated (Title 20) appliances sold in California. This section describes how we assessed compliance for the products listed in Table 70 through online research.

Table 70. Evaluated Products

Appliance	Standards	Effective Date
Pool Heaters	Fed 9	2014
Refrigerators and Freezers	Fed 11	2014
Room Air Conditioners	Fed 12	2014
Dishwashers	Fed 17	2013
Gas Space Heaters	Fed 10	2013

[50] Online at: https://cacertappliances.energy.ca.gov/Pages/ApplianceSearch.aspx

Methodology

For each standard, Cadmus sampled from 10 store websites corresponding to retail locations across California, which included a mix of national retail chains, regional retail stores, and single-location businesses. On each store's website, we used retailers' best seller sorting feature (when available) to select the models with the largest market share for review.

We attempted to collect data for 10 of the most prevalent models at each of the 10 stores, aiming to assess 100 models for each appliance. Based on a default 80% compliance rate, to achieve 90% confidence at ±10% precision, we would need to inspect at least 72 models per appliance standard. In total, we visited a total of 28 store websites to complete the appliance compliance assessment. We were able to utilize many vendors for multiple appliances in this analysis, and researched specialty stores for evaluating compliance with gas space heaters and pool heaters.

Cadmus took three steps to determine compliance for each product. First, we compared each model number against the California Energy Commission (CEC) list of approved models. Then, if a product was not found on the CEC's list, we checked the website listing to determine if the product was ENERGY STAR® certified. If they were, the model was designated as compliant. If a product was not ENERGY STAR certified and did not show up on the CEC list, we conducted a final check to determine if the model's energy usage, as disclosed by the manufacturer, met the appliance efficiency regulations. We primarily used energy usage specifications that came from retailer or manufacturer websites. However, we were unable to locate annual fuel utilization efficiency (AFUE) ratings for the majority of gas space heaters on the retail stores' or manufacturers' websites and had to contact manufacturers directly to retrieve AFUE specifications.

Cadmus calculated the compliance rate using the following formula:

$$Compliance\ Rate = \frac{\sum Models\ Reviewed\ \times \begin{cases} 0\ if\ model\ not\ compliant \\ 1\ if\ model\ compliant \end{cases}}{\sum Models\ Reviewed}$$

Compliance Results

Table 71 shows our results by standard.

Table 71. Compliance Rate by Standard

Standard	Energy Type	Number of Models Reviewed	Number of Compliant Models	Compliance Rate	Confidence and Precision**
Refrigerators and Freezers (weighted average by market share)*	Electric	185	165	95%	90%/3%
Room Air Conditioners	Electric	89	81	91%	90%/5%
Dishwashers	Electric & Gas	93	92	99%	90%/2%
Pool Heaters	Gas	79	75	95%	90%/4%
Gas Space Heaters	Gas	38	36	95%	90%/6%

* Per Cadmus' potential savings section for refrigerators and freezers, the refrigerator and freezer market shares are 91% and 9%, respectively.

** Calculated using the formula: precision (90% confidence) = 1.645[p(1-p)/n]^0.5, where n = number of models and p = compliance rate, where 1.645 corresponds to the z-value for 90% confidence level.

We found all these standards have compliance rates over 90%. Refrigerators and freezers were examined separately and then combined into one compliance rate weighted by market share. For many types of appliances, we found ENERGY STAR certified models that were not listed in the CEC database, suggesting the CEC database was not comprehensive at the time we conducted the analysis.

Cadmus analyzed fewer gas space heaters than other appliances because there were fewer models available online. This may be because California has banned the installation and use of unvented gas space heaters. Only two models that were found online and available for sale in California did not meet minimum AFUE requirements of the appliance efficiency standards.

Appendix B. Net Savings: NOMAD Detail

B.1 Bass Curve Parameters

The findings of the NOMAD analysis are presented in Table 72. The IOU estimated values are compared to the evaluated parameters obtained from the Delphi panels.

Table 72. Appliance standards (title 20 and federal standards) NOMAD parameters

Group	Standard	Description	Evaluated Parameters			IOU Estimates		
			Max Saturation (s)	Leading Behavior (p)	Following Behavior (q)	Max Saturation (s)	Leading Behavior (p)	Following Behavior (q)
2006-2009 Title 20	Std 28b	Televisions – Tier 2	82%	0.008	0.380	82%	0.008	0.380
2011 Title 20	Std 29	Small Battery Chargers – Tier 1	54%	0.007	0.321	54%	0.007	0.321
	Std 30	Small Battery Chargers – Tier 2	60%	0.012	0.241	54%	0.007	0.321
	Std 32	Large Battery Chargers (≥2kW rated input)	40%	0.003	0.275	43%	0.012	0.386
2013 Federal Appliance	Fed 9	Residential Pool Heaters	70%	0.010	0.001	70%	0.010	0.001
	Fed 10	Residential Direct Heating Equipment	58%	0.065	0.168	80%	0.010	0.005
	Fed 11	Residential Refrigerators & Freezers	44%	0.011	0.247	50%	0.020	0.100
	Fed 12	Residential Room AC	53%	0.018	0.214	40%	0.010	0.050
	Fed 13	Fluorescent Ballasts	51%	0.014	0.173	20%	0.010	0.200
	Fed 14	Small Comm. Package ACs	96%	0.100	0.001	96%	0.100	0.001
	Fed 15	Large / Very Large Comm. Package ACs	80%	0.100	0.001	80%	0.100	0.001
	Fed 16	Computer Room ACs	99%	0.700	0.020	99%	0.700	0.020
	Fed 17	Residential Dishwashers	78%	0.019	0.238	90%	0.010	0.040

In the NOMAD parameter assumptions for the utility savings claim, we used a single set of parameters as the input for standards. For the evaluated parameters for these standards, Cadmus solicited separate panelist input for each standard.

As Cadmus conducted a NOMAD evaluation of Televisions – Tier 2 and Small Battery Chargers – Tier 1 during the 2010-2012 Codes and Standards evaluation, Cadmus applied the parameters calculated from the previous evaluation to the current standards for these appliances. Projected savings are small for federal standards 9, 14, 15, and 16 so Cadmus used the parameter assumptions used in the utility savings claim as evaluated inputs to the ISSM model.

B.2 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.[51] The Delphi method is an exercise in group communication among a panel of geographically dispersed experts. Strictly speaking, its elements include (1) structuring of information flow, (2) feedback to the participants, and (3) anonymity for the participants. These characteristics offer distinct advantages over the conventional face-to-face conference as a communication tool. The interactions among panel members are controlled by a panel director or monitor who filters out material not related to the purpose of the group. The usual problems of group dynamics are thus completely bypassed. Clearly, another important advantage is avoiding the costs and logistical challenges involved in bringing experts together in one place.

Cadmus made an effort to research each standard and provide historical market adoption data for the affected product or products leading up the effective date. This process ensured that experts began with a common set of facts and offered a basis for their estimations into the future. Such notes were provided for federal standards 10, 11, 12, and 13.

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.

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

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

The coefficient of innovation (p) captures the effect of consumers who are not influenced by the behavior of others and the coefficient of imitation (q) captures the effect of consumers who are influenced by prior adopters. In the literature on this function, innovation is often referred to as "leading" behavior and imitation is described as "following" behavior.

For the purposes of this analysis, the most critical part of the curve to estimate accurately is 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 Figure 2, which compares a Bass curve that produces 99% market penetration in 18 years to a linear curve.

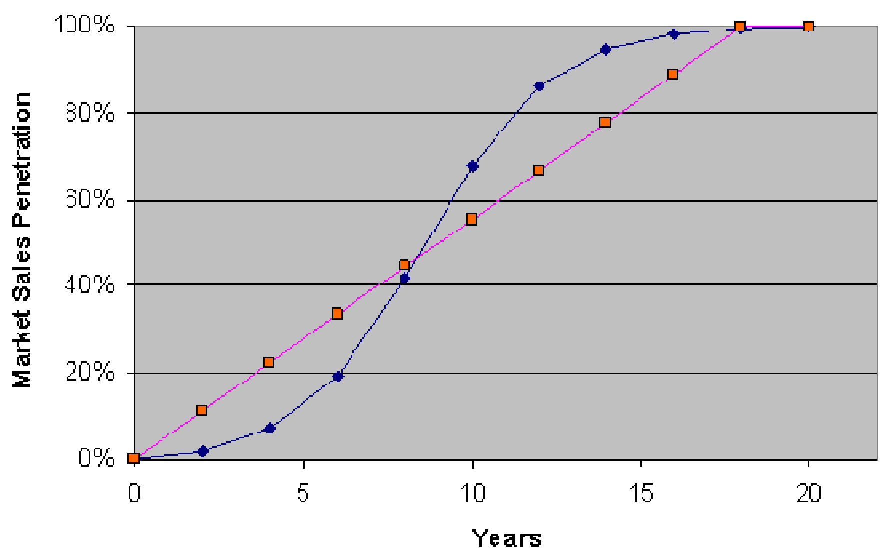

Figure 2. Comparison of typical Bass and linear curves for 18-year market

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)

B.3 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 2010-2012 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 73, 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 73. 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.[52] 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."[53]

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.

