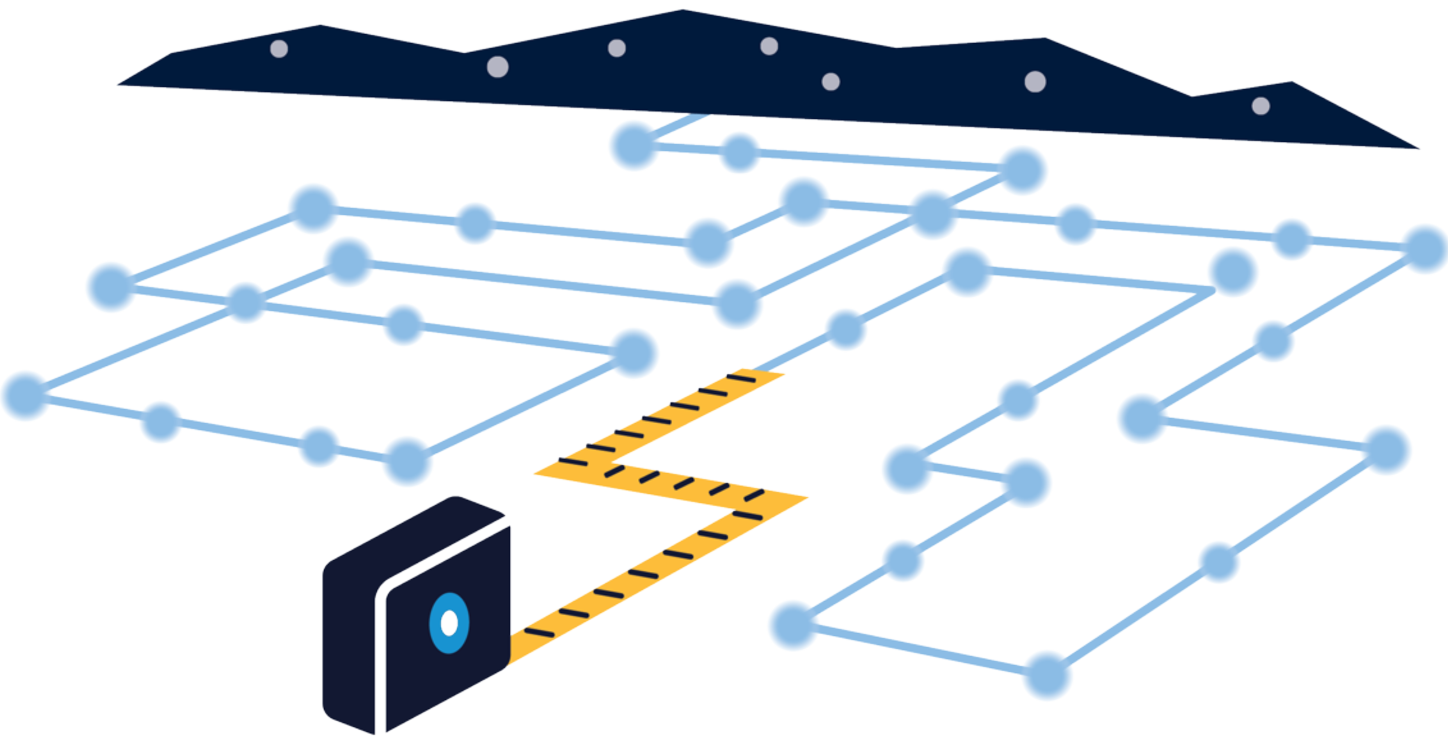
Final Report: PY 2016-2018 Appliance Standards Evaluation Vol. 1

California Public Utilities Commission Energy Efficiency Program Evaluation of Group B Sectors



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Acknowledgements

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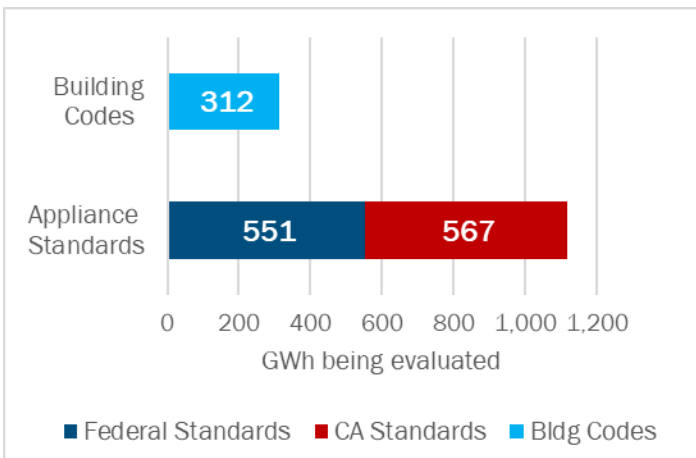
1. Executive Summary

This report describes the evaluation of the electric and gas savings reported by the Investor- Owned Utility statewide Codes and Standards (C&S) Appliance Advocacy Program for program years 2016, 2017, and 2018. It is volume one of a two volume report. Volume one focuses on California state and federal appliance and equipment (product) minimum energy efficiency levels (standards). Volume two will be released at a later date and will focus on California minimum energy efficiency levels for whole building performance (state building codes). The statewide program administrator for this program is Pacific Gas and Electric (PG&E). The overall program is jointly implemented by the four California investor-owned utilities (IOUs). In addition to PG&E, the other IOUs include Southern California Edison (SCE), Southern California Gas (SCG), and San Diego Gas and Electric (SDG&E).

For codes and standards introduced during this three-year period, product standards dominated the new C&S savings. They account for 78% of reported electric savings that became effective from 2016 through 2018. Building codes account for less than a quarter at 22%. The IOUs reported 32 new standards in total. Of these, 15 were introduced in 2016, seven in 2017, and 10 in 2018. Grouping these another way, 13 standards were federal and 19 were state. These savings contributions are illustrated in Figure 1.

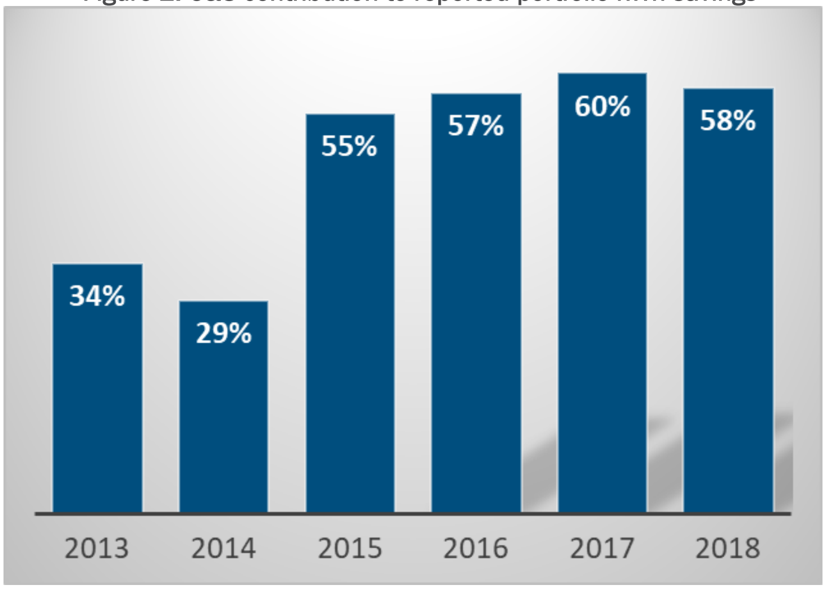
Figure 1: IOU Contributions from reported savings for new codes and standards savings being evaluated (2016-2018)



Source: CEDARS

The two codes and standards advocacy programs (building codes advocacy and appliance standards) have been contributing to an increasing percentage to the overall IOU energy efficiency portfolios. The percentage contribution of reported C&S to the entire energy efficiency portfolio over the last few years is illustrated in Figure 2. A key reason for this increase is because many appliances have become much more efficient over time. When programs install new technologies and replace existing ones, the energy savings is not as big. As a result, there are less cost-effective programs outside of C&S. This is especially apparent in lighting where light-emitting diode (LED) technology has been rapidly adopted by the market rendering most incandescent and some fluorescent technology obsolete, even without more stringent standards.

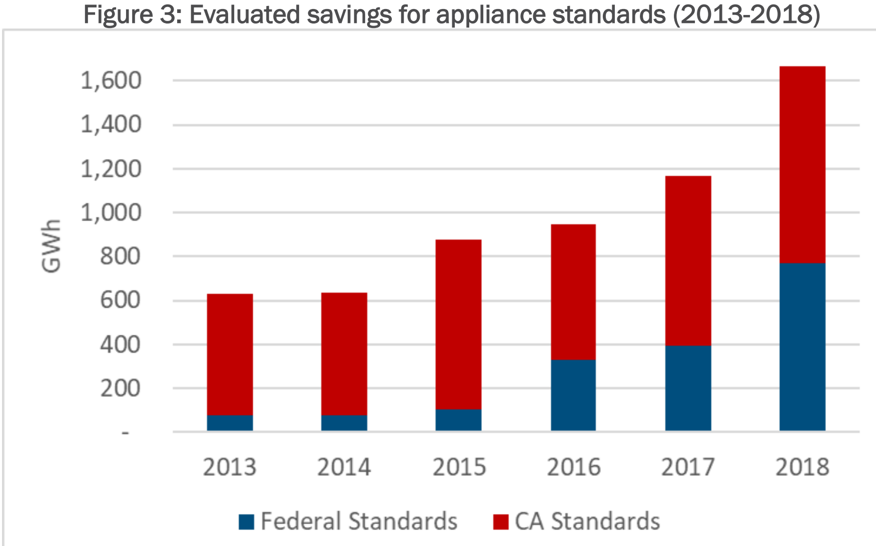
Figure 2: C&S contribution to reported portfolio kWh savings



Source: CEDARS summary_report_ by "Program Category" (a.k.a. claimed net savings)

The increase is not just because other programs have been shrinking. The evaluated savings from standards has been increasing over time also. The next graph (Figure 7) shows this and illustrates how federal standards have been accounting for a larger share of appliance standard savings over time. For example, in 2013 federal standards accounted for 12% of savings. By 2018 their contribution increased to 46% of standards advocacy program savings.

Figure 3: Evaluated savings for appliance standards (2013-2018)



Source: 2013-2015 C&S evaluation (CADMUS vol 1) and 2016-2018 C&S evaluation (ODC vol 1)

1.1 Study Purpose

The purpose of this evaluation is to validate the electric and gas savings reported by these IOUs for their code and standard advocacy subprograms for the years 2016, 2017, and 2018. These savings are used to calculate program cost-effectiveness and as inputs for future planning and goal setting at the statewide level.

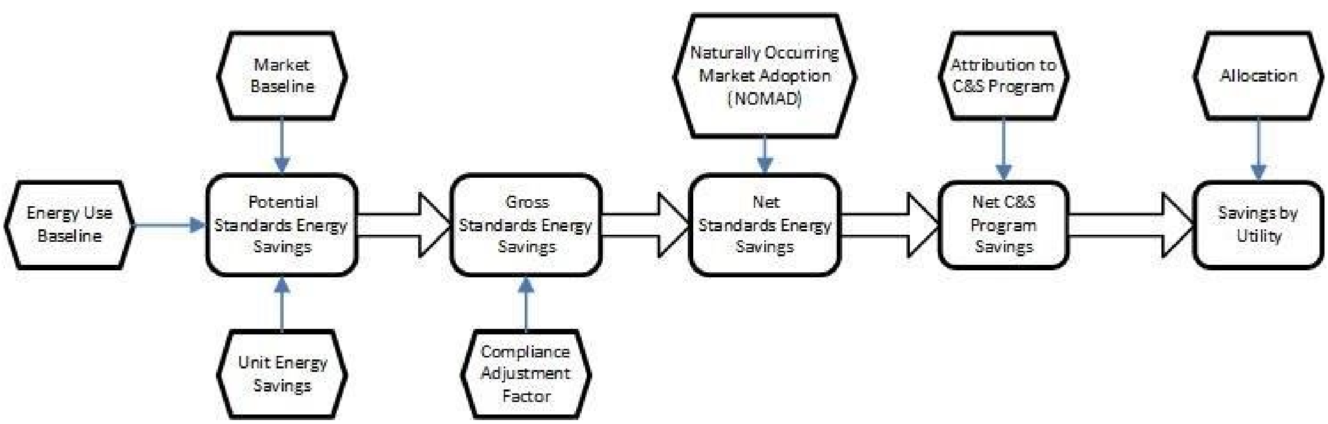
The evaluation includes standards with effective dates from January 1, 2016 through December 31, 2018. For example, in 2018 the IOUs reported C&S savings of 1,789 GWh[1] from 149 codes and standards. Of these 149, only 32 product standards became effective during the evaluation period between 2016 and 2018 (**19 State standards[2] and 13 Federal standards**). These 32 standards account for 41% (733 GWh) of the C&S savings reported in 2018 and are the focus of this evaluation.

1.2 Method

The evaluation followed California's evaluation protocols for codes and standards[3]. The evaluation steps involved with the C&S program are similar in some respects to other programs such as lighting or HVAC rebates, and different in other aspects. For example, unlike programs with a database of participants, for C&S everyone is a participant by default because they legally cannot choose to purchase equipment that does not meet the minimum efficiency standard. This implies that 1) the "number of units" includes identifying all sales throughout the State, and 2) unit energy savings are from prior code to new code or based on market averages if there is no prior code to compare to.

To understand how the IOUs influenced policy decisions a key task of the evaluation is to build the counterfactual, **"What would have happened if the IOUs were not involved in the process of appliance standard development?"** To answer this question the protocols lay out a series of steps to move from what is theoretically possible (Potential Standards Energy Savings) to how much of that can be attributed to the IOU program (referred to as Net C&S Program Savings). The full process we used to calculate net savings by utility is depicted in Figure 4. The next sections explain each step of the process.

Figure 4: Codes and Standards Program Evaluation Protocol Steps



1.2.1 Potential Standards Energy Savings

Since appliance standards affect the entire state by default, the first step is understanding the market potential savings. This is estimated by multiplying the unit energy savings (UES) by the number of units sold. There are two ways to determine the UES for a particular appliance. The first way is to compare an appliance's energy use under the prior standard to its energy use under the new standard. The difference is the unit energy savings used for the evaluation. When no prior standard exists, the new standard is compared to the energy

[1] One GWh is equal to 1,000,000 kWh. One MW is equal to 1,000 kW. One MMTherm is equal to 1,000,000 therms of gas.
[2] State energy efficiency standards also are referred to as Title 20 - the energy conservation section in the California Code of Regulations
[3] California Energy Efficiency Evaluation Protocols: Technical, Methodological, and Reporting Requirements for Evaluation Professionals, CPUC, April 2006. The tool for combining the protocol steps to produce Savings by Utility is the Integrated Standards Savings Model (ISSM)

use of products already in the market[4]. Details for products where no prior standard existed are discussed in Appendix E.

To develop baseline estimates for potential savings, we developed a sampling plan that prioritized standards with the higher savings in the IOU claims.[5] This was a two-stage process. The first stage identified the standards for claimed products that were adopted and that the IOUs worked to promote. The second stage sampled retailers and distributors that sell relevant products.

- First Stage: State- or federally regulated products require that manufacturers perform two steps to get their products approved. First, they must demonstrate that the product meets the energy efficiency requirements of the regulations. Second, they must also certify the product's performance with the California Energy Commission (Energy Commission). The Energy Commission maintains an online database of these certified products. This is one of the main data sources we used to identify product specifications.[6]

  To test this database for reasonableness we also reviewed and assessed prior C&S evaluation reports, C&S program plans, Title 20 standards, Code and Standard Enhancement (CASE) studies[7], Code Change Savings Reports[8], and federal standards.

- Second Stage: Identify and sample relevant retailers and distributors for each product. Given the universe of product possibilities, this stage requires casting a wide net while balancing schedule and budget constraints. The focus of our efforts was to determine the vendors that represent a large percentage of the market share for each product type and their sales channels.

1.2.2 Gross Standards Energy Savings

All products sold in the market may not meet the new standard when it becomes effective. This is because it takes time for inventory stocked under the prior standard to be sold. In addition, some manufacturers (typically from foreign countries) may be unaware of the new standards or simply try to bypass the regulations. We adjusted savings from all products (potential savings) by our estimated rate of compliance with the new standard to determine gross savings.

For standards applicable to multiple classes or categories of products (such as small, large, and very large air conditioners and heat pumps), we first estimated the distribution of product sales and the proportional market share of each product category[9] and categorized these as high, medium, and low priority. Next, we set sample sizes based on priority. For example, over 90% of products for high priority, 70% for medium, and 50% for low priority. We did not examine any product categories that accounted for less than 1% of the market share.

We examined three different distribution channels for applicable products: direct sales from the manufacturers, sales to customers through a wholesaler or distributor, and sales in retail markets. For products that are sold through multiple distribution channels, we used Technical Support Documents

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[4] We construct a sale weighted average UES by product class and compare to the new standard.
[5] The sample plan for estimating compliance also followed this prioritization process.
[6] Savings was based on product information. We did not perform independent testing of product actual energy usage.
[7] Codes and Standards Enhancement (CASE) studies are public documents that provide recommendations to support the California Energy Commission's proceedings to update California's Appliance Energy Efficiency Standards. https://title24stakeholders.com/measures/cycle-2016/
[8] These are internal reports documenting IOU advocacy activity during the course of the standards setting proceedings. They are used by evaluators to gather background for research into program advocacy activity.
[9] Where available, we used market share information reported by the IOUs in code change savings reports that the IOUs provided to the evaluation team.

published by the US Department of Energy (US DOE) and interviews with industry experts to determine the relative market share of each channel.

To define distribution channels, we considered "manufacturer" to mean an Original Equipment Manufacturer of the product, such as Carrier for commercial air conditioners. We considered "distributor" and "wholesaler" to mean resellers whose customers are primarily other businesses or contractors. We considered "retailer" to mean companies who sell products directly to consumers. This included both retailers with a physical storefront (i.e., brick-and-mortar retailers) and online retailers.

Gross savings is an interim step. The main goal for the evaluation, however, is to estimate savings attributable to advocacy program activities. These are referred to as "net" savings. This is where the C&S evaluation differs from other program evaluations. As mentioned earlier, since a standard covers all products sold in the market, everyone who purchases a product is a participant. As such, the traditional approach of moving from gross savings to net savings by identifying free riders (participants who did not need a financial incentive to participate but received one anyway) does not apply. To compensate for this, the C&S evaluation substitutes two other metrics to determine net standards energy savings: Naturally Occurring Market Adoption (NOMAD) and Attribution.

1.2.3 Net Standards Energy Savings

NOMAD is an estimate of what the market was doing without any IOU interventions. It considers questions such as: What was the trend for appliance standard development? How was the product developed? How was the product being applied? What were consumers demanding?

We used an online Delphi method to determine the NOMAD curve for each standard in the evaluation scope. The Delphi method is a structured communication technique that gathers feedback from a group of geographically dispersed experts to ultimately converge into one aggregated response. The Delphi process is commonly used in technology forecasting and policymaking. For the evaluation we identified and recruited 3-5 experts in each field related to the standard being evaluated. This ensured each standard type had a different panel of experts assessing the market for that technology. The final NOMAD curve used for the evaluation was the average of expert estimates. NOMAD does not however, tell us how much influence the IOU advocacy effort had on the product standard.

1.2.4 Net C&S Program Savings

The C&S Advocacy Program's purpose is to advocate for the development and adoption of stricter codes and standards. The degree of influence that IOU advocacy has on the final adopted standard is termed "Attribution". Net C&S Program savings is derived from adjusting Net Standards Energy Savings by attribution. Were IOUs proactive in pressing stricter standards or were they only providing technical support in the process? If they lobbied, did they lobby proactively for their position and how broad was their effort? Did regulators listen to them and adopt their recommendations?

To answer these questions, the evaluation protocols set forth specific factors. The method focuses on three areas. These areas represent the fundamental requirements that must be met for the Energy Commission (for state standards and building codes) or the US DOE (for federal administrative rulemaking) to adopt a standard. The protocols describe these factors as follows:

- Development of compliance determination methods and other special analytic techniques
- Development of code language and technical, scientific, and economic information in support of the standard

- Demonstrating the feasibility or market acceptance of standard adoption

These factors and how they are evaluated are discussed in more detail in section 3.7.1.

1.2.5 Savings by Utility

Once Net C&S Program Savings are calculated, the final step in the evaluation is allocating net savings to each IOU service territory. The IOUs account for about 80% of all electric sales and 99% of all gas sales statewide[10]. Savings credit is allocated by applying IOU service territory specific electric and gas sales ratios to total statewide sales.[11] Adjusting for allocated (IOU Only) savings renders the evaluated savings value (Savings by Utility) that is compared to the IOU savings claim reported to the CPUC.

The results of these steps are presented in the next section.

1.3 Findings

The evaluation found electric and gas savings in each program year, although not always as much as the IOU's claimed. In general,

- In 2016 we found 8% less GWh savings than claimed by the IOUs, 20% less MW savings, and 12% more gas savings.
- In 2017 we found 1% less GWh savings than claimed by the IOUs, 19% less MW savings, but 39% more gas savings.
- In 2018 we found 47% more GWh savings than claimed by the IOUs, 5% more MW savings, and 26% more gas savings.

On a cumulative basis (using first-year savings) for the 2016–2018 period, the evaluation found 30% more GWh savings than the IOUs reported, 3% fewer MW, and 27% more MMtherms.

Over this period, the evaluated savings of 1,450 GWh and 50 MMTherms translates to avoiding approximately 1.4 million tons of CO2 released into the atmosphere.[12] This is equal to the CO2 emissions generated from the total energy use of approximately 155,816 residential homes annually.[13]

Adopted standards for faucets and toilets included water savings. We estimate these standards are expected to save 10.9 billion gallons of water annually. In California, this is enough water to meet the indoor and outdoor supply needs of about 22,000 average households annually.

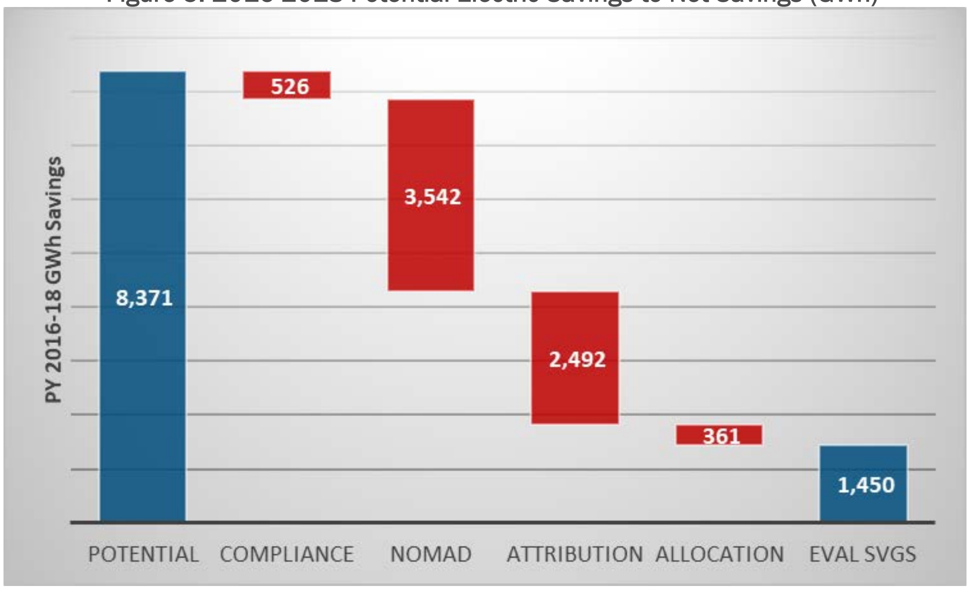
In addition to water savings, we estimate a savings of 52.5 GWh in avoided energy use by not transporting and processing this water.

For electric savings, the new standards had the potential to save 8,371 GWh. Most products complied or exceeded the new standards. The IOUs ultimately received credit for saving 1,450 GWh (17%). The largest downward adjustments came from two factors. One factor was that market forces (NOMAD) pulled the more efficient technologies along. This was especially true as LED lighting became popular in more applications.

[10] California Energy Commission, https://ecdms.energy.ca.gov/gasbyplan.aspx and https://ecdms.energy.ca.gov/elecbyplan.aspx
[11] Electric and gas sales have been used historically. In the next evaluation cycle, program budget will be used to allocate savings per D.16-08-019.
[12] Combines first year savings only. Does not include layering. Source EPA GHG calculator, https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator.
[13] Energy use includes electricity and natural gas. https://www.epa.gov/energy/greenhouse-gases-equivalencies-calculator-calculations-and-references#houseenergy

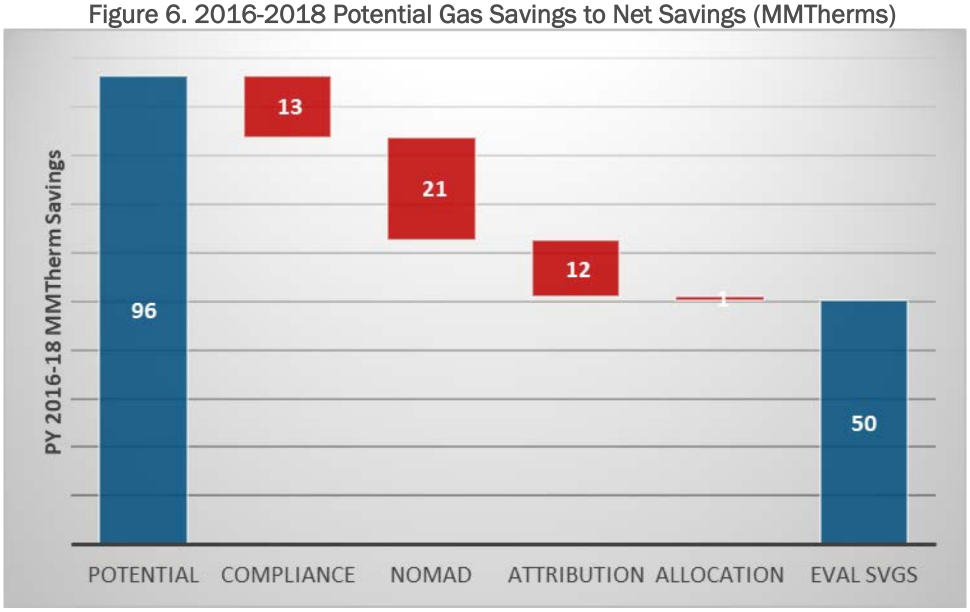
The other was that the program's amount of influence (attribution) over the final adopted standards was diluted in some cases. Figure 5 and Figure 6 show the findings for electric and gas savings in each adjustment step. The graphs illustrate first year savings when all the new standards became effective across 2016 - 2018. A full set of charts for each year and fuel type are provided in section 4.6.1.

Figure 5. 2016-2018 Potential Electric Savings to Net Savings (GWh)



For gas savings, the new standards had the potential to save 96 MMTherms. Most products complied or exceeded the new standards. The IOUs ultimately received credit for saving 50 MMTherms.

Figure 6. 2016-2018 Potential Gas Savings to Net Savings (MMTherms)



1.3.1 Evaluated Savings

By combining all the steps discussed earlier, we derived the evaluated savings by utility to compare with the IOU savings claims (Table 1). In addition to validating or adjusting the IOU claim, these evaluated net savings are used to calculate cost-effectiveness and support statewide forecasting and IOU service area planning.

Table 1. Annual Savings from evaluated product standards only

	GWh			MW			MMTherm		
IOU	2016	2017	2018	2016	2017	2018	2016	2017	2018
PG&E	53.6	115.3	485.9	8.7	17.2	65.9	3.8	7.6	7.7
SCE	53.0	115.5	492.5	8.6	17.3	66.8	-	-	-
SCG	-	-	-	-	-	-	6.0	11.6	11.5
SDG&E	10.9	23.6	100.0	1.8	3.5	13.6	0.4	0.8	0.8
Evaluated Savings	117.5	254.4	1,078.4	19.1	38.0	146.2	10.3	20.0	20.0
Reported by IOUs	127.4	256.2	733.8	23.8	47.0	139.2	9.2	14.4	15.9
Eval Savings as % of Reported	**92%**	**99%**	**147%**	**80%**	**81%**	**105%**	**112%**	**139%**	**126%**

Note: Savings in this table are for the appliance standards advocacy program only

Table 2: Three-year cumulative savings

Cumulative 2016–2018	GWh	MW	MMTherm
Evaluated Savings	1,450.3	203.3	50.3
Reported by IOUs	1,117.5	210.0	39.5
Savings Difference	+32.9 GWh	-6.8 MW	+10.8 MMTherm
Eval Savings as % of Reported	130%	97%	127%

Note: Cumulative values are the sum of first year savings for the appliance standards advocacy program only in each of the three program years

1.4 Conclusion and Recommendations

Most of the standards included in this evaluation became effective in 2018, correlating with the dramatic increase in total savings in 2018. We found more savings in 2018 than the IOUs reported. Although we did find instances of higher compliance levels and higher attribution than forecast by the IOUs, the main difference is because the IOUs underreported the number of units for general service lighting standards[14] in 2018 by using a lower long-term average rather than the actual shipments.

Our primary recommendations are for the development of the Code Change Savings Reports (CCSR) documentation and reporting via the California Energy Data and Reporting System (CEDARS[15]). These documents are the main source of information supporting the IOU claims since most of the parameters that go into developing C&S savings estimates are not available in CEDARS.

During the evaluation, we found that the number of units and unit energy savings was not well correlated with reported gross savings. This disconnect is critical to resolve since standards are adopted or rejected based on data provided in publicly available CASE reports. If the savings claim does not follow from the CASE report

[14] Key differences are referenced later in the report as Std 39, Std 41a, and Fed 37.

[15] CEDARS is a data collection and reporting database sponsored by the CPUC for data associated with California's energy efficiency programs.

(even loosely), then either the claim uses different assumptions than the CASE or more seriously, the decision on the disposition of the statewide standard is based on flawed data. In instances where the California Energy Commission adopts a version of the standard that is not driven by the CASE report, this difference should be captured in lower attribution scores.

- **We recommend that the IOUs develop CCSRs to provide a clearer connection between their activities, their forecast, and their claimed savings.** We realize there is a time lag between standard development, adoption, effective date, and market reaction. Thoroughly documented CCSRs will allow these timing differences to be explicitly called out. This recommendation has begun to be addressed with the IOUs, evaluators, and Energy Division meeting in late 2020 to identify details that should be included in these reports.

In addition to savings documentation inconsistencies, we also found that program reporting was inconsistent across IOUs. In 2016 for example, all appliance standards were reported as part of the building codes advocacy program. Reporting quality at the product level did improve from 2016 to 2018. The quality of administrative costs at the sub program level however is still unknown.

- **We recommend that the statewide program administrator be responsible for quality control** of reporting for all program implementors. Specifically, the IOUs need to be consistent about reporting savings claims under the proper program name and reporting other data fields consistently (i.e. incremental costs).

Finally, the C&S programs account for over 50% of the entire IOU savings claim and that contribution is growing. Unfortunately for the purposes of evaluation, CEDARS does not hold the data necessary to evaluate the IOU C&S savings claims in a timely manner. Specifically, key fields unique to C&S for evaluation include the compliance adjustment factor, NOMAD, and attribution.

- **We recommend that the CPUC request more support data as part of the savings claim filings.** If the data needs are articulated and standardized before the evaluation begins, the evaluation for C&S will require fewer resources and take less time to conduct. One option is for the CPUC to add fields to CEDARS to hold these data. Another approach is for the CPUC, evaluators, and IOUs to jointly develop a standardized reporting format to be filed with the claims so all of the key parameters are available at the same time.

2. Introduction and Overview

The overall C&S portfolio is made up of six subprograms: Building Codes Advocacy, Appliance Standards Advocacy, Compliance Improvement, Reach Codes, Code Readiness, and Planning and Coordination. An overview of these subprograms is provided in Appendix B. The evaluation focuses on the two advocacy programs in the C&S portfolio: Building Energy Efficiency Standards (Title 24 or building codes) and Appliance Efficiency Regulations (Title 20, Federal, or appliance standards). The end result is to validate the electric and gas savings claimed by the IOUs for the years 2016, 2017, and 2018.

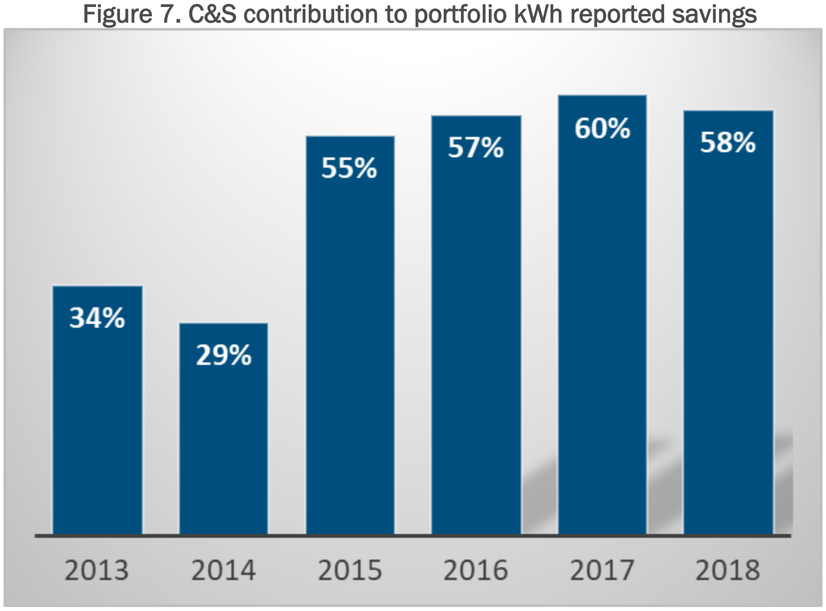
This evaluation is limited to codes and standards with effective dates from January 1, 2016 through December 31, 2018. Codes and standards effective outside these dates are covered in other evaluations. The specific programs included under the deliverable are listed in Table 3 along with their Program ID in the California Energy and Data Reporting System database (CEDARS).

Table 3. IOU Programs being evaluated

Program Type and ID	PG&E	SCE	SCG	SDG&E
Building Codes Advocacy – Title 24	PGE21051	SCE-13-SW-008A	SCG3724	SDGE3249
Appliance Standards Advocacy -- Title 20 and Federal	PGE21052	SCE-13-SW-008B	SCG3725	SDGE3250

The size of the C&S advocacy programs has been growing in proportion to the overall portfolio. During the evaluation period (2016-2018), these two C&S subprograms accounted for more than 58% of portfolio net kWh savings (see Figure 7). They also accounted for 54% of kW reduction and 63% of gas savings.

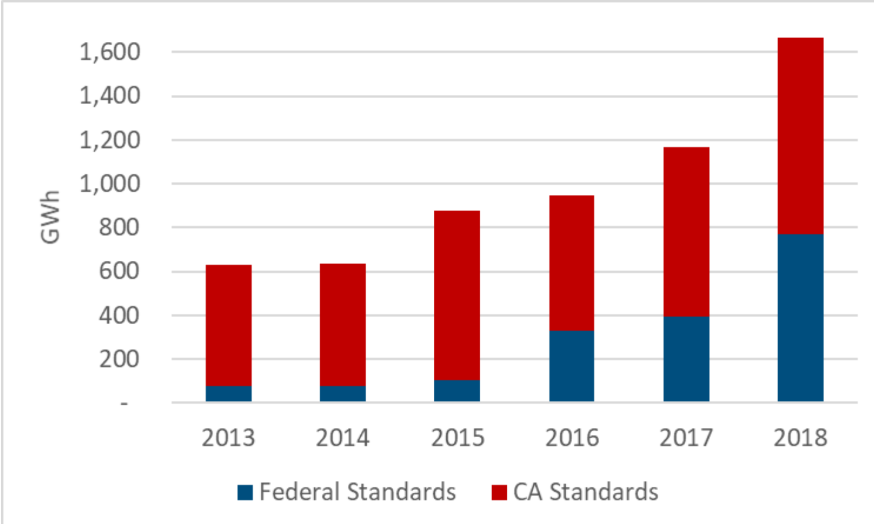
Figure 7. C&S contribution to portfolio kWh reported savings



Source: CEDARS summary_report_ by "Program Category" (a.k.a. claimed net savings)

The next graph (Figure 8) shows how electric savings from standards has been increasing over time. It also shows that federal standards have been accounting for a larger share of appliance standard savings over time. For example, in 2013 federal standards accounted for 12% of savings. By 2018 this contribution had increased to 46% of savings for the standards advocacy program.

Figure 8: Evaluated savings for appliance standards (2013-2018)



Source: 2013-2015 C&S evaluation (CADMUS vol 1) and 2016-2018 C&S evaluation (ODC vol 1)

Within the advocacy programs, state and federal appliance standards accounted for 73% of kWh savings, while building codes accounted for the remaining 27%. The contribution for each advocacy category is provided in Table 4.

Table 4. Savings Contribution by Category

2016-2018			
Category	**GWh**	**MW**	**MMTherm**
Title 24 Non-Residential Alterations	22%	33%	13%
Title 24 Non-Residential New Construction	1%	2%	1%
Title 24 Residential Alterations	2%	2%	3%
Title 24 Residential New Construction	2%	3%	4%
Title 20 Appliance	19%	7%	67%
Federal Appliance	54%	52%	12%
Total	**100%**	**100%**	**100%**

Source: IOU savings reported in CEDARS

2.1 Study Purpose

The purpose of the overall evaluation (Group B, Deliverable 13) is to validate the electric and gas savings claimed by the IOUs for the years 2016, 2017, and 2018. This applies to codes and standards with effective dates from January 1, 2016, through December 31, 2018. This report is volume 1 of a two-volume set.

- Volume 1: appliance standards
- Volume 2: building codes.

Priority for evaluation rigour is based on the magnitude of savings associated with each standard and on the uncertainty of the values used to compute savings.

2.2 Background

Efficiency standards set minimum efficiency levels that new products must meet or exceed. This allows consumers to choose between high efficiency options rather than between high and low efficiency options.

In 1974, the State of California established the Energy Commission. One of its main roles is to, "promote all feasible means of energy and water conservation and all feasible uses of alternative energy and water supply sources."[16] One way the Energy Commission achieves its mission is through the adoption of building and appliance efficiency standards. The standards for buildings and appliances are in the California Administrative Code.[17] They are often referenced using their location in the code. Title 24 for building energy standards and Title 20 for appliance standards.

Starting in the late 1990s, California utilities became more involved in researching, proposing, and promoting efficiency standards through what has become the statewide utility C&S program. The IOUs are involved in the State's building codes and appliance standards setting in several ways, including:

- Advocating for codes and standards that position the state to meet its ambitious energy savings and greenhouse gas (GHG) emissions reductions goals.

[16] California Energy Commission Strategic Plan, June 2014, p 2

[17] In general, we refer to standards that are adopted to regulate building energy efficiency as "codes" and standards that apply to appliances and equipment as "standards."

- Providing technical studies to the Energy Commission as supporting information for state-level decisions on code adoption.
- Supporting compliance improvement efforts at the municipal level through workforce education and code-readiness activities such as supporting local reach codes.

In the Statewide Codes and Standards Program Implementation Plan,[18] the mission of the program is as follows:

> The Codes and Standards program saves energy on behalf of ratepayers by influencing continuous improvements in energy efficiency regulations, improving compliance with existing codes and standards, and working with local governments to develop ordinances that exceed statewide minimum requirements. Both the C&S program advocacy and compliance improvement activities extend to virtually all buildings and potentially any appliance in California.

This includes influencing continuous improvements in energy efficiency regulations, improving compliance with existing codes and standards, and working with local governments to develop ordinances that exceed statewide minimum requirements.

The principal audience for these services is the Energy Commission, which conducts periodic rulemakings (typically every three years). C&S also seeks to influence DOE in setting national appliance standards that affect California.

The IOUs claim energy and gas savings for these services along with reductions in electric peak demand and GHG emissions. These savings, and the IOU level of influence in the standard setting process, are the primary focus of this evaluation.

For example, in 2018 the IOUs claimed net savings of 1,789 GWh from 149 codes and standards.[19] Of these 149, only 43 became effective during the evaluation period between 2016 and 2018 (T24-11 codes, T20-19 standards, Federal-13 standards). These 43 codes and standards account for 51% (993 GWh) of the claimed 2018 savings and are the subject of the overall evaluation. This report focuses on the state and federal product standards. The IOU savings claims for codes and standards with effective dates during the evaluation period are shown in Table 5. A listing of these standards is provided in Appendix B.

Table 5. Total net energy savings of new codes and standards reported by the IOUs

	2016			2017			2018		
Category	**GWh**	**MW**	**MMTherm**	**GWh**	**MW**	**MMTherm**	**GWh**	**MW**	**MMTherm**
Title 24 NRA	0	0	0	51	17	0	68	22	0
Title 24 NRNC	0	0	0	9	6	0	62	38	0
Title 24 RA	0	0	0	17	8	2	28	13	4
Title 24 RNC	0	0	0	26	12	3	64	30	8
Title 20 Appliance	29	3	14	95	6	24	534	84	19
Federal Appliance	107	22	0	222	42	0	236	58	1
Total	**136**	**25**	**13**	**419**	**91**	**30**	**993**	**246**	**32**

[18] The Program Implementation Plan (PIP) for the statewide program can be found on the following webpage: http://eestats.cpuc.ca.gov/Views/Documents.aspx?ReportType=PIP

[19] One GWh is equal to 1,000,000 kWh. One MW is equal to 1,000 kW. One MMTherm is equal to 1,000,000 therms of gas.

Note: 2016 is the year new building codes became effective. NRA = non-residential alterations, NRNC = non-residential new construction, RA = residential alterations, RNC = residential new construction

Data from the California Energy Data and Reporting System (CEDARS) show that for program years 2016 through 2018 the IOUs claimed a total of 5,335 GWh of savings for the codes and standards advocacy program. The majority of these savings (73%) came from standards adopted in prior periods and are outside the scope of this evaluation. The new standards adopted in the 2016-2018 program period account for 27% of total claimed C&S savings.

For these new standards (2016-2018), the majority of savings (79%) came from appliance standards (T20=40% and Fed=39%). The remainder came from new building codes. See Table 5 for a breakdown of savings contribution by standards adoption period.

Table 6. C&S Savings Claim (kWh)

Source of Savings	2005-2009	2010-2012	2013-2015	2016-2018
T20	95%	0%	15%	40%
Fed	0%	33%	13%	39%
T24	5%	67%	72%	22%
	2005-2009	2010-2012	2013-2015	2016-2018
Contribution to Total C&S Claim	**24%**	**17%**	**32%**	**27%**

This Volume 1 report provides findings only for the new appliance standards that appeared in 2016-2018 (Title 20 and Fed). The 2016 building codes (Title 24) will be presented in a separate Volume 2 report.

3. Evaluation Approach

Evaluating codes and standards is performed a little differently than other resource-based programs such as lighting or HVAC rebates. Conceptually, the task of identifying gross and net savings is the same as other program evaluations. The mechanics are different, however, mainly because everyone is a participant by default. The task of the evaluation is to build the counterfactual, **"What would have happened if the IOUs were not involved in the process of appliance standard development?"**

Since appliance standards affect the entire state by default, the first step is understanding the market size. This is market potential savings. It is estimated by multiplying the savings per unit times the number of units sold. All products sold in the market may not meet the new standard, however. To develop gross savings, potential savings is adjusted for the estimated rate of compliance with the new standard.

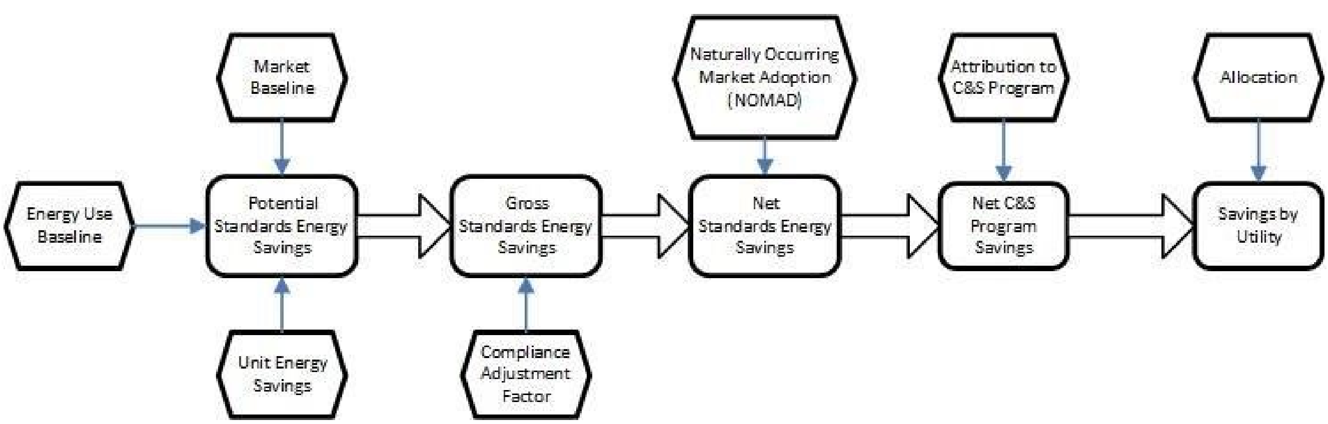
Since the standards cover all appliances sold in the market, everyone is technically a participant. As such, the traditional approach of moving from gross savings to net savings by identifying free riders does not apply. To compensate for this, the C&S evaluation substitutes two other measures: Naturally Occurring Market Adoption (NOMAD) and Attribution.

NOMAD is an estimate of what the market was doing without any IOU interventions. It considers questions such as: What was the trend for appliance standard development? How was technology developing and being applied? What were consumers demanding?

Attribution is the level of IOU influence on the final adopted standard. Were IOUs proactive in pressing stricter standards or were they providing only technical support in the process? If they lobbied, did they lobby for their position and how broad was their effort? Did regulators listen to them and adopt their recommendations?

Net savings is derived from adjusting gross savings by NOMAD and attribution. Once net savings are calculated the final step in the evaluation is allocating net savings to each IOU service territory. The IOUs account for about 80% of all electric sales and 99% of all gas sales statewide. Savings credit is allocated by applying IOU service territory specific electric and gas sales ratios to total statewide sales.[20] Allocated savings is the value that is compared to the savings claim reported to the CPUC. The full process is depicted in Figure 9.

Figure 9. Codes and Standards Evaluation Components and Steps



[20] Electric and gas sales have been used historically. In the next evaluation cycle, program budget will be used to allocate savings per D.16-08-019.

3.1 Developing the Evaluation Components

This evaluation of the appliance standards advocacy program verifies the net savings for state and federal appliance standards that became effective in 2016 through 2018. We outlined the five steps used to estimate net savings in the last section. In this section we discuss the details of our approach to each step.

Throughout these steps we assessed key information developed by the C&S program, such as Codes and Standards Enhancement (CASE) studies and Code Change Savings Report (CCSR) documents. In addition, we reviewed the Database of Energy Efficiency Resources (DEER) as well as conducting interviews/surveys with key program actors (CA IOUs C&S staff, evaluators, and key stakeholders such as the Energy Commission) to estimate market size and savings. We then followed the Integrated Standard Savings Model (ISSM) framework and use protocol-compliant methods to generate results. Table 7 provides a summary of these methods.

Table 7. Overview of Tasks for Deliverable 13B: Assessing Program Standards-Related Savings

Task	Sub-Task	Approach
Task 1. Assess Existing Data and Relevant Information for Sampling Plan	Sampling Measures	We established a sampling frame from Title 20 standards adopted in 2016, along with supplementary documents from the Energy Commission & IOU documents.
	Sampling Retailers & Distributors	We identified both large and small retailers as well as distributors to cover a high percentage of market share for each product.
Task 2. Identify Potential Savings	Establish Baselines	Where previous standards existed, they became the baseline for kWh or therms. Where they did not exist, we estimated the baseline using market research and existing studies. Where multiple values existed due to data from different markets, these values were weighted as necessary to develop inputs compatible with the ISSM formats.
	Establish Demand Reduction Values	We derived electric demand reduction values using factors from DEER, workpapers or other sources, such as avoided cost table calculations.
Task 3. Develop Gross and Net Savings	Estimate Compliance	We utilized web scraping, supplemented by purchased point-of-sale data & interviews, with some site visits where necessary. We used CCSR data to establish criteria.
	Estimate Attribution	We reviewed public records of stakeholder comments and other documents regarding adoption, along with systematic coding for percent influence. We also used interviews to establish projected maximum measure penetration without a change in standard.
	Estimate NOMAD	We applied a Bass Diffusion Curve approach. We presented curves to SMEs via a web-based iterative survey process to produce diffusion curves for each standard.

3.2 Sampling Plan

Sampling for estimating the potential savings of standards takes place in two stages. The first stage is to identify the standards for claimed measures that were adopted and that the IOUs worked to promote. The second stage is to sample the retailers and distributors that sell relevant products. The first stage is straightforward, while the second is less so.

- **First Stage:** State- or federally regulated products require that manufacturers perform two steps to get their products approved. First, they must demonstrate that the product meets the energy efficiency requirements of the regulations. Second, they must also certify the performance of the product with the Energy Commission. The Energy Commission maintains an online database of these certified products at the model level. This is one of the main data sources we used to identify product specifications.

  In addition to the Energy Commission product database, we reviewed and assessed prior C&S evaluation reports, C&S Program Plans, C&S and Compliance Enhancement Evaluation Protocol, Impact Evaluation Protocol, Title 20 standards, CASE studies, CCSRs, and federal standards.

- **Second Stage:** Identify and sample relevant retailers and distributors for each product. This stage is less straightforward and has the potential to use up a lot of time and budget. For example, OEMs have started to market products with Stock Keeping Unit (SKU) identifiers that are unique to individual big box distribution chains like Best Buy, Lowe's, Home Depot, etc. The focus of our efforts was to determine the vendors that represent a large percentage of the market share for each product type, with focus on identifying product platforms. The Energy Commission database along with other sources helped identify product families with similar efficiency characteristics.

We estimated potential savings through the review and assessment of CASE reports and research of market data collected for the C&S program years 2016 through 2018. These estimates also came from external data sources including the US Census Bureau, the Energy Information Administration, and the Consortium for Energy Efficiency. We also reviewed online product listings or conducted interviews with industry experts, retailers, distributors, and manufacturers. If actual sales data was not available or cost-effective to acquire, we estimated compliance rates based on the market share of appliances listed in the Energy Commission database when feasible.

Our team determined which standards and codes to include in this evaluation using their individual effective dates. We included the code or standard in the scope if its effective date was between January 1, 2016 and December 31, 2018. Standards that were promulgated between 2016 and 2018 but did not take effective until after 2018 are excluded from the scope of this evaluation. Title 24 building codes are treated separately in Deliverable 13A.

We presented a preliminary list of in-scope standards at the project coordination group meeting on February 22, 2019. At that meeting, IOU representatives called attention to several standards that are within the scope of this evaluation but were not included in our preliminary list. Specifically, the IOUs recommended the inclusion of the 2008 General Service Lighting Standard that took effect on January 1, 2018 and the 2015 Toilet and Urinal Standards effective on January 1, 2016. The IOUs noted that the treatment and conveyance of potable water consumes a significant amount of energy. Quantified as the "embedded energy" associated with potable water consumption by California, the IOUs noted that these values may be used to estimate savings from measures that reduce water consumption.

We incorporated the IOUs feedback to develop the list of appliance standards included in the evaluation scope. In 2018, the IOUs claimed savings from 100 different appliance standards. Most of became effective in prior years and were evaluated in earlier evaluation cycles. We determined that only 27 became effective between 2016 and 2018 and have not yet been evaluated. The scope of this analysis includes all 27 of the appliance standards that became effective in 2016-2018, presented in Table 8. We verified the effective date of each standard by cross-referencing the Code of Federal Regulations[21] and the California Code of Regulations[22].

Table 8. Appliance Standards included in the Evaluation Scope

Group	Claim Identifier	Description	Effective Date
Appliances			
Federal Standard	Fed 31	Microwave Ovens (Res)	6/17/2016
Federal Standard	Fed 36	Commercial Clothes Washers (Com)	1/1/2018
Federal Standard	Fed 38	Residential Clothes Washers, top loading (Res)	1/1/2018
Electronics			
State Standard	Std 31	Small Battery Chargers – Tier 3 (non-consumer)	1/1/2017
State Standard	Std 42a-b	Computers (workstations, small-scale servers)	1/1/2018
Federal Standard	Fed 29	External Power Supplies (Res)	2/10/2016
Commercial HVAC and Refrigeration Equipment			
Federal Standard	Fed 32	Commercial CAC and HP (<65,000 Btu/hr)	1/1/2017
Federal Standard	Fed 34	Commercial Refrigeration Equipment (Com)	3/27/2017
Federal Standard	Fed 35	Walk-In Coolers and Freezers (Com)	6/5/2017
Federal Standard	Fed 39	Commercial CAC and HP (65,000-760,000 Btu/hr) - Tier 1	1/1/2018
Federal Standard	Fed 41	Commercial Icemakers (Com)	1/28/2018
Commercial and Industrial Equipment			
Federal Standard	Fed 28	Distribution Transformers (Com)	1/1/2016
Federal Standard	Fed 30	Electric Motors (Com)	6/1/2016
Lighting			
State Standard	Std 38	Dimming Fluorescent Ballasts	7/1/2016
State Standard	Std 39	General Service Lamps	1/1/2018
State Standard	Std 40	Small Diameter Directional Lamps	1/1/2018
State Standard	Std 41a	General Service LED Lamps - Tier 1	1/1/2018
Federal Standard	Fed 33	Metal Halide Lamp Fixtures (Com)	2/10/2017
Federal Standard	Fed 37	General Service Fluorescent Lamps (Res)	1/26/2018
Plumbing			
State Standard	Std 33c-d	Lavatory Faucets and Aerators (Res)	7/1/2016
State Standard	Std 33e-f	Kitchen Faucets and Aerators (Res)	1/1/2016
State Standard	Std 33g	Public Lavatory Faucets (Com)	1/1/2016
State Standard	Std 34a-b	Showerheads - Tier 1	7/1/2016
State Standard	Std 34c-d	Showerheads - Tier 2	7/1/2018
State Standard	Std 35a-b	Toilets and Urinals (Res and Com)	1/1/2016
State Standard	Std 36	Urinals	1/1/2016

Note: Identifiers followed by letters denote standards for the same measure but with different source fuel types such as electric or natural gas.

[21] Federal energy and water conservation standards for consumer (residential) products are at 10 CFR 430.32. Federal standards for commercial and industrial equipment are at 10 CFR 431.

[22] California regulations for the appliances in the scope of this evaluation are at 20 CCR §1605.3.

3.2.1 Sampling Prioritization

To make economical use of the resources available for this evaluation, we used different levels of sampling precision for different standards. Our sampling activities prioritized standards with the highest amounts of claimed savings. Standards with high energy savings claims were sampled with higher precision (and, accordingly, a large sample size). We placed a lower priority on achieving high precision when sampling for standards with lower claimed savings. These priority groupings are provided in Table 9.

Table 9. Priority Groupings for In-Scope Appliance Standards

Identifier	Description	IOU Estimate of Total 1st Year Gross Savings*	
		Elec. (GWh)	Gas (MMT)
High-priority Standards First-year Gross Savings: ≥50 GWh/year. Comprise ~80% of total first-year savings			
Std 39	General Service Lamps	380.8	-5.1
Fed 29	External Power Supplies (Res)	115.0	-2.6
Fed 30	Electric Motors (Com)	100.0	0.0
Fed 39	Commercial CAC and HP (65,000-760,000 Btu/hr) - Tier 1	87.6	0.0
Fed 35	Walk-In Coolers and Freezers (Com)	73.4	0.0
Std 40	Small Diameter Directional Lamps	71.7	-1.0
Medium-priority Standards First-year Gross Savings: ≥7.5 and <50 GWh/year, and/or ≥5.0 MMT/year. Comprise ~15% of total first-year savings			
Fed 37	General Service Fluorescent Lamps (Res)	47.5	-0.2
Fed 33	Metal Halide Lamp Fixtures (Com)	33.2	-0.1
Fed 28	Distribution Transformers (Com)	31.0	0.0
Fed 31	Microwave Ovens (Res)	15.7	-0.4
Fed 34	Commercial Refrigeration Equipment (Com)	14.7	-0.3
Fed 38	Residential Clothes Washers, top loading (Res)	13.7	0.7
Std 31	Small Battery Chargers, Tier 3 (non-consumer)	9.1	0.0
Std 33a-d	Lavatory Faucets and Aerators (Res)	8.7	2.7
Std 41a	General Service LED Lamps, Tier 1	8.3	-0.1
Std 34a-b	Showerheads, Tier 1	7.7	5.0
Low-priority Standards First-year Gross Savings: <7.5 GWh/year, and/or <5.0 MMT/year. Comprise ~5% of total first-year savings			
Std 38	Dimming Fluorescent Ballasts	7.0	0.0
Fed 32	Commercial CAC and HP (<65,000 Btu/hr)	5.8	0.0
Std 33e-f	Kitchen Faucets and Aerators (Res)	4.6	1.4

Std 34c-d	Showerheads, Tier 2	3.6	1.1
Fed 41	Commercial Icemakers (Com)	3.0	0.0
Std 33g	Public Lavatory Faucets (Com)	2.8	1.5
Std 35a-b	Toilets and Urinals (Res and Com)	1.8	0.0
Std 42a	Computers (workstations)	1.7	0.0
Fed 36	Commercial Clothes Washers (Com)	1.0	0.0
Std 42b	Computers (small-scale servers)	0.4	0.0
Std 36	Urinals	0.4	0.0

Source: Spreadsheet of IOU internal cost-effectiveness calculations, titled "CET Inputs.xlsx" and submitted by the IOUs in response to the evaluation team's data request from January 8, 2019. Spreadsheet tab "CETInput," columns CH-CJ.

The C&S tracking spreadsheets submitted by the IOUs in response to our data request included estimates of first-year gross savings for electric energy and demand, and natural gas. We used these estimates from the IOUs to prioritize the list of standards for this evaluation. To define different priority levels, we selected threshold levels of first-year gross savings that naturally formed groups of standards comprising roughly 80 percent, 15 percent, and 5 percent of the total first-year gross electric savings. Using these thresholds, we categorized the standards into three priority levels (High, Medium, Low), defined as follows:

- **High-priority standards** have projected first-year gross savings greater than 50 GWh/year. These standards comprise about 80 percent of the total first-year savings projected for the set of in-scope standards. Negative gas savings are projected for three of these standards.
- **Medium-priority standards** have projected first-year gross savings between 7.5 and 50 GWh/year electric savings, or greater than 5.0 MMT/year gas savings. These standards comprise about 15 percent of the total first-year savings projected for the set of in-scope standards.
- **Low-priority standards** have projected first-year gross savings of less than 7.5 GWh/year electric savings, or less than 5.0 MMT/year gas savings. These standards comprise about 5 percent of the total savings projected for the set of in-scope standards.

This sampling prioritization also helped determine prioritization for discussion and consideration when we assessed naturally occurring market adoption (NOMAD) and developed attribution scores.

3.2.2 Stratified Sample Development

We used a stratified sampling approach to divide the total population of products for this evaluation into different sample groups (i.e., different strata) for each standard. With this approach, we developed a separate sample size for each of the standards. This approach allowed us to focus our sampling efforts on the high-priority standards with the highest forecast savings, while maintaining an appropriate level of rigor for the population as a whole.

Table 10 presents the shipment and savings estimates provided by the IOUs, as well as the sample sizes selected for each standard. This table is sorted by the estimated total first-year gross savings for each standard and the standards are grouped into priority levels (as defined previously). The estimates of first-year shipments, savings-per-unit, and total first-year gross savings are referenced from the C&S tracking spreadsheets submitted by the IOUs in response to our data request. These values are used here for the purpose of sample size development. The weight associated with each standard is calculated as the first-year gross electric savings of the standard divided by the first-year gross electric savings for all in-scope standards (1,270 GWh/year).

The coefficient of variation (CV) describes how dispersed the savings-per-unit values for individual products are from the average savings-per-unit value. The sample size to achieve a specific precision and confidence depends on the population's CV. However, the CV is not often known until after samples are drawn and analyzed. As is standard practice for measurement and verification analyses, we assumed a default CV value of 0.5 for all but one of the standards in the population. The exception was the highest-savings standard (Std 31: General Service Lamps). For this standard we analyzed a set of 1,330 general service lighting products determined to be Title 20 compliant and calculated a CV value of 0.37.[23] This calculated CV value indicates that the distribution of per-unit savings values for different GSL products is narrower than the default assumption.

The CPUC's *California Energy Efficiency Evaluation Protocols* states that the target relative precision for verification activities is 90% confidence with 10% precision.[24] Taken as a whole, our sample is designed with 90% confidence with 3% precision, which exceeds the target relative precision for verification activities.[25] Our sample is stratified by different appliance types, and we targeted different precision rates for individual standards depending on the priority of the standard. For high-priority standards, we selected sample sizes to achieve a 90% confidence interval and better than ±10%precision. For medium- and low-priority standards, we selected sample sizes to achieve a 90% confidence interval and better than ±30% precision. Table 10 also reports the relative precision at a 90% confidence for each standard.

For each standard, the unit for the sample size is "number of appliances" (e.g., 250 general service lamps, 75 external power supplies, etc.). Samples were drawn to represent the population of appliances that were sold following the effective date of the standard. Table 10 is sorted by Total 1st Year Electric Savings (GWh/yr).

[23] For this analysis, we referenced a dataset of lighting products included with the 2018 Ex Ante Disposition for Screw-in Lamps Savings Methods, published March 1, 2018 by the CPUC Energy Division.

[24] PUC (2006). "California Energy Efficiency Evaluation Protocols: Technical, Methodological, and Reporting Requirements for Evaluation Professionals." pp.95, 167. Available at: https://www.cpuc.ca.gov/WorkArea/DownloadAsset.aspx?id=5212

[25] This is due to our oversampling of the standard with the highest projected gross savings (Std 39: General Service Lamps).

Table 10. Stratified Sample Sizes for In-Scope Appliance Standards

Priority Level	Identifier	Description	First-Year Shipments (units) [1]	Savings per Unit (kWh/yr) [1]	Total 1st Year Electric Savings (GWh/yr)	Weight	Coefficient of Variation	Sample Size	Relative Precision at 90% Confidence
High	Std 39	General Service Lamps	42,680,000	30	1,280	30.6%	0.4	250	3.9%
	Fed 32	Commercial CAC and HP (<65 kBtu/hr)	272,739	3,543	966	23.1%	0.5	100	8.3%
	Fed 29	External Power Supplies (Res)	42,370,920	9	365	8.7%	0.5	75	9.6%
	Fed 30	Electric Motors (Com)	380,527	810	308	7.4%	0.5	75	9.6%
	Fed 35	Walk-In Coolers and Freezers (Com)	37,463	6,527	245	5.8%	0.5	75	9.6%
	Std 40	Small Diameter Directional Lamps	1,800,000	134	241	5.8%	0.5	75	9.6%
Medium	Fed 37	General Service Fluorescent Lamps (Res)	3,009,201	48	144	3.4%	0.5	20	19.3%
	Fed 28	Distribution Transformers (Com)	88,349	1,169	103	2.5%	0.5	20	19.3%
	Fed 33	Metal Halide Lamp Fixtures (Com)	1,900,000	53	101	2.4%	0.5	20	19.3%
	Fed 39	Commercial CAC and HP (65-760 kBtu/hr), Tier 1	32,944	2,376	78	1.9%	0.5	20	19.3%
	Fed 31	Microwave Ovens (Res)	1,922,542	26	50	1.2%	0.5	20	19.3%
	Fed 34	Commercial Refrigeration Equipment (Com)	227,257	205	47	1.1%	0.5	20	19.3%
	Fed 38	Residential Clothes Washers, top-loadingloading (Res)	1,264,800	35	44	1.0%	0.5	20	19.3%
	Std 31	Small Battery Chargers, Tier 3 (non-consumer)	2,647,764	12	31	0.7%	0.5	20	19.3%
	Std 33a-d	Lavatory Faucets and Aerators (Res)	5,463,482	6	31	0.7%	0.5	20	19.3%
	Std 34a-b	Showerheads, Tier 1	1,602,655	17	27	0.6%	0.5	20	19.3%
Low	Std 41a	General Service LED Lamps, Tier 1	70,000,000	0.4	28	0.7%	0.5	20	19.3%

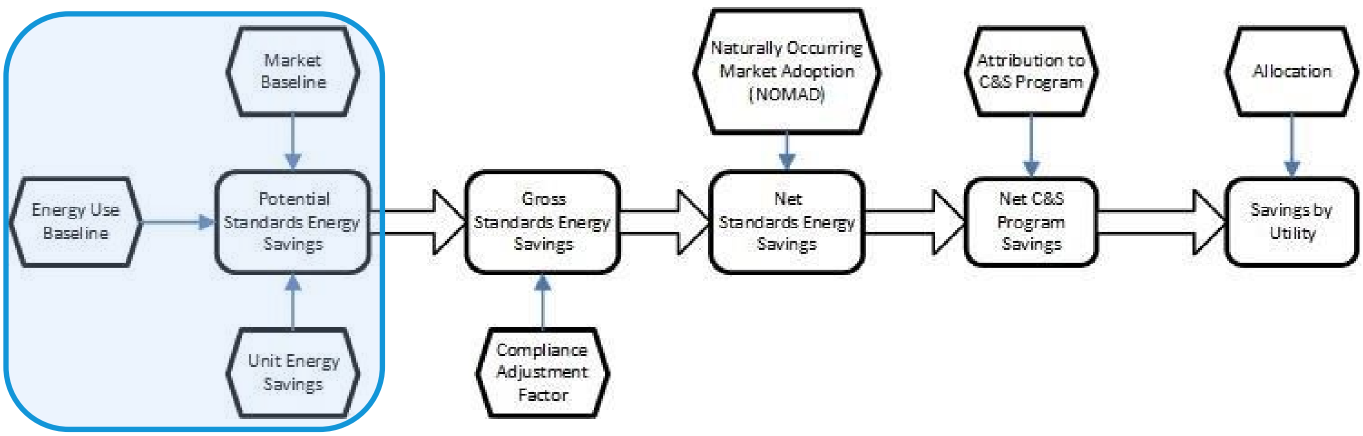
Priority Level	Identifier	Description	First-Year Shipments (units) [1]	Savings per Unit (kWh/yr) [1]	Total 1st Year Electric Savings (GWh/yr)	Weight	Coefficient of Variation	Sample Size	Relative Precision at 90% Confidence
	Std 34c-d	Showerheads, Tier 2	1,602,655	16	26	0.6%	0.5	20	19.3%
	Std 38	Dimming Fluorescent Ballasts	2,438,000	8	20	0.5%	0.5	20	19.3%
	Std 33e-f	Kitchen Faucets and Aerators (Res)	1,399,007	12	17	0.4%	0.5	20	19.3%
	Fed 41	Commercial Icemakers (Com)	27,004	385	10	0.2%	0.5	20	19.3%
	Std 33g	Public Lavatory Faucets (Com)	393,539	26	10	0.2%	0.5	20	19.3%
	Std 35a-b	Toilets and Urinals (Res and Com)	1,717,418	4	6	0.2%	0.5	20	19.3%
	Std 42a	Computers (workstations)	150,000	37	6	0.1%	0.5	20	19.3%
	Fed 36	Commercial Clothes Washers (Com)	22,839	150	3	0.1%	0.5	20	19.3%
	Std 42b	Computers (small-scale servers)	60,000	24	1	0.0%	0.5	20	19.3%
	Std 36	Urinals	101,168	13	1	0.0%	0.5	20	19.3%

[1] Spreadsheet of IOU internal cost-effectiveness calculations, titled “CET Inputs.xlsx” and submitted by the IOUs in response to the evaluation team’s data request from Jan 8, 2019. Spreadsheet tab “Inputs,” columns D-I.