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

53 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.[54]

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." [55]

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.

Process Used to Build Expert Panels

Cadmus prioritized recruitment efforts on those appliance standards that are projected to contribute the most to the overall 2013-2015 gross electricity savings for the Title 20 and federal appliance

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

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

standards under review during the 2013-2015 evaluation cycle. Doing so allowed development of evaluated NOMAD parameters for standards representing nearly 100% of estimated 2013-2015 gross GWh savings.

For standards estimated to have negligible gross electricity savings, Cadmus did not attempt to recruit panelists. Table 74 shows the list for Title 20 and federal appliance standards along with estimates of their gross savings.

Table 74. Title 20 and federal appliance standards with relative gross savings

Group	Standard	Description	IOU Estimate 2013-2015 Gross Savings (GWh)	Percent of Total 2013-2015 Gross Electricity Savings
2006-2009 Title 20	Std 28b*	Televisions – Tier 2	1,072	--
2011 Title 20	Std 29*	Small Battery Chargers – Tier 1	1,179	--
	Std 30	Small Battery Chargers – Tier 2	65	28%
	Std 32	Large Battery Chargers (≥2kW rated input)	59	25%
2013 Federal Appliance	Fed 9**	Residential Pool Heaters	0	0%
	Fed 10	Residential Direct Heating Equipment	0	0%
	Fed 11	Residential Refrigerators & Freezers	41	18%
	Fed 12	Residential Room AC	14	6%
	Fed 13	Fluorescent Ballasts	51	22%
	Fed 14**	Small Comm. Package ACs	0	0%
	Fed 15**	Large / Very Large Comm. Package ACs	0	0%
	Fed 16**	Computer Room ACs	0	0%
	Fed 17	Residential Dishwashers	3	1%

*These standards were evaluated in the 2010-2012 Codes and Standards Evaluation and are not included in the percentages
**These standards have very little savings (round down to zero) and were not part of the NOMAD assessment

Cadmus[56] 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 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 75 presents the number of potential panelists Cadmus identified for each appliance or federal standard and the number of panelists who submitted input in each round. The target for all standards was five submissions. The team focused recruiting efforts on the standards with the greatest GWh savings. In general, we achieved submitted input from approximately 30 – 40% of the identified panelists for each standard.

Cadmus reviewed all adoption curves and associated supporting comments. If it was concluded that a curve and a comment were contradictory or a comment demonstrated that the exercise was misunderstood, then we removed that expert's input from the analysis. These exclusions are the reason for the difference between submitted second round input and the input used for the analysis seen in Table 75. When this occurred, Cadmus documented the decision and the reasons for it.

[56] Cadmus used a California based call center to contact the candidates, administer the survey, and pay out the incentives.

Table 75. NOMAD targets for submitted input

Group	Standard	Description	Number of Panelists Identified	Submitted First Round Input	Submitted Second Round Input	Input Used for Analysis
2006-2009 Title 20	Std 28b*	Televisions – Tier 2	25	9	7	8
2011 Title 20	Std 29*	Small Battery Chargers – Tier 1	16	6	6	6
	Std 30	Small Battery Chargers – Tier 2	25	8	8	7
	Std 32	Large Battery Chargers (≥2kW rated input)	25	9	9	8
2013 Federal Appliance	Fed 10	Residential Direct Heating Equipment	12	6	6	4
	Fed 11	Residential Refrigerators & Freezers	20	7	7	5
	Fed 12	Residential Room AC	16	9	9	7
	Fed 13	Fluorescent Ballasts	22	8	8	7
	Fed 17	Residential Dishwashers	13	7	6	5

*These standards were evaluated in the 2010-2012 Codes and Standards Evaluation. No additional panelists were recruited

B.4 NOMAD Analysis Details for Appliance Standards

This section provides additional information on the NOMAD analysis conducted on the Title 20 and federal 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.

Televisions – Tier 2 – Standard 28b

Figure 3 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.

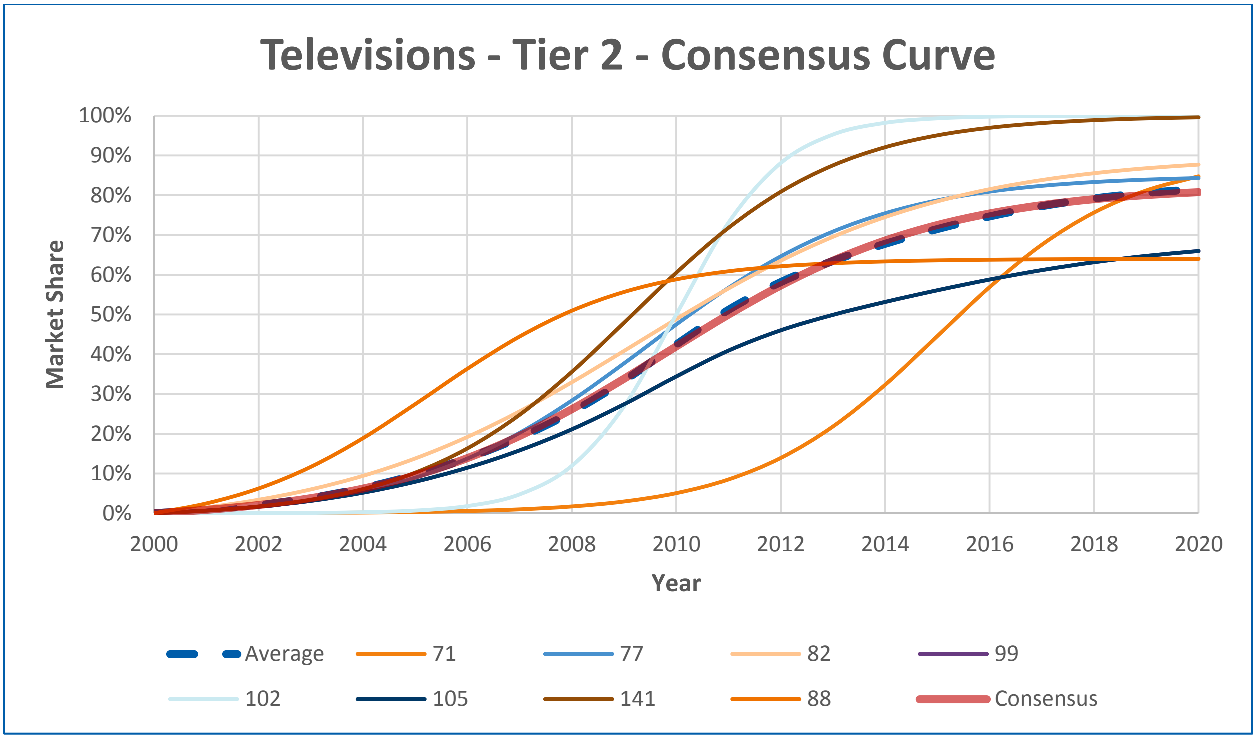

Figure 3. Standard 28b – televisions – tier 2 – consensus curve

Small Battery Chargers – Tier 1 – Standard 29

Figure 4 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.

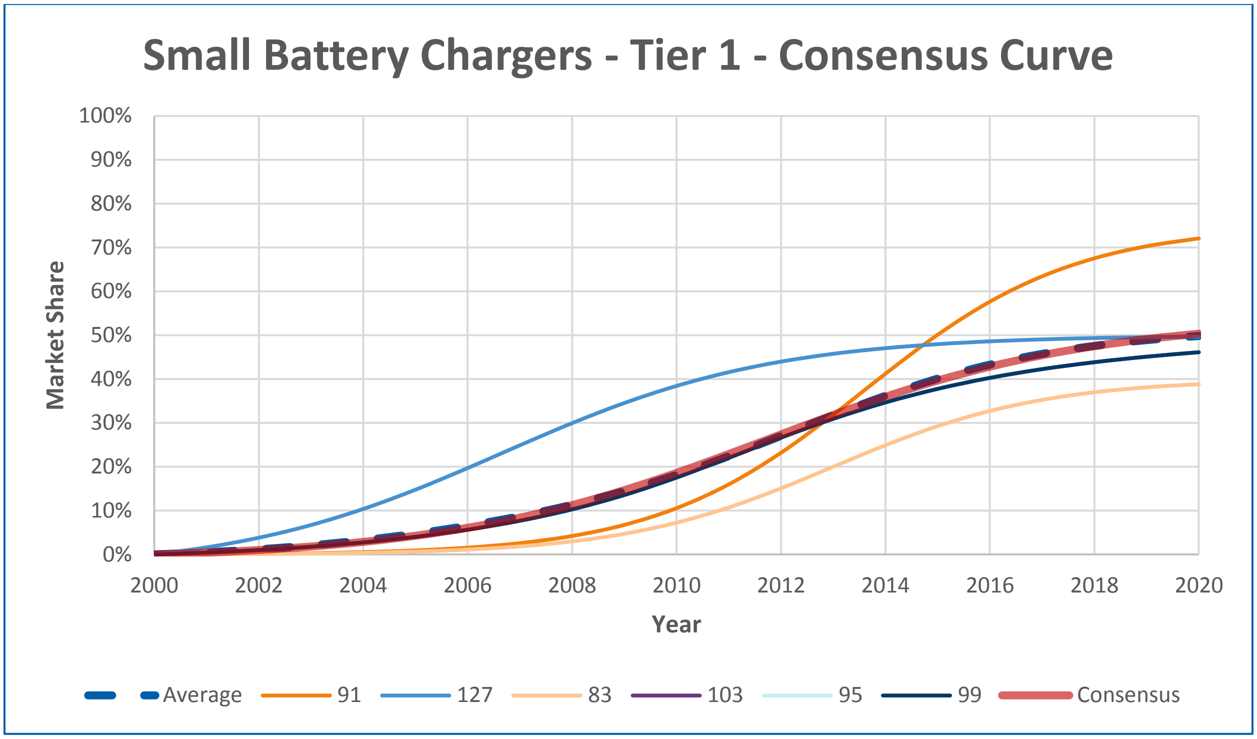

Figure 4. Standard 29 – small battery chargers – tier 1 – consensus curve

Small Battery Chargers – Tier 2 – Standard 30

Figure 5 provides the consensus Bass curve for small battery chargers along with the panelist input used to develop it. Panelists agreed that without mandatory standards, would tend toward 50 to 70 percent market share over the next ten years. One panelist noted that "the market has been transitioning to adaptive chargers that vary voltage to charge faster. Adaptive charging is also higher efficiency..."

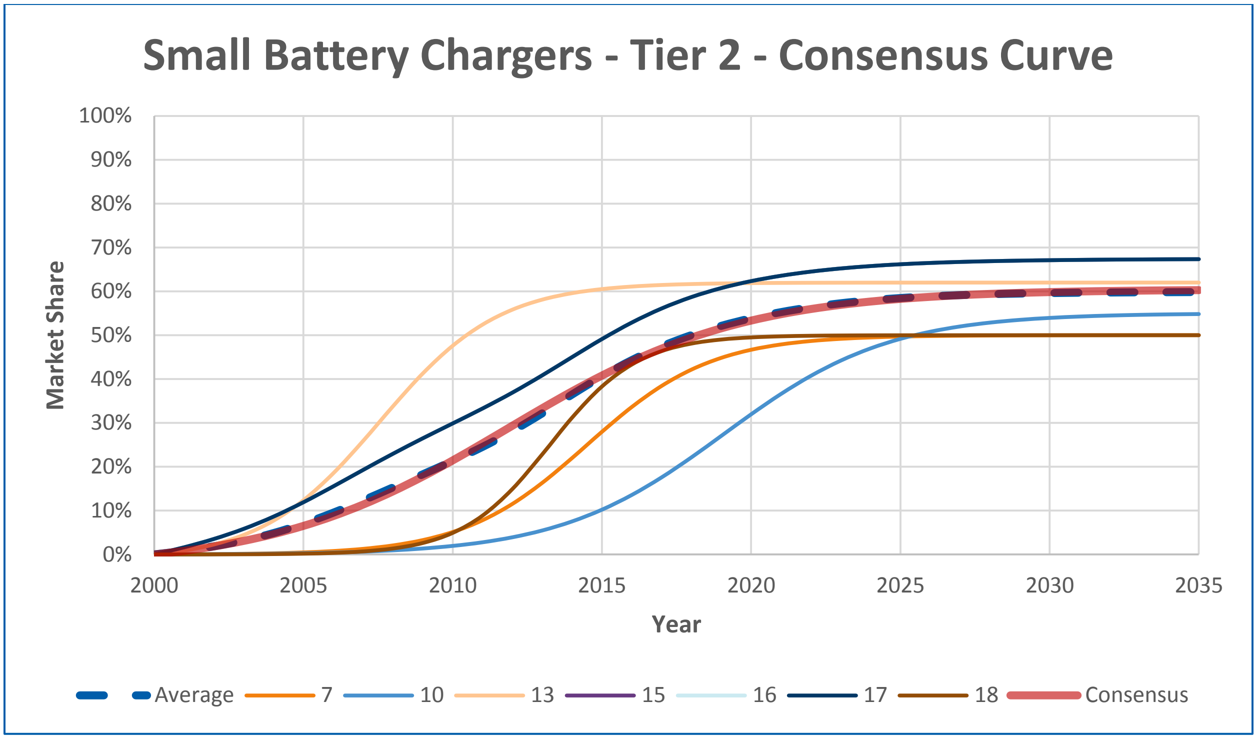

Figure 5. Standard 30 – small battery chargers – tier 2 – consensus curve

Large Battery Chargers – Standard 32

Figure 6 provides the consensus Bass curve for large battery chargers along with the panelist input used to develop it. Panelists agreed that without mandatory standards, manufacturers would have not developed more efficient battery chargers for most applications. One panelist noted, of lift trucks, that "There is little market incentive for manufacturers to improve the efficiency of their battery charging systems because battery charging efficiency does not impact battery life and electricity costs are a marginal part of operators' operational costs." On the other hand, multiple panelists noted, for applications such as electric vehicles, that "the market would demand smarter charging technology, particularly charge termination, as a performance and safety requirement." Panelists felt that this could lead to somewhat earlier adoption, but still later than if the standard were in place.