3.3 Potential Standards Energy Savings

In general, the potential savings refers to the maximum theoretical savings from a standard taking effect in the first full year, assuming every affected unit meets the new standard's requirements. We calculated these savings by multiplying annual unit sales in California by unit energy or demand savings. Our evaluation includes a comparison of IOU net savings by each utility against their claimed savings. As shown in Figure 10 with (blue) box outline, the first step in determining gross and net savings involves estimating potential savings.

Figure 10. Codes and Standards Evaluation Component: Potential



This section describes the process we used and the results we obtained in determining the potential first-year energy and demand savings for each standard in the scope of this project. In general, the potential savings refers to the maximum theoretical savings from a standard taking effect in the first full year, assuming every affected unit meets the requirements of the new standard. We calculated these savings by multiplying annual unit sales in California by unit energy or demand savings.

We estimated the annual product shipments using market data from the IOUs, DOE, and other sources compiled from our team's independent research. We calculated the annual per-unit energy and water savings for each standard as the per-unit energy or water consumption at a baseline level minus the per-unit energy or water consumption at the standards level.[26] We calculated demand savings using peak watt/kWh factors provided to the IOUs by the Energy Commission. In this report, all mentions of demand savings refer to peak summer demand savings.

3.3.1 Discussion of Title 20 Lamp Standards

Three Title 20 standards in the current evaluation scope pertain to lamp products: Standard 39 for general service lamps, Standard 40 for small diameter directional lamps, and Standard 41a for general service LED lamps, all of which took effect on January 1, 2018. This section describes two issues regarding our treatment of these specific lamp standards.

[26] For each standard in the scope of the analysis, if a previous standard covered the product type, then the previous standard serves as the baseline. If there was no previous standard, then the baseline is the market-segment-level average efficiency of covered products that are not compliant with the new standard. The baseline levels are described in more detail in the interim Sub-Task 3 deliverable submitted on August 26, 2019.

3.3.2 Lamp Technology Shifts and Energy-Based Assessment

The Title 20 standards for lamp products are unique in that they mandated a shift in lamp technology, from halogen lamps that perform below the standard to more efficiency compact fluorescents (CFL) and light-emitting diode (LED) lamps that perform well above the minimum standard level. There are very few (if any) lamp products on the market today that just meet the GSL efficacy standard of 45 lumens per watt. From 2018 onward, Standard 39 limits GSL shipments to CFLs (with typical efficacy around 60 lpw) and LED lamps (with typical efficiency around 80 lpw).[27] The typical efficacies of these technologies greatly exceed the minimum standard of 45 lpw.

A conventional estimate of energy savings would calculate the difference between products that perform at the baseline level and products that just meet the new standard. However, a recent process evaluation conducted by TRC recommended performing an energy-based evaluation by assessing the market average unit energy consumption for installations covered by the standard.[28] Therefore, rather than considering the minimum efficacy dictated by Standard 39, this potential savings estimate uses an energy-based assessment that accounts for the market shift to CFL and LED technologies that exceed the minimum standard.[29]

We chose to limit our energy-based assessment to Title 20 lamp products, since these are the only products in the scope of this evaluation that experienced a baseline technology shift to efficiency levels far above the minimum standard.

3.3.3 Avoiding Lamp Double-Counting of Savings

Each of the Title 20 lamp standards has a defined scope of coverage.

General Service Lamps subject to Standard 39 are defined in the Code of Federal Regulations (CFR) and in California's Title 20 as general service incandescent lamps (GSIL) or any light-emitting diode (LED) lamp or compact fluorescent lamp (CFL) intended to replace a GSIL. Specifically, a state regulated GSIL is defined in the Title 20 code as,

> a standard incandescent or halogen type lamp that is intended for general service applications, has a medium [E26] screw base, has a wattage rating no less than 25 watts and no greater than 150 watts; has a rated voltage range at least partially within 110 and 130 volts; has a A-15, A-19, A-21, A-23, A-25, 1602 55 PS-25, PS-30, BT-14.5, BT-15, CP-19, TB-19, CA-22, or equivalent shape as defined in ANSI C78.20-2003; and has a bulb finish of the frosted, clear, or soft white type. The following incandescent lamps are not state-regulated general service incandescent lamps: appliance, black light, bug, colored, infrared, left-hand thread, marine, marine signal service, mine service, plant light, reflector, rough service, shatter resistant, sign service, silver bowl, showcase, three-way, traffic signal, and vibration service or vibration resistant.

Small Diameter Directional Lamps (SDDLs) subject to Standard 40 are defined in the Title 20 code as follows:

> "State-regulated small diameter directional lamp" means a directional lamp that meets all of the following criteria: (1) Capable of operating at 12 volts, 24 volts, or 120 volts; (2) Has an ANSI

[27] This means that, starting in 2018, incandescent and halogen bulbs are retired at the end of their useful life and are replaced by either CFL or LED bulbs.
[28] TRC (2019). C&S Attribution Study Report. pp.59-60. Available at: http://www.calmac.org/publications/Final_Report_CS_Attribution_Study_Mar_2019_(002).pdf
[29] An alternative approach to the energy-based assessment would be to calculate potential savings up to the standard level, and then apply an "overcompliance" factor in the gross savings calculation to account for performance above the standard. We considered this alternative approach but decided that the transparency of our analysis would be improved by accounting for the market shift in our estimate of potential savings.

> ANSLG C81.61-2009 (R2014) compliant pin base or E26 base; (3) Is a non-tubular directional lamp with a diameter of less than or equal to 2.25 inches; (4) Has a lumen output of less than or equal to 850 lumens, or has a wattage of 75 watts or less; and (5) Has a rated life greater than 300 hours.
>
> State-regulated small diameter directional lamp includes incandescent filament, LED, and any other lighting technology that falls within this definition. State-regulated small diameter directional lamp does not include directional lamps with an E26 base that utilize light emitting diodes (LEDs) and are covered under the definition of state-regulated Light Emitting Diode Lamps.

State-regulated LED lamps subject to Standard 41a are defined in the Title 20 code as

> a lamp capable of producing light with Duv[30] between -0.012 and 0.012, and that has an E12, E17, E26, or GU24 base, including LED lamps that are designed for retrofit within existing recessed can housings that contain one of the preceding bases. State-regulated LED lamp does not include a lamp with a brightness of more than 2,600 lumens or a lamp that cannot produce light with a correlated color temperature between 2200K and 7000K.

Our team considered potential areas of overlap in these product definitions to avoid double-counting of savings in our analysis. We observed that there is no overlap between SDDLs and state-regulated LED lamps, since the SDDL definition explicitly excludes lamps that are covered by the state-regulated LED lamp definition. One key area of overlap is that medium base (i.e., E26 base) GSLs using LED technology are also covered under the definition of state-regulated LED lamps. As described in the "Technology Shifts and Energy-Based Assessment" section above, our analysis of GSLs for Standard 39 accounts for savings due to increased efficacy, from a baseline of halogen lamp efficacy up to the current observed market average efficacy. To avoid double counting, our analysis of LED lamps in Standard 41a does not consider savings due to the improved efficacy of LED lamp technology, since savings due to efficacy are counted in Standard 39. The Title 20 standards for state-regulated LED lamps (Standard 41a) also include dimmability requirements for LED lamps that claim to be incandescent replacements, and this dimmability requirement will lead to savings that are not counted in Standard 39 for GSLs. In summary, for LED GSLs, this evaluation counts energy savings due to improved efficacy in Standard 39 and energy savings due to dimmability requirements in Standard 41a.

3.4 Gross Standards Energy Savings

This section contains our assessment of the rate of compliance in the California market with each of the 27 standards in the evaluation scope. Here we summarize the data sources and assumptions. Detailed calculations and results of our compliance analysis are provided in section 4.1.1 and in Appendix F of this report. As shown in Figure 11 the compliance adjustment factor is applied to the potential standards savings to yield the gross standards savings.

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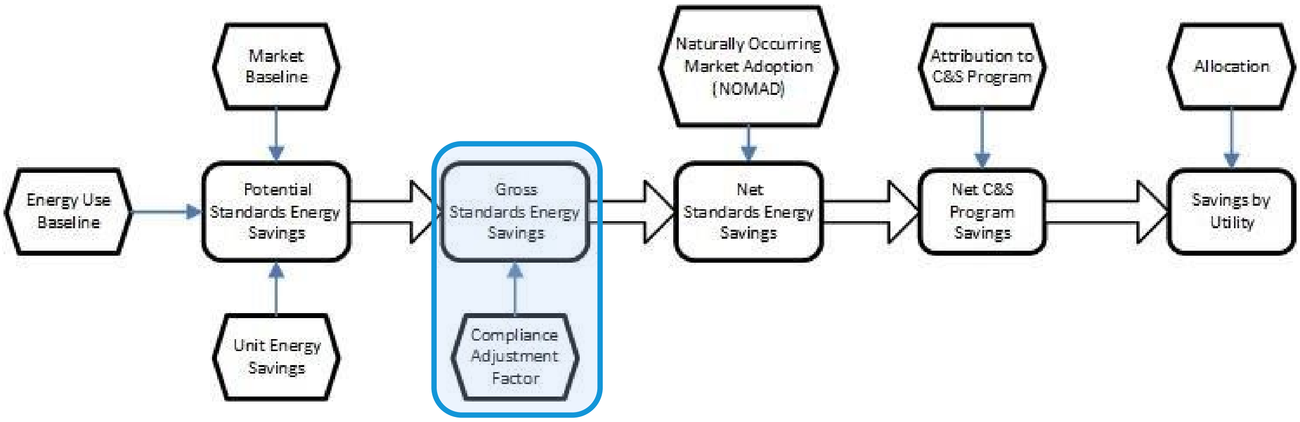
[30] "Duv" is metric describing the color of a light source. In the Title 20 standards, "Duv" means the closest distance from the chromaticity coordinate of the light source to the Planckian locus on the International Commission on Illumination (CIE)(u, 2/3 v') coordinates with "+" sign for above and "-" sign for below the Planckian locus

Figure 11. Evaluation Component: Gross Standards Energy Savings



Ideally, a compliance analysis uses counts of product sales to assess compliance rates because sales data are a good representation of which products are being used (and consuming energy) in the field. Counts of product listings are less reliable because they do not capture the frequency of sales for each listing. For instance, suppose an appliance type has three compliant models and one non-compliant model on the market, and the non-compliant model comprises half of all sales for the appliance type. An analysis based on product sales would conclude compliance is 50%, but an analysis based on product listings would conclude compliance is 75%. Where possible, we assessed compliance rates using product sales data for the relevant time period. For product types where sales data were limited or unavailable, we assessed compliance using counts of product listings. Our approach to sampling to mitigate potential bias is discussed in section 3.4.2.

3.4.1 Sampling Strategy

The table lists target sample size and final sample size for each standard (Table 11). We prioritized the standards by energy savings projections. For each standard, the unit for the sample size is "number of products" (e.g., 250 general service lamps, 75 external power supplies, etc.). We drew samples from populations of products sold after the effective date for each standard.

Table 11. Sample Sizes for Each Standard

Priority Level	Identifier	Description	Target Sample Size	Final Sample Size
High	Std 39	General Service Lamps	250	257
	Std 40	Small Diameter Directional Lamps	75	86
	Fed 29	External Power Supplies	75	150
	Fed 30	Electric Motors	75	120
	Fed 35	Walk-In Coolers and Freezers	75	140
	Fed 39	Commercial CAC and HP, Tier 1	75	90
Medium	Std 31	Small Battery Chargers, Tier 3	20	20
	Std 33a-d	Lavatory Faucets and Aerators	20	20
	Std 34a-b	Showerheads, Tier 1	20	20
	Std 41a	General Service LED Lamps, Tier 1	20	152

Priority Level	Identifier	Description	Target Sample Size	Final Sample Size
	Fed 28	Distribution Transformers	20	27
	Fed 31	Microwave Ovens	20	35
	Fed 33	Metal Halide Lamp Fixtures	20	22
	Fed 34	Commercial Refrigeration Equipment	20	27
	Fed 37	General Service Fluorescent Lamps	20	40
	Fed 38	Residential Clothes Washers	20	20
Low	Std 33e-f	Kitchen Faucets and Aerators	20	20
	Std 33g	Public Lavatory Faucets	20	26
	Std 34c-d	Showerheads, Tier 2	20	20
	Std 35a-b	Toilets	20	20
	Std 36	Urinals	20	21
	Std 38	Dimming Fluorescent Ballasts	20	24
	Std 42a	Computers (Workstations)	20	0*
	Std 42b	Computers (Small-scale Servers)	20	0*
	Fed 32	Commercial CAC and HP, small	20	21
	Fed 36	Commercial Clothes Washers	20	20
	Fed 41	Commercial Icemakers	20	20

* Due to the absence of data in product literature necessary to determine compliance, Guidehouse used the compliance rate estimated by the IOUs after determining that it was reasonable for these standards.

For standards applicable to multiple classes or categories of products (such as small, large, and very large air conditioners and heat pumps), we first estimated the distribution of product sales and the proportional market share of each product class or category.[31] Then, we sampled products from categories that represented a significant combined proportion of the market share. For high-priority standards, we sampled categories that totaled at least 93% of the market share. For medium-priority standards, we studied at least 70% of the market share, and for low-priority standards we studied at least 50% of the market share. We did not examine any product categories that accounted for less than 1% of the market share.

We examined three different distribution channels for applicable products: direct sales from the manufacturers, sales to customers through a wholesaler or distributor, and sales in retail markets. For products sold through multiple distribution channels, we used Technical Support Documents (TSD) published by DOE and interviews with industry experts to determine relative market share of each channel. In some cases, products were sold from wholesalers and manufacturers via contractors. These products would have

[31] Where available, we used market share information reported by the IOUs in code change savings reports that the IOUs provided to the evaluation team.

already been sold by a compliance-bound vendor. Consequently, we did not consider contractors in this analysis.

To define distribution channels, we considered "manufacturer" to mean an Original Equipment Manufacturer of the product, such as Carrier for commercial air conditioners. We considered "distributor" and "wholesaler" to mean resellers whose customers are primarily other businesses or contractors. We considered "retailer" to mean companies who sell products directly to consumers. This included both retailers with a physical storefront (i.e., brick-and-mortar retailers) and online retailers.

3.4.2 Data Collection

To identify sampling sources, we referenced the TSDs to find major manufacturers, distributors, and retailers. If a product is sold via the retail channel, we sampled from both brick-and-mortar and online retailers. For commercial and industrial products, we sampled from major manufacturers, distributors, and wholesalers. If the TSD lacked adequate information to determine a full list of vendors, we discussed the products with Guidehouse and Energy Solutions experts who contributed to the most recent DOE or Energy Commission rulemaking for each standard in order to find alternative sources of products. For some products, these sources were obvious. For example, we looked to big box stores (Best Buy, Home Depot, Walmart, etc.) for consumer microwaves. For other products, the sales channels were less obvious, so we spoke to experts who are familiar with the California market. For example, it was not obvious which brands or vendors dominate the market for walk-in refrigerator doors, but experts helped us identify Styleline, Anthony International, and Commercial Display Systems as choice vendors.

We collected data from each source's website or product catalogues for all the model numbers of each relevant product type. Some websites listed thousands of products for each type.[32] One example of model number nomenclature in provided in the appendix. In these cases, we sorted by bestseller and collected information for the first 100 products, assuming that this would produce a representative set of products that would be available for sale. This data formed our overall population for each source. Once we aggregated a population of a certain product, we drew a sample that met or exceeded the target sample size.

In the process of creating our populations, some products were captured that were not subject to the examined standard. For example, when creating a population of products for the External Power Supplies standard, we searched for products characterized as "phone chargers." The results of the search returned both wall chargers and power banks, but the standard does not cover power banks. We filtered the population to omit such products not covered by the standard. We also examined the models in our sample closely and omitted any that would not be covered by the standard. If this situation occurred, we randomly drew a replacement model from the population to maintain an adequate sample size.

Additionally, some of our sources were national retailers. Therefore, our populations often included some products that would not meet California's rigorous energy efficiency standards but could legally be sold in other states. When creating our final samples for the state standards, we omitted products that the vendor would not ship to California, as these would not be subject to the California's standards.

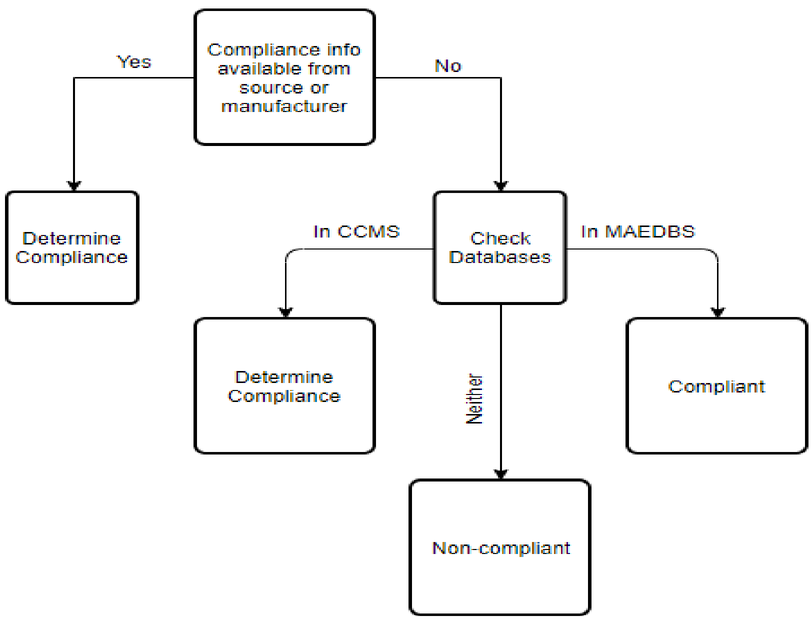
3.4.3 Compliance Calculation

We used the data collected for the sample to calculate a representative compliance rate for each standard. In this section, we discuss how we determined each sampled model's compliance with the standard and how we calculated the final compliance rate for each standard.

[32] For example, a search for battery chargers on Amazon.com returns "over 80,000" results.

After obtaining a final sample from each source, we examined metrics in the source's product literature and the manufacturer's website. If those sources did not contain enough information, we searched through two databases: The DOE Compliance Certification Management System (CCMS)[33] and the Energy Commission Modernized Appliance Efficiency Database System (MAEDBS).[34] If the model was listed in the CCMS and the CCMS contained enough information to confirm compliance, we considered it compliant (the CCMS states that the presence of a model in the database does not necessarily indicate that the model is compliant with the standards). If we found the model in MAEDBS, we ruled it compliant because the Energy Commission will only list products in MAEDBS that comply with the standards. If we could not find the product in either database or had insufficient information to determine compliance, we ruled the product non-compliant. Figure 12 shows the decision process we used to determine whether a given model was compliant with the standard.

Figure 12. Compliance Decision Flowchart



We then calculated overall compliance with each standard, weighting for market share of distribution channel or product type where appropriate. We used this approach to account for the balance of products across each sample size. Some products were "over-compliant" with the standards—that is, their efficiency rating exceeded the standard level. A conventional estimate of energy savings would calculate the difference between products that perform at the baseline level and products that just meet the new standard. A recent process evaluation conducted by TRC, however, recommended that an energy-based evaluation be performed to account for overcompliance by assessing the market average unit energy consumption.[35] **These additional savings above the standard level are accounted for in the potential savings estimate sections by adjusting the unit energy savings (UES) to reflect the true market average energy use of each product.** The compliance estimates discussed in this report do not account for overcompliance. These rates strictly reflect whether a product meets or does not meet the requisite standard.

[33] https://www.regulations.doe.gov/certification-data
[34] https://cacertappliances.energy.ca.gov/Pages/ApplianceSearch.aspx
[35] TRC (2019). C&S Attribution Study Report. pp.59-60. Available at: http://www.calmac.org/publications/Final_Report_CS_Attribution_Study_Mar_2019_(002).pdf

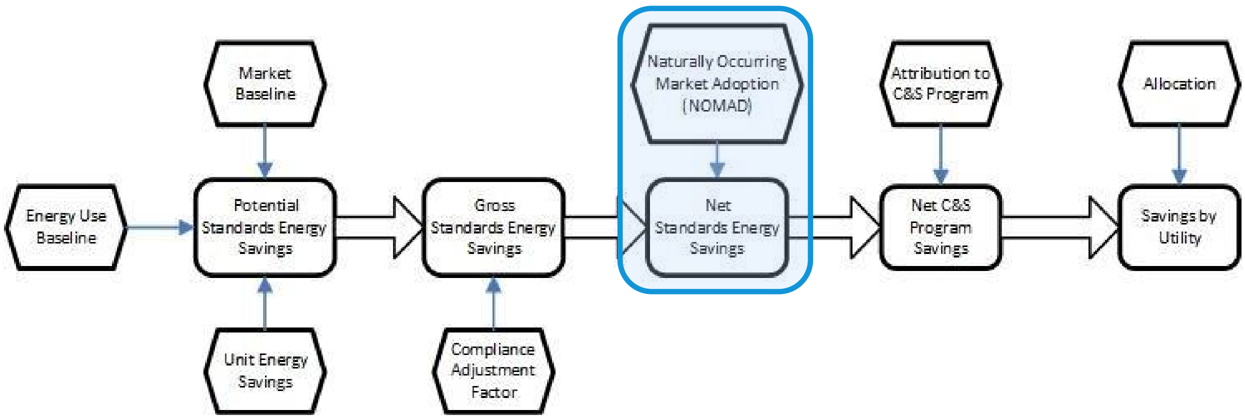
3.5 Where is the Net-to-Gross Ratio?

For C&S advocacy programs, everyone is a non-participant even when they are directly affected by the program outcome—a new code or standard. This is because C&S affects the entire market but has no "participant" data set. As a result, the C&S evaluation equivalent of a Net-to-Gross ratio is calculated by combining components. These are NOMAD and Attribution. This is a key distinction because the CEDARS claim provides only a Net-to-Gross input field for reporting.

3.6 Net Standards Energy Savings

To develop net standards energy savings the next component to estimate for each standard, shown in Figure 13, is the **N**aturally **O**ccurring **MA**rket **AD**option (**NOMAD**). Interpretation of NOMAD is discussed in section 3.6.3.

Figure 13. NOMAD Calculation Component



Historically evaluations use a BASS[36] diffusion model to estimate the rate at which a technology is adopted and its eventual saturation of the market.[37] There are two main ways to develop these curve estimates. One method requires the estimation of four coefficients for each code or standard.

1. t – the year a product enters the market
2. M -- the potential market (the ultimate number of adopters)
3. p -- coefficient of innovation (leading) and
4. q -- coefficient of imitation (following)

Using either method, once the estimates are developed, the estimated level of natural market adoption is subtracted from the measured market adoption (this can be expressed as shipment or sales data) and the difference is net C&S savings attributed to the code or standard. Accounting for the influence of the code or standard is separate from attributing the change to IOU advocacy efforts.

[36] Developed in 1963 by Frank Bass and describes the process of how new products get adopted as an interaction between users and potential users. http://www.bassbasement.org/BassModel/
[37] Market saturation under a BASS framework can be, and often is, defined as less than 100%.

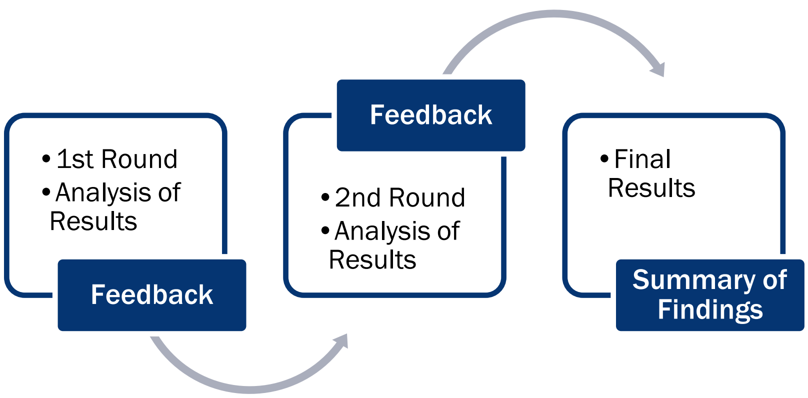
The IOUs have commented that the BASS model may not be the best method for estimating values for all standards. In some cases, a Markov decision process may be a better estimator.[38] The pros and cons of the Markov method as an estimator and its implementation should be explored in more detail to understand the data requirements, method of data collection, and results for evaluation (i.e., defined start and end states, objective function, and actions).

3.6.1 Surveying Process

We used the Delphi method to determine the NOMAD curve for each standard in the evaluation scope. The Delphi method is a structured communication technique that gathers feedback from a group of geographically dispersed experts to ultimately converge into one aggregated response. The Delphi process is commonly used in technology forecasting and policy making.

Navigant acted as the facilitator in the Delphi process and asked a group of experts to anonymously predict the naturally occurring adoption rate in the absence of a standard and explain their reasoning. To assist the participants, Navigant included the IOUs' determined forecast adoption curve as a baseline. After the respondents made their initial predictions, Navigant calculated the average of the results and summarized the respondents' rationale as shown in Figure 14. Navigant then distributed these findings to the same group of experts and encouraged them to consider modifying their responses in light of the new information.

Figure 14. Delphi Surveying Process



Some respondents decided to not to modify their first-round responses after reviewing the group averages. Others modified their responses slightly to match that of the group and provided reasoning accordingly. Respondents commented on the group's summary rationale and added insights on whether they believed it to be accurate.

3.6.2 Expert Selection Process Description

By examining a wide range of sources, we recruited experts to provide input into the Delphi process. These experts included:

- Individuals nominated for the panel by the Program Coordinating Group (PCG)
- Interested parties who participated in the state and Federal rulemaking process for the relevant standards, and whose contact information could be found in public rulemaking documents

[38] The process refers to the actions that happen to move from the current period state to the next period state. For C&S advocacy this would be the IOU actions during the development steps of a code or standard.

- Members of industry and professional associations
- Employees or associates of energy-related nonprofit organizations
- Employees of national laboratories
- Other individuals nominated by anyone belonging to the above categories

Navigant reached out to the identified individuals and followed up with those who did not respond to the initial contact. In all, Navigant contacted approximately 500 potential panelists. Navigant requested a brief statement noting any relevant academic or professional experience, publications, and/or credentials (e.g., P.E., CEM, etc.) from individuals who expressed interest in participating. Navigant selected panelists based on demonstrated expertise related to the technology and attempted to create a balance of affiliations on the panels. Navigant grouped the panelists by the code or standard group in which they had expertise; not every person on each group's panel provided estimates for every product in the group. Table 12 shows the number of participants in each code or standard group.

Table 12. Summary of Panel Participation

Code or Standard Group	# Panelists	# Responded to First Survey	# Responded to Second Survey
Appliances	5	5	5
Electronics	4	4	4
HVAC & Refrigeration	9	5	3
Commercial & Industrial Equipment	7	7	6
Lighting	4	3	3
Plumbing	6	4	4

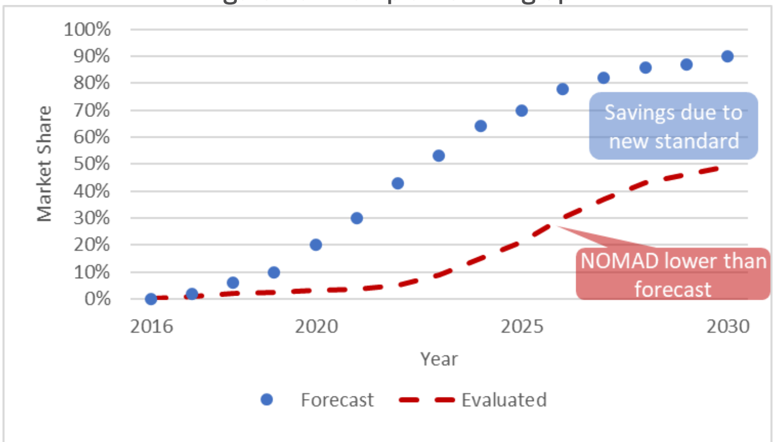
3.6.3 Interpreting the Results

The percent values in the following tables indicate the percent of the market for each product that **would have achieved** efficiency levels equivalent to the standard level **even if the standard had not been passed.**

- Lower NOMAD rates mean that only a small percent of the market would have reached the standard level without the standard being in place—and correspondingly, net savings associated with the standard are higher.
- Higher NOMAD rates mean that a larger percent of the market would have reached the standard level without the standard being in place, indicating that the standard had less of an effect on the market than other, natural market factors.

Lower NOMAD rates correspond to higher net savings and conversely higher NOMAD rates correspond to lower net savings. This concept is illustrated in Figure 15. The evaluated average rate of market adoption is lower than the IOU forecast rate of market adoption. This means that the standard either accelerated savings, increased savings, or affected both simultaneously compared to the IOU forecast. It does not, however, tell us directly how much the IOU advocacy efforts influenced development or adoption of the standard.

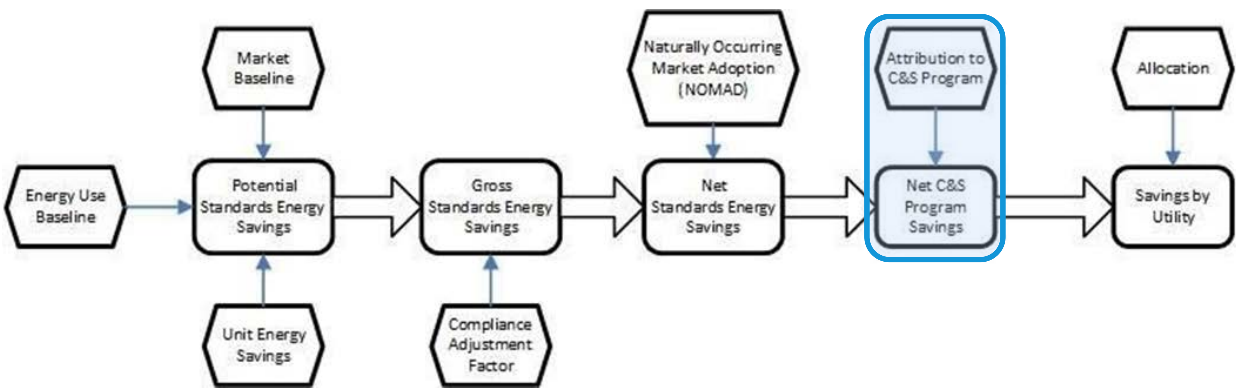
Figure 15. Example NOMAD graph



3.7 Net C&S Program Savings

The final step to develop an estimate of net C&S program savings is attribution. This section summarizes the methodology and findings of our attribution analysis. As shown in Figure 16, the attribution factors are applied to the net standards savings to yield the net C&S program savings. Findings for attribution scores are presented in section 4.4 of this report.

Figure 16. Codes and Standards Evaluation Component



Attribution is the estimate for the level of influence the IOU advocacy activities had on the final standard outcome through a regulatory body (state or federal). The evidence for this influence is provided by the IOUs in a CCSR. This evidence is categorized, weighted, and reviewed by the evaluators and a panel of independent industry experts. The weights and scores are used to develop an attribution value between 0 and 100 percent. Zero percent attribution means no influence and 100 percent means the standard would not have happened without the intervention of the IOU advocacy program. The attribution value is then multiplied against the net C&S savings resulting in the net IOU C&S program savings.

Current factors to determine IOU influence for each new standard are:

5. Compliance determination and other special analytic methods
6. Technical information and standard language
7. Feasibility of meeting the standard

These factors are weighted by the evaluators, then discussed and scored by independent subject matter experts. Three key steps are involved in evaluating attribution scores:

1. We collect information on IOU and stakeholder activities from a variety of sources, including CASE reports, state, and federal rulemaking dockets, and CCSRs provided by the IOUs.
2. We convene a panel of independent codes and standards experts to assess the C&S Program's contributions to the development and adoption of each standard based on a systematic review of the evidence gathered in step one. The expert panel scored the program's contributions in the three factor areas (compliance determination, technical information, and feasibility), which are described in sections 3.7.1.1, 3.7.1.2, and 3.7.1.3.
3. We develop weights for each of the three factor areas based on our assessment of the relative effort required for each factor. We then apply these weights to calculate a summary attribution score for each code or standard as a weighted average of the scores assessed by the expert panel in step 2.

3.7.1 The Attribution to C&S Model

The attribution model used in this analysis comes from the California evaluation protocols and applies to both state-level and federal rulemaking. The model sets forth specific criteria for evaluating the C&S Program's contributions to the development and adoption of codes and standards.

The model focuses on three areas of advocacy activity. These represent the fundamental requirements that must be met for the Energy Commission (for state standards and building codes) or DOE (for federal administrative rulemaking) to adopt a standard. The model describes these factors as follows.

3.7.1.1 Development of Compliance Determination Methods and Other Special Analytic Techniques

For a code or standard to be implemented effectively, manufacturers and enforcement bodies must have tools and methods to determine which buildings and products comply with the code or standard. For product standards, the compliance determination method is typically a test procedure that may be performed to assess the product's energy and/or water consumption. Test procedures may be developed by industry groups, by governmental agencies, or by independent organizations. There are several ways that the C&S Program may contribute to the development or revision of test methods. For example, the program may conduct product testing, participate in standards-making committees, or develop analytical tools that are used to assess product compliance.

3.7.1.2 Development of Code Language and Technical, Scientific, and Economic Information in Support of the Standard

Codes and standards must be defined using careful language that describes which products are covered by the standard, the efficiency requirements of the standard, and the effective date of the standard. The development of regulatory language depends on extensive engineering and economic research. This research estimates the energy and peak demand savings and the economic effect of the standard.

At the state level, much of this research is conducted by the C&S Program and its contractors, and findings are summarized in CASE reports. At the federal level, DOE's contractors prepare market assessments, engineering analyses, and economic analyses to determine whether particular standard levels are technically feasible and economically justified.

There are several ways that the C&S Program may contribute to the development or revision of code language and supporting information. For example, the program may draft and present recommended standard language or use studies and calculations to estimate the energy and demand savings and the cost-effectiveness of a standard.

3.7.1.3 Demonstrating the Feasibility or Market Acceptance of Standard Adoption

An implicit requirement for adopting a new standard is that compliance with the standard is practical and feasible. Supporters of the standard must address stakeholder concerns and demonstrate through market research that stakeholders can comply with the standard. The C&S Program may demonstrate the feasibility of a standard by documenting the market readiness of compliant products, documenting the costs to end users, and documenting any health and environmental externalities.

3.7.2 Data Collection Activities

We began collecting data for the attribution analysis by conducting a systematic and thorough review of available evidence regarding the C&S Program's activities in support of code and standard development. We collected information from a variety of sources, including CCSR and CASE reports provided by the IOUs, public documents (including rulemaking notices, stakeholder comments submitted to rulemaking dockets, and transcripts of public meetings), and interviews with C&S experts who participated in rulemaking proceedings.

Based on this review, we documented the following information for each code and standard:

- Whether or not a prior standard existed
- Any changes to a standard's scope of coverage, the compliance determination method, and the minimum efficiency levels that were introduced by the new standard.
- Any influence that current and prior California standards had in shaping standards developed at the federal level.
- The timeline of the various stages of standards development
- The C&S Program's participation in the standards making process, as evidenced by the IOU's participation in public meetings, publication of reports, filing of comments, and organization of other efficiency advocates.

3.7.3 Estimation of Factor Scores

We then developed criteria to guide our assessment of attribution scores:

1. Attribution should be determined by disinterested third-party technical experts who do not have a stake in the amount of credit that is awarded.
2. Attribution credit should be awarded based on evidence concerning the C&S Program's influence in the development and adoption of standards.
3. The scoring process should be transparent, documented, and repeatable.

Based on document review and interviews we developed a list of potential candidates that met our criteria by inviting candidates to participate and vetting them for any biases. Once the criteria were met, we convened a panel of independent C&S experts to assess attribution scores. The panel consisted of five experts: one representing the Northwest Energy Efficiency Alliance (NEEA); one representing the Midwest Energy Efficiency Alliance (MEEA); one representing the Pacific Northwest National Laboratory (PNNL); one who served as a reviewer for prior CPUC standards savings evaluations; and one independent consultant serving on the boards of several energy efficiency organizations. Two of the five panel members participated in at least one attribution panel for a prior evaluation cycle.

In October 2019, the panel convened for a two-day session at the Portland, Oregon offices of the Northwest Energy Efficiency Alliance. At the meeting, we explained the attribution model and the method used to develop attribution scores. We asked panelists to judge the C&S Program's contributions to each attribution factor relative to the contributions of other stakeholders such as industry representatives, energy efficiency advocates, the CEC, and the DOE. We informed panelists that they should not score attribution factors based on the amount of effort required for each factor, since the amount of effort would be considered separately in the evaluation team's development of factor weights (described in section 3.7.4).

For each code and standard that the panel considered, we delivered a presentation that described the standard's history (e.g., whether a prior standard existed, and whether the standard was initially promulgated in California), the positions of various stakeholders, and the process involved in developing the new standard. We presented evidence describing the C&S Program's contributions related to each of the three factors in the attribution model. Several panelists were active participants in the proceedings for some of the standards considered by the panel, and they offered first-hand knowledge from their experience. The panelists discussed their impressions of the C&S Program's contributions relative to the contributions of other stakeholders. During their discussion, the panelists asked us questions about the rulemaking activities. For several standards, the panelists referenced regulatory notices and comments that were submitted during the standards development process. After discussing their individual opinions regarding factor scores, the panel attempted to reach agreement on scores for each of the three attribution factors. In cases where the panel could not reach agreement on factor scores, we calculated the final score for each factor as an average of the scores that individual panelists assigned to the factor.

To ensure that the panel had adequate time to consider each code and standard presented, the panel session only assessed scores for 18 of the 27 standards in scope for this analysis. The panelist session included standards with estimated first-year gross savings greater than 8 GWh/year, accounting for 98% of the estimated first-year gross savings for all standards evaluated.

Separate from the panel session, we assessed attribution scores for lower priority standards with estimated first-year gross savings of 8 GWh/year or less. These assessments followed a similar format to the panel session in that evaluation team members developed scores considering the development of the standard, the stakeholder involvement, and the evidence provided by the IOUs in the CCSR documents.

3.7.4 Estimation of Factor Weights

Independently of the factor scoring we developed factor weights internally for each code or standard evaluated in this attribution analysis. We based the factor weights on an assessment of the resources expended for each factor area for each code or standard. This assessment drew upon evidence provided in CCSRs and on data collected through the team's review of rulemaking documents and stakeholder interviews.

To validate these internally developed factor weights, we asked the IOUs to provide estimates of the factor weights for each standard. We submitted a data request to the IOUs similar to the surveys used in previous evaluations. For each state and federal code and standard, we asked, "What was the percentage allocation of total stakeholder resources across the factor areas in the development of the standard, where resources are defined in terms of budgets?" We also asked the IOUs to provide a brief explanation as to the reasoning behind their weights.

We compared our internally developed weights to those provided by the IOUs. If the weights proved relatively close, we used the weights developed internally. If large discrepancies arose between the team's estimates and the IOUs' (i.e., generally 10% or more), we reviewed the justification provided by the IOUs, conducted additional research, and adjusted the weights, as necessary.

3.7.5 Calculation of Attribution Scores

Once weights were calculated by the evaluators and scoring was completed by the panel, we calculated the summary attribution score for each code or standard by multiplying the factor score and factor weight for each factor, and then summing the weighted scores. This summary attribution score measures the C&S Program's contribution to the development and adoption of a standard. In our overall evaluation process, these attribution scores are applied to the net standards savings to yield the net codes & standards program savings.

3.7.6 Pilot Testing of New Attribution Factors

As a separate exploratory exercise, we pilot test new attribution factors. In July 2019, the California IOUs published the final report of the C&S Program Advocacy and Attribution Study. This study conducted a high-level process evaluation of the overall IOU C&S advocacy efforts and provided recommendations for improving the attribution methodology and the evaluation approach. The study made a key recommendation relevant to the attribution analysis. Namely, the study recommended that evaluators use additional factors or develop an evaluation method using existing factors to determine attribution for program activities related to,

1. Strategic preparation: to capture planning, coordination, data collection, and solution development activities; and
2. Stakeholder engagement: to identify activity and outreach beyond CASE work to align all stakeholders.

These factors were not used in scoring for this evaluation, but they were "piloted" with experts while developing the attribution scores.

We discussed this recommendation with attribution panelists at the October 2019 panel convened for this analysis. After the panelists had scored several standards using the three attribution factors in the current model, we asked panelists to participate in a pilot test of two new attribution factors. Specifically, we invited panelists to score two federal commercial A/C standards (Fed 32 and Fed 39) using two additional attribution factors for strategic preparation and stakeholder engagement. Following this pilot exercise, we facilitated a panel discussion regarding the feasibility of incorporating these factors in the attribution model.

The panelists offered the following observations regarding a factor related to strategic preparation:

- Strategy is both long-term (i.e., "what are we doing over the next 3-5 years?") and tactical (i.e., "how are we approaching this one rule?"). Panelists felt that a "strategic preparation" factor should consider both the long-term and tactical components of the IOUs' advocacy.
- Panelists expected that the IOUs approach each rulemaking with a strategy in mind, but they noted that it may be difficult for observers to discern their strategy if the IOUs do not provide their strategy.
- Panelists said it would be challenging to score strategic preparation for individual rules. Sometimes, the IOUs' strategy may involve disengaging from one rule to reserve political capital for use on a different rule.
- Panelists did not want to score the "strategic preparation" factor as a function of what was achieved (i.e., was a specific advocacy effort successful). Instead, they were inclined to score this factor based on the effort invested by the IOUs, regardless of the outcome.

- Panelists noted that it would be difficult to assign a weight to a "strategic planning" factor since it is difficult to gauge the effectiveness of a strategy, or the level of effort involved in strategic planning.

The panelists offered the following observations regarding a factor related to stakeholder engagement:

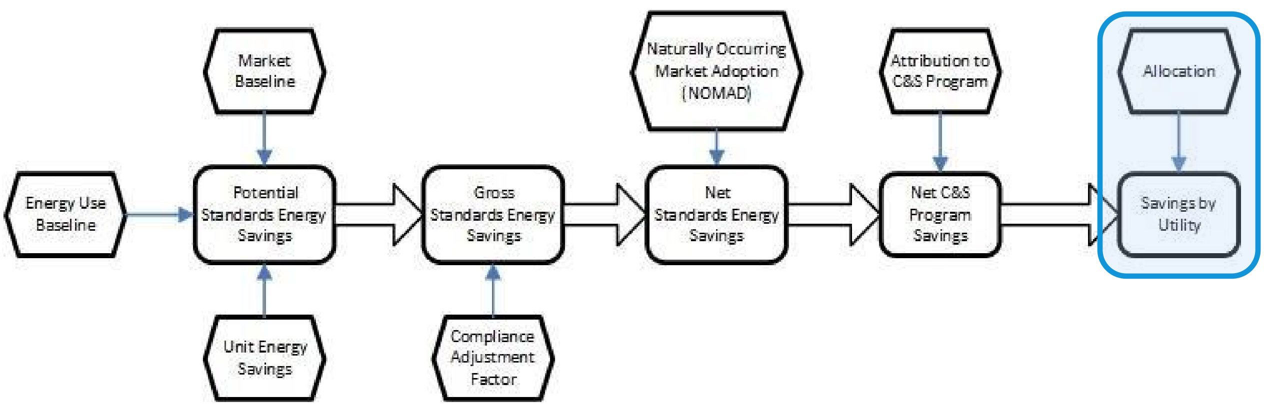
- A "stakeholder engagement" factor would overlap significantly with "rulemaking support," which is already captured by the three factors in the current attribution model.
- Panelists said they were implicitly considering stakeholder engagement in their judgment of the three factors in the current attribution model. If "stakeholder engagement" were defined as a factor at the outset, it would be possible for panelists to remove this implicit consideration when rating the other factors.
- The CCSRs provided by the IOUs report the number of advocate conference calls and strategy sessions. To assess a "strategic preparation" factor, panelists would need information about which stakeholder convened these meetings.

We are providing panel feedback in this report as it may prove useful for modifications of the attribution model applied in future evaluations of savings.

3.8 Savings by Utility

At this point, savings are calculated at the statewide level. However, each IOU is allocated a portion of this statewide savings as credit to their energy efficiency portfolio goals. The last step in the evaluation is allocating these savings to each IOU. In this and prior evaluations the allocation factor is based on electric and gas sales.[39]

Figure 17. Attribution Calculation Step



Through the business planning process, policy decisions for Statewide programs directly affect C&S advocacy. In Decision 16-08-019, Section 4.3 page 55 states, "The lead statewide administrator for each area will not be assigned credit for all of the results of the program; rather, the energy savings will be apportioned to all contributing administrators based on actual customer participation."[40]

Additionally, on page 103, under Conclusions of Law the decision states, "47. Program administrators from whose customers funds are collected for the statewide programs should have both program costs and savings

[39] From 2020 and beyond the weighting factor will be IOU budget expenditures. See Cost Effectiveness report for more details.
[40] D.16-08-019 DECISION PROVIDING GUIDANCE FOR INITIAL ENERGY EFFICIENCY ROLLING PORTFOLIO BUSINESS PLAN FILINGS, 08/25/2016

reflected in their cost-effectiveness showings, savings credit, and ESPI awards based on their proportional contribution to the statewide programs."

Later in Decision 18-05-041, page 82, for business planning that covered 2018-2025 the decision states, "D.16-08-019 addressed the issue of allocation of savings credit for statewide programs based on budget contributed by each IOU PA. 'We clarify that this means that credit for energy savings generated will be based on funding contributed only, and not in relation to the geographic region in which the energy efficiency measure was sold or installed.'"[41]

After consultation with CPUC staff, we interpreted these decisions as applying to programs implemented after 2018. As a result, this evaluation did not use monetary contribution to the statewide program budget to apportion benefits. Instead, we continued to use electric and gas sales volume to apportion C&S savings to each IOU. Administrative costs used for cost-effectiveness were those costs reported by each IOU.

The electric and gas sales volume percentages in Table 13 are derived from California Energy Commission Energy Reports.[42] The values are used to allocate the evaluated statewide benefits and incremental equipment costs, by fuel type, to each utility for the cost effectiveness calculations.

Table 13. Annual Sales 2016-2018

	Electric			Gas		
IOU	2016	2017	2018	2016	2017	2018
PG&E	36.4%	35.8%	36.2%	44.1%	44.5%	45.0%
SCE	35.9%	35.8%	36.7%	0.0%	0.0%	0.0%
SCG	0%	0%	0%	50.0%	49.6%	49.2%
SDG&E	7.4%	7.3%	7.5%	4.5%	4.5%	4.5%
Other	20.3%	21.1%	19.6%	1.3%	1.3%	1.3%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

The "Other" category for electric includes publicly owned load-serving entities, rural electric cooperatives, community choice aggregators and non-IOU electric service providers that report C&S savings values to the Energy Commission (For example: Sacramento Municipal Utility District and Los Angeles Department of Water and Power). Gas sales were adjusted by removing non-retail sales and recalculating the allocations.[43]

[41] D.18-05-041 DECISION ADDRESSING ENERGY EFFICIENCY BUSINESS PLANS, 05/31/2018
[42] California Energy Commissionhttps://ecdms.energy.ca.gov/gasbyplan.aspx and https://ecdms.energy.ca.gov/elecbyplan.aspx
[43] The Kern River Gas Transmission Company accounts for on average approximately 16% of statewide gas sales, but these are directed toward power producers as part of the Western Area Power Administration and so are excluded for C&S allocations.

4. Evaluation Findings

These study results present the six components used to develop energy savings estimates from Potential savings to Net Allocated savings. The savings claim filed in CEDARS by the IOUs, does not contain most of these components. The savings claim includes gross savings, net savings, and a net-to-gross value of 1.0. CCSR and CASE reports are supposed to serve as workpapers for the IOU savings claims, but as we show in this report, that presumption is not necessarily accurate. The IOUs did provide additional information on calculation parameters via a data request, and we used those where feasible.

The IOUs reported 32 new standards in total. Of these, 15 were introduced in 2016, 7 in 2017, and 10 in 2018. Federal standards accounted for 13 standards and state standards made up the remaining 19 standards.

4.1 Potential Savings

Overall IOU electric potential savings (GWh) was about the same as the evaluated savings with a difference of 1%. Overall evaluated demand reduction (MW), however, was 17% higher than IOU CCSR estimates. Potential savings are not explicitly reported in the savings claim. Only gross and net savings are reported. To make comparisons of potential, we used the estimates provided in the IOU CASE and CCSR documents. The values presented here reflect 12 months of savings.

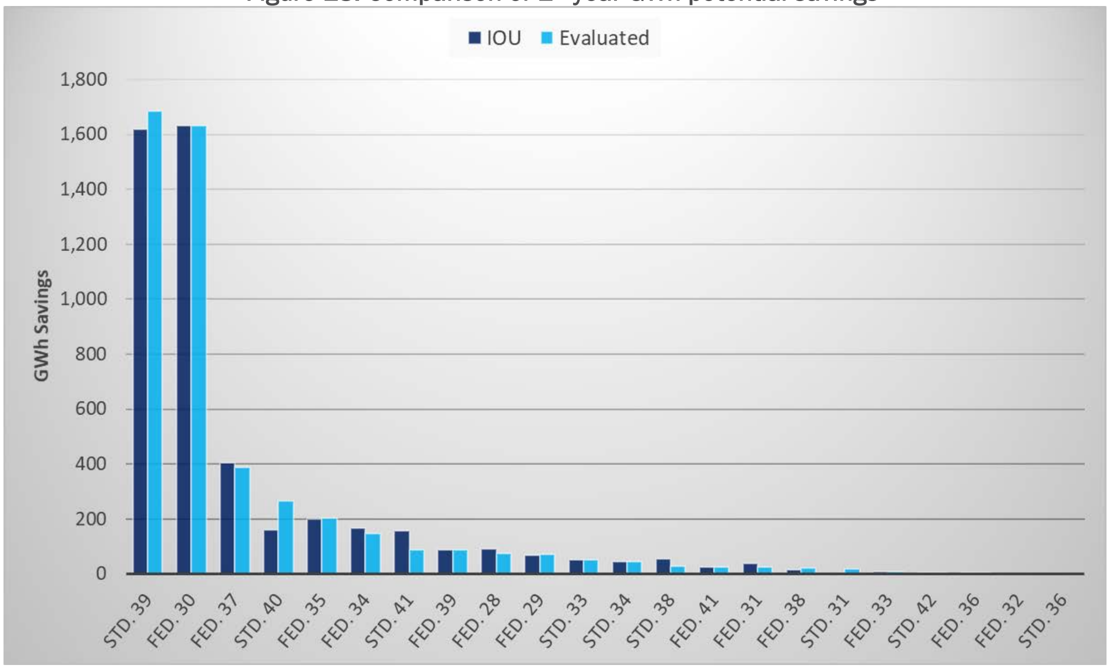
Overall evaluated gas savings was about 30% lower than IOU CCSR estimates. In addition, evaluated water and embedded energy savings were approximately 20% below IOU CCSR estimates. Table 14 provides a summary comparison of estimates along with the percentage difference. Differences greater than 100% indicate that the evaluated results are higher than the CCSR values. Differences lower than 100% indicate that the evaluation estimates less savings than IOU CCSRs. The details for each standard appear in Appendix E later in this report. Electric and natural gas interactive effects are discussed in Section 4.1.1 of this report.

Table 14. Summary of Potential Savings

Total First-Year Potential Savings, California									
Electricity Savings (GWh/year)		Demand Savings (MW)		Natural Gas Savings (Mtherms/year)		Water Savings (million gallons/year)		Embedded Energy Savings (GWh/year)	
IOU CCSR	Evaluated	IOU CCSR	Evaluated	IOU CCSR	Evaluated	IOU CCSR	Evaluated	IOU CCSR	Evaluated
4,831	4,872	602	706	64	45	14,619	11,541	69	56
	101%		117%		71%		79%		81%

Figure 18 shows how approximately 90% of all GWh savings came from 7 standards (4 Fed + 3 State). Two standards, Std 39-General Service Lamps and Fed 30-Motors account for 68% of this.

Figure 18. Comparison of 1st year GWh potential savings



Standards with the greatest differences in savings between reported IOU values and evaluation estimates are in the lamp category (Table 15). Specifically, differences in state and federal lighting standards (Fed 37 and Std 39) are due to changing the classification of lamp types within the standards and using a market average baseline rather than a prior standard baseline.

Table 15. Standards with greatest annual potential GWh savings

Standard ID	Standard Name	First-Year Potential Savings, California					
		Electricity Savings (GWh/year)		Demand Savings (MW/year)		Natural Gas Savings (Mtherms/year)	
		IOU CCSR	Evaluated	IOU CCSR	Evaluated	IOU CCSR	Evaluated
Std 39	General Service Lamps	1,617.6	1,683.6	131.9	137.3	–	–
Fed 30	Electric Motors	1,633.0	1,632.6	230.0	285.7	–	–
Fed 37	General Service Fluorescent Lamps	405.0	388.3	64.0	61.6	–	–
Std 40	Small Diameter Directional Lamps	161.1	265.4	13.1	57.2	–	–
Fed 35	WICF Refrigeration Equipment	147.0	150.1	16.6	17.1	–	–
Fed 34	Commercial Refrigeration Equipment	167.6	145.8	19.0	16.6	–	–
Std 41	General Service LED Quality	155.6	88.7	12.7	19.1	–	–

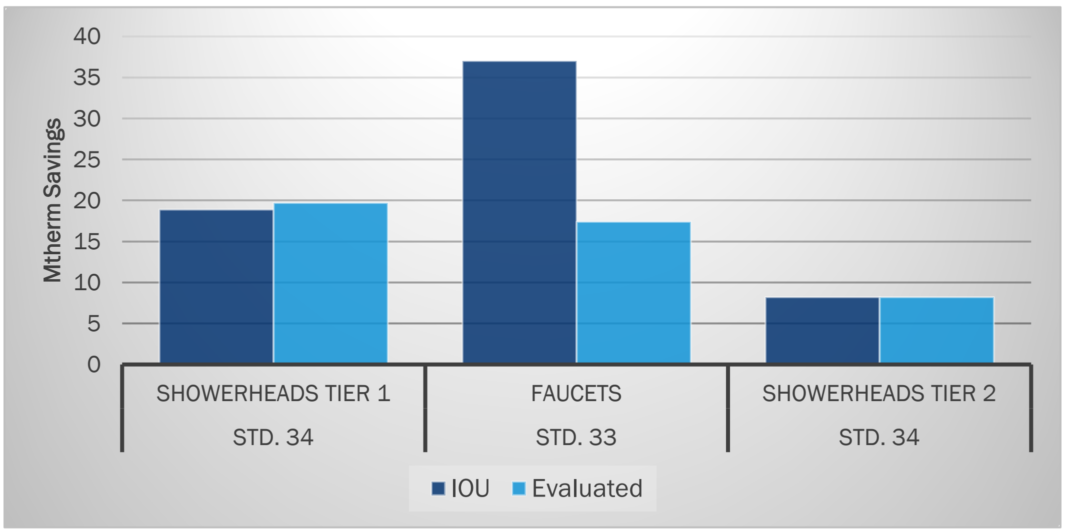
Approximately 99% of all Mtherm savings came from 3 state standards (Table 16 and Figure 19)

Table 16. Standards with greatest annual potential Mtherm savings

Standard ID	Standard Name	First-Year Potential Savings, California					
		Electricity Savings (GWh/year)		Demand Savings (MW/year)		Natural Gas Savings (Mtherms/year)	
		IOU CCSR	Evaluated	IOU CCSR	Evaluated	IOU CCSR	Evaluated
Std 34	Showerheads, Tier 1	31.0	32.3	3.6	4.3	18.9	19.7
Std 33	Faucets	50.1	52.0	6.7	7.1	37.0	17.4
Std 34	Showerheads, Tier 2	13.4	13.4	1.5	1.7	8.2	8.2
Fed 36	Clothes Washers (Com)	3.7	3.7	0.5	0.5	0.3	0.3
Fed 38	Clothes Washers, Tier 2 (Res)	14.0	21.6	2.0	3.2	0.1	-

Note: Savings for these water measures are distributed between electric and gas water heating estimates.

Figure 19. Standards with greatest annual potential Mtherm savings



The difference in savings for Std 33 are due to differences in baseline assumptions. In their CASE report, the IOUs acknowledged the assumption that 50% of faucet water used is hot water. They did not, however, apply this adjustment in their savings calculations. The 50% hot water assumption was applied in the evaluation resulting in the lower therm savings.

The California IOUs report savings resulting from their energy efficiency standards advocacy in CEDARS. The CEDARS database contains gross savings claims, net savings claims, and other data; but CEDARS does not report the potential savings values that are calculated prior to the application of compliance rates. The IOUs provided estimates of potential savings in the form of CASE reports and CCSRs with supporting spreadsheet calculations. Table 17 compares our evaluation results for potential first-year electricity and demand savings to the results presented in the IOUs' CCSRs. First year in this table refers to a 12-month period. It does not prorate for partial calendar years due to effective dates after January 1.

Table 18 compares our evaluation results for potential first-year natural gas, water, and embedded energy savings to the results presented in the IOUs' CCSRs, for relevant standards. A later section of this evaluation compares the evaluated net savings to utilities' net savings claims filed in CEDARS.

Table 17. Summary of California Potential Electricity and Demand Savings, by Standard

Standard ID	Standard Name	First-Year Potential Savings, California					
		Electricity Savings (GWh/year)			Demand Savings (MW/year)		
		IOU CCSR	Evaluated	Difference	IOU CCSR	Evaluated	Difference
Appliances							
Fed 31	Microwave Ovens	38.4	23.5	–39%	7.8	4.8	–39%
Fed 36	Clothes Washers (Com)	3.7	3.7	0%	0.5	0.5	0%
Fed 38	Clothes Washers, Tier 2 (Res)	14.0	21.6	+54%	2.0	3.2	+60%
Electronics							
Std 31	Small Battery Chargers	n/r	18.1	–	n/r	2.2	–
Std 42a	Computers (Workstations)	4.0	5.3	+31%	0.6	0.8	+32%
Std 42b	Computers (Small-Scale Servers)	1.4	1.2	–14%	0.2	0.2	–18%
Fed 29	External Power Supplies	68.4	70.5	+3%	9.2	9.5	+3%
Commercial HVAC and Refrigeration Equipment							
Fed 32	Com. Central A/C and Heat Pump <65kBtu/h	0.9	1.7	+88%	0.6	0.8	+38%
Fed 34	Commercial Refrigeration Equipment	167.6	145.8	–13%	19.0	16.6	–12%
Fed 35	WICF Refrigeration Equipment	147.0	150.1	+2%	16.6	17.1	+3%
	WICF Display Doors	51.3	51.9	+1%	5.8	5.9	+2%
Fed 39	Central A/C and Heat Pump, Tier 1, 65-760 kBtu/h (Com)	87.8	87.8	0%	47.4	47.7	+1%
Fed 41	Icemakers (Com)	25.3	25.2	0%	2.6	2.9	+1%
Commercial and Industrial Equipment							
Fed 28	Distribution Transformers	89.4	74.8	–16%	17.0	14.2	–16%
Fed 30	Electric Motors	1,633.0	1,632.7	0%	230.0	285.7	+24%
Lighting							
Std 38	Dimming Fluorescent Ballasts	54.9	27.1	–51%	8.71	4.3	–51%
Std 39	General Service Lamps	1,617.6	1,683.6	+4%	131.9	137.3	+4%
Std 40	Small Diameter Directional Lamps	161.1	265.4	+65%	13.1	57.2	+335%
Std 41	General Service LED Quality	155.6	88.7	–43%	12.7	19.1	+51%
Fed 33	Metal Halide Lamp Fixtures	10.1	7.2	–29%	0.1	0.9	+680%
Fed 37	General Service Fluorescent Lamps	405.0	388.3	–4%	64.0	61.6	–4%
Plumbing							
Std 33	Faucets	50.1	52.0	+4%	6.7	7.1	+7%
Std 34	Showerheads, Tier 1	31.0	32.3	+4%	3.6	4.3	+19%
	Showerheads, Tier 2	13.4	13.4	+0%	1.5	1.7	+14%
Std 36	Urinals	--	--	–	–	–	–
	Total	**4,831.0**	**4,871.9**	**+1%**	**601.6**	**705.7**	**+17%**

Note: We did not receive a code change savings report (CCSR) with potential savings claims for Standard 31 covering tier 3 small non-consumer battery chargers. The evaluated potential savings are based on estimates of market size and unit energy consumption in the IOUs' 2010 CASE Report and the CEC's 2011 Staff Report for battery chargers.

Table 18. Summary of California Potential Natural Gas, Water, and Embedded Energy Savings, by Standard

Standard ID	Standard Name	First-Year Potential Savings, California								
		Natural Gas Savings (Mtherms/year)			Water Savings (million gal/year)			Embedded Energy Savings (GWh/yr)		
		IOU CCSR	Evaluated	Difference	IOU CCSR	Evaluated	Difference	IOU CCSR	Evaluated	Difference
Std 33	Faucets	37.0	17.4	–53%	5,776.4	5,430.4	–6%	28.0	26.3	–6%
Std 34	Showerheads, Tier 1	18.9	19.7	+4%	3,690.9	3,812.9	+3%	17.9	18.5	+3%
	Showerheads, Tier 2	8.2	8.2	–1%	1,575.3	1,575.3	0%	7.6	7.6	0%
Std 36	Urinals	--	--	--	3,191.6	159.8	–95%	15.5	0.8	–95%
Fed 36	Clothes Washers (Com)	0.3	0.3	–1%	6.0	31.5	+426%	0.2	0.2	+2%
Fed 38	Clothes Washers, Tier 2 (Res)	0.1	0.0	–110%	342.0	494.3	+45%	Included in Electric Savings	2.4	--
Fed 41	Icemakers (Com)	--	--	--	37.1	36.7	–1%	0.2	0.2	0%
Total		**64.5**	**45.5**	**–29%**	**14,619.3**	**11,540.9**	**–21%**	**69.4**	**55.9**	**–19%**

Note: This difference in total savings was due to a spreadsheet cell reference error and not a formula or assumption error.

For several standards, the evaluated savings values differ from the IOU CCSR estimates by more than 20%. Explanations of the differences for selected measures are as follows:

- **Std. 33: Faucets:** The evaluated potential natural gas savings for faucets are 53% lower than the IOU estimate. The calculations supporting the CCSR for lavatory faucets dated April 2019 were supplied in a file named "11 – IOU C&S team 2019 – Savings Assumptions for Title 20 Faucets.xlsx" and they estimate the natural gas consumption associated with heating the hot water consumed from lavatory faucets. We believe these calculations omit a hot water factor of 50% to account for "Percent of faucet use that is hot water." Our calculations include this factor, resulting in a lower estimate of natural gas savings.
- **Std. 36: Urinals**: The evaluated potential water and embedded energy savings for urinals are 95% lower than the IOU estimate. The savings from urinal standards are derived only from changes to wall-mount urinal standards, but the IOUs calculated potential savings using shipments of all product types (i.e., urinals and toilets). This vastly overestimates the potential water savings from urinal standards. Our analysis calculates the first-year potential savings as the product of the per-unit savings and the annual shipments of wall-mount urinals only (i.e., not including toilets, since toilet standards were not updated in the Tier 2 standards in scope for this evaluation).
- **Std. 38: Dimming Fluorescent Ballasts:** The evaluated potential electricity savings for dimming fluorescent ballasts are 51% lower than the IOU estimate. The calculations supporting the CCSR for dimming fluorescent ballasts reference the average energy use for non-qualifying products reported in Table 4.1 of the 2013 CASE report. This value does not appear to reflect the market distribution of different ballast sizes (i.e., the proportion of 1-, 2-, 3-, and 4-lamp ballasts shipped each year). We favored the approach and data presented in Figure 14 of the 2017 Energy Commission Staff Analysis of Dimming Fluorescent Ballasts, which included additional test data gathered in 2014 and reported baseline and standard-level energy use by ballast size.
- **Std. 40: Small Diameter Directional Lamps:** The evaluated potential electricity savings for SDDLs are 65% higher than the IOU estimate. The calculations supporting the IOUs' savings claims for SDDLs were supplied in a file named "12 – IOU C&S Team 2019 – SDDL Savings Assumptions.xlsx." The "Measure Checklist" tab of this file reports a 2018 California shipments value of 1,526,655 units per year in cell C14. We believe this value is incorrectly calculated, since it references the California shipments of SDDLs projected in the "CA Base Case Shipments" tab, and then applies an additional "California Adjustment" factor as though it were scaling national shipments to estimate California shipments. Our evaluation forecasts higher annual California shipments of SDDLs (2,789,000 units per year), resulting in a potential savings estimate that is higher than the IOUs claims.
- **Std. 41: General Service LED Quality:** The evaluated potential electricity savings for the General Service LED Quality standard are 43% lower than the IOU estimate. The calculations supporting the IOUs' savings claims for General Service LEDs were supplied in a file named "12 - IOU C&S Team 2019 – LED Savings Assumptions.xlsx." The IOU calculations use a baseline efficacy value of 81.3 lumens per watt (lpw) for omnidirectional LED lamps, based on the 2015 Energy Commission Staff Report. Our analysis used a higher baseline efficacy value of 97.1 lpw, which was the average observed efficacy of LED lamps for the sample of 141 lamps studied in the compliance analysis for this evaluation. Our use of a higher baseline efficacy led to a lower calculated unit energy savings for omnidirectional LED lamps, which in turn led to a lower weighted average unit energy savings value of 1.31 kWh/year (compared to the IOU calculated value of 2.30 kWh/year).
- **Fed. 28: Distribution Transformers:** The evaluated potential electricity savings for distribution transformers are 16% lower than the IOU estimate. The calculations supporting the savings claims for distribution transformers were supplied in a file named "06 – IOU C&S Team 2019 – Distribution Transformers Savings Assumptions.xlsx." This file calculates a shipments-weighted average baseline

unit energy consumption based on values cited to DOE's Final Rule National Impact Analysis spreadsheet. We referenced the same NIA spreadsheet but were unable to recreate the aggregate energy use values cited in the IOUs' analysis. We suspect there were errors in the IOUs' retrieval of data from DOE's NIA spreadsheet.

- **Fed. 31: Microwave Ovens:** The evaluated potential electricity savings for microwave ovens are 39% lower than the IOU estimate. The IOUs calculated energy savings relative to a baseline of the worst performing unit on the market. Since no prior standard existing for microwave ovens, our evaluation calculated savings relative to a baseline representing the market average unit energy consumption, per guidance from the CPUC's Energy Efficiency Policy Manual.
- **Fed. 33: Metal Halide Lamp Fixtures:** The evaluated potential electricity savings for metal halide lamp fixtures are 29% lower than the IOU estimate. We identified a calculation error in the IOUs' calculation of US shipments for the 150W Indoor representative unit. The IOU calculations erroneously sum the shipments for both the Low and Medium shipments scenarios for the 150W Indoor representative unit, rather than summing the shipments for just the Medium shipments scenario. Because of this, the IOUs' calculations overestimate the shipments and potential electricity savings.
- **Fed. 36: Commercial Clothes Washers:** The evaluated potential water savings for commercial clothes washers are 426% higher than the IOU estimate. The calculations supporting the savings claims for commercial clothes washers (CCWs) were supplied in a file named "08 - IOU C&S Team 2019 - Energy Saving Calculations.xlsx." We believe the calculation of potential California water savings in that spreadsheet contains a formula error that results in an underestimate of potential savings.
- **Fed. 38: Residential Clothes Washers (Tier 2):** The evaluated potential electricity savings for residential clothes washers are 54% higher than the IOU estimate. The calculations supporting the savings claims for RCWs were supplied in a file named "9 - IOU C&S team 2014b.xlsx." The calculations in this file confuse the value of national RCW *stock* with the value of RCW *shipments*, and this mismatch leads to erroneous savings estimates. In the analysis presented here, we use a DOE-reported value for national shipments, and we estimate California's share of national shipments by scaling the national shipments on the basis of housing stock.

The six appendices (A-F) of this report are divided into sections, with each section describing a different standard that we examined in our evaluation. At a minimum, each of these sections contains an assessment of the California market size and the unit energy savings for the standard in question. When there are instances where our evaluation results differ greatly from the estimates supporting the IOUs' savings claims, we identify and describe the cause of the discrepancy.

4.1.1 Interactive Effects

For this evaluation we adopted the definition of interactive effects (IE) provided by ACEEE. Specifically, "*lighting interactive effects refer to the indirect effect on HVAC energy usage due to the installation of energy efficient lighting measures. The decline in heat emitted from high efficiency lighting may lead to an increase in heating requirements and a decrease in cooling requirements.*"[44] In addition, "*interactive effects apply only to interior lighting that operates in mechanically heated or cooled spaces.*" [45]

For kWh or kW an IE factor of 1.0 translates to no savings credit or penalty. An IE factor greater than 1.0 implies an electric savings credit due to the reduced need for electric air conditioning. As lighting technology

[44] Gill, James, Collin Elliot, Jean Shelton, and Jeorge Tagnipes, "Shedding a Cool New Light on a Heated Topic: Verifying Interactive Effects for Retail Lighting Retrofit Participants Using Monthly and AMI Bills", ACEEE, 2016 Summer Study on Energy Efficiency in Buildings, page 6-1

[45] Gowans, Dakers, The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures, Chapter 2: Commercial and Industrial Lighting Evaluation Protocol, NREL/SR-7A30-53827, 2013, page 2-6

moves away from incandescent and toward technologies like LED, even though some heat is produced due to inefficiencies in the semiconductors, these effects can arguably be considered negligible.

For therms, an IE factor of 0.0 translates to no savings credit or penalty. An IE factor less than 0.0 implies more gas is being used for heating to compensate for the reduced heat generated by the lighting fixtures.

We reviewed and updated the IE factors supplied by the IOUs. These are reported in Table 19. We reviewed DEER, CASE, CCSR, and IOU documents to validate and apply IE factors. IE factors are not reported in the claims.

Table 19. Interactive Effect Factors

ID	Standard Name	kWh		kW		Therm	
		IOU	Eval	IOU	Eval	IOU	Eval
Fed 33	Metal Halide Lamp Fixtures (Com)	1.100	1.061	1.320	1.258	(0.005)	(0.007)
Fed 34	Commercial Refrigeration Equipment (Com)	1.050	1.000	1.320	1.000	(0.024)	-
Fed 36	Commercial Clothes Washers (Com)	1.092	1.000	1.235	1.000	(0.006)	-
Fed 37	General Service Fluorescent Lamps (Res)	1.100	1.066	1.227	1.261	(0.005)	(0.006)
Fed 38	Residential Clothes Washers, top loading (Res)	1.040	1.000	1.320	1.000	(0.024)	-
Fed 41	Icemakers (Com)	1.025	1.000	1.160	1.000	(0.012)	-
Std 31	Small Battery Chargers, Tier 3 (non-consumer)	1.100	1.000	1.320	1.000	(0.004)	-
Std 38	Dimming Fluorescent Ballasts	1.100	1.080	1.227	1.269	(0.005)	(0.006)
Std 39	General Service Lamps	1.000	1.000	1.000	1.000	-	-
Std 40	Small Diameter Directional Lamps	1.100	1.066	1.227	1.261	(0.005)	(0.006)
Std 41a	General Service LED Lamps - Tier 1	1.071	1.000	1.209	1.000	(0.007)	-

4.2 Gross Standards Energy Savings

We determined that the majority of the standards met or exceeded the IOU compliance estimates. The following table summarizes our compliance findings (Table 20).

Table 20. Summary of Compliance Rate Findings, by Standard

Comparison to IOU Estimates	Standard	Product	IOU Compliance Estimate	Evaluated Compliance Estimate	Difference*
Higher than IOU Estimates	Std 41a	General Service LED Lamps, Tier 1	77.0%	99.3%	22.0%
	Std 33a-d	Lavatory Faucets and Aerators	85.0%	100.0%	15.0%
	Fed 28	Distribution Transformers	85.0%	100.0%	15.0%
	Fed 34	Commercial Refrigeration Equipment	85.0%	100.0%	15.0%
	Fed 38	Residential Clothes Washers	85.0%	100.0%	15.0%
	Fed 41	Commercial Icemakers	85.0%	100.0%	15.0%
	Fed 30	Electric Motors	85.0%	96.9%	11.9%
	Std 39	General Service Lamps	90.0%	100.0%	10.0%
	Std 34a-b	Showerheads, Tier 1	77.0%	85.0%	8.0%
	Std 33g	Public Lavatory Faucets	85.0%	92.3%	7.3%
	Fed 31	Microwave Ovens	85.0%	91.4%	6.4%
	Std 38	Dimming Fluorescent Ballasts	77.0%	83.3%	6.3%
	Fed 33	Metal Halide Lamp Fixtures	85.0%	86.4%	1.4%
Equal to IOU Estimates	Std 33e-f	Kitchen Faucets and Aerators	85.0%	85.0%	0.0%
	Std 35a-b	Toilets	85.0%	85.0%	0.0%
	Std 42a	Computers (workstations)	85.0%	85.0%	0.0%
	Std 42b	Computers (small-scale servers)	85.0%	85.0%	0.0%
	Fed 32	Commercial CAC and HP, small	100.0%	100.0%	0.0%
Lower than IOU Estimates	Fed 39	Commercial CAC and HP, Tier 1	100.0%	98.5%	-1.5%
	Fed 37	General Service Fluorescent Lamps	85.0%	80.3%	-4.7%
	Fed 36	Commercial Clothes Washers	85.0%	80.0%	-5.0%
	Fed 35	Walk-In Coolers and Freezers	85.0%	78.6%	-6.4%
	Std 34c-d	Showerheads, Tier 2	77.0%	70.0%	-7.0%
	Std 36	Urinals	85.0%	76.2%	-8.8%
	Std 40	Small Diameter Directional Lamps	77.0%	67.4%	-9.6%
	Fed 29	**External Power Supplies**	**85.0%**	**69.7%**	**-15.3%**
	Std 31	**Small Battery Chargers, Tier 3**	**85.0%**	**15.0%**	**-70.0%**

Bold text indicates a result that diverged by more than 15% from the IOUs' compliance estimate.

Two standards were lower than the estimated compliance rates by more than 15%. These were (1) External Power Supplies (EPS), and (2) Small Battery Chargers, Tier 3. The following paragraphs address the discrepancies in more detail.

1. For EPSs, two factors influenced the low compliance rate. First, some major manufacturers of phones and laptops were selling noncompliant chargers, potentially under a provision from the Code of Federal Regulations (CFR) that allows manufacturers to sell chargers that are compatible with older devices.[46] Second, many after-market retailers listed third-party devices without any efficiency information. Many of these third-party manufacturers do not have websites, and among those that do, many lack adequate compliance information.

2. All sampled SBCs lacked adequate technical information from product literature to calculate compliance with the standard. This resulted in non-compliance rulings for all but two products whose literature specifically stated that the products were compliant with the Energy Commission standards. Interestingly, these two products were not included in the Energy Commission's compliance database. We believe that the low compliance rate is most likely due to a lack of awareness and understanding of the standard by the manufacturers, as well as a lack of enforcement to date.

Detailed listings for each code or standard are in 0.

4.3 Net Standards Energy Savings

The following section summarizes the NOMAD results for each of the standards in the evaluation scope. Details are provided in Appendix G. The results are organized first by product group (e.g., lighting products, plumbing products, etc.), and subsequently by priority level within each product group (i.e., those with the highest potential savings are discussed first). Each section includes product-specific insights from the survey respondents, as well as the NOMAD results for each product. The charts illustrating the NOMAD results include an area showing the range of responses among the experts to provide context for the varied predictions of the NOMAD curve. The results and the range do not include the first-round responses and are only representative of the second-round Delphi responses.

The majority of the evaluated NOMAD rates were consistent with IOU CCSR rates—within 15%—especially in the early years of the 35-year timeframe. The number of standards with differences in NOMAD trajectories greater than 15% are listed in Table 21.

Table 21. Count of NOMAD Differences of 15% or More

Standard Priority	2016	2030
High	0	3
Medium	0	3
Low	2	4

For 2016, no high or medium-priority standards had differences greater than 15%. For low-priority measures only two exceeded our 15% threshold. These were, Std 36 Urinals, Commercial, and Fed 32 Commercial Packaged Air Conditioner/Heat Pump, small.

The following paragraphs address these 2016 low-priority measure discrepancies in more detail.

1. For Std 36 Urinals, the average evaluated NOMAD rate in 2016 was 15% lower than the IOU CCSR NOMAD rate in the same year. This lower adoption rate is because, as one panelist stated, "urinals are expensive to replace," even with growing concerns around water conservation in California. This one factor combined with the plumbing issues around replacement indicates building or business owners would be reluctant to seek out more efficient units unless they were forced to by a standard.

[46] e-CFR: Title 10, Chapter II, Subchapter D, Part 430.32, Paragraph (w)(2)

2. For Fed 32 commercial AC/HP less than 65,000 Btu/hour cooling capacity, the evaluated market adoption rate for was 23% lower than the IOU CCSR forecast rate in 2016. Even though the average of the panelist responses was lower than the forecast curve, panelists were split on the influence of ASHRAE 90.1 standards on the commercial AC/HP market. The panel's reasoning for their rating of Fed 32 was consistent with their reasoning for their ratings for Fed 39, the Tier 1 standards for commercial AC/HP between 65,000 and 760,000 Btu/hour cooling capacity. The difference in the outcomes was that the IOU forecast adoption for Fed 32 was much higher than Fed 39 (60% vs 35% in 2016).

Even though the evaluation is focused on the savings claims for years 2016-2018, the trajectories of the NOMAD estimates provide insight into underlying assumptions about the evolution of energy-efficient equipment and consumer behavior. This section provides a summary limited to the high-priority standards,[47] where NOMAD rates differed from the IOU forecast rates by 15% or more by 2030. These were, Std 40 Small Diameter Directional Lamps (SDDL), Fed 29 External Power Supplies (EPS), and Fed 39 Commercial AC/HP, Tier 1.

The following paragraphs address these 2030 high-priority measure discrepancies in more detail.

1. For Std 40 **Small Diameter Directional Lamps (Track lights)**, the average evaluated NOMAD rate in 2030 was **24% lower** than the IOU CCSR NOMAD rate in the same year. The IOUs predicted that 81% of the market would have naturally reached the standard level by 2030, while the expert panel expected that only 57% would reach this standard level. The IOUs developed their adoption curve by calibrating to a 2016 study predicting market penetration rates of directional LEDs from 2015-2035. The expert panelists, however, generally believed that the natural market adoption rate would be lower than the IOU estimate in later years due to technical challenges of improving product efficiency. Without standards in place, manufacturers would not have an incentive to overcome these challenges in product design.
2. For Fed 29 **External Power Supplies** the evaluated market adoption rate for EPS was **15% higher** than the IOU CCSR rate in 2030. The IOUs predicted that 55% of the market would reach the standard level by 2030, while the expert panel predicted that 70% of the market would reach this level. The IOUs predicted a flat adoption curve of 55% throughout the entire forecast period of 2015-2040 based on a US Department of Energy prediction that EPSs would not improve in efficiency beyond 2015. All the panel experts anticipated that the naturally occurring adoption rate would increase over time as opposed to the IOU prediction of a constant market share of 55%. According to the panel experts, the primary reason for this is that the market is demanding faster and more powerful but smaller charging devices, which presents design challenges of heat management. To meet these challenges, manufacturers would naturally incorporate more efficient components.
3. For Fed 39 **Commercial CAC/HP Tier 1**, the average evaluated NOMAD rate was **34% higher** than the IOU CCSR rate in 2030. The IOUs predicted a flat rate of 36% natural market adoption over the course of the analysis period (including in 2030) following estimates given by the US Department of Energy during the standards rulemaking. The expert panel predicted, on average, that 70% of the market would reach this level. These Tier 1 CAC/HP standards updated the energy efficiency requirements for commercial packaged A/C and HP units to align the standard with the ASHRAE 90.1-2013 Tier 1 standards. There was significant disagreement however among the experts on the panel that was not reconciled during the Delphi process. Specifically, some respondents mentioned that states would likely adopt evolving ASHRAE Standard 90.1 levels over time in the absence of federal equipment efficiency regulations. However, others believed there would be no natural increase in market share of this equipment because ASHRAE 90.1 would not increase HVAC efficiency levels without corresponding DOE rulemakings.

[47] "High-priority" standards are those that have projected first-year potential savings greater than 200 GWh/year. These standards comprise about 80% of the total first-year savings projected for the set of in-scope standards.

Table 22 provides a summary of the NOMAD rate evaluated for each of the standards in the scope of this evaluation. The table also compares our evaluation results to the claims presented in CASE or CCSRs and other documentation that the IOUs provided to the evaluation team. We evaluated the range of time between 2015 and 2030. The summary table below compares evaluated results to IOU results in two example years: 2016 and 2030.

Table 22. Summary of NOMAD Findings for Federal and State Appliance Standards

Priority Level	Standard	Product	Natural Market Adoption by 2016			Natural Market Adoption by 2030		
			IOU CCSR	Evaluated Average	Difference*	IOU CCSR	Evaluated Average	Difference*
High	Std 39	General Service Lamps	38%	38%	0%	76%	77%	1%
	Std 40	Small Diameter Directional Lamps	17%	14%	(3%)	81%	57%	(24%)
	Fed 29	External Power Supplies	55%	54%	(1%)	55%	70%	15%
	Fed 30	Electric Motors	59%	54%	(5%)	69%	77%	8%
	Fed 35	Walk-In Coolers and Freezers	0%	9%	9%	22%	19%	(3%)
	Fed 39	Commercial PAC and HP, Tier 1	36%	35%	(1%)	36%	70%	34%
Medium	Std 31	Small Battery Chargers, Tier 3	24%	19%	(5%)	46%	45%	(1%)
	Std 33a-d	Lavatory Faucets and Aerators	9%	13%	4%	52%	28%	(24%)
	Std 34a-b	Showerheads, Tier 1	43%	33%	(10%)	76%	61%	(15%)
	Std 41a	General Service LED Lamps, Tier 1	8%	12%	4%	64%	67%	3%
	Fed 28	Distribution Transformers	4%	2%	(2%)	17%	8%	(9%)
	Fed 31	Microwave Ovens	1%	0%	(1%)	12%	7%	(5%)
	Fed 33	Metal Halide Lamp Fixtures	9%	9%	0%	24%	40%	16%
	Fed 34	Commercial Refrigeration Equipment	23%	19%	(4%)	30%	20%	(10%)
	Fed 37	General Service Fluorescent Lamps	26%	24%	(2%)	31%	18%	(13%)
	Fed 38	Residential Clothes Washers	0%	13%	13%	10%	22%	12%
Low	Std 33e-f	Kitchen Faucets and Aerators	9%	13%	4%	52%	28%	(24%)
	Std 33g	Public Lavatory Faucets	9%	18%	9%	52%	30%	(22%)
	Std 34c-d	Showerheads, Tier 2	16%	13%	(3%)	49%	30%	(19%)
	Std 35a-b	Toilets	39%	45%	6%	48%	61%	13%
	Std 36	Urinals	39%	24%	(15%)	48%	36%	(12%)
	Std 38	Dimming Fluorescent Ballasts	33%	28%	(5%)	49%	23%	(26%)
	Std 42a	Computers (workstations)	10%	11%	1%	48%	50%	2%
	Std 42b	Computers (small-scale servers)	10%	13%	3%	48%	52%	4%
	Fed 32	Commercial CAC and HP, small	63%	40%	(23%)	93%	79%	(14%)
	Fed 36	Commercial Clothes Washers	60%	56%	(4%)	60%	57%	(3%)
	Fed 41	Commercial Icemakers	14%	12%	(2%)	17%	14%	(3%)

Bold text indicates a result that diverged by 15% or more from the IOUs' NOMAD estimate.

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4.4 Net C&S Program Savings

The attribution score findings are grouped as "higher than," "equal to," or "lower than" IOU CCSRs. Table 23 shows attribution factor scores, factor weights, and final attribution scores for each of the standards in the scope of this evaluation. This section concludes with reasons for overall scores that are more than 15% lower than IOU CCSRs.

Table 23. Summary of Attribution Scores for Federal and State Appliance Standards

Comparison to IOU Estimates	Standard	Product	Factor Score			Factor Weight			Final Attribution Score	IOU Attribution Estimate
			Compliance	Technical	Feasibility	Compliance	Technical	Feasibility		
Higher than IOU Estimates	Std 33	Faucets and Aerators	80%	85%	80%	20%	50%	30%	83%	67%
	Std 34	Showerheads	75%	80%	80%	20%	50%	30%	79%	61%
	Std 35	Toilets	86%	64%	73%	20%	40%	40%	72%	67%
	Std 36	Urinals	86%	64%	73%	25%	40%	35%	72%	67%
	Std 39	General Service Lamps	42%	75%	64%	2%	58%	40%	70%	61%
	Std 40	Small Diameter Directional Lamps (Track lights)	72%	85%	80%	10%	50%	40%	82%	61%
	Std 41	LED Quality	50%	79%	79%	20%	40%	40%	73%	61%
	Std 42b	Computers (small-scale servers)	60%	75%	60%	10%	85%	5%	73%	61%
	Std 42a	Computers (workstations)	60%	75%	60%	5%	65%	30%	70%	61%
	Fed 29	External Power Supplies	85%	80%	10%	20%	75%	5%	78%	61%
	Fed 35	Walk-in Coolers and Freezers	49%	80%	79%	40%	30%	30%	67%	61%
	Fed 38	Residential Clothes Washers	75%	73%	75%	25%	45%	30%	74%	61%
Equal to IOU Estimates	Fed 37	General Service Fluorescent Lamps	8%	68%	48%	0%	65%	35%	61%	61%
	Std 31	Battery Chargers	38%	76%	59%	25%	40%	35%	61%	61%
Lower than IOU Estimates	Std 38	Dimming Fluorescent Ballasts	80%	48%	66%	30%	30%	40%	65%	67%
	Fed 33	Metal Halides	30%	48%	50%	10%	50%	40%	47%	61%
	Fed 31	Microwaves	45%	45%	18%	40%	50%	10%	42%	61%
	Fed 34	Commercial Refrigeration	45%	32%	10%	30%	30%	40%	27%	61%
	Fed 28	Distribution Transformers	4%	18%	27%	0%	75%	25%	20%	61%
	Fed 39	Commercial Unitary A/Cs and Heat Pumps	19%	14%	21%	30%	40%	30%	18%	61%
	Fed 41	Commercial Icemakers	17%	17%	13%	25%	60%	15%	16%	61%
	Fed 30	Electric Motors	22%	11%	0%	45%	45%	10%	15%	61%
	Fed 36	Commercial Clothes Washers	44%	8%	0%	10%	90%	0%	12%	61%
	Fed 32	Small Commercial A/Cs and Heat Pumps	6%	8%	7%	20%	40%	40%	7%	61%

Half of the evaluated attribution scores exceeded the IOU CCSR attribution scores. For eight standards, the evaluated attribution score was lower than the IOU attribution estimate by more than 15 percentage points. The following items address the discrepancies in more detail.

- For **microwaves** (Fed 31), panelists noted that the outcome of the rule was heavily influenced by the appliance industry advocates. The IOUs scored some key points, such as the separation of active-mode and off-mode power measurements and the inclusion of combination ovens as covered products. The IOUs' contributions to demonstrating market feasibility were not unique, however, and the IOUs were unsuccessful in their request to combine different product configurations into a single product class.
- For **commercial refrigeration equipment** (Fed 34), the panelists noted that several other groups besides the IOUs contributed to the development of the standard. The IOUs' efforts yielded changes to the compliance determination method through a revision of anti-sweat heater savings assumptions. However, the IOUs' efforts regarding the scope and definition of the standard were not particularly effective. For example, the IOUs requested more stringent standards, separate classes covering secondary coolant systems and remote condensing equipment, and the combination of certain open and doored cooler categories; all these requests were denied.
- For **distribution transformers** (Fed 28), the panelists noted that the IOUs' influence in the standards-making process was limited because there were many parties to the negotiation. Further, the IOUs took what panelists deemed to be a "default position" for efficiency advocates. They asserted that the IOUs took the same position as several other efficiency advocates and that the outcome of the standard could have been the same if the IOUs had not participated.
- For **commercial unitary A/Cs and heat pumps** (Fed 39), the panelists noted that the IOUs' helped support the negotiations that led to the standard, but the IOUs did not drive the negotiations. For example, the IOUs supported, but did not lead, the development of an analytical spreadsheet. The panelists acknowledged that California incentivized high-efficiency commercial A/C systems prior to this standard, but panelists did not find evidence that California's incentives primed the market for the type of equipment covered by this standard.
- For **commercial icemakers** (Fed 41), the panelists noted that DOE did not adopt many of the IOUs' requests or suggestions. For example, the IOUs requested that DOE establish a limit on the potable water use in icemakers. additional requirements for products with ice storage bins, and that DOE group products by customer utility instead of by ice-production technology. DOE did not follow these recommendations. The panelists concluded that the IOUs' efforts resulted in few amendments to the existing standards and test procedures for icemakers.
- For **electric motors** (Fed 30), panelists noted that the Appliance Standards Awareness Project (ASAP) and the American Council for an Energy-Efficient Economy (ACEEE) were major proponents of this rule, and they led the efficiency advocates' negotiations with the National Electrical Manufacturers Association (NEMA). The IOUs supported these negotiations but were not signatories to the final agreement. Panelists assigned a 0% score to the "feasibility" factor, since the final rule adopted NEMA premium standards, which were already met (and therefore feasible) by many available motor products.
- For **commercial clothes washers** (Fed 36), the panelists observed that the C&S Program had little influence on the energy savings estimation method, and that there was no significant program activity to demonstrate feasibility of the standard. Panelists acknowledged that they provided high scores for factor 1 "compliance determination method," and these scores reflect the C&S program's high level of activity on the *residential* clothes washer standard (Fed 38), which directly influenced the commercial clothes washer standard that was ultimately adopted.

- For **small commercial A/Cs and heat pumps** (Fed 32), the panelists noted that outcome of the rule was largely driven by DOE's obligation to adopt revised ASHRAE 90.1 standards.

4.5 Savings by Utility

The final adjustment to statewide savings estimates is allocating savings to IOUs. Savings are calculated on a statewide basis because appliances are sold throughout the state. Most sales occur in the IOU service areas, but the IOUs do not supply electricity and gas across the entire state. These other areas consist of municipal providers, cooperatives, irrigation districts, and companies not regulated by the CPUC. For this evaluation we use California Energy Commission Energy Reports by planning region sales of electric and gas volumes to allocate savings.[48] Gas sales were adjusted by removing non-retail sales and recalculating the allocations.[49] This view provides a fuller picture of savings for distribution system planning. For electricity it includes some of the smaller non-IOU areas for planning purposes. The factors used to allocate savings to IOUs are based on planning regions and presented in Table 24.

Table 24. Electric and gas sales by planning area

	Electric			Gas		
IOU	2016	2017	2018	2016	2017	2018
PG&E	36.4%	35.8%	36.2%	44.1%	44.5%	45.0%
SCE	35.9%	35.8%	36.7%	0.0%	0.0%	0.0%
SCG	0%	0%	0%	50.0%	49.6%	49.2%
SDG&E	7.4%	7.3%	7.5%	4.5%	4.5%	4.5%
Other	20.3%	21.1%	19.6%	1.3%	1.3%	1.3%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Source: California Energy Commission

4.6 Evaluated vs. Reported Savings

The C&S protocols do not use a typical net-to-gross ratio to estimate net savings. Instead, moving from gross to net requires application of NOMAD and Attribution estimates. In this section, we start with gross savings (developed from multiplying evaluated potential savings by evaluated compliance). We then apply the NOMAD and Attribution estimates to derive evaluated net savings. These net savings are still at the statewide level. To credit savings to the IOUs, we apply an allocation factor based on energy sales data provided by the Energy Commission. The resulting IOU only evaluated net savings are compared to the IOU savings claims filed in CEDARS.

Standards with effective dates before 2016 were included in prior evaluations. The savings from those standards were not part of this evaluation scope and were "passed through" from claim totals to evaluation totals. Table 25 shows that as more new standards became effective, they provided a greater contribution to C&S portfolio savings. New standards accounted for nearly half (45%) of the savings in 2016 and 2017. By program year 2018 the new standards contributed two-thirds (62%) of the evaluated kWh savings.

[48] California Energy Commission, https://ecdms.energy.ca.gov/gasbyplan.aspx and https://ecdms.energy.ca.gov/elecbyplan.aspx
[49] The Kern River Gas Transmission Company accounts for on average approximately 16% of statewide gas sales, but these are directed toward power producers as part of the Western Area Power Administration and so are excluded for C&S allocations.

Table 25: Savings estimated by evaluation

Standards Only	Savings from Evaluation 2016	2017	2018	Total	Contribution
Savings kWh					
Prior Standards	828,252,705	914,587,239	237,266,772	1,980,106,716	58%
New Standards	117,486,030	254,405,985	1,078,409,143	1,450,301,158	42%
Total	945,738,735	1,168,993,224	1,315,675,915	3,430,407,874	100%
Savings kW					
Prior Standards	120,121	120,396	35,546	276,063	58%
New Standards	19,062	38,015	146,181	203,258	42%
Total	139,183	158,411	181,727	479,321	100%
Savings Therm					
Prior Standards	8,703,466	8,758,577	9,486,805	26,948,848	35%
New Standards	10,270,326	20,025,099	20,001,415	50,296,840	65%
Total	18,973,792	28,783,676	29,488,220	77,245,688	100%

The next three figures (Figure 20, Figure 21, and Figure 22) illustrate the savings differences by standard. In 2016 and 2017, evaluated savings from standard 33g (Public Lavatory Faucets) shows higher savings due to higher savings per unit and higher adjustment factors in general. Standards (Fed 37 and Std 39) appear for the first time in 2018 (Figure 21) with much higher savings than the claim savings.

Figure 20: 2016 California State and Federal Savings

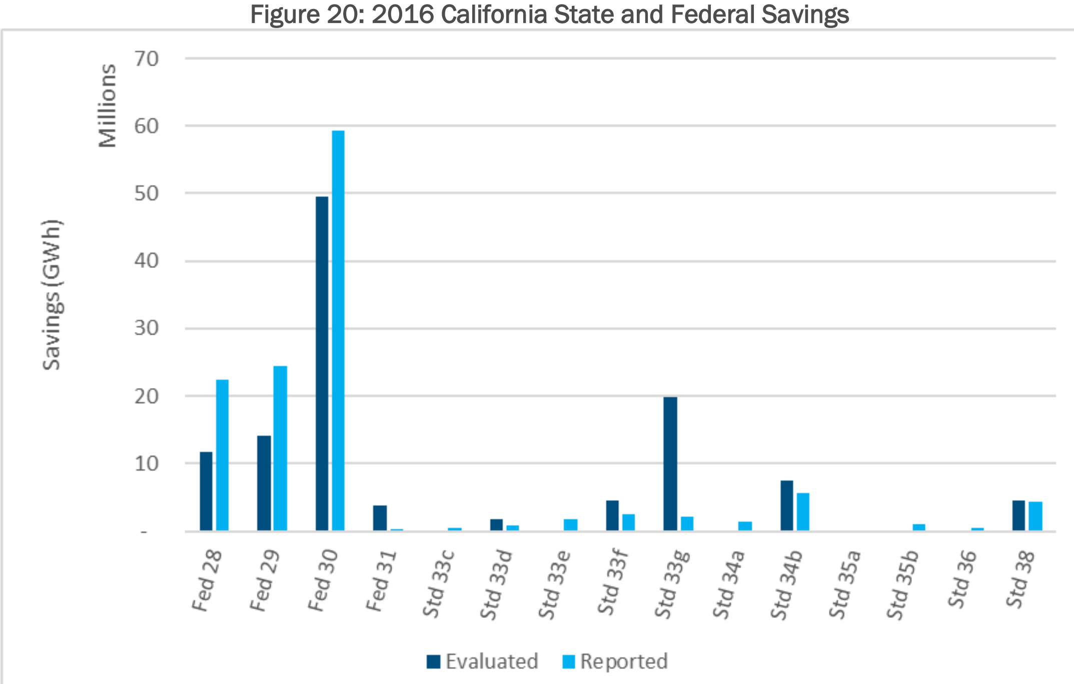


Figure 21: 2017 California State and Federal Savings

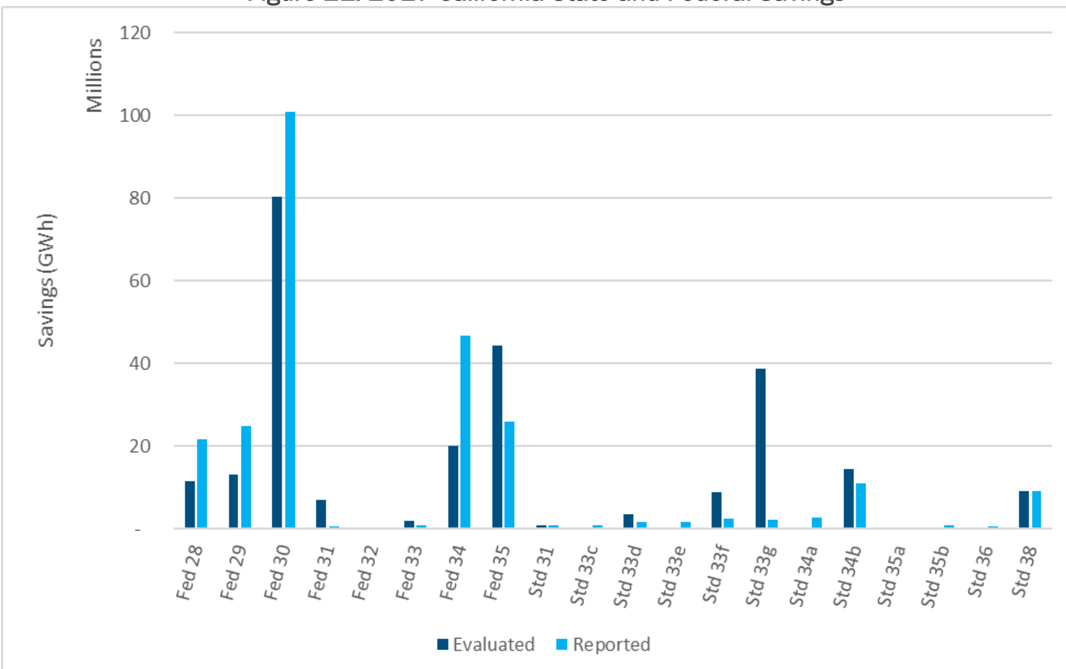
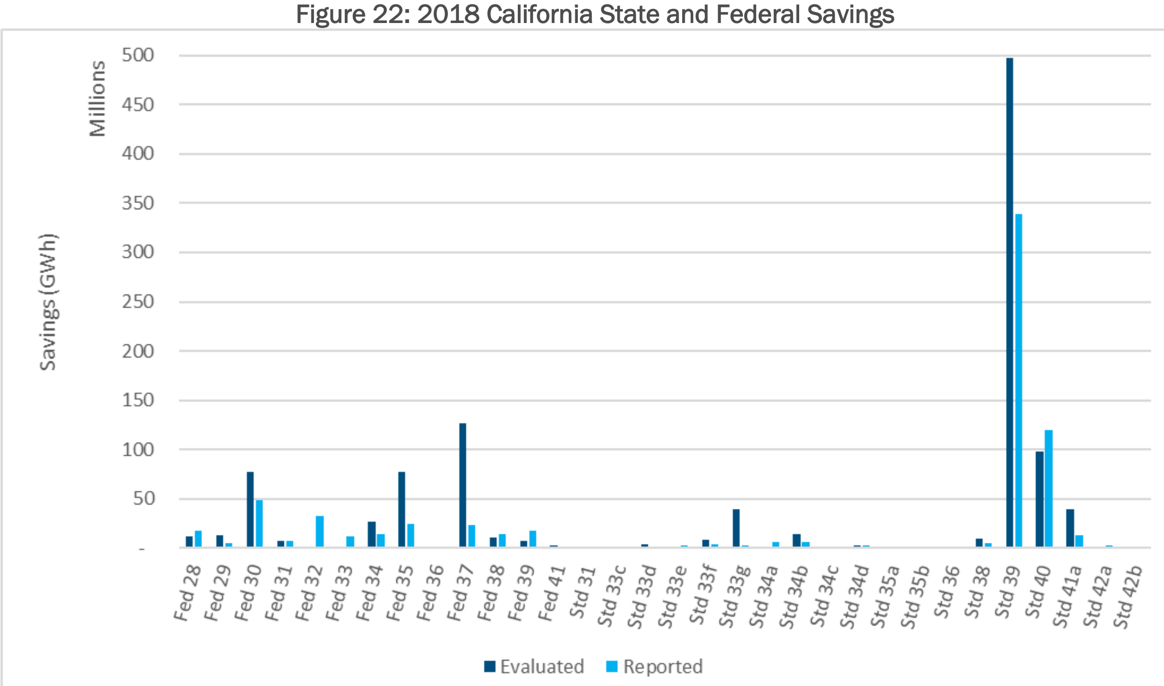


Figure 22: 2018 California State and Federal Savings



4.6.1 Summary Evaluated Electric and Gas Savings (2016–2018)

By applying Table 24 to the evaluated net savings for 2016 through 2018 we see the credit assigned to each IOU (Table 26). The steps from potential savings to evaluated savings are illustrated in waterfall charts. These types of charts show the sequential progression of the evaluation steps to produce the final values compared to the IOU claims.

Details of savings by standard for each evaluated year are presented in Table 27 through Table 32. The IOU only savings are used to calculate cost-effectiveness and can affect service area planning. All tables include interactive effects applied to non-LED lighting standards.

Table 26. Annual Savings from Evaluated Standards

	GWh			MW			MMTherm		
IOU	2016	2017	2018	2016	2017	2018	2016	2017	2018
PG&E	53.6	115.3	485.9	8.7	17.2	65.9	3.8	7.6	7.7
SCE	53.0	115.5	492.5	8.6	17.3	66.8	-	-	-
SCG	-	-	-	-	-	-	6.0	11.6	11.5
SDG&E	10.9	23.6	100.0	1.8	3.5	13.6	0.4	0.8	0.8
Evaluated Totals	117.5	254.4	1,078.4	19.1	38.0	146.2	10.3	20.0	20.0
Reported Totals	127.4	256.3	733.9	23.8	47.0	139.2	9.2	14.4	15.9
Evaluated as a % of Reported	**92%**	**99%**	**147%**	**80%**	**81%**	**105%**	**12%**	**139%**	**126%**

Note: Savings in this table are for the appliance standards advocacy program only

Net IOU only savings are presented for each program year, by standard, in Table 27 through Table 32.

Table 27. 2016 Net Savings Comparison

2016	kWh Net		kW Net		Therm Net	
Standard	Evaluated	Claim	Evaluated	Claim	Evaluated	Claim
Fed 28	11,787,507	22,486,633	2,243	5,134	-	-
Fed 29	14,043,123	24,527,794	1,872	7,040	-	(274,015)
Fed 30	49,587,467	59,260,582	8,678	9,267	-	-
Fed 31	3,894,658	364,390	794	68	-	(4,071)
Std 33c	-	499,564	-	-	1,293,649	710,555
Std 33d	1,772,077	851,667	238	185	-	-
Std 33e	-	1,727,994	-	-	3,336,114	2,004,902
Std 33f	4,576,648	2,431,804	608	521	-	-
Std 33g	19,767,896	2,198,846	2,786	-	1,252,663	2,101,466
Std 34a	-	1,334,323	-	-	4,418,011	4,634,309
Std 34b	7,501,717	5,601,431	994	729	-	-
Std 35a	-	179,510	-	-	-	-

2016	kWh Net		kW Net		Therm Net	
Std 35b	-	1,017,709	-	-	-	-
Std 36	-	548,037	-	-	-	-
Std 38	4,554,937	4,325,884	849	861	(30,111)	(9,003)
Total	**117,486,030**	**127,356,168**	**19,062**	**23,805**	**10,270,326**	**9,164,143**

Table 28. 2016 Evaluation Totals Compared to Claim

	kWh Net	kW Net	Therm Net
Difference	(9,870,138)	(4,743)	1,106,183
Difference %	-8%	-25%	11%
FED Difference	(27,326,644)	(7,922)	278,086
FED Difference %	-26%	-37%	100%
State Difference	17,456,506	3,179	828,097
State Difference %	84%	138%	9%

In 2016, evaluated GWh savings are 8% lower than the IOU claim, kW reduction is 25% lower than the IOU claim and therm savings are 11% higher than the IOU claim (Table 28). The sequential adjustment steps are illustrated in Figure 23.

Figure 23: 2016 Waterfall chart (GWh)

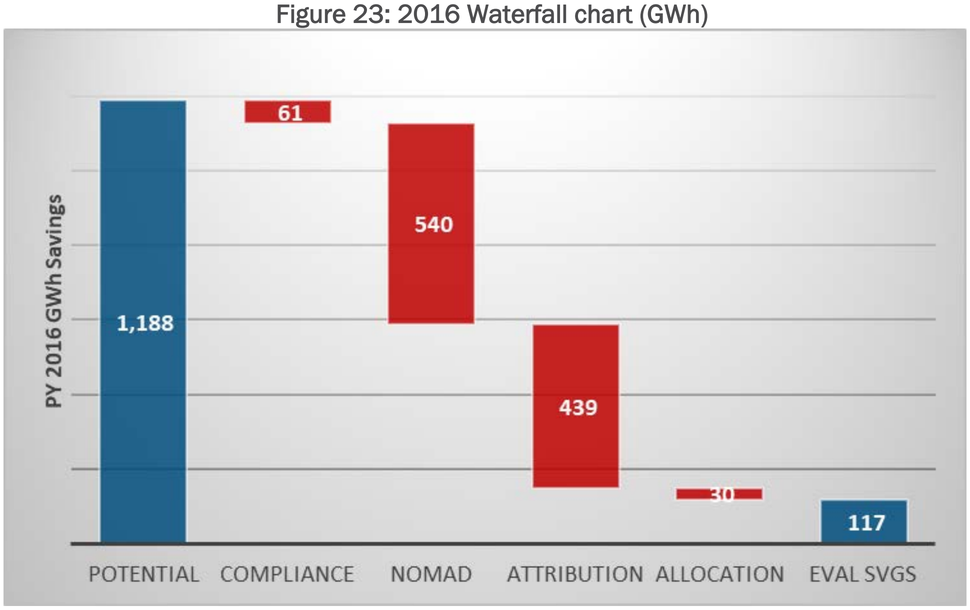


Figure 24: 2016 Waterfall chart (MMTherm)

Table 29. 2017 Net Savings Comparison

2017	kWh Net		kW Net		Therm Net	
Standard	Evaluated	Claim	Evaluated	Claim	Evaluated	Claim
Fed 28	11,638,799	21,594,780	2,214	4,930	-	-
Fed 29	13,206,785	24,864,707	1,761	7,137	-	(277,780)
Fed 30	80,241,011	100,871,107	14,042	15,774	-	-
Fed 31	7,105,896	641,240	1,448	120	-	(7,164)
Fed 32	53,818	-	27	-	-	-
Fed 33	1,957,230	805,280	302	15	(15,950)	-
Fed 34	20,025,401	46,825,772	2,286	10,671	-	-
Fed 35	44,255,790	26,072,881	5,051	3,422	-	-
Std 31	1,015,171	1,010,016	128	829	-	(2,625)
Std 33c	-	994,507	-	-	2,553,376	1,414,535
Std 33d	3,462,253	1,695,454	465	368	-	-
Std 33e	-	1,747,783	-	-	6,584,747	2,027,862
Std 33f	8,941,774	2,459,654	1,188	527	-	-
Std 33g	38,716,444	2,198,846	5,457	-	2,478,513	2,101,470
Std 34a	-	2,639,274	-	-	8,485,626	9,166,610
Std 34b	14,619,566	11,079,509	1,938	1,441	-	-
Std 35a	-	171,597	-	-	-	-
Std 35b	-	977,951	-	-	-	-
Std 36	-	544,220	-	-	-	-
Std 38	9,166,047	9,053,936	1,708	1,803	(61,213)	(18,843)
Total	**254,405,985**	**256,248,514**	**38,015**	**47,037**	**20,025,099**	**14,404,065**

Table 30. 2017 evaluation totals compared to claim

	kWh Net	kW Net	Therm Net
Difference	(1,842,529	(9,022)	5,621,034
Difference %	-1%	-24%	28%
FED Difference	(43,191,037)	(14,938)	268,994
FED Difference %	-19%	-36%	94%
State Difference	41,348,508	5,916	5,352,040
State Difference %	120%	119%	36%

In 2017, evaluated GWh savings are 1% lower than the IOU claim, kW reduction is 24% lower than the IOU claim, but therm savings are 28% higher than the IOU claim. The sequential adjustment steps are illustrated in Figure 25.

Figure 25. 2017 Waterfall chart (GWh)

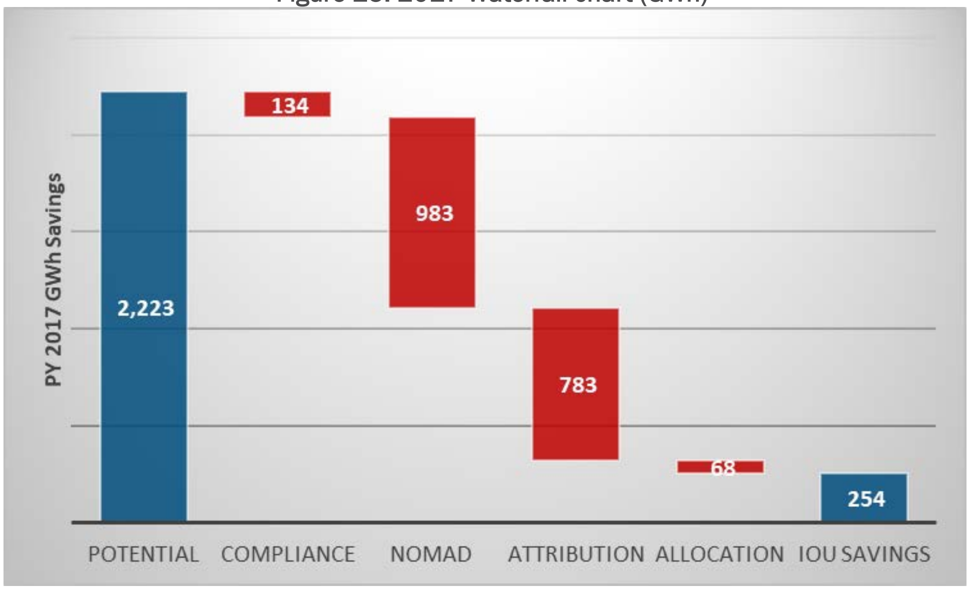


Figure 26: 2017 Waterfall chart (MMTherm)

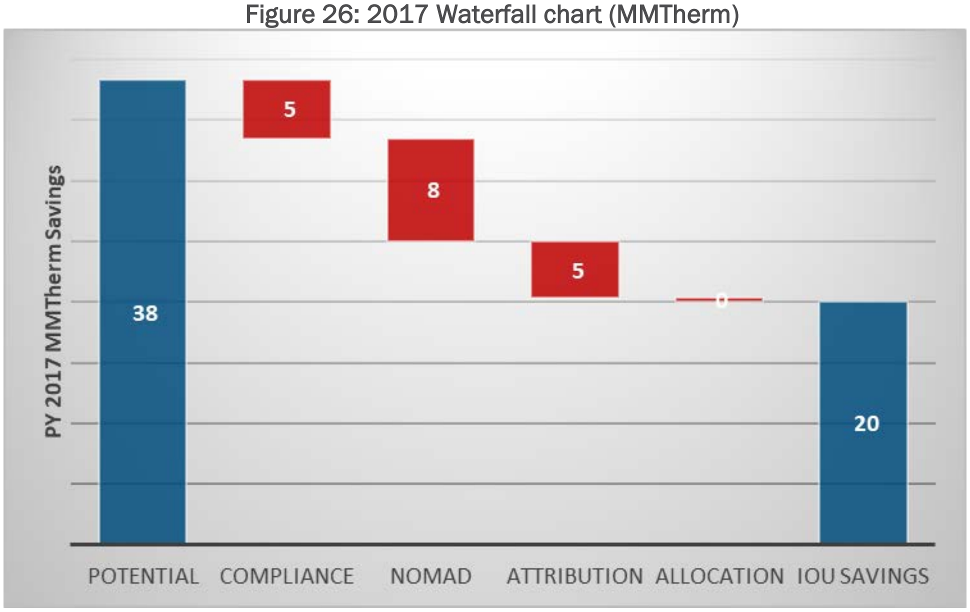


Table 31. 2018 Net Savings Comparison

2018	kWh Net		kW Net		Therm Net	
Standard	Evaluated	Claim	Evaluated	Claim	Evaluated	Claim
Fed 28	11,826,367	18,189,625	2,250	4,153	-	-
Fed 29	12,747,965	5,491,221	1,700	1,580	-	(61,346)
Fed 30	77,278,684	49,143,053	13,524	7,685	-	-
Fed 31	7,205,386	7,042,385	1,468	1,313	-	(78,675)
Fed 32	51,004	32,845,673	25	16,114	-	-
Fed 33	2,215,207	12,366,172	342	3,360	(17,733)	(26,161)
Fed 34	26,396,139	14,513,581	3,013	4,127	-	(162,141)
Fed 35	77,294,926	24,931,990	8,822	3,272	-	-
Fed 36	119,891	548,758	17	73	10,246	-
Fed 37	126,460,826	23,932,627	23,817	4,760	(836,843)	(49,808)
Fed 38	10,952,303	13,977,056	1,619	2,119	(6,375)	1,127,171
Fed 39	6,988,042	17,489,349	3,799	8,580	-	-
Fed 41	2,914,415	1,838,935	332	273	-	(10,522)
Std 31	994,561	1,027,123	125	843	-	(2,669)
Std 33c	-	226,026	-	-	2,521,079	918,419
Std 33d	3,480,031	1,497,383	467	207	-	-
Std 33e	-	3,122,190	-	-	6,501,458	2,746,774
Std 33f	8,987,687	4,398,062	1,194	83	-	-
Std 33g	39,017,119	2,698,923	5,500	179	2,453,569	1,748,692
Std 34a	-	6,325,796	-	-	8,140,200	10,609,292
Std 34b	14,659,764	6,094,179	1,943	773	-	-
Std 34c	-	1,318,076	-	-	1,943,703	2,234,713
Std 34d	2,612,916	2,759,587	348	355	-	-
Std 35a	-	262,988	-	-	-	-
Std 35b	-	1,904,850	-	-	-	-
Std 36	-	493,403	-	-	-	-
Std 38	9,489,423	4,591,450	1,769	914	(62,251)	(9,556)
Std 39	497,286,102	339,204,471	40,487	49,691	-	(2,222,187)
Std 40	97,565,623	119,774,954	24,853	25,424	(645,638)	(784,666)
Std 41a	39,335,044	12,747,911	8,407	2,706	-	(83,514)
Std 42a	2,050,403	2,452,159	290	477	-	-
Std 42b	479,315	636,236	70	127	-	-
Total	**1,078,409,143**	**733,846,192**	**146,181**	**139,188**	20,001,415	**15,893,816**

Table 32. 2018 Evaluation Totals Compared to Claim

	kWh Net	kW Net	Therm Net
Difference	344,562,951	6,993	4,107,599
Difference %	32%	5%	21%
FED Difference	140,140,730	3,319	(1,589,223)
FED Difference %	63%	6%	-215%
State Difference	204,422,221	3,674	5,696,822
State Difference %	40%	4%	38%

In 2018, evaluated GWh savings are 32% higher than the IOU claim, kW reduction is 5% more than the IOU claim and therm savings are 21% higher than the IOU claim. The sequential adjustment steps are illustrated in Figure 27.

Figure 27. 2018 Waterfall chart (GWh)

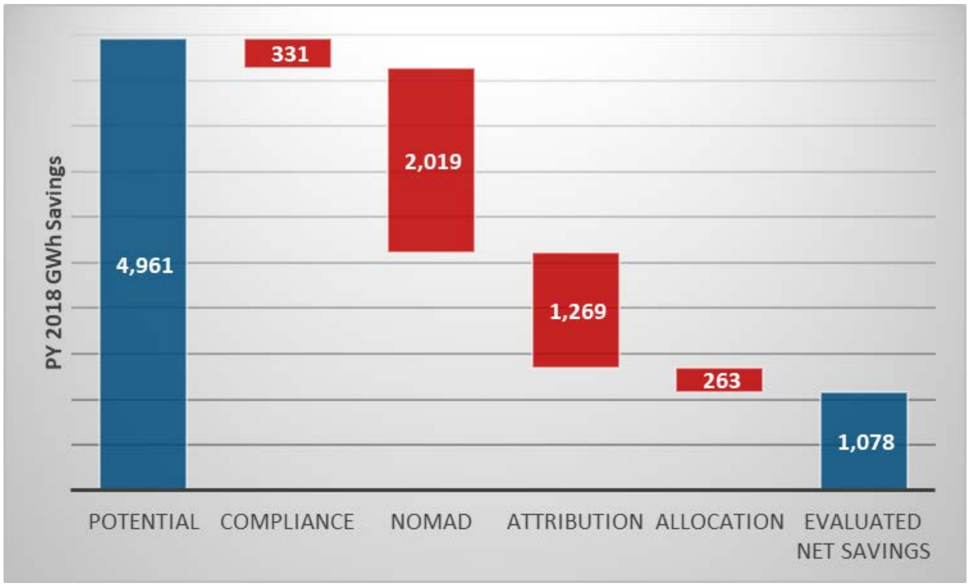
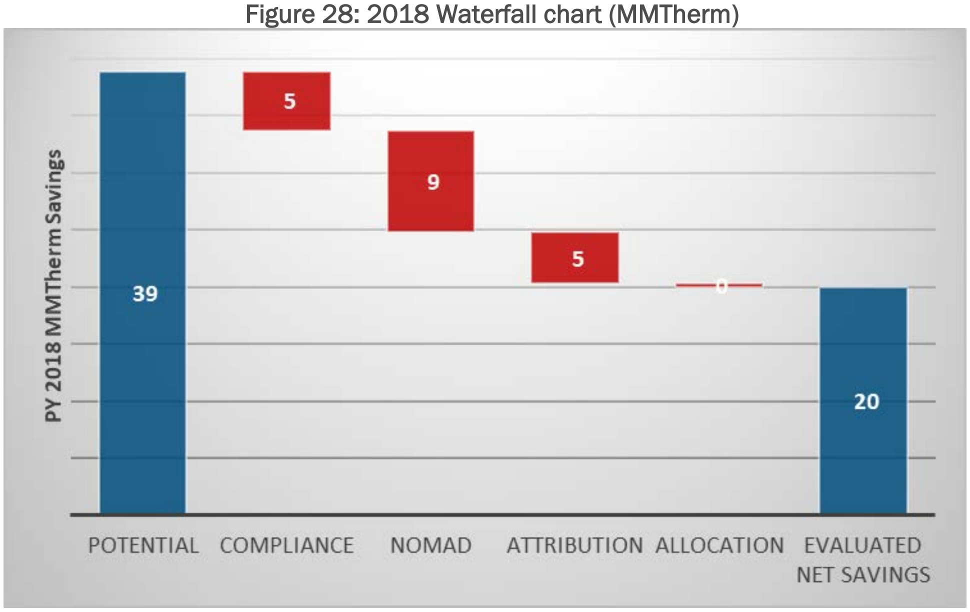


Figure 28: 2018 Waterfall chart (MMTherm)



The aggregate difference in GWh is driven by three lighting standards (Fed 37, Std 39, and Std 41a) effective in 2018. These account for 83% of the total difference.

These same three lighting standards drive the MW difference between evaluated and claimed savings and therm savings. These lighting savings are offset by increases in hot water products. Therm savings are the result of small interactive effects over a large number of units.

4.6.2 Indirect Savings

In addition to direct savings at the appliance level, we estimated indirect potential savings from the new appliance standards. In addition to the electricity directly used by these appliances, they also contribute to reducing water use, saving the energy used for pumping, processing, and reclamation along with the related Greenhouse Gas reductions. These findings are not included as part of the annual savings of Table 34 but presented separately in Table 33 for information purposes only.

Table 33. Indirect Savings

All Standards	Savings per Unit			Annual Savings		
	Gallons of Water	Embedded kWh	GHG	Gallons of Water	Embedded kWh	GHG
Fed 28	-	-		-	-	
Fed 29	-	-		-	-	
Fed 30	-	-		-	-	
Fed 31	-	-		-	-	
Fed 32	-	-		-	-	
Fed 33	-	-		-	-	
Fed 34	-	-		-	-	
Fed 35	-	-		-	-	
Fed 36	1,230	6		31,644,210	152,818	
Fed 37	-	-		-	-	
Fed 38	500	2		512,149,000	2,355,885	
Fed 39	-	-		-	-	
Fed 41	4,400	21		142,168,400	681,762	
Std 31	-	-		-	-	
Std 33c	356	2		894,780,368	4,348,230	
Std 33d	356	2		77,719,428	377,681	
Std 33e	2,112	10		2,718,570,624	13,129,460	
Std 33f	2,112	10		236,132,160	1,140,411	
Std 33g	2,455	12		993,474,670	4,815,621	
Std 34a	2,250	11		3,325,356,000	16,109,502	
Std 34b	2,250	11		278,703,000	1,350,161	
Std 34c	900	4		1,373,829,300	6,716,499	
Std 34d	900	4		115,143,300	562,923	
Std 35a	-	-		-	-	
Std 35b	-	-		-	-	
Std 36	1,755	9		159,794,505	773,934	
Std 38	-	-		-	-	
Std 39	-	-		-	-	
Std 40	-	-		-	-	
Std 41a	-	-		-	-	
Std 42a	-	-		-	-	
Std 42b	-	-		-	-	
Total	**21,576**	**104**		**10,859,464,965**	**52,514,889**	

5. Conclusion and Recommendations

5.1 Conclusion

The evaluation estimated electric, gas, water, and embedded energy savings for 32 new standards in the IOU claims from 2016 through 2018. Of these, 15 standards began in 2016, 5 started in 2017, and 12 were added in 2018. On a cumulative basis for the 2016–2018 period, the evaluation found 30% more GWh savings than the IOUs reported, a 3% reduction in MW, and 6% more MMtherms (Table 34). These higher evaluated GWh savings can be attributed to the 2018 claim. Specifically, two lighting standards – General Service Lamps (Standard 39) and General Service Fluorescent Lamps (Fed 37) that were 1.5 times and 5.3 times higher respectively than the claim. These differences can be attributed to:

1. Std 39: A timing issue that changed the baseline from a mix of incandescent and halogen to halogen only since California standards had already banned incandescent A lamps.
2. Fed 37: The number of units claimed in CEDARS was based on average annual shipments and the evaluation updated the numbers to reflect actual 2018 shipments.

Table 34. Annual Savings from Evaluated Standards

	GWh			MW			MMTherm		
IOU	2016	2017	2018	2016	2017	2018	2016	2017	2018
PG&E	53.6	115.3	485.9	8.7	17.2	65.9	3.8	7.6	7.7
SCE	53.0	115.5	492.5	8.6	17.3	66.8	-	-	-
SCG	-	-	-	-	-	-	6.0	11.6	11.5
SDG&E	10.9	23.6	100.0	1.8	3.5	13.6	0.4	0.8	0.8
Evaluated Savings	117.5	254.4	1,078.4	19.1	38.0	146.2	10.3	20.0	20.0
Reported by IOUs	127.4	256.2	733.8	23.8	47.0	139.2	9.2	14.4	15.9
Eval as % of Claim	92%	99%	147%	80%	81%	105%	112%	139%	126%

Cumulative 2016–2018	GWh	MW	MMTherm
Evaluated Savings	1,450.3	203.3	50.3
Reported by IOUs	1,117.5	210.0	39.5
Savings Difference	+332.9	-6.8	+10. 8
Eval Savings as % of Reported	130%	97%	127%

Note: Cumulative values are the sum of first year savings for the appliance standards advocacy program in each of the three program years

For many other standards in 2018 the IOU claimed number of units and unit energy savings changed dramatically from 2016 and 2017. We are not sure of the reasons for many these changes since technologies and economic conditions remained relatively stable over the period. For two lighting standards, the IOUs found calculation errors on their side explaining the difference. For the remaining standards we could not find any sources (including the CCSRs) to contradict our findings.

As mentioned earlier in the report, in CEDARS the parameters applied to converting gross savings to net savings are not available. One outcome of this is that the gross and net values reported in CEDARS are the same. As a result, there is no way to evaluate the intermediate assumptions without additional data provided by the IOUs.

5.2 Recommendations

Overall, the C&S evaluation of savings proceeded smoothly. The IOUs provided the requested data in a timely manner and offered to facilitate communication with corporate customers and manufacturers if needed.

Overall, our recommendations are limited to the CASE and CCSR developed by the IOUs to support the code and standard development process. These documents are the primary source used by the evaluators to understand and validate estimates and assumptions. In reviewing the CCSRs for the current evaluation cycle we have noted our impressions and recommendations to improve future documentation.

Portions of the CCSR that we found helpful when reconstructing the code setting proceedings:

- **Rulemaking history and timeline.** This helped us understand which earlier rules preceded the current rule and understand if Title 20 standards informed or set a precedent for standards adopted at the federal level.
- **List of key stakeholders and contact information.** This helped us identify individuals for outreach when we assembled panels for the NOMAD analysis.
- **Activities sorted by attribution factor.** This is probably the biggest opportunity to influence the evaluation outcome, since the CCSRs are the primary source of information regarding the C&S team's contributions to different rules. These directly informed the attribution workshops where our panel assigned scores to each attribution factor. The subheading summaries and the detailed text were both useful.
- **Summary tables of ISSM inputs.** These were useful for cross-checking the savings and assumptions in the calculation workbooks.
- **Standardized spreadsheet layouts.** Having roughly the same format for calculation workbooks from all the different product types made it easy for us to review the spreadsheets and validate the calculations.
- **Collection of related documents.** It was helpful to have an archive of source documents associated with each rule. Most of the material we required was included, though we sometimes had to track down Federal TSD files or review CEC dockets.

Sections that could be edited or omitted from individual CCSRs:

- **Logic model diagram and description.** One model can apply to all code and standards setting processes. We recommend developing one representative program theory and model to represent the program. This same model could be included in each appendix or provided once in a document such as the annual business plans.
- **Communications logs.** These logs provided some evidence regarding which stakeholders took the lead on different aspects of the advocacy. However, these communications should be retained for future access, but logs provided in the CCSR can be limited to include only those communications that support particular statements provided throughout the CCSR.

Items not in the CCSR that support the evaluation:

- **Connection to claimed savings.** We reviewed CEDARS claims from utilities for the same evaluation time period, and for several measures we could not understand how the values in the CCSR connected to the claimed savings. In many cases, the CCSR and CEDARS numbers did not match. There will always be differences in timing, but these can be easily explained. As stated earlier, the claim does not include the interim factors moving from gross to net savings. The claim does include number of units and unit energy savings but is not clear if this represents potential savings or something else. During the evaluation we found that the product of number of units and unit energy savings was not well correlated with reported gross savings.
- **Improved naming convention for indexed files.** As mentioned above, it was helpful that the CCSRs included a collection of relevant documents. However, the documents were typically labeled with just the source and publication year (e.g., "C&S 2012"). So, for example, if we wanted to find the original CASE report or the CEC Staff Report, we would have to decipher the CCSR bibliography or open each document individually. We recommend using a file naming convention that indicates the purpose of the document (e.g., "C&S 2012 CASE Report").

Related to this, program reporting was inconsistent across IOUs. In 2016 for example, all appliance standards were reported as part of the building codes advocacy program. Reporting quality at the product level did improve from 2016 to 2018. The quality of administrative costs at the sub program level however is still unknown. We recommend that the statewide program administrator be responsible for quality control for all program implementors. Specifically,

- The **IOUs need to be consistent** about reporting savings claims under the proper program name. This has improved somewhat since 2016, but as of 2018 was still not sufficient for accurate reporting.

We recommend standardizing the data provided by the IOUs for C&S programs or modifying CEDARS to accept all the data necessary to conduct an evaluation of the parameters that lead to claimed savings.

The C&S programs account for over 50% of the entire savings claim and that contribution is growing. The CEDARS dataset is an issue because CEDARS does not hold the data necessary to efficiently evaluate the IOU C&S claims. For example, there is a field for unit energy savings and number of units, but no label to explain what these values represent. Are they supposed to show potential, are they supposed to show gross units? It is not clear. Other fields omitted from CEDARS include the compliance adjustment factor, NOMAD, attribution, and allocation factors used to step from gross to net savings.

- **Provide more data during filing.** If the data needs are articulated and standardized before the evaluation begins, the evaluation for C&S will require fewer resources and take less time to conduct. At the very least this eliminates the need and time to identify and issue very specific data requests to the IOUs for data that may – or may not – exist.
- **Review and document policies** that cause CEDARS to process C&S data differently than it processes data for other programs. One example is that currently CEDARS assigns the same values for net and gross savings for C&S programs only.

One final recommendation is for the CPUC. Considering potential testing of products being evaluated. For some products that are widely available (battery chargers are an example) documentation is not available. In cases where a significant portion of savings cannot be evaluated due to lack of manufacturer documentation, testing should be considered. Any product purchase and testing will be in addition to the baseline evaluation budget. The cost and value of the information to the evaluation will need to be assessed on a case-by-case basis.