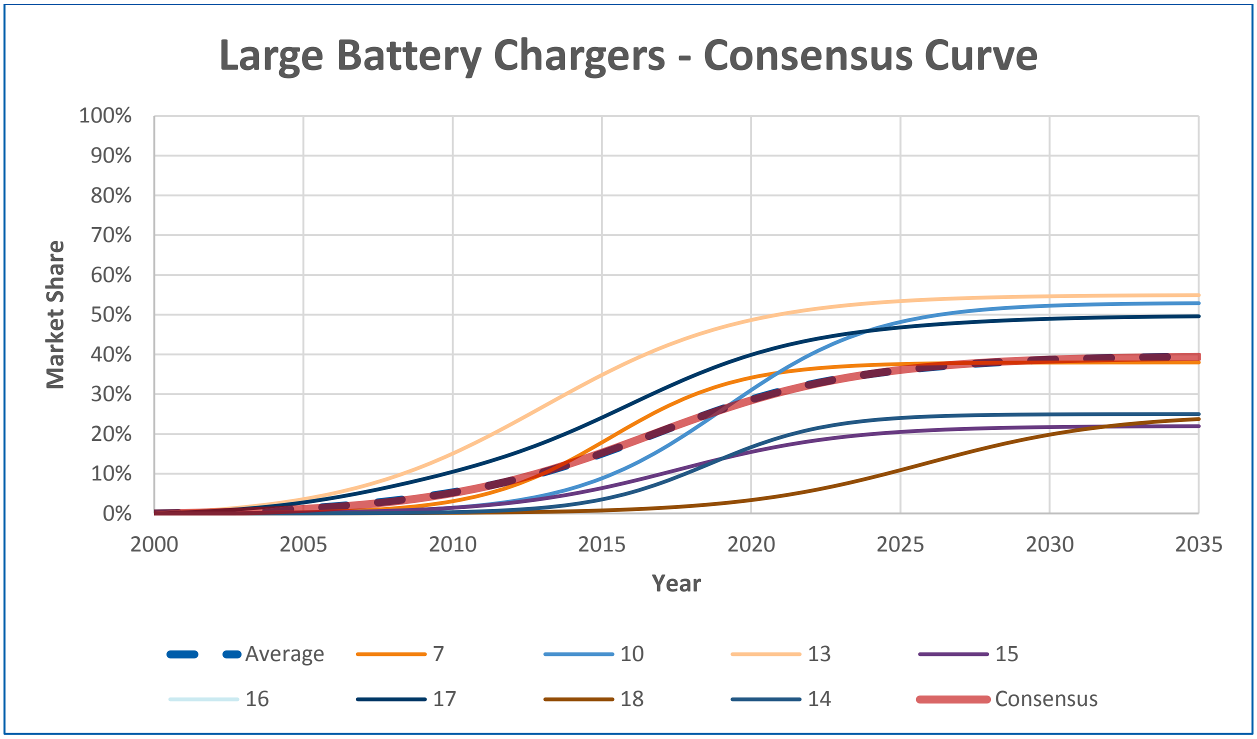

Figure 6. Standard 32 – large battery chargers – consensus curve

Residential Direct Heating Equipment – Standard Fed 10

Figure 7 provides the consensus Bass curve for residential direct heating equipment along with the panelist input used to develop it. In the first round of the panel, there was much disparity between responses, with final saturation values ranging from 20 to 90 percent. In the second round, however, all panelists chose to agree with the average or re-estimate to a curve that was very similar. The main cause of this was the DOE research cited by one panelist which revealed that "approximately 60 percent of models were at or above the efficiency levels set by the standards when the analysis was conducted in 2010." Panelists then agreed that absent standards there would be no significant market driver that would cause an increase in energy efficiency and that the market share would not change significantly.

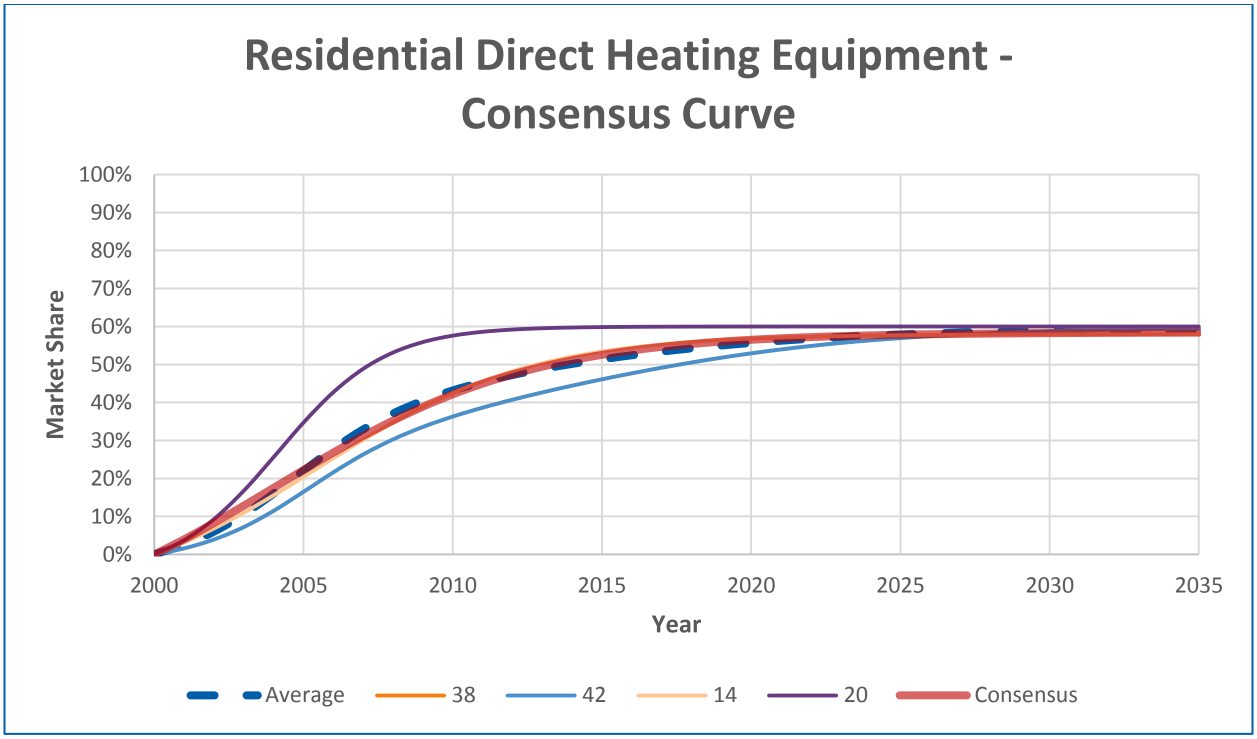

Figure 7. Standard fed 10 – residential direct heating equipment – consensus curve

Residential Refrigerators and Freezers – Standard Fed 11

Figure 8 provides the consensus Bass curve for residential refrigerators and freezers along with the panelist input used to develop it. Panelists agreed that without the federal standard, the adoption of more efficient refrigerators and freezers would have been slow. One panelist submitted the comment that “most people agree that without the progression of standards for these products (3 now, since the first standards were set), these products would still be using considerably more energy than they do today.” And also that “without the standards, most manufacturers would be focused on features, not efficiency.”

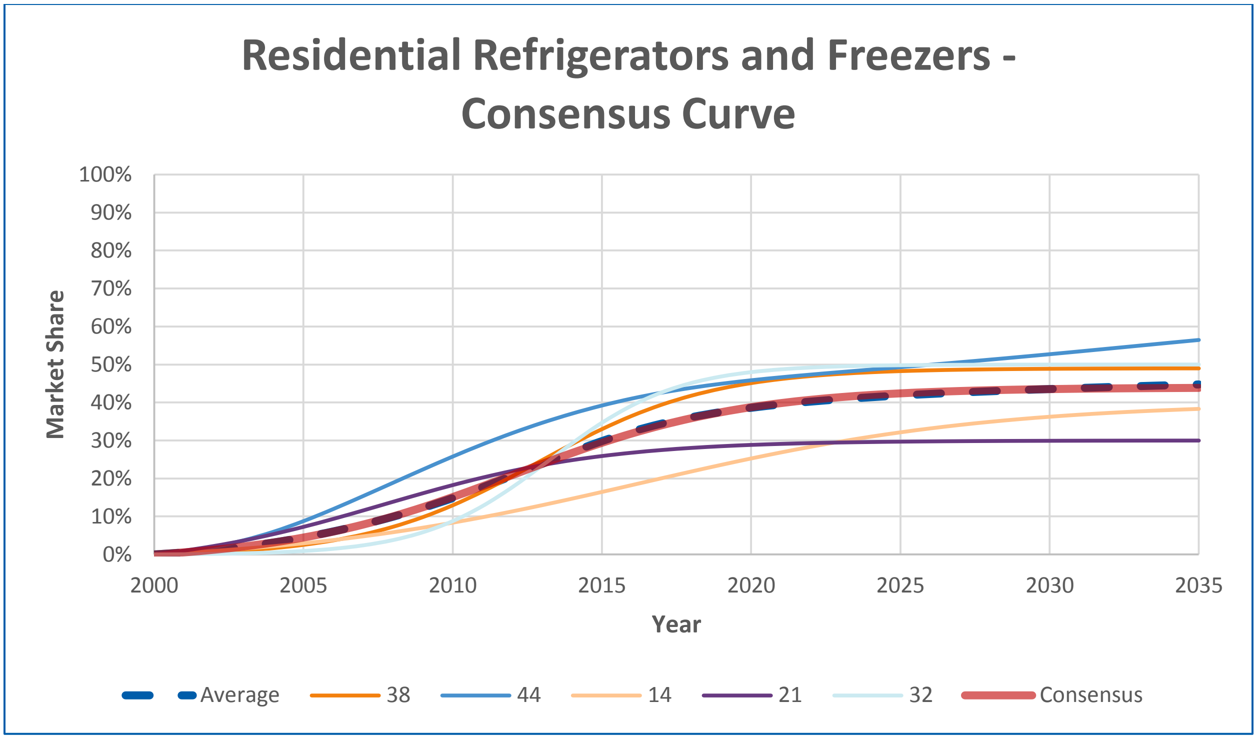

Figure 8. Standard fed 11 – residential refrigerators and freezers – consensus curve

Residential Room Air Conditioners – Standard Fed 12

Figure 9 provides the consensus Bass curve for residential room air conditioners along with the panelist input used to develop it. This was a standard with much disparity between responses in round one, with final saturation values ranging from 25 to 95 percent. In round two, however, all panelists either agreed with the average response or re-estimated their curve to resemble the average more closely. One panelist remarked that "the room AC market is largely driven by first cost, so therefore I expect that market share at levels chosen for standards will remain low absent the standards policy. However, in this market, Energy Star is a powerful driver. I assume that absent standards, we'd still see a revised Energy Star spec that would drive the market to around 50% compliance in time." This sentiment seemed to be shared by most panelists.