Appendix A. Table of Acronyms

Acronym	Definition
A/C	Air conditioner
ACEEE	American Council for an Energy-Efficient Economy
ANSI	American National Standards Institute, a standards-making body
ASAP	Appliance Standards Awareness Project
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers, an industry group and standards-making body
AWEF	Annual walk-in energy factor, a measure of energy efficiency for walk-in coolers and freezers
CAC	Central air conditioner
CASE	Codes and standards enhancement
CCMS	Compliance Certification Management System, a US DOE database with product information
CCR	California Code of Regulations
CCSR	Code change savings report
CEC	California Energy Commission
CFL	Compact fluorescent lamp
CFR	Code of Federal Regulations, where federal minimum efficiency standards are published
COP	Coefficient of performance for air conditioners and heat pumps
CPUC	California Public Utilities Commission
CRE	Commercial refrigeration equipment
CRI	Color rendering index
DEC	Daily energy consumption
DFB	Dimming fluorescent ballast
DOE	The US Department of Energy
EER	Energy efficiency ratio, a measurement of cooling efficiency
EISA	The Energy Independence and Security Act of 2007, which required DOE to add or revise product standards for a variety of products
EPS	External power supply, a class of product
gpf	Gallons per flush, a measurement of energy consumption for some water products
gpm	Gallons per minute, a unit of flow rate
GSFL	General service fluorescent lamps, a type of lighting product
GSL	General service lamp, a type of lighting product
GWh	Gigawatt-hours, a unit of energy
hp	Horsepower, a unit of power for electric motors
HP	Heat pump
HSPF	Heating seasonal performance factor, a measurement of annual heating efficiency
HVAC	Heating, ventilation, and air conditioning
IE	Interactive Effect
IEER	Integrated energy efficiency ratio, a measurement of cooling efficiency
IES	Illuminating Engineering Society, an industry group and standards-making body
IMC	Incremental cost
IMEF	Integrated Modified Energy Factor, a measurement of clothes washer energy efficiency

Acronym	Definition
IOUs	The California Investor-Owned Utilities
ISSM	Integrated Standards Savings Model
IWF	Integrated water factor, a measurement of clothes washer water efficiency
kBtu	Thousand British thermal units, a measurement of energy
kV	Kilovolts, a unit of voltage
kVA	Kilo-volt-ampere, a unit of power used to rate transformers
kWh	Kilowatt-hours, a unit of energy
LBNL	Lawrence Berkeley National Laboratories
LCC	Lifecycle Cost analysis, an analysis conducted by DOE for appliance standards rulemakings
LED	Light emitting diode
lpw	Lumens per watt, a measurement of lighting efficacy
LVDT	Low-voltage dry-type distribution transformers
MAEDBS	Modernized Appliance Efficiency Database System, the CEC's database of compliant products
MDEC	Maximum daily energy consumption
MEF	Modified energy factor, a measurement of clothes washer energy efficiency
MHLF	Metal halide lamp fixture
MMBtu	Million British thermal units, a measurement of energy
MR	Multifaceted reflector, a type of lamp
MVA	Megavolt-amperes, a measurement of transformer capacity
MVDT	Medium-voltage dry-type distribution transformers
MW	Megawatts, a unit of power
NEMA	National Electric Manufacturers Association, a trade association
NIA	National Impacts Analysis, an analysis conducted by DOE for appliance standards rulemakings
NOMAD	Naturally occurring market adoption
NOPR	Notice of proposed rulemaking, a document published during DOE rulemakings to describe a proposed set of standards
NRDC	Natural Resources Defense Council, an environmental advocacy group
OEM	Original equipment manufacturer
PAR	Parabolic aluminized reflector, a type of lamp
psi	Pounds per square inch, a unit of pressure
R	Reflector, a type of lamp
SBC	Small battery chargers, a class of product
SDDL	Small diameter directional lamp
SEER	Seasonal energy efficiency ratio, a measurement of annual cooling efficiency
TSD	Technical Support Document, a document filed in support of each energy conservation standard promulgated by the US Department of Energy
UEC	Unit energy consumption
UES	Unit energy savings
W	Watts, a unit of power
Wh	Watt-hours, a unit of energy
WICF	Walk-in coolers and freezers

Appendix B. Overview of IOU C&S subprograms

The Codes and Standards program is comprised of several sub-programs. Each of the sub-programs is summarized in this section.[50]

The two sub-programs that account for the bulk of the budget and all of energy savings are Building Codes Advocacy and Appliance Standards Advocacy (about 2/3 of the budget) followed by compliance improvement. The program is classified as a “cross-cutting” program since it affects all sectors (Commercial, Residential, Industrial, and Agricultural), and operates at the regional, state, and Federal level.

In the development of Federal, Title 20, and Title 24 standards, early and regular industry outreach is essential to ensure that proposed C&S changes are effective, easily implemented, and not unduly burdensome. Industry opposition is the most significant barrier the C&S program faces to proposal adoption. Several best practices have been developed to ensure that industry stakeholders are engaged with constructively. In general, the C&S Advocacy team:[51]

- Participates in working groups, committees, negotiations, and workshops where applicable to engage with industry outside of the formal rulemaking process,
- Conducts industry outreach through relevant professional societies or trade organizations to present ideas, hear feedback, and come to consensus on disagreements,
- Coordinates with advocates to align positions and collaborate on research, and
- Collects data through field studies, laboratory testing, customer surveys and any other qualitative or quantitative mechanism necessary to acquire high-quality and reliable data.

Building Codes Advocacy

The Building Codes subprogram primarily targets improvements to the Title 24 Building Energy Efficiency Standards that are periodically updated by the California Energy Commission (Energy Commission). The subprogram also seeks changes to national building codes that affect California building codes. Primary activities include developing code enhancement proposals and participating in public rulemaking processes. The program may coordinate with in ratings organizations that are referenced in Title 24 (e.g., the National Fenestration Rating Council, and the Cool Roof Rating Council).

Specific Title 24 program offerings include:

- Support for the implementation of recently adopted versions of the Energy Code, mainly by submitting suggested revisions to the Energy Commission for the compliance manuals, Alternative Compliance Manual, code language clean-up suggestions for the sections not included in CASE reports, forms, and technical support and data for improvements to the compliance software.
- Preparation of CASE Reports and other technical support documentation (i.e., comment letters, memorandum or research results reports) for the next code cycle in coordination with the Energy Commission, which includes:

[50] Fact Sheet, Statewide Codes and Standards Program (2013-2014), California Public Utilities Commission, March 2013
[51] Appendix A: Implementation Plan Template (2.0)

- Conducting building energy use research to advance state policy goals.
- Supporting coordination of Statewide CASE Team stakeholder meetings, public facing website, and other public communication modalities.
- Researching and advocating for methods to remove code compliance barriers to the increased use of renewable energy and energy storage in support of statewide Zero Net Energy (ZNE) and GHG emission reduction goals.
- Supporting the continuous improvement of the compliance software used to comply with the Energy Code.

Appliance Standards Advocacy

The Appliance Standards subprogram targets both state and federal standards and test methods: improvements to Title 20 Appliance Efficiency Regulations by the Energy Commission, and improvements to Federal appliance regulations by the United States Department of Energy (U.S. DOE). Advocacy activities include developing Title 20 code enhancement proposals, participating in the Energy Commission public rulemaking process, submitting comment letters based on IOU research and analysis in U.S. DOE standards proceedings, and participating in direct negotiations with industry. Additionally, the program monitors state and federal legislation and intervenes, as appropriate.

Specific Title 20 and Federal program offerings include:

- Participation in public rulemaking proceedings for both state and federal standards and test methods.
- Developing Title 20 CASE proposals and Federal comment letters based on) research and analysis in DOE standards proceedings and participate in direct negotiations with industry.
- Monitoring state and federal legislation and intervene, as appropriate.

Compliance Improvement

Compliance improvement is increasingly important to the energy efficiency industry in California. California codes have made tremendous advances in the last decade, adopting many efficient technologies and practices supported by IOU incentive and rebate programs. Achieving satisfactory compliance with the codes is a crucial requirement for capturing the code-related energy savings for the long-term benefit of society. Broad compliance is necessary to level the playing field for well-intentioned suppliers and contractors who are otherwise faced with a competitive disadvantage when complying with regulations. Greater compliance strengthens voluntary program baselines and provides a solid foundation for future robust advocacy efforts.

Reach Codes

The Reach Codes subprogram provides technical support to local governments that wish to adopt ordinances that exceed statewide Title 24 minimum energy efficiency requirements for new buildings, additions, or alterations. Support includes research and analysis for establishing required performance levels relative to T-24 and cost effectiveness per Climate Zone, drafting model ordinance templates, and assistance with completing and expediting the application process required for approval by the Energy Commission. The subprogram also supports local governments that seek to establish residential or commercial energy conservation ordinances for existing buildings.

Planning and Coordination

The is not so much a program but more of a budgeting category to facilitate statewide coordination of activities and policies related to building code and appliance standard work. This includes working with the Energy Commission, CPUC, Emerging Technologies program (ETP), WE&T program, and other EE programs to conduct strategic planning in support of the California Energy Efficiency Strategic Plan's policy goals, including Zero Net Energy goals for new construction.

Code Readiness

This is a PG&E activity that implements project level activities with a goal of supporting C&S building code advocacy. These are residential and nonresidential projects that focus on multiple aspects of building design and/or construction. Projects span all topics such as high-performance walls, hot water distribution, HVAC systems and innovative lighting technologies.

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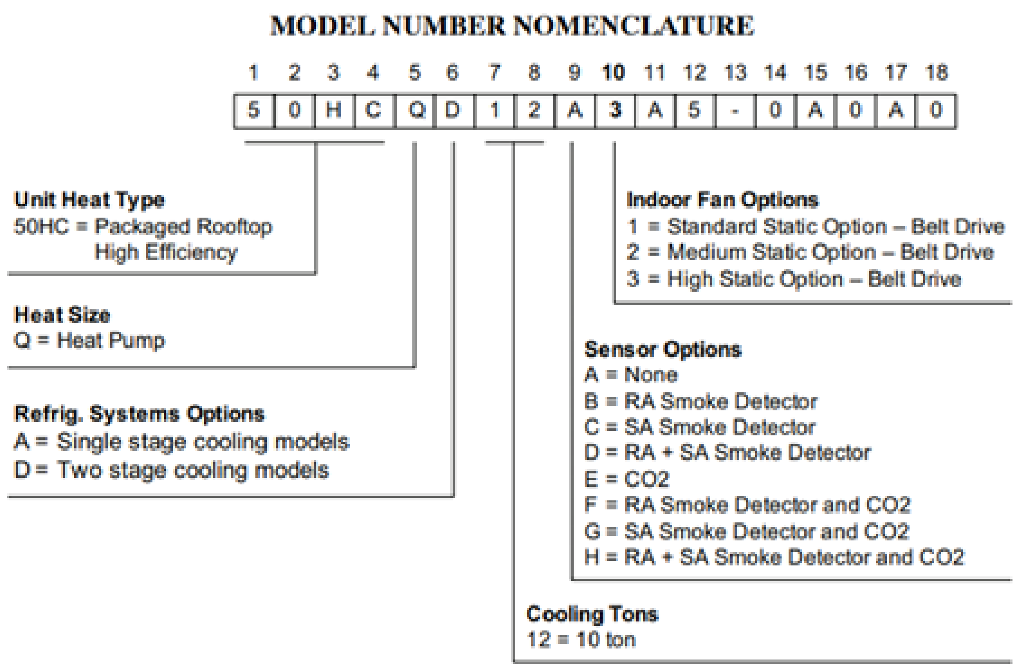
Appendix C. Specific Codes and Standards being evaluated

Effective Year	Measure ID	Measure Name	Potential	Compliance	NOMAD	Attribution
Title 20 Appliance Standards						
2016	Std 33c	Lavatory Faucets and Aerators (Res) w/natural gas, Tier 2	Y	Y	Y	Y
2016	Std 33d	Lavatory Faucets and Aerators (Res) w/electric, Tier 2	Y	Y	Y	Y
2016	Std 33e	Kitchen Faucets and Aerators (Res) w/natural gas	Y	Y	Y	Y
2016	Std 33f	Kitchen Faucets and Aerators (Res) w/electric	Y	Y	Y	Y
2016	Std 33g	Public Lavatory Faucets (Com)	Y	Y	Y	Y
2016	Std 34a	Showerheads w/natural gas, Tier 1	Y	Y	Y	Y
2016	Std 34b	Showerheads w/electric, Tier 1	Y	Y	Y	Y
2016	Std 35a	Toilets and Urinals (Com)	Y	Y	Y	Y
2016	Std 35b	Toilets and Urinals (Res)	Y	Y	Y	Y
2016	Std 36	Urinals	Y	Y	Y	Y
2016	Std 38	Dimming Fluorescent Ballasts	Y	Y	Y	Y
2017	Std 31	Small Battery Chargers, Tier 3 (non-consumer)	Y	Y	Y	Y
2018	Std 34c	Showerheads w/natural gas, Tier 2	Y	Y	Y	Y
2018	Std 34d	Showerheads w/electric, Tier 2	Y	Y	Y	Y
2018	Std 39	General Service Lamps	Y	Y	Y	Y
2018	Std 40	Small Diameter Directional Lamps	Y	Y	Y	Y
2018	Std 41a	General Service LED Lamps, Tier 1	Y	Y	Y	Y
2018	Std 42a	Computers (workstations)	Y	Y	Y	Y
2018	Std 42b	Computers (small-scale servers)	Y	Y	Y	Y
Federal Appliance Standards						
2016	Fed 28	Distribution Transformers (Com)	Y	Y	Y	Y
2016	Fed 29	External Power Supplies (Res)	Y	Y	Y	Y
2016	Fed 30	Electric Motors (Com)	Y	Y	Y	Y
2016	Fed 31	Microwave Ovens (Res)	Y	Y	Y	Y
2017	Fed 32	Commercial CAC and HP (<65,000 Btu/hr)	Y	Y	Y	Y
2017	Fed 33	Metal Halide Lamp Fixtures (Com)s	Y	Y	Y	Y
2017	Fed 34	Commercial Refrigeration Equipment (Com)	Y	Y	Y	Y
2017	Fed 35	Walk-In Coolers and Freezers (Com)	Y	Y	Y	Y
2018	Fed 36	Commercial Clothes Washers (Com)	Y	Y	Y	Y
2018	Fed 37	General Service Fluorescent Lamps (Res)	Y	Y	Y	Y
2018	Fed 38	Residential Clothes Washers, top-loading (Res)	Y	Y	Y	Y
2018	Fed 39	Commercial CAC and HP (65,000-760,000 Btu/hr), Tier 1	Y	Y	Y	Y
2018	Fed 41	Commercial Icemakers (Com)	Y	Y	Y	Y

Appendix D. Model Number Nomenclature

In many cases certain commercial products are built to order, with customized model numbers that specify different configuration options. For example, Carrier has a limited number of product lines for commercial unitary A/Cs (Fed 39), but a typical commercial unitary A/Cs model number looks like “50HCQD08A2A60A0A0.” The nomenclature for that model is explained in the screen capture below: Each digit after the first ~8 digits specify a particular feature or firmware revision, and there are many possible combinations to choose from.



Appendix E. Potential Savings: Product-Specific Results

Standards are grouped by technology category in this and the following appendices.

Appliances

Federal 31: Microwave Ovens

This section presents the results of the evaluation of Federal 31, the federal standard that regulates microwave ovens, which took effect on June 17, 2016. Prior to Federal 31, microwave ovens were not subject to energy efficiency standards. Federal 31 introduced new limits on microwave oven standby power wattage. Table 35 summarizes the evaluation results.

Table 35. Evaluation Results of Federal 31

	Evaluation Results
Description	Microwave Ovens
Effective Date	6/17/2016
California Unit Sales/Year	1,478,000
Unit Energy Savings (kWh)	15.9
Unit Demand Reduction (watts)	3.24
Unit Natural Gas Savings (Therms)	--
First-Year Potential Energy Savings (GWh)	23.5
First-Year Potential Demand Savings (MW)	4.79
First-Year Potential Natural Gas Savings (Therms)	--

List of Data Sources

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

- DOE (2013) National Impact Analysis Spreadsheet. Tabs "Standards Case - PC1" and "Standards Case - PC2" https://www.regulations.gov/document?D=EERE-2011-BT-STD-0048-0024
- DOE (2013). Final Rule Technical Support Document for Residential Microwave Ovens - Stand By Power. Tables 7.3.3 and 7.3.4. https://www.regulations.gov/document?D=EERE-2011-BT-STD-0048-0021
- DOE (2008). Energy Conservation Program for Consumer Products: Notice of Proposed Rulemaking (NOPR) for Residential Dishwashers, Dehumidifiers, and Cooking Products, and Commercial Clothes Washers. Federal Register, October 17, 2008. Vol. 73, no. 202, pp. 62034–62134.

Market Size Analysis

We referenced estimates of annual microwave shipments published by DOE. To estimate national microwave shipments, DOE used a shipments model calibrated with historical shipments data. The shipments model estimates shipments to specific market segments, then aggregates these segments to estimate total product shipments. DOE's shipments model accounts for the combined effects of changes in purchase price, annual operating cost, and household income on the consumer purchase decision. Since microwave ovens are a primarily residential-sector product, we estimated California's share of national microwave shipments using California's share of the national stock of housing units. We calculated that California comprises 10.33% of the national housing units, based on US Census data. Table 36 presents DOE's national shipment estimates and California's estimated share of shipments for microwave ovens.

Table 36. 2016 Shipments of Microwave Ovens, US and California, by Product Class

Product Class	California Share of US Shipments (%)[1]	Annual Shipments, 2016 (millions)		Market Share (%)
		US.[2]	California	
Class 1: Microwave-Only and Countertop Convection	10.33%	14.165	1.463	99.0%
Class 2: Built-In and Over-the-Range Convection	10.33%	0.143	0.015	1.0%
Total	–	**14.308**	**1.478**	

[1]Source: US Census data
[2] Source: DOE 2013 National Impacts Analysis Spreadsheet

Unit Energy and Demand Savings

The annual energy use associated with standby power is estimated as the product of the standby power (in Watts) and the hours per year that the microwave oven is in standby mode. The annual standby hours equal the total hours in a year less the number of hours the microwave oven is in active operation. In the 2008 NOPR for cooking products, DOE determined the average hours of operation for microwaves to be 71 hours per year. Thus, the annual standby hours equal 8,760 hours in a year minus 71 operational hours, or 8,689 hours. We believe this estimate of standby mode hours is reasonable for California.

To estimate the base case energy consumption for the two product classes of microwaves, DOE first defined a set of five efficiency levels ranging from the baseline (i.e., highest standby power) to the lowest standby power. For each of these efficiency levels, the annual energy consumption is estimated as the product of the standby power (in Watts) and 8,689 hours of standby operation. Then, DOE estimated a base case distribution of efficiencies for microwave products and calculated a weighted average efficiency and weighted average annual consumption for both product classes (Table 37). This is consistent with the approach prescribed by the CPUC's *Energy Efficiency Policy Manual*, which is applicable to post-2012 Energy Efficiency Programs. The manual states that the baseline for gross savings should be either the previous standard (if one exists) or the prevailing market practice.

Table 37. Microwave Oven Standby Power and Annual Consumption, by Efficiency Level

Efficiency Level	Class 1: Microwave-Only and Countertop Convection Microwave Ovens			Class 2: Built-In and Over-the-Range Convection Microwave Ovens		
	Standby Power (W)	Average Energy Consumption (kWh/year)	Market Share (%)	Standby Power (W)	Average Energy Consumption (kWh/year)	Market Share (%)
Baseline	4.00	34.76	46%	4.50	39.10	100%
1	2.00	17.38	35%	3.70	32.15	0%
2	1.50	13.03	19%	2.70	23.46	0%
3	1.00	8.69	0%	2.20	19.12	0%
4	0.02	0.17	0%	0.04	0.35	0%
Weighted Average, Base Case	**2.83**	**24.54**	–	**4.50**	**39.10**	–

Source: DOE (2013) Final Rule TSD Tables 10.3.1 and 10.3.2

For both product classes, Federal 31 set standby power limits at efficiency level 3. This limits microwave-only and countertop convection microwave ovens to 1.00 W standby power, and limits built-in and over-the-range convection microwave ovens to 2.20 W standby power. The annual savings per unit is calculated as the difference between the annual consumption at efficiency level 3 and the annual consumption of the base case. Table 38 presents the annual unit energy consumption at the baseline and standard levels and calculates the annual unit energy savings as the different between the baseline and standard-level energy consumption. To calculate demand savings, we referenced a load factor of 56% for residential cooking loads.[52] The final row of Table 38 reports the shipment-weighted savings (using 99.0% for class 1 and 1.0% for class 2).[53]

Table 38. Microwave Oven Standards and Unit Savings Calculation by Product Class Detail

Product Class	Annual Unit Energy Consumption (kWh/year)		Annual Unit Energy Savings (kWh/year)	Annual Unit Demand Savings (W)	Market Share (%)
	Baseline	Standard			
Class 1: Microwave-Only and Countertop Convection	24.55	8.69	15.86	3.23	99.0%
Class 2: Built-In and Over-the-Range Convection	39.10	19.12	19.98	4.07	1.0%
Shipment-Weighted Average	**24.69**	**8.79**	**15.90**	**3.24**	

Federal 38: Residential Clothes Washers

This section presents the results of the evaluation of Federal 38, the federal standard that regulates residential clothes washers (RCWs), which took effect on January 1, 2018. This standard stems from a direct final rule published by DOE in 2012. That rule promulgated two sequential tiers of standards for RCWs. The first tier of RCW standards, with a compliance date of March 7, 2015, was evaluated in a prior evaluation cycle covering the period 2013–2015. This analysis only considers the second tier of standards (with a compliance date of January 1, 2018) and uses the first tier of standards as the baseline level. Table 39 summarizes the evaluation results.

Table 39. Evaluation Results of Federal 38

	Evaluation Results
Description	Residential Clothes Washers
Effective Date	1/1/2018
California Unit Sales/Year	1,024,298

[52] California Energy Commission. 2016. Demand Analysis Office.

[53] The shipment-weighted average annual unit energy savings reported in Table 38 (15.9 kWh/yr.) is significantly lower than the average unit energy savings calculated by the IOUs (26.01 kWh/yr.). The IOUs calculated energy savings relative to a baseline of the worst performing unit on the market. Since no prior standard existing for microwave ovens, our evaluation calculated savings relative to a baseline representing the market average unit energy consumption, per guidance from the CPUC's *Energy Efficiency Policy Manual*. As shown in Table 37, a large portion of shipments in product class 1 outperform the worst unit on the market.

Unit Energy Savings (kWh)	21.1
Unit Demand Reduction (watts)	3.12
Unit Natural Gas Savings (Therms)	−0.01
Unit Water Savings (1,000 gallons)	0.5
Unit Embedded Electricity in Water Savings (kWh)	2.3
First-Year Potential Energy Savings (GWh)	21.58
First-Year Potential Demand Reduction (MW)	3.20
First-Year Potential Natural Gas Savings (MTherms)[1]	−0.01
First-Year Potential Water Savings (million gallons)	494.3
First-Year Potential Embedded Electricity Savings (GWh)	2.40

[1] Note that a negative natural gas savings indicates an increase in natural gas consumption. This is driven by DOE's finding that top-loading, standard size RCWs at efficiency level 6 (EL6) consume more natural gas per cycle than the same class of RCWs at EL2.

List of Data Sources

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

- DOE (2012) Direct Final Rule National Impacts Analysis Spreadsheet for RCWs. EERE-2008-BT-STD-0019-0046
- DOE (2012) Direct Final Rule for RCWs. EERE-2008-BT-STD-0019-0041
- DOE (2012) Direct Final Rule Technical Support Document for RCWs. https://www.regulations.gov/document?D=EERE-2008-BT-STD-0019-0047

Market Size Analysis

To determine the market size for residential clothes washers in California, we referenced the DOE's estimates of nationwide RCW shipments and applied an estimate of California's share of the nationwide shipments. DOE estimated shipments for RCWs using a computer model calibrated against historical records of shipments, and accounting for the effects of new standard levels on product shipments. Details on DOE's shipments analysis are available in chapter 9 of the 2012 Direct Final Rule TSD for RCWs.

Since RCWs are a primarily residential-sector product, we estimated California's share of national RCW shipments using California's share of the national stock of housing units. We calculated that California comprises 10.31% of the national housing units, based on U.S. Census data.[54] Table 40 presents DOE's national shipment estimates and California's estimated share of shipments for RCWs.[55]

Table 40. 2018 Shipments of Residential Clothes Washers, US and California, by Product Class

Product Category	Product Size	California Share of US Shipments (%)[1]	2018 Shipments		Market Share (%)
			US[2]	California	
Front-Loading	Standard	10.31%	5,347,279	551,072	53.8%
	Compact		19,878	2,049	0.2%

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[54] US Census Bureau. "Annual Estimates of Housing Units for the United States, Regions, Divisions, States, and Counties." The Census Bureau shows 14,277,157 housing units in California and 138,537,078 housing units nationwide. https://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml

[55] Note: The calculations supporting the savings claims for RCWs were supplied in a file named "9 - IOU C&S team 2014b.xlsx." Cell D15 of the "CCTR Measure Checklist" tab of this file reports a value of 9,939,180 units for the national RCW *stock* and then divides this value by the RCW lifetime. However, the cell in question references a DOE-reported value of 2018 RCW *shipments*, and this mis-match leads to erroneous savings estimates in the CCTR. In the analysis presented here, we take the 9,939,180-unit value as the national shipments, and we estimate California's share of national shipments by scaling the national shipments on the basis of housing stock.

Top-Loading	Standard	10.31%	4,472,631	460,934	45.0%
	Compact		99,392	10,243	1.0%
	Total	–	**9,939,180**	**1,024,298**	

[1] Source: US Census data
[2] Source: DOE (2012) RCW Direct Final Rule National Impacts Analysis Spreadsheet. EERE-2008-BT-STD-0019-0046. Total RCW shipments from "RCW Shipments Stds Case" tab, cell BC55. Total shipments distributed by equipment class according to market shares in "Summary Results" tab, range H13:K14, interpolated to 2018.

Unit Energy and Demand Savings

The baseline level for Federal 38 corresponds with the federal standards that took effect on March 7, 2015. We referenced the energy consumption and water consumption estimates reported by DOE for the baseline and standard level of each product class. DOE estimates the annual energy and water consumption of clothes washers by multiplying the per-cycle energy and water use by the number of cycles per year. The per-cycle energy consumption associated with a given clothes washer energy use into three components: (1) heating the water, (2) operating the machine, and (3) drying the clothes. Further details regarding annual consumption estimates are available in chapter 7 of DOE (2012) Direct Final Rule Technical Support Document for RCWs.

In addition to the electric savings resulting from more efficient operation of the clothes washer, there are embedded electric savings associated with the reduced water consumption of the standard-level clothes washers. For this analysis, we assumed an embedded electricity value of 4,848 kWh per million gallons of water.[56] We then multiplied the savings by the market share to determine the weighted average unit savings. To calculate demand savings, we referenced a load factor of 77% for the residential clothes washer end use.[57] Table 41 shows the results of our analysis.

Table 41. Residential Clothes Washer Energy and Water Savings, by Product Class

Product Category		Front-Loading RCW		Top-Loading RCW		Shipment-Weighted Average
Product Size		**Standard**	**Compact**	**Standard**	**Compact**	
Market Share		53.8%	0.2%	45.0%	1.0%	-
Annual Unit Electric Consumption (kWh)[1]	Baseline	243.1	173.1	342.6	232.6	287.6
	Standard	243.1	173.1	296.7	189.7	266.6
	Savings	0.0	0.0	45.9	42.9	21.1
Annual Unit Gas Consumption (Therms)[1]	Baseline	11.88	8.52	16.90	12.29	14.13
	Standard	11.88	8.52	17.18	8.62	14.22
	Savings	0.00	0.00	-0.28	3.67	-0.09
Annual Unit Water Consumption (1,000 gal)[1]	Baseline	4.8	3.7	8.4	6.8	6.4
	Standard	4.8	3.7	7.4	5.6	5.9
	Savings	0.0	0.0	1.0	1.2	0.5
Unit Demand Savings (W)		0.0	0.0	6.8	6.4	3.12
Embedded Electric Savings of Water (kWh)		0.0	0.0	5.1	5.5	2.3

[1] DOE (2012) Direct Final Rule National Impacts Analysis Spreadsheet for RCWs. EERE-2008-BT-STD-0019-0046. "Input and Summary" tab.

[56] CPUC Water/Energy Cost-Effectiveness Analysis. Errata to the Revised Final Report. Prepared by Navigant Consulting, Inc. (May 2015)
[57] California Energy Commission. 2016. Demand Analysis Office.

Federal 36: Commercial Clothes Washers



This section presents the results of the evaluation of Federal 36, the federal standard that regulates commercial clothes washers, which took effect on January 1, 2018. Table 42 summarizes the evaluation results.

Table 42. Evaluation Results of Federal 36

	Evaluation Results
Description	Commercial Clothes Washers
Effective Date	1/1/2018
California Unit Sales/Year	25,727
Unit Energy Savings (kWh)	143.7
Unit Demand Reduction (watts)	20.25
Unit Natural Gas Savings (Therms)	10.0
Unit Water Savings (1,000 gallons)	1.23
Unit Embedded Electricity in Water Savings (kWh)	5.94
First-Year Potential Energy Savings (GWh)	3.7
First-Year Potential Demand Reduction (MW)	0.52
First-Year Potential Natural Gas Savings (MTherms)	0.26
First-Year Potential Water Savings (million gallons)	31.5
First-Year Potential Embedded Electricity in Water Savings (GWh)	0.15

List of Data Sources

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

- DOE (2014). Energy Conservation Program: Energy Conservation Standards for Commercial Clothes Washers; Final Rule. EERE-2012-BT-STD-0020-0037
- DOE (2014) Final Rule National Impacts Spreadsheet. EERE-2012-BT-STD-0020-0034
- National Multifamily Housing Council. “Quick Facts: Apartment Stock.” https://www.nmhc.org/research-insight/quick-facts-figures/quick-facts-apartment-stock/

Market Size Analysis

To determine the market size for commercial clothes washers in California, we referenced the DOE’s estimates of nationwide shipments of CCWs and applied an estimate of California’s share of the nationwide shipments. DOE estimated shipments for CCWs with a shipments model calibrated against historical CCW shipments. Commercial clothes washers are divided into two product classes: top-loading washers and front-loading washers. The DOE estimates that both classes are sold into two applications, with 85% of shipments going to multi-family housing and 15% of shipments going to laundromats.[58]

To estimate California's share of national shipments, we used different scaling factors to estimate sales to multi-family housing and to laundromats. California contains about 13.8% of the national stock of apartment units, so we assumed that California receives 13.8% of CCW shipments to multi-family housing.[59] We assumed that the amount of laundromat units scales with the amount of commercial floorspace, and we estimate that California makes up 11.9% of national commercial floorspace.[60] Combining these proportions with the relative shares by application, we estimate that California receives 13.5% of the total national CCW shipments.[61] Table 43 presents the estimated CCW shipments in 2018 by product class for the U.S. and California.

Table 43. 2018 Shipments of Commercial Clothes Washers, US and California, by Product Class.

Product Class	California Share of U.S. Shipments (%)[1]	U.S. Shipments, 2018[2]	California Shipments, 2018	Application	Application Market Share[3]	Share of total shipments
Top-loading CCW	13.5%	132,089	17,855	Multi-family	85%	59.0%
				Laundromat	15%	10.4%
Front-loading CCW	13.5%	58,236	7,872	Multi-family	85%	26.0%
				Laundromat	15%	4.6%
Total	**–**	**190,325**	**25,727**			

[1] Source: Analysis of apartment stock and commercial floorspace
[2] DOE (2014) Final Rule National Impacts Spreadsheet. "Charts" tab, cells D105:E105. EERE-2012-BT-STD-0020-0034
[3] DOE (2014). CCWs Final Rule. Table IV.4.

Unit Energy and Demand Savings

Federal 36 led to a change in the method of calculating efficiency of commercial clothes washers. The DOE changed its energy efficiency metric from modified energy factor (MEF) to MEF_{J2} and changed its water efficiency metric from water factor (WF) to integrated water factor (IWF). Since the efficiency metrics changed, it is difficult to compare past and present per-unit consumption based on efficiency metrics alone. As a result, we determined that the best approach was to use data from DOE's national impacts analysis to assess potential energy savings. We used the DOE's data to determine the baseline level and standard level consumption of electricity, natural gas, and water. In addition to the electric savings resulting from more efficient operation of the clothes washer, there are embedded electric savings associated with the reduced water consumption of the standard-level washers. For this analysis, we assumed an embedded electricity value of 4,848 kWh per million gallons of water.[62] We then multiplied the savings by the market share to determine the weighted average unit savings for each combination of product class and application. To

[58] DOE (2014). CCWs Final Rule. Table IV.4.
[59] National Multifamily Housing Council. "Quick Facts: Apartment Stock." The NMHC shows 2,875,647 apartment units in California and 20,830,586 apartment units nationwide.
[60] Navigant estimated California's share of national commercial floorspace using data from the EIA's Commercial Buildings Energy Consumption Survey (CBECS). CBECs reports total commercial floorspace at the national and regional level, but not at the state level. Navigant found that (1) the Pacific West region (composed of California, Oregon, and Washington) contains 15.4% of the national commercial floor space, and (2) per US Census data, California houses 77.4% of the population of the Pacific West region. Navigant multiplied these shares together to estimate that California's share of national commercial floorspace is 11.9%.
[61] California's share of CCW shipments (13.5%) is the sum of two products: The multifamily share of CCW sales (85%) multiplied by California's share of national apartment units (13.8%) plus the laundromat share of CCW shipments (15%) multiplied by California's share of commercial floorspace (11.9%).
[62] CPUC Water/Energy Cost-Effectiveness Analysis. Errata to the Revised Final Report. Prepared by Navigant Consulting, Inc. (May 2015)

calculate demand savings, we referenced a load factor of 81% for "other" commercial end uses.[63] Table 44 shows the results of our analysis.

Table 44. Commercial Clothes Washer Unit Savings, by Product Class

Application		Top-Loading CCW		Front-Loading CCW		Shipment-Weighted Average
		Multi-Family	Laundromat	Multi-Family	Laundromat	
Annual Unit Electric Consumption (kWh)[1]	Baseline[2]	1,237	326	748	163	965.5
	Standard[3]	1,040	311	650	148	821.8
	Savings	197	15	98	15	144.0
Annual Unit Gas Consumption (MMBtu)[1]	Baseline	6.40	14.15	4.16	9.09	6.75
	Standard	5.53	11.98	3.43	7.61	5.75
	Savings	0.87	2.17	0.73	1.48	1.00
Annual Unit Water Consumption (1,000 gal)[1]	Baseline	29.63	40.91	15.64	21.59	26.80
	Standard	29.30	40.45	12.60	17.40	25.57
	Savings	0.33	0.46	3.04	4.19	1.23
Unit Demand Savings (W)		27.70	2.09	13.82	2.09	20.25
Unit Embedded Electric Savings of Water (kWh)		1.61	2.23	14.72	20.31	5.94
Market Share		**59.0%**	**10.4%**	**26.0%**	**4.6%**	

[1] DOE (2014) Final Rule National Impacts Spreadsheet. "LCC Input" tab, Columns G-I. EERE-2012-BT-STD-0020-0034
[2] The baseline level corresponds with the federal standards that took effect on January 8, 2013.
[3] The standard level corresponds with efficiency level 1 for top-loading CCWs and efficiency level 2 for front-loading CCWs.

Electronics

Standard 31: Small Battery Chargers, Tier 3 (non-consumer)

This section presents the results of our evaluation of Standard 31, the Title 20 standard that regulates small non-consumer battery chargers, which took effect on January 1, 2017. This rule is separate and unique from Tiers 1 and 2 of the small battery charger standard (i.e., Standards 29 and 30) and from the large battery chargers standard (Standard 32), all of which came into effect prior to 2016 and were evaluated in a prior evaluation cycle. Table 45 summarizes the evaluation results for Standard 31.

Table 45. Evaluated Results of Standard 31

	Evaluation Results
Description	Small Battery Chargers, Tier 3 (non-consumer)
Effective Date	1/1/2017
California Unit Sales/Year	2,069,000
Unit Energy Savings (kWh)	8.7
Unit Demand Reduction (watts)	1.1

[63] California Energy Commission. 2016. Demand Analysis Office.

	Evaluation Results
Unit Natural Gas Savings (Therms)	--
First Year Potential Energy Savings (GWh)	18.1
First Year Potential Demand Reduction (MW)	2.2
First Year Potential Natural Gas Savings (MTherms)	--

List of Data Sources

- We did not receive a code change savings report (CCSR) with potential savings claims for Standard 31 tier 3 small non-consumer battery chargers. The evaluated potential savings are based on estimates of market size and unit energy consumption in the IOUs' 2010 CASE Report and the CEC's 2011 Staff Report for battery chargers. We used the following data sources to determine first-year potential savings:
- IOU C&S Team (2010). CASE Report: Analysis of Standards Options for Battery Charger Systems. 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
- CEC (2011). "Staff Report: Staff Analysis of Battery Chargers and Self-Contained Lighting Controls." CEC-400-2011-001-SF.
- Ace Resources (2019). Title 20 Fact Sheet: CA Appliance Efficiency Regulations, Battery Chargers. https://energycodeace.com/download/33843/file_path/fieldList/T20.BatteryChargerSystems

Market Size Analysis

We referenced the 2010 CASE report, which describes different categories of battery charger products and grouped these categories into market segments. Standard 31 covers the small non-consumer market segment, which includes the product categories of emergency backup lighting, handheld barcode scanners, and two-way radios. The 2011 Energy Commission Staff Report provides estimated shipments and compound annual growth rates (CAGR) of these three product categories. We referenced these estimates and projected the shipments to 2017, the year that Standard 31 takes effect, using the following formula:

$$Sales_{2017} = Sales_{2013} \times (1 + CAGR_{2013})^4$$

We calculated market shares for these three categories as a portion of the total small non-consumer battery charger shipments. These shipment estimates and market shares are presented in Table 46.

Table 46. California Stock and Sales for Small Non-Consumer Batter Chargers, in 2013 and 2017

Product Category	California Stock, 2013 (millions)[1]	California Sales, 2013 (millions) [1]	CAGR Sales, 2013 (%)[1]	California Sales, 2017 (millions)	Market Share of Small Non-Consumer Products
Emergency Backup Lighting	7.85	2.000	0%	2.000	96.6%
Handheld Barcode Scanners	0.32	0.030	7%	0.039	1.9%
Two-Way Radios	0.6	0.03	0%	0.030	1.4%
			Total	**2.069**	

Source: Energy Commission Staff Report, October 2011, Table A-1.

Unit Energy and Demand Savings

Navigant referenced assumptions regarding power consumption for battery charger system categories from the 2010 CASE report, which relies on extensive battery charger product testing conducted by Ecos. We referenced charge mode power assumptions from the 2011 Energy Commission Staff Report, which presented updated assumptions that better match the test data available at the time.

We estimate the annual energy consumption per product as a sum of the product of power and duty cycle for the various operating modes of the product. For example, the annual energy consumption of charge mode is calculated by multiplying charge mode power by charge mode duty cycle and by the number of hours in a year. The annual energy consumption for a given product was thus calculated as follows:

$$E_{Annual} = \left[\left(P_{charge} \times D_{charge}\right) + \left(P_{maint} \times D_{maint}\right) + \left(P_{no\ bat} \times D_{no\ bat}\right)\right] \times 8760\ \frac{hours}{year} \times \frac{1\ kWh}{1000\ Wh}$$

Where:

E_{annual} = Annual unit energy consumption (kWh/year)
P_{charge}, P_{maint}, $P_{no\ bat}$ = the power draw for charge, maintenance, and no battery modes (W)
D_{charge}, D_{maint}, $D_{no\ bat}$ = the duty cycle for charge, maintenance, and no battery modes (%)

Note that the equation does not include the unplugged power or unplugged duty cycle because these do not contribute to annual energy use since the unplugged power is always zero. These factors and the calculated annual unit energy consumption are reported in Table 47 for the baseline level, and Table 48 for the standard level. The final row in each of these tables shows the calculated shipment-weighted average annual unit energy consumption. To calculate demand savings, we referenced a load factor of 93% for miscellaneous loads.[64] Demand savings per unit is calculated as the annual electric savings per unit divided by the load factor multiplied by 8,760 hours per year.

The average annual unit energy savings is the difference between the average unit energy consumption at the baseline and standard level, 8.7 kWh/year per unit. The average annual unit demand savings is the difference between the average unit demand at the baseline and standard level, 1.1 W per unit.

[64] California Energy Commission. 2016. Demand Analysis Office.

Table 47. Power Draw, Duty Cycle, and Annual Unit Energy Consumption for Baseline-Level Small Non-Consumer Battery Chargers

Product Category	Baseline Power Draw (W)[1]			Duty Cycle (%)[1]				Baseline Annual Unit Energy Consumption (kWh/year)	Baseline Unit Demand (W)
	Charge	Maintenance	No Battery	Charge	Maintenance	No Battery	Un-plugged		
Emergency Backup Lighting	2.2	1.6	1.6	0%	99%	0%	0%	13.9	1.70
Handheld Barcode Scanners	11.2	3	0.2	13%	52%	35%	0%	27.0	3.32
Two-Way Radios	5.3	2	0.9	19%	31%	50%	0%	18.2	2.23
				Shipment-Weighted Average:				**14.2**	**1.74**

Source: Energy Commission Staff Report, October 2011, Table A-5.

Table 48. Power Draw, Duty Cycle, and Annual Unit Energy Consumption of Standard-Level Small Non-Consumer Battery Chargers

Product Category	Standard-Level Power Draw (W)[1]			Duty Cycle (%)[1]				Standard-Level Annual Unit Energy Consumption (kWh/year)	Standard-Level Unit Demand (W)
	Charge	Maintenance	No Battery	Charge	Maintenance	No Battery	Un-plugged		
Emergency Backup Lighting	1.0	0.62	0.3	0%	99%	0%	0%	5.4	0.66
Handheld Barcode Scanners	3.2	0.61	0.2	13%	52%	35%	0%	7.0	0.86
Two-Way Radios	3.8	0.61	0.3	19%	31%	50%	0%	9.3	1.14
				Shipment-Weighted Average:				**5.5**	**0.67**

Source: Energy Commission Staff Report, October 2011, Table A-6.

Standard 42a-b: Computers



This section presents the results of the evaluation of Standards 42a and 42b, the Title 20 standards that regulate computer workstations and small-scale servers, which took effect on January 1, 2018. Table 49 summarizes the evaluation results.

Table 49. Evaluated Results of Standard 42

	Evaluation Results		
Description	Small-Scale Servers	Workstations	Total or Weighted Average
Effective Date	1/1/2018	1/1/2018	1/1/2018
California Unit Sales/Year	60,000	109,500	169,500
Unit Energy Savings (kWh/year)	20.0	48.0	38.1
Unit Demand Reduction (watts)	2.9	6.8	5.44
Unit Natural Gas Savings (Therms)	--	--	--
First-Year Potential Energy Savings (GWh)	1.20	5.26	6.46
First-Year Potential Demand Reduction (MW)	0.17	0.75	0.92
First-Year Potential Natural Gas Savings (Therms)	--	--	--

List of Data Sources

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

- IOU C&S Team (2013). Computers CASE Report. TN #71813 https://energyarchive.ca.gov/appliances/2013rulemaking/documents/responses/Consumer_Electronics_12-AAER-2A/California_IOUs_Standards_Proposal_Computers_UPDATED_2013-08-06_TN-71813.pdf
- IOU C&S Team (2014). Computers CASE Report Addendum. TN #73899. https://efiling.energy.ca.gov/GetDocument.aspx?tn=73899
- CEC (2016). "Staff Report: Final Analysis of Computers, Computer Monitors, and Signage Displays." TN # 213548. Table 8, 9, 10. https://efiling.energy.ca.gov/GetDocument.aspx?tn=213548&DocumentContentId=23311

Market Size Analysis

We referenced the stock and shipment values presented in table 4.1 of the IOU C&S Team's 2013 CASE Report. Shipments are presented in Table 50.

Table 50. 2017 Stock and Sales of Small-Scale Servers and Workstations in California

	2017 Unit Stock	2017 Unit Sales	Percent of Total Shipments (%)
Small-Scale Servers	180,000	60,000	35%

Workstations	530,000	109,500	65%
Total	**710,000**	**169,500**	

Source: IOU C&S Team's 2013 CASE Report, Table 4.1, less the market share that meets the standard.

Unit Energy and Demand Savings

Prior to Standard 42, no mandatory state or federal efficiency standards existed for computers. We referenced the unit energy consumption estimates for qualifying and non-qualifying products in the workstation and small-scale server categories presented in table 3.1 of the IOUs' 2013 CASE Report. The 2013 CASE Report cites the ENERGY STAR® 5.0 Qualifying Product List as the ultimate source of these consumption figures. We calculated the annual unit energy savings as the difference between the unit energy consumption at the qualifying and non-qualifying levels. To calculate the demand savings, we used a load factor of 80%, calculated as an average of the 74% load factor for commercial office equipment and the 85% load factor for residential televisions (used as a proxy for electronics). See Table 51 for details.

Table 51. Energy Consumption and Savings for Small-Scale Servers and Workstations

Product Type	Annual Unit Energy Consumption (kWh/year)		Annual Unit Energy Savings (kWh/year)	Unit Demand Savings (W)
	Non-Qualifying	Qualifying		
Small-Scale Servers	**298**	**278**	**20.0**	**2.9**
Workstations (Tier 1)	664	616	48.0	6.8
Market-Weighted Average	**534**	**496**	**38.1**	**5.44**

Source: IOU C&S Team's 2013 CASE Report, Table 3.1

Federal 29: External Power Supplies

This section presents the results of the evaluation of Federal 29, the federal standard that regulates external power supplies (EPS), which took effect on February 10, 2016. These devices convert ac power from a wall outlet into lower voltage dc or ac power to be used directly by electronic devices such as laptop computers, printers, cordless phones, cell phones, etc. Federal 29 set minimum standards for efficiency during active mode and set standards for maximum power consumption during no-load mode. Table 52 summarizes the evaluation results.

Table 52. Evaluation Results of Federal 29

	Evaluation Results
Description	External Power Supplies
Effective Date	1/1/2016
California Unit Sales/Year	39,204,734
Unit Energy Savings (kWh/year)	1.80
Unit Demand Reduction (watts)	0.24
Unit Natural Gas Savings (Therms)	--
First-Year Potential Energy Savings (GWh)	70.54
First-Year Potential Demand Reduction (MW)	9.47

First-Year Potential Natural Gas Savings (Therms)	--

List of Data Sources

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

- DOE (2014). Final Rule for External Power Supplies. EERE-2008-BT-STD-0005-0219.
- DOE (2014). Final Rule Technical Support Document for External Power Supplies. EERE-2008-BT-STD-0005-0217.

Market Size Analysis

We estimated the market size using shipment forecasts from DOE. To develop its shipments forecast, DOE combined shipments reported in 2009 with a compound annual growth rate for EPS. DOE reports shipment estimates by product class for the years 2009, 2015, and 2044 in table 9.2 of the 2014 final rule TSD for EPS. We interpolated between these data points to estimate the shipments by product class in 2016, the year the standard came into compliance. Further details on DOE's shipment forecasts are in chapter 9 of the final rule TSD for EPS.

We assume that sales of EPS are directly related to the size of all economic activity, so we estimated California's share of national shipments using California's share of the national GDP. We calculated that in 2017, California comprised 14.36% of the national GDP, based on data from the Bureau of Economic Analysis. Table 53 presents DOE's national shipment estimates and our estimates of California shipments of EPS.

Table 53. External Power Supplies Unit Shipment Estimates, US, and California, by Product Class

Product Class	Rated Voltage Range	2016 Shipments, Thousands		Market Share (%)
		US[1]	California	
B: DC Output, Basic Voltage	0-10.25 W	62,519	8,976.2	22.9%
	10.25-39 W	72,404	10,395.4	26.5%
	39-90 W	49,838	7,155.5	18.3%
	91-250 W	7,394	1,061.6	2.7%
C: DC Output, Low Voltage	All	62,004	8,902.2	22.7%
D: AC Output, Basic Voltage	All	8,431	1,210.4	3.1%
E: AC Output, Low Voltage	All	2,373	340.7	0.9%
X: Multiple Voltage	All	8,096	1,162.4	3.0%
H: High Power	All	3	0.4	0.001%
	Total:	**273,062**	**39,204.7**	

[1] Source: Interpolated from shipment values in 2015 and 2044, presented in DOE (2014) "Final Rule Technical Support Document for External Power Supplies." EERE-2008-BT-STD-0005-0217. Table 9.2.

Unit Energy and Demand Savings

This analysis considers energy and demand savings for non-Class A EPS products.[65] No prior standards existed for non-Class A EPS products, so we assume the baseline is the prevailing market practice. DOE assessed the energy savings for each product class at different efficiency levels as part of its analysis supporting the 2014 Federal rule for EPS products. DOE assumed that manufacturers would respond to a standard by improving the efficiency of underperforming products but not those that already meet or exceed the standard. As such, DOE's analysis only considered the energy savings for products below the adopted standard level. Table 54

[65] In 2005, California adopted Title 20 standards for Class A EPS. In 2007, the Federal Energy Independence and Security Act (EISA) set Federal EPS standards for Class A products at levels similar to California's standards. These new Federal standards preempted California's standards, but did not result in any savings in California, since California already had matching standards in place.

references the average annual unit energy savings by product class reported by DOE. To calculate the demand savings, we assumed that EPS have a similar load profile to televisions, for which the Energy Commission provided a load factor of 85%.[66] We used the shares of total shipments for each product class to estimate the shipment-weighted annual energy savings, reported in the final row of Table 54.

Table 54. External Power Supplies Energy Savings, by Product Class

Product Class	Rated Voltage Range	Standard Level Adopted[1]	Average Unit Energy Savings (kWh/year)[2]	Average Unit Demand Savings (W)	Market Share (%)
B: DC Output, Basic Voltage	0-10.25 W	CSL 3	1.1	0.15	22.9%
	10.25-39 W	CSL 3	2.8	0.37	26.5%
	39-90 W	CSL 3	1.9	0.26	18.3%
	91-250 W	CSL 3	1.5	0.20	2.7%
C: DC Output, Low Voltage	All	CSL 3	0.7	0.10	22.7%
D: AC Output, Basic Voltage	All	CSL 3	3.3	0.44	3.1%
E: AC Output, Low Voltage	All	CSL 3	1.8	0.24	0.9%
X: Multiple Voltage	All	CSL 2	4.2	0.57	3.0%
H: High Power	All	CSL 3	126.5	16.99	0.001%
Shipment-Weighted Average			**1.8**	**0.24**	

[1] Source: DOE (2014). Final Rule for External Power Supplies. EERE-2008-BT-STD-0005-0219. Table V-1.
[2] Source: DOE (2014). Final Rule Technical Support Document for External Power Supplies. EERE-2008-BT-STD-0005-0217. Table 10.4.

Commercial HVAC and Refrigeration Equipment

Federal 32: Commercial Central Air Conditioners and Heat Pumps (<65,000 Btu/hr.)

This section presents the results of the evaluation of Federal 32, the federal standard that regulates three-phase commercial A/Cs and heat pumps with cooling capacity less than 65,000 Btu/hr., which took effect on January 1, 2017. Federal 32 updated the Federal standards for these products to match the standards set in ASHRAE 90.1-2013. Table 55 summarizes the evaluation results.

Table 55. Evaluation Results of Federal 32

	Evaluation Results
Description	Commercial A/C and HP, <65,000 Btu/hr.
Effective Date	1/1/2017
California Unit Sales/Year	29,398
Unit Energy Savings (kWh)	57.5

[66] California Energy Commission. 2016. Demand Analysis Office.

Unit Demand Reduction (watts)	28.5
Unit Natural Gas Savings (Therms)	--
First-Year Potential Energy Savings (GWh)	1.69
First-Year Potential Demand Reduction (MW)	0.84
First-Year Potential Natural Gas Savings (Therms)	--

List of Data Sources

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

- DOE (2015). "Final Rule: Energy Conservation Standards and Test Procedures for Commercial Heating, Air-Conditioning, and Water-Heating Equipment." EERE-2014-BT-STD-0015-0048
- DOE (2015). "Final Rule TSD. ASHRAE Equipment." EERE-2014-BT-STD-0015-0043. Available at: https://www.regulations.gov/document?D=EERE-2014-BT-STD-0015-0043
- DOE (2015). "Final Rule Spreadsheet: 3 phase CAC Life Cycle Cost (LCC)" https://www.regulations.gov/document?D=EERE-2014-BT-STD-0015-0044
- DOE (2011). Furnace and Central Air Conditioners and Heat Pump National Impact Analysis Spreadsheet (Energy Efficiency) and Furnace Installation Analysis Worksheet https://www.regulations.gov/document?D=EERE-2011-BT-STD-0011-0011
- DOE (2011). Direct Final Rule TSD: Residential Central Air Conditioners, Heat Pumps, and Furnaces. https://www.regulations.gov/document?D=EERE-2011-BT-STD-0011-0012

Market Size Analysis

The market size is relatively small for commercial three-phase central A/Cs and heat pumps less than 65,000 Btu/hr. These products compete with residential single-phase central A/Cs and with larger 3-phase commercial A/Cs. The product classes covered by this rule are defined by whether the product is a single-package or split system and by the availability of reverse-cycle heating (i.e., whether the unit is an A/C or a heat pump).

We referenced shipments data from the analysis supporting DOE's 2015 standards rulemaking for ASHRAE equipment. For that analysis, DOE relied on historical shipments of commercial A/Cs and heat pumps provided by the US Census. To project shipments into the future, DOE relied on Annual Energy Outlook (AEO) 2014 forecasts for commercial floor space from 2011 through 2040.[67] DOE assumed that shipments of commercial air conditioners and heat pumps would be related to the growth of commercial floorspace. DOE used this projection, with an average annual growth rate of 1%, to project shipments for each of the four equipment classes through 2040. Further details on DOE's shipments analysis are available in chapter 7 of the 2015 Final Rule TSD for ASHRAE Equipment.

Federal 32 covers commercial-sector products, and we assume that shipments of commercial central A/Cs and heat pumps scale in proportion to a geography's total commercial floor space. We estimated that California holds 11.9% of the national commercial floor space.[68]

[67] US Department of Energy-Energy Information Administration, Annual Energy Outlook 2014, April 2014. Washington, DC. Report No. DOE/EIA-0383(2014). http://www.eia.gov/forecasts/aeo/pdf/0383%282014%29.pdf

[68] Navigant estimated California's share of national commercial floorspace using data from the EIA's Commercial Buildings Energy Consumption Survey (CBECS). CBECS reports total commercial floorspace at the national and regional level, but not at the state level. Navigant found that (1) the Pacific West region (composed of California, Oregon, and Washington) contains 15.4% of the national commercial floor space, and (2) per US Census data, California includes 77.4% of the population of the Pacific West region. Navigant multiplied these shares together to estimate that California's share of national commercial floorspace is 11.9%.

Table 56 presents the estimated shipments of commercial central A/Cs and heat pumps under 65,000 Btu/hr.

Table 56. 2017 Shipments of Commercial Central Air Conditioners and Heat Pumps (<65,000 Btu/hr.), U.S. and California, by Product Class.

Product Class	California Share of U.S. Shipments (%)	2017 Shipments		Market Share
		U.S.[1]	California	
Split-system AC	11.9%	80,210	9,536	32.4%
Single-package AC	11.9%	122,271	14,537	49.4%
Split-system HP	11.9%	19,634	2,334	7.9%
Single-package HP	11.9%	25,157	2,991	10.2%
Total	–	**247,272**	**29,398**	

[1] Source: DOE (2015). "Final Rule TSD. ASHRAE Equipment." EERE-2014-BT-STD-0015-0043. Tables 4.2.1, 4.2.2, 4.2.3.

Unit Energy and Demand Savings

This evaluation is assessing the energy savings resulting from the Federal 32 standard. Following the guidance set forth by the CPUC's *Energy Efficiency Policy Manual*, this evaluation considers the baseline level to be equivalent to the prior standards that were in effect for commercial A/Cs and heat pumps under 65,000 Btu/hr. This is different from the baseline level that DOE reported in its analysis supporting Federal 32.[69] DOE conducted its analysis for Federal 32 using a baseline level equivalent to the ASHRAE 90.1-2013 standards for commercial A/Cs and heat pumps.[70] DOE's analysis also reported energy consumption values for levels corresponding to the prior standards.

We referenced the energy consumption estimates reported by DOE for different efficiency levels for each product class. DOE based these consumption estimates on their analysis of single-phase equipment installed in commercial buildings as presented in the national impact analysis associated with the 2011 Direct Final Rule for residential central air conditioners and heat pumps. For its commercial analysis, DOE relied on the use of the EnergyPlus building simulation software to estimate the energy consumption of this equipment at different efficiency levels for 237 climates around the US for a typical commercial application: a small office building. Further details on DOE's energy use analysis are available in chapter 7 of DOE's 2011 Direct Final Rule TSD.

We calculated the annual unit energy savings for each product class as the difference between the unit energy consumption at the baseline and standard levels. To calculate demand savings, we referenced a load factor of 23% for commercial air conditioning loads.[71] We chose not to distinguish heat pumps and air conditioners in our demand savings calculations, since DOE's annual electric consumption values focused on savings from cooling mode operation.

Table 57 references the average annual unit energy consumption by product class reported by DOE and the unit energy savings we calculated. We used the shares of total shipments for each product class to estimate the shipment-weighted annual energy savings, reported in the final row of Table 57.

[69] The Energy Policy and Conservation Act of 1975 (EPCA) requires that if ASHRAE 90.1 standards for commercial air-conditioning and heating equipment are amended, DOE must adopt the amended energy conservation standards at the new efficiency level in ASHRAE Standard 90.1, unless clear and convincing evidence supports a determination that adoption of a more-stringent efficiency level as a national standard would produce significant additional energy savings and be technologically feasible and economically justified.
[70] ANSI/ASHRAE/IES Standard 90.1-2013. "Energy Standard for Buildings Except Low-Rise Residential Buildings." Tables 6.8.1-1 and 6.8.1-2.
[71] California Energy Commission. 2016. Demand Analysis Office.

Table 57. Energy Savings for Commercial Central Air Conditioners and Heat Pumps (<65,000 Btu/hr.), by Product Class

Product Class	Standard Levels[1]		Annual Electricity Consumption (kWh/year)[2]		Annual Unit Electricity Savings (kWh/year)	Unit Demand Savings (W)	Market Share (%)
	Baseline	Standard	Baseline	Standard			
Split-system AC	13.0 SEER	13.0 SEER	2,701	2,701	0	0	32.4%
Single-package AC	13.0 SEER	14.0 SEER	2,701	2,614	87	43.2	49.4%
Split-system HP	13.0 SEER 7.7 HSPF	14.0 SEER 8.2 HSPF	2,740	2,660	80	39.7	7.9%
Single-package HP	13.0 SEER 7.7 HSPF	14.0 SEER 8.0 HSPF	2,740	2,660	80	39.7	10.2%
Shipment-Weighted Average			**2,708**	**2,651**	**57.5**	**28.5**	

[1] Code of Federal Regulations. 10 CFR 431.97, Tables 1 to 4.
[2] Source: DOE (2015). Final Rule Spreadsheet: 3 phase CAC Life Cycle Cost (LCC). "Summary" tab, range W9:W34.

Federal 34: Commercial Refrigeration Equipment

This section presents the results of the evaluation of Federal 34, the federal standard that regulates commercial refrigeration equipment (CREs), which took effect on March 27, 2017. Federal 34 increased the stringency of minimum standards for some existing equipment classes and expanded the coverage of the regulation to include new equipment classes. Since CREs are available in various sizes within each equipment class, DOE used a linear foot of equipment as the unit basis for CREs.

Table 58 summarizes the evaluation results.

Table 58. Evaluation Results of Federal 34[72]

	Evaluation Results
Description	Commercial Refrigeration Equipment
Effective Date	3/27/2017
California Unit Sales/Year	799,800 linear feet
Unit Energy Savings (kWh/year per linear foot)	182.3 kWh/year per linear foot
Unit Demand Reduction (watts)	20.81
Unit Natural Gas Savings (Therms)	--
First-Year Potential Energy Savings (GWh)	145.8 GWh
First-Year Potential Demand Reduction (MW)	16.64
First-Year Potential Natural Gas Savings (Therms)	--

List of Data Sources

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

- DOE (2014). "CRE Final Rule Notice." EERE-2010-BT-STD-0003-0104
- DOE (2014). "Final Rule Technical Support Document: Commercial Refrigeration Equipment," EERE-2010-BT-STD-0003-0102.

Market Size Analysis

The product classes for CREs are defined based on the equipment category, configuration, and operating temperature, as illustrated in Table 59. We referenced shipments data from the analysis supporting DOE's 2014 standards rulemaking for CREs. For that analysis, DOE developed a stock-and-flow shipments model that is driven by equipment saturations (expressed as the number of units per building) and floorspace projections by building type. Details on DOE's shipments analysis are available in chapter 9 of the 2014 Final Rule TSD for CREs.

CREs are primarily commercial-sector products, and we assume that shipments of CREs scale in proportion to a geography's total commercial floorspace. We estimated that California holds 11.9% of the national commercial floorspace.[73]

[72] The calculations supporting the savings claims for commercial refrigeration equipment were supplied in a file named "09 – IOU C&S Team 2019.xlsx." The "IMC & UES Calcs" tab of this file reports UEC values by equipment class in column M, and these values are cited to TSD Table 10.2.4. These UEC values match the UECs published in the 2013 Notice of Proposed Rulemaking (NOPR) TSD. However, DOE published revised UEC values in the 2014 Final Rule TSD, and these revised values are referenced in the evaluation team's analysis.

[73] Navigant estimated California's share of national commercial floorspace using data from the EIA's Commercial Buildings Energy Consumption Survey (CBECS). CBECs reports total commercial floorspace at the national and regional level, but not at the state level. Navigant found that (1) the Pacific West region (composed of California, Oregon, and Washington) contains 15.4% of the national commercial floor space, and (2) per US Census data, California houses 77.4% of the population of the Pacific West region. Navigant multiplied these shares together to estimate that California's share of national commercial floorspace is 11.9%.

Table 59 presents the estimated CRE shipments (in terms of thousands of linear feet) by product class for the US and California.

Table 59. 2017 Shipments of Commercial Refrigeration Equipment Affected by Federal 34, US and California, by Product Class.

Equipment Family	Condensing Configuration, Remote (RC), Self-Contained (SC)	Rating Temp. 38°F (M), 0°F(L), -15°F (I)	Product Class	U.S. Shipments, 1,000s of Linear Feet, 2017	California Shipments, 1,000s of Linear Feet, 2017	Share of Total Shipments (%)
Vertical Open (VOP)	RC	M	VOP.RC.M	692	82.3	10.29%
	RC	L	VOP.RC.L	34	4.0	0.51%
	SC	M	VOP.SC.M	87	10.3	1.29%
Vertical Closed Transparent (VCT)	RC	M	VCT.RC.M	54	6.4	0.80%
	RC	L	VCT.RC.L	719	85.5	10.69%
	SC	M	VCT.SC.M	323	38.4	4.80%
	SC	L	VCT.SC.L	13	1.5	0.19%
	SC	I	VCT.SC.I	20	2.4	0.30%
Vertical Closed Solid (VCS)	SC	M	VCS.SC.M	1707	202.9	25.38%
	SC	L	VCS.SC.L	1008	119.8	14.98%
	SC	I	VCS.SC.I	7	0.8	0.10%
Semi vertical Open (SVO)	RC	M	SVO.RC.M	551	65.5	8.19%
	SC	M	SVO.SC.M	74	8.8	1.10%
Service Over Counter (SOC)	RC	M	SOC.RC.M	141	16.8	2.10%
	SC	M	SOC.SC.M	13	1.5	0.19%
Horizontal Open (HZO)	RC	M	HZO.RC.M	87	10.3	1.29%
	RC	L	HZO.RC.L	269	32.0	4.00%
	SC	M	HZO.SC.M	7	0.8	0.10%
	SC	L	HZO.SC.L	13	1.5	0.19%
Horizontal Closed Transparent (HCT)	SC	M	HCT.SC.M	7	0.8	0.10%
	SC	L	HCT.SC.L	27	3.2	0.40%
	SC	I	HCT.SC.I	27	3.2	0.40%
Horizontal Closed Solid (HCS)	SC	M	HCS.SC.M	296	35.2	4.40%
	SC	L	HCS.SC.L	40	4.8	0.59%
Pull-Down (PD)	SC	M	PD.SC.M	511	60.8	7.60%
			Total	**6727**	**799.5**	

Source: DOE 2014 Final Rule TSD for CREs, Table 9.6

Unit Energy and Demand Savings

For CRE product classes that were previously covered by federal standards, the baseline level corresponds with the federal standards that took effect on January 1, 2010 and January 1, 2012. For product classes not previously covered by standards, the baseline level corresponds to the least efficient equipment available on the market. DOE's 2014 final rule for CREs set the standard level at TSL3, which comprises different efficiency levels for different product classes, as illustrated in Table 60. In their analysis supporting the 2014 final rule, DOE used a computational energy consumption model to estimate the annual energy consumption (in terms of kWh/year per linear foot) of each efficiency level for each product class. We referenced the energy consumption estimates reported by DOE for the baseline and standard level of each product class. These estimates are presented in Table 60. We calculated the annual unit energy savings for each product class as the difference between the unit energy consumption at the baseline and standard levels. To calculate demand savings, we referenced a load factor of 100% for the commercial refrigeration end use.[74] We used the shares of total shipments for each product class to estimate the shipment-weighted annual energy savings, reported in the final row of Table 60.

Table 60. CREs Annual Energy Consumption, Baseline and Standard Levels, by Product Class

Product Class	Efficiency Level Adopted as Standard[1]	Average Annual Unit Energy Consumption (kWh/linear ft/yr)[2]		Average Annual Unit Energy Savings (kWh/linear ft/yr)	Average Unit Demand Savings (W/linear ft)	Share of Total Shipments (%)[3]
		Baseline	Standard			
VOP.RC.M	EL 1	1,425	1,156	269	30.71	10.3%
VOP.RC.L	EL 1	3,212	3,192	20	2.28	0.5%
VOP.SC.M	Baseline	2,738	2,738	0	-	1.3%
VCT.RC.M	EL 1	391	338	53	6.05	0.8%
VCT.RC.L	EL 2	1074	996	78	8.90	10.7%
VCT.SC.M	EL 3	567	457	110	12.56	4.8%
VCT.SC.L	EL 5	2,813	1,392	1,421	162.21	0.2%
VCT.SC.I	EL 1	1,674	1,657	17	1.94	0.3%
VCS.SC.M	EL 4	512	299	213	24.32	25.4%
VCS.SC.L	EL 5	1,336	988	348	39.73	15.0%
VCS.SC.I	EL 4	1,608	1,479	129	14.73	0.1%
SVO.RC.M	EL 1	1,087	896	191	21.80	8.2%
SVO.SC.M	Baseline	2,402	2,402	0	-	1.1%
SOC.RC.M	Baseline	692	692	0	-	2.1%
SOC.SC.M	Baseline	843	843	0	-	0.2%
HZO.RC.M	Baseline	440	440	0	-	1.3%
HZO.RC.L	Baseline	984	984	0	-	4.0%
HZO.SC.M	EL 1	1,338	1,292	46	5.25	0.1%
HZO.SC.L	Baseline	2,730	2,730	0	-	0.2%
HCT.SC.M	EL 4	179	86	93	10.62	0.1%
HCT.SC.L	EL 4	392	184	208	23.74	0.4%
HCT.SC.I	Baseline	334	334	0	-	0.4%
HCS.SC.M	EL 3	130	111	19	2.17	4.4%
HCS.SC.L	EL 3	168	133	35	4.00	0.6%
PD.SC.M	EL 3	732	552	180	20.55	7.6%
Shipment-Weighted Average:		**934.3**	**752.0**	**182.3**	**20.81**	

[1] Source: DOE 2014 Final Rule Notice. Table V.1 for Trial Standard Level 3
[2] Source: DOE 2014 Final Rule TSD for CREs, Table 10.2.4
[3] Source: DOE 2014 Final Rule Notice. Table IV.3

[74] California Energy Commission. 2016. Demand Analysis Office.

Federal 35: Walk-In Coolers and Freezers

This section presents the results of the evaluation of Federal 35, the federal standard that regulates walk-in coolers and freezers (WICFs), which took effect on June 5, 2017. For WICF products, DOE maintains separate standards for the performance of refrigeration system components and the performance of WICF envelope components. Federal 35 amended existing performance standards for WICF display doors and set new standards for several classes of refrigeration components.[75] The refrigeration systems considered here are limited to indoor and outdoor medium temperature dedicated condensing systems. Table 61 summarizes the evaluation results and uses separate columns to report the savings resulting from refrigeration component standards and from display door standards.

Table 61. Evaluation Results of Federal 35

	Evaluation Results	
Description	WICFs Refrigeration Systems	WICFS Display Doors
Effective Date	6/5/2017	6/5/2017
California Unit Sales/Year	18,904	48,946
Unit Energy Savings (kWh)	7,939	1,060
Unit Demand Reduction (watts)	906	121.0
Unit Natural Gas Savings (Therms)	--	--
First-Year Potential Energy Savings (GWh)	150.1	51.9
First-Year Potential Demand Reduction (MW)	17.13	5.92
First-Year Potential Natural Gas Savings (Therms)	--	--

List of Data Sources

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

- DOE (2014) Energy Conservation Standards for Walk-In Coolers and Freezers; Final Rule. EERE-2008-BT-STD-0015-0141
- DOE (2014) Final Rule TSD. EERE-2008-BT-STD-0015-0131
- DOE (2014) Final Rule National Impact Analysis Spreadsheet for Refrigeration Systems. EERE-2008-BT-STD-0015-0135. https://www.regulations.gov/document?D=EERE-2008-BT-STD-0015-0135

[75] In 2015, a US Court of Appeals vacated standards for six product classes affected by the 2014 rule and formed a working group to renegotiate the standards. In 2017, DOE issued a new final rule covering the product classes for which standards were vacated. However, since DOE's 2017 rule does not require compliance until July 10, 2020, it is outside the scope of this evaluation and is not considered here.

Market Size Analysis

We estimated the market size for WICF refrigeration systems using shipment forecasts from the US Department of Energy. DOE developed shipment models for complete WICF boxes and all their components: refrigeration systems, panels, and doors. The shipment model for the complete WICF units is the core shipment model that is driven by floorspace projections and the average lifetime of a complete WICF unit. The output from the shipments model for complete WICF units forms the basis of the shipment models for refrigeration systems and envelope components. DOE's 2014 Final Rule TSD provides shipment forecasts by equipment class (TSD table 9.6.3) and breaks down the equipment classes by capacity (TSD table 9.5.7). We multiplied these together to estimate the shipments per capacity per class. Further details on DOE's shipments model are available in chapter 9 of DOE's 2014 Final Rule TSD.

The sales of WICFs are directly related to the size of all economic activity, so we estimated California's share of national shipments using California's share of the national GDP. We calculated that California comprises 14.36% of the national GDP, based on data from the Bureau of Economic Analysis.

Walk-In Coolers and Freezers, Refrigeration Systems

Table 62 presents DOE's national shipment estimates and our estimates of California shipments for WICF refrigeration systems.

Table 62. 2017 Shipments of Walk-In Coolers and Freezers Refrigeration Systems, US and California, by Product Class

Condensing Unit Location	Cooling Capacity (Btu/h)	Equip. Class Index	California Share of US Shipments (%)	2017 Estimated Shipments of WICF Refrigeration Systems		Market Share of Medium DC Systems (%)
				US[1]	California	
Indoor	6,000	DC.M.I.006	14.36%	6,107	877	4.6%
	18,000	DC.M.I.018	14.36%	2,908	417	2.2%
	54,000	DC.M.I.054	14.36%	485	70	0.4%
	96,000	DC.M.I.096	14.36%	194	28	0.1%
Outdoor	6,000	DC.M.O.006	14.36%	18,296	2,627	13.9%
	18,000	DC.M.O.018	14.36%	54,888	7,881	41.7%
	54,000	DC.M.O.054	14.36%	24,395	3,502	18.5%
	96,000	DC.M.O.096	14.36%	24,395	3,502	18.5%
		Total	–	**131,668**	**18,904**	

[1] Source: DOE (2014) Final Rule TSD for Walk-in Coolers and Freezers. Table 9.6.3. p.9-21

Unit Energy and Demand Savings

Prior to the Federal WICF rule that took effect on June 5, 2017, there were no national standards for WICF refrigeration system efficiency. We referenced the energy consumption estimates reported by DOE for the baseline and standard level of each product class. To estimate the annual energy consumption of the refrigeration systems at different efficiency levels, DOE used results of an engineering energy model that was vetted by stakeholders during the rulemaking process.[76] The energy model estimated refrigeration systems' net capacity and on-cycle system power at different ambient conditions, as well as the off-cycle evaporator fan power and the defrost power. The methodology for estimating annual energy use is described further in chapter 7 of DOE (2014) Final Rule TSD for Walk-in Coolers and Freezers.

[76] A description of DOE's engineering models is presented in chapter 5 of DOE (2014) Final Rule TSD for Walk-in Coolers and Freezers.

We calculated the annual unit energy savings for each product class as the difference between the unit energy consumption at the baseline and standard levels. Table 63 references the average annual unit energy consumption by product class reported by DOE and the unit energy savings we calculated. To calculate demand savings, we referenced a load factor of 100% for the commercial refrigeration end use.[77] We used the shares of total shipments for each product class to estimate the shipment-weighted annual energy savings, reported in the final row of Table 63.

Table 63. Walk-In Coolers and Freezers Energy Savings for Direct Condensing Medium Temperature Systems, by Product Class

Equip. Class Index	Adopted Efficiency Level at TSL2[1]	Annual Electricity Consumption per System (kWh/yr)[2]		Annual Energy Savings (kWh/yr)	Annual Demand Savings (W/yr)	Market Share of Medium DC Systems (%)
		Baseline	Standard			
DC.M.I.006	EL6	5,377	3,348	2,029	232	4.6%
DC.M.I.018	EL6	15,160	10,487	4,673	533	2.2%
DC.M.I.054	EL6	40,040	26,526	13,514	1,543	0.4%
DC.M.I.096	EL7	73,006	48,393	24,613	2,810	0.1%
DC.M.O.006	EL7	3,911	2,256	1,655	189	13.9%
DC.M.O.018	EL5	10,465	5,878	4,586	524	41.7%
DC.M.O.054	EL7	28,167	15,448	12,719	1,452	18.5%
DC.M.O.096	EL8	48,744	31,705	17,039	1,945	18.5%
Shipment-Weighted Average		**19,995**	**12,056**	**7,939**	**906**	

[1] DOE (2014) Final Rule National Impact Analysis Spreadsheet for Refrigeration Systems. EERE-2008-BT-STD-0015-0135. "AEER by TSL" tab, range B4:H26.
[2] *Ibid.*, "LCC Inputs" tab, range B3:M29

Walk-In Coolers and Freezers, Display Doors

Table 64 presents DOE's national shipment estimates and our estimates of California shipments for WICF display doors.

Table 64. 2017 Shipments of Walk-In Coolers and Freezers Display Doors, US and California, by Product Class

Product Class	2017 Number of Units Shipped		Market Share of WICF Display Doors
	US[1]	California	
Display Door, Medium Temperature	314,855	45,205	92.4%
Display Door, Low Temperature	26,053	3,741	7.6%
Total	**340,908**	**48,946**	

[1] Source: DOE (2014) Final Rule TSD for Walk-in Coolers and Freezers. Table 9.6.8.

Unit Energy and Demand Savings

The baseline level represents WICF products that just comply with federal standards that took effect on January 1, 2009, which imposed certain design requirements on WICF equipment. Federal 35 increased the stringency of standards for display doors,

For doors, we referenced DOE estimates of the energy consumption per door at each efficiency level from DOE's National impact analysis (NIA) spreadsheet. DOE estimated the total electrical energy consumption of each door by (1) calculating the refrigeration energy consumption required to compensate for heat infiltration

[77] California Energy Commission. 2016. Demand Analysis Office.

through the door, and (2) adding any direct electrical energy consumed by the door (i.e., for lighting or defrost components). DOE calculated the refrigeration load by multiplying the U-factor for the door by the reference temperature difference between the exterior and the interior, as specified in the DOE test procedure. More details on the DOE's energy use estimates are available in chapter 7 of DOE (2014) Final Rule TSD for Walk-in Coolers and Freezers.

We calculated the annual unit energy savings for each product class as the difference between the unit energy consumption at the baseline and standard levels. Table 65 references the average annual unit energy consumption by product class reported by DOE and the unit energy savings we calculated. To calculate demand savings, we referenced a load factor of 100% for the commercial refrigeration end use.[78] We used the shares of total shipments for each product class to estimate the shipment-weighted annual energy savings, reported in the final row of Table 65.

Table 65. Energy Savings for Walk-In Coolers and Freezers Display Doors, by Product Class

Product Class	Adopted Efficiency Level[1]	Annual Electricity Consumption per System (kWh/yr)[2]		Annual Energy Savings (kWh/yr)	Demand Savings (W)	Market Share of Display Doors (%)
		Baseline	Standard			
Display Door, Medium Temp.	EL3	1,414	466	948	108	92.4%
Display Door, Low Temp.	EL4	3,997	1,578	2,419	276	7.6%
Shipment-Weighted Average:		**1,611**	**551**	**1,060**	**121.0**	

[1] DOE (2014) Final Rule National Impact Analysis Spreadsheet for Components. EERE-2008-BT-STD-0015-0134. "TSL Mapping" tab, Range C6:K6.

[2] *Ibid.*, "LCC Inputs" tab, range C8:H9, with Refrigeration System specified as TSL2 in cell C64.

Federal 39: Commercial Air Conditioners and Heat Pumps 65,000–760,000 Btu/hr.



This section presents the results of the evaluation of Federal 39, the federal standard that regulates commercial air conditioners and heat pumps with cooling capacities from 65,000 Btu/hr. to 760,000 Btu/hr., which took effect on January 1, 2018. Federal 39 increased the stringency of energy conservation standards for small, large, and very large commercial A/Cs and heat pumps. Federal 39 implemented two tiers of standards. Tier 1 increases standards to match the efficiency standards in ASHRAE 90.1-2013, with a compliance date of January 1, 2018. Tier 2 increases standards further, with a compliance date of January 1, 2023. This evaluation only considers the Tier 1 standards. Table 66 summarizes the evaluation results.

Table 66. Evaluation Results of Federal 39

	Evaluation Results
Description	Commercial Air Conditioners and Heat Pumps, 65,000 Btu/hr. to 760,000 Btu/hr.
Effective Date	1/1/2018 (Tier 1)

[78] California Energy Commission. 2016. Demand Analysis Office.

California Unit Sales/Year	33,940
Unit Energy Savings (kWh)	2,586
Unit Demand Reduction (watts)	1,405.8
Unit Natural Gas Savings (Therms)	--
First-Year Potential Energy Savings (GWh)	87.8
First-Year Potential Demand Reduction (MW)	47.71
First-Year Potential Natural Gas Savings (Therms)	--

List of Data Sources

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

- DOE (2015) Direct Final Rule: Small, Large, And Very Large Commercial Package Air Conditioning and Heating Equipment. https://www.regulations.gov/document?D=EERE-2013-BT-STD-0007-0113
- DOE (2015) Direct Final Rule Technical Support Document: Small, Large, And Very Large Commercial Package Air Conditioning and Heating Equipment. https://www.regulations.gov/document?D=EERE-2013-BT-STD-0007-0105
- DOE (2015) Direct Final Rule National Impact Analysis (NIA) Spreadsheet. https://www.regulations.gov/document?D=EERE-2013-BT-STD-0007-0107

Market Size Analysis

We referenced market size data from the analysis supporting DOE's 2015 standards rulemaking for commercial package air conditioning and heating equipment. For that analysis, DOE projected shipments for three specific market segments: (1) shipments to new construction, (2) replacement shipments going into existing buildings, and (3) existing buildings acquiring new equipment for the first time. DOE then aggregated the results to estimate total shipments. DOE's analysis reports shipment estimates by year, broken out by equipment type and cooling capacity, as illustrated earlier in Table 56. Further details on DOE's shipments analysis are available in chapter 9 of DOE (2015) Direct Final Rule Technical Support Document: Small, Large, And Very Large Commercial Package Air Conditioning and Heating Equipment.

Federal 39 covers commercial-sector products, and we assume that shipments of commercial central A/Cs and heat pumps scale in proportion to a geography's total commercial floor space. We estimated that California holds 11.9% of the national commercial floor space.[79] Table 67 presents the estimated shipments of small commercial central A/Cs and heat pumps.

Table 67. 2018 Shipments of Commercial Air Conditioners and Heat Pumps (65,000 to 760,000 Btu/hr.), U.S. and California, by Product Class

Equipment Type	Cooling Capacity Range	Equipment Category	California Share of U.S. Shipments (%)	2018 Shipments		Market Share (%)
				U.S.[1]	California	
Commercial Packaged A/C	≥65 kBtu/h and <135 kBtu/h	7.5-ton CPAC	11.9%	170,061	20,219	59.6%
	≥135 kBtu/h and <240 kBtu/h	15-ton CPAC	11.9%	68,541	8,149	24.0%
	≥240 kBtu/h and <760 kBtu/h	30-ton CPAC	11.9%	22,051	2,622	7.7%

[79] Navigant estimated California's share of national commercial floorspace using data from the EIA's Commercial Buildings Energy Consumption Survey (CBECS). CBECs reports total commercial floorspace at the national and regional level, but not at the state level. Navigant found that (1) the Pacific West region (composed of California, Oregon, and Washington) contains 15.4% of the national commercial floor space, and (2) per US Census data, California includes 77.4% of the population of the Pacific West region. Navigant multiplied these shares together to estimate that California's share of national commercial floorspace is 11.9%.

Commercial Packaged Heat Pump	≥65 kBtu/h and <135 kBtu/h	7.5-ton CPHP	11.9%	19,785	2,352	6.9%
	≥135 kBtu/h and <240 kBtu/h	15-ton CPHP	11.9%	3,832	456	1.3%
	≥240 kBtu/h and <760 kBtu/h	30-ton CPHP	11.9%	1,195	142	0.4%
			Total	**285,465**	**33,940**	

[1] Source: DOE (2015) Direct Final Rule National Impact Analysis (NIA) Spreadsheet. “Shipment Data” tab, columns F-M.

Unit Energy and Demand Savings

The test procedure amendments associated with Federal 39 replaced the existing cooling efficiency metric, EER, with a new cooling efficiency metric, IEER. The IEER metric accounts for seasonal variation in cooling loads and IEER ratings are not directly comparable to EER ratings (*i.e.*, improvements to IEER do not necessarily lead to improvements in EER, and vice versa). DOE selected a baseline level for its energy use analysis based on ASHRAE 90.1-2010 standard levels as well as a review of products available on the market.

We referenced the energy consumption estimates reported by DOE for the baseline and Tier 1 standard level of each product class. To estimate the annual energy consumption of different efficiency levels, DOE conducted simulations of hourly whole building, cooling system, and ventilation energy use for a sample of 1,033 commercial buildings based on CBECS1995. This building energy use analysis covering a variety of building types in multiple climate locations. More details on DOE’s energy use analysis are available in chapter 7 of DOE (2015) Direct Final Rule Technical Support Document: Small, Large, And Very Large Commercial Package Air Conditioning and Heating Equipment.

We calculated the annual unit energy savings for each product class as the difference between the unit energy consumption at the baseline and standard levels. Table 68 references the average annual unit energy consumption by product class reported by DOE and the unit energy savings we calculated. To calculate demand savings, we calculated a shipment-weighted load factor of 21%. This average load factor blends the 23% load factor for commercial air conditioning (linked to commercial A/C classes, comprising 91% of shipments) with a 0% load factor for commercial space heating (linked to commercial heat pump classes, comprising 9% of shipments). We used the shares of total shipments for each product class to estimate the shipment-weighted annual energy savings, reported in the final row of Table 68.

Table 68. Energy Savings for Commercial Air Conditioners and Heat Pumps (65,000 to 760,000 Btu/hr.), by Product Class

Equipment Category	Annual Unit Electricity Consumption (kWh/yr)						Annual Unit Electricity Savings (kWh/yr)	Unit Demand Savings (W)	Market Share
	Baseline (Efficiency Level 0)			Standard Level (Efficiency Level 1)					
	Cooling	Heating	Total	Cooling	Heating	Total			
7.5-ton CPAC	17,872	-	17,872	17,413	-	17,413	459	249.5	59.6%
15-ton CPAC	39,461	-	39,461	32,354	-	32,354	7,107	3,863.5	24.0%
30-ton CPAC	63,329	-	63,329	57,645	-	57,645	5,683	3,089.4	7.7%
7.5-ton CPHP	18,191	3,440	21,631	17,687	3,379	21,066	565	307.1	6.9%
15-ton CPHP	41,305	6,549	47,854	33,713	6,549	40,262	7,592	4,126.7	1.3%
30-ton CPHP	66,464	13,898	80,362	60,242	13,898	74,140	6,222	3,382.1	0.4%
Shipment-Weighted Average			**27,492**			**24,905**	**2,586**	**1,405.8**	

[1] Source: DOE (2015) Direct Final Rule National Impact Analysis (NIA) Spreadsheet. “LCC Data” tab, range D5:E55.

Federal 41: Commercial Icemakers

This section presents the results of Navigant's evaluation of Federal 41, the federal standard that regulates commercial icemakers, which took effect on January 28, 2018. Table 69 summarizes the evaluation results.

Table 69. Evaluation Results of Federal 41

	Evaluation Results
Description	Commercial Icemakers
Effective Date	1/28/2018
California Unit Sales/Year	32,311
Unit Energy Savings (kWh)	781
Unit Demand Reduction (watts)	89.1
Unit Natural Gas Savings (Therms)	--
Unit Water Savings (1,000 gallons)	4.4
Unit Embedded Electricity in Water Savings (kWh)	21.1
First-Year Potential Energy Savings (GWh)	25.2
First-Year Potential Demand Reduction (MW)	2.88
First-Year Potential Natural Gas Savings (MTherms)	--
First-Year Potential Water Savings (million gallons)	36.7
First-Year Potential Embedded Electricity Savings (GWh)	0.18

List of Data Sources

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

- DOE (2014) Final Rule Technical Support Document: Automatic Commercial Ice Makers. EERE-2010-BT-STD-0037-0136. https://www.regulations.gov/document?D=EERE-2010-BT-STD-0037-0136
- DOE (2015) Final Rule: Energy Conservation Standards for Automatic Commercial Ice Makers; Final Rule. EERE-2010-BT-STD-0037-0137. https://www.regulations.gov/document?D=EERE-2010-BT-STD-0037-0137

Market Size Analysis

To determine the market size for commercial icemakers in California, we referenced DOE estimates of nationwide shipments of commercial icemakers and applied an estimate of California's share of the nationwide shipments. DOE estimated shipments for icemakers with a stock turnover model calibrated against historical shipment data for different product classes. Further details on DOE's shipments estimates are in chapter 9 of DOE (2014) Final Rule Technical Support Document: Automatic Commercial Ice Makers.

The sales of icemakers are directly related to the size of all economic activity, so we estimated California's share of national shipments using California's share of the national GDP. We calculated that California comprises 14.36% of the national GDP, based on data from the Bureau of Economic Analysis. Table 70 presents DOE's national shipment estimates and our estimates of California shipments for commercial icemakers.

Table 70. 2018 Shipments of Commercial Icemakers, US and California, by Product Class

Ice Production Method	Product Category	Cooling Means	Product Class Code	2018 Shipments		Market Share (%)
				US[1]	California	
Batch	Ice-Making Head	Water	IMH-W-Small-B	9,263	1,330	4.1%
		Water	IMH-W-Med-B	5,760	827	2.6%
		Water	IMH-W-Large-B-1	813	117	0.4%
		Water	IMH-W-Large-B-2	261	37	0.1%
		Air	IMH-A-Small-B	63,704	9,146	28.3%
		Air	IMH-A-Large-B-1	33,229	4,771	14.8%
		Air	IMH-A-Large-B-2	6,157	884	2.7%
	Remote Condensing Unit	Any	RCU-*-Large-B-1	13,637	1,958	6.1%
		Any	RCU-*-Large-B-2	645	93	0.3%
	Self-Contained Unit	Water	SCU-W-Large-B	527	76	0.2%
		Air	SCU-A-Small-B	35,116	5,042	15.6%
		Air	SCU-A-Large-B	17,176	2,466	7.6%
Continuous	Ice-Making Head	Air	IMH-A-Small-C	9,469	1,360	4.2%
		Air	IMH-A-Large-C	2,923	420	1.3%
	Remote Condensing Unit	Any	RCU-*-Small-C	2,276	327	1.0%
	Self-Contained Unit	Air	SCU-A-Small-C	24,081	3,457	10.7%
			Total	**225,037**	**32,311**	

[1] Source: DOE (2014) Final Rule Technical Support Document: Automatic Commercial Ice Makers. EERE-2010-BT-STD-0037-0136. Table 9.4.2

Unit Energy and Demand Savings

The baseline level for batch-type icemakers corresponds with the federal standards that took effect on January 1, 2010. Standards for commercial icemakers vary based on equipment type and cooling type. No prior standards existed for continuous-type icemakers. The baseline for continuous-type equipment is assumed to be the least efficient equipment available at the time standards were promulgated. In analysis supporting the 2015 standards rule for icemakers, DOE selected representative equipment sizes for each equipment class and estimated the annual energy and water use of each representative unit.

We referenced the energy consumption and water consumption estimates reported by DOE for the baseline and standard level of each product class. In addition to the electric savings resulting from more efficient operation of the icemaker, there are embedded electric savings associated with the reduced water consumption of the standard-level icemakers. For this analysis, we assumed an embedded electricity value of 4,848 kWh per million gallons of water.[80] We then multiplied the savings by the market share to determine the weighted average unit savings. To calculate demand savings, we referenced a load factor of 100% for the commercial refrigeration end use.[81] Table 71 shows the results of our analysis.

[80] CPUC Water/Energy Cost-Effectiveness Analysis. Errata to the Revised Final Report. Prepared by Navigant Consulting, Inc. (May 2015)
[81] California Energy Commission. 2016. Demand Analysis Office.

Table 71. Commercial Icemaker Energy and Water Savings, by Product Class.

Product Class Code	Adopted EL at TSL3[1]	Annual Electricity Use (kWh/year)[2]		Annual Electricity Savings (kWh/ year)	Unit Demand Savings (W)	Annual Water Use (1,000 gal/year)[3]		Annual Water Savings (1,000 gal/year)	Embedded Electric Savings of Water (kWh/yr)	Market Share (%)
		Baseline	Standard			Baseline	Standard			
IMH-W-Small-B	3	2,832	2,411	421	48.1	80.7	78.9	1.8	8.7	4.1%
IMH-W-Med-B	2	6,040	5,439	601	68.6	223.6	223.6	0.0	0.0	2.6%
IMH-W-Large-B-1	1	9,166	9,166	0	0.0	421.1	421.1	0.0	0.0	0.4%
IMH-W-Large-B-2	1	15,868	15,868	0	0.0	767.2	767.2	0.0	0.0	0.1%
IMH-A-Small-B	3A	3,535	2,901	634	72.4	11.3	11.3	0.0	0.0	28.3%
IMH-A-Large-B-1	3A	7,350	6,192	1,158	132.2	27.4	24.3	3.1	15.2	14.8%
IMH-A-Large-B-2	3	11,999	10,591	1,408	160.7	45.7	45.7	0.0	0.0	2.7%
RCU-*-Large-B-1	2	11,679	10,514	1,165	133.0	45.7	45.7	0.0	0.0	6.1%
RCU-*-Large-B-2	2	18,671	16,807	1,864	212.8	72.0	72.0	0.0	0.0	0.3%
SCU-W-Large-B	5	3,499	2,630	869	99.2	74.0	69.4	4.6	22.3	0.2%
SCU-A-Small-B	5	2,177	1,639	538	61.4	5.7	3.4	2.3	11.2	15.6%
SCU-A-Large-B	5	3,011	2,265	746	85.2	9.1	6.1	3.0	14.5	7.6%
IMH-A-Small-C	4	4,299	3,445	854	97.5	5.7	5.7	0.0	0.0	4.2%
IMH-A-Large-C	3	8,270	7,033	1,237	141.2	17.0	17.0	0.0	0.0	1.3%
RCU-*-Small-C	4	7,737	6,195	1,542	176.0	14.6	14.6	0.0	0.0	1.0%
SCU-A-Small-C	4	3,416	2,738	678	77.4	4.0	4.0	0.0	0.0	10.7%
Shipment-Weighted Average		**4,808**	**4,027**	**781**	**89.1**	**25.7**	**24.6**	**1.1**	**5.5**	

[1] Source: DOE (2014) Final Rule Technical Support Document: Automatic Commercial Ice Makers. EERE-2010-BT-STD-0037-0136. Table V-1.
[2] Source: DOE (2014) Final Rule Technical Support Document: Automatic Commercial Ice Makers. EERE-2010-BT-STD-0037-0136. Table 7.2.2
[3] *Ibid.* Table 7.3.1

Commercial and Industrial Equipment

Federal 28: Distribution Transformers

This section presents the results of the evaluation of Federal 28, the federal standard that regulates distribution transformers, which took effect on January 1, 2016. A distribution transformer's function is to “step down” the voltage before being consumed by an end-use appliance, motor, or other piece of equipment. Federal 28 increased the stringency of minimum efficiency standards for low-voltage dry-type (LVDT) and medium-voltage dry-type (MVDT) transformers. Table 72 summarizes the evaluation results.

Table 72. Evaluation Results of Federal 28

	Evaluation Results
Description	Distribution Transformers
Effective Date	1/1/2016
California Unit Sales/Year (Megavolt-amperes, MVA)	11,859 MVA
Unit Energy Savings (kWh/year/MVA)	6,307 kWh/year/MVA
Unit Demand Reduction (watts/MVA)	1,200
Unit Natural Gas Savings (Therms)	--
First-Year Potential Energy Savings (GWh)	74.79 GWh
First-Year Potential Demand Reduction (MW)	14.2 MW
First-Year Potential Natural Gas Savings (MTherms)	--

List of Data Sources

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

- DOE (2013) Energy Conservation Standards for Distribution Transformers; Final Rule. EERE-2010-BT-STD-0048-0762.
- DOE (2013) Final Rule Technical Support Document for Distribution Transformers. EERE-2010-BT-STD-0048-0760.
- DOE (2013) National Impacts Analysis Spreadsheet. EERE-2010-BT-STD-0048-0765.

Market Size Analysis

We estimated the market size using shipment forecasts from DOE. DOE developed a shipments model to predict shipments of distribution transformers. The shipments model estimates the rate at which the in-service stock of transformers may be replaced by new, more efficient units after an energy conservation standard becomes effective. The core of the shipments analysis is an accounting model that DOE developed to simulate how current and future purchases are incorporated into and gradually replace the in-service stock. In estimating the effects of potential new standards on shipments, the model accounts for the combined effects on the purchase decision of increases in purchase price and decreases in annual operating costs, and consumer income. DOE's shipments analysis forecasts the capacity of transformers shipped each year using a unit basis of megavolt-amperes (MVA). Our analysis adopts this convention rather than forecasting the number of distribution transformers shipped each year. Further details on DOE's shipment forecasting model are in chapter 9 of the final rule TSD for distribution transformers.

We assume the sales of distribution transformers are directly related to the size of all economic activity, so we estimated California's share of national shipments using California's share of the national GDP. We calculated that in 2017, California comprised 14.36% of the national GDP, based on data from the Bureau of Economic Analysis. Table 73 presents DOE's national shipment estimates and our estimates of California shipments for distribution transformers.

Table 73. 2016 Shipments of Distribution Transformer Equipment, US and California, by Product Class

Equipment Class Name	Equipment Class Index	2016 Shipments per Equipment Class (MVA)		Market Share (%)
		US[1]	California	
Liquid-immersed, medium voltage, single-phase	1A	7,788	1,118	9.43%
	1B	15,766	2,264	19.09%
Liquid-immersed, medium voltage, three-phase	2A	31,796	4,565	38.50%
	2B	2,224	319	2.69%
Dry-type, low-voltage, single-phase	3	641	92	0.78%
Dry-type, low-voltage, three-phase	4	17,730	2,546	21.47%
Dry-type, medium-voltage, single-phase, 20-45 kV BIL	5	12	2	0.01%
Dry-type, medium-voltage, three-phase, 20-45 kV BIL	6	981	141	1.19%
Dry-type, medium-voltage, single-phase, 46-95 kV BIL	7	15	2	0.02%
Dry-type, medium-voltage, three-phase, 46-95 kV BIL	8	5,151	740	6.24%
Dry-type, medium-voltage, single-phase, ≥95 kV BIL	9	3	0	0.00%
Dry-type, medium-voltage, three-phase, ≥95 kV BIL	10	489	70	0.59%
Total	**All**	**82,596**	**11,859**	**100%**

[1] Source: DOE (2013). National Impacts Analysis Spreadsheet. "Annual Impacts" tab.

Unit Energy and Demand Savings

The baseline level corresponds with the federal standards that took effect on January 1, 2007 and January 1, 2010. DOE standards vary with transformer construction and kVA rating. To estimate the unit energy savings, we referenced the analysis conducted by DOE in support of the 2013 final rule for distribution transformers. For liquid immersed transformers, DOE developed a statistical simulation model to estimate the hourly load characteristics of liquid-immersed transformers and to develop a correlation between hourly loads and system loads. For dry-type transformers, DOE used empirical estimates of load characteristics to estimate monthly average (root mean square) loads and peak coincident loads. DOE then obtained used of transformer energy losses from their LCC analysis to calculate the total energy use by the stock of transformers for each year for both a base case and a standards case. The losses per transformer are calculated as the sum of no-load losses plus load losses. The load losses are the rated load loss times the square of the root mean square load, adjusted for load growth. The annual unit energy consumption for distribution transformers is given by the following equation:

$$UEC(y) = E_{NL} + E_{LL} \times [RMS \times LAdjust(y)]^2$$

Where:

UEC(y) = annual unit energy consumption for a given year, *y*,
E_{NL} = rated no-load losses per kVA capacity,
E_{LL} = rated load losses per kVA capacity,
RMS = root mean square, and
LAdjust(y) = load adjustment factor for year *y*.

Further details on the energy use calculation methodology are in chapter 10 of the final rule TSD for distribution transformers. We referenced the energy consumption values reported in the DOE's Final Rule National Impact Analysis, "Annual Impacts" tab, columns H-I and AF-AG. We converted these values, reported in quadrillion Btus per year, to units of kWh/year. Table 74 reports the annual energy use per MVA for each of the equipment classes considered. The annual energy savings per MVA is calculated in Table 74 as the difference between the annual energy use at the baseline and standard levels. The final row of Table 74 presents the shipment-weighted average energy use and energy savings for distribution transformers. Distribution transformers are used in the transmission of electricity, so demand savings are calculated using an average load factor of 60% for all sectors and end uses.[82]

Table 74. Distribution Transformer Energy Savings, by Product Class

Equipment Class Name	Equip. Class Index	Annual Energy Use per MVA (kWh/yr/MVA)[1]		Annual Energy Savings per MVA (kWh/yr/MVA)	Annual Demand Savings per MVA (W/MVA)	2016 Market Share (%)
		Baseline Level	Standard Level			
Liquid-immersed, medium voltage, single-phase	1A	28,324	27,531	792	151	9.43%
	1B	33,594	31,618	1,976	376	19.09%
Liquid-immersed, medium voltage, three-phase	2A	22,013	18,307	3,706	705	38.50%
	2B	21,872	19,190	2,682	510	2.69%
Dry-type, low-voltage, single-phase	3	43,481	43,481	0	0	0.78%
Dry-type, low-voltage, three-phase	4	47,744	29,506	18,238	3,470	21.47%
Dry-type, medium-voltage, single-phase, 20-45 kV BIL	5	29,160	25,360	3,801	723	0.01%
Dry-type, medium-voltage, three-phase, 20-45 kV BIL	6	23,793	20,056	3,736	711	1.19%
Dry-type, medium-voltage, single-phase, 46-95 kV BIL	7	35,039	28,503	6,536	1,244	0.02%

[82] California Energy Commission. 2016. Demand Analysis Office.

Dry-type, medium-voltage, three-phase, 46-95 kV BIL	8	27,660	21,797	5,863	1,115	6.24%
Dry-type, medium-voltage, single-phase, ≥95 kV BIL	9	36,386	29,972	6,414	1,220	0.00%
Dry-type, medium-voltage, three-phase, ≥95 kV BIL	10	28,140	23,182	4,958	943	0.59%
Shipment-Weighted Average		**30,919**	**24,612**	**6,307**	**1,200**	

[1] Source: Energy use values calculated based on shipment, line loss, and non-line loss coefficients reported in the DOE (2013) National Impacts Analysis spreadsheet, "Annual Impacts" tab. EERE-2010-BT-STD-0048-0765. When using DOE's NIA spreadsheet to model the savings of a particular equipment class, it is critical to correctly specify the equipment class (by setting cell F10 on the "National Impact Summary" tab) and the trial standard level (by setting cell X3 on the "Annual Impacts" tab).[83]

Federal 30: Electric Motors

This section presents the results of the evaluation of Federal 30, the federal standard that regulates electric motors, which took effect on June 1, 2016. Federal 30 added new product classes to the scope of Federal standards and increased the stringency of existing motors standards. Table 75 summarizes the evaluation results.

Table 75. Evaluation Results of Federal 30

	Evaluation Results
Description	Electric Motors
Effective Date	6/1/2016
California Unit Sales/Year	743,429
Unit Energy Savings (kWh)	2,196
Unit Demand Reduction (watts)	384.3
Unit Natural Gas Savings (Therms)	--
First-Year Potential Energy Savings (GWh)	1,632.7
First-Year Potential Demand Reduction (MW)	285.7
First-Year Potential Natural Gas Savings (Therms)	--

[83] The calculations supporting the savings claims for distribution transformers were supplied in a file named "06 – IOU C&S Team 2019 – Distribution Transformers Savings Assumptions.xlsx." The "Calcs" tab of this file calculates a shipments-weighted average baseline unit energy consumption of 3,929 kWh/year, based on values cited to DOE's Final Rule National Impact Analysis spreadsheet. We referenced the same NIA spreadsheet but was unable to recreate the aggregate energy use values clipped in the "NIA Annual Impacts tab excerpts" tab of the IOUs' analysis. We suspect there were errors in the IOUs' retrieval of data from the NIA spreadsheet. For instance, the No Load Loss coefficients cited in column G of the "NIA Annual Impacts tab excerpts" do not match the values output from the NIA spreadsheet, which are referenced from cells C42:N42 of the "LCC Data by Equipment Class" tab of the Final Rule NIA Spreadsheet.
Also: Note that the IOUs calculated savings claims for distribution transformers in terms of energy use and energy savings *per design line* instead of *per equipment class*. Navigant calculated savings per equipment class to maintain consistency with how DOE categorized and reported unit shipments.

List of Data Sources

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

- DOE (2014). Energy Conservation Standards for Commercial and Industrial Electric Motors; Final Rule. EERE-2010-BT-STD-0027-0117
- DOE (2014). Final Rule Technical Support Document for Commercial and Industrial Electric Motors. EERE-2010-BT-STD-0027-0108

Market Size Analysis

We estimated the market size using shipment forecasts from the US Department of Energy. DOE developed shipments forecasts using a model to simulate how future purchases are incorporated into an in-service stock of aging motors that are gradually replaced. To formulate its total shipments estimates, DOE used databases of motor field data, the US Census Bureau's Current Industrial Reports, and stakeholder input to develop a distribution of shipments across each of the three equipment class groups (NEMA Design A and B, NEMA Design C, and fire pump motors). Within each category, motor shipments were split into subcategories by horsepower ratings, rotational speeds (corresponding to 2-pole, 4-pole, 6-pole, and 8-pole motors), and two enclosure types (open or enclosed); projections within each of these subcategories were summed to arrive at shipments at the equipment class level. Further details on DOE's shipment forecasting model are in chapter 9 of the final rule TSD for electric motors.

Electric motors are primarily commercial-sector products, and we assume that shipments of electric motors scale in proportion to a geography's total commercial floorspace. We estimated that California holds 11.9% of the national commercial floorspace.[84]

Table 76 presents the estimated electric motor shipments by product category for the US and California. Fire pump motors are omitted from this analysis due to very low savings and market share.

Table 76. Electric Motor Shipment Estimates, US and California, by Product Category

Product Category	California Share of US Shipments (%)	2016 Shipments		Market Share (%)
		US[1]	California	
NEMA Designs A & B	11.9%	6,241,364	742,036	99.8%
NEMA Design C	11.9%	11,195	1,331	0.2%
Total	–	**6,252,559**	**743,367**	

[1] Source: DOE (2014) "Final Rule Technical Support Document for Commercial and Industrial Electric Motors. EERE-2010-BT-STD-0027-0108. Table 9.3.1

Unit Energy and Demand Savings

The baseline level for Federal 30 corresponds with the federal standards that took effect on December 19, 2010. DOE's motor efficiency standards vary by motor design type, enclosure type, horsepower, and number of poles. The IOUs developed and submitted a spreadsheet that calculates the shipment-weighted average annual energy savings for different motor design types. The IOUs' calculation method is summarized below.

[84] Navigant estimated California's share of national commercial floorspace using data from the EIA's Commercial Buildings Energy Consumption Survey (CBECS). CBECs reports total commercial floorspace at the national and regional level, but not at the state level. Navigant found that (1) the Pacific West region (composed of California, Oregon, and Washington) contains 15.4% of the national commercial floor space, and (2) per US Census data, California houses 77.4% of the population of the Pacific West region. Navigant multiplied these shares together to estimate that California's share of national commercial floorspace is 11.9%.

DOE reports the distribution of electric motor shipments by design type (Designs A, B, and C, fire pump motors, and brake motors), by enclosure type (enclosed or open), by motor size (from 1 hp to 500 hp), by sector (commercial or industrial), by application (air compressor, fan, pump, material handling, and other), and by pole count (2-, 4-, 6-, or 8-pole). The IOUs' spreadsheet combines all these product variables into master tables that calculate the share of shipments for every possible combination of these attributes. For instance, the IOUs' spreadsheet calculates that shipments of 1-hp, 2-pole, enclosed, Design A motors used in industrial air compressors make up 0.0106% of total electric motor shipments.

DOE also reports the annual hours of operation and the average annual load for motors by sector, application, and motor size. For instance, the DOE reports that 1-hp industrial air compressor motors typically operate 5,729 hours/year at an average load of 72.1%. The IOUs' spreadsheet references these annual hour and load values. The spreadsheet calculates the baseline-level and standard-level annual energy consumption as follows:

$$AEC = \frac{P \times Hours \times Load}{\mu}$$

Where:

AEC = annual energy consumption (in kWh/year)
P = the rated motor size (in kilowatts)
Hours = the annual hours of operation (hours/year)
Load = the typical operating load (in percent of rated power)
μ = the motor efficiency (in percent)

The spreadsheet calculates unit energy savings as the difference between the energy consumption at the baseline and standard levels. This calculation is performed for every combination of motor attributes described above. Then, the IOUs' spreadsheet calculates shipment-weighted annual energy consumption values and energy savings values for each motor design type.

We reviewed the IOUs' spreadsheet and found their calculations to be accurate. To calculate demand savings, we referenced load factors for the commercial end uses where electric motors are typically employed (refrigeration, ventilation, air conditioning, and other uses) and we calculated a consumption-weighted average load factor of 65% for these end uses, using load factors supplied by the CEC.[85] Table 77 shows the results of this analysis.

Table 77. Electric Motors Annual Energy Consumption and Savings, by Design Type

Equipment Class	Unit Energy Consumption (kWh/yr)		Unit Energy Savings (kWh/yr)	Unit Demand Savings (W)	Market Share (%)
	Baseline Level	Standard Level			
NEMA Designs A & B Motors	81,815	79,615	2,199	384.9	99.8%
NEMA Design C Motors	55,976	55,280	696	121.7	0.2%
Shipment-Weighted Average	**81,749**	**79,553**	**2,196**	**384.3**	

[85] California Energy Commission. 2016. Demand Analysis Office.

Lighting

Standard 38: Dimming Fluorescent Ballasts

This section presents the results of the evaluation of Standard 38, the Title 20 standard that regulates dimming fluorescent ballasts. Table 78 summarizes the evaluation results.

Table 78. Evaluated Results of Standard 38

	Evaluation Results
Description	Dimming Fluorescent Ballasts
Effective Date	7/1/2016
California Unit Sales/Year	3,119,866
Unit Energy Savings (kWh)	8.7
Unit Demand Reduction (watts)	1.38
Unit Natural Gas Savings (Therms)	--
First-Year Potential Energy Savings (GWh)	27.1
First-Year Potential Demand Reduction (MW)	4.3
First-Year Potential Natural Gas Savings (Therms)	--

List of Data Sources

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

- CEC (2015). "Staff Analysis of HVAC Air Filters, Dimming Fluorescent Ballasts, and Heat Pump Water Chilling Packages." Appendix B. https://efiling.energy.ca.gov/GetDocument.aspx?tn=222021
- DOE. "Technical Support Document for Fluorescent Ballast Final Rule." November 2011. http://www.regulations.gov/#!documentDetail;D=EERE-2007-BT-STD-0016-0067
- DOE (2013). "Final Rule National Impacts Analysis Spreadsheet: Fluorescent Ballasts." https://www.regulations.gov/document?D=EERE-2007-BT-STD-0016-0073
- California IOU C&S Team (2013). "Dimming Fluorescent Lamp Ballasts: Codes and Standards Enhancement (CASE) Initiative for PY 2013: Title 20 Standards Development." https://efiling.energy.ca.gov/GetDocument.aspx?tn=71809

Market Size Analysis

Fluorescent ballasts are typically purchased either as part of new fluorescent fixtures or as replacement ballasts for existing fixtures. We reviewed estimates of dimming fluorescent ballast sales and stocks presented in the 2013 CASE Report. The shipments estimate in the 2013 CASE Report was based on the DOE analysis conducted in support of federal fluorescent ballast standards. The product classes within the scope of this analysis are instant start (IS), rapid start (RS), and programmed start (PS) ballasts that operate medium bipin (MBP) lamps; these in-scope classes are labeled as product classes 1-5 in DOE's analysis. Title 24 primarily affects the retrofit and new construction markets (as opposed to replace on burnout), so this analysis only considers retrofit and new construction shipments. We referenced forecasts of national fluorescent ballasts from DOE's 2013 Final Rule National Impacts Analysis spreadsheet, and we scaled these values to estimate 2016 shipments in California.

The IOU C&S Team projected a sharp increase in dimming fluorescent ballast sales in California due to changes to the California Building Efficiency Standards (Title 24, Part 6), adopted by the Energy Commission in 2012, that required an increased amount of multi-level lighting control capabilities in non-residential spaces.

Fluorescent ballasts are primarily commercial-sector products, and we assume that shipments of fluorescent ballasts scale in proportion to a geography's total commercial floor space. We estimated that California holds 11.9% of the national commercial floorspace.[86] Table 79 presents the estimated fluorescent ballast shipments by product class for the US and California.

Table 79. Fluorescent Dimming Ballast Market Size Analysis

Product Class		2016 Fluorescent Ballast Shipments for Retrofit and New Construction Applications		Market Share (%)
ID	Description	US[1]	California	
1, 3	2-Lamp Normal BF 4ft MBP IS & RS	15,842,628	1,883,531	60.4%
2	2-Lamp Normal BF 4ft MBP PS	2,348,392	279,200	8.9%
4	4-Lamp Normal BF 4ft MBP IS & RS	6,653,775	791,068	25.4%
5	4-Lamp Normal BF 4ft MBP PS	1,396,816	166,067	5.3%
	Total	**26,241,611**	**3,119,866**	

[1]Source: DOE (2013) Final Rule National Impacts Analysis Spreadsheet. Tab "Repl retro+new E," range AL3:AL53.

Unit Energy and Demand Savings

Deep dimming fluorescent ballasts are designed to dim fluorescent bulbs below 50 percent of their maximum output. Prior to Standard 38, no state or federal efficiency standards, test procedures, or labeling requirements existed for deep-dimming fluorescent ballasts. We considered using a baseline of conventional dimming (i.e., non-deep dimming) fluorescent ballasts. However, California's Title 24 building codes require deep-dimming capability for linear fluorescent luminaires and U-bent fluorescent luminaires rated over 13 watts.[87] Additionally, ballasts with deep-dimming capabilities may perform differently than ballasts without deep-dimming capabilities. We ultimately used a baseline of ballasts with deep-dimming capability, with the baseline energy use equivalent to the average energy use of deep-dimming ballasts that do not meet Standard 38.

We reviewed the unit energy savings estimates in the CEC's 2015 Staff Report, which drew heavily from the IOUs' 2013 CASE Report. In 2013, the CASE team tested the performance of 34 dimming fluorescent ballasts in two categories: (1) ballasts that meet the minimum standards proposed and adopted by the CEC, and (2) ballasts that do not meet the minimum standards. The annual unit energy consumption is calculated as a sum of the annual energy used in operating mode and in standby mode. Standby mode energy consumption for

[86] Navigant estimated California's share of national commercial floorspace using data from the EIA's Commercial Buildings Energy Consumption Survey (CBECS). CBECs reports total commercial floorspace at the national and regional level, but not at the state level. Navigant found that (1) the Pacific West region (composed of California, Oregon, and Washington) contains 15.4% of the national commercial floor space, and (2) per US Census data, California houses 77.4% of the population of the Pacific West region. Navigant multiplied these shares together to estimate that California's share of national commercial floorspace is 11.9%.

[87] See table 130.1-A of Title 24, Part 6, which requires that linear fluorescent and U-bent fluorescents >13 W have at least one control step in the range of 20-40% of full rated power.

standards-level products is calculated as the product of 1 watt of standby power draw and 5,576 hours of standby time.

The annual unit energy savings is calculated as the difference between the annual energy use at the baseline and at the standard level (Table 80). To determine the peak demand and peak demand reduction potential associated with fluorescent ballasts, we used a load factor of 72% for commercial interior lighting.[88]

Table 80. Unit Energy Use of Deep-Dimming Fluorescent Ballasts, at Baseline and Standard Efficiency Levels

Ballast Type	Annual Energy Consumption (kWh/yr)[1]		Unit Energy Savings (kWh/yr)	Unit Demand Savings (W)	Market Share (%)[2]
	Baseline	Standard			
1 Lamp	98.3	95.6	2.7	0.43	11%
2 Lamp	177.2	171	6.2	0.98	43%
3 Lamp	263.3	252.5	10.8	1.71	19%
4 Lamp	317.3	303.7	13.6	2.16	27%
Shipments-Weighted Average	**222.7**	**214.0**	**8.7**	**1.38**	

[1] Source: Source: Energy Commission (2015) "Staff Analysis of HVAC Air Filters, Dimming Fluorescent Ballasts, and Heat Pump Water Chilling Packages" Figure 14, p.42.

[2] Source: 2013 CASE Report, Table 4.2

Standard 39: General Service Lamps

This section presents the results of the evaluation of Standard 39, the Title 20 standards for Tier 2 regulations for general service lamps (GSLs), which took effect on January 1, 2018. California adopted the Title 20 standard for GSLs in 2006. However, the Energy Independence and Security Act (EISA), which was signed into law in December 2007, required California to replace its existing Title 20 GSL standard with the federal standards as specified in EISA. The provisions of EISA allow California to adopt the federal standards with accelerated effective dates. Table 81 summarizes the evaluation results.

Table 81. Evaluated Results of Standard 39

	Evaluation Results
Description	General Service Lamps
Effective Date	1/1/2018
California Unit Sales/Year	74,501,124
Unit Energy Savings (kWh)	22.6
Unit Demand Reduction (watts)	1.84
Unit Natural Gas Savings (Therms)	--
First-Year Potential Energy Savings (GWh)	1,683.6

[88] California Energy Commission. 2016. Demand Analysis Office.

First-Year Potential Demand Reduction (MW)	137.3
First-Year Potential Natural Gas Savings (Therms)	--

List of Data Sources

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

- Appliance Standards Awareness Project (ASAP) and American Council for an Energy-Efficient Economy (ACEEE) (2018). "US light bulb standards save billions for consumers, but manufacturers seek a rollback." https://appliance-standards.org/sites/default/files/light_bulb_brief_appendices.pdf
- DOE (2010). ENERGY STAR® CFL Market Profile. https://www.energystar.gov/ia/products/downloads/CFL_Market_Profile_2010.pdf
- DOE (2014). Preliminary National Impact Analysis. https://www.regulations.gov/document?D=EERE-2013-BT-STD-0051-0024
- DOE (2015). Historical General Service Lamp Shipments Estimates. https://www.regulations.gov/document?D=EERE-2013-BT-STD-0051-0037
- DOE (2016) - Energy Savings Forecast of Solid-State Lighting in General Illumination Applications https://www.energy.gov/sites/prod/files/2016/09/f33/energysavingsforecast16_2.pdf
- DOE (2017). 2015 U.S. Lighting Market Characterization. https://www.energy.gov/sites/prod/files/2017/12/f46/lmc2015_nov17.pdf

Market Size Analysis

We compared different market analyses and forecasts of GSL shipments to develop the market size analysis presented here. We estimate the total shipments of GSLs in a given year as the sum of the new shipments resulting from growth in the stock of GSLs plus the sum of stock turnover due to replacement of different lamp technologies.

Shipments Due to Growth in GSL Stock

DOE (2017) reports the stock of A-shape lamps for different technologies in the residential and commercial sectors. The report estimates that for A-shape GSLs, the residential sector contains 97.8% of installed stock, and the commercial sector contains 2.2% of installed GSL stock. DOE (2016) reports the growth rate of GSL stock in each sector. Based on projections of floorspace growth in both sectors from the EIA's Annual Energy Outlook 2015, the report estimates that the GSL stock in the residential sector has a growth rate of 1.17% and GSL stock in the commercial sector has a growth rate of 0.99%. We calculated a sector-weighted average growth rate of 1.17% for GSL installed stock. We use this growth rate to forecast the total installed GSL stock and the shipments of new GSL stock through 2018. Table 82 presents the total installed GSL stock and the shipments of new GSLs resulting from projected growth in the total GSL stock.

Table 82. GSL Shipments from Growth in General Service Lamp Stock, US, 2015-2018

Year	Total US installed GSL Stock	GSL Shipments Resulting from Growth in GSL Stock, US
2016	3,589,655,590	41,373,590
2017	3,631,511,604	41,856,014
2018	3,673,855,666	42,344,062

Shipments Due to Replacement of Retired GSL Stock

Separate from the shipments resulting from growth in GSL stock, we estimated the shipments of lamps resulting from replacement of GSL stock that is retired at end of life. Different lamp technologies have different associated lifetimes. Therefore, to accurately assess the turnover of GSL stock in a given year, we first estimated the historical installed GSL stock by different technologies.

DOE (2010) and DOE (2015) provide historical shipment data for different A-lamp GSL products. Combining these historical shipments with average lamp lifetime by technology enables the construction of a stock turnover model that estimates the number of lamps by lamp technology that are retired each year. We reviewed the stock turnover model developed by the IOU C&S Team in support of their savings claims, and we found their model to be accurate. Table 83 presents the number of lamps retired each year, by lamp technology. To facilitate shipment calculations, this analysis assumes that lamps are retired at the end of the year and are replaced by shipments in the following year. For instance, lamp retirements in 2017 would precipitate replacement shipments in the year 2018.

Table 83. Annual End-of-Year General Service Lamp Retirements by Lamp Technology, US, 2015–2018

Year	Incandescent	Halogen	CFL	LED	Total
2015	221,093,419	112,971,722	174,994,014	8,021	509,067,176
2016	86,094,403	275,291,332	229,990,644	17,679	591,394,058
2017	63,304,760	354,951,304	272,032,611	39,629	690,328,304

Total GSL Shipments

The total GSL shipments each year is the sum of the GSL shipments resulting from growth in GSL stock and the GSL retirements in the prior year. We referenced the California adjustment parameter calculated by the IOUs, which estimates that GSL shipments to California comprise 10.17% of the total US shipments of GSLs. This adjustment parameter gauges the portion of US GSLs stock that exists in California using a stock-weighted ratio of residential and commercial floorspace in California to that of the US. The factor includes deductions to avoid double-counting of savings between the GSLs Original Scope Tier 2 standard and the 2016 and 2019 Title 24 Nonresidential and Residential Indoor Lighting Power Densities standards.[89] Table 84 presents the total GSL shipments for the US and California.

Table 84. Annual General Service Lamp Retirements by Lamp Technology, US, 2015-2018

Year	Stock Growth, US[1]	Replacements, US[2]	Total Shipments, US	California Share of US Shipments[3]	Total Shipments, California
2016	41,373,590	509,067,176	550,440,766	10.17%	55,971,069
2017	41,856,014	591,394,058	633,250,072	10.17%	64,391,458
2018	42,344,062	690,328,304	732,672,366	10.17%	74,501,124

[1] From Table 82, [2] From Table 83

[3] Source: California adjustment parameter calculated by the IOUs

Unit Energy and Demand Savings

[89] The 2016 and 2019 Title 24 Nonresidential and Residential Indoor Lighting Power Densities standards effectively required all commercial buildings to use either fluorescent or LED lighting by 2018, so the California adjustment parameter deducts the entirety of the commercial portion of the GSLs market. In the residential sector, Title 24 lighting standards have required that all new construction be constructed with high-efficacy (CFL or LED) lighting since 2016, so the portion of annual added GSL stock due to residential new construction was also deducted.

The baseline level for GSLs corresponds with the GSLs Original Scope Tier 1 standard.[90] The baseline case represents a hypothetical scenario in which all GSL consumers remain minimally compliant with this standard. Effectively, the baseline scenario represents 100% market share for halogen lamps. This assumption of 100% market share for halogen lamps does not represent reality, since many consumers purchase lamps that exceed the Original Scope Tier 1 standard. The NOMAD analysis that will be conducted in a future step of this evaluation will account for shipments of lamps that exceed the baseline standard.

As described in section 3.3.1, "Discussion of Title 20 Lamp Standards," we conducted an energy-based assessment of annual unit energy savings for GSLs. We calculate the savings as the difference between the baseline annual unit energy consumption and the market average unit energy consumption calculated for the post-standards scenario. The annual unit energy consumption of each lamp type is calculated as the product of the lamp wattage and the annual operating hours. We determined the lamp wattages for different lamp types based on the typical efficacies of incandescent and halogen lamps reported in DOE (2017), and the average market efficacies of CFL and LED lamps observed during our compliance assessment. We referenced annual operating hours for different lamp types in different sectors (residential and commercial) from DOE (2017) and calculated a market-weighted average of 760 annual operating hours for GSLs. To calculate the demand savings, we referenced a load factor of 1.40 presented in the IOU C&S Team's savings analysis.

For the four lamp types considered here, Table 85 presents the efficacy, wattage, market shares, and unit energy consumption for the baseline and post-standards scenarios. The final row of Table 85 presents the market-weighted average unit energy consumptions for the baseline and post-standards scenarios, which are used to calculate the unit energy and demand savings.

Table 85. Energy Consumption and Savings for General Service Lamps

Lamp Type	Efficacy (lpw)[1]	Wattage (W)	Market Share (%)		Unit Energy Consumption (kWh/yr)		Unit Energy Savings (kWh/yr)	Unit Demand Savings (W)
			Baseline	Standard	Baseline	Standard		
Incandescent	10.0	63.0	0%	0%	47.9	47.9		
Halogen	17.1	36.8	100%	0%	28.0	28.0		
CFL	65.3	9.6	0%	19%	7.3	7.3		
LED	97.1	6.5	0%	81%	4.9	4.9		
Market-Weighted Average					**28.0**	**5.4**	**22.6**	**1.84**

[1] Sources: DOE (2017) for incandescent and halogen types. Average market efficacies of CFL and LED types were observed during the compliance assessment.

Standard 40: Small Diameter Directional Lamps

[90] The GSLs Original Scope Tier 1 standard specifies maximum power ratings for GSLs depending on their lumen output: 29W maximum for 310-749 lumens; 43W maximum for 750-1049 lumens, 53W maximum for 1050-1489 lumens, and 72W maximum for 1490-2600 lumens.

This section presents the results of the evaluation of Standard 40, the Title 20 standard that regulates small diameter directional lamps (SDDLs), which took effect on January 1, 2018. Table 86 summarizes the evaluation results.

Table 86. Evaluated Results of Standard 40

	Evaluation Results
Description	Small Diameter Directional Lamps
Effective Date	1/1/2018
California Unit Sales/Year	2,789,000
Unit Energy Savings (kWh)	95.2
Unit Demand Reduction (watts)	20.5
Unit Natural Gas Savings (Therms)	--
First-Year Potential Energy Savings (GWh)	265.4
First-Year Potential Demand Reduction (MW)	57.17
First-Year Potential Natural Gas Savings (MTherms)	--

List of Data Sources

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

- IOU C&S Team (2013). "Codes and Standards Enhancement (CASE) Initiative: Small Diameter Directional Lamps." July. TN #71763. https://efiling.energy.ca.gov/GetDocument.aspx?tn=71763
- CEC (2014). "Draft Staff Report: Analysis of Small Diameter Directional Lamp and Light Emitting Diode Lamp Efficiency Opportunities." September. https://ww2.energy.ca.gov/2014publications/CEC-400-2014-020/CEC-400-2014-020-SD.pdf
- CEC (2015). "Staff Report: Analysis of Small Diameter Directional Lamp and General Service Light-Emitting Diode (LED) Lamp Efficiency Opportunities." October. https://efiling.energy.ca.gov/GetDocument.aspx?tn=206387&DocumentContentId=12014
- DOE (2016). "Energy Savings Forecast of Solid-State Lighting in General Illumination Applications." https://www.energy.gov/sites/prod/files/2016/10/f33/energysavingsforecast16_0.pdf
- DOE (2017). "Adoption of Light-Emitting Diodes in Common Lighting Applications." https://www.energy.gov/sites/prod/files/2017/08/f35/led-adoption-jul2017_0.pdf
- Navigant Consulting (2002). "U.S. Lighting Market Characterization - Volume 1: National Lighting Inventory and Energy Consumption Estimate." https://www1.eere.energy.gov/buildings/publications/pdfs/corporate/lmc_vol1.pdf
- Navigant Consulting (2011). "Energy Savings Estimates of Light Emitting Diodes in Niche Lighting Applications." http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/nichefinalreport_january2011.pdf
- Soraa (2013). "Data for Small Diameter Directional (MR) Lamps." TN #70726. p.10. https://efiling.energy.ca.gov/GetDocument.aspx?tn=70726&DocumentContentId=7834

Market Size Analysis

Standard 40 does not include directional lamps with an E26 base that use LEDs and are covered under the Standard 41a for state-regulated LED Lamps. A 2017 DOE study of LED adoption reported a national installed base in the year 2016 of 44.1 million SDDLs, of which 21.0 million use LED technology and 23.1 million do not use LEDs.[91] A 2011 Navigant study of niche lighting applications reported that SDDL stocks are divided, with roughly 35% installed in residential applications and 65% installed in commercial applications.[92] We concur with the IOUs' estimate that SDDL stock will grow at an annual rate of about 1.3%,[93] and we estimated US stocks of SDDLs in 2018 based on this base stock and growth rate. We assume the sales of SDDLs are directly related to the size of all economic activity, so we estimated California's share of national stock using California's share of the national GDP. We calculated that in 2017, California comprised 14.36% of the national GDP, based on data from the Bureau of Economic Analysis.

We estimate that halogen SDDLs have a lifetime of 3,000 hours, and that annual shipments for replacement applications depend on the lamp's annual operating hours, which differ for residential and commercial applications. Navigant's 2002 "U.S. Lighting Market Characterization" indicates that commercial low voltage halogen lamps operate approximately 3,270 hours per year, while residential general service halogen lamps operate 840 hours per year. We assume these operating hours are representative of all commercial and residential SDDL lamps. Based on these operating hours, we estimate that 28% of the residential baseline SDDL stock will be replaced each year (840 operating hours / 3,000 lifetime hours) and 109% of the commercial baseline SDDL stock will be replaced each year (3,270 operating hours / 3,000 lifetime hours)

Table 87 presents the estimated SDDL baseline stock and shipments by sector for the US and California.[94]

Table 87. Small Diameter Directional Lamp Baseline Shipment Estimates, US, and California, by Product Category

Sector	2018 Stock of Baseline SDDLs (thousands)		Replacement Rate[3]	2018 Shipments, California (thousands)		
	US[1]	California[2]		Replacement[4]	New[5]	Total
Residential	8,297	1,191	28%	334	15	349
Commercial	15,408	2,212	109%	2,411	29	2,440
Total	**23,705**	**3,403**	–	**2,745**	**44**	**2,789**

[1] Assumes US stock of 23.1 million non-LED SDDLs in 2016, growing at an annual rate of 1.3%.
[2] Scaled based on California's share of US GDP.
[3] Equals annual operating hours divided by assumed lifetime of 3,000 hours for baseline SDDLs.
[4] Product of California stock and replacement rate.
[5] Product of California stock and 1.3% growth rate.

To facilitate the energy and demand savings calculations, we estimated the market shares of SDDLs by capacity and voltage type. SDDLs are divided into three representative lamp types based on their rated output, with 20W-equivalent lamps providing 240 lumens on average, 35W-equivalent lamps providing 500 lumens on average, and 50W-equivalent lamps providing 750 lumens on average. SDDLs are also distinguished by whether they are designed for a line voltage of 120V or for a low voltage of 12V. For the purposes of this Report, we refer to the 50W, 35W, and 20W lamp designations and 50W-e, 35W-e, and 20W-e as the equivalent lamp for lower wattage replacement lamps. According to Soraa (2013):

- SDDL sales are split roughly 70%, 20%, 10% among 50W-e, 35W-e, and 20W-e lamps
- SDDL sales are split roughly 90% and 10% between low voltage and line voltage lamps

[91] DOE (2017). "Adoption of Light-Emitting Diodes in Common Lighting Applications." p. 41-42.
[92] Navigant Consulting (2011). "Energy Savings Estimates of Light Emitting Diodes in Niche Lighting Applications." p.17.
[93] 2013 CASE Report, p.23.
[94] The calculations supporting the IOUs' savings claims for SDDLs were supplied in a file named "12 – IOU C&S Team 2019 – SDDL Savings Assumptions.xlsx." The "Measure Checklist" tab of this file reports a 2018 California shipments value of 1,526,655 units in cell C14. We believe this value is incorrectly calculated, since it references the California shipments of SDDLs projected in the "CA Base Case Shipments" tab, and then applies a "California Adjustment" factor as though it were scaling national shipments to estimate California shipments.

Table 88 calculates the overall market shares for representative SDDL product categories and voltage types.

Table 88. Small Diameter Directional Lamp Market Shares, by Product Category and Voltage Type

Product Category	Lamp Type Market Share (%)	Voltage Type	Voltage Type Market Share (%)	Overall SDDL Market Share (%)
20W equivalent	10%	Low	90%	9%
		Line	10%	1%
35W equivalent	20%	Low	90%	18%
		Line	10%	2%
50W equivalent	70%	Low	90%	63%
		Line	10%	7%

Unit Energy and Demand Savings

Prior to Standard 40, no state or federal efficiency standards existed for SDDLs. The baseline for this standard is assumed to be conventional halogen lamps that comprised over 92% of the SDDL market. We assumed that baseline halogen lamps achieve typical efficacy of 12 to 15 lumens per watt (lpw) depending on the lamp capacity, and lamps meeting the requirements of Standard 40 achieve the minimum standard level of 80 lpw.