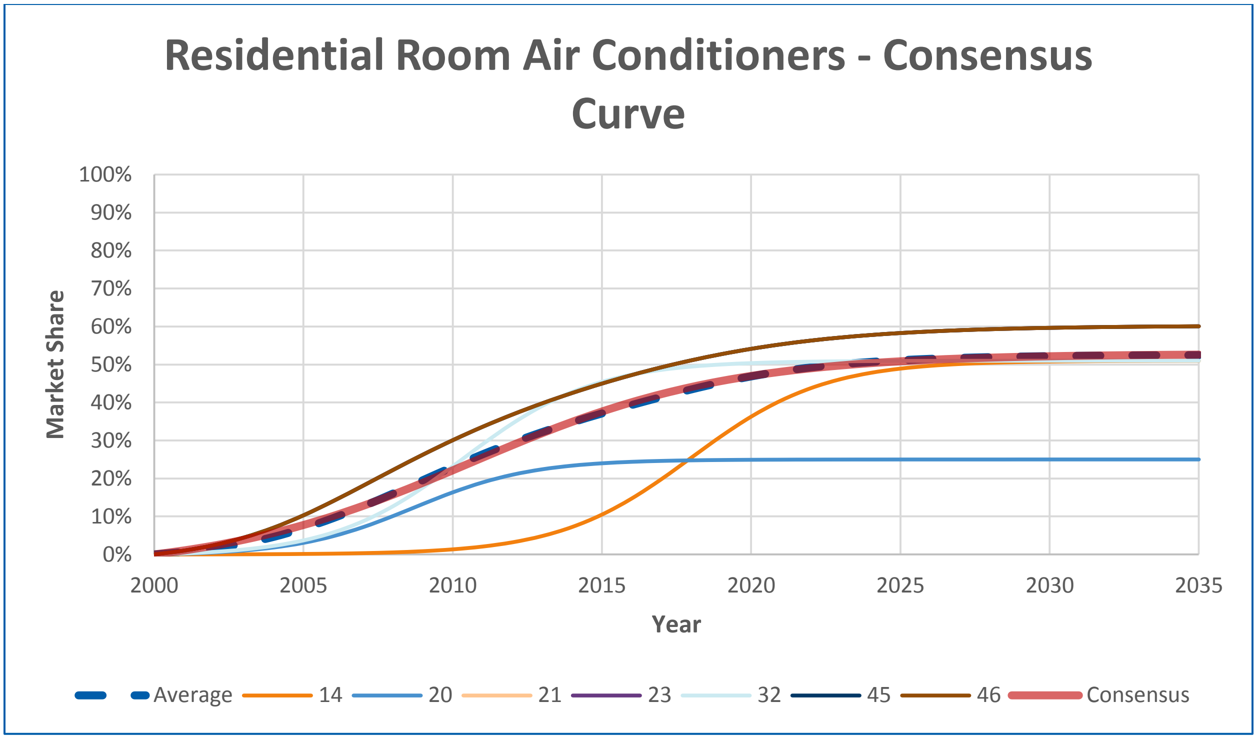

Figure 9. Standard fed 12 – residential room air conditioners – consensus curve

Fluorescent Ballasts – Standard Fed 13

Figure 10 provides the consensus Bass curve for fluorescent ballasts along with the panelist input used to develop it. Panelists held different opinions about the effect of federal standards on the adoption of efficient fluorescent ballasts. Some panelists suggested that manufacturers would focus more on developing LED technology and have little interest in spending the money required to update fluorescent lamp systems. Other panelists felt that, despite this, high efficiency fluorescent ballasts would remain in high demand and, even absent standards, their market share would continue to gradually increase. Only one of the seven panelists agreed with the round one average Bass curve. Five of the seven stuck with their original response and one re-estimated.

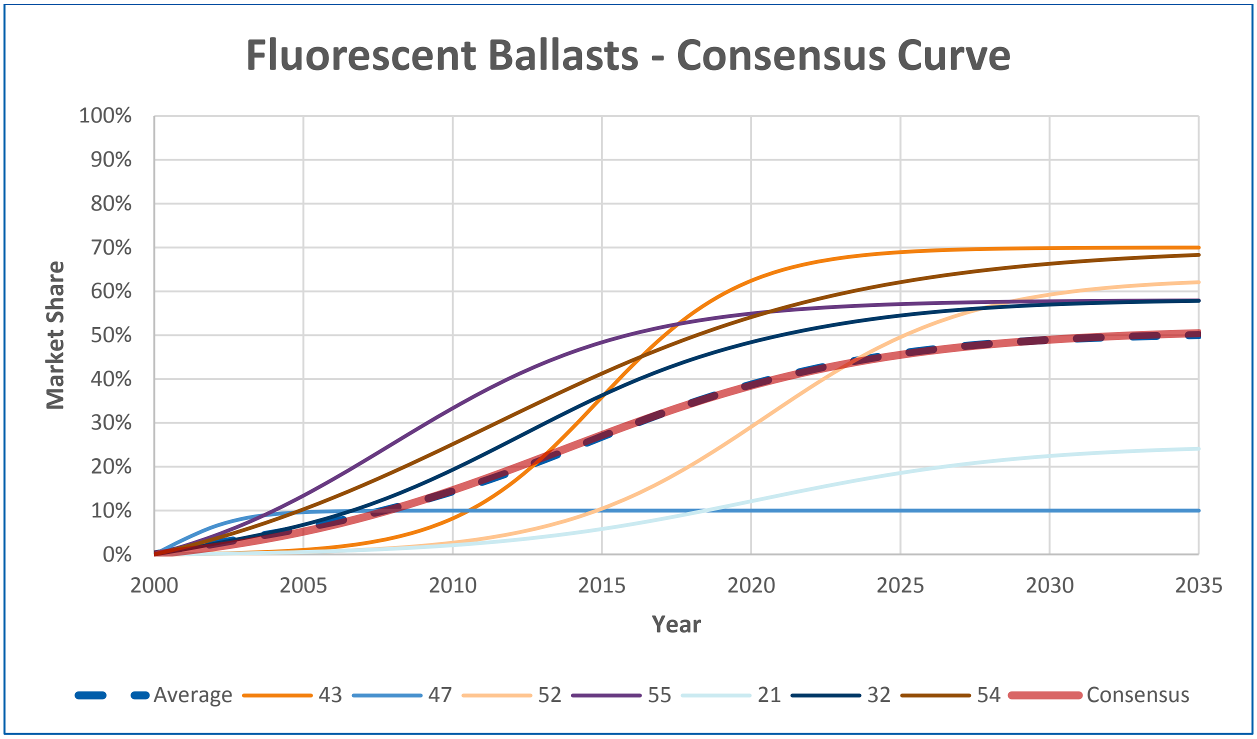

Figure 10. Standard fed 13 – fluorescent ballasts – consensus curve

Residential Dishwashers – Standard Fed 17

Figure 11 provides the consensus Bass curve for residential dishwashers along with the panelist input used to develop it. In general, panelists agreed that even without the federal standard, the adoption of more efficient dishwashers would have been relatively quick. Most panelists felt the market for efficient dishwashers was influenced more by ENERGY STAR than by the California standards and so predicted very high market share absent standards. One panelist believes that “in the absence of codes and standards, there is little incentive for manufacturers to continue to improve efficiency. Annual savings per unit are relatively small so unlikely to drive large market shifts. Higher priced high-efficiency models often have longer cycle times and will appeal mainly to the most eco-conscious consumer. “