For lamps that operate at low voltage, additional power is lost by a power supply that converts line voltage to the low voltage supplied to the lamp. We assume that this additional power loss is about 10% of the lamp's rated power, and when we calculate the energy consumption of low voltage lamps, we apply a "power multiplier" factor of 1.1 to account for the power lost in the power supply. For lamps operating at line voltage, we assume the power draw of the lamp fixture is the same as the power draw of the lamp (i.e., a power multiplier of 1.0 for line voltage lamps).

The wattage for each lamp type is calculated as the lamp brightness (in lumens) divided by the lamp efficacy (in lumens per watt), multiplied by a power multiplier (1.1 for low voltage lamps or 1.0 for line voltage lamps). The annual unit energy consumption at the baseline or standard level is calculated as the product of the annual operating hours and the lamp wattage. We assume a market weighted average annual operating hour of 2,420 hours (combining 3,270 commercial operating hours at 65% of the market with 840 residential operating hours at 35% of the market).

To calculate the demand savings, we referenced a load factor of 53% presented in the 2013 CASE Report.[95] This factor is a weighted average of the coincident load for the commercial interior lighting end use and the residential cooking and lighting end use. Table 89 presents the assumptions and calculations that yield the annual unit energy consumption, unit energy savings, and unit demand savings for SDDLs.

Table 89. Small Diameter Directional Lamp Energy Savings, by Lamp Category

Product Type		20W-e		35W-e		50W-e		Market Weighted Average
Voltage Type		Low	Line	Low	Line	Low	Line	
Market Share (%)		9%	1%	18%	2%	63%	7%	
Efficacy (lpw)	Baseline	12	12	14	14	15	15	
	Standard	80	80	80	80	80	80	
Brightness (lumen)		240	240	500	500	750	750	
Power multiplier (unitless)		1.1	1	1.1	1	1.1	1	
Wattage (W)	Baseline	22	20	39.6	36	55	50	

95 2013 CASE Report, p.25.

	Standard	3.3	3	6.88	6.25	10.31	9.38	
Annual Unit Energy Consumption (kWh/yr)	Baseline	53.2	48.4	95.8	87.1	133.1	121.0	116.6
	Standard	8.0	7.3	16.6	15.1	24.9	22.7	21.4
Annual Unit Energy Savings (kWh/yr)		45.2	41.1	79.2	72.0	108.1	98.3	95.2
Unit Demand Savings (W)		9.7	8.9	17.1	15.5	23.3	21.2	20.5

Standard 41a: General Service LED Lamps, Tier 1

This section presents the results of the evaluation of Standard 41a, the Title 20 standard that regulates light emitting diode (LED) quality. For the LED quality standard, the Energy Commission established a tiered standard with a Tier 1 standard that became effective on January 1, 2018, and a Tier 2 standard that became effective on January 1, 2019. This analysis only considers the effects of the Tier 1 standard for LED Quality. Table 90 summarizes the evaluation results.

Table 90. Evaluated Results of Standard 41a

	Evaluation Results
Description	LED Quality – Tier 1
Effective Date	1/1/2018
California Unit Sales/Year	67,729,194
Unit Energy Savings (kWh)	1.31
Unit Demand Reduction (watts)	0.28
Unit Natural Gas Savings (Therms)	--
First-Year Potential Energy Savings (GWh)	88.73
First-Year Potential Demand Reduction (MW)	19.11
First-Year Potential Natural Gas Savings (Therms)	--

List of Data Sources

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

- ASAP (2016). Comments in response to the DOE's Notice of Proposed Rulemaking on Energy Conservation Standards for General Service Lighting. https://appliance-standards.org/sites/default/files/ASAP%20GSL%20NOPR%20comments%20May%2016%202016.pdf
- ASAP & ACEEE (2018). "Issue Brief: US light bulb standards save billions for consumers, but manufacturers seek a rollback." Figure 1A. https://appliance-standards.org/sites/default/files/light_bulb_brief_appendices.pdf

- California IOU C&S Team (2013). CASE Report: Analysis of Standards Proposals for LED Replacement Lamp Quality. TN #71758. https://efiling.energy.ca.gov/GetDocument.aspx?tn=71758&DocumentContentId=7909
- CEC (2014). "Draft Staff Report: Analysis of Small Diameter Directional Lamp and Light Emitting Diode Lamp Efficiency Opportunities." September. https://ww2.energy.ca.gov/2014publications/CEC-400-2014-020/CEC-400-2014-020-SD.pdf
- CEC (2015). "Staff Report: Analysis of Small-Diameter Directional Lamp and General Service Light-Emitting Diode (LED) Lamp Efficiency Opportunities." October. https://efiling.energy.ca.gov/getdocument.aspx?tn=206387
- DOE (2015). "Historical General Service Lamp Shipments Estimates." https://www.regulations.gov/document?D=EERE-2013-BT-STD-0051-0037
- DOE (2016). "General Service Lamps NOPR National Impact Analysis." https://www.regulations.gov/document?D=EERE-2013-BT-STD-0051-0040
- DOE (2017). "2015 U.S. Lighting Market Characterization." https://www.energy.gov/sites/prod/files/2017/12/f46/lmc2015_nov17.pdf

Market Size Analysis

We referenced sales forecasts for LED lamps from a shipment analysis provided by the IOU C&S Team. The IOUs' shipment analysis referenced forecasts of directional and decorative lamp shipments from the Energy Commission 2015 Staff Report. Their forecast projected shipments of omnidirectional LED lamps based on nationwide shipment forecasts for general service lamps, from the DOE's 2015 Lighting Market Characterization, and on forecasts of LED market penetration in ASAP & ACEEE (2018). Table 91 presents the shipments in 2018 as well as the average annual shipment values over the period 2018 to 2035.

Table 91. California Shipments of LED Lamps, Average of 2018-2035, by Product Type

Lamp Type	2018 Shipments, California	Average Annual Shipments, California, 2018-2035[1]	Market Share (%)
Omni-directional	64,671,913	32,284,326	80.7%
Directional	1,901,699	3,740,282	9.3%
Decorative	1,155,582	3,990,475	10.0%
Total	**67,729,194**	**40,015,084**	**100.0%**

[1] Source: California IOUs Shipments Analysis Summary

Unit Energy and Demand Savings

Prior to Standard 41a, no state or federal efficiency standards existed for General Service LED Lamps.

Standard 41a requires all LED lamps less than 2,600 lumens that produce white light and have an E12, E17, E26, or GU-24 base to have a minimum efficacy of 68 lpw. Standard 41a also include aggressive color rendering requirements, with a minimum requirement of 82 CRI and individual R1-R8 color scores of 72.[96] Though dimmability is not required for all lamps, products that claim incandescent equivalency on their packaging must be dimmable down to 10% with reduced flicker and low noise. Several of these requirements (e.g., CRI, flicker, noise) were designed to accelerate the market's acceptance of LED lamps as replacements

[96] Since there is an incremental cost of increasing CRI but not for increasing efficacy, it is assumed in this analysis that the consumer seeking to purchase a minimally compliant product will choose a lamp with the effective minimum CRI. To meet the standard at this minimum CRI, the efficacy must be 84.2 lpw.

for conventional lighting technologies, and these do not have a significant impact on the lamps' energy consumption. A previous section of this report, "Discussion of Title 20 Lamp Standards," notes that medium-base LED GSLs are covered by both Standard 39 and this Standard 41a. For these LED GSLs, our evaluation counts energy savings due to improved efficacy in Standard 39 and energy savings due to dimmability requirements in this Standard 41a.

The annual unit energy consumption of an LED lamp is calculated as the sum of the energy consumption in active mode and standby mode. For baseline-level non-dimmable lamps, the active mode energy consumption is the product of a lamp's full output wattage and its annual operating hours. For standard-level dimmable lamps, the active mode energy consumption is the sum of the energy consumption at each dimming level, with the consumption at each dimming level calculated as the product of the dimmed wattage and the operating hours for that dimming level.[97]

A lamp's full output wattage is calculated as the lamp's lumen output divided by its efficacy. The assumed baseline efficacy for each product type is an average of the efficacies for all lamp models available for each type, reported in the Energy Commission 2015 Staff Report, Table B-1. For standard-level lamps, the efficacy is determined for lamps at the effective minimum color rendering index (CRI) that just meet the minimum compliance score.[98]

Standby mode energy consumption is calculated to reflect the portion of the market comprised of "smart bulbs." Per ASAP (2016), we assume a typical standby wattage of 0.5 watts at both the baseline and standard levels, and per DOE (2016), we assume that smart lamps comprise about 21.8% of LED lamp sales in 2018. We calculate a shipment-weighted standby mode wattage of 0.11 watts, the product of the typical standby wattage and the smart lamp market share.

To calculate demand savings, we referenced a load factor of 53% presented in the 2013 CASE Report.[99] This factor is a weighted average of the coincident load for the commercial and residential sectors associated with interior lighting and cooking, respectively. Table 92 presents the assumptions and calculations that yield the annual unit energy consumption, unit energy savings, and unit demand savings for general service LEDs.[100]

Table 92. General Service LED Energy Savings, by Lamp Category

	Lamp Type			Market-Weighted Average
	Omni-Directional	Directional	Decorative	
Market Share	80.7%	9.3%	10.0%	
Annual Operating Hours[1]	759.2	937.5	839.5	
Lumen Output (lumens)	800	950	350	
Baseline Efficacy (lpw)[2]	97.1	69.0	72.3	
Baseline Full Output Wattage (W)[3]	8.2	13.8	4.8	
	Lamp Type			

[97] We referenced estimates of each lamp type's operating hours at each dimming level from the 2013 CASE Report.

[98] Since it costs more for manufacturers to improve a lamp's CRI than to improve a lamp's efficacy, we assume that manufacturers will optimize their costs by producing lamps at the minimum effective CRI and the lowest efficacy that allows them to meet the minimum compliance score.

[99] 2013 CASE Report, p.25.

[100] Note: The calculations supporting the savings claims for General Service LEDs were supplied in a file named "12 - IOU C&S Team 2019 – LED Savings Assumptions.xlsx." Cell H12 of the "UES & IMC Calcs" reports a baseline efficacy value of 81.3 lpw for omnidirectional LED lamps, based on the 2015 Energy Commission Staff Report. Our analysis used a higher baseline efficacy value of 97.1 lpw, which was the average observed efficacy of LED lamps for the sample of 141 lamps studied in the compliance analysis for this evaluation (forthcoming). Our use of a higher baseline efficacy led to a lower calculated unit energy savings for omnidirectional LED lamps, which in turn led to a lower weighted average unit energy savings value of 1.31 kWh/year (compared to the IOU calculated value of 2.30 kWh/year).

	Omni-Directional	Directional	Decorative	Market Weighted Average
Baseline Active Mode Energy Consumption (kWh/yr)	6.25	12.91	4.06	
Standard-Level Efficacy (lpw)[4]	84.2	84.2	84.2	
Standard-Level Full Output Wattage (W)[3]	9.5	11.3	4.2	
Standard-Level Active Mode Energy Consumption (kWh/yr)[3]	5.4	7.9	2.4	
Shipment-Weighted Standby Mode Wattage (W)	0.11	0.11	0.11	
Standby Mode Energy Consumption (kWh/yr)	0.87	0.85	0.86	
Baseline Unit Energy Consumption (kWh/yr)	7.12	13.76	4.92	**7.52**
Standard-level Unit Energy Consumption (kWh/yr)	6.28	8.78	3.23	**6.21**
Unit Energy Savings (kWh/yr)	0.84	4.98	1.69	**1.31**
Unit Demand Savings (W)	0.18	1.07	0.36	**0.28**

1 Source: For omni-directional lamps, DOE (2017). For directional and decorative lamps, this is a market-weighted average of operating hours for residential and commercial sectors reported in Energy Commission (2015).

2 Efficacy of omni-directional lamps is based on sampling and observations conducted in the compliance assessment portion of this evaluation. Efficacies for directional and decorative lamps are based on the Energy Commission 2015 Staff Report, Table B-1.

3 Calculated as lumen output divided by efficacy.

4 Per Title 20, calculated as the minimum compliance score of 282 minus 2.3 times the effective minimum CRI of 86.

Federal 37: General Service Fluorescent Lamps

This section presents the results of the evaluation of Federal 37, the federal standard that regulates general service fluorescent lamps, which took effect on January 26, 2018. Table 93 summarizes the evaluation results.

Table 93. Evaluation Results of Federal 37

	Evaluation Results
Description	General Service Fluorescent Lamps (GSFLs)
Effective Date	1/26/2018
California Unit Sales/Year	50,821,000
Unit Energy Savings (kWh)	7.6
Unit Demand Reduction (watts)	1.21
Unit Natural Gas Savings (Therms)	--

First-Year Potential Energy Savings (GWh)	388.3
First-Year Potential Demand Reduction (MW)	61.57
First-Year Potential Natural Gas Savings (Therms)	--

List of Data Sources

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

- DOE (2014) Final Rule: General Service Fluorescent Lamps and Incandescent Reflector Lamps. EERE-2011-BT-STD-0006-0067
- DOE (2014) Final Rule Technical Support Document: General Service Fluorescent Lamps and Incandescent Reflector Lamps. EERE-2011-BT-STD-0006-0066
- DOE (2014) Final Rule National Impacts Analysis Spreadsheet. EERE-2011-BT-STD-0006-0062
- Williams, A., B. Atkinson, K. Garbesi, E. Page, and F. Rubinstein (2012). Lighting controls in commercial buildings. Leukos 8(3): 161-180. http://www.tandfonline.com/doi/abs/10.1582/LEUKOS.2012.08.03.001#.VJsCS14AIA

Market Size Analysis

The product classes for GSFLs are defined based on the lamp type, the ballast technology, and the ballast factor option, as illustrated in Table 94. We referenced shipments data from the analysis supporting DOE's 2014 standards rulemaking for GSFLs. To estimate GSFL shipments, DOE developed a consumer-choice-based model that projects consumer purchases based on sector-specific consumer sensitivities to first costs and operating costs of lamps, as revealed by historical data. The model allows switching between certain product classes, where there is historical evidence that switching has occurred. The inputs and outputs of the shipments model are reported in DOE's 2014 Final Rule National Impact Analysis spreadsheet. More details on DOE's shipments analysis are available in chapter 11 of DOE (2014) Final Rule Technical Support Document: General Service Fluorescent Lamps and Incandescent Reflector Lamps.

GSFLs are primarily commercial-sector products, and we assume that shipments of GSFLs scale in proportion to a geography's total commercial floorspace. We estimated that California holds 11.9% of the national commercial floorspace.[101] Table 94 presents the estimated GSFL shipments by product class for the US and California.

Table 94. 2018 Shipments of General Service Fluorescent Lamps, US and California, by Product Class

Lamp Type	Ballast Technology	Ballast Factor Option	Ballast Option ID	2018 Base Case Shipments (1,000s)		Market Share (%)
				U.S.[1]	California	
4-Foot Medium Bipin	Instant Start	Normal	B1.IN	233,739	27,789	54.7%
		Low	B1.IL	33,299	3,959	7.8%
	Programmed Start	Normal	B1.PN	34,039	4,047	8.0%
		Low	B1.PL	6,059	720	1.4%
	Dimming	N/A	B1.D	21,092	2,508	4.9%
	Instant Start	Normal	B1R.IN	9,449	1,123	2.2%

[101] Navigant estimated California's share of national commercial floorspace using data from the EIA's Commercial Buildings Energy Consumption Survey (CBECS). CBECs reports total commercial floorspace at the national and regional level, but not at the state level. Navigant found that (1) the Pacific West region (composed of California, Oregon, and Washington) contains 15.4% of the national commercial floor space, and (2) per US Census data, California includes 77.4% of the population of the Pacific West region. Navigant multiplied these shares together to estimate that California's share of national commercial floorspace is 11.9%.

		Low	B1R.IL	3,538	421	0.8%
8-Foot Slimline	Instant Start	Normal	B2.IN	9,324	1,109	2.2%
		Low	B2.IL	3,022	359	0.7%
8-Foot Recessed Double Contact High Output	Programmed Start	Normal	B3.I	4,009	477	0.9%
4-Foot Miniature Bipin Standard Output	Programmed Start	Normal	B4.PN	8,796	1,046	2.1%
		Low	B4.PL	3,330	396	0.8%
	Dimming	N/A	B4.D	1,308	156	0.3%
4-Foot Miniature Bipin High Output	Programmed Start	Normal	B5.PN	38,687	4,600	9.1%
	Dimming	N/A	B5.D	3,792	451	0.9%
2-Foot U-Shaped	-	-	-	13,982	1,662	3.3%
			Total	**427,465**	**50,823**	

[1] Source: DOE (2014) Final Rule National Impacts Analysis Spreadsheet. "Lamp Shipments-GSFL" tab, row 24.

Unit Energy and Demand Savings

The baseline level for Federal 37 corresponds with the federal standards for GSFLs that took effect on July 14, 2012. To calculate the unit energy consumption (UEC) for different GSFL product classes, we followed the method prescribed in section 12.2.3.2 of the 2014 Final Rule Technical Support Document for GSFLs and IRLs. First, we calculated the average annual UEC for each GSFL option by multiplying the average lamp power consumption by the ballast factor and the average annual hours of use for that lamp in the sector under consideration, and then dividing by the ballast luminous efficiency (BLE) for the ballast option being considered. The unit energy consumption is calculated as:

$$UEC_{l,B,GSFL} = \frac{100 \times RAP_{l,GSFL} \times BF_B \times \bar{u}_{GSFL}}{1000 \times BLE_B}$$

Where:

$UEC_{l,B,GSFL}$ = the annual UEC of GSFL option *l*, when it is couple to ballast option *B*
$RAP_{l,GSFL}$ = the reference arc power of GSFL option *l*
BF_B = the ballast factor of ballast option *B*
BLE_B = the ballast luminous efficacy of ballast option *B*
$\bar{u}_{GSFL}$ = the average annual hours of use for a GSFL, representing an average of sector-specific hours-of-use distributions

To account for the savings of lighting controls, the calculations prescribed by DOE reduce the UEC by a fixed 30 percent for the stock of lighting in which controls based on switching only were assumed to operate. This savings estimate was based on a meta-analysis of field measurements of energy savings from commercial lighting controls by Williams et al. (2012). We accounted for the effects that lighting controls have on unit energy consumption using the method prescribed in section 12.2.3.2 of the 2014 Final Rule Technical Support Document. For each lamp option (regardless of ballast type), the unit energy consumption of lamps installed on switching-only lighting control systems was computed using the following formula:

$$UEC_i(y) = UEC_l \times \left(1 - LC_{adopt}(y) + LC_{adopt}(y) \times LC_{effect}\right)$$

Where:

$UEC_l(y)$ = weighted average annual energy consumption (kWh) of lamp option *l*,
UEC_l = annual unit energy consumption (kWh) of lamp option *l*, operating under full power for the average number of hours of use per year, computed using the previous equation,
$LC_{adopt}(y)$ = the lumen capacity fraction of lighting estimated to be operating under switching-only lighting controls in year y, and
LC_{effect} = a parameter describing the effect of switch-based lighting controls on energy consumption, taken to be 0.7.

For lamps at the baseline level, we referenced the values for these variables from the "Energy Savings" tab of DOE's Final Rule National Impact Analysis spreadsheet. Table 95 presents the values of each of these variables for baseline level lamps, as well as the annual energy consumption (in kWh/year) calculated for each product class. For lamps above the baseline level, we noted that the DOE analysis reports different arc powers and ballast factors for lamps used in different applications. We calculated shipment-weighted average variable values using the market shares of lamps installed on each ballast type, reported in the "Lamp Shipments-GSFL" tab of DOE's Final Rule National Impact Analysis spreadsheet. Then, using these shipment-averaged variables, we calculated the annual energy consumption (in kWh/year) for each product class at the standard-level efficiency adopted by Federal 37. These standard-level values are reported in

Table 96.

Finally, Table 97 references the average annual unit energy savings by product class we calculated. To calculate demand savings, we referenced a load factor of 72% for the commercial interior lighting end use.[102] We used the shares of total shipments for each product class to estimate the shipment-weighted annual energy savings, reported in the final row of Table 97.

Table 95. Annual Energy Consumption Calculations for Baseline-Level General Service Fluorescent Lamps

Ballast Option ID	Arc Power, RAP (W)	Ballast Factor, BF	Ballast Luminous Efficacy, BLE	Annual Operating Hours, ū (hours/yr)	Lumen Capacity Fraction, LC_{adopt}	Annual Energy Consumption (kWh/yr)
	Baseline					Baseline
B1.IN	29.0	0.876	93.19	4,065	0.141	106.1
B1.IL	29.0	0.780	92.39	4,065	0.141	95.3
B1.PN	29.0	0.883	91.67	4,065	1.000	79.4
B1.PL	29.0	0.759	90.36	4,065	1.000	69.3
B1.D	29.0	0.590	81.30	4,065	0	85.5
B1R.IN	29.0	0.870	89.30	634	0	17.9
B1R.IL	29.0	0.830	89.70	634	0	17.0
B2.IN	57.0	0.870	94.30	4,065	0.447	185.1
B2.IL	57.0	0.770	93.50	4,065	0.447	165.2
B3.I	84.0	0.950	89.00	4,065	0.447	315.6
B4.PN	27.8	1.000	92.10	4,065	0.447	106.3
B4.PL	27.8	0.850	89.20	4,065	0.447	93.3
B4.D	27.8	0.670	92.10	4,065	0	82.2
B5.PN	53.8	1.000	92.40	4,065	0.447	205.0
B5.D	53.8	0.670	92.40	4,065	0	158.6

[102] California Energy Commission. 2016. Demand Analysis Office.

Table 96. Annual Energy Consumption Calculations for Standard-Level General Service Fluorescent Lamps

Ballast Option ID	Efficiency Level Adopted at TSL4 [1]	Arc Power, RAP (W)	Ballast Factor, BF	Ballast Luminous Efficacy, BLE	Annual Operating Hours, ū (hours/yr)	Lumen Capacity Fraction, LC_{adopt}	Annual Energy Consumption (kWh/yr)
		Standard					Standard
B1.IN	2	26.5	0.876	93.19	4,065	0.141	96.8
B1.IL	2	28.2	0.780	92.39	4,065	0.141	92.6
B1.PN	2	26.6	0.883	91.67	4,065	1.000	72.9
B1.PL	2	29.0	0.759	90.36	4,065	1.000	69.3
B1.D	2	28.7	0.558	81.30	4,065	0.000	80.1
B1R.IN	2	27.1	0.870	89.30	634	0.000	16.8
B1R.IL	2	28.0	0.830	89.70	634	0.000	16.4
B2.IN	0	57.0	0.870	94.30	4,065	0.447	185.1
B2.IL	0	57.0	0.770	93.50	4,065	0.447	165.2
B3.I	0	84.0	0.950	89.00	4,065	0.447	315.6
B4.PN	2	26.4	1.000	92.10	4,065	0.447	100.7
B4.PL	2	27.0	0.850	89.20	4,065	0.447	90.5
B4.D	2	27.8	0.565	92.10	4,065	0.000	69.4
B5.PN	1	51.0	1.000	92.40	4,065	0.447	194.4
B5.D	1	53.8	0.603	92.40	4,065	0.000	142.6

[1] Source: DOE (2014) Final Rule: General Service Fluorescent Lamps and Incandescent Reflector Lamps. Table VII.1

Table 97. General Service Fluorescent Lamps Annual Energy Consumption and Savings, by Product Class[103]

Ballast Option ID	Annual Unit Energy Consumption (kWh/yr)		Annual Unit Energy Savings (kWh/yr)	Unit Demand Savings (W)	Market Share (%)
	Baseline	Standard			
B1.IN	106.1	96.8	9.2	1.46	54.7%
B1.IL	95.3	92.6	2.7	0.43	7.8%
B1.PN	79.4	72.9	6.6	1.04	8.0%
B1.PL	69.3	69.3	0.0	0.00	1.4%
B1.D	85.5	80.1	5.4	0.85	4.9%
B1R.IN	17.9	16.8	1.2	0.18	2.2%
B1R.IL	17.0	16.4	0.6	0.09	0.8%
B2.IN	185.1	185.1	0.0	0.00	2.2%
B2.IL	165.2	165.2	0.0	0.00	0.7%
B3.I	315.6	315.6	0.0	0.00	0.9%
B4.PN	106.3	100.7	5.5	0.88	2.1%
B4.PL	93.3	90.5	2.7	0.43	0.8%
B4.D	82.2	69.4	12.8	2.03	0.3%
B5.PN	205.0	194.4	10.6	1.67	9.1%
B5.D	158.6	142.6	15.9	2.53	0.9%
2-ft U-shape	106.1	96.8	9.2	1.46	3.3%
Shipment-Weighted Average	**112.2**	**104.6**	**7.6**	**1.21**	

[103] The calculations supporting the savings claims for GSFLs were supplied in a file named "14 – IOU C&S Team 2019.xlsx." The "IMC & UES Calcs" tab of this file calculates a shipments-weighted average unit energy consumption values of 117.1 kWh/year at the baseline and 109.1 kWh/year at the standard level. We noted that the unit energy consumption values we calculated for each product class match the IOUs' calculations. However, we believe the IOUs' spreadsheet contains an error in the calculation of 2018 total shipments and 2018 market shares, which leads to a discrepancy in the shipment-weighted average values. See cells G25:H25 of the "IMC & UES Calcs" tab.

Federal 33: Metal Halide Lamp Fixtures



This section presents the results of the evaluation of Federal 33, the federal standard that regulates metal halide lamp fixtures (MHLF), which took effect on February 10, 2017. No prior standards existed for MHLFs rated <150W or >500W. Federal 33 updated MHLF energy conservation standards for MHLFs rated between 50W and 1000W. For MHLFs rated between 150W and 500W, this update had no effect in California, since the state's Title 20 regulations were already equally or more stringent than the 2014 DOE rule. Thus, this analysis only considers updates to standards for products rated below 150W or above 500W. Table 98 summarizes the evaluation results.

Table 98. Evaluation Results of Federal 33

	Evaluation Results
Description	Metal Halide Lamp Fixtures
Effective Date	2/10/2017
California Unit Sales/Year	164,067
Unit Energy Savings (kWh)	43.8
Unit Demand Reduction (watts)	5.7
Unit Natural Gas Savings (Therms)	--
First-Year Potential Energy Savings (GWh)	7.19
First-Year Potential Demand Reduction (MW)	0.94
First-Year Potential Natural Gas Savings (Therms)	--

List of Data Sources

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

- DOE (2014) Final Rule Technical Support Document. Energy Conservation Program for Consumer Products and Certain Commercial and Industrial Equipment: Metal Halide Lamp Fixtures. https://www.regulations.gov/document?D=EERE-2009-BT-STD-0018-0069
- DOE (2014) Final Rule. National Impact Analysis Spreadsheet https://www.regulations.gov/document?D=EERE-2009-BT-STD-0018-0067
- DOE (2014) Final Rule. Life Cycle Cost Spreadsheet https://www.regulations.gov/document?D=EERE-2009-BT-STD-0018-0066

Market Size Analysis

We referenced shipments data from the analysis supporting DOE's 2014 standards rulemaking for MHLFs. DOE projected MHLF shipments using a three-step process. First, DOE combined historical fixture shipment data from the U.S. Census Bureau with lamp shipment data from the National Electrical Manufacturers Association (NEMA) to estimate the total historical shipments of each fixture type. Second, DOE calculated an installed stock for each fixture in 2017 based on the average service lifetime of each fixture type. Third, DOE developed annual shipment projections for 2017–2046 by modeling fixture purchasing events (such as replacement and new construction) and applying assumptions regarding growth rate, replacement rate, and emerging technologies penetration rate.

We assume that sales of MHLFs are directly related to the size of all economic activity in a region, so we estimated California's share of national shipments using California's share of the national GDP. We calculated that California comprises 14.36% of the national GDP, based on data from the Bureau of Economic Analysis. Table 99 presents DOE's national shipment estimates and our estimates of California shipments for MHLFs.

Table 99. Shipments of Metal Halide Lamp Fixtures Affected by Fed. 33 in 2017, U.S. and California, by Product Class.

Product Class	Wattage Range (W)	Representative Unit Wattage (W)	Indoor/ Outdoor	California Share of U.S. Shipments (%)[1]	U.S. Shipments, 2017[2]	California Shipments, 2017	Share of Total Shipments (%)
1	50-100	70	Indoor	14.36%	161,490	23,186	14.1%
2	50-100	70	Outdoor	14.36%	484,471	69,558	42.4%
3	100-150	150	Indoor	14.36%	81,971	11,769	7.2%
4	100-150	150	Outdoor	14.36%	191,265	27,461	16.7%
5	500-2000	875	Indoor	14.36%	23,902	3,432	2.1%
6	500-2000	875	Outdoor	14.36%	71,703	10,295	6.3%
7	500-2000	1000	Indoor	14.36%	31,982	4,592	2.8%
8	500-2000	1000	Outdoor	14.36%	95,946	13,775	8.4%
Total	–	–	–	–	**1,142,730**	**164,067**	**100%**

[1] Source: U.S. Bureau of Economic Analysis
[2] Source: DOE National Impacts Analysis Spreadsheet, EERE-2009-BT-STD-0018-0067, "Shipments" tab.

Unit Energy and Demand Savings

The annual energy use of MHLFs is determined using information on the fixture's rated power (i.e., the wattage of bulb they accept), the fixture efficiency, and their operating hours per year. To assess the annual energy consumption of each product class, DOE selected a representative unit wattage to represent the class. For instance, in product class 1, with a wattage range of 50W-100W, DOE selected a representative wattage of 70W. For each product class, DOE conducted a market scan to identify the baseline fixture efficiency available. DOE defined and evaluated efficiency levels above the baseline differently for different product classes.

For product classes 1 through 4 (i.e., fixtures rated ≥50W and <150W), DOE used power law equations to define four efficiency levels above the baseline and up to the maximum technologically feasible level. For product classes 5 through 8, DOE used linear equations to define two efficiency levels above the baseline.[104] For all classes, these equations are used to calculate the fixture efficiency of the representative unit wattage at each efficiency level. Table 100 shows the fixture efficiencies at the baseline and at the standard level that DOE adopted. For each class, the input power (in Watts) at the baseline and standard levels is calculated as the rated fixture power divided by the fixture efficiency. Then, the annual unit energy consumption is calculated as the product of the input power and the annual operating hours. For each class, the unit energy savings is calculated as the difference between the unit energy consumption at the baseline and standard levels. Since MHLFs may be used in interior and exterior applications, we calculated demand savings using a weighted average load factor that combines interior and exterior usage. We combined the CEC-reported load factor of

[104] Section 5.17 of the DOE's Final Rule TSD for MHLFs contains a summary of the efficiency levels considered in DOE's analysis.

72% for interior lighting (44% of MHLF market) with an assumed load factor of 100% for exterior lighting (56% of MHLF market) to determine a market-weighted average load factor of 88%.

Finally, the shipment-weighted average unit energy consumption is calculated using the shares of total shipments for each class and presented in the final column of Table 100.

Table 100. Metal Halide Lamp Fixture Power, Operating Hours, and Annual Consumption, by Product Class

Product Class:		1	2	3	4	5	6	7	8	Shipment Weighted Average
Wattage Range (W)		50-100	50-100	100-150	100-150	500-2000	500-2000	500-2000	500-2000	
Representative Unit Wattage (W)		70	70	150	150	875	875	1000	1000	
Indoor / Outdoor		Indoor	Outdoor	Indoor	Outdoor	Indoor	Outdoor	Indoor	Outdoor	
Annual Use (hrs./yr.)[1]		3,865	4,399	4,240	4,399	5,613	4,399	5,613	4,399	
Fixture Efficiency (%)[2]	Baseline	72.0%	72.0%	78.4%	78.4%	92.1%	92.1%	91.8%	91.8%	
	Standard	78.3%	78.3%	82.5%	82.5%	93.1%	93.1%	93.6%	93.6%	
Input Power (W)	Baseline	97.2	97.2	191.3	191.3	950.1	950.1	1,089.3	1,089.3	302.5
	Standard	89.4	89.4	181.8	181.8	939.8	939.8	1,068.4	1,068.4	292.6
Unit Energy Consumption (kWh/yr)	Baseline	375.8	427.7	811.2	841.6	5,332.7	4,179.3	6,114.4	4,791.9	1,382.3
	Standard	345.5	393.3	770.9	799.8	5,275.4	4,134.4	5,996.8	4,699.8	1,338.5
Annual Unit Energy Savings (kWh/yr)		30.2	34.4	40.3	41.8	57.3	44.9	117.6	92.2	43.8
Unit Demand Savings (W)		3.9	4.5	5.2	5.4	7.5	5.8	15.3	12.0	5.7
Share of Total Shipments (%)		**14.1%**	**42.4%**	**7.2%**	**16.7%**	**2.1%**	**6.3%**	**2.8%**	**8.4%**	

[1] Source: DOE Final Rule TSD, Tables 7.2.1 and 7.2.2.
[2] Fixture efficiency is calculated using equations from DOE's Final Rule TSD, Table 5.17.1.

Plumbing

Standard 33c-g: Faucets and Aerators



This section presents the results of the evaluation of Standard 33, the Title 20 standards that regulate Lavatory and Kitchen Faucets and Aerators, which took effect on July 1, 2016. For residential lavatory faucets, the Energy Commission established a tiered standard with a Tier 1 standard that became effective on

September 1, 2015 and a Tier 2 standard that became effective on July 1, 2016. This analysis only considers the effects of the Tier 2 standard for residential lavatory faucets. Table 101 summarizes the evaluation results.

Table 101. Evaluated Results of Standard 33

	Evaluation Results
Description	Lavatory and Kitchen Faucets and Aerators
Effective Date	7/1/2016
California Unit Sales/Year	Natural Gas Heating: 4,066,396 units Electric Heating: 469,026 units Total: 5,066,653 units[1]
Unit Energy Savings (kWh/year)	111.0
Unit Demand Reduction (watts)	15.2
Unit Natural Gas Savings (Therms/year)	4.27
Unit Water Savings (gallons/year)	1,702
Unit Embedded Energy Savings (kWh/year)	5.2
First Year Potential Energy Savings (GWh/year)	52.0
First Year Potential Demand Reduction (MW)	7.1
First Year Potential Natural Gas Savings (MTherms)	17.4
First Year Potential Unit Water Savings (million gallons)	5,430
First Year Potential Embedded Energy Savings (GWh)	26.3

The total faucet sales for all fuel types is greater than the sum of faucet sales to applications with electric and natural gas-fired water heating, since a portion of total sales are to applications with other fuel types that are not considered here.

List of Data Sources

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

- Aquacraft, Inc. Water Engineering and Management (2000). Seattle Home Water Conservation Study: The Impacts of High Efficiency Plumbing Fixture Retrofits in Single-Family Homes. Prepared for Seattle Public Utilities and the US Environmental Protection Agency. https://energy.mo.gov/sites/energy/files/1-seattle-home-water-conservation-final-report-2000.pdf
- California IOU C&S Team (2013) Title 20 Residential Faucets and Faucet Accessories CASE Report - Proposed Standards. TN #71810
- CEC (2014). Staff Analysis of Toilets, Urinals, and Faucets. Document #14-AAER-1.
- CEC (2015). Staff Analysis of Water Efficiency Standards for Toilets, Urinals, And Faucets. TN #203718.
- CEC (2015). Staff Analysis of Lavatory Faucet Appliance Standards. TN #205513.

Market Size Analysis

New faucets are installed in replacement and new construction applications. We referenced data from the IOUs' MeasureSET analysis regarding historical and forecasted sales of faucets in new construction and replacement applications with different water heating fuels. The total faucet sales for all fuel types are used to determine the potential water savings and the potential savings of embedded energy. Sales of faucets to applications with electric or natural gas-fired water heating are used to determine the potential energy savings due to water heating. Note that the total faucet sales for all fuel types is greater than the sum of faucet sales to applications with electric and natural gas-fired water heating, since a portion of total sales are to applications with other fuel types that are not considered here. Table 102 presents annual shipments by application, water heating fuel, and sales scenario.

Table 102. Lavatory and Kitchen Faucets Market Size in California, 2016

Application	Water Heating Fuel	Sales for New Construction, 2016	Sales for Replacements, 2016	Total Sales, 2016
Residential Lavatory Faucets	Natural Gas	252,732	2,260,696	2,513,428
	Electric	21,952	196,361	218,313
	All Fuel Types	310,009	2,773,045	3,083,054
Residential Kitchen Faucets	Natural Gas	125,660	1,161,541	1,287,201
	Electric	10,915	100,890	111,805
	All Fuel Types	154,139	1,424,786	1,578,925
Public Lavatory Faucets[1]	Natural Gas	21,247	244,520	265,767
	Electric	11,105	127,803	138,908
	All Fuel Types	32,352	372,322	404,674
Total	**Natural Gas**	**399,639**	**3,666,757**	**4,066,396**
	Electric	**43,972**	**425,054**	**469,026**
	All Fuel Types	**496,500**	**4,570,153**	**5,066,653**

[1] The Energy Commission Staff Analysis assumes that shipments of public lavatory faucets are equal to that of commercial toilets. Shipments from the Commercial Toilets CASE Report are used here as a proxy for faucets.

Source: IOU MeasureSET Market Analysis

Unit Energy and Demand Savings

We calculated the water savings and embedded energy of water savings for all faucets using water heated by any fuel type. For all faucets, the per-unit water savings are calculated as the product of the rated faucet flow rate (in gallons per minute), a derating factor of 0.67 to estimate the actual flow rate,[105] the average duration of faucet use, the number of uses per day, and the number of days per year.

The baseline flow rates were assumed to be:

- 1.5 gpm (rated) for residential lavatory faucets, equal to Tier 1 standards effective September 1, 2015;
- 2.15 gpm (rated) for residential kitchen faucets, referenced from 2013 CASE Report; and
- 1.45 gpm (rated) for public lavatory faucets, calculated using average water consumption and average duration of use from the Energy Commission 2014 Staff Analysis.

We referenced the average duration of faucet use and the number of faucet uses per day for each faucet type from the CEC's 2014 Staff Analysis and the IOUs' 2013 CASE Report. For residential kitchen faucets, we assume an additional 3 gallons per day are consumed to fill pots and pans. For this analysis, Navigant assumed an embedded electricity value of 4,848 kWh per million gallons of water.[106]

[105] The derating factor is a correction factor to reflect actual flow of a faucet due to line pressure variation, incomplete opening of faucet's valve, and actual performance of flow restrictor gasket. For instance, application of this derating factor means that a faucet rated at 2.2 gpm would actually deliver only 1.5 gpm (2.2gpm x 0.67) on average. Source: Energy Commission (2014) Staff Analysis of Toilets, Urinals, and Faucets. Docket Number 14-AAER-1. CEC-400-2014-007-SD.

[106] CPUC Water/Energy Cost-Effectiveness Analysis. Errata to the Revised Final Report. Prepared by Navigant Consulting, Inc. (May 2015)

Table 103 presents these assumptions and the calculated annual water savings and embedded energy savings for three faucet types. The final row of Table 103 presents the shipment weighted average annual water savings and embedded energy savings.

Table 103. Faucet Unit Water Savings and Unit Embedded Energy Savings

Faucet Type	Flow Rate (gallons/minute)		Minutes per Use	Uses per Faucet per Day	Use Days per Year	Unit Annual Water Use (gal/yr)		Unit Annual Water Savings (gal/yr)	Unit Embedded Energy of Water Savings (kWh/yr)	Market Share (%)
	Baseline	Standard				Base	Standard			
Res. Lavatory Faucets	1.50 rated 1.01 actual	1.20 rated 0.80 actual	0.62	7.9	365	1,781	1,424	356	1.7	60.8%
Res. Kitchen Faucets	2.15 rated 1.44 actual	1.80 rated 1.21 actual	0.62	40.1	365	14,095	11,982	2,112	10.2	31.2%
Public Lavatory Faucets	1.45 rated 0.97 actual	0.50 rated 0.34 actual	0.62	24.0	260	3,744	1,289	2,455	11.9	8.0%
Shipment Weighted Average								**1,072**	**5.2**	

The energy savings estimate depends on the proportion of faucet water use that is hot water and the amount of energy used to heat each gallon of hot water. We used thermodynamic calculations to determine the amount of energy used to provide hot water for natural gas and electric water heaters (Table 104). We assume that water is heated from an inlet temperature of 65°F to a supply temperature of 124°F. The efficiency of water heaters is measured using an energy factor (EF) metric, which describes the proportion of consumed energy that is converted to water heat. We assume typical energy factors of 0.60 EF for natural gas water heaters and 0.90 EF for electric water heaters. The energy needed to heat a gallon of water is calculated as follows, and converted to kilowatt-hours of electricity or therms of natural gas using the appropriate conversion factor:

$$E = \frac{c_p \times \Delta T \times m}{EF}$$

Where:

E = energy needed to heat a gallon of water (in BTU/gal)
c_p = specific heat of water (in BTU/lb °F)
ΔT = the temperature rise (in °F)
m = mass of water per gallon (in lb/gal)
EF = the energy factor of the water heater (unitless)

Table 104. Water Heating Energy Consumption for Electric and Natural Gas Water Heaters

	Electric Water Heater	Natural Gas Water Heater
Specific Heat of Water at 100°F, 1 atm (Btu/lb °F)	0.998	0.998
Mass of Water at 100°F, 1 atm (lb/gal)	8.29	8.29
Water temperature rise, from 65° to 124° (°F)	59	59
Shipment-Weighted Energy Factor (unitless)	0.90	0.60
Conversion Factor	3,412 Btu/kWh	100,000 Btu/therm
Water Heating Consumption	**158.9 kWh/1000 gal**	**8.13 therm/1000 gal**

Finally, the electric and natural gas savings per faucet are calculated as the product of the annual water savings, the water heating consumption, and the assumption that 50% of faucet water used is hot water.[107] Table 105 presents the annual electric and natural gas savings per faucet for the three faucet types considered, as well as the shipment-weighted average electric and natural gas savings per faucet. To calculate demand savings, we referenced a load factor of 86% for residential faucets,[108] and a load factor of 81% for commercial faucets.[109] Demand savings per faucet is calculated as the annual electric savings per faucet divided by the load factor multiplied by 8,760 hours per year.

Table 105. Unit Electric and Gas Savings of Faucets

Faucet Type	Annual Electric Savings per Faucet (kWh/yr)	Market Share of electric (%)	Load Factor (%)	Demand Savings per Faucet (W)	Annual Natural Gas Savings per Faucet (therms/yr)	Market Share of Gas Faucets (%)
Residential Lavatory Faucets	28.3	46.5%	86%	3.8	1.45	61.8%
Residential Kitchen Faucets	167.9	23.8%	86%	22.3	8.59	31.7%
Public Lavatory Faucets	195.1	29.6%	81%	27.5	9.99	6.5%
Shipment-Weighted Average:	**111.0**	**Shipment-Weighted Average:**		**15.2**	**4.27**	

Standard 34a-d: Showerheads, Tier 1, and Tier 2



[107] The assumption of 50% hot water use is based on East Bay MUD and US EPA (2003). Residential Indoor Water Conservation Study: Evaluation of High Efficiency Indoor Plumbing Fixture Retrofits in Single-Family Homes in the East Bay Municipal Utility District Service Area. https://www.ebmud.com/index.php/download_file/force/1463/1365/?residential_indoor_wc_study_0.pdf
[108] Brown, Richard E., and Jonathan G. Koomey. 2002. "Electricity Use in California: Past Trends and Present Usage Patterns." Table 3. Energy Policy (also LBNL-47992). vol. 31, no. 9. July. pp. 849-864.
[109] California Energy Commission. 2016. Demand Analysis Office.

This section presents the results of the evaluation of Standard 34, the two tiers of Title 20 standards that regulate showerheads, which took effect on July 1, 2016 and July 1, 2018. Table 106 summarizes the evaluation results.

Table 106. Evaluated Results of Standard 34

	Evaluation Results		
Description	Showerheads Tier 1	Showerheads Tier 2	Showerheads Total
Effective Date	7/1/2016	7/1/2018	--
California Unit Sales/Year	1,696,827	1,752,557	3,449,384
Unit Energy Savings (kWh)	261.0	104.4	365.4
Unit Demand Reduction (watts)	34.6	13.9	48.5
Unit Natural Gas Savings (Therms)	13.4	5.3	18.7
Unit Water Savings (1,000 gallons)	2.25	0.90	3.15
Unit Embedded Electricity in Water Savings (kWh)	10.9	4.4	15.3
First Year Potential Energy Savings (GWh)	32.3	13.4	45.7
First Year Potential Demand Reduction (MW)	4.3	1.7	6.0
First Year Potential Natural Gas Savings (MMTherms)	19.7	8.2	27.9
First Year Potential Water Savings (million gallons)	3,812.9	1,575.3	5,388.0
First Year Potential Embedded Electricity Savings (GWh)	18.5	7.6	26.1

List of Data Sources

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

- California IOU C&S Team (2015). Title 20 Showerheads CASE Report - Proposed Standards. TN #205606
- California Department of Water Resources (2011). "California Single Family Water Use Efficiency Study. Prepared by Aquacraft, Inc. Water Engineering and Management. http://water.cityofdavis.org/Media/PublicWorks/Documents/PDF/PW/Water/Documents/California-Single-Family-Home-Water-Use-Efficiency-Study-20110420.pdf

Market Size Analysis

New showerheads are installed in replacement and new construction applications. This analysis, like the analysis presented in the 2015 Showerheads CASE report, only considers showerheads installed in residential applications. We referenced data from the Energy Commission Demand Analysis Office regarding historical and forecasted housing stock and projected annual residential dwelling starts for the single family, multi-family, and mobile sectors. We assume that showerheads have a lifetime of 10 years,[110] and that the annual replacement rate is equal to the inverse of the product lifetime. We estimate that 10% of the existing stock of showerheads is replaced each year. We assumed that there are 1.3 showerheads per single family home and one showerhead per multi-family home or mobile home.[111] This analysis only considers showerhead

[110] National Renewable Energy Laboratory (NREL). National Residential Efficiency Measures Database. Retrofit Measures for Showers. Accessed 11/19/2019. https://remdb.nrel.gov/measures.php?gId=6&ctId=399

[111] California Department of Water Resources (2011). "California Single Family Water Use Efficiency Study. Prepared by Aquacraft, Inc. Water Engineering and Management. p.183.

installations in homes with water heaters fueled by electricity or natural gas. A 2014 CPUC residential saturation study found that 87.1% of California homes use natural gas-fired water heaters and 7.3% use electric water heaters.[112] In Table 107, housing stock and new construction data are combined with assumptions regarding replacement rate, showerhead saturation, and water heater fuel type to estimate the total number of new showerheads installed in 2016 and 2018.

Table 107. Showerheads Market Size in California, 2016 and 2018

2016 Market Size, for Tier 1 Standard	Housing Type			Total
	Single Family	Multi-Family	Mobile	
Total Housing Units, 2016	8,157,014	4,224,411	436,805	12,818,230
Total Installed Showerheads, 2016	10,604,118	4,224,411	436,805	15,265,334
New Construction Housing Units, 2016	107,557	30,155	314	138,026
Showerhead Replacements, 2016	1,060,412	422,441	43,680	1,526,533
Showerheads in New Construction, 2016	139,824	30,155	314	170,293
Total New Showerheads, 2016				1,696,826
New Showerheads for Homes with Natural Gas Water Heaters (87.1% of total), 2016				1,477,936
New Showerheads for Homes with Electric Water Heaters (7.3% of total), 2016				123,868
2018 Market Size, for Tier 2 Standard	**Single Family**	**Multi-Family**	**Mobile**	**Total**
Total Housing Units, 2018	8,594,722	4,311,776	460,437	13,366,935
Total Installed Showerheads, 2018	11,173,139	4,311,776	460,437	15,945,352
New Construction Housing Units, 2018	99,356	28,572	286	128,214
2018 Market Size, for Tier 2 Standard	**Single Family**	**Multi-Family**	**Mobile**	**Total**
Showerhead Replacements, 2018	1,117,314	431,178	46,044	1,594,536
Showerheads in New Construction, 2018	129,163	28,572	286	158,022
Total New Showerheads, 2018				1,752,557
New Showerheads for Homes with Natural Gas Water Heaters (87.1% of total), 2018				1,526,477
New Showerheads for Homes with Electric Water Heaters (7.3% of total), 2018				127,937

Unit Energy and Demand Savings

Low-flow showerheads save energy by reducing the amount of hot water used per shower, thereby reducing the amount of energy needed to provide hot water. The estimate of energy savings begins with an estimate of annual water usage at different efficiency levels. We estimated the annual water usage of showerheads as follows:

$$AWU = \frac{SPD \times Days}{SPH}(Duration \times V \times DF + WW)$$

Where:

AWU = Annual water usage per showerhead (in gallons/year per showerhead)
SPD = the average number of showers per household per day
SPH = the average number of showerheads per household
Days = the number of shower days per year
Duration = the average shower duration (in minutes)

http://water.cityofdavis.org/Media/PublicWorks/Documents/PDF/PW/Water/Documents/California-Single-Family-Home-Water-Use-Efficiency-Study-20110420.pdf

[112] CPUC, Energy Division. "WO21: Residential On-site Study: California Lighting and Appliance Saturation Study (CLASS 2012)." Prepared by DNV-GL on behalf of San Diego Gas and Electric, Southern California Gas Company, Southern California Edison and Pacific Gas and Electric. November 24, 2014. http://www.energydataweb.com/cpucFiles/pdaDocs/1096/2014%2005_21%20WO21%20CLASS%20Final%20Report.pdf

V = the showerhead flow rate (in gallons/minute)
DF = a derating factor that corrects the showerhead's rated flow rate to the actual flow rate (unitless)
WW = water wasted per shower while occupants wait for hot water to arrive to the shower (gallons)

For Tier 1 standards, the baseline flow rate is the California Title 20 standard of 2.5 gpm at 80 psi that took effect on January 1, 1994, and the standard level flow rate is 2.0 gpm. For Tier 2 standards, the baseline level flow rate is the Tier 1 standard (2.0 gpm) and the standard-level flow rate is 1.8 gpm. Other factors besides flow rate were sourced from a 2011 study of residential water use by the California Department of Water Resources. We assumed that 0.1 gallons of water is wasted for each shower while occupants wait for hot water to arrive to the shower. Table 108 presents the assumptions for each factor in the calculation, as well as the calculated annual water usage per showerhead at the baseline and standard levels, and the water savings per showerhead.

Table 108. Annual Water Savings per Showerhead for Tier 1 and Tier 2 Standards

	Tier 1	Tier 2
Average shower duration (minutes/shower)	8.7	8.7
Number of showers per household per day	1.97	1.97
Shower days per year	365	365
Showerheads per household	1.192	1.192
Shower time per shower head (minutes/year)	5,250	5,250
Baseline flow rate (gpm)	2.5	2
Standard-level flow rate (gpm)	2	1.8
Derating Factor	0.856	0.856
Water wasted per shower (gal)	0.1	0.1
Baseline annual water use per showerhead (gal/year)	11,296	9,049
Standard-level annual water use per showerhead (gal/year)	9,049	8,150
Annual water savings per showerhead (gallons/year)	**2,247**	**899**

The energy savings estimate depends on the proportion of shower water use that is hot water and the amount of energy used to heat each gallon of hot water. We used thermodynamic calculations to determine the amount of energy used to provide hot water (Table 109). We assume that water is heated from an inlet temperature of 65°F to a supply temperature of 124°F. The efficiency of water heaters is measured using an energy factor (EF) metric, which describes the proportion of consumed energy that is converted to water heat. We assume typical energy factors of 0.60 EF for natural gas water heaters and 0.90 EF for electric water heaters. The energy needed to heat a gallon of water is calculated as follows, and converted to kilowatt-hours of electricity or therms of natural gas using the appropriate conversion factor:

$$E = \frac{c_p \times \Delta T \times m}{EF}$$

Where:

E = energy needed to heat a gallon of water (in BTU/gal)
c_p = specific heat of water (in BTU/lb °F)
ΔT = the temperature rise (in °F)
m = mass of water per gallon (in lb/gal)
EF = the energy factor of the water heater (unitless)

Table 109. Water Heating Energy Consumption for Electric and Natural Gas Water Heaters

	Electric Water Heater	Natural Gas Water Heater
Specific Heat of Water at 100°F, 1 atm (Btu/lb °F)	0.998	0.998

Mass of Water at 100°F, 1 atm (lb/gal)	8.29	8.29
Water temperature rise, from 65° to 124° (°F)	59	59
Shipment-Weighted Energy Factor	0.90	0.60
Conversion Factor	3,412 Btu/kWh	100,000 Btu/therm
Water Heating Consumption	158.9 kWh/1000 gal	8.13 therm/1000 gal

Finally, the electric and natural gas savings per showerhead are calculated as a product of the annual water savings, the water heating consumption, and the assumption that 73.1% of water used for showering is hot water (based on a 2000 report from Seattle and EPA) (Table 110).[113] In addition to the energy savings resulting from water heating consumption, there are embedded electric savings associated with the reduced water consumption of the standard-level showerheads. For this analysis, we assumed an embedded electricity value of 4,848 kWh per million gallons of water.[114] To calculate demand savings, we referenced a load factor of 86% for residential showerheads.[115] Demand savings per faucet is calculated as the annual electric savings per showerhead divided by the load factor multiplied by 8,760 hours per year.

Table 110. Annual Energy Savings per Showerhead for Tier 1 and Tier 2 Standards

	Tier 1	Tier 2
Annual water savings per showerhead (gallons/year)	2,247	899
Annual gas savings per showerhead (therms/year)	13.4	5.3
Annual electric savings per showerhead (kWh/year)	261.0	104.4
Demand savings per showerhead (W)	34.6	13.9
Annual embedded energy savings per showerhead (kWh/year)	10.9	4.4

Standards 35a-b and 36: Toilets and Urinals

This section presents the results of the evaluation of Standards 35 and 36, the Title 20 standards that regulate toilets and urinals. Standards for toilets and urinals were introduced over two tiers, and the standards that took effect on January 1, 2016 represent the second tier of standards. Standard 35, the Tier 2 standard for toilets, did not increase the stringency of Title 20 water use regulations for toilets above the Tier 1 standard, so no savings are expected relative to the Tier 1 baseline. Standard 36, the Tier 2 standard for urinals, increased the stringency of Title 20 regulations for wall-mounted urinals. Table 111 summarizes the evaluation results.

[113] Seattle Public Utility and United States Environmental Protection Agency (2000). Seattle Home Water Conservation Study: The Impacts of High Efficiency Plumbing Retrofits in Single-Family Homes. Prepared by Aquacraft, Inc. Water Engineering and Management. p.34. https://energy.mo.gov/sites/energy/files/1-seattle-home-water-conservation-final-report-2000.pdf

[114] CPUC Water/Energy Cost-Effectiveness Analysis. Errata to the Revised Final Report. Prepared by Navigant Consulting, Inc. (May 2015)

[115] Brown, Richard E., and Jonathan G. Koomey. 2002. "Electricity Use in California: Past Trends and Present Usage Patterns." Table 3. Energy Policy (also LBNL-47992). vol. 31, no. 9. July. pp. 849-864.

Table 111. Evaluated Results of Standard 35 and Standard 36[116]

	Evaluation Results	
Description	Toilets	Urinals
Effective Date	1/1/2016	1/1/2016
California Unit Sales/Year	1,717,418	101,168 (of which, 91,051 sales of wall-mount urinals)
Unit Energy Savings (kWh)	0	0
Unit Demand Reduction (watts)	0	0
Unit Natural Gas Savings (Therms)	0	0
Unit Water Savings (gallons)	0	1,755
Unit Embedded Energy Savings (kWh)	0	8.5
First-Year Potential Energy Savings (GWh)	0	0
First-Year Potential Demand Reduction (MW)	0	0
First-Year Potential Natural Gas Savings (Therms)	0	0
First-Year Potential Water Savings (million gals)	0	159.8
First-Year Potential Embedded Energy Savings (GWh)	0	0.77

List of Data Sources

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

- California IOU C&S Team (2013) CASE Report: Toilets & Urinals.
- California Urban Water Conservation Council, CUWCC (2005), "Potential Best Management Practices (PBMP) Report: High Efficiency Plumbing Fixtures – Toilets and Urinals." Prepared by John Koeller, Koeller and Company. https://efiling.energy.ca.gov/GetDocument.aspx?tn=71102&DocumentContentId=7980
- US EPA (2009) WaterSense Specification for Flushing Urinals Supporting Statement. p.5 https://www.epa.gov/sites/production/files/2017-01/documents/ws-products-support-statement-urinals.pdf

Market Size Analysis

Toilets

New toilets are installed in residential and commercial buildings into replacement and new construction applications. We referenced data from the IOU C&S Team's 2013 CASE Report regarding historical and forecasted sales of toilets and urinals in new construction and replacement applications. The assumptions for residential installed stock in the CASE Report analysis are based on the number of California housing units and on assumptions regarding the number of toilet fixtures per household (2.12 toilets per single-family home and 1.4 toilets per multi-family housing unit). The CASE Report also draws stock and sales estimates from CUWCC (2005). The lifetime of a residential toilet is assumed to be 25 years, and the replacement rate for

[116] The calculations supporting the IOUs' savings claims for toilets and urinals were supplied in a file named "13 – IOU C&S Team 2019 –Savings Assumptions Title 20 T&U.xlsx." The "Measure Checklist" tab of this file reports savings of Tier 2 standards relative to Tier 1 in range B25:C32. These savings are derived only from changes to wall-mount urinal standards, but the IOUs multiplied the per-unit savings by shipments of all product types (urinals and toilets) to estimate a first-year potential savings of 3,192 million gallons of water and 15.47 GWh of embedded electricity. Here, we calculate the first-year potential savings as the product of the per-unit savings and the annual shipments of wall-mount urinals only (i.e., not including toilets, since toilet standards were not updated in Tier 2).

residential toilets is the inverse of the product lifetime, or 4% per year. Residential shipments were calculated as the sum of 4% of existing toilet stock and the sales from new construction.

The assumptions for commercial installed stock in the MeasureSET analysis start with a historical estimate of 1992 commercial toilet stocks and then extrapolate that stock value through 2016 using estimates of growth in non-farm commercial employment. The lifetime of a commercial toilet is assumed to be 12 years, and the replacement rate for residential toilets is the inverse of the product lifetime, or about 8% per year. Similar to the residential sector, commercial sales are calculated as the sum of new sales due to sector growth, plus 8% of the existing installed stock. Table 112 presents the 2016 toilet stock and shipment values for both sectors.

Table 112. Stock and Shipments of Residential and Commercial Toilets in California, 2016

Year	Residential				Commercial			
	Stock (millions)	New Construction Sales	Replacement Sales	Total Sales	Stock (millions)	New Construction Sales	Replacement Sales	Total Sales
2016	25.7	284,392	1,028,352	1,312,744	4.7	32,352	372,322	404,674

Urinals

New urinals are installed in commercial buildings into replacement and new construction applications. We referenced data from the IOUs' 2013 CASE Report regarding historical and forecasted urinal sales. Lacking an authoritative source of commercial urinal stock, the CASE Report estimated that the total number of urinals is 25% of the total number of toilets since the Uniform Plumbing Code requires that buildings have one urinal for every three to four toilets. Based on a scan of available urinal products, the analysis submitted by the IOUs estimates market shares of 90% for wall-mounted urinals and 10% for floor-mounted and trough-style urinals. We found these estimates to be reasonable. Table 113 presents the 2016 stock and shipment values for both urinal types.

Table 113. Stock and Shipments of Urinals in California, 2016

Year	Wall-Mount				Floor-Mount and Trough-Style			
	Stock (millions)	New Construction Sales	Replacement Sales	Total Sales	Stock (millions)	New Construction Sales	Replacement Sales	Total Sales
2016	1.047	7,279	83,772	91,051	0.116	809	9,308	10,117

Unit Energy, Demand, and Water Savings

Since Standard 35 did not affect the water use regulations for toilets, we determined the water and energy savings due to Standard 35 to be zero, as noted in Table 111. The remainder of this section describes the calculation of energy savings from new standards for wall-mount urinals promulgated in Standard 36. We assumed that urinals draw only cold water, so we did not estimate electric or natural gas energy savings or demand savings associated with water heating. The savings estimates for this standard are limited to water use savings and embedded energy of water savings.

The annual per-unit water savings are calculated as follows:

$$AWS = V \times UPD \times Days$$

Where:

AWS = the annual per-unit water savings (in gallons/year)
V = the volume savings per use (in gallons/use)

UPD = the estimated number of uses per day (in uses/day)
Days = the estimated days of use per year (in days/year)

The baseline flush volume is the Tier 1 standard level of 0.50 gallons per flush, and the standard-level flush volume is the Tier 2 standard level of 0.125 gallons per flush. We referenced usage assumptions from EPA (2009), which assumed that on average urinals are used 18 times per day for 260 days of the year. For this analysis, we assumed an embedded electricity value of 4,848 kWh per million gallons of water.[117] Table 114 shows the calculated per-unit water usage, the annual water savings, and the annual embedded energy savings.

Table 114. Wall-Mount Urinal Unit Water Savings and Unit Embedded Energy Savings, 2016

Flush Volume (gallons/flush)		Uses per Day	Use Days per Year	Annual Water Use (gal/yr)		Annual Water Savings (gal/yr)	Embedded Energy of Water Savings (kWh/yr)
Baseline (Tier 1)	Standard (Tier 2)			Baseline (Tier 1)	Standard (Tier 2)		
0.50	0.125	18	260	2,340	585	1,755	8.5

[117] CPUC Water/Energy Cost-Effectiveness Analysis. Errata to the Revised Final Report. Prepared by Navigant Consulting, Inc. (May 2015)

Appendix F. Compliance: Product-Specific Results

The following sections discuss the compliance results for each of the standards in the evaluation scope. The results are organized first by product group (e.g., lighting products, plumbing products, etc.) and then by priority level within each product group (i.e., those with the highest potential savings are discussed first). Each section includes product-specific considerations for sampling and data collection, as well as the compliance results for each product.

Appliances

This section covers the following standards:

- Fed 31 Microwave Ovens
- Fed 38 Residential Clothes Washers
- Fed 36 Commercial Clothes Washers

Federal 31: Microwave Ovens

Table 115 provides and overview of the standard for microwave ovens.

Table 115. Summary Table for Microwaves

Products Covered	Microwave-only ovens, countertop convection microwave ovens, and built-in and over-the-range microwave ovens
Standard Summary	The standard requires a microwave's standby power to be no more than 1 watt for countertop ovens and 2.2 watts for built-in and over-the-range ovens.
Priority	Medium Priority
Target Sample Size	20
Total Sample Size	35
Distribution Channels	Retailers
Market Share Covered	99%
Total Retailers Represented	7 Retailers

Sampling and Data Collection

We focused exclusively on countertop microwave ovens because these account for 99% of the market according to the 2013 DOE Final Rule National Impact Analysis.[118] We were unable to find documentation on retailer websites, manufacturer websites, or product manuals and specification sheets showing microwave standby power values. However, we were able to identify all but three of the models in our sample in either MAEDBS or CCMS to verify compliance with the standard (Table 116).

[118] Department of Energy. 2013. National Impact Analysis - Microwave

Compliance Results

Table 116. Compliance Results for Microwaves

Standard	Compliant Models	Total Models Reviewed	Compliance Rate
Federal 31 Microwaves	32	35	91.4%

The three non-compliant models we sampled were not present in MAEDBS database and had no documentation to verify standby power consumption. Two of these products are “retro” style microwaves; the third is a professional microwave intended for commercial applications.

Federal 38: Residential Clothes Washers

Table 117. Summary Table for Residential Clothes Washers

Products Covered	Clothes washers for use in residential living areas
Standard Summary	Amended standards for front-loading and top-loading residential clothes washers went into effect
Priority	Medium Priority
Target Sample Size	20
Total Sample Size	20
Distribution Channels	Distributors
Market Share Covered	99%
Total Distributors Represented	5 distributors

Sampling and Data Collection

We sampled 20 residential clothes washers from five distributor catalogues and websites (as described in Table 117). We sampled only standard-sized washers as these represented 99% of the market share based on the 2019 Code Change Savings Report (CCSR) documents. We collected data on each sampled model’s Integrated Modified Energy Factor (IMEF) and Integrated Water Factor (IWF), as well as each model’s loading type (front or top) to determine the necessary IMEF and IWF levels. If we did not find a model’s IMEF or IWF level in product literature, and it was not available in the CCMS or MAEDBS, we ruled the product non-compliant.

Compliance Results

Table 118 shows the compliance rate we obtained.

Table 118. Compliance Results for Residential Clothes Washers

Standard	Compliant Models	Total Models Reviewed	Compliance Rate
Federal 38 Residential Clothes Washers	20	20	100%

Federal 36: Commercial Clothes Washers

Table 119. Summary Table for Commercial Clothes Washers

Products Covered	Clothes washers for use in commercial settings with volumes under 4 cubic feet.
Standard Summary	This new standard decreased minimum modified energy factor for top and front-loading washers and decreased maximum water factor for front-loading washers.
Priority	Low Priority
Target Sample Size	20
Total Sample Size	20
Distribution Channels	Manufacturers
Market Share Covered	>90%
Total Manufacturers Represented	2 Manufacturers

Sampling and Data Collection

We sampled 20 commercial clothes washers from two manufacturer catalogues and websites (Table 119). The two manufacturers represented 90% of the market share based on the Federal rulemaking Technical Support Documents.[119] Lacking additional information, we assumed all models to have equal market shares. We collected data on each sampled model's Modified Energy Factor (MEF) and Integrated Water Factor (IWF), as well as each model's loading type (front or top) to determine the necessary MEF and IWF levels. For models not listed in the CCMS or MAEDBS, if we could not find enough information elsewhere to determine compliance, we ruled the product non-compliant.

Compliance Results

Table 120 shows the compliance rate we obtained.

Table 120. Compliance Results for Commercial Clothes Washers

Standard	Compliant Models	Total Models Reviewed	Compliance Rate
Federal 36 Commercial Clothes Washers	16	20	80%

For the four non-compliant products, MEF, IWF, or any other information on energy use were not available, nor were they listed in the CCMS or MAEDBS, so we assumed these were operating at a baseline level of energy use and ruled these non-compliant.

Electronics

This section covers the following standards:

- Fed 29 External Power Supplies
- Std 31 Small Battery Chargers, Tier 3
- Std 42a Computers (workstations)

119 DOE (2014) Final Rule TSD Table 3.6.1

- Std 42b Computers (small-scale servers)

Standard 31: Small Battery Chargers, Tier 3 (SBC)

Table 121. Summary Table for Small Battery Chargers

Products Covered	Small battery charger systems, such as two-way radios, handheld barcode scanners, electronic calibration equipment and golf-cart chargers
Product Summary	This new standard mandated a maximum annual energy consumption in kilowatt hours per year (kWh/year) as a function of battery energy.
Priority	Medium/Low Priority
Target Sample Size	20
Total Sample Size	20
Distribution Channels	Retailers
Overall Market Share Covered	100%
Total Manufacturers and Retailers Represented	5 Retailers

Sampling and Data Collection

We sampled 20 small battery charger systems from five different retailers (Table 121). We focused on battery chargers for handheld barcode scanners, two-way radios, and handheld calibration equipment because our discussions with industry experts indicated that these are the most common types of products covered by the standard. We collected data on each sampled battery system's capacity, number of ports, maintenance mode power, and no-battery power to determine compliance. For models not listed in MAEDBS, if we could not find enough information in product literature to determine compliance, we ruled the product non-compliant.

Compliance Results

We obtained the compliance rates shown in Table 122.

Table 122. Compliance Results for Small Battery Chargers

Category	Compliant Models	Total Models Reviewed	Compliance Rate
Std 31 Small Battery Chargers	3	20	15%

None of the sampled models had enough technical information in the product literature to determine compliance, and none of the models we sampled were listed in MAEDBS. However, two models stated in product literature that these were Energy Commission compliant, so we assumed those two were compliant with the California standard because the marking indicated that the manufacturer was aware of the standard requirements. Given the very low amount of information available, we also reached out to several manufacturers. One responded with compliance information, and we considered their products compliant accordingly. The others did not respond. We believe that the low compliance rate is most likely due to a lack of manufacturer awareness and understanding of the standard in the market, as well as a lack of enforcement to date.

Standard 42a-b: Computers

Table 123. Summary Table for Computers

Products Covered	Small-scale servers and workstations
Standard Summary	This standard establishes an internal power-supply unit energy requirement and a maximum power consumption requirement.
Priority	Low Priority
Target Sample Size	40 total (20 for servers and 20 for workstations)
Total Sample Size	N/A
Distribution Channels	N/A
Market Share Covered	N/A
Total Manufacturers and Retailers Represented	N/A

Sampling and Data Collection

We were unable to obtain any data from major manufacturers or distributors of these products that would allow us to determine compliance with the standard (Table 123). Additionally, none of our sampled products appeared to be listed in MAEDBS.[120] The IOUs estimated a compliance rate of 85% for each standard, and we determined that this estimate was reasonable through consultation with industry experts at Energy Solutions who assisted with the development of the standard. Furthermore, the savings claims for these two standards represent approximately 0.1% of the total savings claimed for all 2016–2018 standards, so any deviation from these compliance estimates would have an insignificant effect on overall aggregate savings for this evaluation.

Compliance Results

We determined that compliance rates were consistent with the IOUs' estimates, as noted in Table 124.

Table 124. Compliance Results for Computers

Standard	IOU Estimated Compliance Rate	Evaluated Compliance Rate
Std 42a – Workstations	85%	85%
Std 42b – Small-Scale Servers	85%	85%

Federal 29: External Power Supplies (EPS)

Table 125. Summary Table for External Power Supplies

Products Covered	External Power Supplies
Standard Summary	This new standard set a minimum efficiency during active mode and a maximum power consumption during no-load mode for both Class A and non-class External Power Supplies (EPS).
Priority	High Priority
Target Sample Size	75

[120] For workstations, model number formatting in MAEDBS often appeared to be different from that on manufacturer websites, so it was not feasible to search for models in MAEDBS.

Total Sample Size	150
Distribution Channels	Manufacturers and Retailers
Market Share Covered	94%
Total Manufacturers and Retailers Represented	5 Manufacturers and 9 Retailers

Sampling and Data Collection

We discussed this standard with representatives from Lawrence Berkeley National Laboratories (LBNL) who stated most external power supplies are sold with the device they are designed to service, such as a phone charger with its corresponding phone. The manufacturers that we sampled from were major manufacturers of phones and computers. Other sources included aftermarket retailers, such as online e-commerce sites where replacement power supplies can be bought.

We sampled 150 external power supplies from five phone and computer manufacturers and nine aftermarket retailer product websites (Table 125). We sampled only low and basic voltage power supplies as these represented 94% of the market share based on the 2019 CCSR documents. We collected data on each sampled model's efficiency and no-load power, as well as the voltage, output power and nameplate information, to determine the necessary efficiency level. We supplemented our online data collection with shelf surveys at brick-and-mortar stores because online literature often lacked the necessary product information to determine compliance. If we did not find a model's efficiency in either the manufacturer or distributor product literature, we looked for a "VI" marking (International Efficiency Marking Protocol) on the nameplate, which indicates the product is compliant with the most recent Department of Energy (DOE) standard levels.

Compliance Results

Based on the market share information in the Federal TSD[121] and our discussions with Guidehouse, LBNL and industry experts, we weighted our compliance value by distribution channel. Major manufacturers represented 89.6% of the distribution market share and aftermarket retailers represented the remaining 10.4%.[122] After weighting for distribution channel, we obtained the compliance rate shown in Table 126.

Table 126. Compliance Results for External Power Supplies

Standard	Compliant Models	Total Models Reviewed	Weighted Compliance Rate
Federal 29 External Power Supplies	76	150	69.7%

Table 126 summarized the compliance results for external power supplies. Most sales of external power supplies come from major manufacturers, like Apple and Dell, that have a high level of awareness of the standards. Due to this and discussions with Guidehouse experts, who contributed to the 2015 DOE rulemaking, we anticipated a high rate of compliance among external power supplies. However, analysis of our sample showed that only 72.2% of the major manufacturer models complied with the standard. We do not believe this is due to manufacturers selling older inventory, as the standard took effect in 2016. In the three years before we completed our analysis, manufacturers had sufficient time to sell all previous inventory. Of the five non-compliant manufacturer models, all had the roman numeral, "V," which confirms compliance with

[121] DOE (2014) Final Rule TSD

[122] International Data Corporation (IDC). 2018. *IDC Quarterly Mobile Phone Tracker, 2018Q1 Historical Release*, Framingham, MA, May 2018.

the previous standard. Since the previous standard did not meet the requirements of the 2016 standard, we assumed any products indicating compliance with the previous standard would be non-compliant with the current standard. It is possible that these models are exempt from the energy conservation standards, under a provision in the Code of Federal Regulations allowing sales of chargers that are compatible with older models of phones and laptops (and thus, may be legally sold).[123] However, such models still lower the overall compliance rate of inventory sold that comply with the 2016 Federal standard.

Most of the aftermarket models did not have any efficiency, no-load power, or "VI" marking information, and consequently, only 47.7% of these models complied with the standard. We ruled models non-compliant where we lacked information to determine compliance. We learned that online retailers put the responsibility of compliance on their sellers, rather than checking compliance themselves. Many of these sellers are small operations, often without their own websites or any manufacturer contact information. Proliferation of products and manufacturers makes it difficult to detect noncompliance and take enforcement action.

Commercial HVAC and Refrigeration Equipment

This section covers the following standards:

- Fed 35 Walk-In Coolers and Freezers
- Fed 39 Commercial CAC and HP (65-760 kBtu/hr), Tier 1
- Fed 34 Commercial Refrigeration Equipment
- Fed 41 Commercial Icemakers
- Fed 32 Commercial CAC and HP (<65 kBtu/hr)

Federal 32: Commercial Air Conditioners and Heat Pumps, small

Table 127. Summary Table for Commercial Air Conditioners and Heat Pumps, small

Products Covered	Commercial Package Air Conditioners and Heat Pumps (less than 65,000 Btu/hour cooling capacity)
Standard Summary	This new standard increased energy conservation standards for commercial packaged A/C and HP units with cooling capacities less than 65 kBtu. This change aligns the standard with ASHRAE 90.1-2013.
Priority	Low Priority
Target Sample Size	20
Total Sample Size	21
Distribution Channels	Manufacturers and Wholesalers
Market Share Covered	100%
Total Manufacturers and Wholesalers Represented	2 Manufacturers and 2 Wholesalers

[123] e-CFR: Title 10, Chapter II, Subchapter D, Part 430.32, Paragraph (w)(2). https://www.ecfr.gov/cgi-bin/text-idx?SID=200fd28ae22e577fb51c97b5f6775f0d&mc=true&node=pt10.3.430&rgn=div5#se10.3.430_134

Sampling and Data Collection

We sampled 21 air conditioners and heat pumps from two distributor and two manufacturer product catalogues and websites (Table 127). We collected data on each sampled model's Seasonal Energy Efficiency Ratio (SEER) and Heating Seasonal Performance Factor (HSPF), as well as the cooling capacity, to determine compliance. Air conditioners only require a SEER rating, while heat pumps require both a SEER and an HSPF rating.

Compliance Results

We obtained the compliance rate shown in Table 128.

Table 128. Compliance Results for Commercial Air Conditioners and Heat Pumps - small

Standard	Compliant Models	Total Models Reviewed	Weighted Compliance Rate
Federal 32 Small ACs and HPs	21	21	100%

We discussed this standard with Guidehouse experts who contributed to 2015 DOE rulemaking efforts. The evaluation team determined that commercial air conditioners and heat pumps are likely to have a high rate of compliance with the standard, since almost no channels exist for non-compliant products to enter the market. Our results agreed with this perspective.

Federal 34: Commercial Refrigeration Equipment

Table 129. Summary Table for Commercial Refrigeration Equipment

Products Covered	Commercial Reach-in Refrigerators and Freezers
Standard Summary	This updated standard added new equipment classes and increased stringency for some of the existing classes.
Priority	Medium Priority
Target Sample Size	20
Total Sample Size	27
Distribution Channels	Manufacturers and Distributors
Market Share Covered	70%
Total Manufacturers and Distributors Represented	7 Manufacturers and 2 Distributors

Sampling and Data Collection

We sampled 27 commercial refrigeration equipment units from seven manufacturers and two distributors (Table 129). While there are twenty-five equipment classes covered by the standard, we included the following types in our sample, which collectively represent 70% of the market share:

- Vertical closed solid, self-contained, medium temperature
- Vertical closed solid, self-contained, low temperature
- Vertical closed transparent, remote-condensing, low temperature
- Vertical closed transparent, self-contained, medium temperature
- Horizontal closed transparent, self-contained, medium temperature

We collected data on each sampled model's daily energy consumption, as well as its volume or total display area as applicable, to determine the necessary maximum daily energy consumption (MDEC) level. If the model was not listed in CCMS or MAEDBS, we calculated the DEC from specifications in the product literature. We based our calculations on the assumption that commercial freezers and refrigerators cycle on and off and use their maximum power about one-third of the time.[124]

Compliance Results

Based on the market share information in the Federal rulemaking TSD, seven major manufacturers were heavily represented in the market.[125]

We therefore weighted by major manufacturer market share to obtain the compliance rate shown in Table 130.

Table 130. Compliance Results for Commercial Refrigeration Equipment

Standard	Compliant Models	Total Models Reviewed	Compliance Rate
Federal 34 Commercial Refrigeration	27	27	100%

Federal 35: Walk-in Coolers and Freezers

Table 131. Summary Table for Walk-in Coolers and Freezers

Products Covered	Display doors and dedicated condensing units for refrigerators (medium temperature)
Standard Summary	This new standard set separate performance standards for walk-in box components and refrigeration components. It also updated the standards for medium temperature dedicated condensing units and for cooler and freezer doors.
Priority	High Priority
Target Sample Size	75
Total Sample Size	140
Distribution Channels	Manufacturers and Wholesalers
Market Share Covered	100%
Total Manufacturers and Wholesalers Represented	11 Manufacturers and 6 Wholesalers

Sampling and Data Collection

We sampled 61 display doors and 79 medium temperature dedicated condensing systems from eleven manufacturer and six wholesaler product catalogues and websites (Table 131). We collected data on each display door model's daily energy consumption (DEC) and each condensing system's Annual Walk-in Energy Factor (AWEF) to determine compliance.

[124] https://homeguides.sfgate.com/calculate-cost-run-refrigerator-69603.html calculation assistance for MDEC
[125] DOE (2014) Final Rule TSD Figure 3.2.2

If we could not find enough information in the literature or CCMS or MAEDBS, we referred to a manufacturer's website (if the sampled model came from a wholesaler's website). If none of these options provided enough information, we ruled the product non-compliant.

Many of the condensing systems did not have AWEF values listed in any of the data sources. We created a model to estimate the AWEF from other metrics in the product literature such as refrigeration capacity, power usage, condensing temperature, evaporating temperature, ambient temperature, and refrigerant type.

Compliance Results

Based on the market share information in the Federal rulemaking Technical Support Documents, we weighted our compliance value for condensing systems by distribution channel.[126] Manufacturers represented 56.8% and wholesalers represented 43.2% of the distribution market share. For display doors, we only sampled from manufacturers, so we calculated an overall compliance level for those models.

We then weighted both display doors and condensing systems together by total energy savings to obtain the compliance rate shown in Table 132.

Table 132. Compliance Results for Walk-in Coolers and Freezers

Standard	Proportion of Energy Savings	Compliant Models	Total Models Reviewed	Weighted Compliance Rate
Dedicated condensing systems (medium temperature)	74.1%	59	79	74.6%
Display doors	25.9%	55	61	90.2%
Federal 35 Walk-In Coolers and Freezers	100%	114	140	78.6%

For display doors, most of the models were listed in both databases or had a disclaimer that stated, "DOE compliant." There are relatively few manufacturers and the manufacturers are clearly aware of the standard. Since they are responsible for complying with the standard, it would be relatively simple for the DOE to verify compliance and take enforcement action if necessary. Due to these circumstances, we ruled products marked as "DOE Compliant" as compliant with the standards. One manufacturer had models without enough information to determine compliance, so we ruled those non-compliant.

We determined that the DOE was not enforcing the standards for medium temperature dedicated condensing systems until January of 2020, and we drew our sample and conducted our compliance analysis in 2019.[127] As a result, we believe that the manufacturers did not have an incentive to comply prior to 2020.

Commercial Air Conditioners and Heat Pumps, Tier 1

Table 133. Summary Table for Commercial Air Conditioners and Heat Pumps, Tier 1

Products Covered	Commercial Package Air Conditioners (AC) and Heat Pumps (HP) between 65,000 and 760,000 Btu/hour cooling capacity
Standard Summary	This standard updates energy efficiency requirements for commercial packaged A/C and HP units with cooling capacities

[126] DOE (2014) Final Rule TSD Figure 6.3.1

[127] https://appliance-standards.org/product/walk-coolers-and-freezers Appliance Standards Awareness Project states that DOE will use discretion and delayed enforcement until 2020.

	between 65 kBtu and 760 kBtu. This update aligns the standard with the ASHRAE 90.1 2013 tier 1 standards.
Priority	High Priority
Target Sample Size	75
Total Sample Size	90
Distribution Channels (market share)	Manufacturers and Wholesalers
Market Share Covered	100%
Total Manufacturers and Wholesalers Represented	4 Manufacturers and 4 Wholesalers

Sampling and Data Collection

We sampled 90 air conditioners and heat pumps from four distributor and four manufacturer product catalogues and websites (Table 133). We collected data on each sampled model's Integrated Energy Efficiency Ratio (IEER) and Coefficient of Performance (COP), as well as the cooling capacity, to determine compliance. Air conditioners only required an IEER rating, while heat pumps required both an IEER and a COP rating.

If we did not find IEER and/or COP values in the sampling source, we referred to a manufacturer's website (if the sampled model came from a wholesaler's website). For models not listed in MAEDBS or CCMS, if we could not find enough information elsewhere to determine compliance, we ruled the product non-compliant.

Compliance Results

These products are distributed to consumers through several steps in a supply chain, which may include manufacturers, wholesalers, and contractors. Based on the market share information in the Federal rulemaking TSD, we collected data from companies representing the first step of the supply chain: sales from manufacturers and wholesalers to contractors or directly to end users.[128] Manufacturers represented 17.5% and wholesalers represented 82.5% of the distribution market share. We weighted by these distribution channels to obtain the compliance rate shown in Table 134,:

Table 134. Compliance Results for Commercial Air Conditioners and Heat Pumps, Tier 1

Standard	Compliant Models	Total Models Reviewed	Weighted Compliance Rate
Federal 39 Commercial ACs and	89	90	98.5%

We discussed this standard with Guidehouse experts who conducted the market assessment supporting DOE's 2015 rule for commercial ACs and HPs. That study determined that commercial ACs and HPs likely have a high rate of compliance with the standard, since almost no channels exist for non-compliant products to enter the market. For the non-compliant sample, we were unable to determine the IEER value in the source or manufacturer literature. We were unable to verify the model year of this product and thus were not able to determine whether it was manufactured before the compliance date of the standard. Therefore, we considered this product to be non-compliant.

[128] DOE (2015) Final Rule TSD Figure 6.1.1

Federal 34: Commercial Icemakers

Table 135. Summary Table for Commercial Icemakers

Product Covered	Commercial Icemakers
Product Summary	This new standard increased stringency for batch-type icemakers and expanded the scope to include larger capacity equipment and new equipment types. It also expanded coverage to include continuous icemakers.
Priority	Low Priority
Target Sample Size	20
Total Sample Size	20
Distribution Channels	Manufacturers and Distributors
Overall Market Share Covered	70%
Total Manufacturers Represented	4 Manufacturers

Sampling and Data Collection

We sampled 20 commercial icemakers from four manufacturers (Table 135). One of the manufacturers represented a much larger percentage of the market share than the others (40%), so we selected a proportional number of products from each manufacturer when creating our sample (while still randomly selecting models from each manufacturer's product selection). Although the standard applies to 13 different product types, we selected our sample from the product categories with the highest market share:

- Small Air-cooled Batch-type Icemaking Heads
- Large Air-cooled Batch-type Icemaking Heads
- Small Air-cooled Batch-type Self-contained Units
- Small Air-cooled Continuous-type Self-contained Units

These product classes collectively represented over 70% of the market share. We collected data on each sampled model's energy use (kWh/100 pounds) and its harvest rate (pounds/day) to determine compliance.

Compliance Results

We obtained the final compliance rate shown in Table 136.

Table 136. Compliance Results for Commercial Icemakers

Standard	Compliant Models	Total Models Reviewed	Compliance Rate
Federal 34 Commercial Icemakers	20	20	100%

Commercial and Industrial Equipment

This section covers the following standards:

- Fed 30 Electric Motors
- Fed 28 Distribution Transformers

Federal 28: Distribution Transformers

Table 137. Summary Table for Distribution Transformers

Products Covered	Low and medium voltage dry-type and medium voltage distribution transformers
Standard Summary	The new standard increases the stringency of efficiency requirements for Low-Voltage Dry-Type (LVDT) and Medium-Voltage Dry-Type (MVDT) distribution transformers from the baseline level of the 2010 Federal standards.
Priority	Medium Priority
Target Sample Size	20
Total Sample Size	27
Distribution Channels	Manufacturers
Market Share Covered	100%
Total Manufacturers Represented	6 Manufacturers

Sampling and Data Collection

We sampled 27 distribution transformers from six major manufacturers (Table 137). Based on our discussions with Guidehouse experts who worked on the most recent DOE Rulemaking, we only sampled low-voltage dry-type transformers. Almost all medium-voltage transformers are custom-made for primarily utility end-users. Consequently, we lacked the product information to determine compliance and had to consider other market factors that would influence compliance rates. For example, we assumed that these customers have a high level of awareness of the standard and would specify standards-compliant equipment in their orders. Additionally, due to the relatively small number of discrete manufacturers and end-users with no intermediaries in the distribution chain, enforcing non-compliance would be simple.

Due the reasons just stated, we assumed that 100% of the medium-voltage transformers complied with the standard and sampled only low-voltage type transformers. We collected data on each sampled model's efficiency, as well as the phase and size, to determine the necessary efficiency level.

Two manufacturers listed an efficiency value, while the other four stated that all their transformers meet the 2016 DOE standards. We ruled these compliant because identifying the 2016 DOE standard increases the likelihood that compliance can be investigated, therefore the companies would have an incentive to report this factually.

Compliance Results

We obtained the compliance rate shown in Table 138 by combining the compliance rate of sampled low-voltage transformers with the assumed 100% compliance rate of medium-voltage transformers.

Table 138. Compliance Results for Distribution Transformers

Standard	Compliant Models	Total Models Reviewed	Compliance Rate
Federal 28 Distribution Transformers	27	27	100%

We discussed this standard with Guidehouse experts and determined that distribution transformers likely have a high rate of compliance with the standard, as most of the medium-voltage units are custom-made and detection of non-compliance for low-voltage units is straightforward. Our results agreed with this perspective.

Federal 30: Electric Motors

Table 139. Summary Table for Electric Motors

Products Covered	Electric Motors
Standard Summary	The new standard increases the stringency of efficiency requirements for electric motors and additionally covers new product classes. The new standard regulates NEMA designs A, B, and C and aligns the federal motor power efficiency standards to that of NEMA Premium efficiency.
Priority	High Priority
Target Sample Size	75
Total Sample Size	120
Distribution Channels	Manufacturers and Distributors
Market Share Covered	99.8%
Total Manufacturers and Wholesalers Represented	5 Manufacturers and 7 Distributors

Sampling and Data Collection

We sampled 120 electric motors from seven distributor and five manufacturer product catalogues and websites (Table 139). We sampled only National Electric Manufacturers Association (NEMA) Design A and B motors as these represented 99.8% of the market share based on the 2019 CCSR documents. We collected data on each sampled model's efficiency, as well as the horsepower, number of poles, and enclosure type, to determine the necessary efficiency level. If we did not find a model's efficiency in either the manufacturer or distributor product literature, we looked for a marking that stated "NEMA Premium efficiency," which is equivalent to the standard levels.

Compliance Results

Based on the market share information in the Federal rulemaking TSD, we determined that electric motors are typically sold to consumers through two channels: direct sales from the manufacturer or sales through a distributor. [129] Using this information, we weighted our compliance value by distribution channel. Because manufacturers represented 25.5% and distributors represented 74.5% of the distribution market share, we obtained the compliance rate shown in Table 140.

Table 140. Compliance Results for Electric Motors

Standard	Compliant Models	Total Models Reviewed	Weighted Compliance Rate
Federal 30 Electric Motors	117	120	96.9%

We discussed this standard with Guidehouse experts and determined that electric motors are likely to have a high rate of compliance with the standard, since the Federal standards are equivalent to pre-existing NEMA premium standards. Our results agreed with this perspective. The few non-compliant motor models were

[129] DOE (2014) Final Rule TSD section 6.1.1

manufactured by one company, which published no efficiency information. We ruled these models non-compliant because we lacked information to determine compliance.

Lighting

This section covers the following standards:

- Std 39 General Service Lamps
- Std 40 Small Diameter Directional Lamps
- Fed 37 General Service Fluorescent Lamps
- Fed 33 Metal Halide Lamp Fixtures
- Std 41a General Service LED Lamps - Tier 1
- Std 38 Dimming Fluorescent Ballasts

Standard 38: Dimming Fluorescent Ballasts (DFBs)

A summary of this standard for the compliance evaluation is shown in Table 141. The results are provided in Table 142.

Table 141. Summary Table for Dimming Fluorescent Ballasts

Products Covered	Deep-dimming ballasts (ballasts that dim below 50% of max output) designed to operate fluorescent lamps
Standard Summary	The standard sets requirements for maximum standby power consumption, power factor and minimum weighted ballast luminous efficacy.
Priority	Low Priority
Target Sample Size	20
Total Sample Size	35
Distribution Channels	Distributors
Market Share Covered	100%
Total Retailers Represented	3 Distributors

Sampling and Data Collection

We drew our product sample from ballasts designed to operate T5, T8, and T12 tubular and U-shaped fluorescent lamps. We excluded any ballasts which were not capable of dimming to below 50% of max output. We were unable to find documentation on distributor websites, manufacturer websites, or product data sheets and catalogs showing standby power consumption or weighted ballast luminous efficacy values. However, we were able to identify all but four of the models in our sample in the Energy Commission MAEDBS and verify compliance. We weighted market share equally amongst all models reviewed.

Compliance Results

Table 142. Compliance Results for Dimming Fluorescent Ballasts

Standard	Compliant Models	Total Models Reviewed	Compliance Rate

Standard 38 Dimming Fluorescent Ballasts	20	24	83.3%

The four non-compliant models we sampled were not present in MAEDBS and had no documentation to verify standby power consumption, power factor, or weighted ballast luminous efficacy. Three of the models were labelled as Energy Commission non-compliant products on distributor or manufacturer websites but still appeared to be available for sale in California.

Standard 39: General Service Lamps (GSLs)

A summary of this standard for the compliance evaluation is shown in Table 143.

Table 143. Summary Table for General Service Lamps

Products Covered	General service incandescent, halogen, compact fluorescent (CFL), and LED lamps
Standard Summary	California implemented the Federal 45 lumens per watt (lpw) standard for general service lamps with an accelerated effective date.
Priority	High Priority
Target Sample Size	250
Total Sample Size	257 (235 CFL and LED, plus 22 halogen)
Distribution Channels	Retailers
Market Share Covered	100%
Total Retailers Represented	9 Retailers

Sampling and Data Collection

The standard applies only to lamps with a medium (E26) screw base that operate between 310-2,600 lumens and 110-130 volts. We also excluded specialty lamps which the standard explicitly exempts from consideration including (among others) colored lamps, appliance lamps, bug lamps, rough service lamps, and 3-way lamps. We sampled only from A-shaped lamps and T-shaped spiral CFLs, as these types are generally synonymous with general service lamps.[130] We drew our random sample from more than 2,000 products collected from retailer websites.

In general, incandescent and halogen lamps do not meet the standard while CFL and LED lamps exceed it. We weighted our samples by technology type according to the 2019 shipment shares estimated by the IOUs in the CCSR: 0% incandescent, 0% halogen, 13% CFL and 87% LED. We calculated a legal compliance rate that represents the percent of our sample meeting or exceeding the 45 lpw standard. The additional energy savings associated with CFL and LED efficacies that exceed the 45 lpw standard are considered in the Potential Energy Savings evaluation.

Compliance Results

Table 144. Compliance Results for General Service Lamps

Technology	Market Share	Sample Size	Average Efficacy (lumens per watt)	Legal Compliance

[130] https://appliance-standards.org/product/general-service-lamps

CFL	13%	94	65.3	100%
LED	87%	141	97.1	100%
Total (Weighted)	100.0%	235	78.6	100%

We attempted to corroborate the assumption that incandescent and halogen lamps comprise essentially 0% of the market share of GSLs in California (See Table 144). We did this by collecting data on incandescent and halogen lamp models for sale elsewhere in the US and determining if those lamp models were subject to the California standard and being sold in California. Of the 750 models of incandescent and halogen lamps we examined, only 22 halogen lamp models were subject to the standard and being sold in California, which suggests that major lighting retailers are generally restricting the stocking and shipment of non-compliant GSLs in California.[131] These findings support our assumption that incandescent and halogen lamps constitute an insignificant portion of the GSL market in California, and thus we proceeded with the shipment shares in the CCSR that assume 0% of the GSL market consists of incandescent and halogen lamps.

Every sampled CFL and LED product met or exceeded the standard. We evaluated a weighted legal compliance rate of 100% as a result of the assumed 0% incandescent and halogen market shares.

Standard 40: Small Diameter Directional Lamps (SDDLs)

Table 145. Summary Table for Small Diameter Directional Lamps

Products Covered	Directional lamps with a diameter of 2.25 inches or smaller and pin or medium (E26) bases
Standard Summary	The standard establishes a minimum rated lifetime requirement of 25,000 hours and requires either: (1) an efficacy of at least 80 lumens per watt; or (2) an efficacy of at least 70 lumens per watt (lpw) and a CRI of at least 95.
Priority	High Priority
Target Sample Size	75
Total Sample Size	86
Distribution Channels	Retailers and Distributors
Market Share Covered	100%
Total Retailers Represented	4 Retailers and 2 Distributors

Sampling and Data Collection

We sampled MR, PAR, and R-shaped bulbs with diameters less than 2.25 inches (primarily MR16 and MR11 shape codes). Because the standard specifies that only lamps with a medium (E26) or pin base are subject to the standard, we did not sample from integrated track lighting fixtures or replacement track heads. In accordance with the standard, we also excluded lamps that: do not operate at 12, 24 or 120 volts; are brighter than 850 lumens; are greater than 75 watts; and have lifetimes less than 300 hours.

Compliance Results

Table 146. Compliance Results for Small Diameter Directional Lamps

Technology	Legally Compliant Models	Total Models Reviewed	Average Efficacy	Legal Compliance	Energy Use Compliance

[131] These average efficacy of these 22 halogen lamps was 17.0 lumens per watt.

			(lumens per watt)		
Incandescent	0	1	7.2	0%	0%
Halogen	0	26	11.3	0%	0%
LED	26	59	73.1	44.1%	98.5%
Total	26	86	54.6	30.2%	67.4%

In general, we determined that the SDDL market in California still includes a significant proportion of non-compliant halogen lamps (See Table 146). Major brick-and-mortar lighting retailers that restrict the stocking and shipment of other non-compliant Title 20 lighting products in California (such as GSLs and state-regulated LED lamps) do not appear to do the same for SDDLs.

In the CCSR documents, the IOUs did not assume any market shares by lamp technology type (incandescent, halogen, and LED). The proportion of lamps by technology type in our sample and their resulting weight in the compliance calculation reflects the relative proportion of each that we found for sale on retailer and distributor websites. Of the 86 models available for sale in California that we randomly sampled, 59 were LEDs, 26 were halogens, and one was an incandescent lamp. The average efficacy among all samples was 54.6 lpw.

Among the 59 LED products sampled, 44.1% fully complied with the standard. 98.5% of the LEDs had an efficacy of at least 70 lpw, while 23.7% had an efficacy of at least 80 lpw. Although almost all sampled LED lamps met the minimum efficacy standard of 70 lpw, most did not have the required CRI. 67.4% of the sampled models were compliant with the energy use standards. These results are consistent with our understanding that the standard set a relatively high bar that is not easy for manufacturers to meet.

Standard 41a: General Service LED Lamps, Tier 1

Our approach the General Service Lamps is summarized in Table 147.

Table 147. Summary Table for General Service LED Lamps, Tier 1

Products Covered	Omnidirectional, directional, and decorative LED lamps
Standard Summary	The standard establishes a minimum efficacy standard of 68 lumens per watt and requires a minimum compliance score of 282 (compliance score is equal to the sum of efficacy and 2.3 times the CRI of a lamp) in addition to other quality metrics noted below.
Priority	Medium Priority
Target Sample Size	20
Total Sample Size	152
Distribution Channels	Retailers
Market Share Covered	100%
Total Retailers Represented	8 Retailers

Sampling and Data Collection

We were able to draw a sample size that was much larger than our target size because the population of products from which we drew our sample for the LED standard was the same as the population from which we drew our sample for the LED-portion of the General Service Lamps standard.[132] However, because the two standards do not apply to all of the same products, we excluded different products in the population before drawing random samples for the two standards. For the LED standard, we sampled only from lamps with E12, E17, E26, or GU24 bases. We excluded lamps with a brightness of more than 2,600 lumens or less than 200 lumens (150 lumens for candelabra bases), as well as any lamps whose correlated color temperature was not within the range of 2,200–7,000K. Finally, we excluded specialty type bulbs such as colored or multi-colored lamps, ultraviolet lamps, bug lamps, and plant growth lamps. Our sampling pool primarily consisted of general service A-shaped lamps but also included decorative C-shaped candelabra lamps.

In addition to an efficacy requirement, the standard establishes requirements for several other quality metrics including color point, CRI (Ra), individual R1-R8 color scores, power factor, rated lifetime, and ENERGY STAR® specifications. Despite reviewing retailer and distributor websites, manufacturer catalogs, and product data sheets, many of these metrics were difficult to identify for products in our sample. Therefore, we selected the four metrics that were the most readily available and relevant for energy savings on which to base our compliance determination:

- **Efficacy**: Does the lamp have an efficacy of at least 68 lumens per watt?
- **Rated Lifetime**: Does the lamp have a rated life of at least 10,000 hours?
- **Color Rendering Index (CRI)**: Does the lamp have a CRI of at least 82?
- **Compliance Score**: Does the lamp have a compliance score of at least 282?[133]

We identified efficacy and rated lifetime values for every sampled product; however, we were often unable to find CRI values (and therefore unable to calculate a compliance score). In these cases, we deemed the product to be non-compliant with respect to the CRI standard and the overall standard.

Compliance Results

Table 148. Compliance Results for General Service LED Lamps, - Tier 1

Standard	Compliant Models	Total Models Reviewed	Average Efficacy (lumens per watt)	Legal Compliance Rate	Energy Compliance Rate
Standard 41a General Service LED Lamps	60	152	94.2	39.5%	99.3%

The low compliance rate is not a result of low-efficacy LED lamps but rather a result of low-CRI LED lamps (or lamps lacking information on CRI). The compliance rates with respect to each evaluated metric were:

- **Efficacy**: 99.3% compliance rate
- **Rated Lifetime**: 100% compliance rate
- **Color Rendering Index (CRI)**: 43.4% compliance rate[134]
- **Compliance Score**: 63.2% compliance rate[135]

[132] The General Service Lamp standard required a larger sample size, so we collected product information for many more LED lamps than would be necessary for evaluating the LED standard alone.
[133] Compliance score is equal to the sum of efficacy and 2.3 times the CRI.
[134] CRI values could not be found for 21.7% of samples. These were considered non-compliant.
[135] Many products met the compliance score requirement despite non-compliant CRI values due to sufficiently high efficacy.

While 39.5% of sampled products complied with all four metrics, almost all products (99.3%) met the efficacy standard of 68 lpw. The average efficacy of the samples was 94.2 lpw. Extra savings from the LED quality standard will be included in Unit Energy Savings for the General Service Lamp Potential Energy Savings analysis.

Federal 37: General Service Fluorescent Lamps (GSFLs)

A summary of this standard for the compliance evaluation is shown in Table 149. The results are provided in Table 150.

Table 149. Summary Table for General Service Fluorescent Lamps

Products Covered	4-foot and 8-foot tubular fluorescent lamps and 2-foot U-shaped fluorescent lamps designed for general service applications
Standard Summary	The standard increases the stringency of existing efficacy (lumens per watt) standards for common types of general service fluorescent lamps.
Priority	Medium Priority
Target Sample Size	20
Total Sample Size	40
Distribution Channels	Retailers and Distributors
Market Share Covered	90%
Total Retailers Represented	2 Retailers and 4 Distributors

Sampling and Data Collection

The standard sets efficacy standards for six specific types of common tubular fluorescent lamps. According to DOE's 2014 Shipments Analysis, the dominant product type with more than 80% of the market share is 4-foot medium bi-pin lamps.[136] Therefore, our sample consists primarily of 4-foot medium bi-pin lamps. We collected models of T5, T8, T12, and U-shaped lamps from retailer and distributor websites and, according to the standard, excluded lamps with a CRI greater than or equal to 87 and lamps that did not fall under one of the six regulated general service types.

Compliance Results

Table 150. Compliance Results for General Service Fluorescent Lamps

Standard	Compliant Models	Total Models Reviewed	Weighted Compliance Rate
Federal 37 GSFLs	27	40	80.3%

In determining compliance, we only considered the efficacy of the lamps. The compliance rate for the 27 models from distributors was 81.5%, while the compliance rate for the 13 models from retailers was 38.5%. After weighting these compliance rates by their corresponding market shares (97.2% distributors and 2.8% retailers), we calculated a weighted compliance rate of 80.3%.

[136] DOE (2014) Final Rule TSD

Federal 33: Metal Halide Lamp Fixtures (MHLFs)

A summary of this standard for the compliance evaluation is shown in Table 151. The results are provided in Table 152.

Table 151. Summary Table for Metal Halide Lamp Fixtures

Products Covered	Ballasts designed to operate metal halide lamps between 50–150 watts and 500–1000 watts.
Standard Summary	The standard adopts a required minimum efficiency, defined as the ratio between the lamp operating wattage and ballast input wattage, for metal halide lamp ballasts.
Priority	Medium Priority
Target Sample Size	20
Total Sample Size	22
Distribution Channels	Distributors
Market Share Covered	80%
Total Retailers Represented	4 Distributors

Sampling and Data Collection

We determined that many major lighting distributors maintain webpages for products that are not available for sale, are out of stock, or are outdated (i.e., no longer included in manufacturer catalogs). Given that the standard applies to products *manufactured after* the effective date of the standard and given documentation on the websites of major manufacturers claiming that non-compliant products are no longer being manufactured, we concluded that distributors are still selling ballasts manufactured prior to the standard effective date.

For the purposes of estimating compliance, we excluded products that we judged as manufactured prior to the standard effective date from our sample. Products no longer listed on manufacturer catalogs or websites, low on stock, and/or not available from other major online merchants fell into this category.

Compliance Results

Table 152. Compliance Results for Metal Halide Lamp Fixtures

Standard	Compliant Models	Total Models Reviewed	Compliance Rate
Federal 33 Metal Halide Lamp Fixtures	19	22	86.4%

We identified three non-compliant models. These three models had ballast efficiencies that were less than the required efficiency for their specifications. We calculated a compliance rate of 86.4%.

Plumbing

This section covers the following standards:

- Std 33a-g Faucets
- Std 34a-b Showerheads

- Std 35a-b Toilets
- Std 36 Urinals

Standard 33c-g: Faucets

A summary of this standard for the compliance evaluation is shown in Table 153.

Table 153. Summary Table for Faucets

Products Covered	Residential Lavatory Faucets, Public Lavatory Faucets, and Kitchen Faucets
Standard Summary	The standard lowers the maximum allowable flow rate of faucets offered for sale after the effective date.
Priority	Medium/Low Priority
Target Sample Size	60 (20 residential lavatory faucets, 20 public lavatory faucets, and 20 kitchen faucets)
Total Sample Size	66 (20 residential lavatory faucets, 26 public lavatory faucets and 20 kitchen faucets)
Distribution Channels	Manufacturers and Retailers
Market Share Covered	100%
Total Manufacturers and Retailers Represented	3 Manufacturers and 6 Retailers

Sampling and Data Collection

We sampled 20 residential lavatory faucets, 26 public lavatory faucets, and 20 kitchen faucets from product catalogues and websites of six retailers and three manufacturers. We collected data on flowrate in gallons per minute to determine compliance.

For models not listed in MAEDBS, if we could not find enough information elsewhere to determine compliance, we ruled the product non-compliant.

Compliance Results

We assessed compliance with the CEC's requirements for gallons per minute (gpm) for each of the individual categories. Due to the lack of further information, we assumed equal market share for each retailer and manufacturer. We obtained the compliance rates shown in Table 154.

Table 154. Compliance Results for Faucets

Category	Compliant Models	Total Models Reviewed	Compliance Rate
Std 33a-d Residential Lavatory Faucets	20	20	100%
Std 33e-f Kitchen Faucets	17	20	85%
Std 33g Public Lavatory Faucets	24	26	92.3%

Some, but not all, of the major retail and supplier websites had policies that restricted sales to California based on each model's flowrate. For models that did not meet the standards, we checked if we could ship them to California or purchase them from a store in California. All five of the models that did not meet the standards were ruled non-compliant because they were available for sale to California customers Our results suggest that not every retailer is compliant with California standards, and manufacturers and distributors may be unaware of the CEC's stricter requirements.

Standard 34a-d: Showerheads

A summary of this standard for the compliance evaluation is shown in Table 155.

Table 155. Summary Table for Showerheads

Product Covered	Residential Showerheads
Product Summary	This standard took effect in two stages, or tiers. The Tier 1 standard lowered the maximum allowable flow rate to 2.0 gpm for showerheads manufactured between July 1, 2016 and July 1, 2018. The Tier 2 standard lowered the maximum allowable flow rate to 1.8 gpm for showerheads manufactured on or after July 1, 2018.
Priority	Medium Priority (Tier 1); Low Priority (Tier 2)
Target Sample Size	20
Total Sample Size	20
Distribution Channels	Manufacturers and Distributors
Overall Market Share Covered	100%
Total Manufacturers and Distributors Represented	1 Manufacturer and 4 Distributors

Sampling and Data Collection

We sampled 20 showerheads from five manufacturer and distributor product websites. We collected data on the flowrate of each model in gallons per minute (gpm) to determine compliance. We evaluated the same sample for compliance with both tiers (i.e., Tier 1 and Tier 2) because these applied to the same product types. For models not listed in MAEDBS, if we could not find enough information elsewhere to determine compliance, we ruled the product non-compliant.

Compliance Results

We assessed compliance by the California's state standards for gallons per minute for each tier of compliance. We obtained the compliance rates shown in Table 156.

Table 156. Compliance Results for Showerheads

Category	Compliant Models	Total Models Reviewed	Compliance Rate
Std 34a Showerheads Tier 1 – July 1, 2016 (2.0 gpm)	17	20	85%
Std 34b Showerheads Tier 2 – July 1, 2018 (1.8 gpm)	14	20	70%

Some, but not all, of the major retail websites had policies that restricted sales to California based on each model's flowrate. For models that did not meet the standards, we checked that we could ship them to California from the website or purchase them from a store in California. All three of the models that did not meet the standards were still available for sale in California, therefore, we ruled them non-compliant. Our results suggest that not every site is compliant with California's standards, and manufacturers and distributors may be unaware of the California's stricter requirements.

Standard 35a-b: Toilets

A summary of this standard for the compliance evaluation is shown in Table 157.

Table 157. Summary Table for Toilets

Products Covered	Residential toilets
Standard Summary	The standard lowered the maximum allowable water consumption of all toilets sold or offered for sale on or after the effective date to 1.29 gallons per flush.
Priority	Low Priority
Target Sample Size	20
Total Sample Size	20
Distribution Channels	Retailers
Market Share Covered	100%
Total Retailers Represented	5 Retailers

Sampling and Data Collection

We sampled 20 toilets from five retailer product websites. We collected data on the flowrate of each model in gallons per flush (gpf) to determine compliance. For models not listed in MAEDBS, if we could not find enough information elsewhere to determine compliance, we ruled the product non-compliant.

Compliance Results

We obtained the compliance rates shown in Table 158.

Table 158. Compliance Results for Toilets

Standard	Compliant Models	Total Models Reviewed	Compliance Rate
Std 35 Toilets	17	20	85%

Some, but not all, of the major retail websites had policies that restricted sales to California based on each model's flowrate. For models that did not meet the standards, we checked if we could ship them to California from the website or purchase them from a store in California. All three of the models that did not meet the standards were still available for sale in California, and thus, we ruled them non-compliant. Our results suggest that not every site is compliant with California standards, and manufacturers and distributors may be unaware of the CEC's stricter requirements.

Standard 36: Urinals

A summary of this standard for the compliance evaluation is shown in Table 159.

Table 159. Summary Table for Urinals

Products Covered	Urinals
Standard Summary	The standard lowered the maximum allowable water consumption of all non-trough type urinals sold or offered for sale on or after January 1, 2016 and set new stringent standards for wall-mounted urinals.
Priority	Low Priority
Target Sample Size	20
Total Sample Size	21
Distribution Channels	Retailers and Manufacturers
Market Share Covered	90%
Total Retailers and Manufacturers Represented	1 Retailer and 4 Manufacturers

Sampling and Data Collection

Wall mounted urinals represented 90% of the market share so we sampled 21 wall-mounted units from one retailer and four manufacturer product websites. We collected data on the flowrate of each model in gallons per flush (gpf) to determine compliance. For models not listed in MAEDBS, if we could not find enough information elsewhere to determine compliance, we ruled the product non-compliant.

Compliance Results

We obtained the compliance rates shown in Table 160.

Table 160. Compliance Results for Urinals

Standard	Compliant Models	Total Models Reviewed	Compliance Rate
Std 36 Urinals	16	21	76.2%

Some, but not all, of the major retail websites had policies that restricted sales to California based on each model’s flowrate. For models that did not meet the standards, we checked if we could ship them to California from the website or purchase them from a store in California. All five of the models that did not meet the standards were still available for sale in California, and thus, we ruled them non-compliant. Our results suggest that not every site is compliant with California standards, and manufacturers and distributors may be unaware of the CEC’s stricter requirement.

Appendix G. NOMAD: Product-Specific Results

The following sections discuss the NOMAD results for each of the standards in the evaluation scope. The results are organized first by product group (e.g., lighting products, plumbing products, etc.) and by priority level within each product group (i.e., those with the highest potential savings are discussed first). Each section includes product-specific insights from the survey respondents, as well as the NOMAD results for each product. The charts illustrating the NOMAD results include an area showing the range of responses among the experts to provide context for the varied predictions of the NOMAD curve. The results and the range do not include the first-round responses and are only representative of the second-round Delphi responses.

Appliances

This section covers the following standards:

- Fed 31 Microwave Ovens
- Fed 38 Residential Clothes Washers
- Fed 36 Commercial Clothes Washers

Fed 31 Microwave Ovens

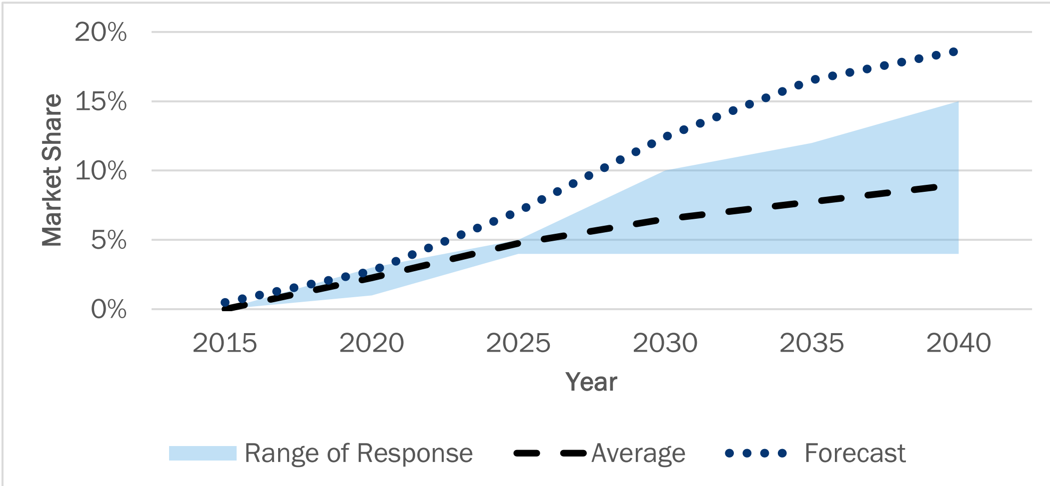
A summary of this standard for the NOMAD evaluation is shown in Table 161. The results are provided in Figure 29.

Table 161. Summary Table for Microwaves

Products Covered	Microwave-only ovens, countertop convection microwave ovens and built-in and over-the-range microwave ovens.
Standard Summary	The standard requires a microwave's standby power to be no more than 1 watt for countertop ovens and 2.2 watts for built-in and over-the-range ovens.
Priority	Medium Priority
# of Respondents – Round 1	4
# of Respondents – Round 2	4

NOMAD Results

Figure 29. Fed 31 Microwave Ovens



There was consensus among the survey respondents that the forecast adoption curve was aggressive, although the respondents slightly disagreed on the rate of adoption in the later years from 2030 to 2040. Respondents did not expect most manufacturers to improve microwave efficiency without standards, because there are no other market forces driving efficiency improvements. Some respondents noted that consumers may prefer microwaves with more features (e.g., internet connectivity or a brighter display), which may be more energy intensive than the current standby mode allowance.

Fed 38 Residential Clothes Washers

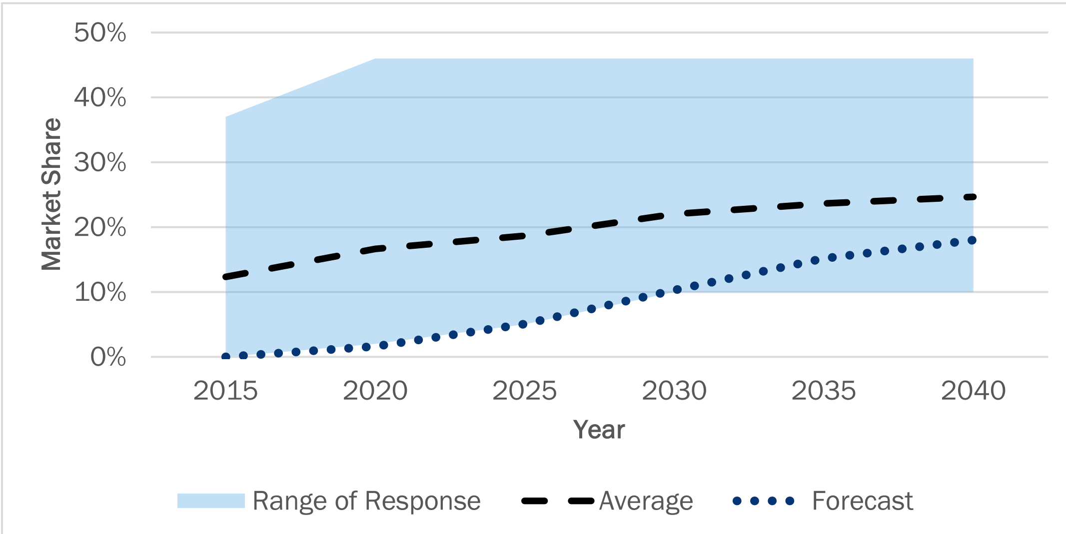
A summary of this standard for the NOMAD evaluation is provided in Table 162. The results are shown in Figure 30. Fed 38 Residential Clothes Washers.

Table 162. Summary Table for Residential Clothes Washers

Products Covered	Clothes washers for use in residential living areas.
Standard Summary	Amended standards for front-loading and top-loading residential clothes washers went into effect.
Priority	Medium Priority
# of Respondents – Round 1	3
# of Respondents – Round 2	3

NOMAD Results

Figure 30. Fed 38 Residential Clothes Washers



While some respondents believed that the forecast curve was accurate, one respondent believed that the naturally occurring adoption rate would be much higher. They claimed front-loading clothes washer market would be dominated by products meeting ENERGY STAR® criteria, which would lead to an increased market adoption of this equipment. Another respondent disagreed and noted “there is a strong tendency towards increased cycle times for high efficiency washing machines, which reduces product utility to consumers” and would consequently support a low adoption rate.

Fed 36 Commercial Clothes Washers

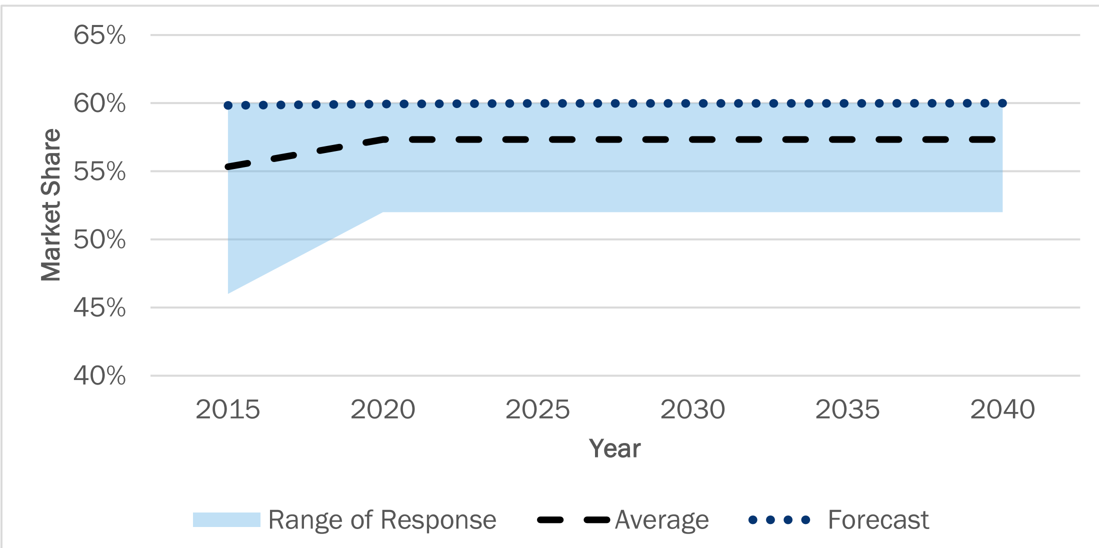
A summary of this standard for the NOMAD evaluation is provided in Table 163. The results are shown in Figure 31.

Table 163. Summary Table for Commercial Clothes Washers

Products Covered	Clothes washers for use in commercial settings with volumes under 4 cubic feet
Standard Summary	This new standard decreased minimum modified energy factor for top and front-loading washers and decreased maximum water factor for front-loading washers.
Priority	Low Priority
# of Respondents – Round 1	3
# of Respondents – Round 2	3

NOMAD Results

Figure 31. Fed 36 Commercial Clothes Washers



There was consensus among the respondents that the forecast adoption rate was reasonable. One respondent stated that unlike other consumer products "the energy efficiency savings will generally benefit the same entity that purchases the equipment." Therefore, commercial businesses may value energy savings more than individual consumers would when purchasing equipment.

Electronics

This section covers the following standards:

- Fed 29 External Power Supplies
- Std 31 Small Battery Chargers, Tier 3
- Std 42a Computers (workstations)
- Std 42b Computers (small-scale servers)

Std 31 Small Battery Chargers, Tier 3 (SBC)

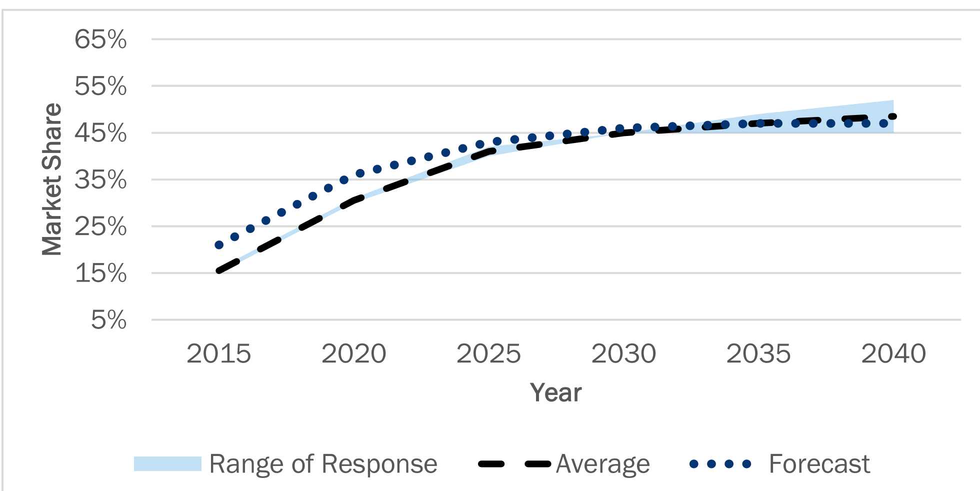
A summary of this standard for the NOMAD evaluation is provided in Table 164.

Table 164. Summary Table for Small Battery Chargers

Products Covered	Small battery charger systems, such as two-way radios, handheld barcode scanners, electronic calibration equipment and golf-cart chargers
Product Summary	This new standard mandated a maximum annual energy consumption in kilowatt hours per year (kWh/year) as a function of battery energy.
Priority	Medium/Low Priority
# of Respondents – Round 1	2
# of Respondents – Round 2	2

NOMAD Results

Figure 32. Std 31 Small Battery Chargers, Tier 3



The respondents all converged their adoption curves upon seeing the average of the round one curve. Furthermore, the consensus opinion hewed closely to the forecast curve (Figure 32). Some respondents expected natural market adoption of these efficient small battery chargers to increase as non-lithium competition is retired from the market. One respondent noted that non-lithium battery manufacturers are currently able to "cheat" the test procedure by not fully charging during the float stage, and therefore falsely demonstrate the adoption of the standard.

Std 42 Computers

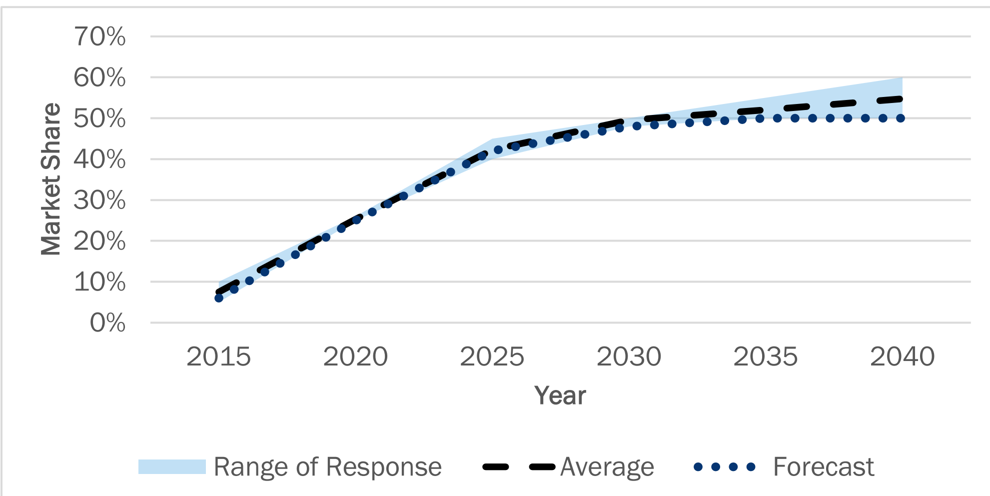
A summary of this standard for the NOMAD evaluation is provided in Table 165.

Table 165. Summary Table for Computers

Products Covered	Small-scale servers and workstations
Standard Summary	This standard establishes an internal power-supply unit energy requirement and a maximum power consumption requirement.
Priority	Low Priority
# of Respondents – Round 1	4
# of Respondents – Round 2	4

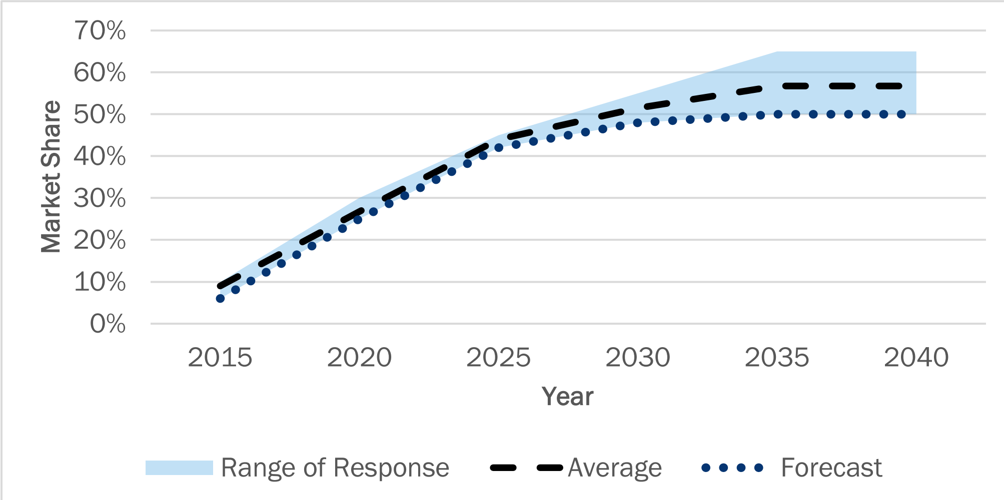
NOMAD Results

Figure 33. Std 42a Computers (Workstations)



Most respondents' answers were similar to the forecast values and the majority of the respondents slightly modified their round one curves to match that of the group (Figure 33). There was general agreement among the respondents that computer components are gradually becoming more efficient over time to meet design challenges of heat management. The respondents also expected components to become less expensive over time.

Figure 34. Std 42b Computers (Small-scale Servers)



The respondents agreed that the forecast curve was relatively accurate and there was minor variability in the responses (Figure 34). Some respondents believed that computer components are becoming more efficient and cheaper by way of the market, enabling high market adoption of efficient servers. Another respondent believed the excess heat created by inefficient power supply units would motivate rebate programs and incentives to promote efficient products.

Fed 29 External Power Supplies (EPS)

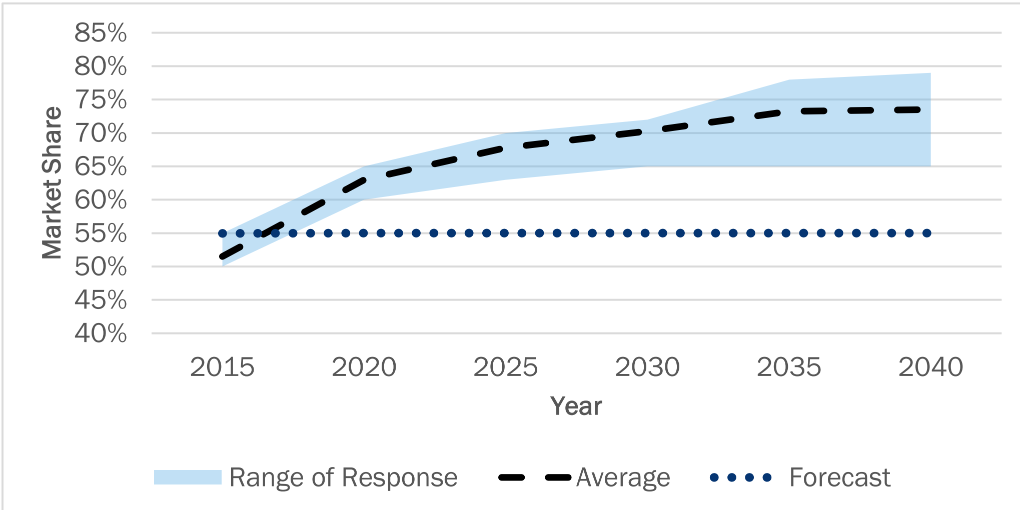
A summary of this standard for the NOMAD evaluation is provided in Table 166. The results are shown in Figure 35.

Table 166. Summary Table for External Power Supplies

Products Covered	External Power Supplies
Standard Summary	This new standard set a minimum efficiency during active mode and a maximum power consumption during no-load mode for both Class A and non-class External Power Supplies (EPS).
Priority	High Priority
# of Respondents – Round 1	4
# of Respondents – Round 2	4

NOMAD Results

Figure 35. Fed 29 External Power Supplies



All respondents agreed that the naturally occurring adoption rate will increase over time as opposed to the forecast curve that stays constant at a market share of 55% (Figure 35). Some respondents suggested that manufacturers would naturally incorporate more efficient components to meet design challenges of heat management while responding to market demands for faster charging and smaller devices. Others mentioned emerging consumer demand for USB Power Delivery EPSs will lead to high market adoption of EPSs at this efficiency level. One respondent remarked that "the active components in power supplies are becoming cheaper while passives are increasing in price. Over time, that will lead to more efficient active components displacing passives, hence lowering cost and increasing efficiency."

Commercial HVAC and Refrigeration Equipment

This section covers the following standards:

- Fed 35 Walk-In Coolers and Freezers
- Fed 39 Commercial CAC and HP (65-760 kBtu/hr), Tier 1
- Fed 34 Commercial Refrigeration Equipment
- Fed 41 Commercial Icemakers
- Fed 32 Commercial CAC and HP (<65 kBtu/hr)

Fed 32 Commercial Package Air Conditioners and Heat Pumps, <65,000 Btu/hour

A summary of this standard for the NOMAD evaluation is provided in Table 167. The results are shown in Figure 36.

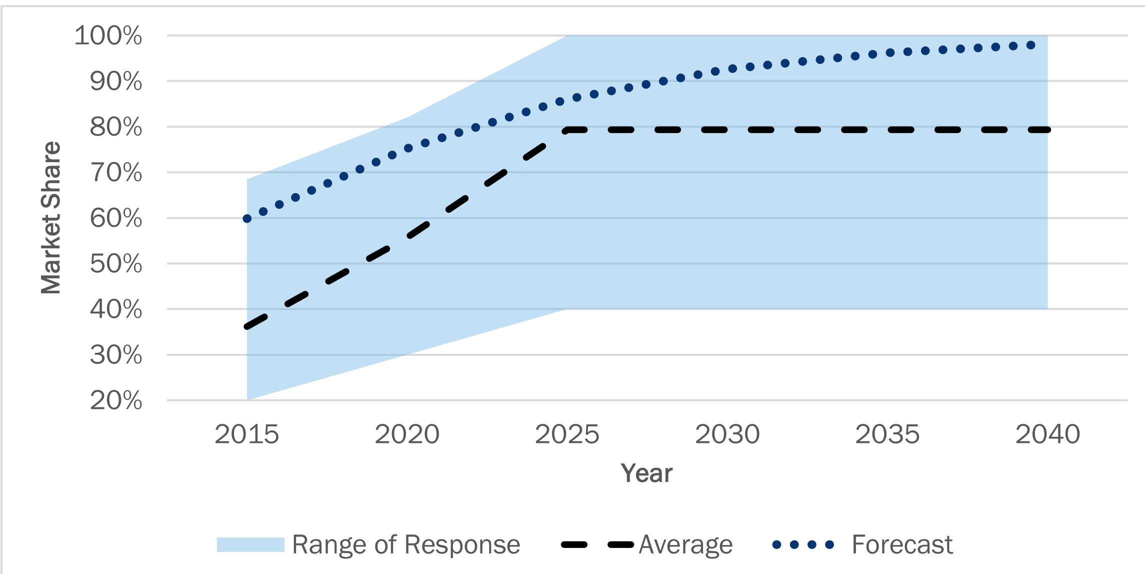
Table 167. Summary Table for Commercial Air Conditioners and Heat Pumps, <65,000 Btu/hour, small

Products Covered	Commercial Package Air Conditioners and Heat Pumps (less than 65,000 Btu/hour cooling capacity)

Standard Summary	This new standard increased energy conservation standards for commercial packaged A/C and HP units with cooling capacities less than 65 kBtu. This change aligns the standard with ASHRAE 90.1-2013.
Priority	Low Priority
# of Respondents – Round 1	4
# of Respondents – Round 2	3

NOMAD Results

Figure 36. Fed 32 Commercial CAC and HP (<65 kBtu/hr)



While the survey respondents disagreed on the exact adoption curve, most respondents agreed that the forecast curve overestimated the market adoption. Some respondents remarked that there is little incentive for property owners and tenants to invest in this equipment given other cost concerns in building or managing a building. Some respondents mentioned that states would likely adopt evolving ASHRAE Standard 90.1 in the absence of federal equipment efficiency regulations. Some expected economic benefits in total life-cycle costs and falling prices over time to lead to more consumer purchases.