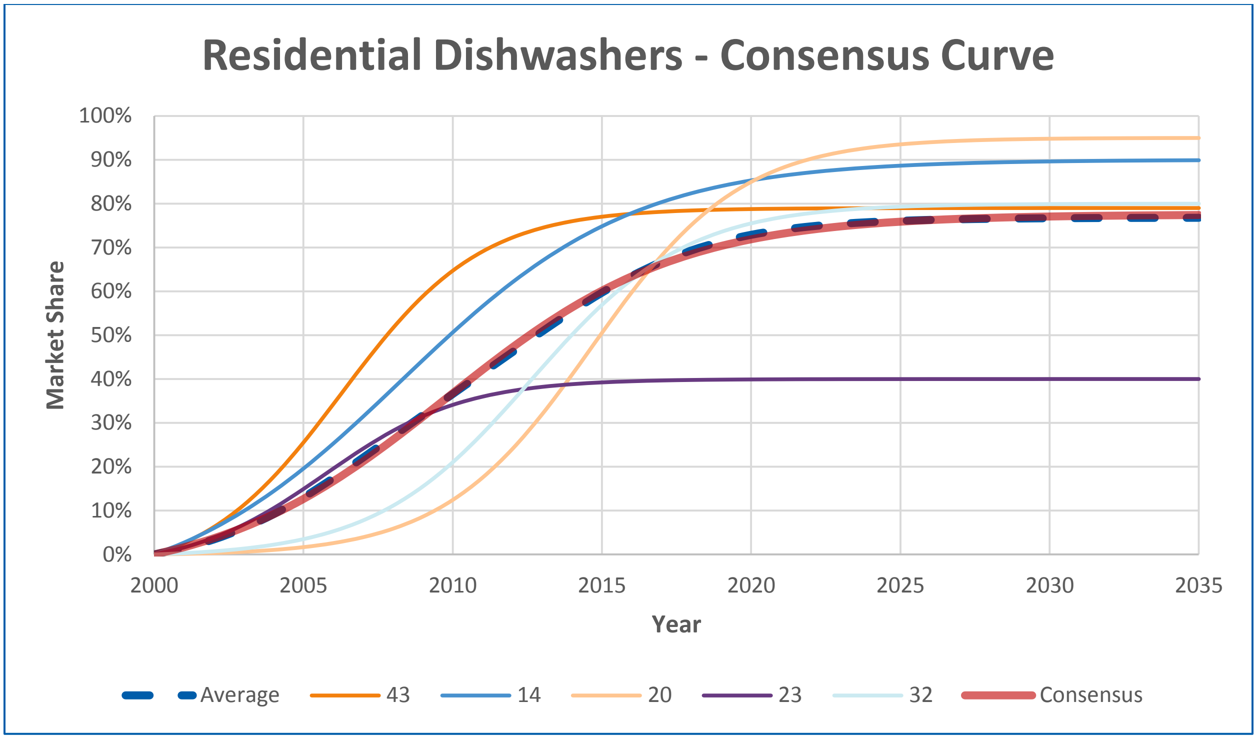

Figure 11. Standard fed 17 – residential dishwashers – consensus curve

Appendix C. Net Program Savings: Attribution Detail

This appendix provides additional information about the attribution scores for standards that represent significant savings.

C.1 Standard 28b, Televisions Tier 2

Standard 28b attribution was evaluated during the 2010-2012 code cycle with the attribution panel in June 2013. The panel choose to evaluate both tier 1 and tier 2 together as they were adopted in the same code cycle. The panel determined an overall attribution score of 60% when weighted became a final attribution score of 61% for televisions. For factor one the panelists noted that the IOU's and their consultants there were multiple proposed test methods and that the bulk of the credit was for factor one was based on the IOU defense of proposed test method. For factor two, the panel distinguished between secondary and primary data sources for technical information and gave more credit towards IOU efforts when primary data collection took place. Additionally, the panel concluded that data from incentive programs run by IOUs could be considered primary data even if the data was never intended to support codes and standards efforts. For factor three, the panel felt that the IOUs were instrumental in mounting support for the standard and defending to the legislature against fierce opposition from industry groups such as the consumer electronics association. While the panel gave credit to the IOUs for helping build a coalition to support adoption they also provided credit to those groups that were a part of the coalition supporting the standard particularly industry groups and the CEC.

C.2 Standard 29 & 30, Small Battery Chargers – Tier 1 & 2

Standard 29 was combined with standards 30 and 32 into one rulemaking. Standards 29 and 30 cover small battery charger rated at more than 20 watt-hours, and standard 32 covers larger battery chargers with rated inputs of greater than 2kW.

The panel determined an overall attribution score of 58% for small battery chargers (standard 29 and 30). For factor one, the panel gave credit for the C&S program developing models to estimate energy savings, and for incorporating NOMAD curves for each type of battery charger. Factor two scores considered the origination of CEC data funded by PIER, and C&S program analysis of secondary data. Arguments also focused around the C&S program work developing incremental cost inputs, leading to a factor two score of 50%. Factor three discussions again focused on data availability and C&S program support for the standard.

C.3 Standard 32, Large Battery Chargers, Effective 1/1/2014

The panel determined an attribution score of 90% for large battery chargers. This attribution score was given for each of the three factor areas. After reviewing the evidence provided, they determined that the C&S program did the vast majority of the work required to create this standard.

For factor one, the panel determined that the C&S program developed the adopted test procedure for large battery chargers. The panel determined that for factor two, the C&S program wrote the majority of the language, and assigned an accordingly high attribution score. Factor three discussions again focused on data availability and C&S program support for the standard.

C.4 Federal 11, Residential Refrigerators and Freezers

Federal 11 covered three types of residential refrigeration: refrigerators, refrigerator-freezers, and freezers. This standard regulates over 18 separate product classes based on refrigerator/freezer type, total volume, location of freezer compartment, method of defrost, existent of automatic ice maker, and existence of through-the-door ice maker.

This standard received a high attribution score 37%. The factor one attribution score was particularly high, with a score of 60%. This score was due to the C&S program proposing test procedures for automatic ice makers, including data and placeholder values, and the C&S program's push to incorporate data from an SCE study of bottom mount refrigerator-freezers. The discussion noted that in this standard, there was a clear pattern of causation, where the C&S program proposed a change to the standard, and DOE subsequently adopted that proposal.

Factors two and three received scores of 30% and 20%, following panel discussions where the panel pulled on their experience in DOE discussions revolving around demand response requirements for refrigeration requirements. The panel decided for factor two that the C&S team acted as a participant rather than a leading force. Factor three received a score of 20% after the panel looked at the evidence provided regarding refrigeration vacuum insulation panels, and considered influence other stakeholders had on the feasibility of implementing the standard.

C.5 Federal 23, Small Electric Motors

Federal standard 23 regulates Small Electric Motors under the NEMA definition of a small electric motor, and covers three product classes including capacitor-start induction-run, capacitor-start capacitor-run, and polyphase motors.

The C&S program advocated for the inclusion of electronically commutated motors (ECMs) during this rulemaking, but they were not eventually added to the standard language. The panel discussed this, but did not attribute any factor one credit for the effort. Regarding factor two, the panel was surprised to see that a supplemental rulemaking included larger motors, but that the C&S program did not claim any credit for the addition. A similar discussion was had regarding the C&S program contributions to factor three. All in all, the panel gave 0% attribution for factor one, and 10% each for factors two and three.

C.6 Federal 13, Fluorescent Ballasts

Fluorescent ballasts are used to operate and limit the amount of current running through a lamp in commercial and limited residential applications. Standard 13 regulates rapid start ballasts, programmed start ballasts, and instant start ballasts. The covered ballasts operate at input voltages of 120 or 277 volts, and have a power factor of 0.9 or 0.5 for commercial and residential applications, respectively.

The panel gave a score of 80% for factor one. These discussions focused on how engaged the C&S program was regarding the development of and advocacy for a realistic test method. The panel felt that the C&S program worked against considerable opposition from other stakeholders to maintain the stringency of the standard. For factor two, the panel gave a score of 65%. The C&S program successfully advocated for the inclusion of T5s and T12s into the standard. This advocacy, in the eyes of the panel, prevented a compliance loophole, and gave the panel confidence that the C&S program had made a stronger standard. Factor three also received a high score of 80%. This was due to the C&S program pushing back against opposition from other stakeholders and successfully maintaining the stringency of the standard.

Appendix D. Uncertainty Analysis Detail

This section provides additional information on the inputs used for the Monte Carlo analysis that was used to explore the uncertainty around the Phase One evaluation results. As noted in Section 5.5 of the evaluation report, the Monte Carlo analysis is structured to allow each of the inputs shown in Table 76 to be randomly selected from a range with bounds set by the user and a triangular distribution similar to a normal distribution within the set bounds.

Cadmus considered the specific inputs for the six standards that were found to be responsible for over 99% of the net electric energy savings. The bounds for the inputs for these standards were set as indicated in Table 76. The bounds for all other standards were set to be plus or minus 20% as shown in the last line of the table.

Table 76. Range of Inputs to Uncertainty Analysis for Selected Standards

REF	Standard	Unit Savings			Market Volume	Compliance	NOMAD	Attribution
		Energy kWh	Demand kW	Gas Therms				
Std28b	Televisions - Tier 2	± 5%	± 5%	± 20%	± 10%	± 5%	± 20%	± 20%
Std 29	Small Battery Chargers–Tier 1	± 20%	± 20%	± 20%	± 10%	± 10%	± 20%	± 20%
Std 32	Large Battery Chargers	± 20%	± 20%	± 20%	± 30%	± 10%	± 20%	± 20%
Fed 11	Residential Refrig./ Freezers	± 10%	± 10%	± 20%	± 10%	± 10%	± 20%	± 20%
Fed 12	Residential Room AC	± 20%	± 20%	± 20%	± 10%	± 10%	± 20%	± 20%
Fed 13	Fluorescent Ballasts	± 20%	± 20%	± 20%	± 20%	± 10%	± 20%	± 20%
All other standards		± 20%	± 20%	± 20%	± 20%	± 10%	± 20%	± 20%

As noted in Section 5.5 of the report, we set the input ranges based on our judgement that the audience would be interested in the expected change in results in cases where inputs were different from the evaluated values.

To see if we might gain some additional insight, we reviewed the source data for the inputs to the six standards with the bulk of the savings. We summarized the results of this review in Table 77. Based on this review, we made the following adjustments to the uncertainty ranges for these standards.

- For Standard 28b, Standard 29, Federal 11, and Federal 12, we judged that the market data was unlikely to vary by as much as 20%. We set the range as plus or minus 10% accordingly.
- For standard 32, we found that market data was more difficult to obtain and judged that the market could vary by more than 20%. We set the uncertainty range at plus or minus 30% for this reason.
- For Standard 28b and Federal 11, we had substantial data to use in our analysis of unit savings. On this basis, we judged that the values were unlikely to vary by as much as 20%. For this

reason, we set the uncertainty ranges at plus or minus 5% for Standard 28b and plus or minus 10% for Federal 11.

- For compliance, we include the calculated confidence and precision of the evaluated values in Table 77. We adjusted the compliance uncertainty range for all six standards to be consistent with the precision values for the samples we evaluated.

Table 77. Additional Detail on Sources and Uncertainty Ranges

REF	Unit Savings		Market Volume	Compliance	NOMAD	Attribution
	Energy kWh	Demand kW				
Std28b	Values have high confidence and precision based on large random sample		Single source: NPD	Values have high confidence and low precision based on large random sample (95/5 confidence/ precision)	Value 69% Range 55% to 83%	Value 61% Range 49% to 73%
Std 29	Weighted average values of many product types		Three sources but not for most product types	121 products sampled. (90/8 confidence/precision)	Value 36% Range 29% to 43%	Value 58% Range 46% to 70%
Std 32	Cadmus used limited data to calculate unit values based on duty cycle.		Assigned a large range due to very limited market data	42/54 models checked were compliant. (90/11 confidence/precision)	Value 78% Range 62% to 94%	Value 90% Range 72% to 100%
Fed 11	Values based on DOE TSD and DEER		Single source: AHAM	165/185 models found to be compliant (90/6 confidence/ precision)	Value 15% Range 12% to 18%	Value 37% Range 30% to 44%
Fed 12	Weighted average values of product classes and res/ commercial sector mix.		Single source: AHAM	81/89 models found to be compliant (90/5 confidence/ precision)	Value 22% Range 18% to 26%	Value 24% Range 19% to 29%
Fed 13	Weighted average values of product types		DOE and US gov't. sources to calculate California sales	161/200 models found to be compliant (90/6 confidence/ precision)	Value 27% Range 22% to 32%	Value 74% Range 59% to 89%

Appendix E. Responses to Comments Received on Draft Report

This appendix includes in the table below all of the comments received on the draft document through the CPUC Evaluation Project Public Review Site (http://www.energydataweb.com/). For each comment, the table includes the responses developed by the CPUC staff, the CPUC advisors, and the evaluators.

No.	Topic	Section/ Reference:	Question or Comment	Change(s) to Report?	Response
1	Interactive effects for SoCalGas (SCG)	Table ES-7, Table ES-8, Table 24, and Table 30.	Comment: The 2010-12 C&S Impact Evaluation report states (pg. 3) that "CPUC policy is to exclude interactive effects from SCG savings estimates." In the draft Phase One Appliances report, there isn't a similar discussion and interactive effects are shown for SCG in Table ES-7, Table ES-8, Table 24, and Table 30. There are also tables that show savings that exclude interactive effects, but it may be helpful to explain which savings will ultimately be attributed to SCG (presumably excluding interactive effects given the comment from the 2010-12 Impact Evaluation).	Yes. Text only.	We continue to provide evaluated savings for SCG that exclude interactive effects consistent with CPUC policy. The text has been revised (in the Executive Summary and in the body of the report) to clearly identify attributed SCG savings.
2	Table 4 labels for "Potential" and "IOU Share"	Table 4; pg. 15	Comment: Given that "Potential" and "IOU Share" could be interpreted different ways, it may be helpful to change "Potential" to "Statewide Potential" and "IOU Share" to "IOU Net Program Savings."	Yes. Text only.	We have decided to keep table labels consistent with prior report. The text has been revised (in the Executive Summary and in the body of the report) to emphasize that values are statewide unless they are explicitly labelled as IOU Share.
3	Savings from EISA lighting standards	Section 2.4; pg. 20	Comment: The report notes that savings from four lighting standards (Std 11b, Std 25, Std 26, Std 27) have discontinued because of preemption by federal lighting standards established by Energy Independence and Security Act of 2007 (EISA 2007). During the 2010-12 Impact Evaluation process, the IOUs submitted a memo (January 24, 2014) to the CPUC that outlined the history of IOU activities that contributed to the EISA lighting standards and suggested that the CPUC should consider attribution. Ultimately, the 2010-12 Impact Evaluation didn't include a discussion of the memo or a recommendation on how or if EISA lighting savings should be evaluated for the IOUs. Could the final Phase One Appliances report include a discussion of that memo and provide a recommendation on whether these federal standards should be considered for evaluation in a future cycle?	No	A similar comment (reference #12) was received on the prior evaluation report (Statewide Codes and Standards Program Impact Evaluation Report [of program years 2010-2012], DRAFT 07032014. As documented in our response to that comment, "the evaluation team was focused on determination of attribution for standards for which savings were included in the IOU responses to CPUC requests." In the current evaluation cycle, there were no estimated savings for the Federal EISA standard in the IOUs response to the CPUC data request. The suggested recommendation is not necessary: If the