Fed 34 Commercial Refrigeration Equipment

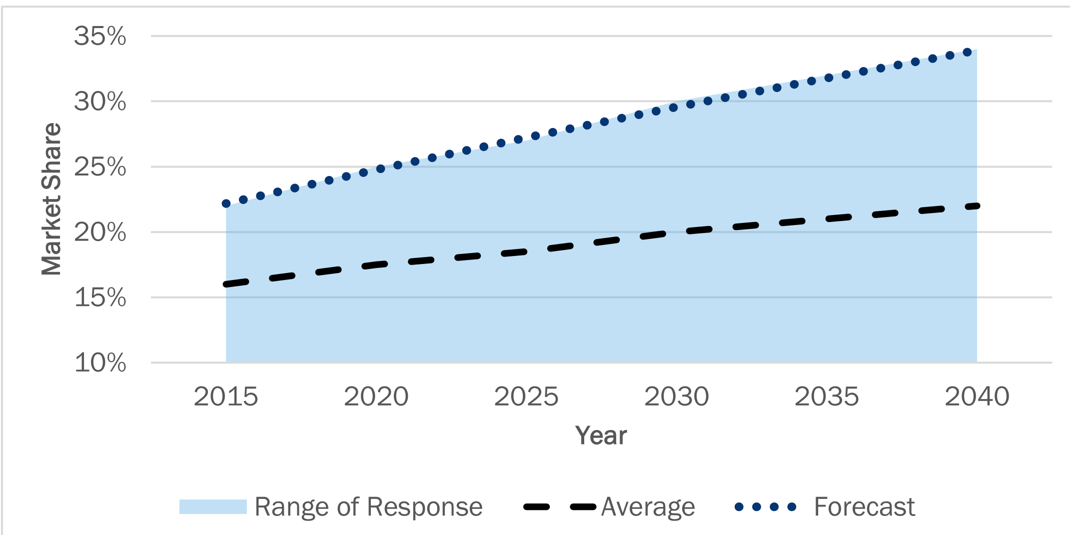
A summary of this standard for the NOMAD evaluation is provided in Table 168. The results are shown in Figure 37.

Table 168. Summary Table for Commercial Refrigeration Equipment

Products Covered	Commercial Reach-in Refrigerators and Freezers
Standard Summary	This updated standard added new equipment classes and increased stringency for some of the existing classes.
Priority	Medium Priority
# of Respondents – Round 1	3
# of Respondents – Round 2	2

NOMAD Results

Figure 37: Fed 34 Commercial Refrigeration Equipment



Survey respondents disagreed about the sensitivity of customers to upfront costs. Some believed that customers would not be willing to pay higher initial prices for more efficient equipment and suggested a lower NOMAD rate. Others predicted a higher rate and believed that the energy intensiveness of CRE encourages life-cycle economic calculations that favor energy-efficient equipment regardless of standards. One respondent claimed that "efficiency is a very distant consideration" and believed that there would be no naturally occurring market adoption.

Fed 35 Walk-in Coolers and Freezers

A summary of this standard for the NOMAD evaluation is provided in Table 169. The results are shown in Figure 38.

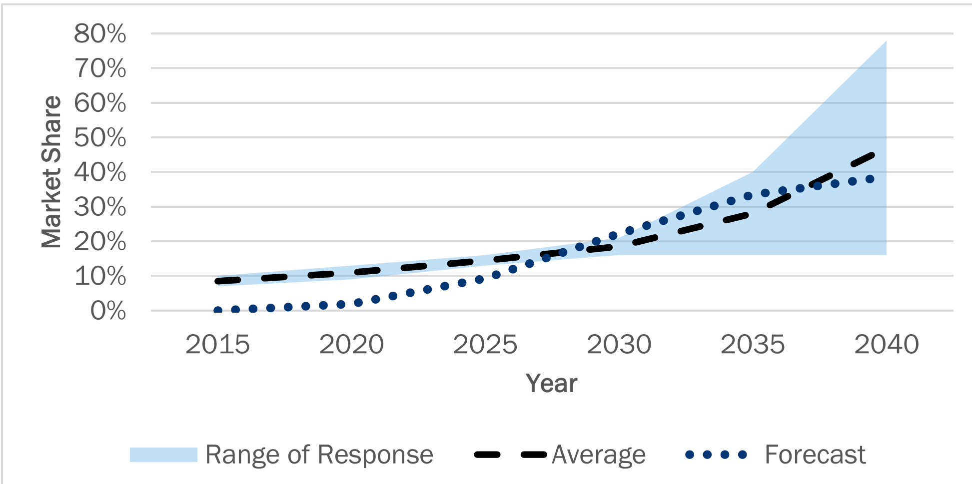
Table 169. Summary Table for Walk-in Coolers and Freezers

Products Covered	Display doors and dedicated condensing units for refrigerators (medium temperature)

Standard Summary	This new standard set separate performance standards for walk-in box components and refrigeration components. It also updated the standards for medium temperature dedicated condensing units and for cooler and freezer doors.
Priority	High Priority
# of Respondents – Round 1	3
# of Respondents – Round 2	2

NOMAD Results

Figure 38. Fed 35 Walk-In Coolers and Freezers



Some respondents suggested incentives in the market are more understated than in the forecast projections. Another respondent mentioned that the energy intensiveness of WICF encourages life-cycle economic calculations that would favor energy-efficient equipment, leading to a higher rate of market adoption than that estimated by the CA IOUs. One respondent thought that the IOU market share estimates appeared to be incorrectly extrapolated from DOE data, and thus too low. This respondent recalculated the market share based on other DOE data regarding shipments and savings.

Fed 39 Commercial Air Conditioners and Heat Pumps, 65,000–760,000 Btu/hour, Tier 1

A summary of this standard for the NOMAD evaluation is provided in Table 170. The results are shown in Figure 39.

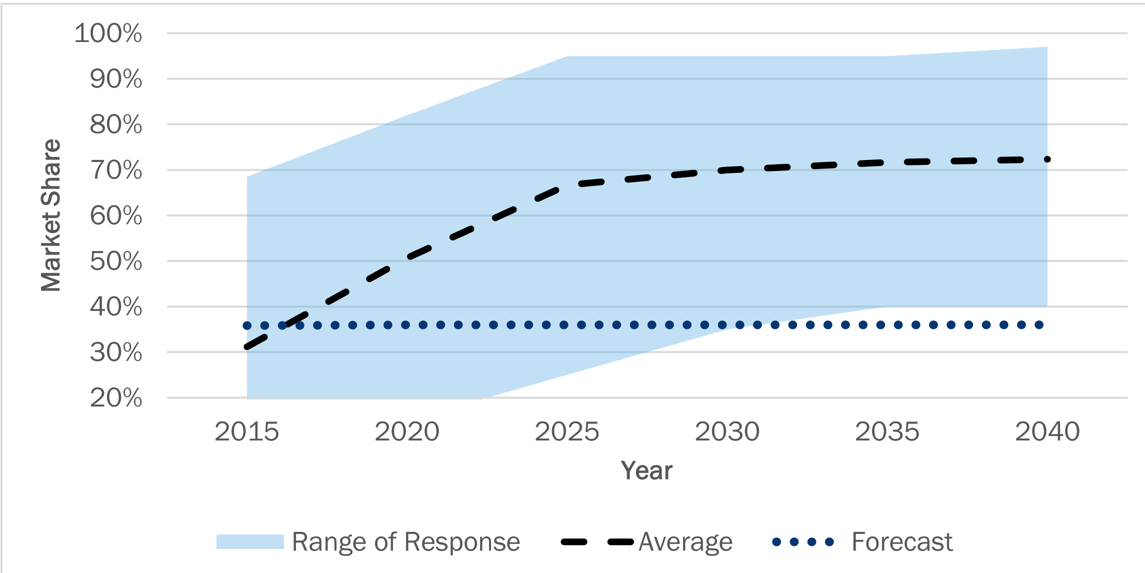
Table 170. Summary Table for Commercial Air Conditioners and Heat Pumps – 65,000-760,000 Btu/hour, Tier 1

Products Covered	Commercial Package Air Conditioners (AC) and Heat Pumps (HP) between 65,000 and 760,000 Btu/hour cooling capacity
Standard Summary	This standard updates the energy efficiency requirements for commercial packaged A/C and HP units with cooling capacities between 65 kBtu and 760 kBtu. This update aligns the standard with the ASHRAE 90.1 2013 tier 1 standards.
Priority	High Priority
# of Respondents – Round 1	4

# of Respondents – Round 2	3

NOMAD Results

Figure 39. Fed 39 Commercial CAC and HP (65-760 kBtu/hr), Tier 1



There was disagreement among the respondents in the predictions of the adoption curves. Some respondents mentioned that states would likely adopt evolving ASHRAE Standard 90.1 in the absence of federal equipment efficiency regulations. However, others believed there would be no natural increase in market share of this equipment, believing that ASHRAE 90.1 would not increase HVAC efficiency levels without corresponding DOE rulemakings. Some expected economic benefits in total life-cycle costs and falling prices over time to lead to more consumer purchases.

Fed 41 Commercial Icemakers

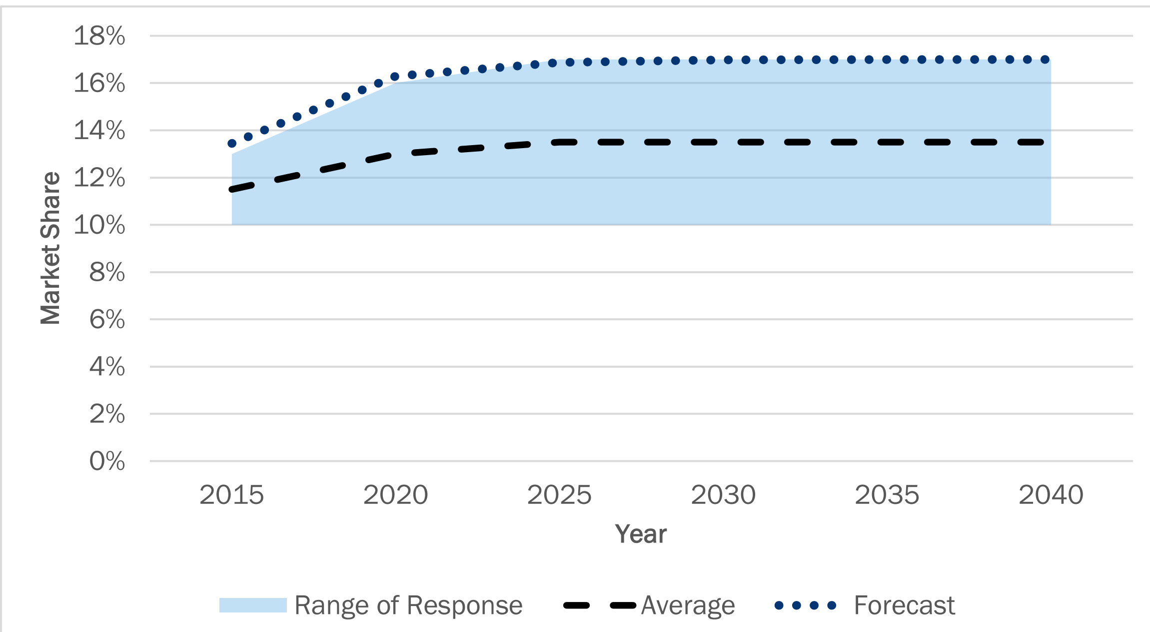
A summary of this standard for the NOMAD evaluation is provided in Table 171. The results are shown in Figure 40.

Table 171. Summary Table for Commercial Icemakers

Product Covered	Commercial Icemakers
Product Summary	This new standard increased stringency for batch-type icemakers and expanded the scope to include larger capacity equipment and new equipment types. It also expanded coverage to include continuous icemakers.
Priority	Low Priority
# of Respondents – Round 1	3
# of Respondents – Round 2	2

NOMAD Results

Figure 40: Fed 41 Commercial Icemakers



Survey respondents recommended a lower natural rate of market adoption than the forecast estimates because commercial customers of icemakers tend to operate on short planning windows that favor short-term consideration of upfront costs over life-cycle cost calculations.

Commercial and Industrial Equipment

This section covers the following standards:

- Fed 30 Electric Motors
- Fed 28 Distribution Transformers

Fed 28 Distribution Transformers

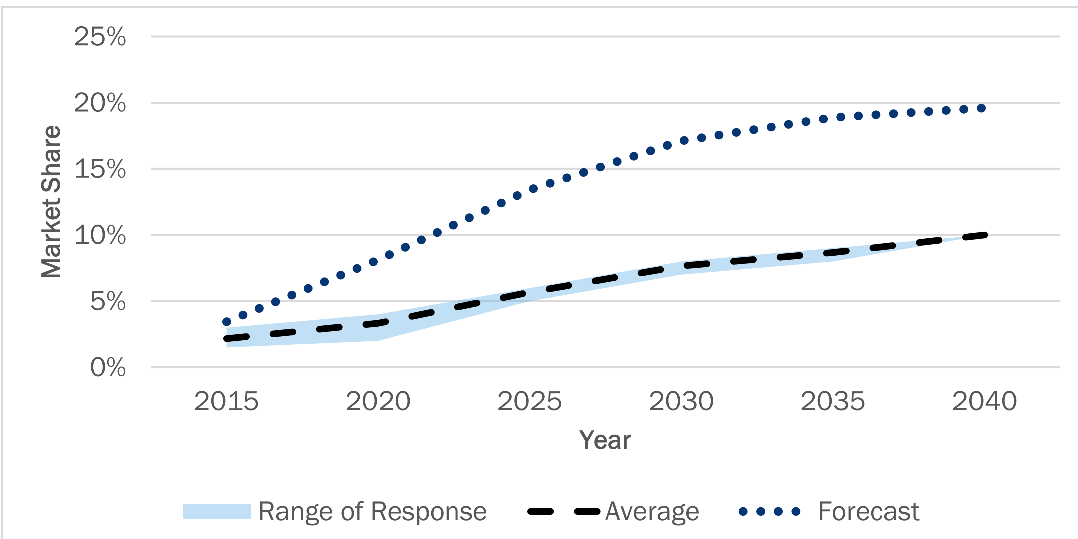
A summary of this standard for the NOMAD evaluation is provided in Table 172.

Table 172. Summary Table for Distribution Transformers

Products Covered	Low and medium voltage dry-type and medium voltage distribution transformers
Standard Summary	The new standard increases the stringency of efficiency requirements for Low-Voltage Dry-Type (LVDT) and Medium-Voltage Dry-Type (MVDT) distribution transformers from the baseline level of the 2010 Federal standards.
Priority	Medium Priority
# of Respondents – Round 1	3
# of Respondents – Round 2	3

NOMAD Results

Figure 41. Fed 28 Distribution Transformers



Respondents agreed with one another and predicted lower market adoption than the forecast estimates (Figure 41). Most respondents noted that purchasers are very sensitive to first cost and would likely pass on the higher operating costs of inefficient transformers to ratepayers.

Fed 30 Electric Motors

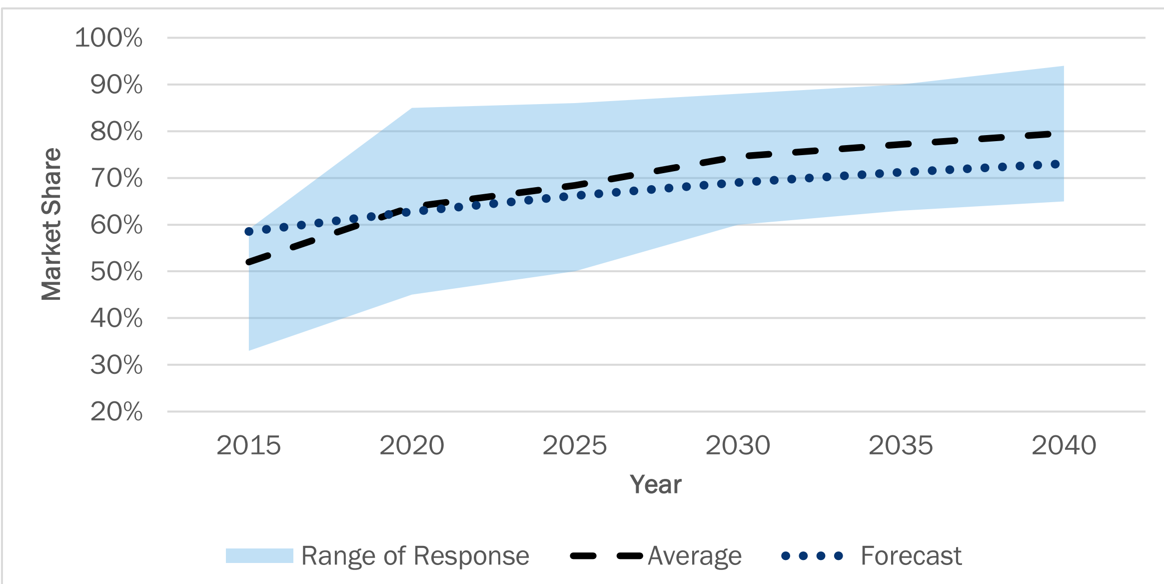
A summary of this standard for the NOMAD evaluation is provided in Table 173.

Table 173. Summary Table for Electric Motors

Products Covered	Electric Motors
Standard Summary	The new standard increases the stringency of efficiency requirements for electric motors and additionally covers new product classes. The new standard regulates NEMA designs A, B, and C and aligns the federal motor power efficiency standards to that of NEMA Premium efficiency.
Priority	High Priority
# of Respondents – Round 1	5
# of Respondents – Round 2	5

NOMAD Results

Figure 42. Fed 30 Electric Motors



The respondents in general believed the naturally occurring market adoption rate is similar to the one proposed by the IOUs (Figure 42). Some respondents believed that the uptake on efficient motors would be very slow without regulatory support. However, others mentioned that there is innovation on the manufacturer side that will push market adoption further.

Lighting

This section covers the following standards:

- Std 39 General Service Lamps
- Std 40 Small Diameter Directional Lamps

- Fed 37 General Service Fluorescent Lamps
- Fed 33 Metal Halide Lamp Fixtures
- Std 41a General Service LED Lamps, Tier 1
- Std 38 Dimming Fluorescent Ballasts

Std 38 Dimming Fluorescent Ballasts (DFBs)

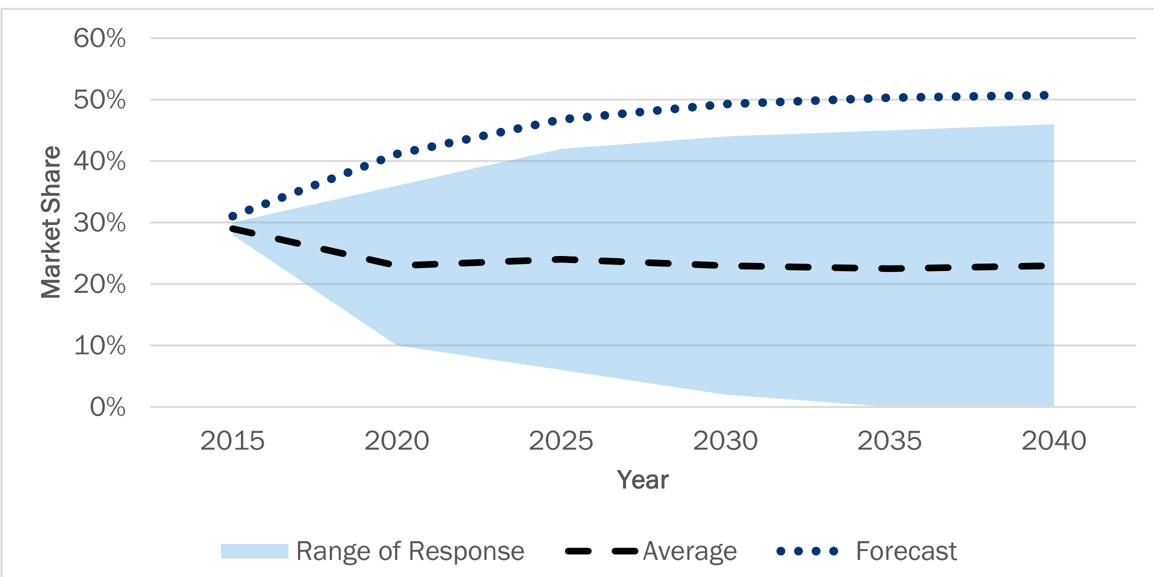
A summary of this standard for the NOMAD evaluation is shown in Table 174.

Table 174. Summary Table for Dimming Fluorescent Ballasts

Products Covered	Deep-dimming ballasts (ballasts that dim below 50% of max output) designed to operate fluorescent lamps
Standard Summary	The standard sets requirements for maximum standby power consumption, power factor and minimum weighted ballast luminous efficacy.
Priority	Low Priority
# of Respondents – Round 1	2
# of Respondents – Round 2	2

NOMAD Results

Figure 43. Std 38 Dimming Fluorescent Ballasts



The respondents noted there would be little or no investment in this type of product and expect the market to naturally phase it out. However, there was disagreement surrounding the final market share values (see Figure 38). One respondent agreed with the forecast value, while another believed that there would be no market share by 2040.

Std 39 General Service Lamps (GSLs)

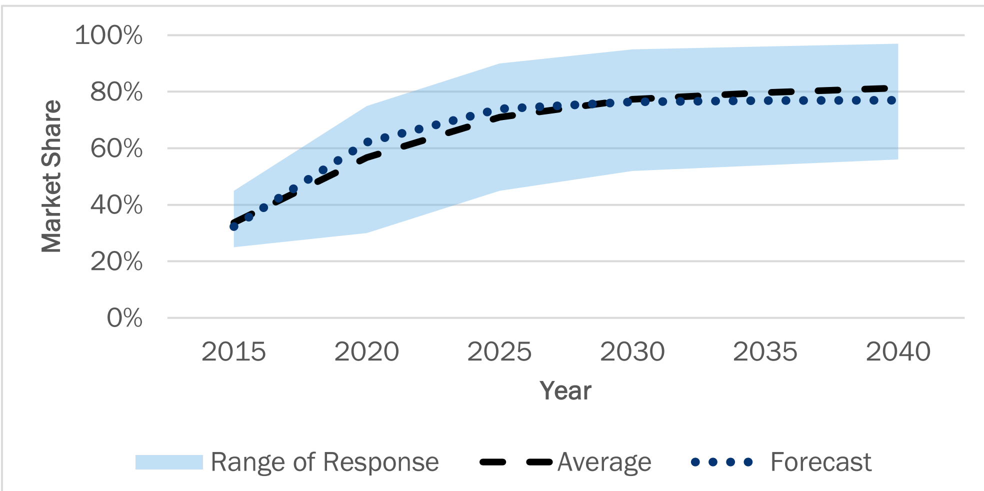
A summary of this standard for the NOMAD evaluation is provided in Table 175.

Table 175. Summary Table for General Service Lamps

Products Covered	General service incandescent, halogen, compact fluorescent (CFL), and LED lamps
Standard Summary	California implemented the Federal 45 lumens per watt (lpw) standard for general service lamps with an accelerated effective date.
Priority	High Priority
# of Respondents – Round 1	3
# of Respondents – Round 2	3

NOMAD Results

Figure 44. Std 39 General Service Lamps



The survey responses showed a relatively high adoption rate, in agreement with the forecast curve (Figure 44). Respondents suggested this technology would be favored in the market due to its competitiveness in performance compared to other bulbs on the market. Another remarked that “a good portion of this is market-driven, not standards-driven” and therefore expects the technological improvements will drive higher adoption.

Std 40 Small Diameter Directional Lamps (SDDLs)

A summary of this standard for the NOMAD evaluation is provided in Table 176.

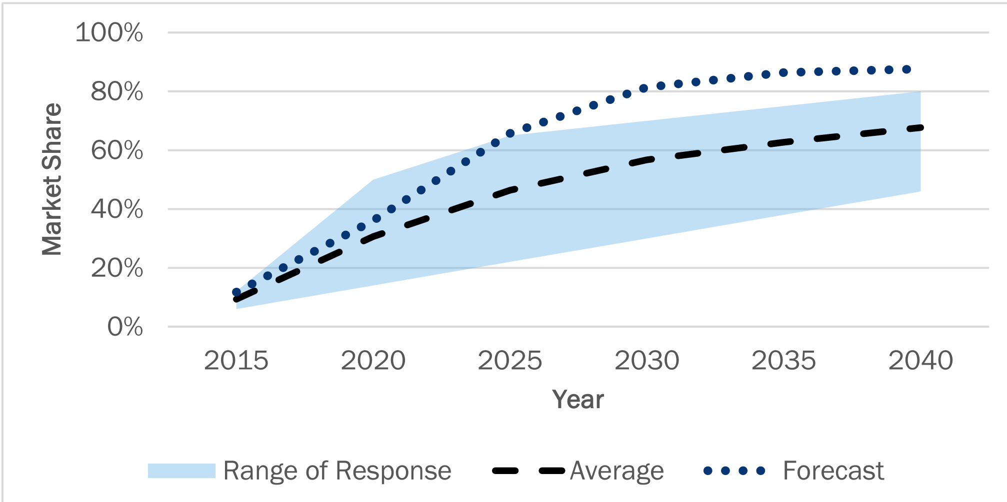
Table 176. Summary Table for Small Diameter Directional Lamps

Products Covered	Directional lamps with a diameter of 2.25 inches or smaller and pin or medium (E26) bases
Standard Summary	The standard establishes a minimum rated lifetime requirement of 25,000 hours and requires either: (1) an efficacy of at least 80 lumens per watt; or (2) an efficacy of at least 70 lumens per watt (lpw) and a CRI of at least 95.
Priority	High Priority

# of Respondents – Round 1	3
# of Respondents – Round 2	3

NOMAD Results

Figure 45. Std 40 Small Diameter Directional Lamps



Respondents generally believed that the market adoption rates are slightly lower than the forecast estimates (Figure 45). One respondent stated that the "transition will slow in the future as current technical limitations limit lumen output." Another claimed that the SDDLs are "the least technologically resolved category at the moment." Without standards in place, manufacturers would not have an incentive to overcome these challenges in product design.

Std 41a General Service LED Lamps, Tier 1

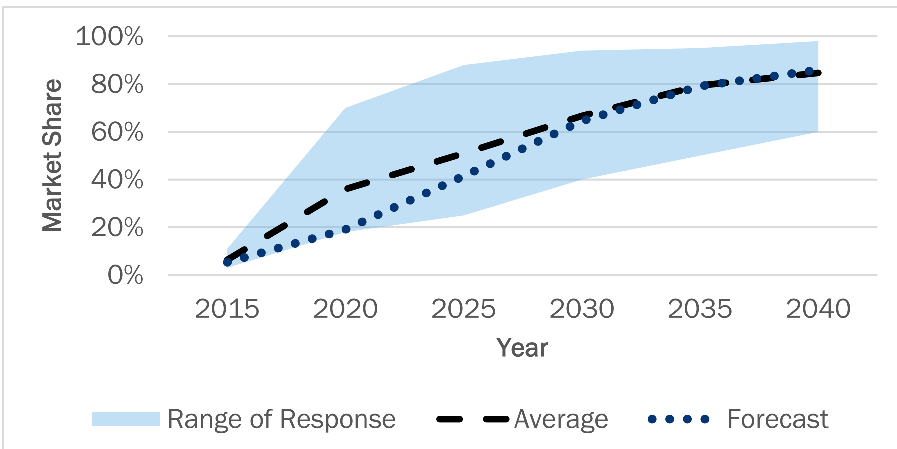
A summary of this standard for the NOMAD evaluation is provided in Table 177.

Table 177. Summary Table for General Service LED Lamps, Tier 1

Products Covered	Omnidirectional, directional, and decorative LED lamps
Standard Summary	The standard establishes a minimum efficacy standard of 68 lumens per watt and requires a minimum compliance score of 282 (compliance score is equal to the sum of efficacy and 2.3 times the CRI of a lamp) in addition to other quality metrics noted below.
Priority	Medium Priority
# of Respondents – Round 1	3
# of Respondents – Round 2	3

NOMAD Results

Figure 46. Std 41a General Service LED Lamps, Tier 1



Most respondents predicted that the efficient general service LED lamps will quickly gain market share to almost 100% by 2040 (Figure 46). The respondents believed "stringent CA regulations are inhibiting adoption by requiring specially-designed, more expensive products which limit consumer choice" and would hamper market adoption. Some respondents were certain the market would show strong adoption of these LEDs in absence of the standard.

Fed 33 Metal Halide Lamp Fixtures (MHLFs)

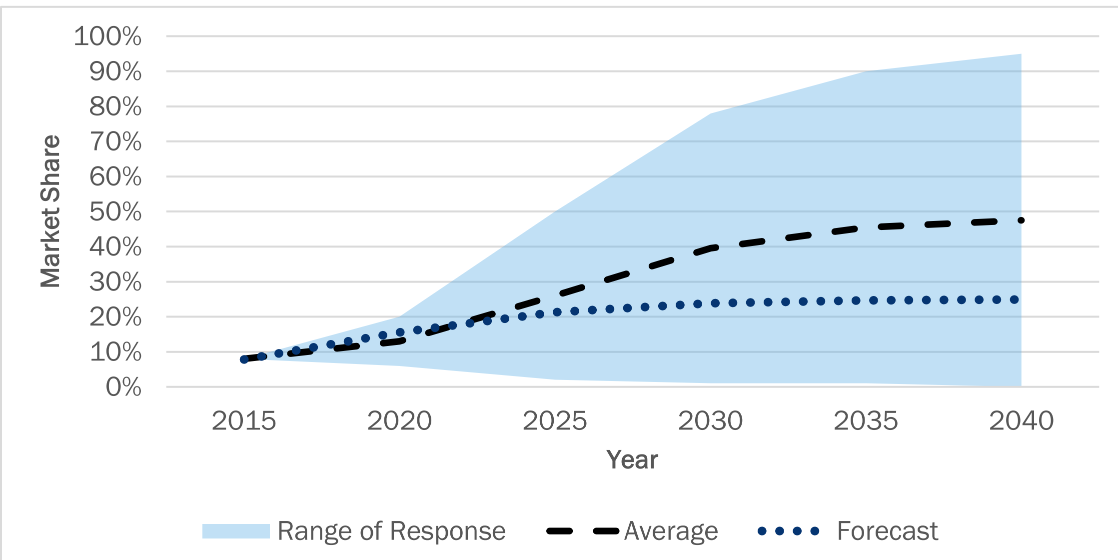
A summary of this standard for the NOMAD evaluation is provided in Table 178. The results are shown in Figure 47.

Table 178. Summary Table for Metal Halide Lamp Fixtures

Products Covered	Ballasts designed to operate metal halide lamps between 50–150 watts and 500–1000 watts
Standard Summary	The standard adopts a required minimum efficiency, defined as the ratio between the lamp operating wattage and ballast input wattage, for metal halide lamp ballasts.
Priority	Medium Priority
# of Respondents – Round 1	2
# of Respondents – Round 2	2

NOMAD Results

Figure 47. Fed 33 Metal Halide Lamp Fixtures



The respondents noted there would be little or no investment in this type of product and expect the market to naturally phase metal halide lamp fixtures out. However, there was disagreement among the experts surrounding the final market share value. One respondent claimed that the metal halide lamp fixtures will almost completely adopt the efficient technology in future, while another believed there would be no adoption of the efficient technology by 2040.

Fed 37 General Service Fluorescent Lamps (GSFLs)

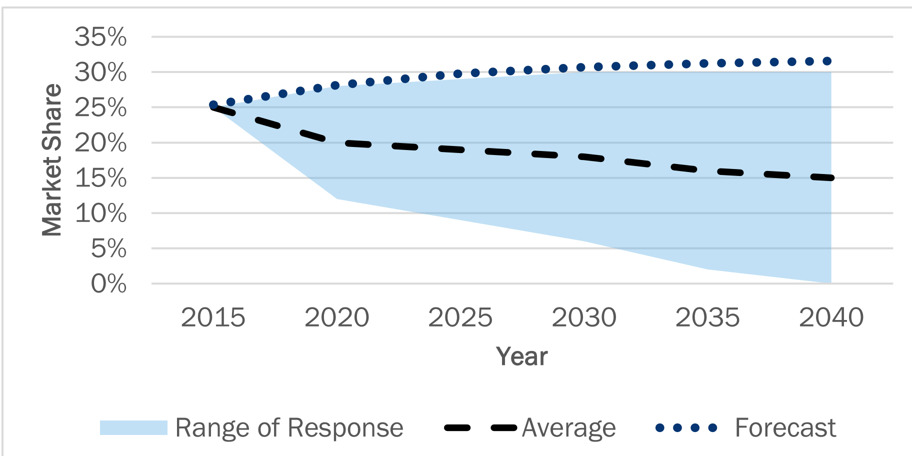
A summary of this standard for the NOMAD evaluation is provided in Table 179. The results are shown in Figure 48.

Table 179. Summary Table for General Service Fluorescent Lamps

Products Covered	4-foot and 8-foot tubular fluorescent lamps and 2-foot U-shaped fluorescent lamps designed for general service applications
Standard Summary	The standard increases the stringency of existing efficacy (lumens per watt) standards for common types of general service fluorescent lamps.
Priority	Medium Priority
# of Respondents – Round 1	2
# of Respondents – Round 2	2

NOMAD Results

Figure 48. Fed 37 General Service Fluorescent Lamps



One expert agreed with the forecast curve, while another believed that there would be no market share of the product by 2040. The respondents noted there would be little or no investment in this type of product and expect the market to naturally phase these lamps out.

Plumbing

This section covers the following standards:

- Std 33a-g Faucets
- Std 34a-b Showerheads
- Std 35a-b Toilets
- Std 36 Urinals

Std 33a-g Faucets, Lavatory and Kitchen

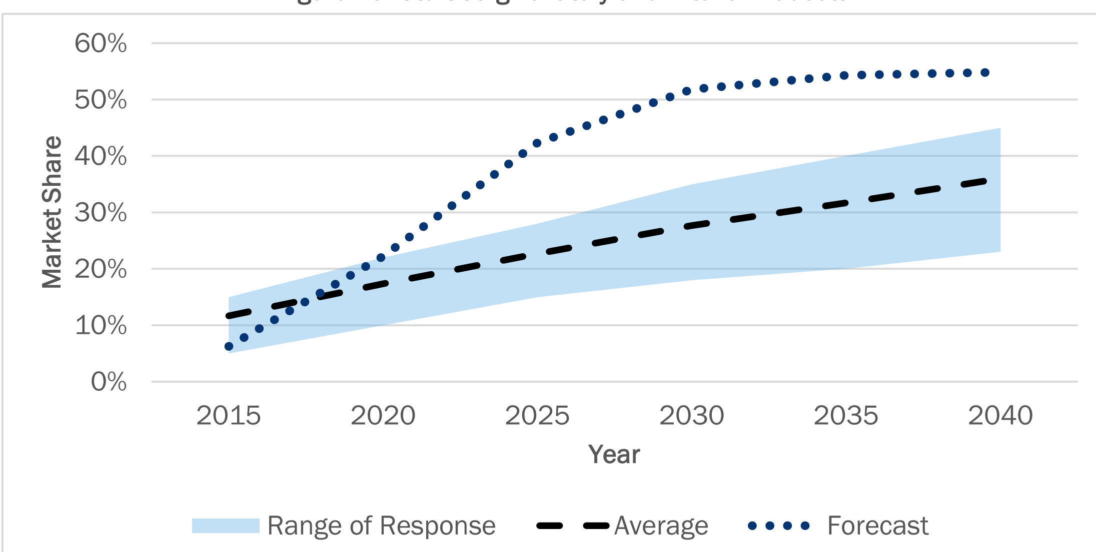
A summary of this standard for the NOMAD evaluation is provided in Table 180.

Table 180. Summary Table for Faucets

Products Covered	Residential Lavatory Faucets, Public Lavatory Faucets, and Kitchen Faucets
Standard Summary	The standard lowers the maximum allowable flow rate of faucets offered for sale after the effective date.
Priority	Medium/Low Priority
# of Respondents – Round 1	3
# of Respondents – Round 2	3

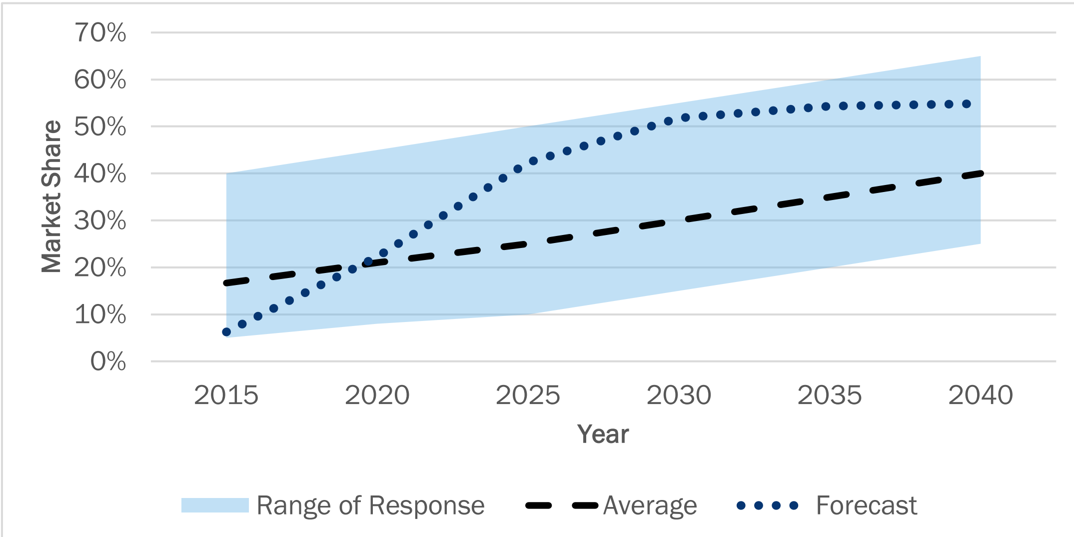
NOMAD Results

Figure 49. Std 33a-g Lavatory and Kitchen Faucets



The respondents all agreed that the forecast adoption curve was overly aggressive in their estimate of market share in the future years (Figure 49). Though there was consensus on the shape of the adoption curve, the respondents offered differing views on the cause of adoption. One respondent explained that there is little incentive for consumers to pursue water-efficient appliances, while another disagreed and stated that "consumers are pursuing 'greener' products as consumer awareness and belief in climate change and overall impact takes more of a center stage. Lower flow rates/flush volumes is an easy way for consumes to feel like they're making a difference that doesn't require any behavior change." Other respondents claimed housing growth or other states adopting water efficiency standards were the primary drivers of adoption.

Figure 50. Std 33a-g Public Lavatory Faucets



While most respondents believed the forecast estimates were slightly aggressive, one respondent believed that the market share of public lavatory faucets in 2015 was much higher than the 6% forecast value (see Figure 50). The respondent claimed that the 0.5 gpm is the status quo for public lavatory faucets in California because this was required by the California plumbing code prior to the 2016 standard being established, although the previous plumbing code was not strictly enforced. The respondent noted that "it is likely that as drought or water scarcity issues persisted, code enforcement would have gotten stronger." Others noted that in the absence of standards, manufacturers would make faucets exceeding 0.5 gpm and purchasers would not seek out more efficient options.

Std 34a-d Showerheads

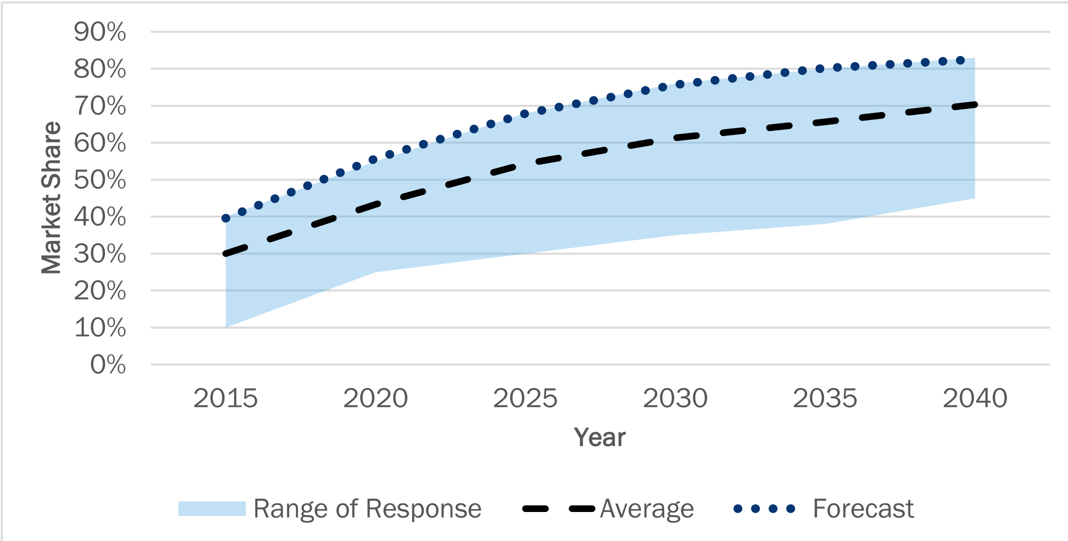
A summary of this standard for the NOMAD evaluation is provided in Table 181. The results are shown in Figure 51.

Table 181. Summary Table for Showerheads

Product Covered	Residential Showerheads
Product Summary	This standard took effect in two stages, or tiers. The Tier 1 standard lowered the maximum allowable flow rate to 2.0 gpm for showerheads manufactured between July 1, 2016 and July 1, 2018. The Tier 2 standard lowered the maximum allowable flow rate to 1.8 gpm for showerheads manufactured on or after July 1, 2018.
Priority	Medium Priority (Tier 1); Low Priority (Tier 2)
# of Respondents – Round 1	3
# of Respondents – Round 2	3

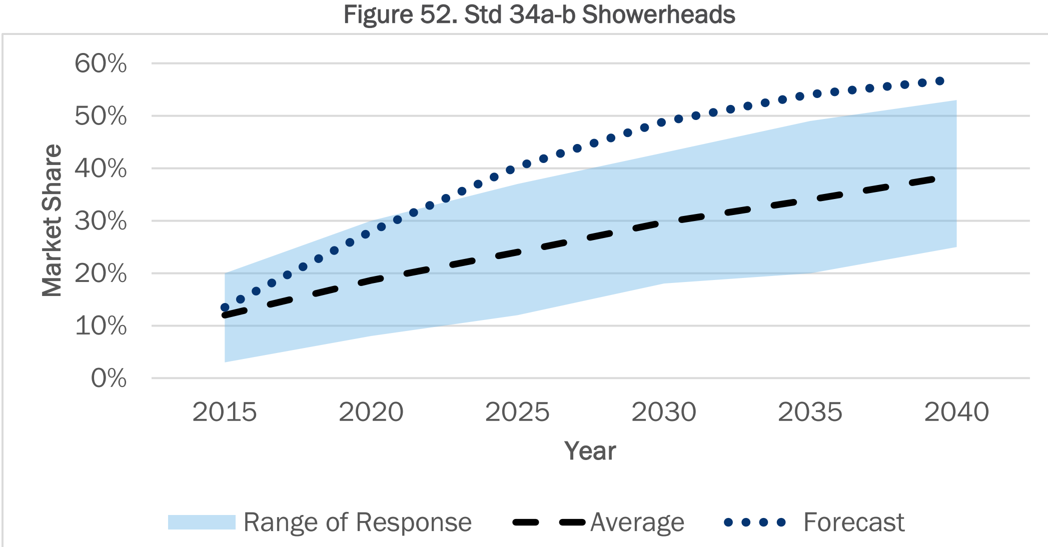
NOMAD Results

Figure 51. Std 34a-b Showerheads



While there was some consensus that the forecast curve looked reasonable, one respondent thought that that consumers' desire for high volume showerheads would slow down natural market adoption in California in the absence of standards. Others believed that 2.0 gpm showerheads would gain market share in the U.S. overall due to other states adopting requirements.

Figure 52. Std 34a-b Showerheads



The respondents generally believed that the true adoption curve sits below the IOUs' estimates (Figure 52). Some respondents believed water scarcity concerns would drive natural market adoption. Others suggested that housing construction and consumer desires for high volume showerheads would disincentivize natural market adoption. The respondent with the least aggressive adoption curve argued that showerhead manufacturers "would not make a 1.8 gpm product if not required" based on his experience on attending multiple codes and standards meetings.

Std 35a-b Toilets – Residential

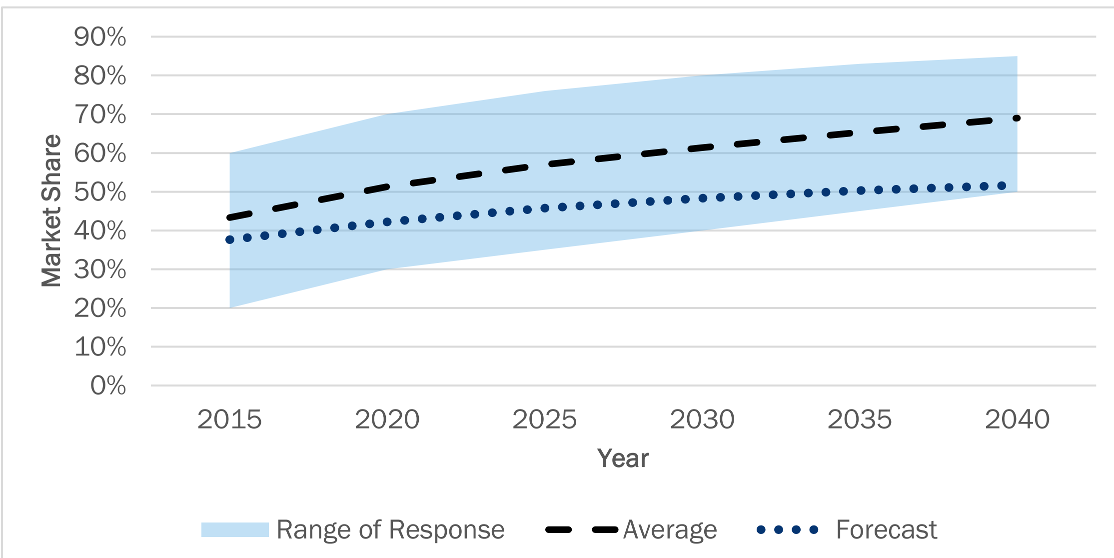
A summary of this standard for the NOMAD evaluation is provided in Table 182.

Table 182. Summary Table for Toilets

Products Covered	Residential toilets
Standard Summary	The standard lowered the maximum allowable water consumption of all toilets sold or offered for sale on or after the effective date to 1.29 gallons per flush.
Priority	Low Priority
# of Respondents – Round 1	3
# of Respondents – Round 2	3

NOMAD Results

Figure 53. Std 35a-b Toilets



Most respondents believed that the adoption rate for toilets would be slightly higher than the forecast estimates (Figure 53). Some respondents cited the housing market as the main driver for market adoption of this product. One suggested that other states' adoption of higher standards would make efficient appliances prevalent in the market, while others suggested that toilets' function requires a significant amount of water, which would slow down market adoption of lower-flow products.

Std 36 Urinals – Commercial

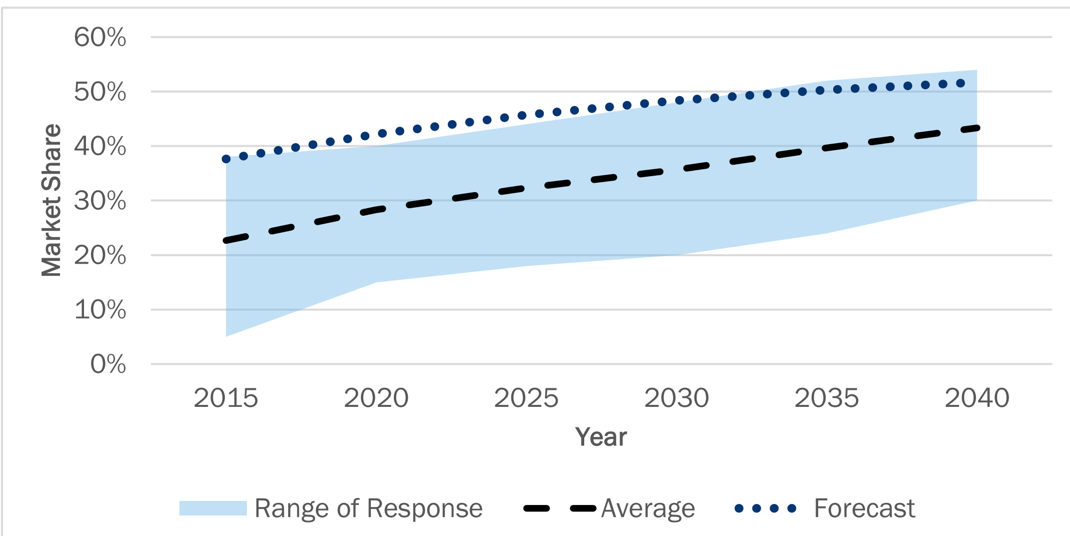
A summary of this standard for the NOMAD evaluation is provided in Table 183.

Table 183. Summary Table for Urinals

Products Covered	Urinals
Standard Summary	The standard lowered the maximum allowable water consumption of all non-trough type urinals sold or offered for sale on or after January 1, 2016 and set new stringent standards for wall-mounted urinals.
Priority	Low Priority
# of Respondents – Round 1	3
# of Respondents – Round 2	3

NOMAD Results

Figure 54. Std 36 Urinals



Water conservation concerns would drive market adoption, according to some respondents (see Figure 54). Some respondents believed there would be little market incentive to grow the market share of water efficient urinals. The respondent with the least aggressive adoption curve claimed that “urinals are expensive to replace” and “issues of drain line carry, clogging, smell, etc. would not be worth it if it is not required.”

Appendix H. Response to IOU Comments

In Table 184 we address questions and comments from the IOU review team.

Table 184: Evaluator response to IOU comments

IOU Comment	Page	Eval response
"Legally", rather than "technically?"	2	We agree with this distinction and the sentence has been edited. The original intent was that while it may not be legal to sell a non-compliant product, technically many products may still be available for purchase.
I believe this should be Figure 2	2	Yes. Thank you. The figure numbering has been adjusted throughout the report
Please note, at least in a footnote, that you did no independent measurement/assessment of actual energy usage of individual product performance. Consequently, the evaluated products without certification information were assumed to meet the previous standard level or market baseline, thereby yielding no savings. Also note that this has the effect of providing a downward bias on savings since the products may have been more efficient than the previous code or the market baseline.	2	Footnote added on testing. See answer to comment for p.26 (below). It's true that we did not conduct independent measurements on products, and it's true that we assumed non-compliant products had zero savings. It is possible that some of these non-compliant products exceeded the prior baseline level, but I don't see how we can claim that the standard influenced those savings.
I have not commented on this section within the Summary, but comments later in the text might impact this section. That said, please consider showing the total State and federal appliance standards savings for the three years, i.e., include not only the evaluated savings, but also State and federal appliance standards savings for 2016-18 that were previously evaluated.	6	The summary table has been updated to include previously evaluated standards
Isn't this what CADMUS proposed via the ISSM model?	7	CADMUS proposed it, but it never came to full fruition. The ISSM version used in this evaluation includes data and formatting to develop net savings and generate output for cost-effectiveness in CET input format.
You may want to consider adding a brief description of each sub-program since many readers may not be aware of what is the purview of each sub-program.	8	We have added images of products covered by the standards and included basic descriptions in some cases. These are provided in Appendix E. Potential Savings
Please include source note.	8	Source added in report body
Please include source note.	9	Source added in report body
Please consider adding a bit more detail in the description of each standard, how they save energy, sectors covered, etc.	15	The report appendix with potential now includes short descriptions and images of each standard.

IOU Comment	Page	Eval response
Please consider retaining this ordering of standards through the various tables in other sections of the report. The order shifts and may make it somewhat more difficult for the reader who is reviewing multiple factors for a given standard.	16	In general, report and appendix standards have been reordered. Exceptions are where standards are categorized for sampling purposes.
Other than for the compliance improvement sampling how is this sampling employed? Is it directly used in the assessment of potential, NOMAD, and/or attribution?	19	The sample sizes were used only for our compliance assessment. The binning (high/med/low) was used to prioritize our attribution assessment. E.g., we used default attribution scores for water products (showerheads, faucets, urinals) and computer products (workstations, small servers).
This sentence is somewhat unclear; consider removing “or estimates”	23	“or estimates” deleted. Thank you.
Please note that you have assumed that every non-compliant sample point operated at baseline usage, i.e., old standard or market baseline, thereby creating a downward bias in savings since said measures may actually operate above the baseline (but not be fully compliant).	26	Yes, we assumed zero savings for products we found to be non-compliant, but we disagree that it biases our findings. It is possible that some non-compliant products performed above the previous baseline but below the standard, so they would save energy relative to the previous baseline. We do not consider this a factor biasing our evaluated savings. Specifically, If a product does not comply, then we presume it was not affected by the standard. Maybe the product does save some energy, but this is outside the influence of the standard. Assigning some partial savings due to the standard would imply that a manufacturer’s decision process is something like this, “There’s a new product standard in place so I’ll make one that is halfway to compliance with it.”
This statement is in conflict with footnote 27 which states “2020 and beyond.”	35	Using budget to allocate savings will take place starting in 2020. Text revised to reflect this.
Would you please provide a note that explains why: 1) why Fed 33, Fed 37, T20 38 and T20 40 kWh interactive effects (IE) decreased while therm IE increased; 2) why no IE was assumed for T20 39 and T20 41a; and 3) why IE was zeroed out for other devices likely to be in conditioned space, e.g. small battery chargers and residential clothes washers. Are these interactive effects consistent with those employed in DEER and those employed with the Potential and Goals study? If not, is there an intent to alter DEER interactive effects	44	We reviewed CASE, CCSR, and IOU documents to validate IOU estimates for IE. Findings relatively little information to support the IOU estimates we developed our values using a statewide average of DEER values for screw-in lamps. The P&G study also used DEER values but assigns them by climate zone and building type.

IOU Comment	Page	Eval response
to be consistent with these numbers. Similarly, does Navigant intend to treat interactive effects in the Potential and Goals study in the manner portrayed in this C&S impact assessment?		
Can you give examples of when it has affected service area planning?	53	This comment refers to planning and analysis conducted by the California Energy Commission - not detailed T&D planning by IOUs.
Consider deleting “lower”	62	“lower” deleted. Thank you.
Please consider placing a copy of this table in the executive summary.	62	We have added this summary table to the executive summary. Thank you for the suggestion.

Please explain why the MW evaluated/claimed is so much lower than the GWh evaluated/claimed. Particular attention in the explanation should be given to: Fed 28 Distribution Transformers, Fed 29 External Power Supplies, Fed 34 Commercial Refrigeration Equipment, and Std 38 Dimming Fluorescent Ballasts. Also please note whether the CPUC definition of peak demand for energy efficiency evaluation purposes was employed (and if not, why not).	62	Table 33 has been updated. In the initial draft the table shows cumulative (2016-2018) values for GWh and therms, but only 2018 values for MW. In addition, the allocation factors were applied twice in this table resulting in an overall IOU only evaluated savings value that was too low. **Regarding savings to particular standards:** **Fed 28 Distribution Transformers** o The evaluators calculated demand (MW) was the same as the IOUs' method. This was based on the potential energy savings and a load factor. Demand savings (MW) = (1000 MW per GW) x Energy Savings (GWh) / (8760 hours/year x Load factor of 60%) o The evaluators calculated an annual first year energy savings of 74.8 GWh, which is lower than the IOUs' estimate of 89.4 GWh. Because the demand savings are derived from the energy savings, the evaluated estimate of first year demand savings (14.2 MW) was lower than the IOUs estimate (17.0 MW). o The evaluators used the same data source as the IOUs (US DOE National Impacts Analysis spreadsheet). The DOE NIA spreadsheet requires that users specify both the equipment class and the trial standard level to determine the correct coefficients for load losses (LL) and no-load losses (NLL), which are inputs in the energy consumption calculation. The evaluators believe the IOU calculations referenced the NLL coefficients incorrectly and used the same NLL coefficient of 2.34 for equipment classes 2 through 10. This resulted in an overestimate of the baseline energy consumption and an overestimate of energy savings for these classes. **Fed 29 External Power Supplies** o The evaluator's method for calculating demand (MW) was the same as the IOUs' method and was based on the potential energy savings and a load factor. Demand savings (MW) = (1000 MW per

		GW) x Energy Savings (GWh) / (8760 hours/year x Load factor of 85%) o The evaluators calculated an annual energy savings of 70.5 GWh, which is higher than the IOUs' estimate of 68.4 GWh. Because the demand savings depend on the energy savings, the evaluator's estimates of first year demand savings (9.5 MW) were also higher than the IOUs estimate (9.2 MW). Fed 34 Commercial Refrigeration Equipment o The evaluator's method for calculating demand (MW) was the same as the IOUs' method and was based on the potential energy savings and a load factor. Demand savings (MW) = (1000 MW per GW) x Energy Savings (GWh) / (8760 hours/year x Load factor of 100%) o The evaluators calculated an annual energy savings of 145.8 GWh, which is lower than the IOUs' estimate of 168.0 GWh. Because the demand savings depend on the energy savings, the evaluator's estimates of first year demand savings (16.6 MW) were also lower than the IOUs estimate (19.0 MW). o The evaluators agree with the IOUs savings calculation method but disagree with the IOUs source of unit energy consumption (UEC) values. The UEC values in the IOUs' calculation match the UECs published in the DOE's 2013 Notice of Proposed Rulemaking (NOPR) TSD. However, the DOE published revised UEC values in the 2014 Final Rule TSD that were lower than the NOPR values referenced by the IOUs. The evaluation team referenced the revised Final Rule values, resulting in estimates of energy and demand savings that are lower than the IOUs' estimates. Std 38 Dimming Fluorescent Ballasts o The evaluator's method for calculating demand (MW) was the same as the IOUs' method and was based on the potential energy savings and a load factor. Demand savings (MW) = (1000 MW per

		GW) x Energy Savings (GWh) / (8760 hours/year x Load factor of 72%) o The evaluators calculated an annual energy savings of 27.1 GWh, which is lower than the IOUs' estimate of 54.9 GWh. Because the demand savings depend on the energy savings, the evaluator's estimates of first year demand savings (4.3 MW) were also lower than the IOUs estimate (8.7 MW). o For unit energy consumption values, the evaluators used a more recent data source than the IOUs. The IOUs' calculation references *Dimming Fluorescent Ballasts Codes and Standards Enhancement Initiative*. August 5, 2014, PG&E SCE SDG&E SCG, Table 4.1, pp 13. Following this report, additional testing was conducted, with results reported by the CEC in 2015. The evaluators referenced this updated data, in *Staff Analysis of HVAC Air Filters, Dimming Fluorescent Ballasts, and Heat Pump Water Chilling Packages*. February 2015. CEC. Figure 14, pp B-3. The updated data shows a higher weighted average unit energy consumption in the base case (222.7 kWh vs. 209.0 kWh) and in the standards case (214.0 kWh vs. 182.5 kWh). **Regarding peak savings:** The definition for peak outlined above is the definition employed in the CASE reports which drive the IOU savings calculations for C&S. This is not however the CPUC/DEER definition of peak. Recall from the C&S Harmonization Study in 2019 that there are different definitions between the CPUC and the CEC on peak demand savings. This difference carries over to IOU C&S calculations via the CEC CASE report calculations. If the IOUs do modify the CASE calculations for C&S the adjustments should be explicitly stated – perhaps in the CCSRs? The two definitions are stated here:

IOU Comment	Page	Eval response
		CEC "Peak" definition – Coincident peak is defined as the maximum hourly energy consumption throughout the year. It occurs on a specific day and during a specific hour. Each utility's day/hour of coincident peak can vary. The coincident peak is calculated based on electricity demand which does not account for customer self-generation and transmission losses. **CPUC "Peak" definition** – Peak is defined by DEER as the average demand impact as would be "seen" at the electric grid level for a measure averaged across 15 hours from 4 p.m. to 9 p.m. during the "hottest" three consecutive weekday period.[1] DEER identifies these three days for each of the 16 California climate zones, based on the weather data sets developed for the California Title 24 Building Energy Efficiency Standards.
We believe that the share of gas sales for "Other" in Table 13 (page 40) may be inappropriate given the intended use of the annual sales numbers for savings allocation purposes. The gas "other" category jumped from 1% historically to approximately 18%. We believe this may be due to the inclusion of gas sales to WAPA. We believe that the "other" gas sales values used for determining the total IOU share of statewide C&S savings should only include retail providers of natural gas for non-power generation use. Previous impact evaluations had defined the "other" gas sales category as primarily the City of Long Beach. While the CEC source you employed for gas sales may be accurate it is not appropriate to implicitly allocate 17% of C&S gas saving to providers who are not directly serving end-use customers. Please also note that this may impact draft C&S goals in the 2021 Potential and Goals study.	40	Thank you. Yes, we agree that sales to power producers should be removed for allocation purposes. After consultation with the Energy Commission, sales via the Kern River Transmission Company (part of WAPA) were removed and the allocations were recalculated for this evaluation.

[1] Source: DEER Resolution E-4952. Note: three-day period selected by taking the highest sum of the average temperature from noon to 6 p.m. over the three-day period, and the peak temperature within the three-day period. A three-day period cannot include weekends or holidays.

Appendix I. Response to Recommendations

Study ID	Study Type	Study Title	Study Manager			
CPU0235.01	Impact Evaluation	PY 2016-2018 Appliance Standards Evaluation Vol. 1	CPUC			
Recommendation	**Program or Database**	**Summary of Findings**	**Additional Supporting Information**	**Best Practice / Recommendation**	**Recommendation Recipient**	**Affected Workpaper or DEER**
1	State and Federal Standards Advocacy & State Codes Advocacy	The CCSRs support the savings claims (similar to workpapers). This documentation is expensive to produce and historically, the type of information to include is ambiguous. The evaluators identified several types of information or practices to include as the most informative for evaluation purposes		Items to include: 1)Rulemaking history and timelines. 2)List of key stakeholders and contact information. 3)Activities sorted by attribution factors. 4)Summary tables of ISSM inputs. 5)Standardized spreadsheet layouts (as much as practical). 6)Collection of related documents.	Program Administrator	CCSR
2	State and Federal Standards Advocacy & State Codes Advocacy	The CCSRs support the savings claims (similar to workpapers). This documentation is expensive to produce and historically, the type of information to include is ambiguous. The evaluators identified several types of information or practices to exclude since they provide little insight for evaluation purposes		Items to exclude: 1)Logic models and theory of change. These can be included in Business plans or other documents, as necessary. 2)Communication logs	Program Administrator	CCSR
3	State and Federal Standards Advocacy & State Codes Advocacy	There are two areas where the CCSR could improve by including better information.		1)The connection from CCSR assumptions to claimed savings should be clear. 2)Supporting files should be indexed and described or have standardized naming conventions that provide topic information.	Program Administrator	CCSR

Study ID	Study Type	Study Title	Study Manager			
CPU0235.01	Impact Evaluation	PY 2016-2018 Appliance Standards Evaluation Vol. 1	CPUC			
Recommendation	**Program or Database**	**Summary of Findings**	**Additional Supporting Information**	**Best Practice / Recommendation**	**Recommendation Recipient**	**Affected Workpaper or DEER**
4	State and Federal Standards Advocacy & State Codes Advocacy	Better quality control. The program administrator should verify the basics of reporting to CPUC. For example, we found standards reported as codes across		Develop protocols for each IOU for consistent reporting of program categories, measure names, and savings per unit.	Program Administrator	CEDARS
5	State and Federal Standards Advocacy & State Codes Advocacy	Many parameters for C&S do not exist in traditional program. As a result, CEDARS does not provide fields to report and maintain these values.		Data needs for non-CEDARS parameters need to be articulated and standardized so they can be submitted by program administrator with standard claim data.	CPUC, evaluators, and program administrator	CEDARS or CCSR
6	State and Federal Standards Advocacy & State Codes Advocacy	The CEDARS system treats C&S differently from other EE programs. One example is that gross savings are overwritten with net savings. There may be other data handling differences we did not identify.		Review and document policies on how C&S data are treated in CEDARS. Where treatment does not follow standard practice, document and either explain what is happening and why or change the data handling procedures. This will increase transparency for all parties.	CPUC	CEDARS
7	State and Federal Standards Advocacy	Some product manufacturers do not provide technical details of their products. In cases where this occurs, the evaluation could test products to improve the overall sample precision.		Consider allocating a contingent budget specifically for testing products that contribute significantly to savings, but do not have sufficient technical documentation for evaluation.	CPUC	

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