No.	Topic	Section/ Reference:	Question or Comment	Change(s) to Report?	Response
					IOUs estimate savings for a standard, then the evaluation will include it.
4	Program Adjustment for Televisions	Section 4.3; pg. 37	Comment: The second bullet point on page 37 states that, "No IOU programs have provided incentives for televisions in the two years prior to the 2013 effective date of the Tier 2 standard so there is no basis for an adjustment to the Tier 2 NOMAD." For the record, the IOUs did provide TV incentives for levels that meet or exceeded Tier 2 levels from Q1 2010 thru at least the standard's effective date of January 1, 2013. (See Figure 3-1 in the Business and Consumer Electronics Program Impact Evaluation Report: http://www.calmac.org/publications/WO34_BCE_Impact_Evaluation_Report_-_Phase_1_FINAL_2013-04-15.pdf). Given the first bullet point on page 37, we don't believe this will materially change the Impact Evaluation analysis but we wanted to comment for accuracy.	Yes. Text only.	The report language has been revised to reflect the information included in the Business and Consumer Electronics Program Impact Evaluation Report.
5	Savings for Standard 30 Small Battery Chargers – Tier 2	Section 5.2.3; pg. 48. Appendix Section B.4; pages 75-76.	Comment: The report states that, "the evaluation team determined that the market for tablets was in its infancy at the time this standard was developed, therefore, it contributes no savings." Could you expand on this rationale? We're not aware of that this rationale has been considered for any other standards in the past and are concerned about precedent. There have been multiple past occasions where the C&S team has explored or developed standards for emerging technologies that were poised for market expansion—and thus important energy impacts/savings. Further, the Bass curves presented in the Appendix for this standard certainly indicates that the standard changed the normally occurring market adoption and resulted in savings.	Yes. Text only.	The main reason for the absence of evaluated savings is not that the technology was in its infancy. Rather, the issue is that the evaluators are unable to find any information regarding an appropriate baseline level of efficiency. This issue was reviewed in the C&S Project Coordination Group meeting on two occasions along with our request for baseline data. We rely on data provided but we have not received any evidence of a baseline level of efficiency. The report text has been revised to clearly state the issue.
6	Savings for Standard Federal 13, Fluorescent Ballasts, Effective November 11, 2014	Table 49 and Table 50	As shown in Table 49 and Table 50 of the evaluation, the evaluation team found smaller energy and demand unit savings than the IOU estimates, as well as a smaller market size and fewer annual shipments, leading to a fraction of the estimated potential, gross, and net savings (Draft CPUC Report 2016, p. 53). We have reviewed the analysis to identify discrepancies between the evaluation and the IOU team estimates. In the sections below we provide comments on the annual shipments and the per unit savings analysis for fluorescent ballasts.	Yes. Evaluated savings and text.	After review of the comments provided, we revised the evaluated savings from fluorescent ballasts. The revised values are about three times larger than the earlier finding and are from 60-80% of the IOU estimates for potential, gross, and net savings. These revisions have been included in the report and appendices.

No.	Topic	Section/ Reference:	Question or Comment	Change(s) to Report?	Response
6a	IOU C&S Program Comment on Ballast Shipment Estimates		Cadmus estimated 717,887 annual ballast shipments in 2015 in California, in the Appendix of the evaluation. The IOU estimate of annual ballast shipments previously submitted was 1,795,746. Upon further review, we find both of these numbers to be too low. The DOE's estimate of national sales in 2015 is approximately 119 million (DOE 2011 Technical Support Document from the DOE Final Rule). Assuming that California comprises about 12% of the national market, the CA shipment estimate would be approximately 14 million, and we recommend this value be used in the evaluation. (Our previous estimate of 1.79 million was submitted in error – the 12% adjustment for CA population was accidentally applied twice). The evaluation conducted four calculation steps to derive annual ballast shipments from a starting point of the total stock of fluorescent lamps. We believe these steps introduced uncertainty and resulted in understated ballast shipment estimates. We recommend that the evaluation team reduce the margin for error associated with these calculation steps, and instead use DOE's models. However, if the evaluation does proceed with the current approach, we provide the following comments for consideration.		We recommend that data from a 2011 report not be used to substantiate shipment estimates since more recent data is available. The LED commercial market has transformed more rapidly than anticipated when the analysis was completed nearly 5 years ago.
6a	On Converting Lamp Stock to Lamp Shipments		It appears the evaluation team obtained the total stock of fluorescent lamps and divided it by an assumed measure life of 19.43 years to derive the annual lamp sales. However, 19.43 years is a fixture life, not a typical lamp life. Lamps are replaced much more often than fixtures. Lamps typically are rated for 24,000-30,000 hours (which means half are burned out by 24,000-30,000 hours). This translates to about 5-7 years life in most commercial / industrial applications (assuming 3,000-5,000 hours). DOE's lamp life assumptions are provided here: If the evaluation team were to divide the total installed base by a more appropriate lamp life (~5-7 years) rather than fixture life, it would calculate a much higher number of annual shipments – about 45 to 50 million, rather than the 17 million calculated. This would in turn lead to higher ballast shipment estimates. Additionally, DOE provides lamp shipment numbers is the General Service Fluorescent Lamp Final Rule TSD (about 450 million nationally, about 52		Cadmus: We reviewed our analysis and found that section 8.2.4 of the TSD provides average lifetime and not the maximum which is what we used. Our analysis should be updated to use 12.6 years (C), 10.3 years (I), and 15 years (Res) which would reflect an updated average ballast lifetime of 12.98 years We agree with the comment regarding ballast measure life (which we have revised from 19.43 to 12.98 years) and ballast to fixture replacement rate (revised from 8:1 to 4:1).

No.	Topic	Section/ Reference:	Question or Comment	Change(s) to Report?	Response
			million in CA assuming 12% population). It would be more straightforward to use these lamp sales estimates rather than try to convert a stock estimate into a sales estimate.		
6a	Converting Lamp Shipments to Ballast Shipments		The evaluation team assumed that 1 ballast is shipped for every 8 lamps shipped. However, the relationship between ballast sales and lamp sales is not a well-established relationship in the lighting industry, and this conversion rate could be impacted by a number of factors, so we recommend caution in using this conversion. By our review, we find a smaller number of lamps are likely shipped for every ballast shipped. For example, most ballasts are rated at about 50,000-60,000 hours, and DOE's Final Rule states that typical ballast life is 10-15 years (Final Rule page 70582), which is about double lamp life. Also, 2-lamp ballasts are the most common ballast shipped, for most product classes except sign ballasts (Final Rule TSD Page 5-14). Because lamp life is twice as long as ballast life, and 2 lamp ballasts are the most common type, we would expect to see about 4 lamps sold for every 1 ballast sold, in most applications. DOE research finds that for 4' MBP lamps, 1 and 2 lamp ballasts are as common as 3 and 4 lamp ballasts – suggesting an average of about 2.5 lamps operate per ballast (for most other product classes, 2 lamp ballasts represent that vast majority). Accordingly, the number of lamps sold per ballast sold may be closer to 4-5.		We agree with the comment. We revised to a 4.72 to 1 ratio and updated our calculations accordingly.
6a	The Incursion of LED Tube Lamps		The evaluation appears to have found that LED tubes have reached 50% market share in the linear tube lamp market, though we did not find a citation for this. We agree that LED tubes are gaining in market share but believe fluorescent tubes are still a significant majority. According to DOE's NIA TSD spreadsheet from the latest Final Rule for general service lamps, LED tubes were projected to hit ~3.5% by 2015, ~10% by 2020, and ~44% by 2030. It is possible that LED adoption has outpaced DOE's original estimate of 3.5% by 2015, but it is not likely beyond ~10-15%. We request more information from the evaluation team regarding its estimate that 50% market has already been achieved.		Cadmus: Information we received from two prominent manufacturers – GE and Philips – indicated that 2015 was the year LED and Fluorescent ballasts equaled one another for the first time. We don't believe we should use the DOE's technical document for the basis of what's happening in the market given it was developed 6 years ago.

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6b	IOU C&S Program Comment on Ballast Per Unit Savings		The per unit savings analysis in the evaluation appears to be very similar to the IOU analysis for most of the major product types, but the evaluation does not include sign ballasts (product class 5) in its analysis. Despite representing a small portion of the total sales, sign ballasts have very high per unit savings, and thus are an important component of the per unit savings calculation. Below we provide our per unit savings methodology. We generated market share estimates for each product class based on data provided in Chapter 10 of the Final Rule TSD, and associated shipments excel spreadsheet (Final TSD, Tables 10.3.3 through 10.3.7). These tables provide the following data:		We agree with the recommendation. Savings from sign ballasts (Product class 5) are now included in the evaluated savings.
			Within each product class, we have obtained the per unit savings from the most representative scenarios (lamp type and number of lamp) analyzed by DOE. Where multiple usage scenarios were analyzed as ‘representative’ within one product class, the values were averaged to generate one representative value. These per unit savings values were weighted by the relative market share of each product class:		
			We recommend that the evaluators include the sign ballast (product class 5) savings in its analysis of per unit savings, given the significant savings achieved by these products.		